THESIS

A FRAMEWORK FOR EVALUATING ENVIRONMENTAL COMMITMENT TRACKING PROGRAMS IN STATE DEPARTMENTS OF TRANSPORTATION

Submitted by

Andrew Christopher Fillion

Department of Construction Management

In partial fulfillment of the requirements

For the degree of Master of Science

Colorado State University

Fort Collins, Colorado

Fall 2011

Master's Committee:

Advisor: Mehmet Ozbek

Caroline Clevenger
Peter Taylor

ABSTRACT

A FRAMEWORK FOR EVALUATING ENVIRONMENTAL COMMITMENT TRACKING PROGRAMS IN STATE DEPARTMENTS OF TRANSPORTATION

Environmental tracking systems (ETSs) are used by state Departments of Transportation (DOTs) as well as by Federal agencies to track environmental commitments on construction projects from the project development stage through design, construction, and project completion. In this study a framework is developed that any state DOT can use to evaluate existing ETSs implemented by other state DOTs. This framework will allow that state DOT to identify the system that best meets its needs with the ultimate purpose of adopting that system. The framework's main function will be to identify and prioritize the features that a state DOT is looking for in an ETS, to evaluate existing ETSs used by other state DOTs with respect to those features, and to provide a final recommendation on which ETS should be adopted by that state DOT. The developed framework was implemented at the Colorado Department of Transportation (CDOT). The findings and recommendations for that implementation example are also included in this study.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AASHTO: American Association of State Highway and Transportation Officials

AHP: Analytic Hierarchy Process

ARTBA: American Road and Transportation Builders Association

C.R.: Consistency Ratio (as defined in AHP)

CalTrans: California Department of Transportation

CAP: Communicating All Promises tracking tool

CAT X: Categorical Exclusions

CDOT: Colorado Department of Transportation

CE: Categorical Exclusion

CEDAR: Comprehensive Environmental Data and Reporting

COTS: Commercial Off-The-Shelf software

CTS: Commitment Tracking System

DCEC: District Construction Environmental Coordinator

DOTs: Departments of Transportation

DTSD: Division of Transportation System Development

EA: Environmental Assessment

ECOPAC: Environmental Commitments & Obligations Package for Construction

EIS: Environmental Impact Statement

EPA: Environmental Protection Agency

ETS: Environmental Tracking System

FDOT: Florida Department of Transportation

FHWA: U.S. Department of Transportation Federal Highway Administration

FLH: Federal Lands Highways

GOTS: Government Off-The-Shelf software

INDOT: Indiana Department of Transportation

IT: Information Technology

KYTC: Kentucky Transportation Cabinet

LDCA: Local Design and Concept Acceptance

NEPA: National Environmental Policy Act

NJDOT: New Jersey Department of Transportation

NYSDOT: New York State Department of Transportation

OIS: Office of Information Systems

OSS: Open Source Software

PD&E: Project Development & Environmental

PL&EM: District 4 Planning and Environmental Management

Precon: Oracle Preconstruction database

PS&E: Plans, Specifications, and Estimates

PSS: Program Support System

RFP: Requests for Proposals

SEMS: Statewide Environmental Management System

STEVE: Standard Tracking and Exchange Vehicle for Environmental

TDOT: Tennessee Department of Transportation

TxDOT: Texas Department of Transportation

USFWS: U.S. Fish and Wildlife Service

VDOT: Virginia Department of Transportation

WisDOT: Wisconsin Department of Transportation

WSDOT: Washington State Department of Transportation

WYDOT: Wyoming Department of Transportation

CHAPTER 1: INTRODUCTION

Environmental commitments are actions that are intended to avoid, minimize, or mitigate environmental impacts on a construction project (American Association of State Highway and Transportation Officials, 2006). Tracking environmental commitments on construction projects can be a challenge for state Departments of Transportation (DOTs) and Federal agencies. The implementation of an effective Environmental Commitment Tracking System, or Environmental Tracking System (ETS), can provide the means necessary to document and demonstrate to all stakeholders that such commitments have been or are being met. From the time a project is in the developmental phase to the time it has been constructed, state and Federal laws require commitments to be met as a basis for receiving project approval and funding (American Association of State Highway and Transportation Officials, 2006). Furthermore, the successful tracking of commitments on projects is necessary for the execution of a successful environmental management strategy. In order to maintain the public trust, DOT's and Federal agencies require reliable commitment tracking systems (Venner, 2007).

1.1 Background on Environmental Commitments

The majority of environmental commitments come from the National Environmental Policy Act (NEPA), which was signed into law on January 1, 1970. The Act created a process for the protection, maintenance, and enhancement of the environment. This national environmental policy provides a process for implementing these goals within the Federal agencies. The NEPA process requires Federal agencies to incorporate environmental considerations into their planning and decision making process. This includes preparing a statement assessing the impacts that a Federal project would have on the environment (United States Environmental Protection Agency, 2010).

There are three levels of analysis in the NEPA process for Federally funded projects. The first level is a categorical exclusion (CE). At this level an undertaking may not require an environmental analysis if it meets certain criteria. This may include a Federal agency having previously determined that similar undertakings had no significant impact on the environment. Some agencies have developed a list of actions that regularly fall into this category. If this is the case, the actions are considered to be categorically excluded from requiring an environmental evaluation under NEPA regulation (United States Environmental Protection Agency, 2010). Examples of CEs include the construction of pedestrian and bicycle paths and lanes, landscaping, improvements to existing rest areas, and the installation of fencing, signs, and railroad warning devices where no substantial land acquisition or traffic disruption will occur (U.S. Executive Branch, 2011).

The second level of analysis in the NEPA process is an environmental assessment (EA) in which a Federal agency determines whether the specific project would significantly impact the environment. If the answer is no, then the agency issues a finding of no significant impact (FONSI). Included in the FONSI can be measures that the agency plans to take to mitigate the potential of an action having a significant impact on the environmental. The third level of analysis is an environmental impact statement (EIS). If during the EA it is determined by the Federal agency that the proposed undertaking may significantly affect the environment, than an EIS is prepared. An EIS is a more detailed evaluation of the proposed actions and may include possible alternatives. Outside sources and other Federal agencies may provide input in the preparation of the EIS (United States Environmental Protection Agency, 2010).

1.2 The Federal Agencies' Role in the NEPA Process

The role that the Federal agency takes during the NEPA process is based on the Federal agency's expertise and relationship to the proposed undertaking. While there may be more than one Federal agency involved in an undertaking, one will be designated as the lead agency and will supervise the preparation of the environmental analysis. If there is a state, tribal, or local agency which has special expertise in regards to the environmental issue or jurisdiction, they may act as a joint lead agency or as a cooperating agency with the Federal agency in the NEPA process. As a cooperating agency, they assist the lead agency at the earliest possible time in the NEPA process. This is done through assisting in the scoping process, developing information and preparing an environmental analysis in the cooperating agency's area of expertise, and providing additional staff support to assist the lead Federal agency (United States Environmental Protection Agency, 2010).

Though the majority of environmental commitments are a result of the NEPA process, environmental commitments come about from various documents and at various stages in the environmental review process. Examples of sources, which include those agencies cooperating in the environmental review process from where the environmental commitments can arise from are state Environmental Agencies, the U.S Army Corps of Engineers, local agencies, and the U.S. Fish and Wildlife Service (American Association of State Highway and Transportation Officials, 2006). These agencies will often times issue permits or statements which contain the commitments that must be met as part of receiving project approval.

1.3 Overview of Environmental Commitment Tracking Systems

ETSs are used by state DOTs as well as by Federal agencies to track environmental commitments on construction projects from the project development stage through design, construction, and ultimately to project completion (Washington State Department of Transportation, 2010). An ETS's purpose is to provide those who are responsible for carrying out the commitments with a means for tracking the status of the commitments as well as maintaining the necessary information that is tied to that commitment. This can include permits, locations, and the ways and means to be used for carrying out the commitment.

Equally important is the accountability that a tracking system can provide. Having the ability to provide documentation to the Federal and cooperating agencies which shows a commitment was met is another goal of an ETS. This can be done through creating a report that documents the date it was completed and the responsible party who signed off on its' completion (Venner, 2007).

1.4 Current Status

Given that the Federal government does not have a standard ETS, many state DOTs and Federal agencies currently have many different methods for tracking environmental commitments ranging from paper based tracking systems in the form of lists and spreadsheets to specialized databases and web based systems. The Colorado Department of Transportation (CDOT) uses a Microsoft Excel spreadsheet. Not part of a server or web based system, the spreadsheet remains a single hard copy throughout the life of a project. Texas Department of Transportation (TXDOT), Washington State Department of Transportation (WSDOT), and Florida's Department of Transportation (FDOT) are among the states which have web or server based systems all varying in degrees of functionality (Cambridge Systematics, 2006).

1.5 Problem Definition

The need to track environmental commitments on all state DOT construction projects continues to grow as environmental policies shape the way projects are carried out. Tracking environmental commitments is a difficult task, especially on large complex projects. The status and proper tracking of these commitments can have both financial and civic ramifications. When deciding what type of an ETS to implement, there are many different deciding factors. Examples include first cost, system maintenance cost, ease of use, and technical features.

It is important when an organization has decided to commit both the time and financial resources to implementing a new system to ensure that it will be effectively implemented by the members of the organization and ultimately by the end users of that system. End users include many state DOT employees such as project managers, environmental project managers, regional managers, field personnel, and in some cases outside agencies, consultants, and contractors working on state DOT projects.

While all the different end users of the ETS may have the same goal of making sure that the environmental commitments on a project are met, their specific needs for an ETS are often different. The state DOT environmental project manager may want a system that can easily print reports allowing them to provide documentation to a Federal agency showing that the commitments were met on a project. A state DOT field superintendent may want a system that allows them to easily locate where it is that a commitment is to be carried out, the technical requirements of it, and an explanation of why it is required. The goal of selecting the type of ETS which best meets the needs of an organization and all the parties responsible for utilizing the system can be a difficult task.

1.6 Research Objective

The objectives of this research are as follows:

1) To develop a framework that any state DOT can use to evaluate existing ETSs implemented by other state DOTs. This framework will allow that state DOT to identify the system that best meets its needs with the ultimate purpose of adopting that system. This framework's main function will be to identify and prioritize the features that a state DOT is looking for in an ETS, to evaluate existing ETSs used by other state DOTs with respect to those features, and to be able to provide a final recommendation on which ETS should be adopted by that state DOT.

2) To present an implementation example of this framework for CDOT.

1.7 Scope

1) The focus of the framework developed in this research is to evaluate other state DOTs' ETSs based solely on technical features. As discussed in section 5.4, cost and ease of use are identified as future research areas.

2) The scope of this research is limited to developing a framework that can evaluate existing ETSs and provide a final recommendation based on that evaluation as opposed to developing a brand new ETS to meet the needs of the state DOT. Making use of the best practices from other state DOTs makes the most sense in a tough economic

environment. The sharing of information through synthesis projects and cooperative learning is common practice in the state DOT industry, and although the complete needs of the state may not be captured in already existing states' ETSs, it will provide valid and satisfactory results.

3) The developed framework will be implemented for CDOT only due to the geographic location (i.e., Colorado) of the researcher undertaking this project and availability of data.

CHAPTER 2: LITERATURE REVIEW

2.1 Types of Environmental Commitments

Environmental commitments are required as conditions of project approval during the environmental review process. These efforts may be put forth during project design, construction, mitigation, stewardship, and maintenance (American Association of State Highway and Transportation Officials, 2009). Examples would include, requiring native plant species to be used when revegetating disturbed areas, requiring the use of construction equipment that has been retrofitted with technologies to minimize emissions, required mitigation such as the replacement of wetlands, or stewardship and maintenance efforts such as retrofitting existing roadways with storm water management facilities and follow-on efforts of those facilities (American Association of State Highway and Transportation Officials, 2006).

2.2 Commitments in Contracts

When implementing environmental commitments, it is important that they are communicated to the design team and to the construction contractors. Environmental commitments are considered to be either project design commitments, construction commitments, or modified commitments. What differentiates these commitments is the phase during the project in which the commitment is to be met in and who the responsible party is for carrying out the commitment (American Association of State Highway and Transportation Officials, 2006).

2.2.1 Design Commitments

Design commitments are specific requirements that must be met by design as well as possible guiding principles during the design phase. The design team should receive a list of these commitments as well as any consultants who are responsible for the designing of a particular section of a project. Examples of design commitments include incorporating the building of a retaining wall in the construction of a project to minimize wetlands impacts, continued coordination with municipalities and neighborhood associations to minimize any socioeconomic impacts of the project, and instructions to minimize the need for land acquisition. If design-build is the project delivery method that is to be used for a specific project, it is important to incorporate the design commitments with the construction commitments in the contract (American Association of State Highway and Transportation Officials, 2006).

2.2.2 Construction Commitments

Construction commitments are the commitments which must be met during the construction phase of the project. While these commitments are likely to have been developed during the project development or design phase, it is important that they are included in the bid documents to ensure that contractors take into account the required measures and responsibilities that will be expected of them when developing their bids for the project. Examples would include providing alternate access routes for the public during construction as well as ensuring public access to businesses and residences. It is important that any design commitments which are to be completed by a design-build contractor (if this is the project delivery method to be used) be included in the bid documents (American Association of State Highway and Transportation Officials, 2006).

2.2.3 Modified Commitments

Changes in environmental commitments can occur during the design or construction phases of a project. Altering, deleting, or the adding of commitments can all be expected and are common on projects. Reasons for the modifying of commitments can include that new information has been acquired about the environmental conditions on a project or because there have been changes made to the scope. When modifying commitments on a project, it is important to contact and receive approval from the agency that was responsible for granting approval on a project, based on the condition that a commitment would be met (American Association of State Highway and Transportation Officials, 2006).

2.3 Examples of Common Environmental Commitments in Projects

Commitments can be utilized to reduce the impacts on sensitive areas and add desirable features to a project. They can help to blend projects more pleasantly with the surrounding environment, avoid disrupting the natural wildlife and habitat, and protect and preserve cultural and historic monuments (Tennessee Department of Transportation, 2007). Although there is not a readily available comprehensive list of environmental commitments to be considered on transportation projects, the following list from the Tennessee Department of Transportation (TDOT) (Tennessee Department of Transportation, 2007), and the U.S. Department of Transportation Federal Highway Administration (U.S Department of Transportation Federal Highway Administration, 2001) provide some common examples:

- Noise barriers to help mitigate construction noise
- Color coordinating of newly placed concrete and rocks to the surrounding areas

- The texturing and coloring of bridges
- The seeding of right of ways and medians with native plants and vegetation
- The planting of native trees or the saving of native trees so they can be replanted after the project is completed
- Monitoring and controlling existing and future water quality in the construction affected areas
- Providing residents of homes and business displaced by projects with comparable and safe relocation assistance
- Committing to off-season construction to avoid habitat during the breeding season of an endangered species
- Creating wildlife underpasses
- Incorporating drainage structures into highways to prevent or control the release of water and debris into protected water resources
- Landscaping to serve as visual screens
- Creating landscaped gateways into communities
- The inclusion of public art on overpasses
- Providing signage to recognize specific cultural or historical resources
- Relocating a historic structure such as a building or bridge

2.4 Summary of Literature Findings on Environmental Commitment Tracking Systems

The goal of an ETS is to track commitments from their inception (usually in project development) to their completion. This can include tracking through the design and construction phases and continue to the passing off for long term maintenance if required. The key components for having an ETS as described by the Washington State Department of Transportation (WSDOT) is knowing exactly what the departments is committed to doing, ensuring it gets done, documenting it was completed, looking for ways to improve fulfilling like commitments in the future, and maintaining it (Washington State Department of Transportation, 2008).

In 2006, the American Association of State Highway and Transportation Officials developed a practitioner's handbook for tracking environmental commitments. In this handbook the importance of having established procedures for communicating and tracking environmental commitments on complex projects is highlighted. Complying with environmental commitments is a legal requirement and the consequences of non-compliance can be severe. Penalties for failing to implement commitments made during the NEPA process as well as violating permit conditions include losing Federal funding on projects, work stoppages, litigation, and can cause long-term damage to relationships with resource agencies. When designing or implementing a commitment tracking system, potential elements can include a commitment tracking database, agency coordination, and an Environmental Management System (EMS) (American Association of State Highway and Transportation Officials, 2006).

2.4.1 WisDOT Study

In 2008, The Division of Transportation System Development (DTSD) within the Wisconsin Department of Transportation (WisDOT) performed a study to locate states which have developed successful tracking mechanisms to ensure that departments within an organization communicate with each other and that commitments stay attached to projects throughout their life. In the study, it was found that some states were using forms and lists while others states such as Illinois, Montana, New York, and Washington State had developed specialized databases to track commitments (CTC & Associates LLC, 2008).

2.4.2 ICF Study

In 2006, a study was done by the independent consulting firm, ICF Consulting. The study was conducted to benchmark six state DOTs' ETSs. While numerous paper-based commitment programs exist, this study was confined to state DOT's using electronic systems. The objective of the study was to provide the Federal Lands Highways (FLH) with an inventory of what was available in terms of tracking systems. Kentucky, Illinois, Maryland, New York, Texas, and Washington were evaluated based on each state's system's features. These features include the tracking systems reporting, filtering, and project management functions. The study identified the Texas DOT and the Washington State DOT as the lead states with active, web based environmental commitment tracking systems (Venner, 2007).

2.4.3 FHWA Study

In 2002 the Federal Highway Administration (FHWA) sponsored a Domestic Scan Tour on Environmental Commitment Implementation. The purpose of the scan was to identify successful practices and procedures to ensure the follow through of commitments made both during and after the NEPA process. The scan team consisted of members from Federal and state departments as well as from other outside offices. Included were representatives from the FHWA Headquarters Office of Project Development and Environmental Review, FHWA Division Offices, state Departments of Transportation (DOT's), the U.S. Environmental Protection Agency (EPA), the U.S.

DOT Volpe National Transportation Systems Center, the American Association of State Highway and Transportation Officials (AASHTO), and the American Road and Transportation Builders Association (ARTBA) (U.S. Department of Transportation Federal Highway Administration, 2002).

The team visited seven state DOTs to review successful processes, procedures, and methodologies used in fulfilling environmental commitments. The seven states visited were Colorado, Indiana, Kentucky, New Jersey, New York, Texas, and Wyoming. The team found a wide range of programs and systems being used, some more sophisticated than others. However, all the states reviewed were dedicated to ensuring the successful implementation of environmental commitments. During the process, the team observed that to achieve success, the implementation must be a part of the transportation project development process. Along with having a system in place that works effectively, communication throughout the entire process from planning to construction through maintenance is essential for success. Communication between the agencies and the state DOTs throughout the environmental review process allows for an overall understanding of the commitments and permit agreements (U.S. Department of Transportation Federal Highway Administration, 2002).

The ultimate objective of the study was to assist states, FHWA Divisions, environmental resource agencies, and the private sector in successfully complying with environmental commitments throughout the entire transportation design, development, and construction processes (U.S. Department of Transportation Federal Highway Administration, 2002). The approaches that were gathered during the domestic scan provided for a wide range of possibilities for improving processes and systems of tracking commitments and ensuring compliance. The best management practices and the states in which these innovative practices are performed are provided in the study. The following is a list of those findings (U.S. Department of Transportation Federal Highway Administration, 2002):

- **Environmental Ethic/Stewardship** – Empowering employees to act as environmental stewards through encouraging them to include environmental consideration as an essential element of the transportation project development process, New York State Department of Transportation (NYSDOT).
- **Staffing** – Employing an environmental coordinator responsible for working with the construction and maintenance staff and crews in coordinating and monitoring the implementation of mitigation commitments, Wyoming Department of Transportation (WYDOT).
- **Training** – Mandating that consultants currently working on Indiana Department of Transportation (INDOT) projects or offering professional services go through a 3-day NEPA training on unique environmental aspects, INDOT.
- **Guidance Documents** – Development of pocket guides addressing environmental compliance issues that may be encountered during the construction or maintenance of projects and advice on how to handle unforeseen issues and where to go for assistance when problems arise, Texas Department of Transportation (TxDOT).
- **Commitment Assurance** – Improving communication among all parties involved in the transportation process through the "Communicating All Promises" (CAP) approach, which tracks and demonstrates follow-through on all commitments

made from planning through construction and maintenance, Kentucky Transportation Cabinet (KYTC).

- **Tracking Mechanisms** – Development of a Cultural Historic Preservation List intended to help improve its relationship with the State Historic Preservation Office. The list includes a project description, identifies program and project managers, lists target dates for specific activities, estimates mitigation costs, and provides status updates, New Jersey Department of Transportation (NJDOT).
- **Public Involvement** – Creation of a public involvement office and website, ongoing stakeholder meetings, and public education workshops in a low-income minority community, where many of those impacted by the project only speak Spanish. The Kelly Parkway Corridor Study took place in San Antonio, Texas, TxDOT.
- **Interagency Coordination** – Created a Council of Resource Agencies (Council) which includes the U.S. Forest Services, the U.S. Army Corps of Engineers, the U.S EPA, the Bureau of Land Management, and U.S. Fish and Wildlife Services. The Council's purpose is to address project commitments and discuss concerns with resource agencies prior to a project's construction, CDOT.

2.5 Required Features of an ETS

When developing a commitment tracking database, a statewide system provides the most comprehensive and efficient method. However, because most states do not have such a system, it is important to customize the database to meet the needs of individual projects. In doing so, the most important task is creating the appropriate database fields as well as the ability to create data entry forms and standard reports. It is also necessary when creating an environmental commitment tracking system to enable the users to adapt, change, and update commitments during the project, maintain appropriate security, and have the ability to enter new commitments into the system (American Association of State Highway and Transportation Officials, 2006).

According to the 2006 ICF Consulting study (ICF Consulting, 2006a), FLH was in need of an updated ETS as its current system was not able to ensure that commitments were being kept. At the time that the report was written, FLH was looking for a system that could track commitments through the transportation development and construction process. The ICF report gives a very thorough listing of what the required features of a centralized commitment tracking system are. The main recommended features that a system should have as outlined in the study are (ICF Consulting, 2006b):

- **Permit Tracking** – Keeping track of permits and ensuring they are obtained and their obligations are met.
- **Viewing Commitments and Permits** – Ability to retrieve and update the details of commitments and permits as wells as sort and filter by project name, expiration date, and the party responsible for carrying out the commitment.
- **Configure Notifications and Alerts** – Automatically generated emails to the appropriate parties regarding deadlines, required activities, and changes to permits and commitments.
- **Document Management** – Ability to store electronic copies of permits, contracts, and other Microsoft Word and Adobe PDF documents.

- **Reporting** – Ability to collect comprehensive data based on specified criteria and create annual and ad-hoc reports for both internal use and those required by outside regulatory agencies.
- **Performance Measurement** – Facilitation of tracking environmental performance and measurement of progress toward performance according to success criteria.
- **User Administration and Security** – Provide access to partner agencies, construction staff, and project staff in the field. Ability to change responsible party for commitments when there is employee turnover and allow for multiple people to add new commitments.

In this study (ICF Consulting, 2006b), commitment tracking was included in the list of required features of an ETS. For the purpose of this research it has been excluded as commitment tracking is the main objective of the framework, and not a feature of the system.

2.6 Software for ETSs

As part of the 2006 study, ICF Consulting provided FLH with a report on recommendations for what type of technology should be used to implement their ETS. The four types of technology explored were; custom software, open source software, a government off-the-shelf system, and a commercial off-the-shelf system. The four main criteria used to measure the software options were, feature sets, cost, flexibility, and the time it would take to implement the software (ICF Consulting, 2006a).

A custom software system would provide FLH with the flexibility of creating a system to meet all their necessary requirements and modify it to their own needs.

However, starting from a blank slate and not making use of other systems' existing features makes this the most expensive option with long implementation times and concerns regarding the customer support available (ICF Consulting, 2006a).

The Open Source Software (OSS) system would take advantage of existing systems' features in the marketplace. These existing features would be utilized as the foundation in the development of an ETS to meet FLH's needs, allowing for a much shorter implementation time. However, despite being less expensive than the custom system, the OSS system is costly enough for it to be considered one of the downfalls of this option. Other cons include features being limited to what is available; and similar to the custom software, there are concerns regarding the customer support available for these systems (ICF Consulting, 2006a).

The government off-the-shelf (GOTS) system that was evaluated in this study is WSDOT's web-based system. Utilizing this type of system, which has already been developed, would allow for a short implementation time and uses the best practices developed by WSDOT. The cons of a GOTS system is that it only provides FLH with a minimal set of the desired capabilities in such a system, and would be expensive because so many modifications would be necessary. Similar to other non-commercial systems, receiving customer support for this type of system would be considered a negative aspect (ICF Consulting, 2006a).

The fourth system analyzed, which is also the recommended system, is the commercial off-the-shelf (COTS) system. The study analyzed two commercially available systems which are continually revised and updated to meet the changing needs of environmental programs, and have the capability to provide the feature set that can meet all of FLH's requirements. As the systems already have the majority of the features built within them, short implementation time is achieved with minor modifications and configuring. The costs of both COTS systems are comparable to the other systems, and because they are commercial products, technical support would be provided by the vendors. The cost for ongoing annual maintenance by the vendor is the main con of these systems. Through the findings in this report the product recommended by ICF Consulting that FLH implements to serve as their ETS is a COTS system available from Intelex Technologies, Inc. (ICF Consulting, 2006a).

CHAPTER 3: METHODOLOGY / DEVELOPED FRAMEWORK

Qualitative research methods include exploring and understanding the significance that has been attributed to a social or human problem by an individual or a group (Creswell, 2009). It is the researcher's responsibility to interpret the meaning of the data collected that was gathered through practices such as open-ended questions that were asked in the participant's normal settings. Collaborating with the participants and understanding what their beliefs are, all while considering the context of the participants will be essential (Creswell, 2009). Qualitative research produces findings that have not been arrived at by statistical procedures. This can include an individual's experiences with and feeling towards the phenomena that is being researched (Strauss, 1998).

Quantitative research methods utilize numerical data collected. The numbered data collected can be analyzed using statistical procedures, and tests objective theories by examining the relationship among the variables. Surveys, closed-ended interview questions, and the numerical data are all approaches used as a means of gathering data in quantitative research (Creswell, 2009).

A sequential mixed methods research approach will be the strategy employed in the framework developed in this study. Sequential mixed methods strategy is utilized when the researcher seeks to expand on the findings of one method with another method (Creswell, 2009). For the purpose of this study, a qualitative interview process should be the first step for exploratory purposes, followed by quantitative surveys to be performed, with the data collected to be evaluated using the Analytical Hierarchy Process (AHP).

The methodology developed consists of five steps: (i) conducting interviews to get a better understanding of a state DOT's needs with respect to an ETS, more specifically the features that state DOT employees prefer to have in an ETS; (ii) developing metrics based on those features to be able to evaluate the ETSs used by other state DOTs with respect to those features; (iii) assigning weights to those metrics to establish the importance of the features relative to each other based on the state DOT's preferences using a rigorous quantitative method (i.e., Analytic Hierarchy Process); (iv) performing a qualitative evaluation of existing ETSs implemented by other state DOTs; and (v) performing a quantitative evaluation of existing ETSs implemented by other state DOTs. This chapter discusses these five steps in detail.

3.1 Step 1 - Conducting Interviews

The first step of the framework calls to perform interviews to better understand the state DOT's needs with respect to an ETS, more specifically, to better understand the state DOT's preferred features for an ETS. The interviews should include both open-ended questions and closed-ended questions. The main objective of the open-ended questions is to gain an overall understanding of the problems being faced by the state DOT under investigation. Specific closed-ended questions should also be asked to allow the researcher to develop a list of metrics (as discussed in Section 3.2) based on the state DOT's desired features in an ETS (Creswell, 2009).

The selection of the interviewees should be considered a very important part of Step 1 and requires careful attention as the preferences determined by these individuals will represent the preferences of the organization as a whole. Participants should include professionals from the state DOT, which is seeking to evaluate the existing ETSs to identify the system that best meets its' needs with the ultimate purpose of adopting that system. This study calls for environmental managers, project managers, regional managers, and other representatives from the state DOT's central headquarters' office to be included in the group of people to be interviewed. Specific participants should be chosen as target recruits based on their knowledge of ETSs, the fact that they would be ETS end-users, or because of their involvement with the state DOT NEPA process. Furthermore, it would be valuable to interview personnel from the FHWA as the FHWA works closely with the state DOTs to ensure that environmental commitments are being met on Federal highway projects.

Recruitment of participants should be done through letters sent via email. Once the participants have agreed to be interviewed, they should be sent a copy of the questions they will be asked. These questions will be developed based on the literature review. In the list of questions each participant receives should also be a blank section with the words "to be provided at interview". In its complete form, this section should include a list of ETS proposed features. Leaving this section blank prior to the interview is intended to not bias the participants' ability to prepare for and answer the open-ended question, "What are some important technical features of an environmental tracking system for the state DOT?" It is important to not overlook any preferred features and to get as much information as possible about the state DOT's preferences because this information should be subsequently used to develop metrics to evaluate the ETSs used by other state DOTs.

The preferred method is to interview each participant in a face-to-face, one-on-one setting at the participant's location of work. This will allow for the participants to provide historical information and elaborate on their areas of expertise. Further this will allow the researcher to control the line of questioning and gain insight into the participants' work environments (Creswell, 2009).

It is recommended that the interviews take no longer than1 hour and be tape recorded with the permission of the participants. Keeping the interview times to a minimum helps keep the focus of the interviewee and ensures high quality responses during the entire interview process (Creswell, 2009). After conducting the interviews, the researcher should summarize and transcribe the interviews. The transcriptions should then be sent back to the individual participants. This will allow the participants the opportunity to make modification to the transcription in the cases in which the interviewee felt that the interviewer had misinterpreted his/her responses, or the interviewee wants to make changes to his/her responses. Along with their individual transcribe, each individual should also be sent a transcribe presenting an anonymous summary of the group's responses to each question. The purpose of sending this comprehensive document is to give each participant an opportunity to change his/her responses based on the other participants' responses. The final responses to interview questions should be recorded after this stage.

3.2 Step 2 - Developing Metrics

In this step, the feedback that is gathered during the interviews is aggregated and used to develop a comprehensive list of metrics to evaluate ETSs in use by other state DOTs. As discussed in the previous section, during the interview step, participants should be asked both open-ended and closed-ended questions about ETS features. Features positively cited by the majority of the participants are considered preferred and are to be included in the list of metrics. The metrics, which are the ETS features as expressed by the participants to be important to an ETS, are to be used in the development of pairwise comparison surveys as discussed in the next section.

3.3 Step 3 – Assigning Weights to Metrics

The list developed in Section 3.2 Step 2 – Developing Metrics, is an unranked list of preferred features by a state DOT. To fully capture the expectations of a state DOT with respect to an existing ETS, it is necessary to assess the importance of each metric relative to one another. By prioritizing the desired features, it is then possible to quantitatively evaluate and compare existing ETSs (as explained in Section 3.5 Step 5 – Quantitative Evaluation of Other States' ETSs) and to identify which system(s) best captures the state DOT's preferences. Therefore, once the final list of metrics is developed, the next step is to determine the importance of each metric by assigning weights to those metrics. A well-structured quantitative multi-criteria decision analysis method as discussed below, AHP is used to accomplish this.

In decision making, individuals make three general types of judgments to express importance, preference, or likelihood, and use them to choose the best among alternatives. The judgments are based on knowledge from memory or from analyzing benefits, costs, and risks. Past knowledge allows us to develop standards in rating the alternatives one at a time. This is useful in repetitive instances when it is recognized that the outcome must conform to established norms. Without norms, one compares alternatives against one another instead of rating them. AHP includes both the rating and comparison methods. In developing a reliable hierarchic structure or feedback network, the criteria of various types of influences, stakeholders, and decision alternatives must be included to determine the best choice (Saaty, 1994).

AHP is a method that assists people to organize their thoughts and judgments to make effective decisions by providing an objective mathematical calculation which can identify the inescapably subjective and personal preferences present in individual or group decision making (Saaty & Vargas, 2001). AHP is a general theory of measurement (Saaty, 1987) developed by Thomas L. Saaty for dealing with economic, socio-political, and complex technological problems (Saaty & Vargas, 1991). The theory's initial developments took place in the early 1970s while Saaty was doing contingency planning for the Department of Defense (Saaty, 1980). AHP allows for the application of data, experience, insight, and intuition in a logical and thorough way during the decision making process.

The main purpose of AHP is to derive weights for the factors (in this case metrics) under investigation, indicating their perceived importance (Saaty, 1977). AHP involves making pairwise comparisons between two factors at a time. In comparing two factors the question the participant answers is: "Which of the two is more important, and how much more important is it than the other?" (Aczél & Saaty, 1983). Pairwise comparisons are fundamental to the AHP process as priorities are set through the judging of pairs for their relative importance (Saaty, 1987). The scale of importance used to assign values to the factors in question is shown in Table 3.1. Furthermore, surveys are used to provide a quantitative or numeric description of the opinions of a population through studying a sample of that population. The purpose of surveys is to generalize the attitude or feelings toward a problem as felt by a group. Employing surveys that are collected at one-point in time, allows for the rapid turnaround of data collection (Creswell, 2009).

Table 3.1: Scale of Importance (Saaty, 1980).

Intensity of Importance	Definition
1	Equal importance of both alternatives
3	Moderate importance of one alternative over another
5	Strong importance of one alternative over another
7	Very strong importance of one alternative over another
9	Extreme importance of one alternative over another
2,4,6,8	Intermediate values between adjacent scale values

Once the pairwise comparisons are completed, a mathematical procedure is used to derive the quantitative values that represent the weights for each factor. AHP, by requiring pairwise comparisons, structures complex decision problems into levels that allow the decision maker to focus on smaller and simpler sets of decisions (Harker, 1989). The premise of AHP is that humans are more capable of making relative rather than absolute judgments (Linkov, et al., 2006).

A hypothetical example is presented herein to familiarize the reader with the AHP. In this example, a construction contractor wants to assign weights to four different factors that can be used in making a bid/no bid decision. The factors are (A) location of project, (B) project delivery method to be employed on the project, (C) having a previous working relationship with the project owner, and (D) the contractor's current backlog. Table 3.2 presents the results of the pairwise comparison made for this example through the use of a matrix.

Table 3.2: Pairwise Comparison Matrix for the Hypothetical Example

Importance of factor	A	B	C	D
A	1	5	7	3
B	1/5	1	3	1/3
C	1/7	1/3	1	1/7
D	1/3	3	7	1

For the pairwise comparisons, each of the factors in the leftmost column of the matrix is compared to each of the factors in the row on top. In the example, where the factor A is compared to factor C, A is considered to be of very strong importance over C, so a seven is entered into cell (A,C). When this comparison is made, there is no need to compare factor C to factor A as the reciprocal of the value that is used in comparing factor A to factor C is used in the reciprocal cell of the matrix. Therefore, the reciprocal of seven (1/7), is entered into cell (C,A). This can be done for all comparisons, resulting in the need to only empirically complete comparisons for the upper right of the matrix. The lower left values are merely the reciprocals of the values entered in the upper right. A factor is equally important when it is compared to itself, so where column A meets row A, in cell (A,A) the number one is inserted. In any other instance when a factor is compared to itself, the number one would be inserted into that cell, resulting in all of the diagonal cells to have a value of one (Saaty, 1980).

Once the pairwise comparisons are made and the matrix is completely filled out, the mathematical procedure to derive the quantitative values that represent the weights for each factor is performed. This procedure is discussed below and illustrated in Table 3.3.

Table 3.3: Mathematical Computations to Determine Weights in AHP

Importance of factor	A	B	C	D	Product of entries in each row	(n)th root of product	Weight
A	1.000	5.000	7.000	3.000	105	3.201	0.553
B	0.200	1.000	3.000	0.333	.1998	0.669	0.116
C	0.143	0.333	1.000	0.143	0.0068	0.287	0.050
D	0.333	3.000	7.000	1.000	6.993	1.626	0.281
						5.783	1.000

The first step of the mathematical procedure is to multiply the entries in a row and take the $(n)^{th}$ root of that product; where (n) represents the number of factors in the data set. For this example, n = 4 because there are four factors compared. After the $(n)^{th}$ root is calculated (in this case, the 4^{th} root) for each of the rows, the obtained values are normalized, resulting in a good approximation of the weights assigned to each factor as shown in the last column in Table 3.3 (Saaty, 1980). To normalize the $(n)^{th}$ roots, the $(n)^{th}$ root of each row is divided by the sum of all the $(n)^{th}$ roots. For example, to normalize the first row's $(n)^{th}$ root, 3.201 is divided by 5.783, $\left(\frac{3.201}{5.783}\right)$. The weights for each variable, shown in the last column, will sum to 1 as shown in Table 3.3 (Render & Stair, 2000).

AHP also requires the calculation of the consistency ratio (C.R.). The C.R. is a measure to identify how consistent the participant was in making pairwise comparisons. This measure of consistency is important because inevitably inconsistencies will occur when making multiple pairwise comparisons. For example, assume when factor F_1 is compared to factor F_2 the participant gives it a value of three times as important ($F_1 = 3F_2$), and, subsequently, assume when factor F_2 is compared to factor F_3 the participant gives it a value of two times as important ($F_2 = 2F_3$). If when the same participant compares F_1 to F_3 and does not give it a value of six times as important, it contradicts the transitive property of algebra ($F_1 = 6F_3$), and shows the participant is inherently being inconsistent (Saaty, 1994).

Calculating the C.R. consists of four steps as illustrated in Table 3.4. The first step is taking the sum of each column (resulting in the SUM row as shown in Table 3.4) and multiplying it by the weight for that respective factor to get the SUM PV as shown in Table 3.4 (Figueroa, 2010; Saaty, 1987). In Table 3.4 the SUM PV for factor A is 1.676*0.553 = 0.927.

Table 3.4: Mathematical Computations to Determine the Consistency Ratio (C.R.) in AHP

Importance of metric	A	B	C	D	Weight
A	1.000	5.000	7.000	3.000	0.553
B	0.200	1.000	3.000	0.333	0.116
C	0.143	0.333	1.000	0.143	0.050
D	0.333	3.000	7.000	1.000	0.281
SUM	1.676	9.333	18.000	4.476	1.000
SUM PV	0.927	1.083	0.9	1.258	

The second step is taking the sum of all the cells in the SUM PV row to get the value know as Lambda-max $(0.927 + 1.083 + 0.9 + 1.258) = 4.168$ (Figueroa, 2010; Saaty, 1987).

The third step is calculating the consistency index (C.I.). The formula $\frac{(\text{Lambda max} - n)}{(n-1)}$, where *n* is equals the total number of variables in the matrix being compared is used to compute the C.I. (Saaty, 1980). The C.I. calculation for the matrix is $\frac{(4.168-4)}{(4-1)} = 0.056$.

The final step in calculating the C.R. consists of taking the C.I. and dividing it by the appropriate random index (R.I.) number from Table 3.5. The R.I. Table was developed by Saaty and provides a different R.I. number for different matrix sizes, i.e., total number of factors (n) included in the pairwise comparisons (Saaty, 1980). For this example, the appropriate R.I. is 0.9 (corresponding to 4 factors) and thus the C.R. is equal to $\left(\frac{0.056}{0.90}\right) = 0.062$.

Table 3.5: Random Index (R.I) according to Matrix Size (n) (Saaty, 1980).

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

AHP literature suggests that when the C.R. is less than 0.10, the decision maker's responses (i.e. pairwise comparisons) are considered to be relatively consistent (Figueroa, 2010; Saaty, 1987). The C.R. evaluates the probability that the matrix was filled in using a completely random manner by the participant. If consistent judgments are made, the C.R. decreases and thus should be below 0.10, the accepted upper limit for C.R. (Harker, 1989).

Following the AHP methodology, a pairwise comparison survey should be developed and sent to the participants asking each member to individually complete the survey. The surveys should define the metrics and provide instructions on how to indicate preference when making pairwise comparisons of the metrics. It should also include a brief description of AHP and how the data collected from the survey will be used in this method of data analysis (Creswell, 2009). The respondents should be asked to make the pairwise comparisons and indicate their preferences using the charts provided by circling the appropriate value (an example of which is shown in Figure 3.1) as opposed to completing matrixes. This will enable them to complete the survey in the most efficient way and to prevent possible confusions that may occur when dealing with large matrixes. Once the surveys are returned to the researcher, the survey responses are to be transferred into appropriate pairwise comparison matrixes in Microsoft Excel to perform the computations as required by the AHP.

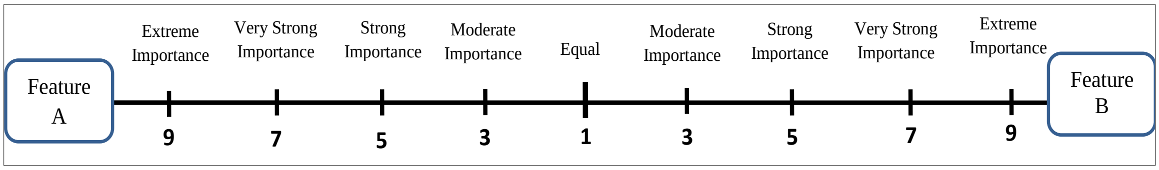


Figure 3.1: Example Pairwise Comparison Chart used in the AHP Surveys

To combine the judgments of the participants into a single group judgment for each pairwise comparison, AHP literature suggests using the geometric mean of the individual judgments (Aczél & Saaty, 1983; Saaty, 1989). Therefore, such a process should be followed to develop the final pairwise comparison matrix representing the overall judgment of the group of respondents with respect to the importance of metrics. This final matrix is then used to perform the AHP computations and to eventually compute the weight assigned to each metric by the participants. As discussed above, those weights will represent the state DOT's views with respect to the importance of an ETS's features relative to each other. The C.R. should also be calculated for an overall group matrix to identify the consistency of the group's responses. This calculation is similar to that used to determine individual C.R.s, except that for the individual matrixes C.I. is calculated using the formula $\frac{(\text{Lambda max} - n)}{(n - 1)}$. For the overall group matrix, the formula $\frac{(\text{Lambda max} - n)}{n}$ is used to obtain the C.I. (Saaty, 1989).

3.4 Step 4 - Qualitative Evaluation of Other States' ETSs

This step of the methodology will be a qualitative evaluation of other states' ETSs by performing a thorough literature review and using a brief survey that is to be sent to state DOTs. The selection of these states is be based on the fact that the literature reviewed by the researcher consistently mentions these states as those with leading ETSs.

These states' DOT environmental program departments are to be contacted via email and asked to participate in this study by completing a very short survey to identify which of the features determined to be preferred by the state DOT in Step 2 - Developing Metrics are present in their existing ETS. Each state should be asked to respond to this survey by simply placing a check mark in the appropriate box in a Microsoft Excel file, with an option to elaborate in a comments section. An example of the survey to be utilized is shown in Table 3.6.

Table 3.6: Example of ETS survey sent to States

Feature	Yes	No	Comments
A			
B			
C			

3.5 Step 5 – Quantitative Evaluation of Other States' ETSs

Once the feedback from the other states has been received, a quantitative evaluation is to be performed to determine which state's ETS most closely matches the needs of the state DOT. This quantitative evaluation should use the features that were identified by the state DOT to be important (see Section 3.2 Step 2 - Developing Metrics) and their respective weights as obtained using the AHP process (see Section 3.3 Step 3 - Assigning Weights to Metrics). The quantitative score for each state's ETS is to be computed by assigning the determined weight to each feature that states identified as present in their ETS (see Section 3.4 Step 4 - Qualitative Evaluation of Other States' ETSs) and then adding all those weights. This approach ensures that the ETS with features that were ranked higher by the state DOT (in terms of their importance as deemed by the state DOT) to receive the highest quantitative score as opposed to the ETS with the most amount of features, albeit not necessarily the features most preferred by the state DOT. A hypothetical example of a survey returned by a participating state DOT with the weights included is shown in Table 3.7.

Table 3.7: Hypothetical example of State returned ETS Survey

Feature	Yes	No	Comments
A	X (.02)		
B		X (.03)	This is outside of the ETSs capabilities
C	X (.15)		
Total	.17	.03	

CHAPTER 4: FRAMEWORK IMPLEMENTATION AND FINDINGS

This chapter discusses the findings of this study as gathered through the implementation of the five-step methodology discussed in Chapter 3. The developed framework for evaluating existing ETSs for identifying the one to adopt was implemented at CDOT. CDOT formed a study panel with the goal of evaluating ETSs used by other state DOTs and identifying the most appropriate one for use at CDOT. The study panel members worked with the researcher to form a list of participants who would assist in the implementation of the developed framework. This chapter discusses the implementation of the framework.

4.1 Step 1 - Conducting Interviews and Step 2 - Developing Metrics

The first step of the framework was to perform interviews to better understand CDOT's needs with respect to an ETS, more specifically, to better understand CDOT's preferred features for an ETS. The interviews included both open-ended questions and closed-ended questions.

Participants (as shown in Table 4.1) included professionals from the FHWA Colorado Division, CDOT headquarters' office, and CDOT's regional offices. Specific participants were chosen as target recruits based on the recommendations of the CDOT Study Panel due to their knowledge of ETSs, the fact that they would be ETS end-users, or because of their involvement with the CDOT NEPA process.

Table 4.1: Interviewees by affiliation and position

Interviewee	Affiliation	Position
1.	CDOT	Planning and Environmental Manager – Region 1
2.	CDOT	Deputy Water Quality Program Manager
3.	CDOT	Environmental Project Manager – Region 1
4.	FHWA – Colorado Division	Environmental Program Manager
5.	CDOT	South Program Manager – Region 4
6.	Affiliation not reported	Position not reported
7.	FHWA - Colorado Division	Program Delivery Team Leader
8.	CDOT	Environmental Planner
9.	CDOT	Program Engineer – Region 5
10.	CDOT	Resident Engineer -Pueblo Region 2
11.	Affiliation not reported	Position not reported

Recruitment of participants was done through letters sent via email (Appendix I) in accordance with the research protocol approved by Colorado State University's Institutional Review Board (IRB). Once the participants agreed to be interviewed, they were sent a copy of the questions they would be asked (Appendix II). These questions were developed based on the literature review. The list of questions each participant received also had a blank section with the words "to be provided at interview". In its complete form, this section included a list of ETS proposed features (Appendix II, question #13). Leaving this section blank prior to the interview was intended to not bias participants' ability to prepare for and answer the open-ended question, "What are some important technical features of an environmental tracking system for CDOT?" (Appendix II, question #12). It was important to not overlook any preferred features and to get as much information as possible about CDOT's preferences because this information would subsequently be used to develop metrics to evaluate the ETSs used by other state DOTs.

Nine interviews were conducted in person; and two were conducted over the phone. The entire group of participants agreed to have the interviews recorded. The recordings will be kept in a secure location in the Principal Investigator's (PI's) office until 10/1/2014 as stated in the IRB approved research protocol. After conducting the interviews, the researcher summarized and transcribed the interviews. The transcriptions were then sent back to the individual participants. This allowed the participants the opportunity to make modification to the transcription in the cases in which the interviewee felt that the interviewer had misinterpreted his/her responses, or the interviewee wanted to make changes to his/her responses. Four of the eleven interviewees made minor changes to their interview responses. Along with their individual transcribe, each individual was also sent a transcribe presenting an anonymous summary of the group's responses to each question. The purpose of sending this comprehensive document was to give each participant an opportunity to change his/her responses based on the other participants' responses. After reviewing the group's summary of responses, no participant chose to make changes to his/her responses. The final responses to interview questions were recorded after this stage.

Table 4.2 presents the overall results of the interviews and metrics developed from the applicable open-ended and closed-ended questions. More specifically, Table 4.2 provides the applicable questions focusing on the preferences of CDOT with respect to the features of the ETS they want to adopt, a summary of responses to those questions, and the metric developed based on those responses. A detailed explanation for each metric is provided in Appendix III.

Table 4.2: Metrics Developed from the Interview Results

Questions	Summary of the Responses	Metric Developed
How should the system deal with commitments that change or are dropped between the planning and construction phases of a project? (Do you want them to be grayed out, or disappear or show progression of changes etc.)	All 11 interviewees in favor of having the capability to track deleted or modified commitments.	Track deleted or modified commitments
How should the system deal with permits?	9 in favor of having the capability to track permits.	Track permits
Who should be able to input or edit information in the CDOT tracking system?	2 votes for everyone at CDOT. 9 votes for selected individuals.	Control which CDOT employees can input/edit information
		Allow multiple CDOT employees to input/edit information
		Allow stakeholders to input/edit information
Should information for a single project be entered by one person or multiple people?	9 votes for multiple persons. 2 votes for one person.	Control which CDOT employees can input/edit information
		Allow multiple CDOT employees to input/edit information
		Allow stakeholders to input/edit information
Who should be able to view (not edit) information in the CDOT tracking system, both internally and externally?	Internally - 6 votes for anyone within CDOT, 5 votes for those with permission within CDOT. Externally - 7 votes for those with permission	Allow ALL CDOT employees to view information
		Allow external stakeholders to view information
		Control which CDOT employees can view information
Should each projects data be stored in separate files or should data for all projects be linked or stored in a single, centralized system?	9 votes for single centralized file. 2 votes for separate files.	Store data in single centralized file
If projects are linked, should individuals who can view a single project's information be able to view all projects or should there be hierarchical permission for viewing data?	5 votes for requiring hierarchical permission. 6 votes for no hierarchical permission.	Allow ALL CDOT employees to view information
		Control which CDOT employees can view information
What is the best way to access such a system? (i.e. web based, oracle/server based).	Web based 7 votes. Server based 2 votes. No response because question is not applicable to interviewees expertise - 2 votes.	Web based

Questions	Summary of the Responses	Metric Developed
What tools, currently used by CDOT, should the system be compatible with (e.g., ProjectWise, SharePoint, etc.)?	SharePoint -7 votes, ProjectWise - 7 votes, SAP - 2 votes, Escan - 2 votes.	Integrate with ProjectWise Integrate with SharePoint
What are some important technical features of an environmental tracking system for CDOT? (For example, ease of filtering or searching.)	Filter/Search - 5 votes	Sort and filter data
Should the system be able to sort or filter data?	11- yes	
Should the system provide document management and/or data storage functions? (i.e. hyperlinks to word documents or permits etc.)	8 - yes, 2 - no, 1 – maybe	Document Management
Should the system be GIS compatible?	6 - yes, 4 - no, 1- not sure.	GIS compatible
Should the system be able to generate notifications? (i.e. send notification prior to permit due date, or alert team after commitment has been fulfilled).	8 - yes, 1 - no, not necessary	Generate notifications
Should the system have the capability to create standard reports? (i.e. for annual reporting to regulatory agencies).	9 - yes, 1 - no, 1- no opinion	Standard Reports
Should the system differentiate between projects that are Categorical Exclusions (CAT X), Environmental Assessments (EA), or Environmental Impact Statements (EIS)?	7 - yes, 4 – no	Differentiate between CAT X, EA, & EISs

As can be seen in Table 4.2, the question "If projects are linked, should individuals who can view a single project's information be able to view all projects or should there be hierarchical permission for viewing data?" had 5 "yes" and 6 "no" answers; yet a metric was developed based on that question (even though majority did not think it was an important feature). It was believed that the 45.5% "yes" response rate justified its inclusion.

Responses indicated that there was not enough support to develop metrics based on the features included in certain questions. Table 4.3 lists those questions and the summary of the responses. These features were eliminated from the list of metrics developed.

Table 4.3: Features for which a Metric is not Developed

Questions for which a Metric is not Developed	Reasoning
Should the system include and/or differentiate by Environmental Assessment (EA) and Environmental Impact Statement (EIS) related items?	9 - no, 2 – yes
Should the system be customizable by region?	9 - no, 1- yes, 1 N/A
Should the system be customizable by project?	10 - no, 1- yes

4.2 Step 3 - Assigning Weights to Metrics

Using the 18 metrics shown in Table 4.2, the pairwise comparison survey (see Appendix III) was developed to implement the AHP methodology discussed in Chapter 3. Using 18 metrics, 153 pairwise comparisons were developed. An electronic version of this survey was sent to the seven CDOT study panel members along with the explanation for each metric and instructions on how to complete the survey (see Appendix III). Six of the seven members completed the survey and returned it to the researcher.

Once the six respondents completed their individual pairwise comparisons, the results and their reciprocals were transferred into the matrixes prepared in Microsoft Excel to be able to perform the computations required by AHP. The first computation was to determine the C.R. of each individual respondent to see how consistent he/she was. Table 4.4 presents the results for the C.Rs. It is important to note that in computing the C.R. for each respondent, the R.I. was assumed to be 1.59 (i.e., the value that corresponds to a 15*15 matrix as shown in Table 3.4) even though the matrices developed in this study were 18*18. The original R.I. table provides the values for R.I. for matrices up to 15*15; and it is conservative to use the value that corresponds to a 15*15 matrix. (Figueroa, 2010) showed that the R.I. value does not significantly change for matrixes greater than 13*13.

Table 4.4 C.R. for each Respondent

	Participant #1	Participant #2	Participant #3	Participant #4	Participant #5	Participant #6
C.R.	0.124	0.082	0.155	0.199	0.370	0.148

A C.R. of 0.10 or less is generally considered acceptable in the literature (Saaty, 1980)(as was discussed in Chapter 3). However, for this study, there were 18 items included in the pairwise comparison matrix. To account for any added complication for the respondents, the threshold of 0.20 was used since it is also considered to be satisfactory (Page, 1997). Given this threshold, the pairwise comparison survey of participant # 5 (C.R. of 0.370), was decided to not be used in the development of the pairwise comparison matrix. The significantly high C.R. indicates a high-level of inconsistency by the respondent when completing the pairwise comparison matrix which may adversely affect the accuracy of the results; hence the researcher decided to not include his/her responses in developing the overall group judgment matrix.

The remaining five matrixes were combined using the approach discussed in Chapter 3 to develop the overall group matrix which was used to compute the weight assigned to each metric by the five Study Panel members. Table 4.5 presents the final results with respect to the weight calculated for each metric in descending order. The overall group matrix of the five participants has a C.R. of 0.028, indicating a high-level of consistency in the overall group judgment of importance of metrics relative to each other.

Table 4.5 Final Weights assigned to each Metric as calculated through AHP

Metric	Weight
Track deleted or modified commitments	0.1468
Track permits	0.1406
Standard Reports	0.0979
Sort and filter data	0.0975
Generate notifications	0.0693
Document Management	0.0537
GIS compatible	0.0526
Control which CDOT employees can input/edit information	0.0495
Integrate with ProjectWise	0.0432
Store data in a single centralized file	0.0395
Web based	0.0371
Differentiate between CAT X, EA, & EISs	0.0368
Allow multiple CDOT employees to input/edit information	0.0361
Integrate with SharePoint	0.0269
Allow ALL CDOT employees to view information	0.0208
Allow external stakeholders to view information	0.0194
Control which CDOT employees can view information	0.0170
Allow external stakeholders to input/edit information	0.0153

As discussed earlier, the metrics in Table 4.5 represent the features considered to be important by the Study Panel members. These, along with their weights, are used to evaluate how closely the existing ETSs used at various state DOTs match the preferences of CDOT. As seen in Table 4.5, the “Track deleted or modified commitments” metric has the largest weighting factor (0.1468) among the 18 metrics (indicating the highest preference of CDOT in an ETS), followed very closely by the “Track permits” (0.1406). “Allow external stakeholders to input/edit information” (0.0153), “Control which CDOT employees can view information” (0.0170), and “Allow external stakeholders to view information” (0.0194) metrics obtained the three lowest weighting factors.

4.3 Step 4 - Qualitative Evaluation of Other States' ETSs

This section presents the qualitative evaluation of ETSs provided by eight different states. The states with ETSs evaluated are: California, Florida, Kentucky, New York, Tennessee, Texas, Virginia, and Washington. Originally, only seven states were included in this study. The literature reviewed by the researcher consistently mentioned these states as those with leading ETSs. However, it was brought to the researchers' attention during the initial stages of contacting these states, that the Virginia Department of Transportation (VDOT) has an ETS that is more than sufficient to be included in the study.

In gathering the information presented herein, a literature review was performed in addition to conducting a short survey. For this short survey, the same list of metrics (i.e., technical features) that were used for the pairwise comparison surveys completed by the CDOT study panel members were sent to the eight states to identify which of those features each state's ETS possesses. The request was sent via email asking them to participate in the study (Appendix IV) along with the survey (Appendix V).

4.3.1 California Department of Transportation (CalTrans)

CalTrans utilizes an environmental tracking tool called the Standard Tracking and Exchange Vehicle for Environmental (STEVE) projects that was developed in the software FileMaker Pro. At the time that the survey was filled out, STEVE was in the process of being implemented statewide. This was expected to be completed by March 31, 2011. Initially, CalTrans is focused on bringing all of their environmental planners on board with STEVE, with future phases to include remaining internal partners and eventually with limited access, the external partners (S. Yokoi, personal communication, March 1, 2011). Table 4.6 presents the survey that was returned by CalTrans, indicating STEVE's features.

Table 4.6: CalTrans ETS (STEVE)

Features	Yes	No	Comments
Allow ALL state DOT employees to view information	X		
Allow external stakeholders to view information		X	We are currently researching this opportunity as a future phase.
Allow multiple state DOT employees to input/edit information	X		
Allow external stakeholders to input/edit information		X	
Control which state DOT employees can input/edit information	X		
Control which state DOT employees can view information	X		Environmentally sensitive areas are protected.
Differentiate between CAT X, EA, & EISs	X		
Document Management	X		Initial phase is smaller scale document management.
GIS compatible		X	We are currently researching this opportunity as a future phase.
Generate notifications	X		Notification appears on their personalized dashboard, does not generate email.
Integrate with ProjectWise		X	
Integrate with SharePoint		X	
Sort and filter data	X		
Standard Reports	X		
Store data in a single centralized file	X		
Track deleted or modified commitments	X		Tracks only modified commitments, not deleted.
Track permits	X		
Web based		X	Not at this time. This capability does exist and is being considered for use in a future phase.

To further explain results shown in Table 4.6, although the respondent selected "yes" for the "Track deleted or modified commitments" feature, because the system tracks only modified commitments, and does not track deleted commitments, an attribute critical to this feature, this feature will be treated as "not existing" for the purpose of this study while performing the quantitative evaluation in Section 4.4.

4.3.2 Florida DOT (FDOT)

FDOTs' ETS was developed in Microsoft Project Suite by the states' District 4 Planning and Environmental Management (PL&EM) services office. It is intended to inform the state's district design, construction, and maintenance departments of the environmental concerns and commitments made during the NEPA process. This electronic database identifies commitments made during the Project Development & Environmental (PD&E) phase and documents how these commitments will be incorporated into final design and monitors their compliance during construction (Florida Department of Transportation, 2011).

The commitments are entered into the ETS by assigned environmental liaisons who input status updates during each phase of the project. However, during the construction phase, the District Construction Environmental Coordinator (DCEC) will update the ETS. For major projects, the PD&E phase is the first phase of documentation and coordination of the commitments. In the past at FDOT, the challenge was to track and document the implementation of the commitments made during the development of projects. Now the ETS documents the most current status of each environmental commitment on the project (Florida Department of Transportation, 2011).

During each of the following development phases of a project, the items that are input into the ETS at FDOT are (Florida Department of Transportation, 2011):

- **PD&E**: Commitments to stakeholders, any pertinent issue and its corresponding resolution, correspondences, and or concurrence letters from project stakeholders.

- **Design**: Agency or stakeholder correspondences, issues and their resolutions, general project updates or changes, re-evaluation documents, and environmental certifications.
- **Construction**: The DCEC will document construction related NEPA issues during and after the construction phase. Examples of the documentation include whether an as-built project was constructed in accordance with all the commitments and expectations determined in the planning/design phases, and if not, then proper FHWA documentation authorizing changes would be required.

The ETS Section in Project Suite has three categories (Florida Department of Transportation, 2011):

- **NEPA Compliance**: Allows the viewer to see the environmental liaison assigned, the date of Local Design and Concept Acceptance (LDCA), class of action (PCE, Type II Categorical Exclusion, Environmental Assessment, or Environmental Impact Statement), commitments made during PD&E, and the type and approval date of each re-evaluation.
- **ERC Comments:** Provides a link to a display of comments made during the design of the project.
- **Status (ETS):** Shows the issues that are pending and/or the resolution for each issue identified during the design of the project. It also serves as an electronic library for PDF copies of any correspondences from stakeholders, PL&EM environmental certifications, reports or assessments, and the signed re-evaluation generated during the project's design.

Table 4.7 presents the survey that was returned by FDOT, indicating the current ETSs' features.

Table 4.7: FDOT ETS

Features	Yes	No	Comments
Allow ALL state DOT employees to view information	X		
Allow external stakeholders to view information	X		FHWA Partners & contractors granted access
Allow multiple state DOT employees to input/edit information	X		
Allow external stakeholders to input/edit information	X		FHWA Partners & contractors granted access
Control which state DOT employees can input/edit information	X		
Control which state DOT employees can view information	X		
Differentiate between CAT X, EA, & EISs	X		
Document Management	X		
GIS compatible	X		
Generate notifications	X		
Integrate with ProjectWise		X	We do integrate with other custom systems at FDOT
Integrate with SharePoint		X	Probably a nice to have
Sort and filter data	X		
Standard Reports	X		
Store data in a single centralized file	X	X	
Track deleted or modified commitments	X		
Track permits	X		
Web based	X		

Upon receiving the survey, it was not clear if FDOTs' ETS stored data in a single centralized file. Upon receiving further clarification, it was understood that FDOTs' ETS does store data in a single centralized file (P. McGilvray, personal communication, March 2, 2011) and will be treated so for the purpose of this study.

4.3.3 Kentucky Transportation Cabinet (KYTC)

KYTC utilizes an Oracle Preconstruction (Precon) database system for the tracking of project commitments. Within the system, the state has developed a commitment tracking tool called "Communicating All Promises" (CAP). CAP tracks and shows the progression of all commitments from the planning and construction phases through maintenance. Commitments are posted in the state's online tracking system for use by contractors and remain in the lead project engineer's files. CAP institutionalizes commitments made by KYTC improving the efficiency among all parties involved in the transportation process (Venner Consulting, 2009).

During the course of project development, many commitments (promises) are made by different individuals associated with the project. In order to insure that the commitments made during the project development phase are kept, the project manager will accumulate all promises and track those promises in the preconstruction database system (Kentucky Transportaton Cabinet, 2005; Venner Consulting, 2009).

All commitments made after the planning phase are communicated to the Project Manager, and then must be approved by the Project Team before they are officially logged into the CAP system by the Project Manager. The system allows for the entering of a description of the promise, the date and to whom the promise was made, and the location of the work or activities to fulfill the commitment. The system is not designed to allow deletions. If a promise is to be modified or retracted, an additional entry is required to document this change (Kentucky Transportaton Cabinet, 2005). Table 4.8 presents the survey that was returned by KYTC, indicating its current ETS' features.

Table 4.8: KYTC ETS

Features	Yes	No	Comments
Allow ALL state DOT employees to view information	X		
Allow external stakeholders to view information		X	
Allow multiple state DOT employees to input/edit information	X		
Allow external stakeholders to input/edit information		X	
Control which state DOT employees can input/edit information	X		
Control which state DOT employees can view information	X		Current permission is for everyone in Highway Department to view
Differentiate between CAT X, EA, & EISs	X		
Document Management		X	
GIS compatible		X	
Generate notifications		X	
Integrate with ProjectWise		X	
Integrate with SharePoint		X	
Sort and filter data	X		
Standard Reports	X		
Store data in a single centralized file	X		
Track deleted or modified commitments	X		
Track permits	X		
Web based	X		

4.3.4 New York State Department of Transportation (NYSDOT)

NYSDOT's Program Support System (PSS) lists all state DOT projects in progress along with information regarding project costs, status, and anticipated milestones. An Environmental Commitments & Obligations Package for Construction (ECOPAC) records the actual compliance of construction projects (Venner Consulting, 2009).

ECOPAC is a systematic, simple, and standardized form used to highlight and transfer environmental commitments made during project design. ECOPAC tracks commitment compliance throughout all construction activities with respect to the environmental issues identified and highlighted during project development. Established in an effort to assure consistency in reporting and tracking statewide environmental information, the form is developed by NYSDOT design staff and allows for the environmental commitments to be communicated to construction staff (AASHTO, 2003; Venner Consulting, 2009).

The ETS utilizes a Microsoft Access database located on regional servers with not all users having access to the servers. However, those users who do have access to the server have access to the database (S. Kappeller, personal communication, March 10, 2011). Table 4.9 reflects the survey that was returned by NYSDOT, indicating the current ETSs' features.

Table 4.9: NYSDOT

Features	Yes	No	Comments
Allow ALL state DOT employees to view information		X	
Allow external stakeholders to view information		X	
Allow multiple state DOT employees to input/edit information	X		
Allow external stakeholders to input/edit information		X	
Control which state DOT employees can input/edit information	X		
Control which state DOT employees can view information	X		
Differentiate between CAT X, EA, & EISs	X		
Document Management		X	
GIS compatible		X	
Generate notifications		X	
Integrate with ProjectWise		X	
Integrate with SharePoint		X	
Sort and filter data	X		
Standard Reports	X		
Store data in a single centralized file		X	
Track deleted or modified commitments		X	
Track permits	X		
Web based		X	

4.3.5 Tennessee Department of Transportation (TDOT)

TDOT utilizes the Statewide Environmental Management System (SEMS) aimed to facilitate communication amongst TDOT and its partners during the project development phase. This includes the FHWA, Federal resource agencies, state resource agencies, contractors, and any other interested stakeholders. SEMS streamlines project delivery as well as documents, monitors, and tracks commitments made between TDOT and various project stakeholders (Cole, 2009).

SEMS demonstrates accountability and helps with organizational management. It is accessed through a web portal with the objective of improving communication and collaboration amongst TDOT and the project stakeholders. The system tracks, communicates, demonstrates fulfillment of project commitments, and acts as a tool for collecting and preserving these promises (American Society of Highway Engineers, 2008). Table 4.10 reflects the survey that was returned by TDOT, indicating the current ETSs' features.

Table 4.10: TDOT ETS

Features	Yes	No	Comments
Allow ALL state DOT employees to view information	X		
Allow external stakeholders to view information		X	
Allow multiple state DOT employees to input/edit information	X		
Allow external stakeholders to input/edit information		X	
Control which state DOT employees can input/edit information	X		
Control which state DOT employees can view information	X		
Differentiate between CAT X, EA, & EISs		X	
Document Management		X	
GIS compatible		X	
Generate notifications	X		
Integrate with ProjectWise		X	We do not use ProjectWise
Integrate with SharePoint		X	We do not use SharePoint
Sort and filter data	X		
Standard Reports	X		
Store data in a single centralized file		X	
Track deleted or modified commitments	X		
Track permits		X	Separate database tracks Permits info.
Web based	X		

4.3.6 Texas Department of Transportation (TxDOT)

TxDOT is in the process of implementing a new system called the Texas Environmental Compliance Oversight System. The system is currently being built and will be released on August, 8 2011 (M. Coleman, personal communication, March 1, 2011). The new ETS is a replacement for the current ETS that is a desktop application that was created 13 years ago using PowerBuilder with a SQL Server database. The survey filled out by the TxDOT representative reflects the features of the new system as shown in Table 4.11 (M. Coleman, personal communication, March 1, 2011). Because a new ETS will be implemented in August, the features of the existing ETS are not discussed in this study.

Table 4.11: TxDOT ETS

Features	Yes	No	Comments
Allow ALL state DOT employees to view information		X	View is limited to our application users.
Allow external stakeholders to view information	X		
Allow multiple state DOT employees to input/edit information		X	
Allow external stakeholders to input/edit information	X		
Control which state DOT employees can input/edit information	X		
Control which state DOT employees can view information	X		
Differentiate between CAT X, EA, & EISs	X		
Document Management	X		
GIS compatible	X		There is currently no GIS integration but GIS is planned for a future release.
Generate notifications	X		
Integrate with ProjectWise			Not used by Environmental staff at TxDOT. Application is compatible with web services.
Integrate with SharePoint	X		
Sort and filter data	X		
Standard Reports	X		
Store data in a single centralized file	X		Centralized DMS and enterprise Oracle database
Track deleted or modified commitments	X		
Track permits	X		
Web based	X		

Although the feature "GIS compatible" was initially checked, after reviewing the related comment in the survey, it was determined that despite the state having plans for implementing this feature in the future, the new system will not possess this at the time of the initial implementation. Therefore, this feature will be treated as "not existing" for the purpose of this study while performing the quantitative evaluation of this state in Section 4.4. Additionally, based on the comment for the "Integrate with ProjectWise" feature, it will be treated as "not existing" for the purpose of this study while performing the quantitative evaluation of this state in Section 4.4.

4.3.7 Virginia Department of Transportation (VDOT)

VDOT utilizes the Comprehensive Environmental Data and Reporting (CEDAR) system. VDOT has developed and enabled CEDAR for use on all types of environmental projects, including those that receive Federal funding and are required to be submitted to NEPA, as well as those that are fully funded by the state. Even though the state projects are outside of the NEPA process, they are still required to undergo a state environmental review process that requires agency consultation (The Volpe National Transportation System Center, 2005).

CEDAR is a spatially enabled project management tool that VDOT initiated in 2002. CEDAR tracks project progress and improves internal, interagency, and consultant communication. CEDAR enables users to notify other users in separate departments or agencies with questions and concerns, track projects, send email notifications, and assign roles and responsibilities (The Volpe National Transportation System Center, 2005). Table 4.12 presents the survey that was returned by VDOT, indicating its current ETS' features.

Table 4.12: VDOT ETS

Features	Yes	No	Comments
Allow ALL state DOT employees to view information	X		
Allow external stakeholders to view information	small yes	X	We have a handful of people from FHWA that access CEDAR through our external secure portal to view environmental data. But as far as all our external business partners (DGIF, DCR, DHR, DEQ, Corp of Engineers, etc.) we do not have the application set up outside the agency; although this is the direction we'd like to go with the application. At this time, the application is still primarily internal to VDOT.
Allow multiple state DOT employees to input/edit information	X		
Allow external stakeholders to input/edit information		X	
Control which state DOT employees can input/edit information	X		CEDAR is permissions based - we use NT authentication. Viewing and editing permission are assigned by the system administrator.
Control which state DOT employees can view information	X		
Differentiate between CAT X, EA, & EISs	X		
Document Management	X		
GIS compatible	X		
Generate notifications	X		
Integrate with ProjectWise		X	
Integrate with SharePoint		X	
Sort and filter data	X		
Standard Reports	X		
Store data in a single centralized file	X		
Track deleted or modified commitments	X		
Track permits	X		
Web based	X		

After reviewing the related comment in the survey, it was determined that despite the state having plans for fully implementing the "Allow external stakeholders to view information" feature in the future, currently the system has a very limited application of this feature. Therefore, this feature will be treated as “not existing” for the purpose of this study while performing the quantitative evaluation of this state in Section 4.4.

4.3.8 Washington State Department of Transportation (WSDOT)

The WSDOT Commitment Tracking System (CTS), developed in 2005, allows the WSDOT to store commitments in a secure computer network server and manage the responsibility (WSDOT or contractor) and implementation method (guidance document or contract) for the commitment. It allows for the storing of compliance records, documents the status of commitments, and reports details about commitments from their inception through project delivery and on to maintenance (Washington State Department of Transportation Environmental Services Office, 2010).

The CTS tracks commitments established in environmental documents, including those prepared to meet the National Environmental Policy Act, State Environmental Policy Act, Endangered Species Act, permits, approvals, letters, and agreements. Currently, the CTS tracks environmental commitments, but the system can be expanded to accept all types of commitments (e.g., design, utilities, and real estate/right of way). However, no plan or budget exists to perform such an expansion. The CTS allows users to assign staff to commitments and to identify existing guidance documents that help them successfully comply with the commitments. The CTS facilitates developing the contract during the Plans, Specifications, and Estimates (PS&E) process. It also allows the design and construction offices to manage the status of their commitments, and provides compliance recording and reporting features that support existing policy and permit requirements (Washington State Department of Transportation Environmental Services Office, 2010).

The decision of who will be the person responsible for entering commitments into the CTS for each respective project is made by the project team, or the region. Traditionally, permit coordinators are responsible for entering environmental commitments, and statewide commitments are entered by WSDOT Headquarters Environmental Services Office (ESO) staff. Because commitments are sometimes made late in the project development process or even during construction, the CTS allows the design and construction office staff to enter commitments (Washington State Department of Transportation Environmental Services Office, 2010). Table 4.13 reflects the survey that was returned by WSDOT, indicating the CTS' features.

Table 4.13: WSDOT ETS

Features	Yes	No	Comments
Allow ALL state DOT employees to view information	X		
Allow external stakeholders to view information		X	No for network security reasons.
Allow multiple state DOT employees to input/edit information	X		
Allow external stakeholders to input/edit information		X	This would be desirable in the future to allow agencies to input their permit conditions. But it is a long way off.
Control which state DOT employees can input/edit information	X		Roles/responsibilities are part of the system security.
Control which state DOT employees can view information		X	Open to all employees
Differentiate between CAT X, EA, & EISs	X		Yes, based on document type. Please see CTS User Manual.
Document Management	X		See CTS User Manual.
GIS compatible	X	X	Collects location information, but currently doesn't display via GIS.
Generate notifications	X		In a limited capacity, primarily when a user is added to a project team…it sends the user an email.
Integrate with ProjectWise		X	
Integrate with SharePoint		X	It is web based so I imagine it does, we just don't utilize it.
Sort and filter data	X		See CTS User Manual.
Standard Reports	X		See CTS User Manual.
Store data in a single centralized file	X		
Track deleted or modified commitments	X		
Track permits	X		
Web based	X		

Although the two features, “GIS compatible” and “Generate notifications” were checked as existing features in the CTS, further evaluation of the related comments revealed that these features should be treated as “not existing” for the purpose of this study while performing the quantitative evaluation of this state in Section 4.4. The ability to collect location information without displaying that information within a GIS interface does not meet the criterion of having the capability of integrating with GIS. Similarly, only sending a new project team member an email does not meet the criterion for the feature "Generating notifications" as such feature's intended purpose is to generate notifications for other reasons (e.g., when environmental commitments are entered or met). Furthermore, even though the comment about the "Integrate with SharePoint" alludes to the possibility of that feature being existent, the mere fact that the system is web based does not guarantee its ability to integrate with SharePoint; and since such feature is not being utilized as indicated by the respondent, it will be treated as not existing" for the purpose of this study while performing the quantitative evaluation of this state in Section 4.4.

4.4 Step 5 - Quantitative Evaluation of Other States' ETSs

The survey responses for all eight states are compiled in Table 4.14. FDOT (total count 16) and TxDOT and VDOT (total count 14) have the most number of features consistent with the features CDOT prefers to have in its ETS. NYSDOT (total count 7) and TDOT (total count 9) have the fewest.

Table 4.14 Other states' ETS features

Features	**California (CalTrans)**	**Florida (FDOT)**	**Kentucky (KYTC)**	**New York (NYSDOT)**	**Tennessee (TDOT)**	**Texas (TxDOT)**	**Virginia (VDOT)**	**Washington State (WSDOT)**
Allow ALL state DOT employees to view information	X	X	X		X		X	X
Allow external stakeholders to view information		X				X		
Allow multiple state DOT employees to input/edit information	X	X	X	X	X		X	X
Allow external stakeholders to input/edit information		X				X		
Control which state DOT employees can input/edit information	X	X	X	X	X	X	X	X
Control which state DOT employees can view information	X	X	X	X	X	X	X	
Differentiate between CAT X, EA, & EISs	X	X	X	X		X	X	X
Document Management	X	X				X	X	X
GIS compatible		X					X	
Generate notifications	X	X			X	X	X	
Integrate with ProjectWise								
Integrate with SharePoint						X		
Sort and filter data	X	X	X	X	X	X	X	X
Standard Reports	X	X	X	X	X	X	X	X
Store data in a single centralized file	X	X	X			X	X	X
Track deleted or modified commitments		X	X		X	X	X	X
Track permits	X	X	X	X		X	X	X
Web based		X	X		X	X	X	X

As discussed in Chapter 3, the quantitative score for each state's ETS is computed by assigning the predetermined weight (using AHP) to each feature and adding those weights together. A higher quantitative score for an ETS indicates a higher correlation of available features to CDOT's preferred features. At the bottom, Table 4.15 ranks each state's ETS's ability to meet CDOT's need.

According to the results of the quantitative evaluation, FDOT's ETS is the leading candidate with a score of 0.9299 out of a possible score of 1.0. VDOT is second at

0.8952 and TxDOT is third at 0.8473. While both VDOT's and TxDOT's ETSs possess 14 of 18 desired features (a different 14 features), by using the weights identified by AHP this study demonstrates that VDOT's 14 features are more preferred by CDOT.

Table 4.15: State ETS priority vector weights and AHP score

Features	California (CalTrans)	Florida (FDOT)	Kentucky (KYTC)	New York (NYSDOT)	Tennessee (TDOT)	Texas (TxDOT)	Virginia (VDOT)	Washington State (WSDOT)
Allow ALL state DOT employees to view information	0.0208	0.0208	0.0208		0.0208		0.0208	0.0208
Allow external stakeholders to view information		0.0194				0.0194		
Allow multiple state DOT employees to input/edit information	0.0361	0.0361	0.0361	0.0361	0.0361		0.0361	0.0361
Allow external stakeholders to input/edit information		0.0153				0.0153		
Control which state DOT employees can input/edit information	0.0495	0.0495	0.0495	0.0495	0.0495	0.0495	0.0495	0.0495
Control which state DOT employees can view information	0.0170	0.0170	0.0170	0.0170	0.0170	0.0170	0.0170	
Differentiate between CAT X, EA, & EISs	0.0368	0.0368	0.0368	0.0368		0.0368	0.0368	0.0368
Document Management	0.0537	0.0537				0.0537	0.0537	0.0537
GIS compatible		0.0526					0.0526	
Generate notifications	0.0693	0.0693			0.0693	0.0693	0.0693	
Integrate with ProjectWise								
Integrate with SharePoint						0.0269		
Sort and filter data	0.0975	0.0975	0.0975	0.0975	0.0975	0.0975	0.0975	0.0975
Standard Reports	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979
Store data in a single centralized file	0.0395	0.0395	0.0395			0.0395	0.0395	0.0395
Track deleted or modified commitments		0.1468	0.1468		0.1468	0.1468	0.1468	0.1468
Track permits	0.1406	0.1406	0.1406	0.1406		0.1406	0.1406	0.1406
Web based		0.0371	0.0371		0.0371	0.0371	0.0371	0.0371
TOTALS (AHP score)	**0.6587**	**0.9299**	**0.7196**	**0.4754**	**0.5720**	**0.8473**	**0.8952**	**0.7563**
Ranking	6	1	5	8	7	3	2	4

In the following section, a summary as well as a recommendation will be made as to which states' ETS should be implemented at CDOT in utilizing the framework laid out in this section.

CHAPTER 5: CONCLUSIONS

5.1 Summary of Research

The purpose of the study "A Framework for Evaluating Environmental Commitment Tracking Programs in State Departments of Transportation" was to develop a framework that any state DOT can use to evaluate existing ETSs implemented by other state DOTs. This framework allows that state DOT to identify the system that best meets its needs with the ultimate purpose of adopting that system. The framework's main function is to identify and prioritize the features that a state DOT is looking for in an ETS, to evaluate existing ETSs used by other state DOTs with respect to those features, and to be able to provide a final recommendation on which ETS should be adopted by that state DOT based on those features.

The development of this framework was deemed necessary as the need to track environmental commitments on state DOT construction projects continues to grow as environmental policies shape the way projects are carried out. Tracking environmental commitments is a difficult task, especially on large complex projects.

The scope of this research was limited to developing a framework that can evaluate existing ETSs as opposed to developing a brand new ETS to meet the needs of the state DOT. Making use of the best practices and the sharing of information through synthesis projects and cooperative learning is a common practice in the state DOT industry. Furthermore, it is important to note that the extent of this research was to evaluate other state DOTs ETSs based solely on technical features.

The developed framework utilizes both qualitative and quantitative research methods and consists of the following five steps to achieve its purpose:

- **Step 1 - Conducting Interviews:** The first step of the framework is to perform interviews to better understand the state DOT's needs with respect to an ETS. More specifically, interviews are aimed at better understanding the state DOT's preferred technical features for an ETS.
- **Step 2 - Developing Metrics:** This step is performed to aggregate the feedback gathered in the interviews to develop a comprehensive list of metrics to evaluate ETSs in use by other state DOTs.
- **Step 3 - Assigning Weights to Metrics:** Once the final list of metrics is developed, the next step is to assess the importance of each metric relative to one another as determined by the state DOT by assigning weights to those metrics through the AHP process.
- **Step 4 - Qualitative Evaluation of Other States' ETSs:** This step includes performing a qualitative evaluation of other states' ETSs through literature reviews, as well as asking those states identified as leaders to fill out surveys indicating which features their ETS possesses.
- **Step 5 - Quantitative Evaluation and Comparison of ETSs:** Once the feedback is received from the states selected in Step 4, this step is performed to determine which state's ETS most closely matches the needs of the state under investigation. This quantitative evaluation uses the features that were identified by the state DOT to be important in Step 2, and their respective weights as obtained using the AHP process in Step 3.

5.2 Implementation Example of the Framework and Findings

5.2.1 Overview of the Implementation Example

Ultimately the developed framework was implemented at CDOT, under the direction of a CDOT study panel group consisting of 6 CDOT regional and headquarters' employees. The objective was to provide research expertise as well as evaluation services in assisting CDOT in their selection and implementation of an ETS. The analysis intended to minimize program development and redevelopment costs and ultimately to provide CDOT with an effective, efficient, and reliable method to assess and demonstrate environmental commitment completion on all projects. A brief description of this implementation effort with respect to the relevant steps of the developed framework is discussed below:

- **Step 1 - Conducting Interviews and Step 2 - Developing Metrics:** Through interviewing 11 industry experts, (9 CDOT participants and 2 FHWA participants) 18 features as expressed by the participants were identified as the most important features for an ETS to possess. Appropriate metrics were developed based on those features.
- **Step 3 - Assigning Weights to Metrics:** AHP was utilized to identify the weights of metrics relative to each other. Pairwise comparison surveys were sent to the study panel members and the required computations were performed on their responses to assign weights to each of the 18 metrics. These weights indicate the importance of each feature according to CDOT's preferences and are summarized in Table 4.5.

- **Step 4 - Qualitative Evaluation of Other States' ETSs:** CalTrans, FDOT, KYTC, NYSDOT, TDOT, TxDOT, and WSDOT, were selected to be included in the study based on the fact that the literature reviewed by the researcher consistently mentioned these states as those with leading ETSs. Furthermore, VDOT was added to this study after one of the other seven participating states brought it to the researcher's attention that VDOT is a state with a leading ETS. Target state DOTs were contacted in March 2011 and asked to complete a survey indicating which of the 18 features (that CDOT prefers to have in its ETS) their ETS possesses. The information collected through this survey along with the information gathered through the literature review enabled the researcher to perform a comprehensive qualitative evaluation of these states and present the findings in 4.3, the Qualitative Evaluation of Other States' ETSs.
- **Step 5 - Quantitative Evaluation and Comparison of ETSs**: The quantitative evaluation of other states' ETSs was performed to assess how well an ETS's set of features correlated to CDOT's preferences. The quantitative score for each state's ETS was computed by assigning the predetermined weight (calculated using AHP) to each feature supported by a given ETS (determined through the survey of state DOTs) and adding all those weights together.

5.2.2 Findings of the Implementation Example

All of the framework steps discussed above allowed the researcher to fully understand CDOT's expectations for its ETS and to perform a comprehensive evaluation of existing ETSs to be able to provide the findings discussed in this section.

The detailed findings of this research with respect to the ETS currently used by CalTrans, FDOT, KYTC, NYSDOT, TDOT, TxDOT, VDOT, and WSDOT are presented in Chapter 4. Based on the quantitative evaluation assessing how well these ETSs' features correlate to CDOT's preferences, it is recommended that CDOT adopt FDOT's existing ETS for long-term implementation. It provides 16 of CDOT's 18 desired features while supporting 93% of CDOT's (weighted) preferences. VDOT's ETS achieves the second highest ranking, providing 14 features and supporting almost 90% of CDOT's weighted preferences. TxDOT's ETS is third, also providing 14 features while supporting almost 85% of CDOT's weighted preferences.

FDOT's ETS is a project management tool which can be used during the entire life-cycle of the project, and as a web-based system allows for flexible external control, and the access and viewing of the data stored is located in a centralized location. In addition, the system is GIS compatible, is capable of filtering data, tracking and deleting commitments, permits etc. and can generate standard reports and project team notifications.

TxDOT's and VDOT's ETSs are web-based as well, and are capable of filtering data, tracking and deleting commitments, permits etc. and can generate standard reports and project team notifications. The main differences include: TxDOT's ETS is not currently GIS compatible, and while both TxDOT's and VDOT's ETSs store their data in a single, centralized location, their functionalities vary with regard to controlling which and how many employees or external stakeholders can view, input, or edit information.

5.3 Concluding Remarks

In conclusion, this research developed a framework (as presented in Chapter 3) which was implemented at one state DOT, CDOT. However, the details and information provided in this study should serve as a strong indicator of how this framework can be used by any state DOT when evaluating state ETSs. While each state DOT's list of preferred features in an ETS may be different, this framework allows a state DOT to capture its preferences with respect to the technical features of an ETS through the methodological assigning of weights to each feature and then to identify the ETS (used by another state DOT) that best meets those preferences.

Furthermore, with minor adjustments, the developed framework can serve as a decision making tool in capacities outside of the evaluation of states' ETSs if utilized among organizations that share information such as state DOTs. Examples include 1) evaluating construction scheduling software, 2) evaluating estimating software, and 3) evaluating software that electronically generates Requests for Proposals (RFPs).

5.4 Future Research

Overall, an ETS must satisfy certain high level expectations. When evaluating ETS, the five main areas to consider are 1) technical features, 2) cost, 3) ease of use, 4) the ability to track commitments during the entire life of the commitment (from project planning through construction and maintenance), and 5) the ability to accommodate all the ETS's different end users (i.e. environmental project managers, regional mangers, and field personnel).

The collection of cost data for each ETS and evaluating ETSs' ease of use were beyond the scope of this research project. However, both items, along with technical features are considered to be the most important criteria in selecting which ETS is ultimately the best for a state DOT to adopt and should be considered in future research.

In performing a cost benefit analysis, it will be important when collecting the cost data to evaluate each ETS's cost in a very comprehensive matter. This includes both the internal costs and external costs associated with the first cost and maintenance costs of the ETS. When evaluating the internal and external costs associated with ETSs, it is necessary to understand that state DOTs can vary in how they maintain their accounting records. An example would be that some states have in-house information technology (IT) systems development and maintenance staff, while others states contract out this work. This can lead to large differences when comparing the cost of implementing an ETS and the time that is charged to develop and maintain the system.

The second area for future research consideration is the ETS's ease of use. In terms of software, user friendliness and user satisfaction can depend greatly on the end-user's technical skills and knowledge of the subject matter. For this reason, it is recommended that the future end-users, those who have experience with their own states' ETSs, assess the other states' ETSs under investigation. Overall, ease of use is a very important criterion, and can be a critical factor in determining whether a new ETS is accepted or rejected by its future end-users as well as fully utilized after implementation.

REFERENCES LIST

AASHTO. (2003). CASE STUDY 8. *New York State Department of Transportation (NYSDOT) New York State DOT's Environmental Initiative* Retrieved May, 03, 2011, from http://environment.transportation.org/pdf/programs/casestudy_8_ny.pdf

Aczél, J., & Saaty, T. L. (1983). Procedures for Synthesizing Ratio Judgements. *Journal of Mathematical Psychology, 27*(1), 93-102. doi: 10.1016/0022-2496(83)90028-7

American Association of State Highway and Transportation Officials. (2006). AASHTO Practitioner's Handbook. In A. C. f. E. Excellence (Ed.), *Tracking Compliance with Environmental Commitments/Use of Environmental Monitors* (Vol. 04): American Association of State Highway and Transportation Officials.

American Association of State Highway and Transportation Officials. (2009). Electronic Environmental Study Form and Project Commitment Tracking (EESF). In A. T. I. Group (Ed.), *Additionally Selected Technologies 2009*.

American Society of Highway Engineers. (2008). Tennessee Department of Transportation *Statewide Storm Water Management Plan*.

Cambridge Systematics, I., Parsons Brinckerhoff, & Venner Consulting, Inc.,. (2006). National Cooperative Highway Research Program (NCHRP). Web-Only Document 103: *Final Report for NCHRP Research Results Digest 317: Prototype*

Software for an Environmental Information Management and Decision Support System.

Cole, E. (2009). Environmental Stewardship and Transportation in Tennessee *East Tennessee Environmental Conference March 11, 2009 Kingsport, Tennessee*.

Creswell, J. W. (2009). *Research Design :Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, Calif.: Sage Publications.

CTC & Associates LLC. (2008). Transportation Synthesis Report. In WisDOT Research & Library Unit (Ed.), *Tracking Environmental Mitigation Projects: A Survey of Methods Used by State DOTs*: Wisconsin Department of Transportation.

Figueroa, C. F. (2010). *Development of VDOT'S Maintenance Asset Weighting Factors.* Master of Science Degree in Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Florida Department of Transportation. (2011). Environmental Tracking System Fact Sheet.

Harker, P. T. (1989). The Art and Science of Decision Making: The Analytic Hierarchy Process. In B. L. Golden, E. A. Wasil & P. T

The Analytic Hierarchy Process: Applications and Studies (Harker ed.). New York: Springer-Verlag.

ICF Consulting. (2006a). Federal Highway Administration (FHWA) Office of Federal Lands Highways (FLH) Commitment Tracking System *Task 3: Benchmarking Findings and Recommendations Report*. Fairfax: ICF Consulting.

ICF Consulting. (2006b). Federal Highway Administration (FHWA) Office of Federal Lands Highways (FLH) Commitmment Tracking System *Task 2: Current*

Practices and IT Platforms Summary and Findings Report. Fairfax: ICF Consulting.

Kentucky Transportaton Cabinet. (2005). Highway Design - Administrative Procedures. *Conceptual Design* Retrieved May, 02, 2011, from http://transportation.ky.gov/design/designmanual/admin/CHAPTER2.pdf

Linkov, I., Satterstrom, F. K., Kiker, G., Batchelor, C., Bridges, T., & Ferguson, E. (2006). From Comparative Risk Assessment to Multi-Criteria Decision Analysis and Adaptive Management: Recent Developments and Applications. *Environment International*, *32*(8), 1072-1093. doi: 10.1016/j.envint.2006.06.013

Page, S. L. (1997). *An Application of the Analytic Hierarchy Process and Conjoint Method to Analyze Farm Management Decisions.* Masters of Science, Colorado State University, Fort Collins, CO.

Render, B., & Stair, J., R.M. (2000). *Quantitative Analysis for Managment* (Seventh ed.). Upper Saddle River: Prentice-Hall, Inc.

Saaty, R. W. (1987). The Analytic Hierarchy Process-What it is and How it is Used. *Mathematical Modelling*, *9*(3-5), 161-176. doi: 10.1016/0270-0255(87)90473-8

Saaty, T. L. (1977). A Scaling Method for Priorities in Hierarchical Structures. *Journal of Mathematical Psychology, 15*(3), 234-281. doi: 10.1016/0022-2496(77)90033-5

Saaty, T. L. (1980). *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*. New York: McGraw-Hill International Book Co.

Saaty, T. L. (1989). Group Decision Making and the AHP. In B. L. Golden, E. A. Wasil & P. T *The Analytic Hierarchy Process: Applications and Studies* (P.T. Harker ed.). New York: Springer-Verlag.

Saaty, T. L. (1994). How to Make a Decision: The Analytic Hierarchy Process. *Interfaces*, *24*(6), 19-43.

Saaty, T. L., & Vargas, L. G. (1991). *Prediction, Projection, and Forecasting: Applications of the Analytic Hierarchy Process in Economics, Finance, Politics, Games, and Sports*. Boston: Kluwer Academic Publishers.

Saaty, T. L., & Vargas, L. G. (2001). *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process*. Boston: Kluwer Academic Publishers.

Strauss, A. L. (1998). *Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory*. Thousand Oaks: Sage Publications.

Tennessee Department of Transportation. (2007). Tennessee Environmental Procedures Manual Retrieved February, 2, 2011, from http://www.tdot.state.tn.us/environment/manuals/Chapter9EnvironCommitments07.pdf

The Volpe National Transportation System Center. (2005). GIS for Environmental Stewardship and Streamlining *An Overview of State DOT Practices*.

U.S Department of Transportation Federal Highway Administration. (2001, July, 19 2007). Construction. *Final Report Accomplishment of Environmental Commitments Process Review November 2001* Retrieved February, 2 2011, from http://www.fhwa.dot.gov/construction/reviews/reven3.cfm

U.S. Department of Transportation Federal Highway Administration. (2002). Domestic Scan: Environmental Commitment implementation Innovative and Successful Approaches. *Executive Summary* Retrieved November 11, 2010, from http://www.environment.fhwa.dot.gov/strmlng/domScanRpt/execsumm.asp

U.S. Executive Branch. (2011). *Highways*. GPO Retrieved from http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=7c13a2bc3a9a718a0e292ece9ee8a86e&rgn=div8&view=text&node=23:1.0.1.8.43.0.1.9&idno=23.

United States Environmental Protection Agency. (2010). National Environmental Policy Act (NEPA). *Basic Information* Retrieved November 11, 2010, from http://www.epa.gov/compliance/basics/nepa.html#requirement

Venner Consulting. (2009). NCHRP Project 25-25(04) Environmental Stewardship Practices, Procedures, and Policies for Highway Construction and Maintenance. In M. Venner (Ed.), *2.3.2 Environmental Commitment Tracking Through Construction & Maintenance*.

Venner, M., Allen, B., Youman, M., Barylski, M., & DeWit, M. (2007). Benchmarking State DOT Environmental Commitment Tracking Systems.

Washington State Department of Transportation. (2008). Statewide Assessment *Best Practices of Incorporating Environmental Commitments into Contracts*.

Washington State Department of Transportation. (2010). WSDOT’s Environmental Management System (EMS) Retrieved November 11, 2010, from http://www.wsdot.wa.gov/Environment/EMS/default.htm

Washington State Department of Transportation Environmental Services Office. (2010). Commitment Tracking System User's Manual.

Appendix I: Email Recruitment Letter

E-Mail Recruitment Letter

This e-mail is being sent to request your participation in a one-on-one interview for a study conducted by Andrew Fillion under the supervision of Dr. Caroline Clevenger, Dr. Mehmet Ozbek, and the Department of Construction Management at Colorado State University. The purpose of this study is to determine what features and capabilities are important to you as an employee of the Colorado Department of Transportation (CDOT) in an environmental commitment tracking system.

You were carefully selected for participation in this study and we are hopeful that you will agree to be a part of the interviews being conducted for this study. It is important to note that there are no right or wrong answers, but rather we are interested in hearing about what functional and technical features and capabilities are important to you in an environmental commitment tracking system.

You will be asked to participate in 1 one-on-one interview. The one-on-one interview is expected to last approximately 45-60 minutes. You will be asked to answer the following questions provided in the attachment. We are providing you with these questions for two reasons:

1. We are sensitive to your already busy schedule and are extremely appreciative of any time you can dedicate towards this study. We thought that it would helpful for you to have the opportunity to review the questions before the interview.

2. By contemplating the answers ahead of time it will ensure that we are both able to maximize the results of our 1 hour interview.

Please note that participation in this study is voluntary and there are no known direct risks or benefits to the participants. If you are willing to participate in this study please respond to this e-mail and let me know of your availability from 12/01/10 – 12/31/10. We will be scheduling the 1 hour one-on-one interviews during this period. If you are not able to meet during those dates, please let me know and we can make arrangements to meet at a time that is most convenient for you. The contribution that you will make is an essential component to gaining a better understanding of what employees of CDOT are looking for in an environmental commitment tracking system. Your decision to participate or not to participate in this study will have NO impact on your employment status with CDOT.

Thank you for your time and I look forward to hearing from you.

Sincerely,

Andrew Fillion

Email:

phone #

cell #

Appendix II: Interview Questions

What should an Environmental Commitment Tracking System do?

1. In an ideal world, what are all of the elements (i.e. fields of data) that should be tracked in an environmental commitment tracking system for CDOT? (List all you can think of).
2. Are the fields used in the current CDOT mitigation commitment monitoring and reporting spreadsheet sufficient?
   a) What fields, if any, are unnecessary?
   b) What additional fields should be added?
3. How should the system deal with commitments that change or are dropped between the planning and construction phases of a project? (Do you want them to be grayed out, or disappear or show progression of changes etc.)
4. How should the system deal with permits?

How should it be implemented?

5. Who should be able to input or edit information in the CDOT tracking system?
6. Should information for a single project be entered by one person or multiple people?
7. Who should be able to view (not edit) information in the CDOT tracking system, both internally and externally?
8. Should each projects data be stored in separate files or should data for all projects be linked or stored in a single, centralized system?

9. If projects are linked, should individuals who can view a single project's information be able to view all projects or should there be hierarchical permission for viewing data?
10. What is the best way to access such a system? (i.e. web based, oracle/server based).
11. What tools, currently used by CDOT, should the system be compatible with (e.g., ProjectWise, SharePoint, etc.)?

Technical Features of an Environmental Tracking System (ETS)

12. What are some important technical features of an environmental tracking system for CDOT? (For example, ease of filtering or searching.)
13. Of the comprehensive list provided below, which technical features are important for CDOT?
    a) Should the system provide document management and/or data storage functions? (i.e. hyperlinks to word documents or permits etc.)
    b) Should the system be GIS compatible?
    c) Should the system be able to generate notifications? (i.e. send notification prior to permit due date, or alert team after commitment has been fulfilled).
    d) Should the system have the capability to create standard reports? (i.e. for annual reporting to regulatory agencies).
    e) Should the system be able to sort or filter data?

f) Should the system differentiate between projects that are Categorical Exclusions (CAT X), Environmental Assessments (EA), or Environmental Impact Statements (EIS)?

g) Should the system include and/or differentiate by Environmental Assessment (EA) and Environmental Impact Statement (EIS) related items?

h) Should the system be customizable by region and/or project?

   i. If yes, does this differentiation require only different data element(s) or a different technical approach?

i) Should the system be customizable by region?

j) Should the system be customizable by project?

<u>Assessment, how will you know if it's working properly?</u>

14. How will you know if the ETS is working correctly?

15. What is the most important measure of success for the ETS?

<u>Additional Questions?</u>

16. What are examples of environmental commitments that are Colorado specific?

17. What are examples of environmental commitments that are relevant in every State?

18. What elements (fields of data) in an ETS implemented at CDOT do you feel would only apply to Colorado?

19. What are universal elements (fields of data) necessary for every States DOT?

20. What is the most important technical feature for an ETS in Colorado?

21. What is the most important technical feature for an ETS for use in every State?

Appendix III: Pairwise Comparison Survey

Name: …………………………………………   Date: …………………………..

Project Title: Evaluation of Environmental Commitment Tracking Programs for Use at CDOT

The objective of this survey is to collect information from CDOT Study Panel members. This information will enable the CSU research team to prioritize the metrics[1] that were developed to evaluate environmental commitment tracking systems currently used by other state DOTs. It will help us determine how important one metric is compared to another according to CDOT's preferences. This survey is a part of a structured technique, Analytic Hierarchy Process[2] (AHP), which will be used to assign a quantitative value (i.e., a weight) to each metric. We will then use these weights to objectively assess the existing environmental commitment tracking systems with the ultimate purpose of identifying the one that best fits CDOT's needs.

Instructions: Please perform pairwise comparisons between the metrics shown on the diagrams provided on pages 3-28 of this document by circling the number which best represents the relative importance of one metric in comparison to the other. Table 1 below provides the scales to be used for those comparisons. There are 18 metrics resulting it 153 pairwise comparisons. It is estimated that completing the survey will take approximately 1 hour. If you have any questions with respect to this survey, please contact one of the CSU research team members.

Table 1: Scale of Importance

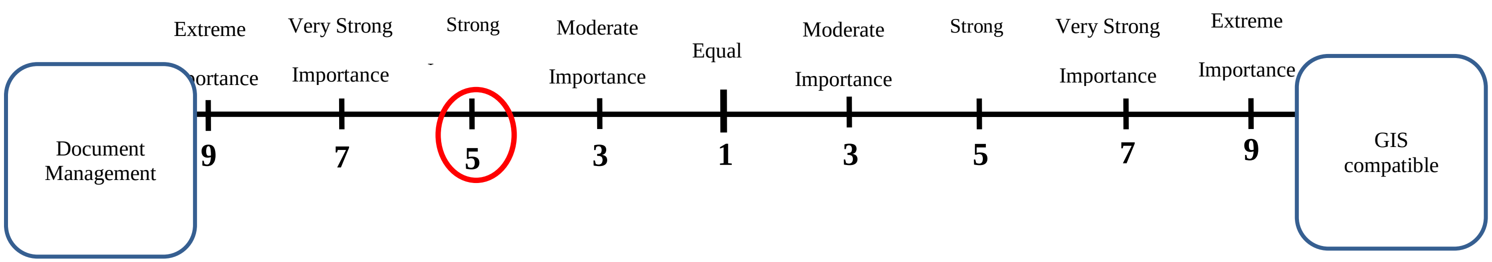
Numerical value*	Scale
1	Equal importance of both metrics
3	Moderate importance of one metric over another
5	Strong importance of one metric over another
7	Very strong importance of one metric over another
9	Extreme importance of one metric over another

*: Intermediate values (2, 4, 6, and 8) are not shown on the diagrams but respondents can also choose and mark those intermediate values between adjacent scale values (1, 3, 5, 7, and 9) shown on diagrams.

[1] For a list of metrics in alphabetical order, please refer to page 2 of this document.
[2] For a brief overview of Analytic Hierarchy Process, please refer to page 29 of this document.

Example:

You, the expert, circle “5” on the left side of the pairwise comparison diagram if you feel that having “document management” capabilities (as explained on page 2) is strongly more important than being “GIS compatible” (as explained on page 2) for an environmental commitment tracking system:



NOTE: The full explanations of metrics are provided on page 2 and should be referred to while performing the pairwise comparisons.

LIST AND EXPLANATION OF METRICS IN ALPHABETICAL ORDER

Allow ALL CDOT employees to view information: Environmental Tracking System (ETS) data is available to be viewed by all CDOT employees for a given project.

Allow external stakeholders to view information: ETS allows for external project stakeholders (e.g., agencies like FHWA, contractor, etc.) to view environmental commitment project data for a given project.

Allow multiple CDOT employees to input/edit information: ETS allows for multiple (versus only one) CDOT employees to input/edit information in the tracking system for a given project.

Allow external stakeholders to input/edit information: ETS allows for external project stakeholders (e.g., agencies like FHWA, contractor, etc.) to input/edit information in the tracking system for those projects which they are involved with.

Control which CDOT employees can input/edit information: ETS has the capability to assign permissions to a select group of CDOT employees allowing only them to input/edit information in the tracking system for a given project.

Control which CDOT employees can view information: ETS has the capability to assign permissions to a select group of CDOT employees allowing only them to view tracking data for a given project.

Differentiate between CAT X, EA, & EISs: ETS has the capability to differentiate between data that emerges from Categorical Exclusions (CAT X), Environmental Assessments (EA), and Environmental Impact Statements (EIS).

Document Management: ETS has the capability to manage documents (i.e., storing and linking related documents such as word and pdf files for easy retrieval and/or versioning control).

GIS compatible: ETS has the capability of integrating with GIS.

Generate notifications: ETS can generate and deliver notifications to a set of recipients.

Integrate with ProjectWise: ETS has the capability of integrating with ProjectWise.

Integrate with SharePoint: ETS has the capability of integrating with SharePoint.

Sort and filter data: Users can easily find and view only the commitments and permits that are relevant to a particular person or project.

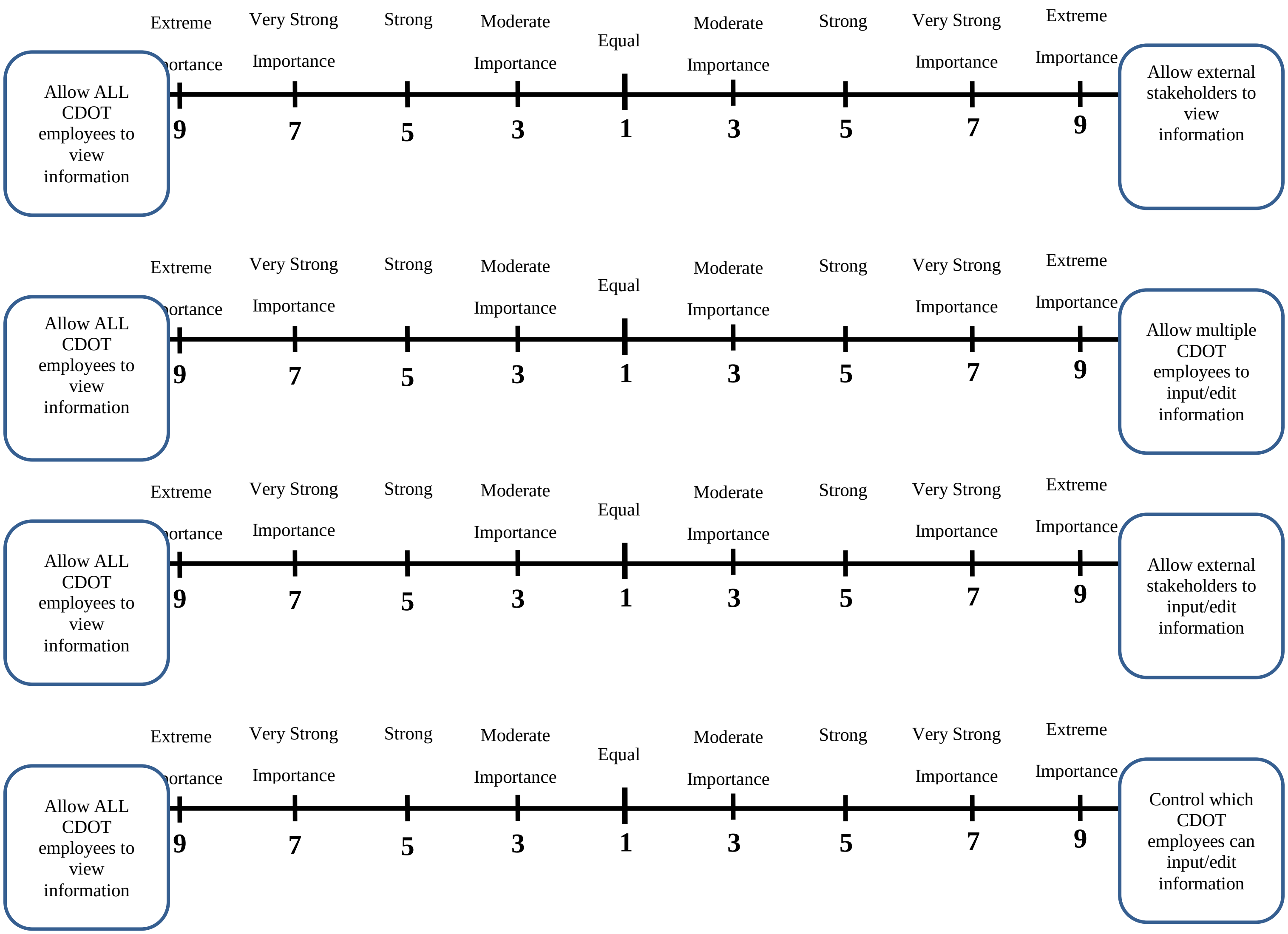
Standard Reports: ETS has the capability to generate standard reports (e.g., for annual reporting to regulatory agencies or internal auditing purposes).

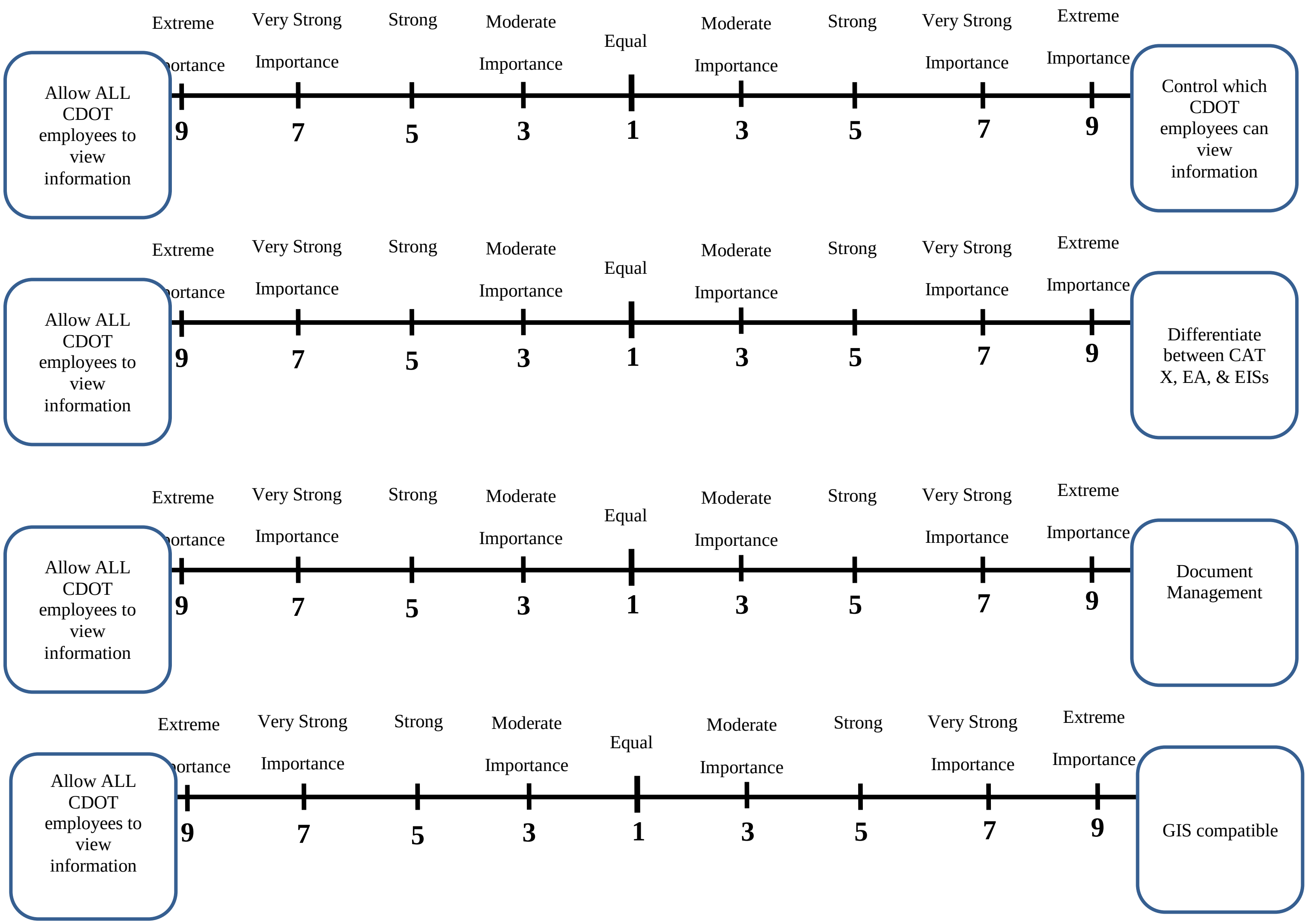
Store data in a single centralized file: ETS has the capability to link and store numerous projects' tracking data into one single centralized file. In other words, ETS can store each project's environmental commitment tracking data in its' own file as well as in a single centralized master file.

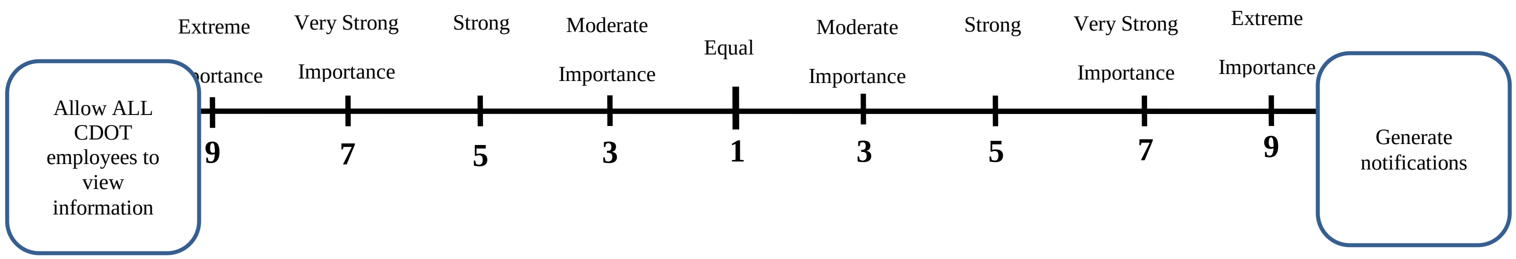
Track deleted or modified commitments: Modified commitments are tracked showing a progression of change and deleted commitments remain in system (e.g., grayed out) for future referencing rather than being dropped from system.

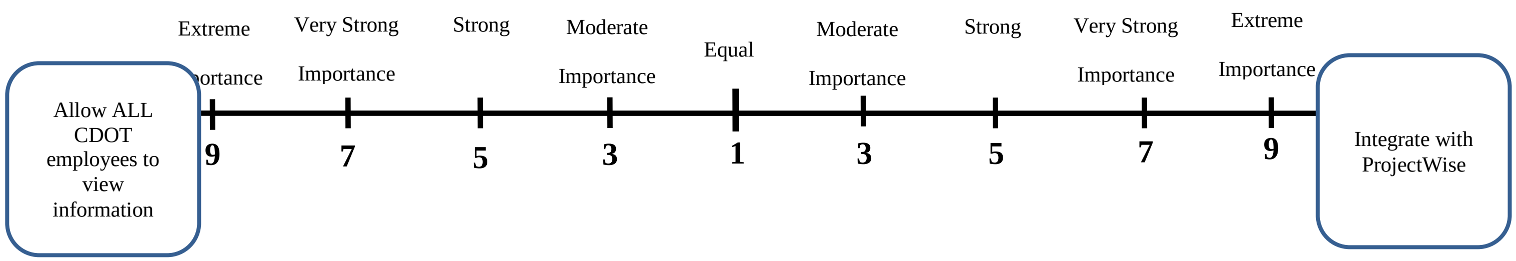
Track permits: ETS has the capability to add, modify, and delete permit details.

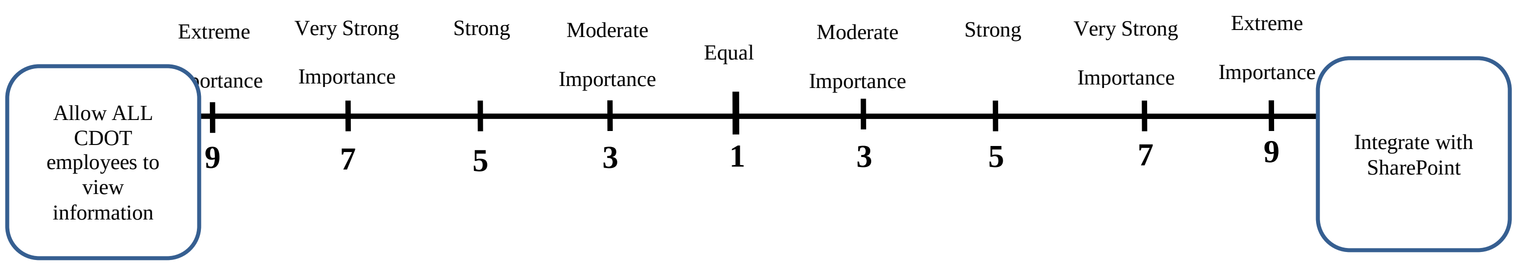
Web based: ETS can be accessed via a web browser over the Internet.

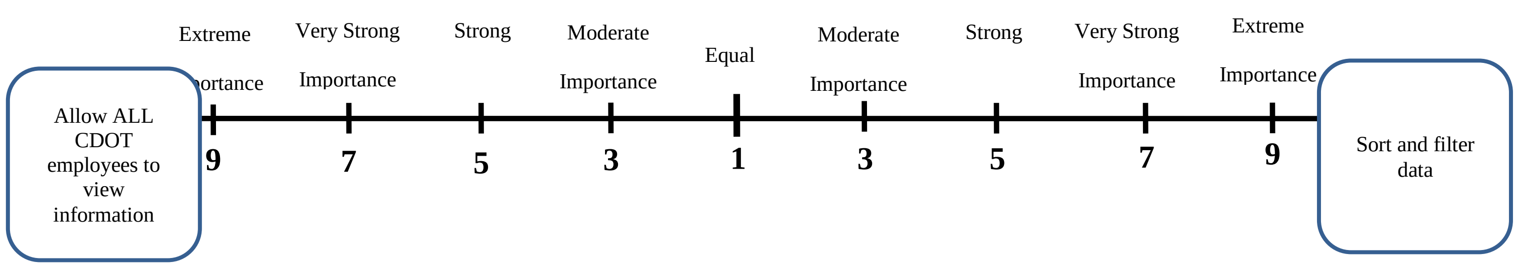

Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Allow ALL CDOT employees to view information
Allow external stakeholders to view information
Allow ALL CDOT employees to view information
Allow multiple CDOT employees to input/edit information
Allow ALL CDOT employees to view information
Allow external stakeholders to input/edit information
Allow ALL CDOT employees to view information
Control which CDOT employees can input/edit information

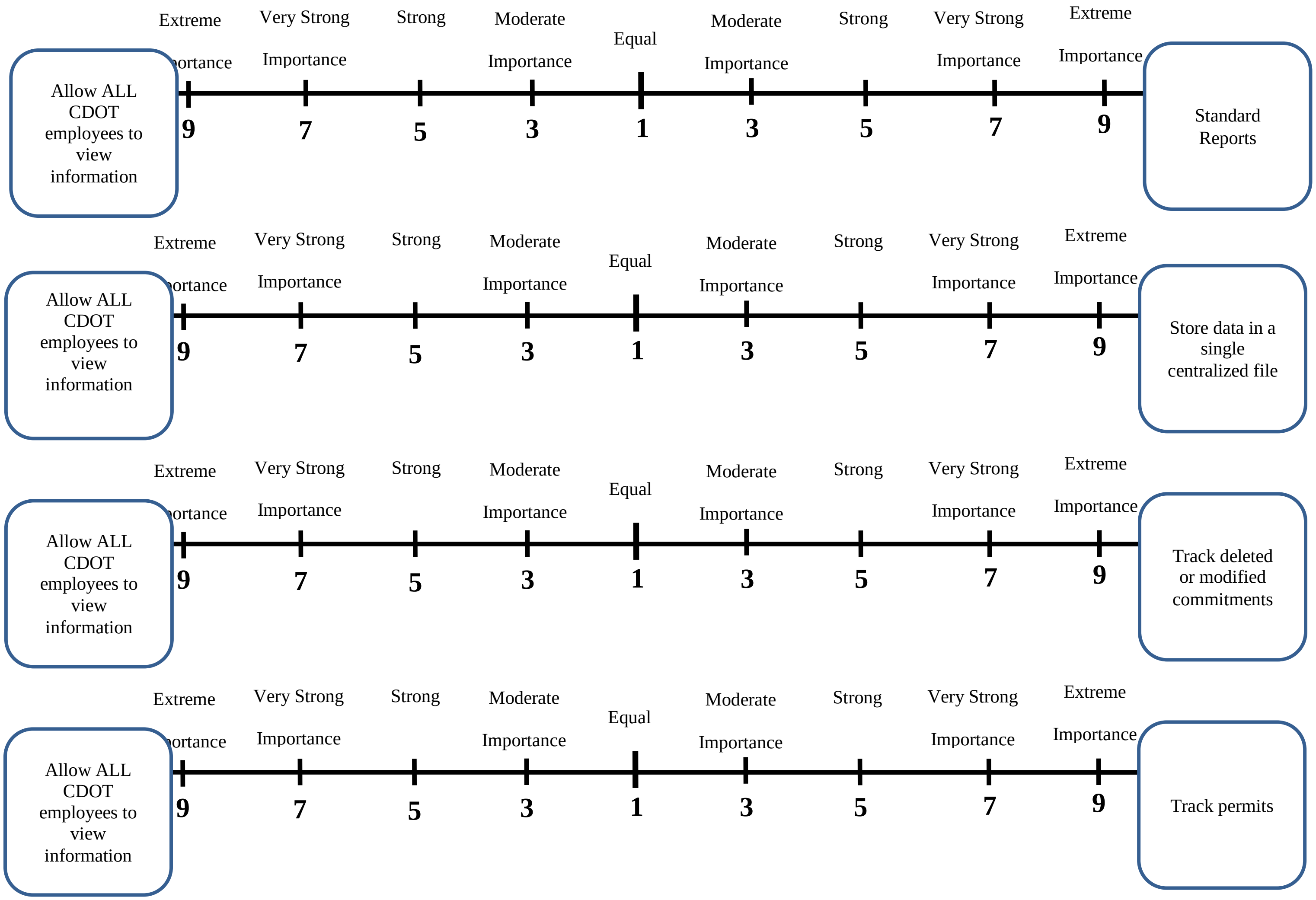

Extreme
Importance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Allow ALL CDOT employees to view information
Control which CDOT employees can view information
Allow ALL CDOT employees to view information
Differentiate between CAT X, EA, & EISs
Allow ALL CDOT employees to view information
Document Management
Allow ALL CDOT employees to view information
GIS compatible


Allow ALL CDOT employees to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Generate notifications

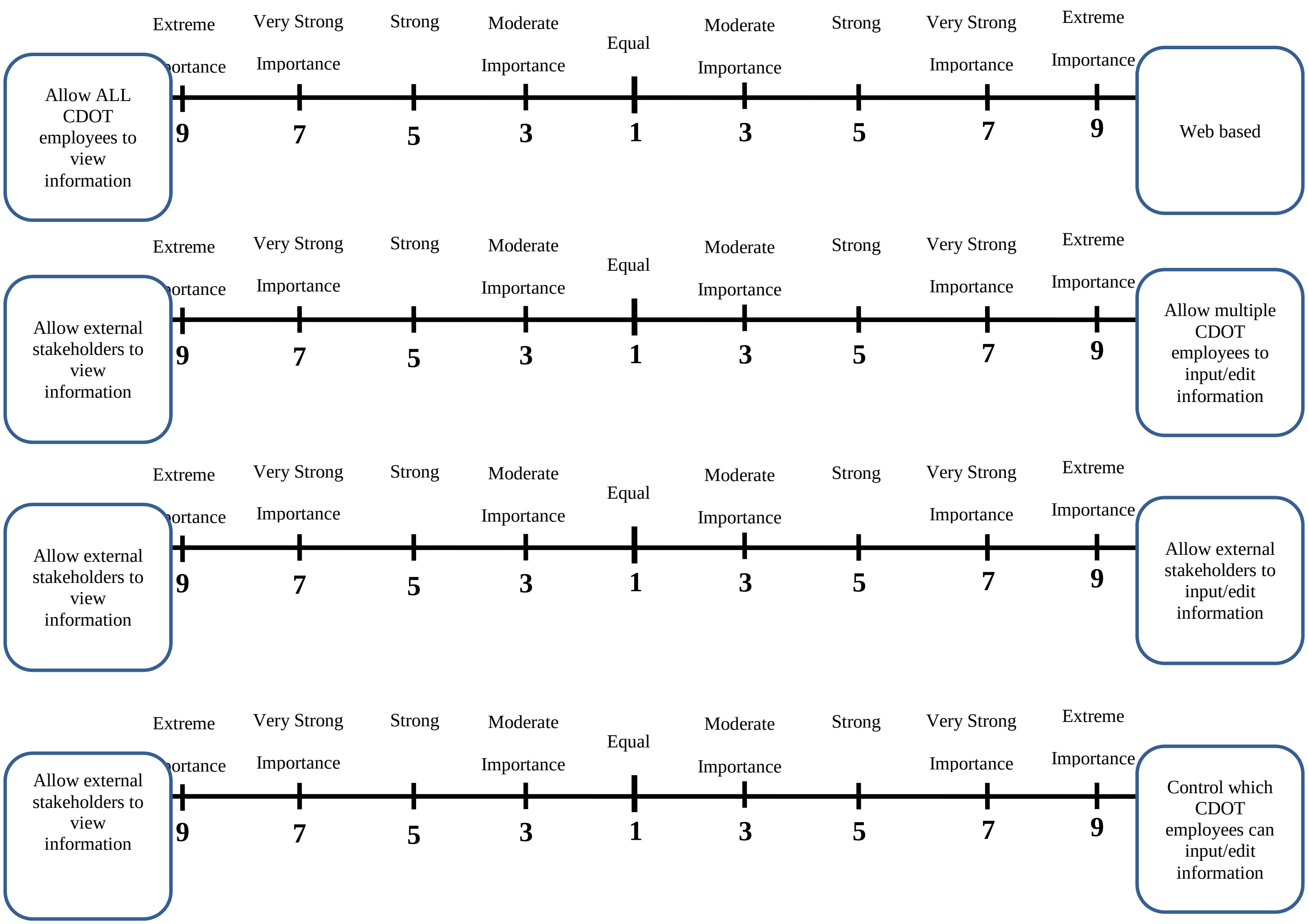

Allow ALL CDOT employees to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise

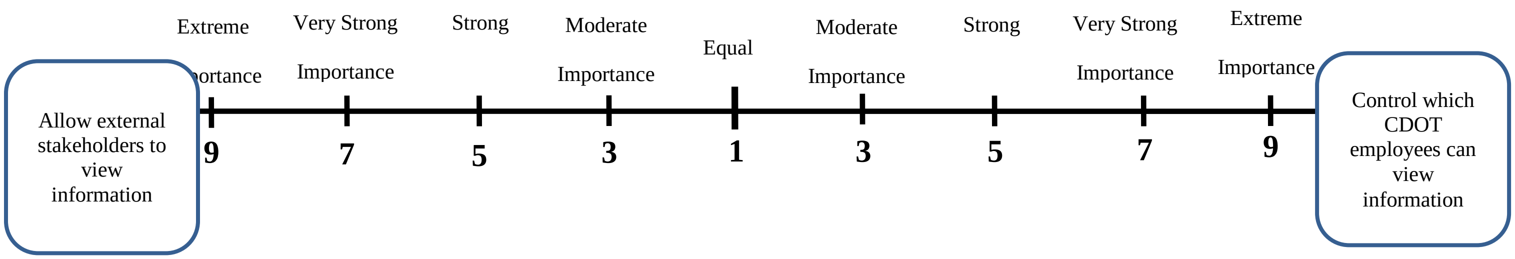

Allow ALL CDOT employees to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint

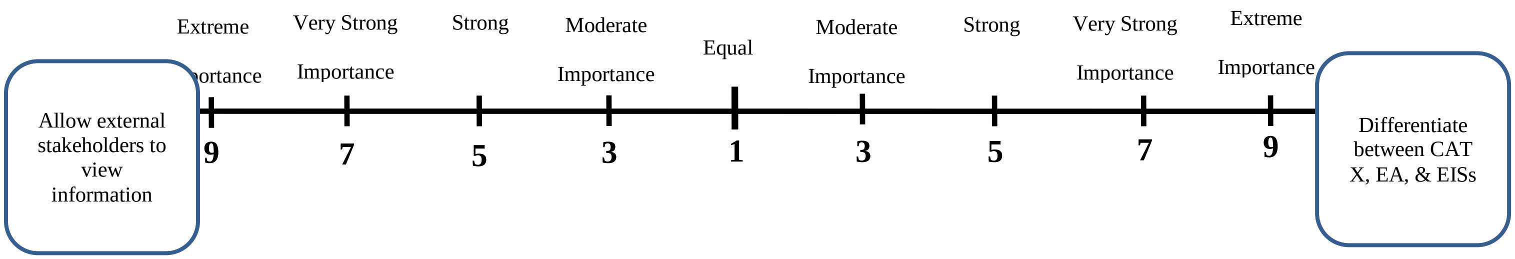

Allow ALL CDOT employees to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Sort and filter data

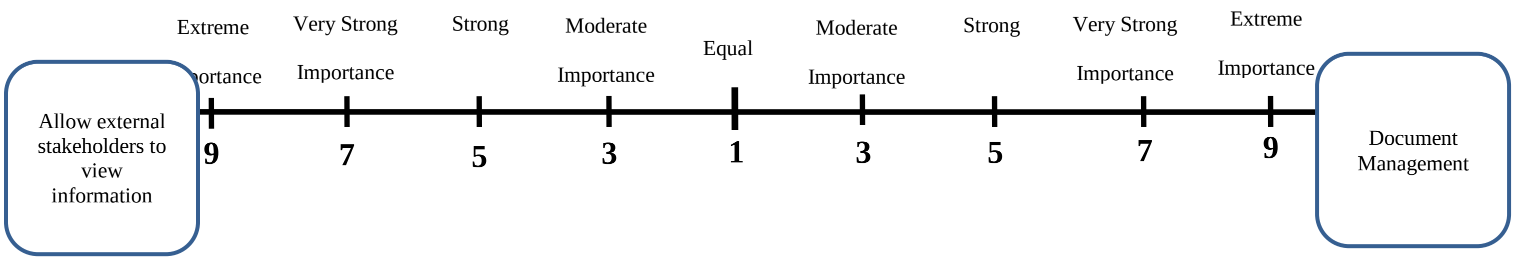


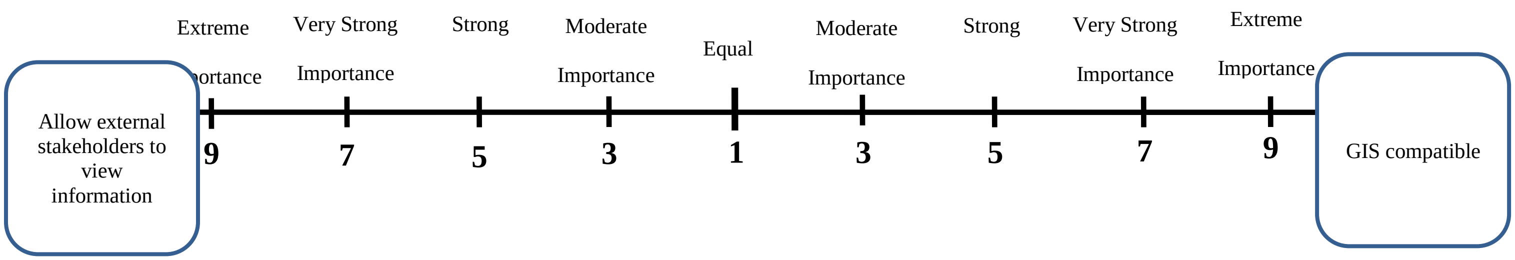
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Allow ALL CDOT employees to view information
9 7 5 3 1 3 5 7 9
Standard Reports
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Allow ALL CDOT employees to view information
9 7 5 3 1 3 5 7 9
Store data in a single centralized file
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Allow ALL CDOT employees to view information
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Allow ALL CDOT employees to view information
9 7 5 3 1 3 5 7 9
Track permits

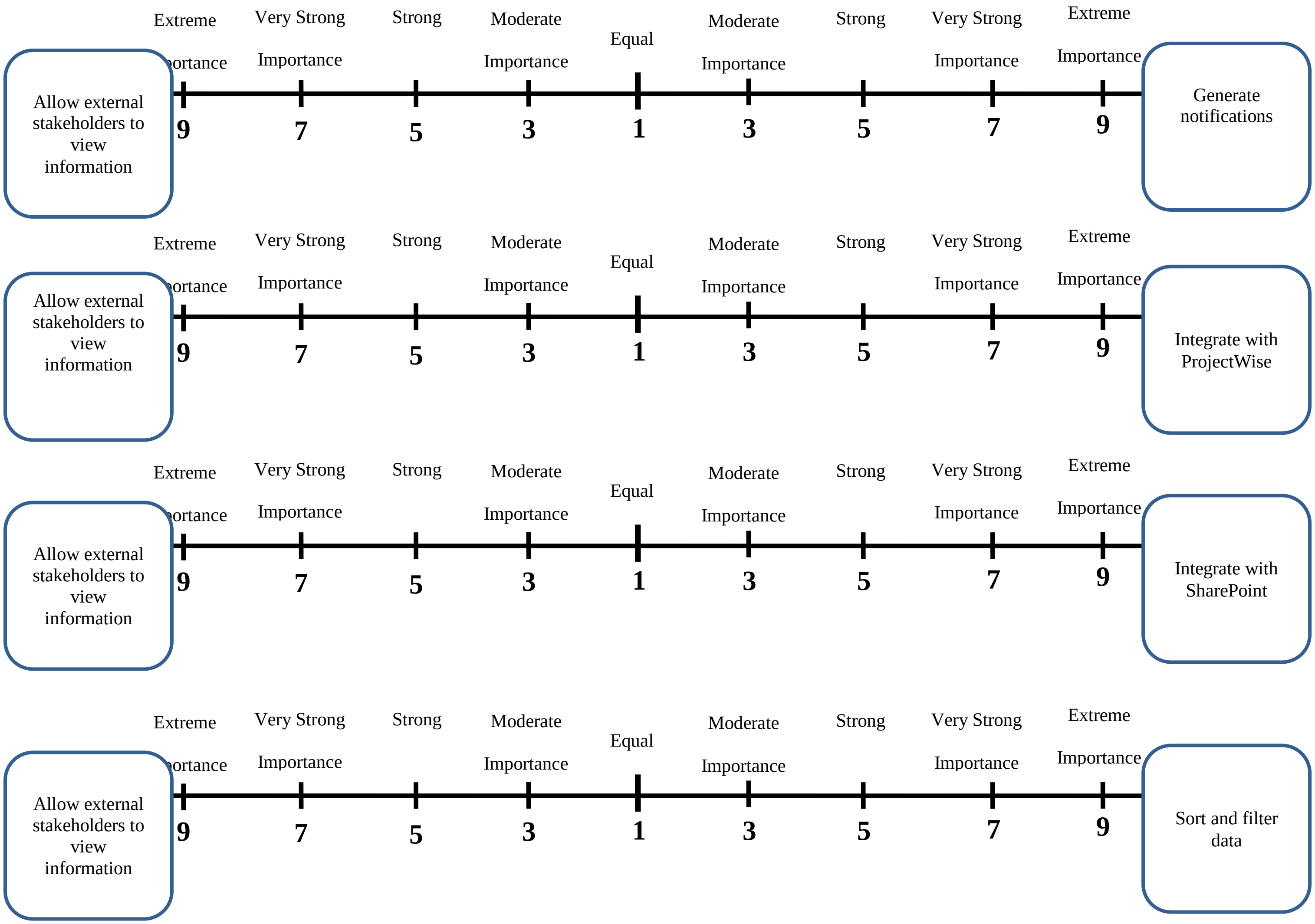

Allow ALL CDOT employees to view information
Web based
Allow external stakeholders to view information
Allow multiple CDOT employees to input/edit information
Allow external stakeholders to view information
Allow external stakeholders to input/edit information
Allow external stakeholders to view information
Control which CDOT employees can input/edit information
Extreme
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9


Allow external stakeholders to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Control which CDOT employees can view information

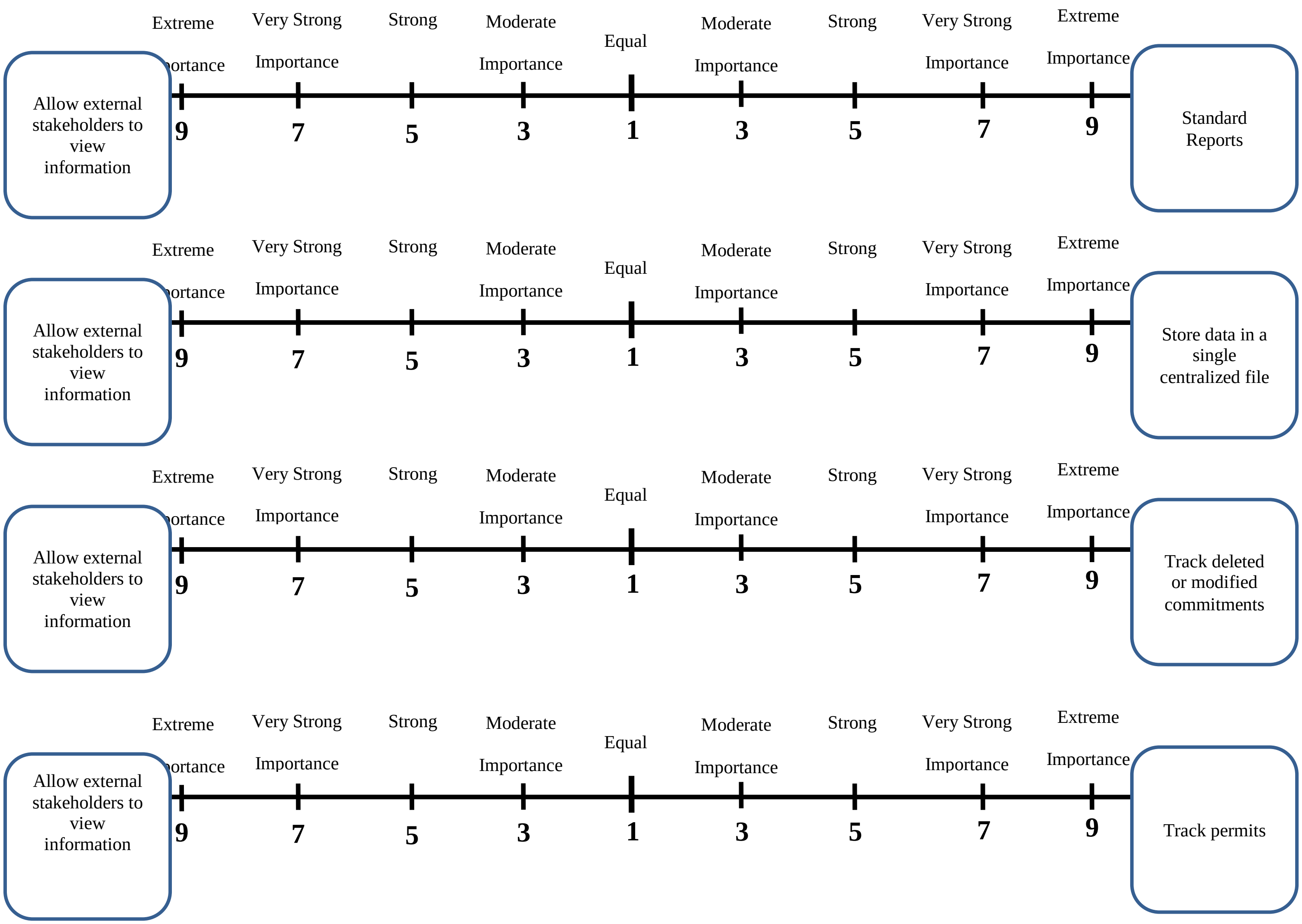

Allow external stakeholders to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Differentiate between CAT X, EA, & EISs

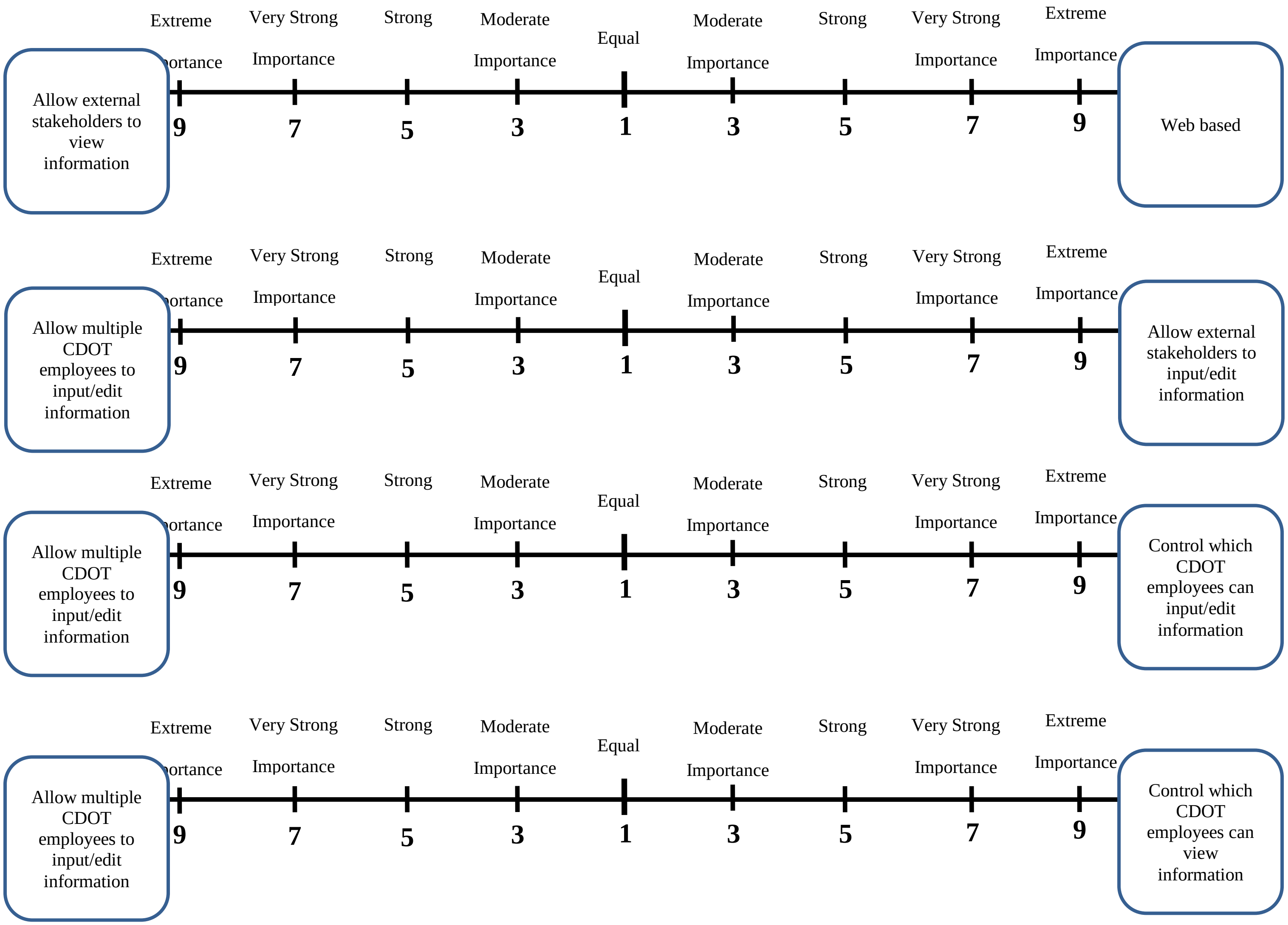

Allow external stakeholders to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Document Management

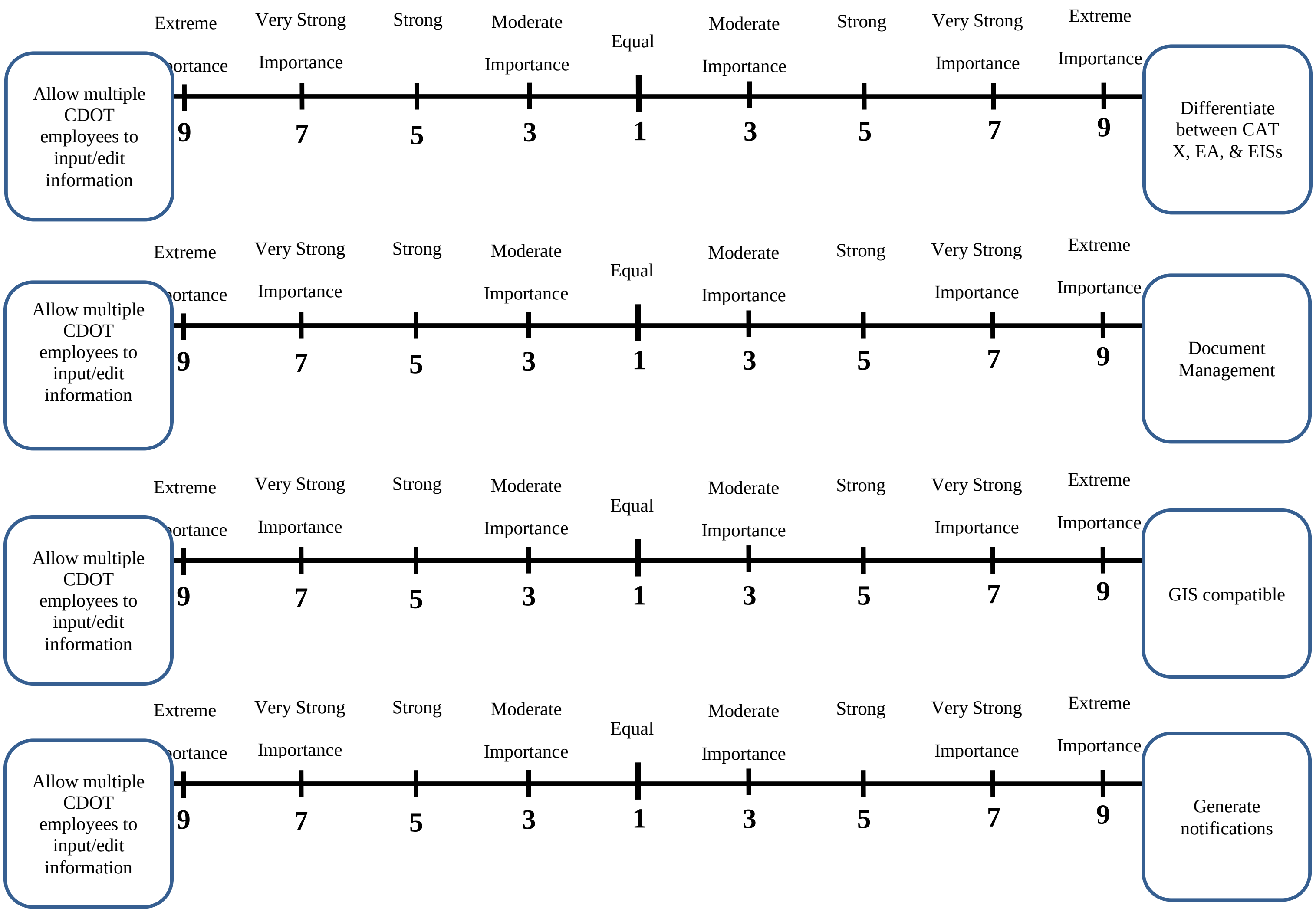

Allow external stakeholders to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
GIS compatible

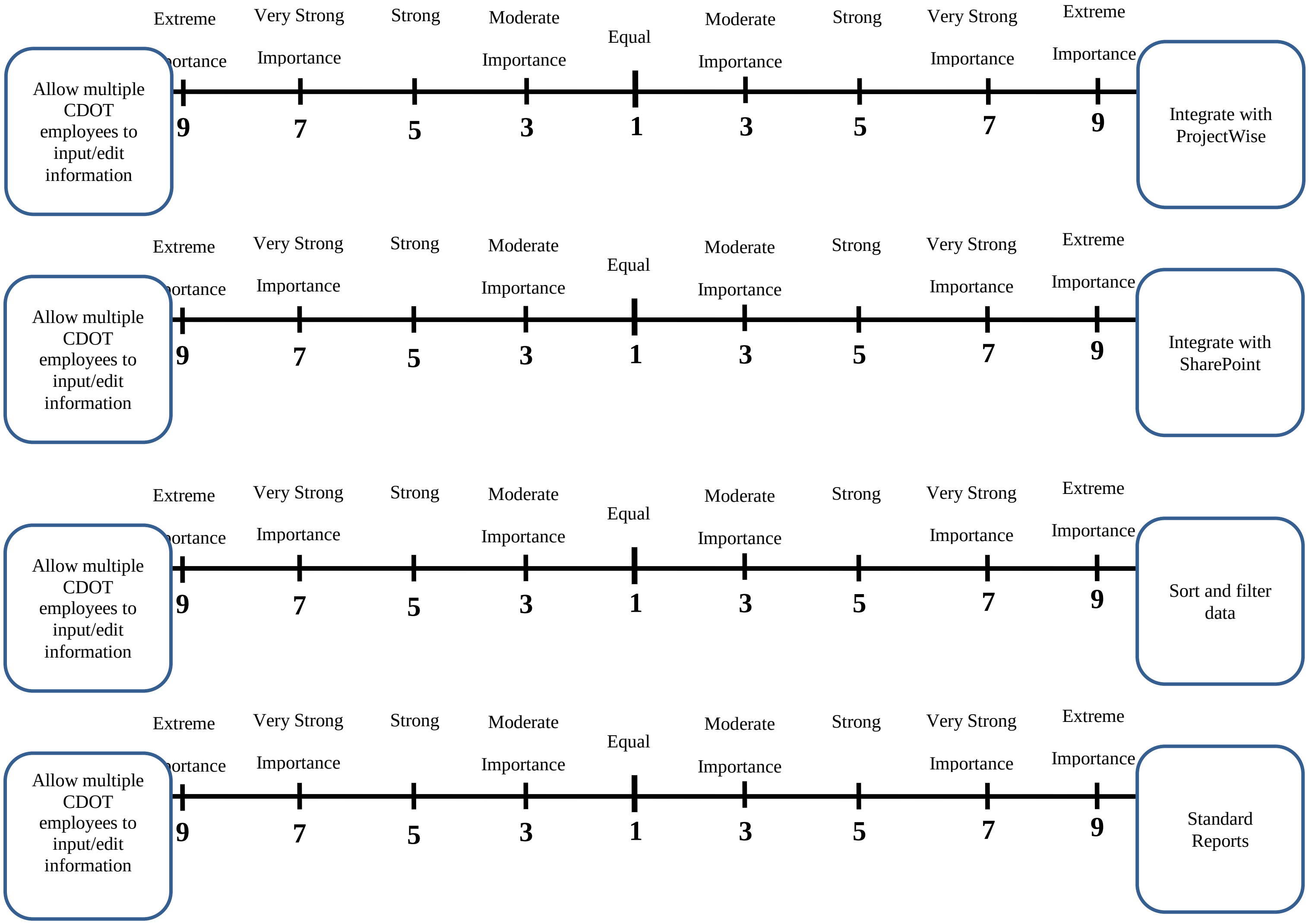


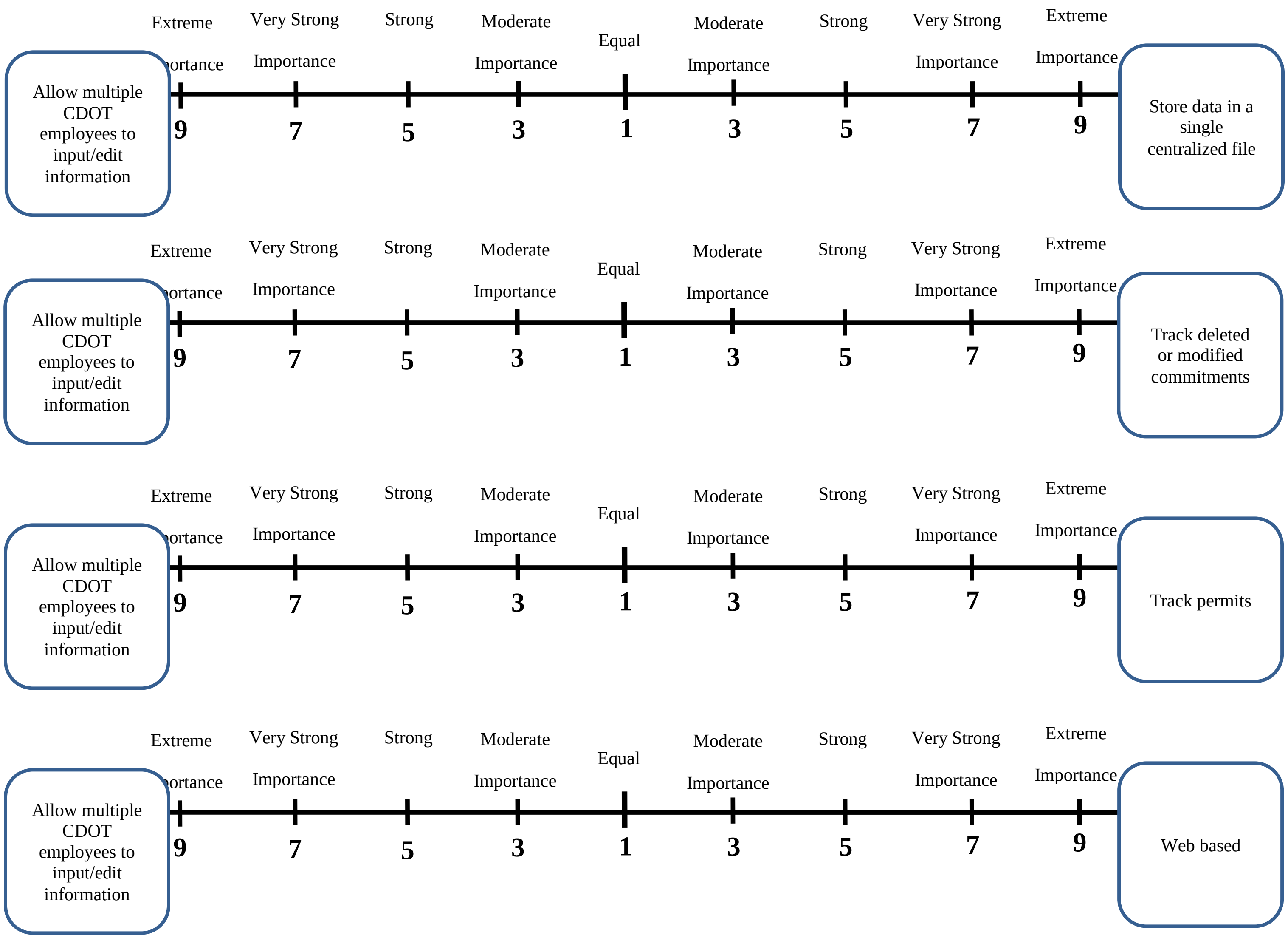
Allow external stakeholders to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Generate notifications
Allow external stakeholders to view information
Integrate with ProjectWise
Allow external stakeholders to view information
Integrate with SharePoint
Allow external stakeholders to view information
Sort and filter data

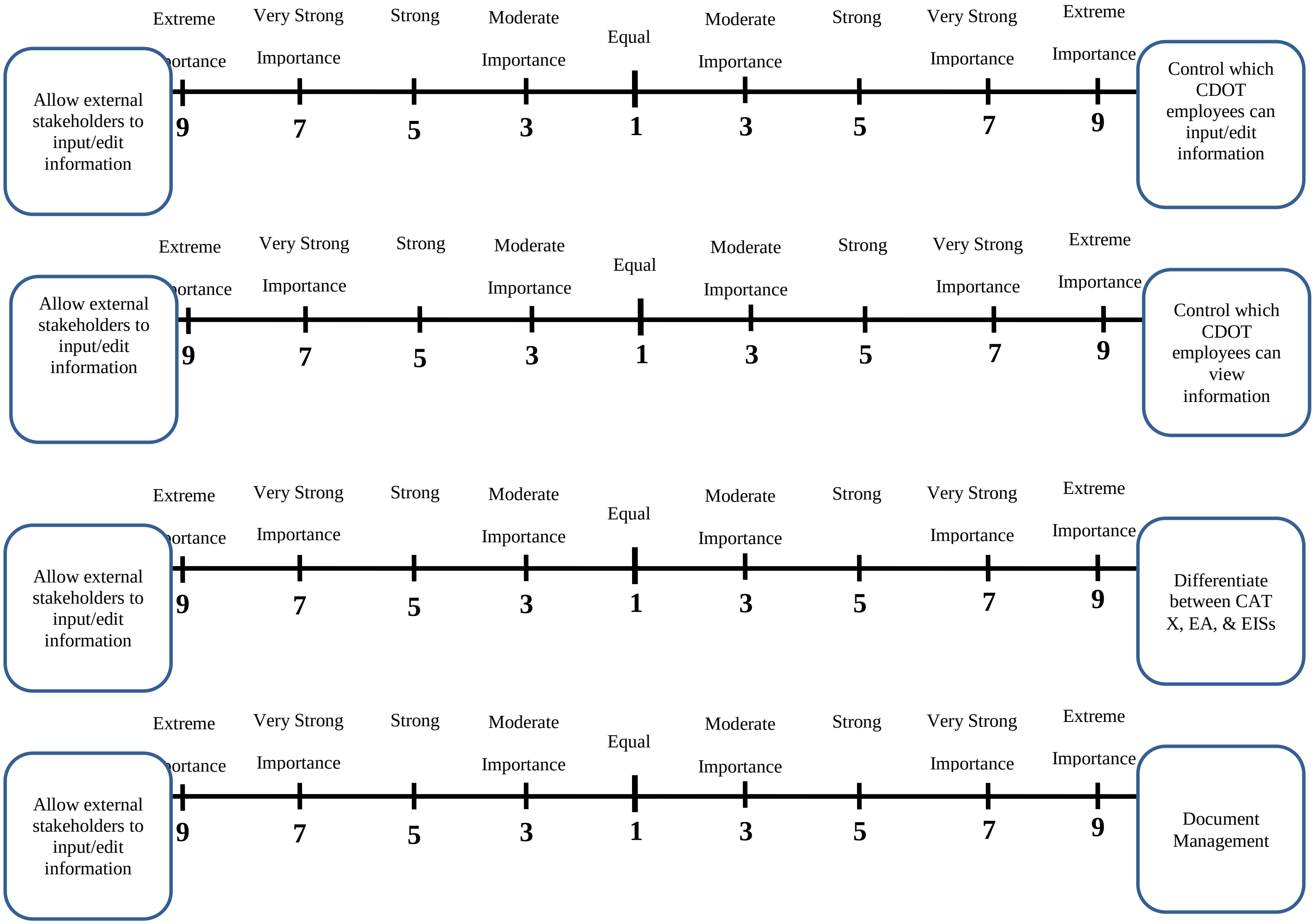

Allow external stakeholders to view information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Standard Reports
Allow external stakeholders to view information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file
Allow external stakeholders to view information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Allow external stakeholders to view information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Track permits

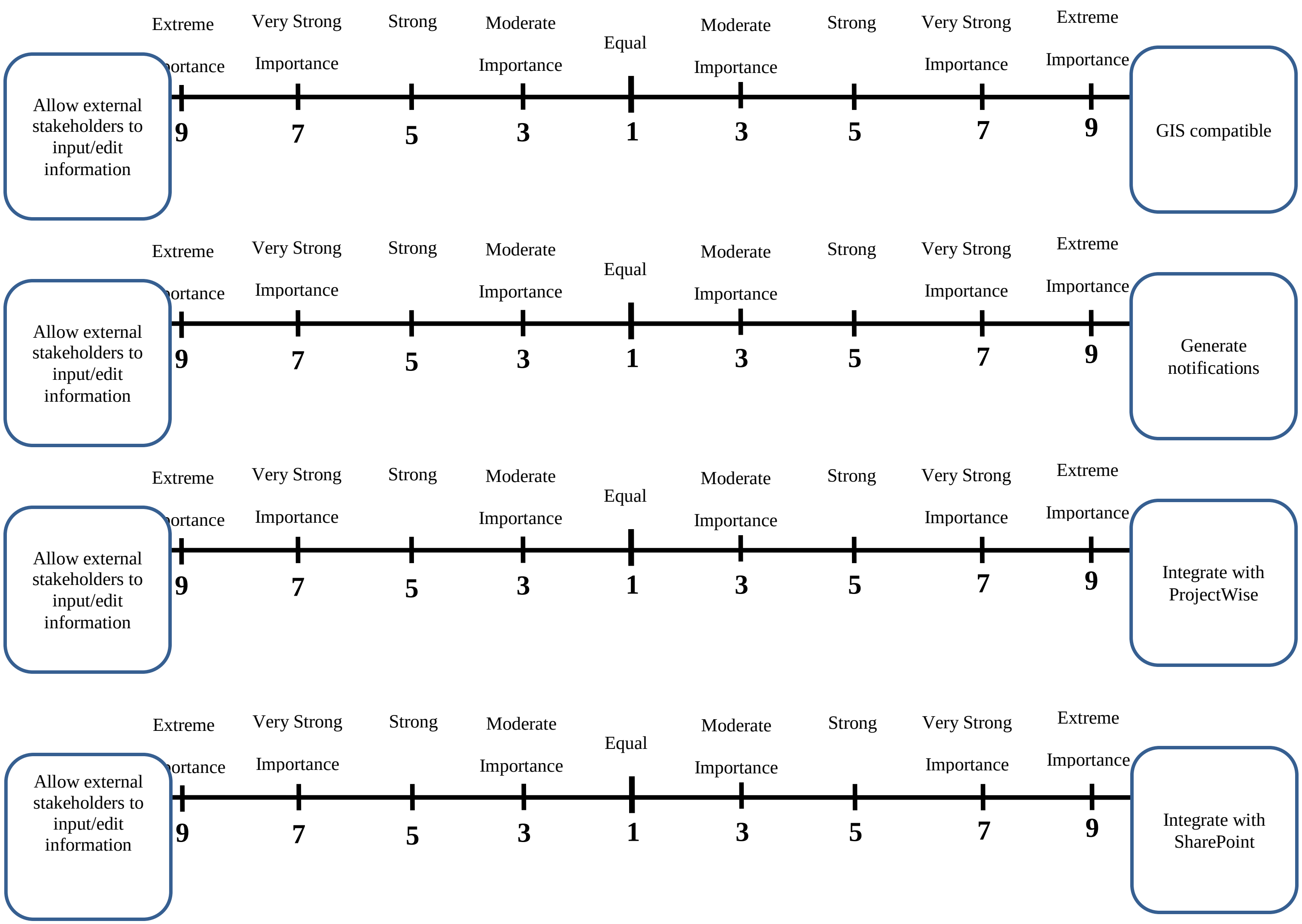

Allow external stakeholders to view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based
Allow multiple CDOT employees to input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Allow external stakeholders to input/edit information
Allow multiple CDOT employees to input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Control which CDOT employees can input/edit information
Allow multiple CDOT employees to input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Control which CDOT employees can view information

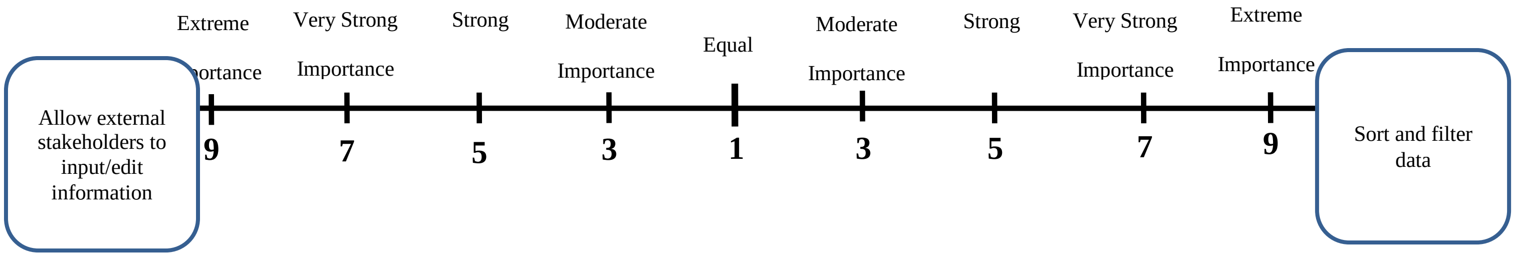

Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Allow multiple CDOT employees to input/edit information
Differentiate between CAT X, EA, & EISs
Allow multiple CDOT employees to input/edit information
Document Management
Allow multiple CDOT employees to input/edit information
GIS compatible
Allow multiple CDOT employees to input/edit information
Generate notifications

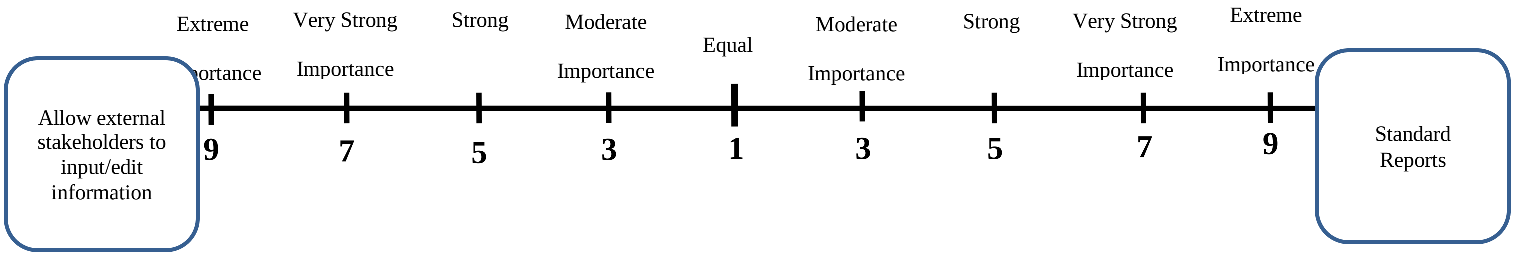

Allow multiple CDOT employees to input/edit information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise
Allow multiple CDOT employees to input/edit information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint
Allow multiple CDOT employees to input/edit information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Sort and filter data
Allow multiple CDOT employees to input/edit information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Standard Reports

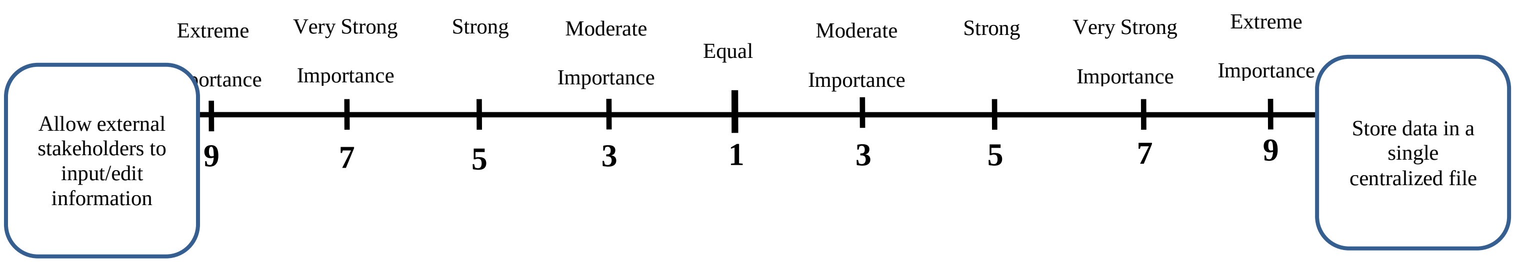

Allow multiple CDOT employees to input/edit information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file
Allow multiple CDOT employees to input/edit information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Allow multiple CDOT employees to input/edit information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Track permits
Allow multiple CDOT employees to input/edit information
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Web based

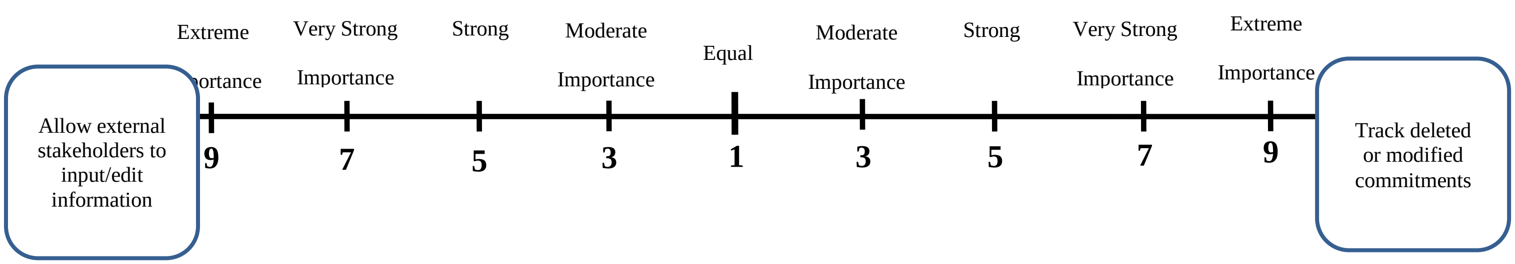

Extreme
Importance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Allow external stakeholders to input/edit information
Control which CDOT employees can input/edit information
Allow external stakeholders to input/edit information
Control which CDOT employees can view information
Allow external stakeholders to input/edit information
Differentiate between CAT X, EA, & EISs
Allow external stakeholders to input/edit information
Document Management

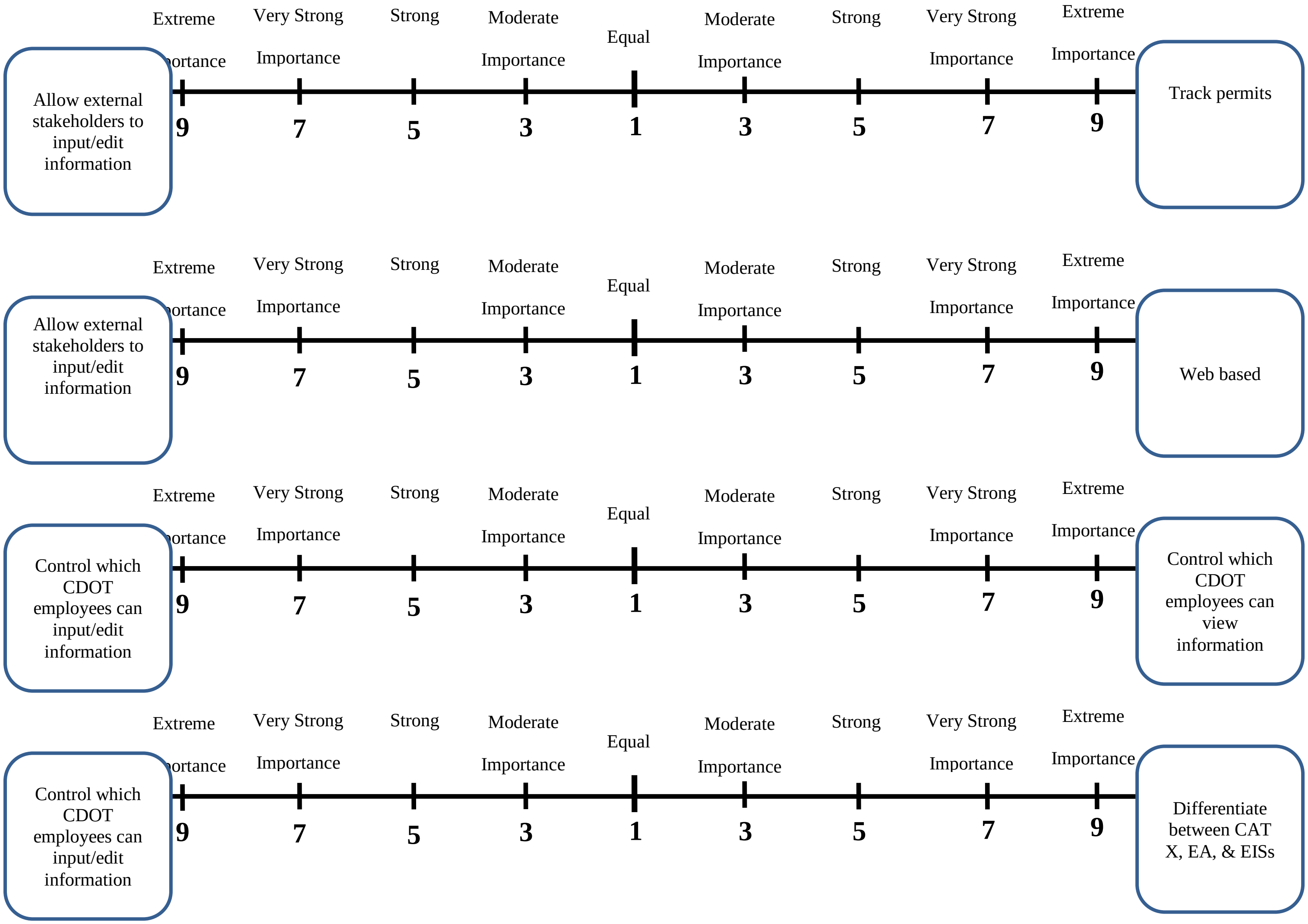

Allow external stakeholders to input/edit information
Extreme
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
GIS compatible
Allow external stakeholders to input/edit information
Extreme
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Generate notifications
Allow external stakeholders to input/edit information
Extreme
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise
Allow external stakeholders to input/edit information
Extreme
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint


Allow external stakeholders to input/edit information
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Sort and filter data

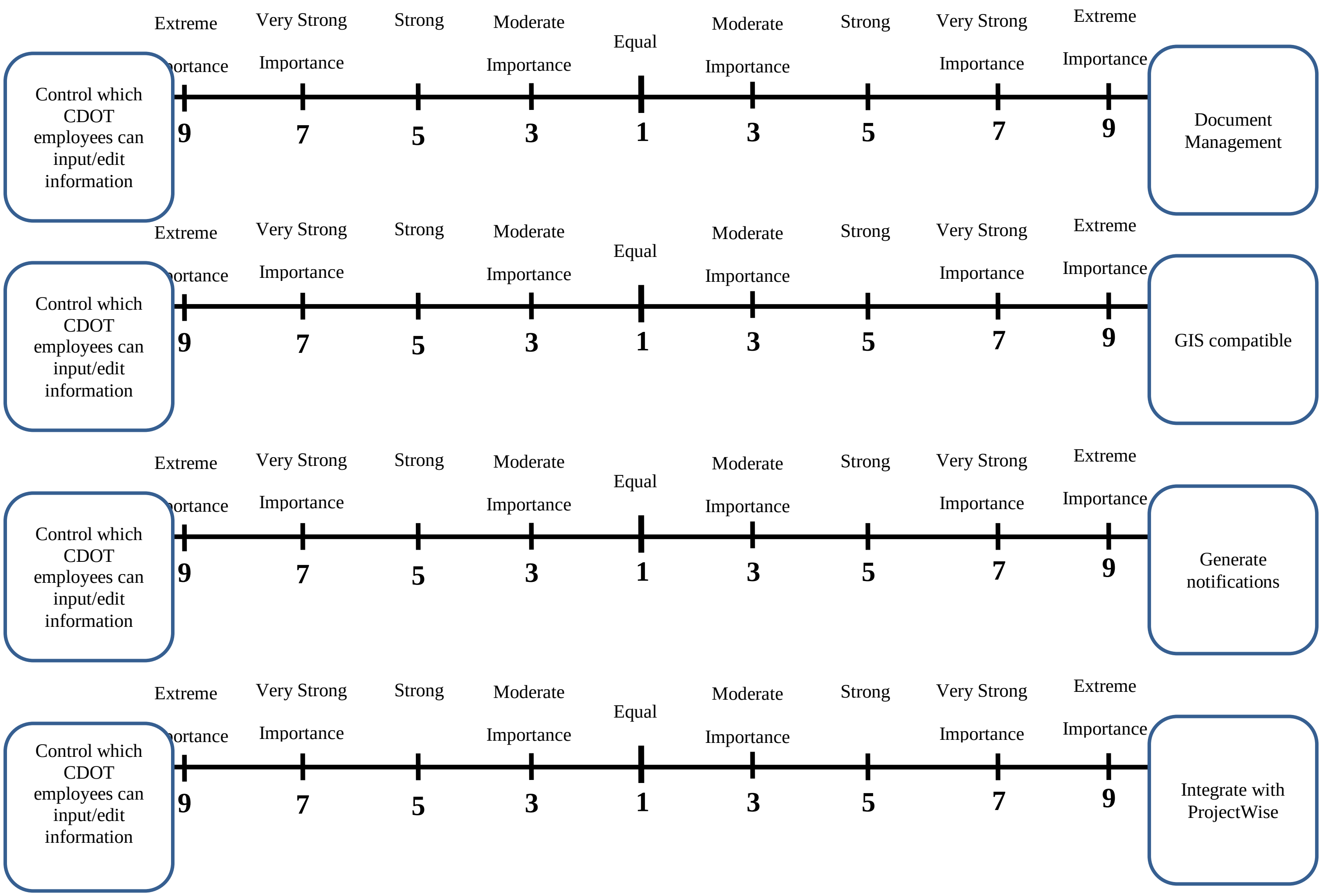

Allow external stakeholders to input/edit information
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Standard Reports

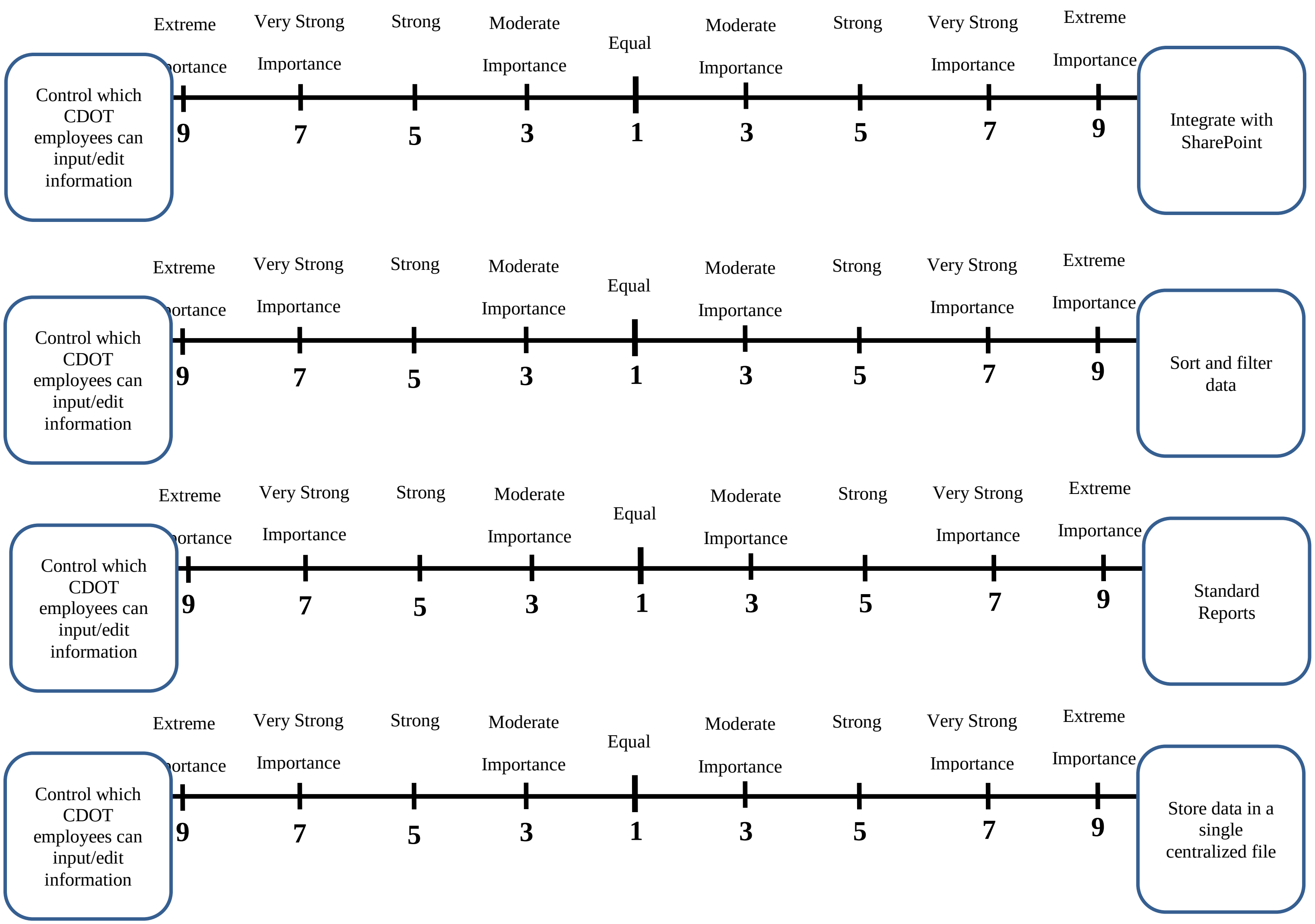

Allow external stakeholders to input/edit information
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file

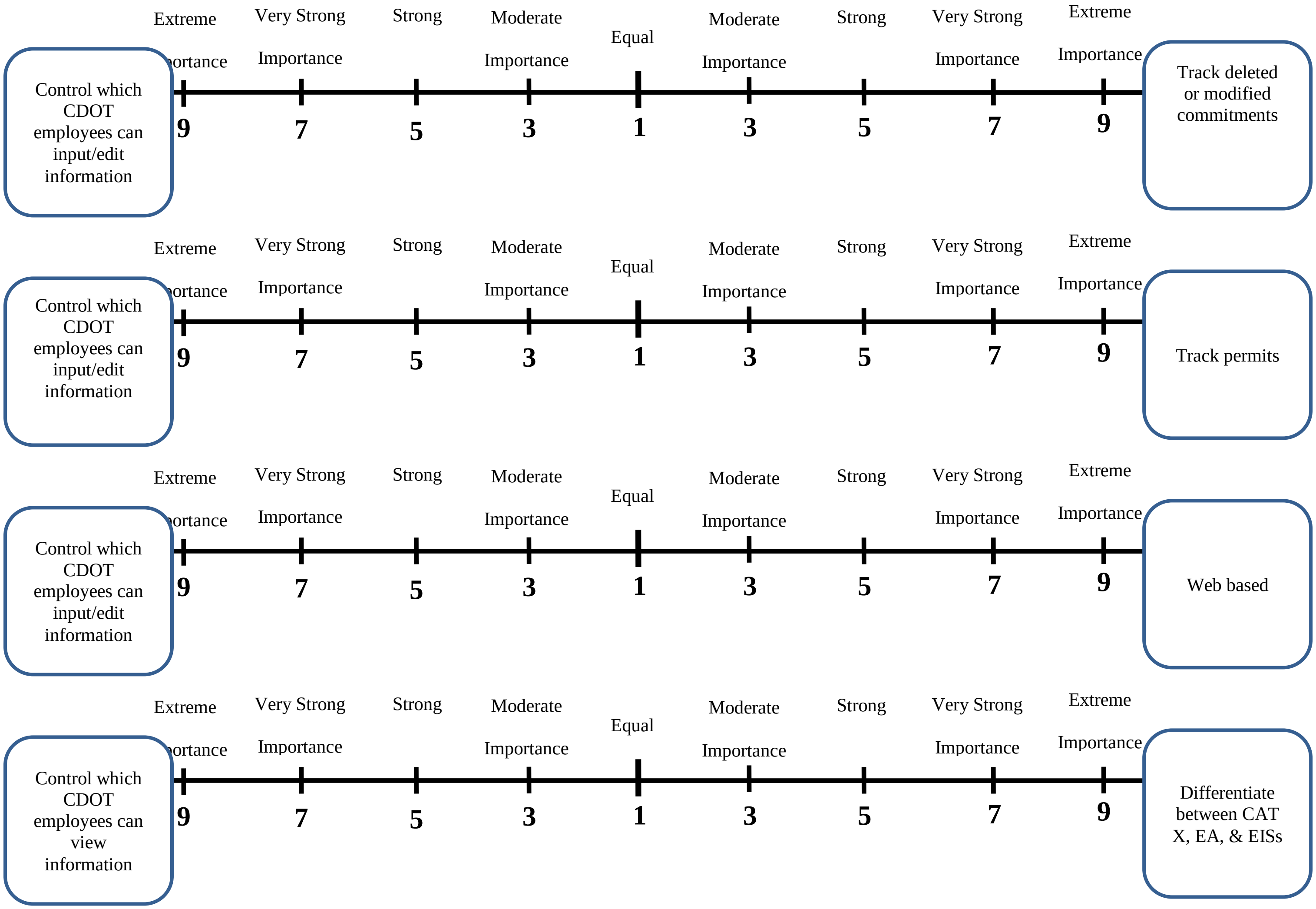

Allow external stakeholders to input/edit information
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments

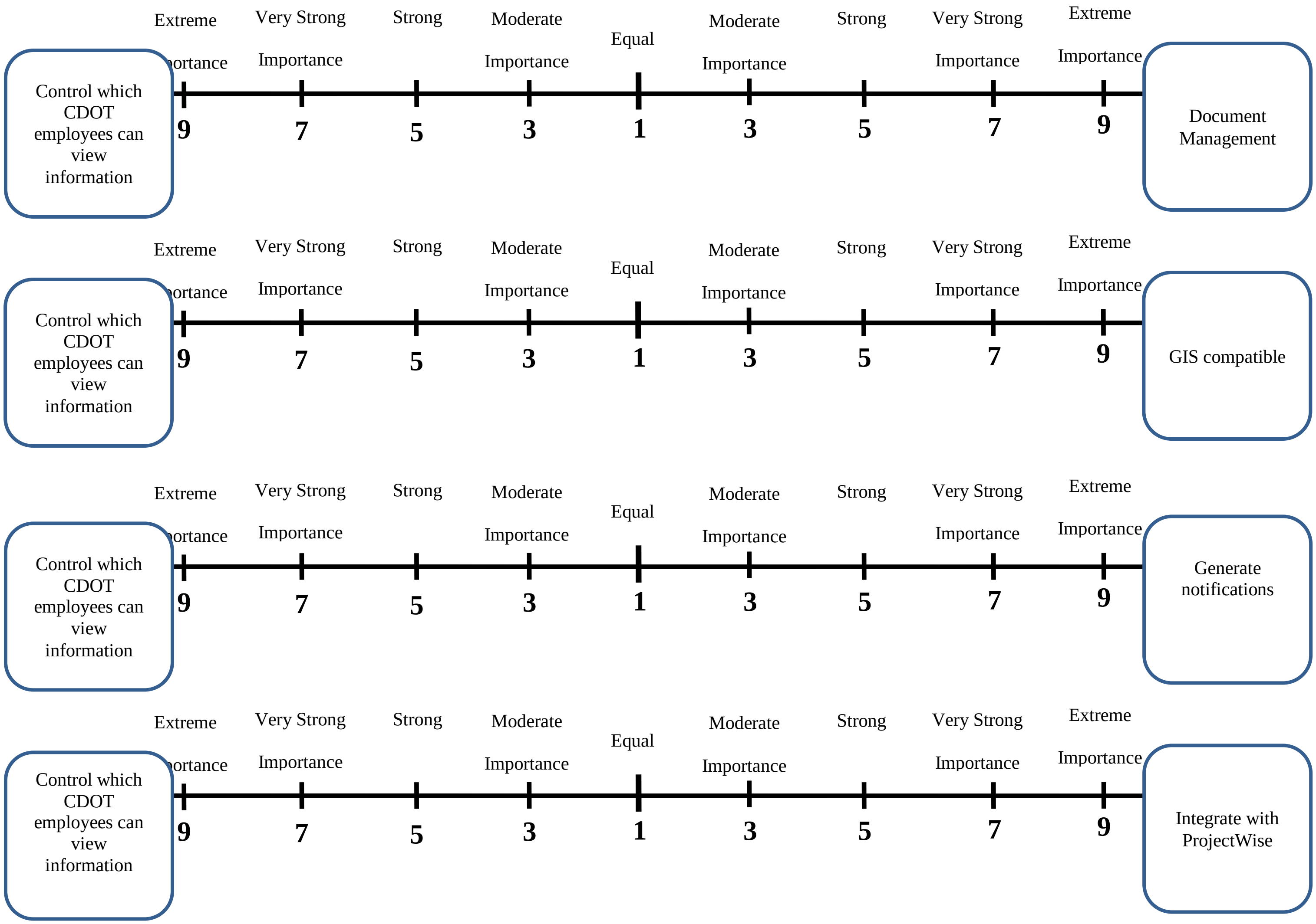


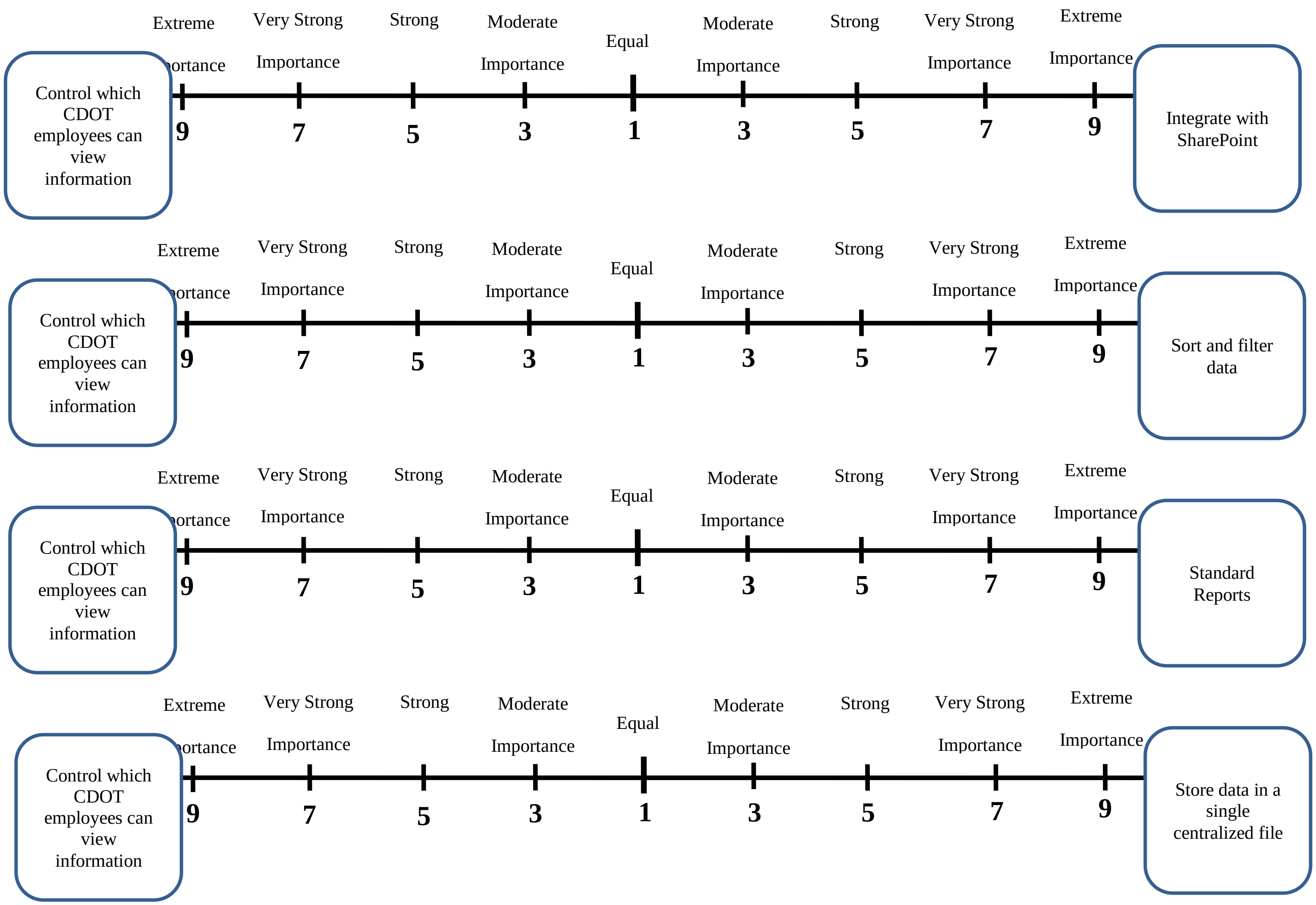
Allow external stakeholders to input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits
Allow external stakeholders to input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Control which CDOT employees can view information
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Differentiate between CAT X, EA, & EISs

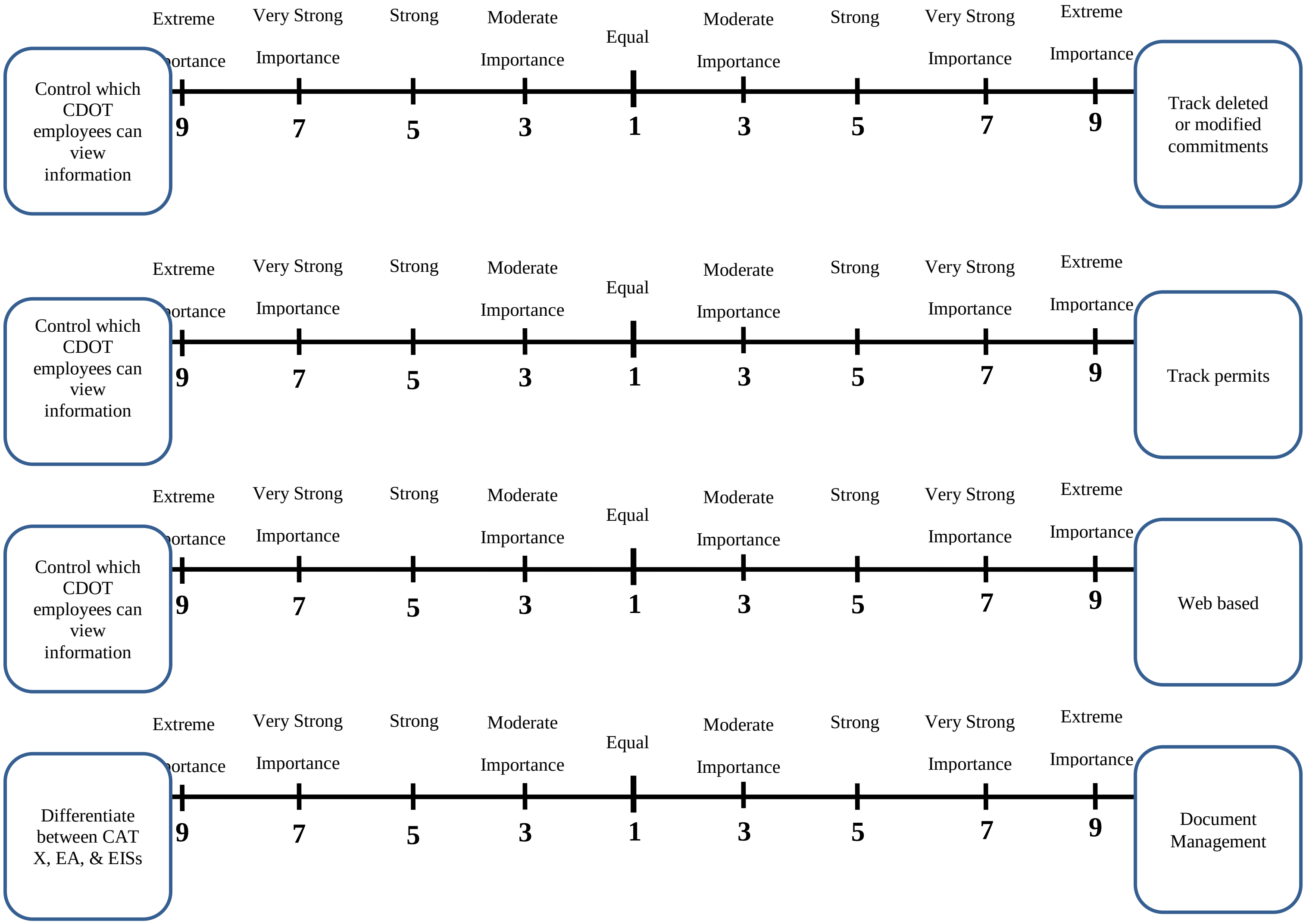

Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Document Management
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
GIS compatible
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Generate notifications
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise

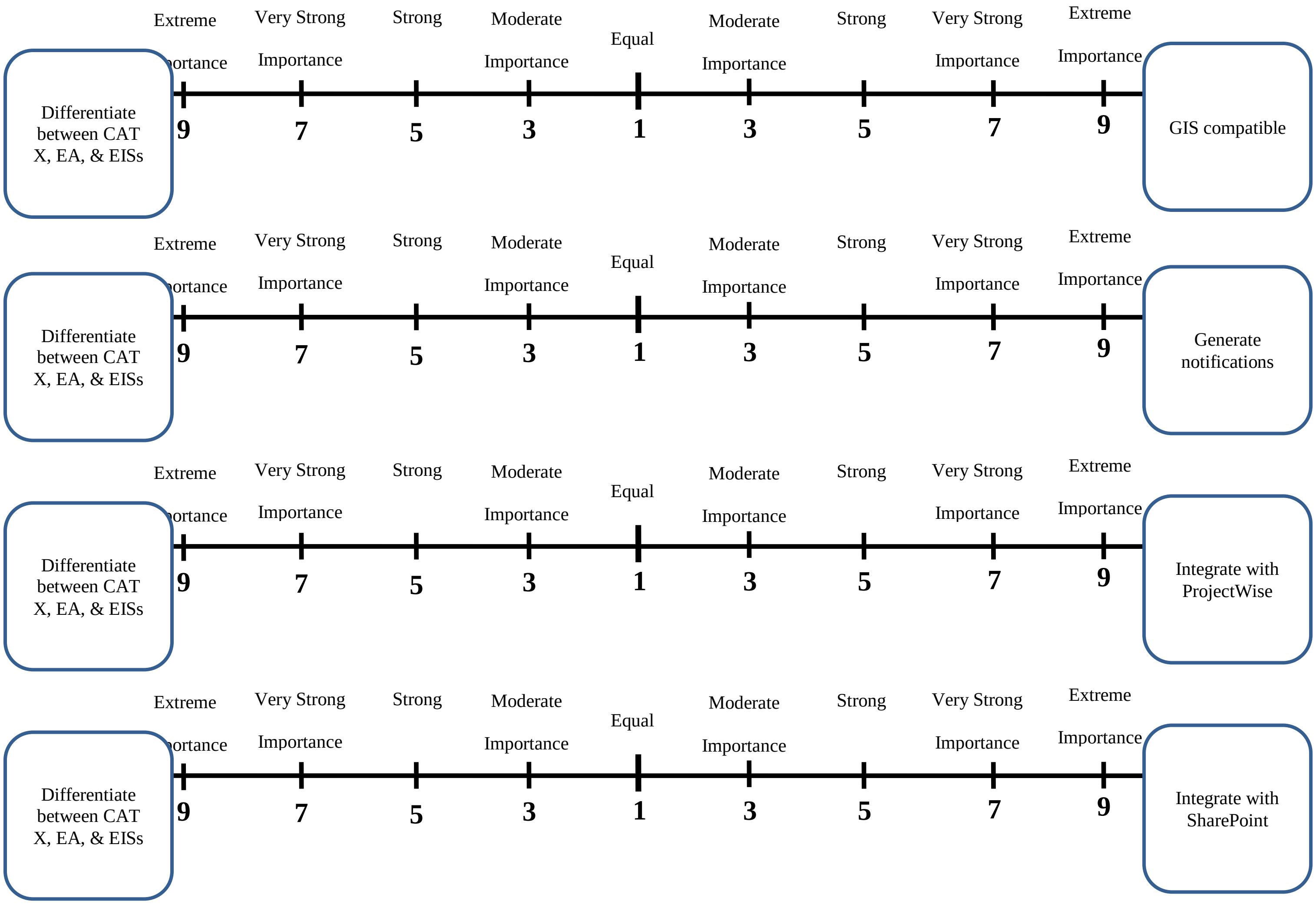

Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Sort and filter data
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Standard Reports
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file

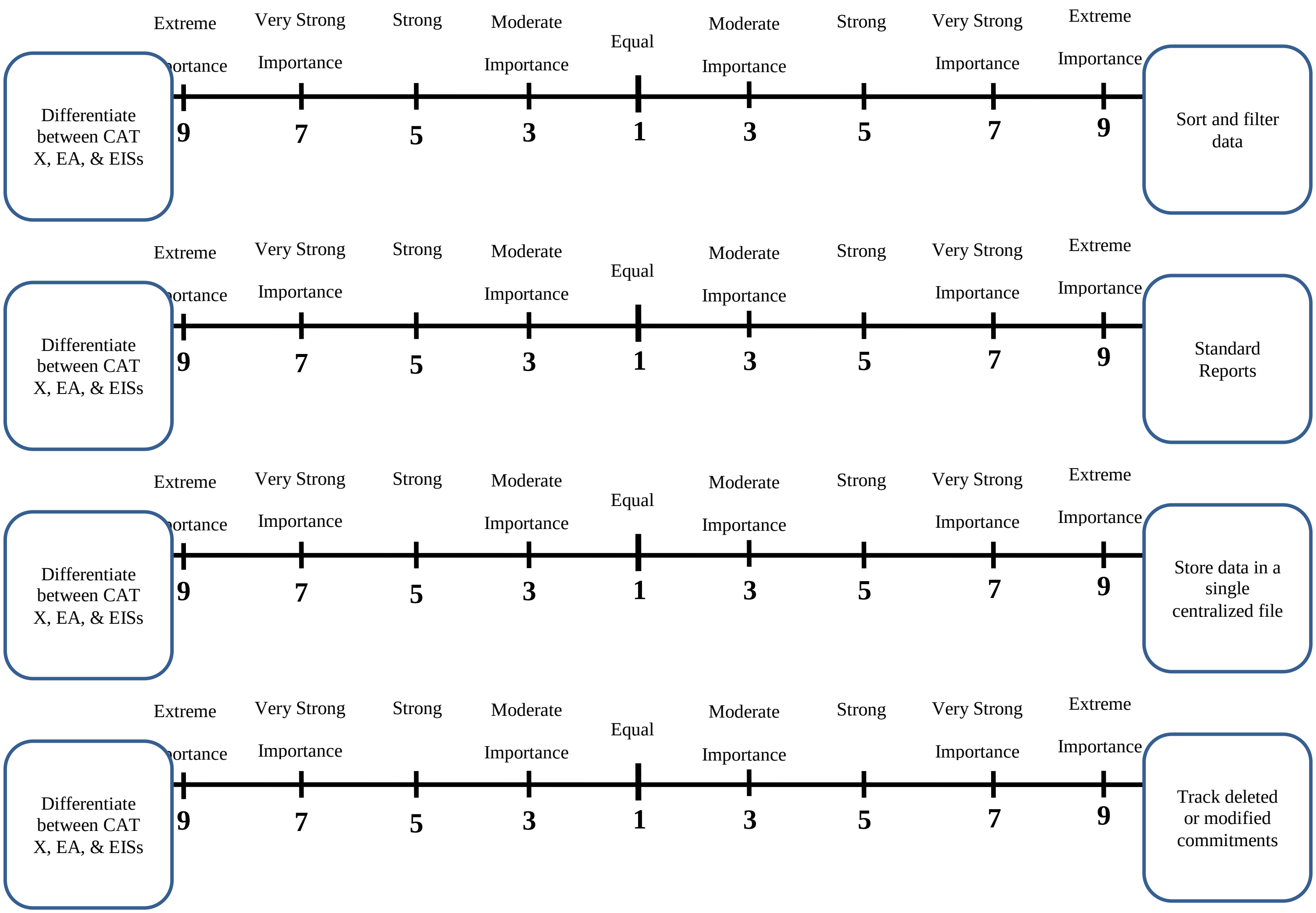

Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits
Control which CDOT employees can input/edit information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based
Control which CDOT employees can view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Differentiate between CAT X, EA, & EISs


Control which CDOT employees can view information
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Document Management
Control which CDOT employees can view information
9 7 5 3 1 3 5 7 9
GIS compatible
Control which CDOT employees can view information
9 7 5 3 1 3 5 7 9
Generate notifications
Control which CDOT employees can view information
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise

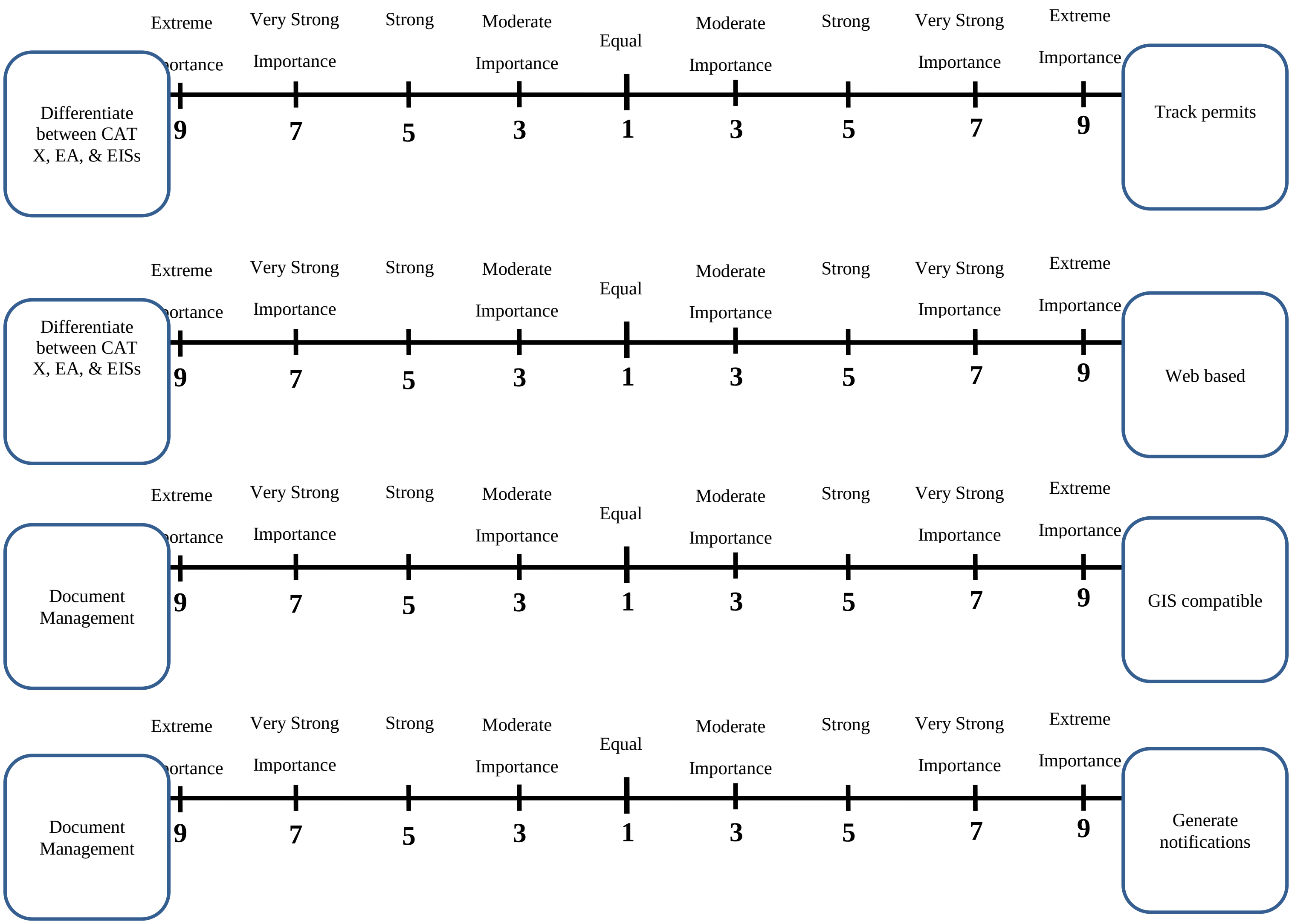

Control which CDOT employees can view information
Extreme
portance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint
Control which CDOT employees can view information
Extreme
portance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Sort and filter data
Control which CDOT employees can view information
Extreme
portance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Standard Reports
Control which CDOT employees can view information
Extreme
portance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file

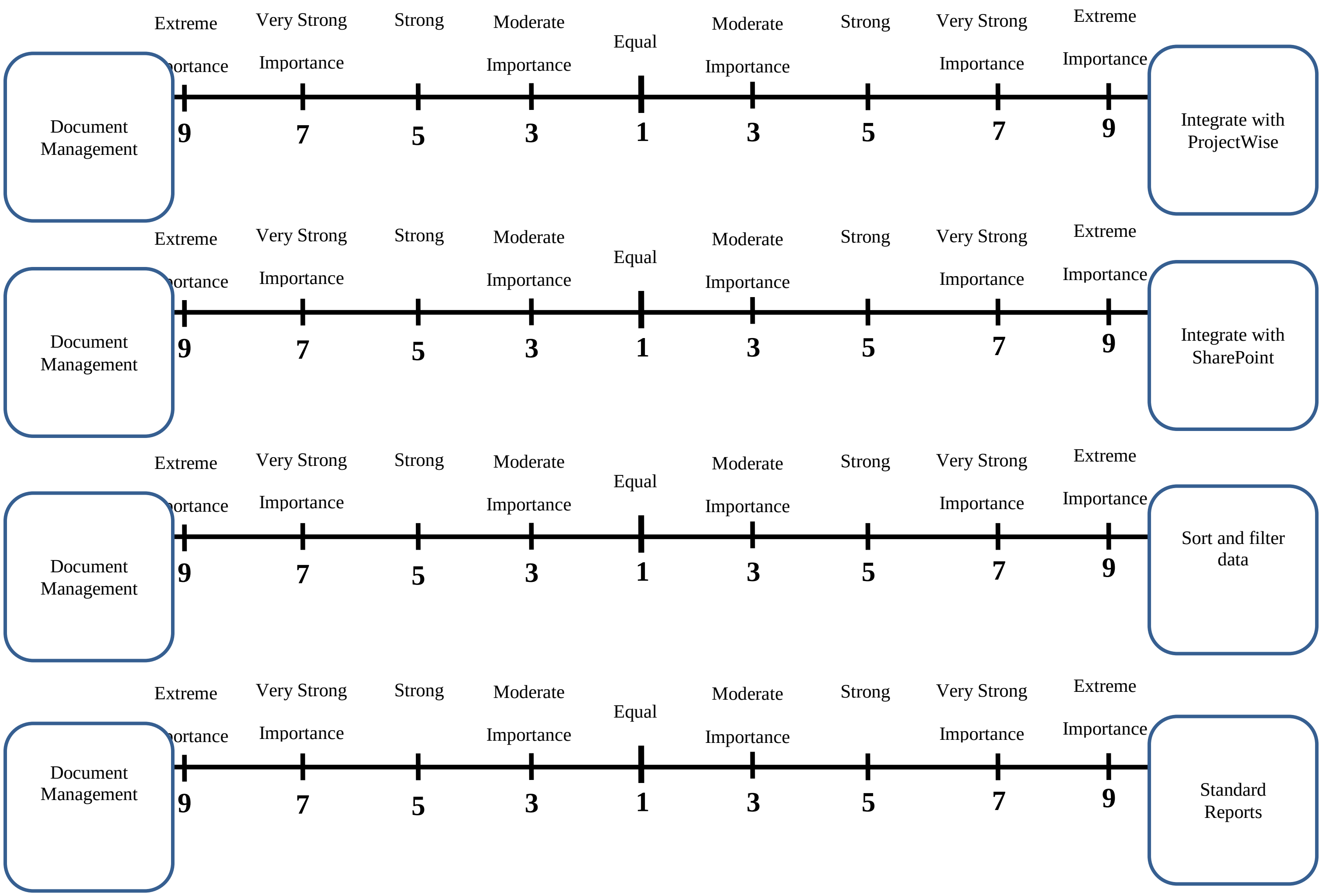

Control which CDOT employees can view information
Extreme ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Control which CDOT employees can view information
Extreme ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits
Control which CDOT employees can view information
Extreme ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based
Differentiate between CAT X, EA, & EISs
Extreme ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Document Management

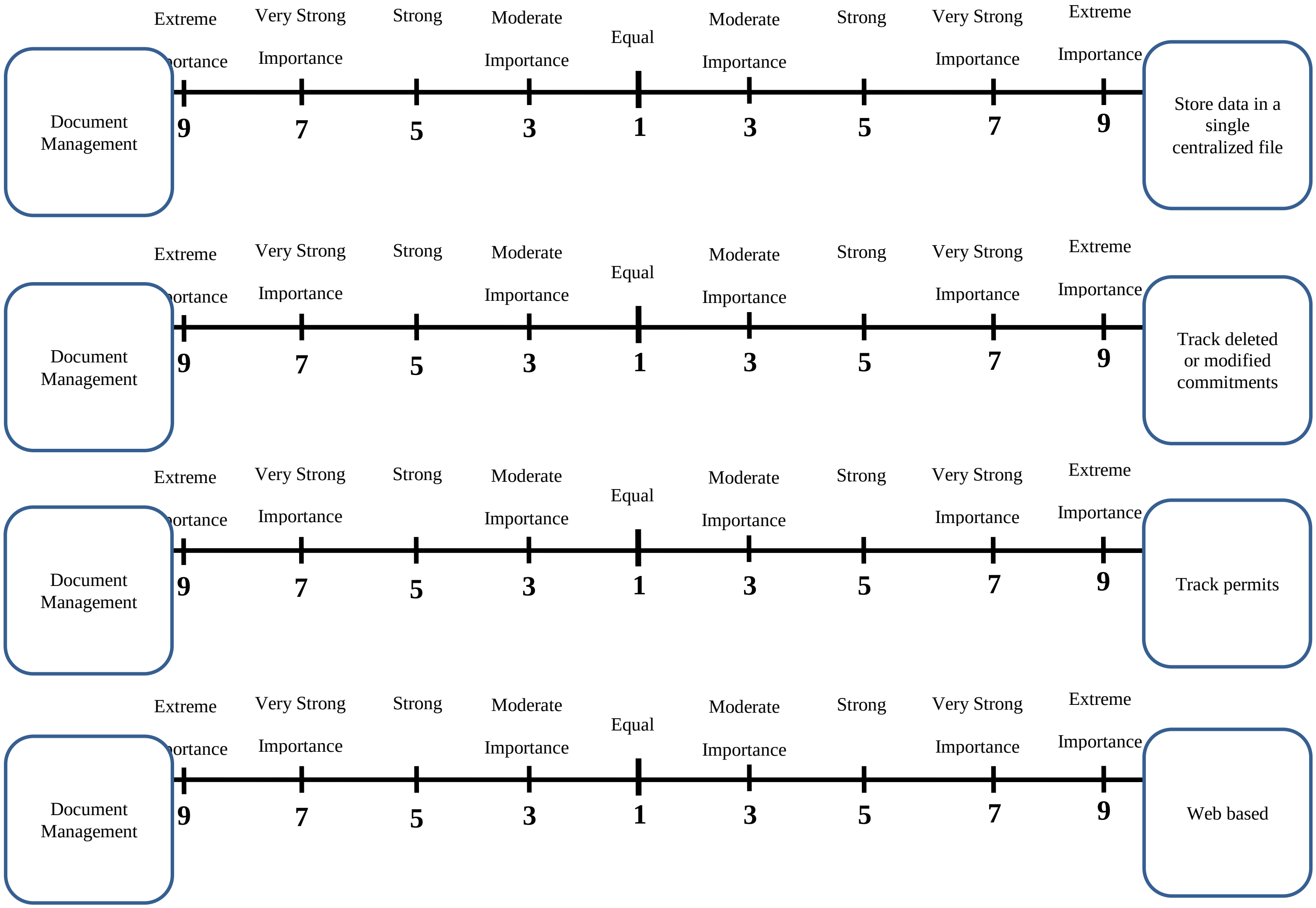

Differentiate between CAT X, EA, & EISs
Extreme
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
GIS compatible
Differentiate between CAT X, EA, & EISs
Extreme
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Generate notifications
Differentiate between CAT X, EA, & EISs
Extreme
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise
Differentiate between CAT X, EA, & EISs
Extreme
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint



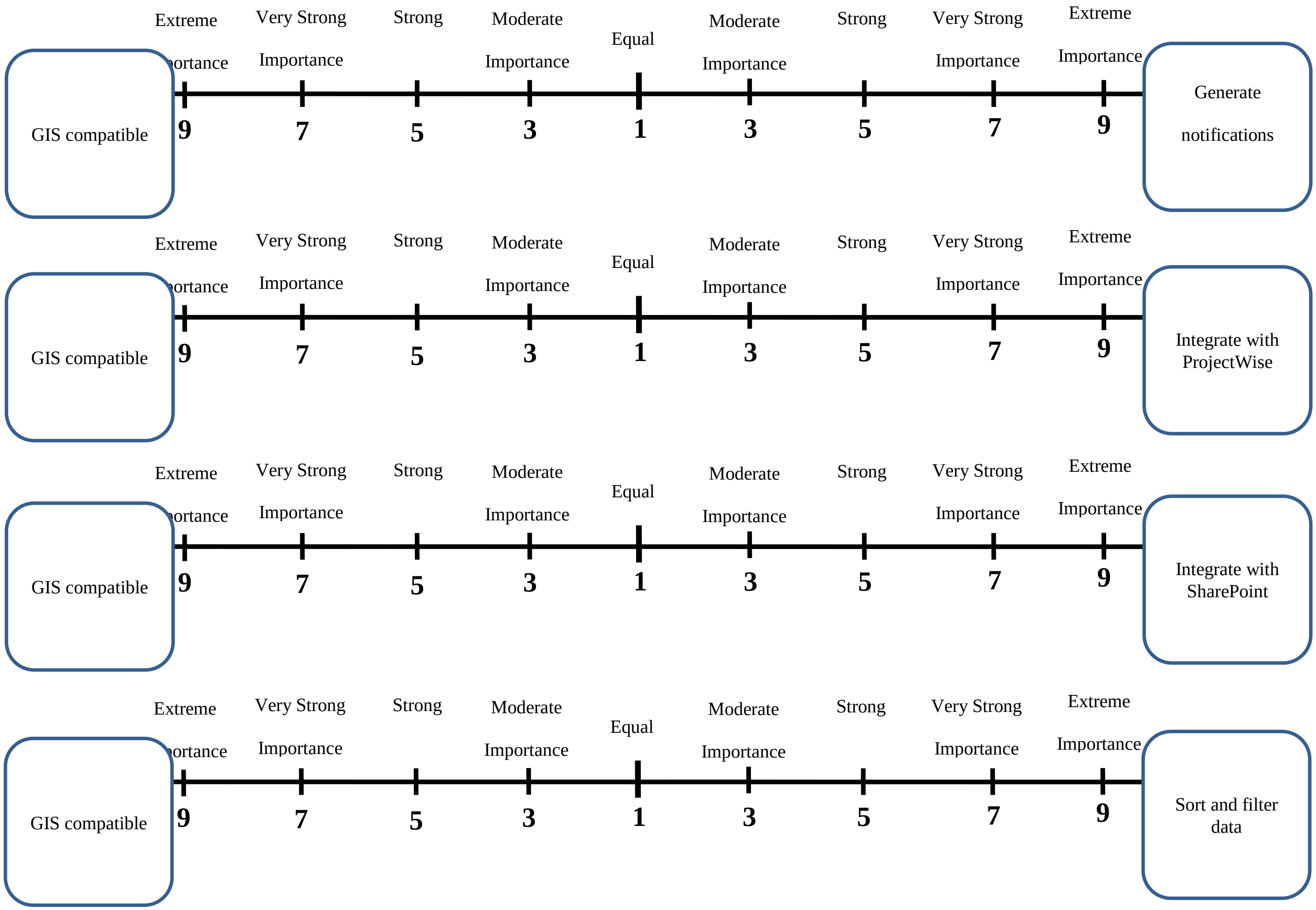
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Differentiate between CAT X, EA, & EISs
Sort and filter data
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Differentiate between CAT X, EA, & EISs
Standard Reports
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Differentiate between CAT X, EA, & EISs
Store data in a single centralized file
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Differentiate between CAT X, EA, & EISs
Track deleted or modified commitments

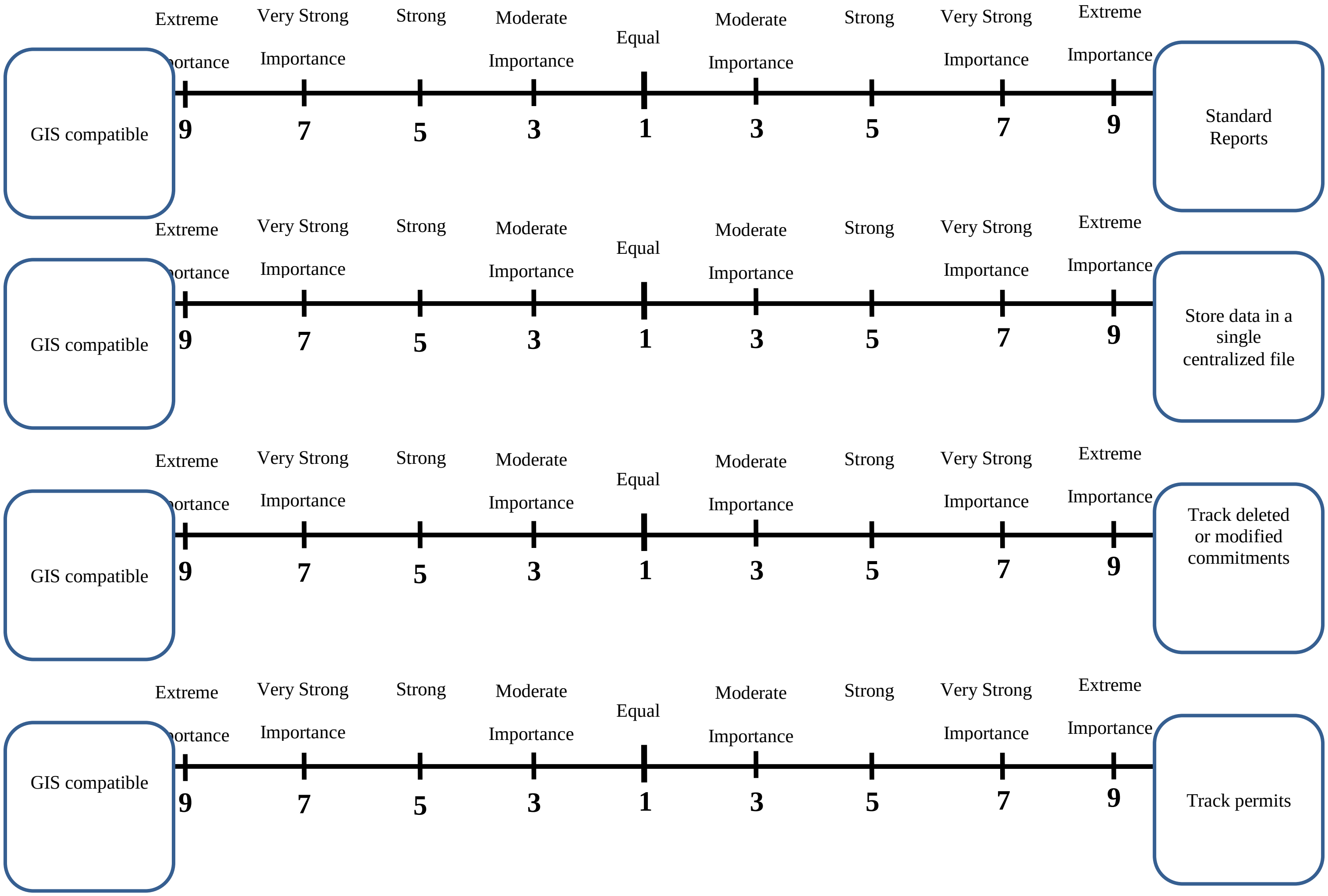

Differentiate between CAT X, EA, & EISs
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits
Differentiate between CAT X, EA, & EISs
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based
Document Management
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
GIS compatible
Document Management
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Generate notifications

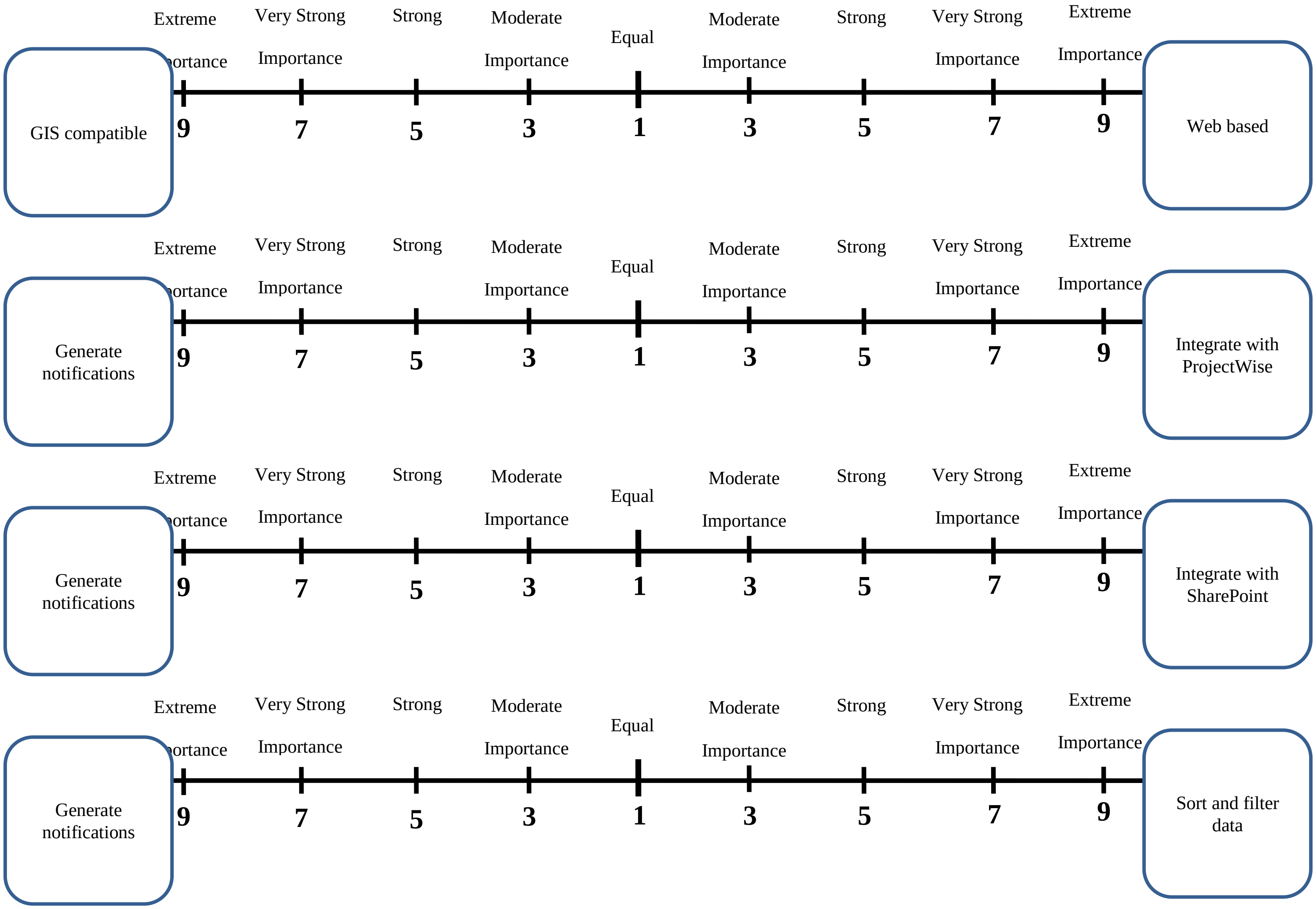

Document Management
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise
Document Management
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint
Document Management
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Sort and filter data
Document Management
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Standard Reports

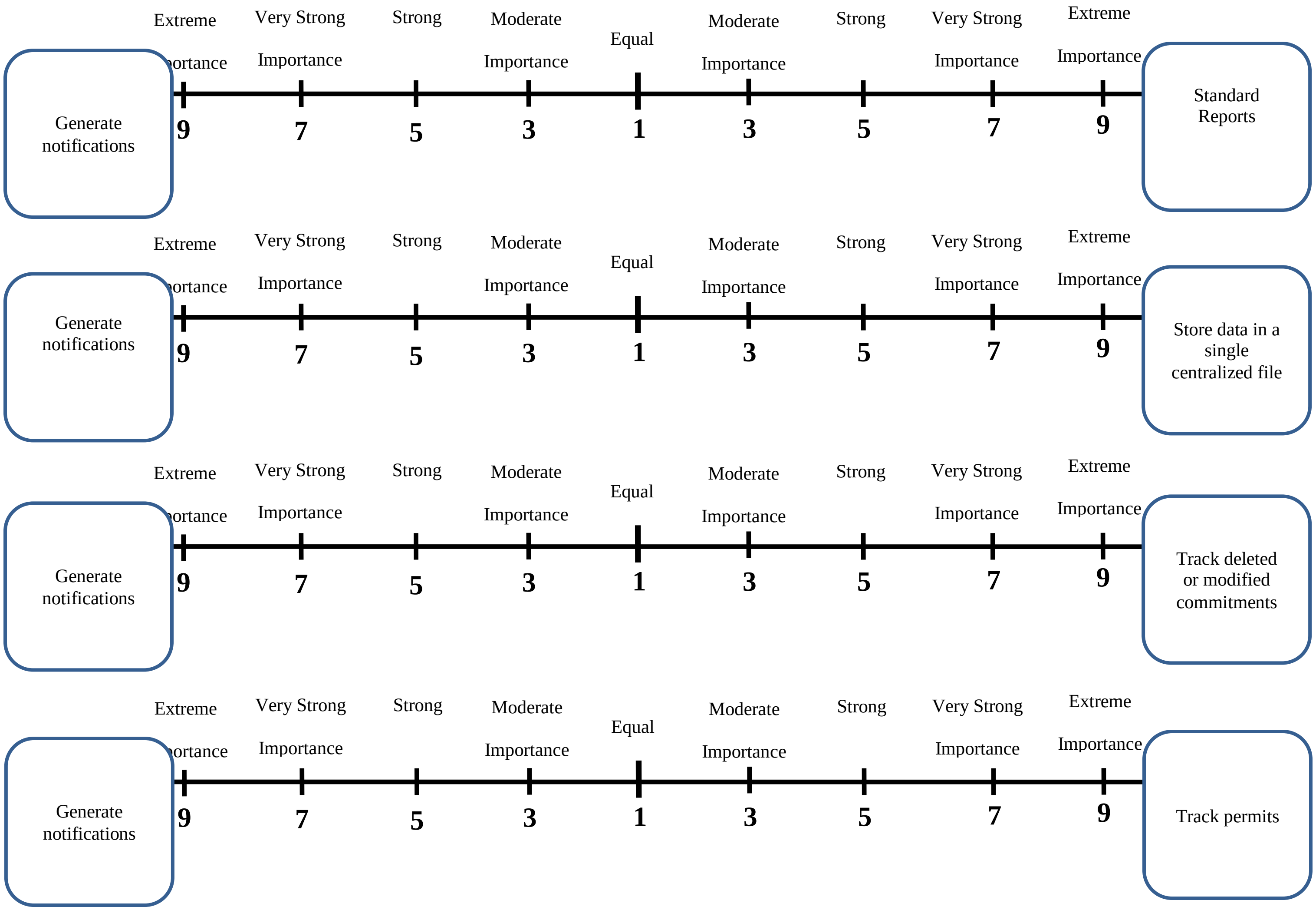


Document Management
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file
Document Management
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Document Management
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits
Document Management
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based

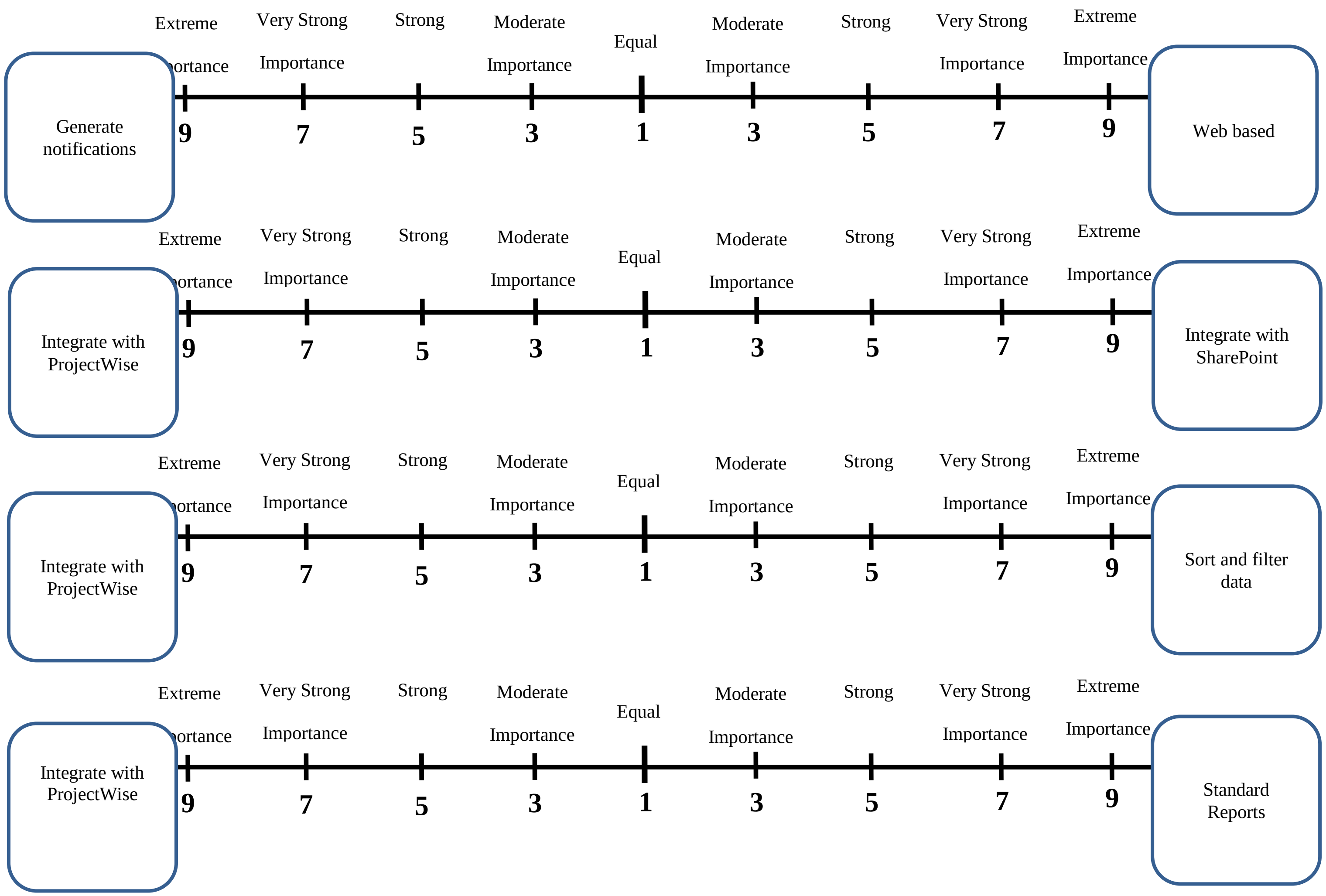

GIS compatible
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Generate notifications
GIS compatible
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise
GIS compatible
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint
GIS compatible
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Sort and filter data

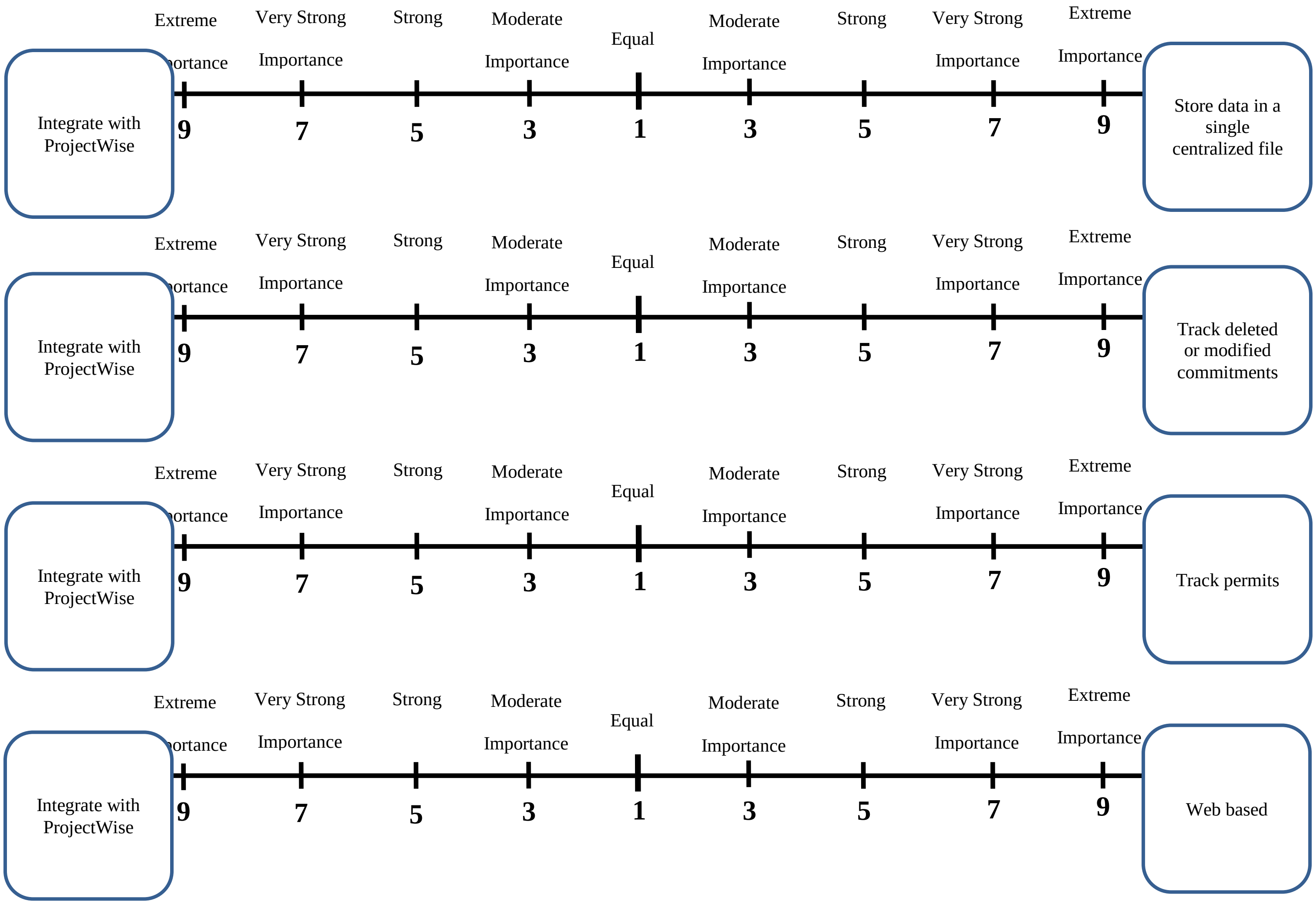

GIS compatible
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Standard Reports
GIS compatible
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file
GIS compatible
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
GIS compatible
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits

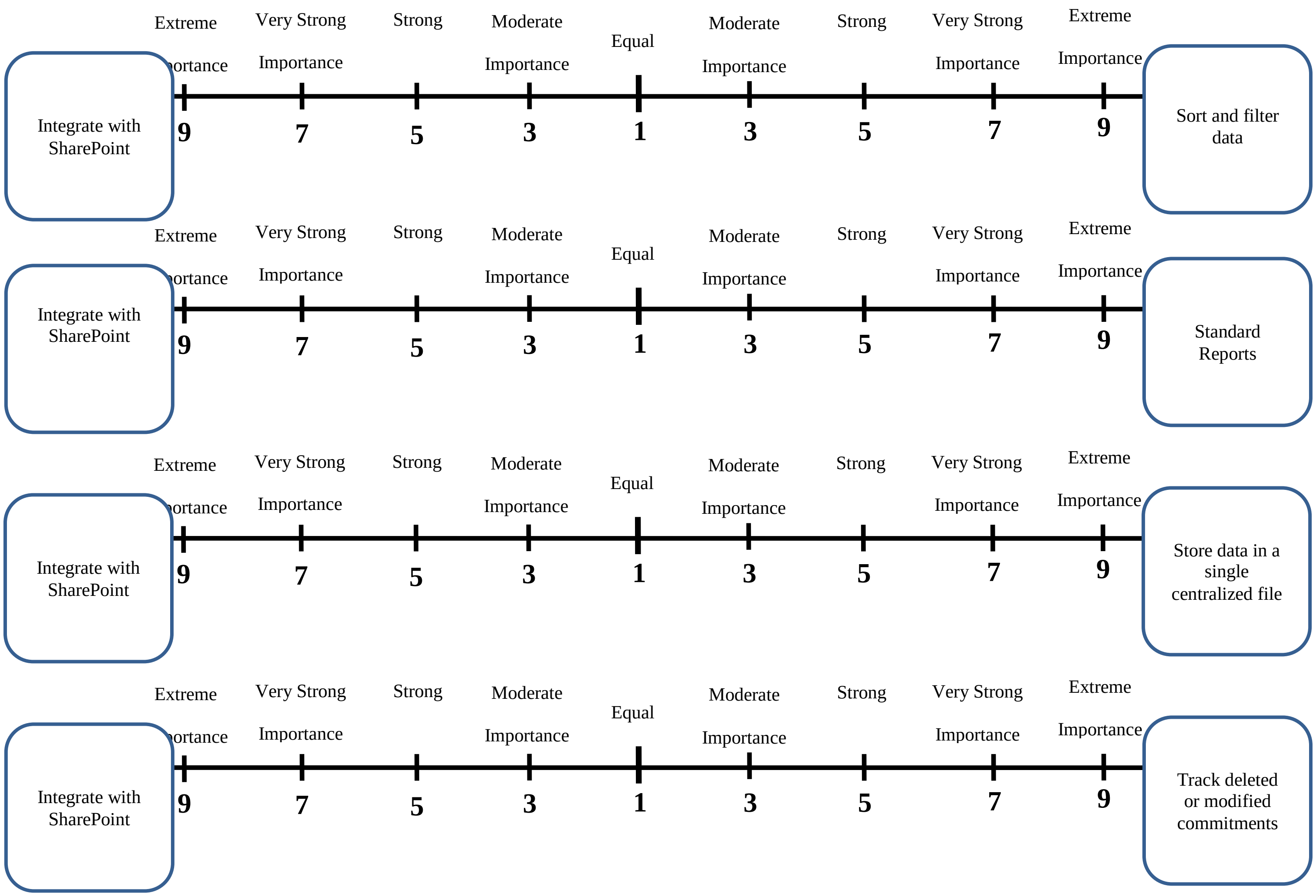

GIS compatible
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Web based
Generate notifications
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Integrate with ProjectWise
Generate notifications
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Integrate with SharePoint
Generate notifications
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
9 7 5 3 1 3 5 7 9
Sort and filter data

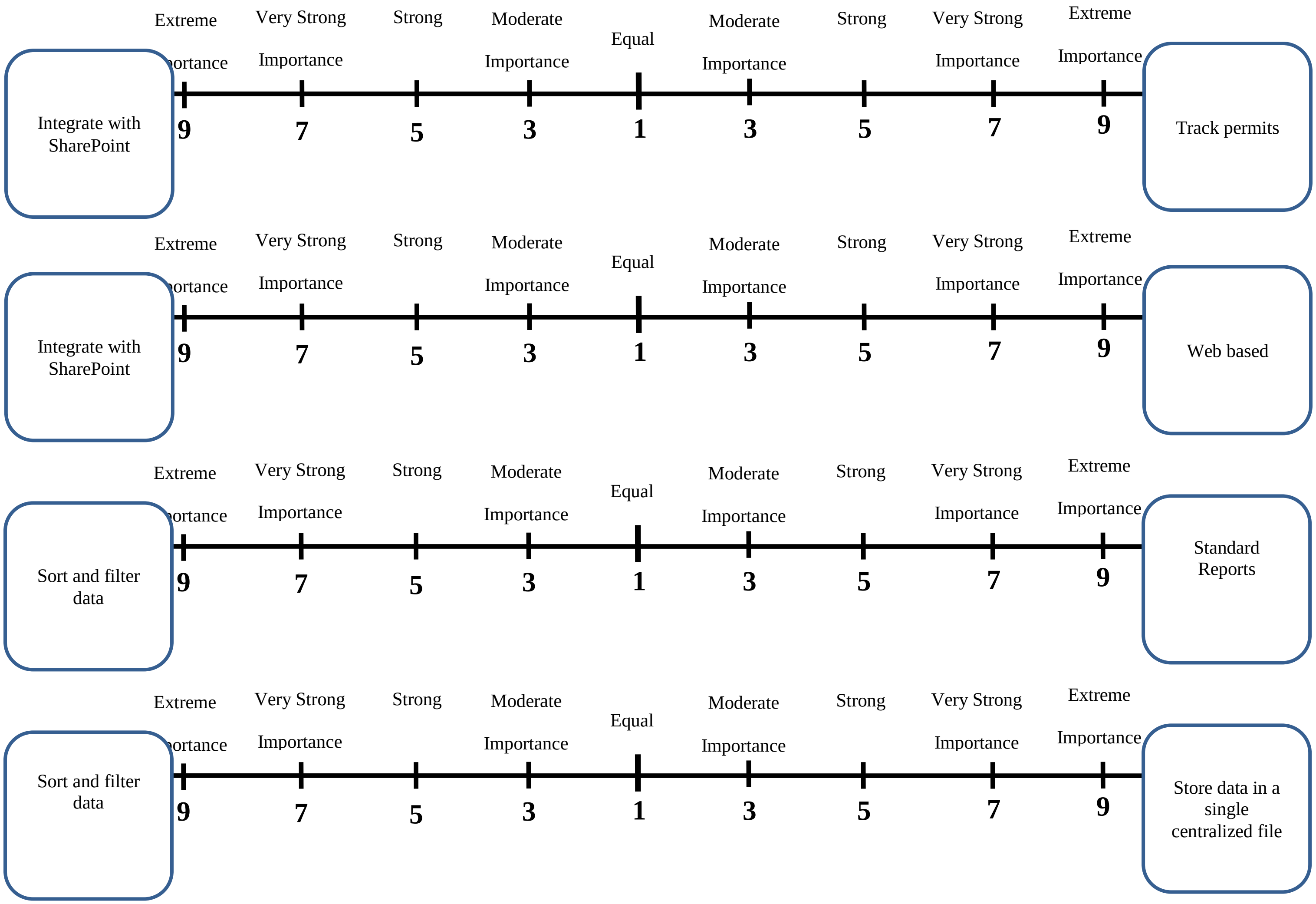


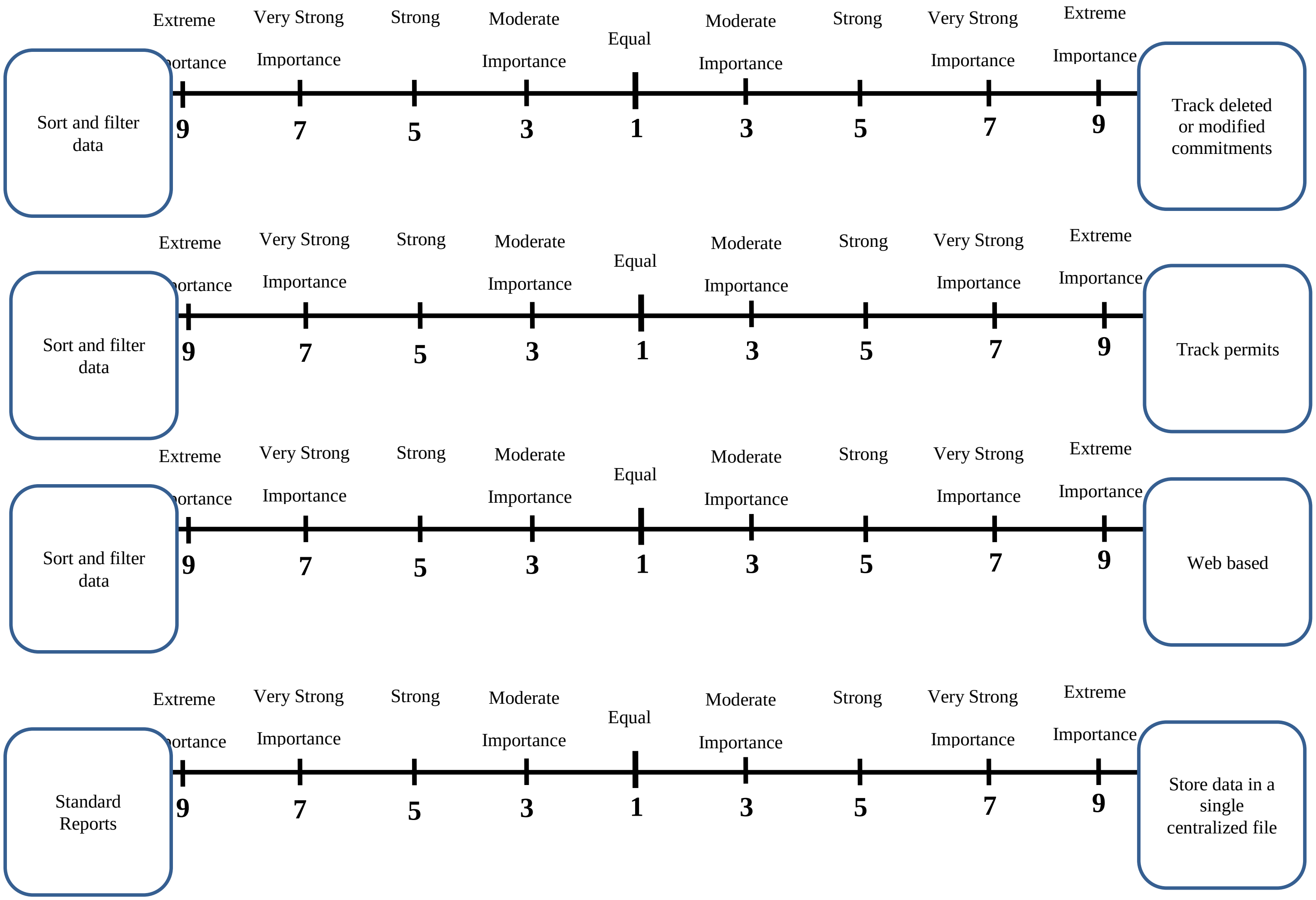
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Generate notifications
9 7 5 3 1 3 5 7 9
Standard Reports
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Generate notifications
9 7 5 3 1 3 5 7 9
Store data in a single centralized file
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Generate notifications
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Extreme
ortance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Generate notifications
9 7 5 3 1 3 5 7 9
Track permits


Generate notifications
Web based
Integrate with ProjectWise
Integrate with SharePoint
Integrate with ProjectWise
Sort and filter data
Integrate with ProjectWise
Standard Reports
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
9
7
5
3
1

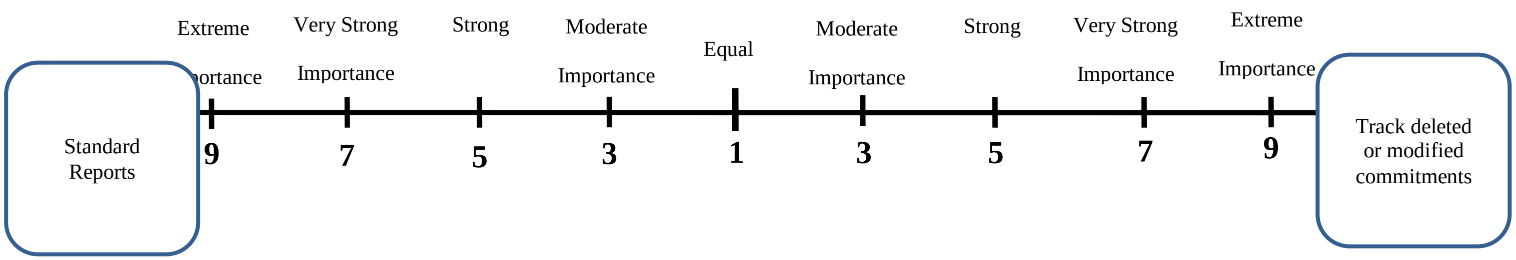

Extreme
portance
Very Strong
Importance
Strong
Moderate
Importance
Equal
Moderate
Importance
Strong
Very Strong
Importance
Extreme
Importance
Integrate with ProjectWise
9 7 5 3 1 3 5 7 9
Store data in a single centralized file
Integrate with ProjectWise
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Integrate with ProjectWise
9 7 5 3 1 3 5 7 9
Track permits
Integrate with ProjectWise
9 7 5 3 1 3 5 7 9
Web based

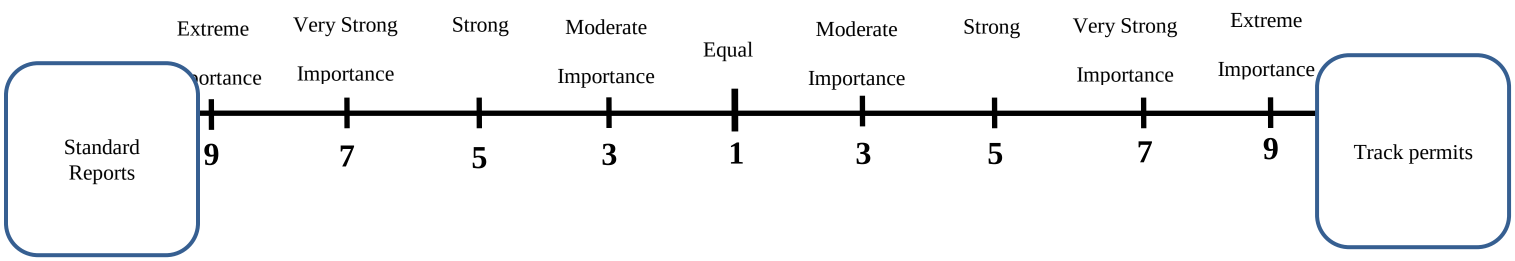

Integrate with SharePoint
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Sort and filter data
Integrate with SharePoint
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Standard Reports
Integrate with SharePoint
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file
Integrate with SharePoint
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments

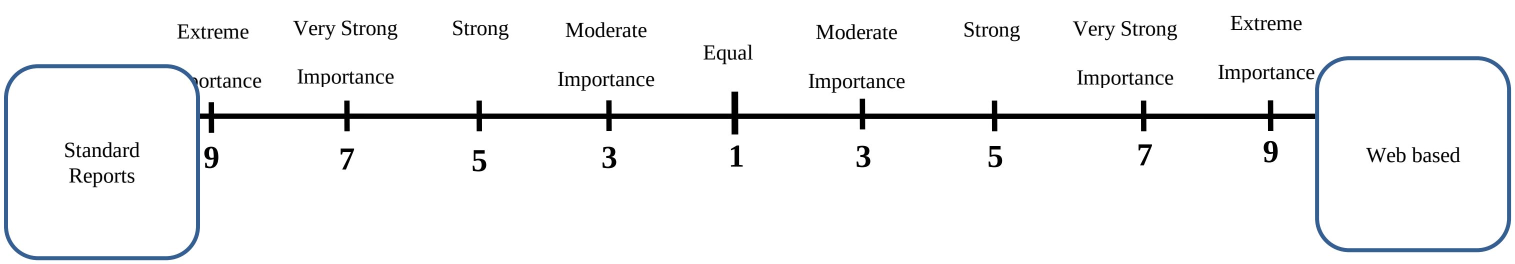

Integrate with SharePoint
Extreme portance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits
Integrate with SharePoint
Extreme portance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based
Sort and filter data
Extreme portance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Standard Reports
Sort and filter data
Extreme portance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Store data in a single centralized file

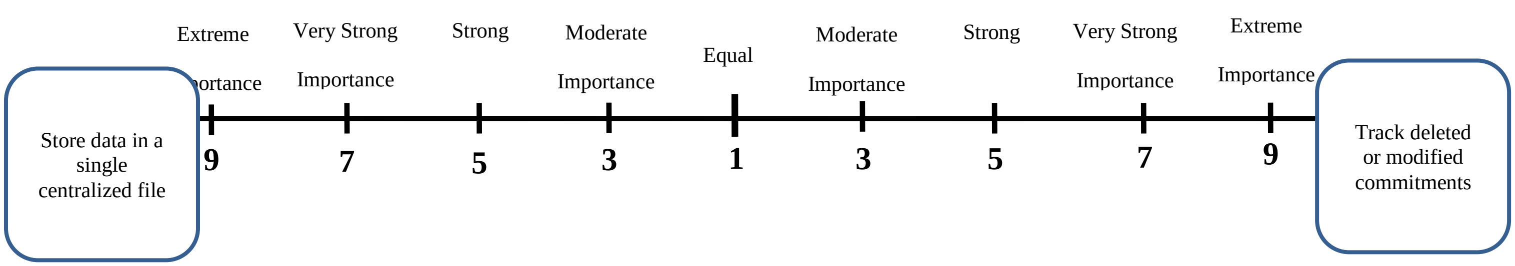


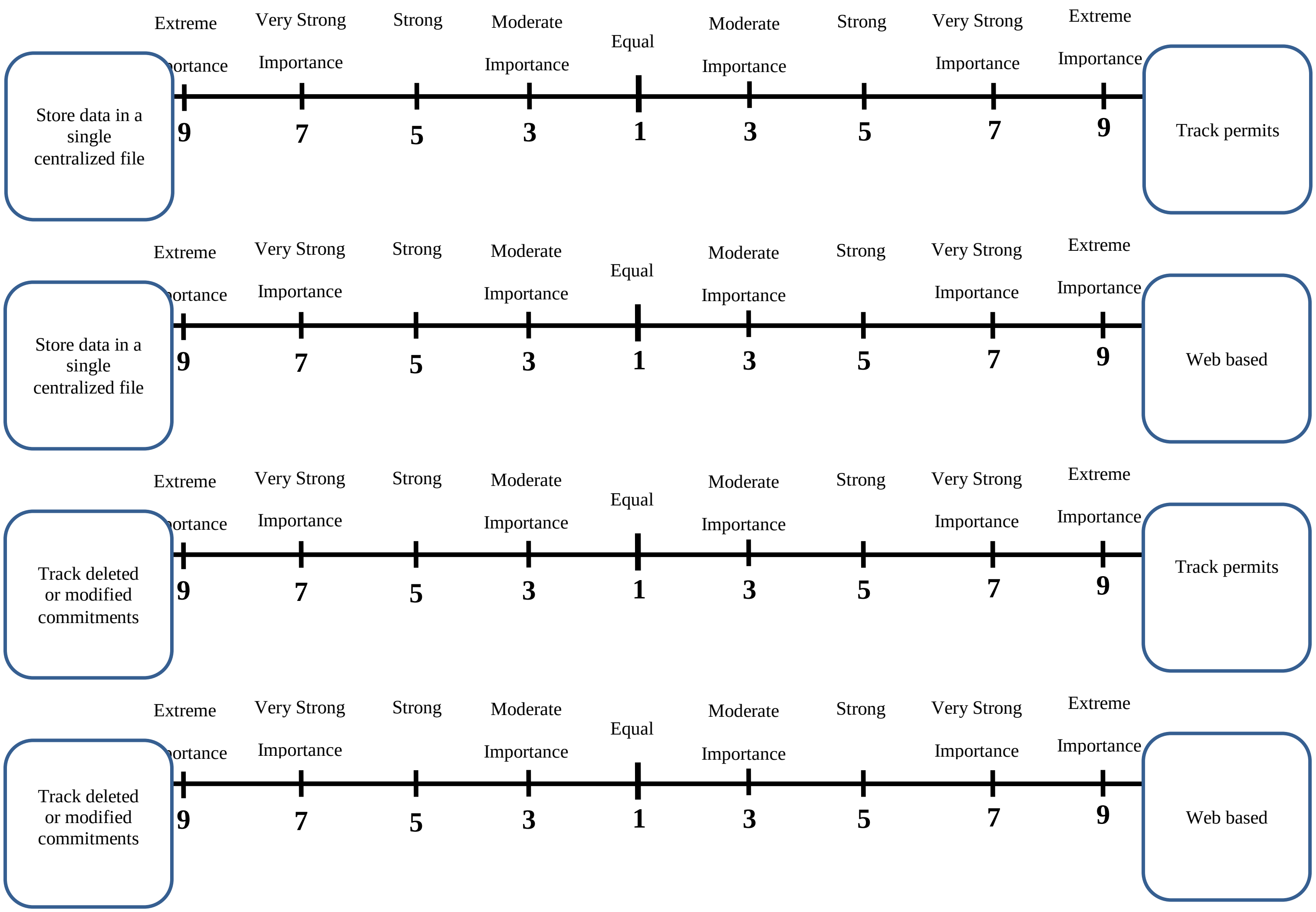
Sort and filter data
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments
Sort and filter data
9 7 5 3 1 3 5 7 9
Track permits
Sort and filter data
9 7 5 3 1 3 5 7 9
Web based
Standard Reports
9 7 5 3 1 3 5 7 9
Store data in a single centralized file

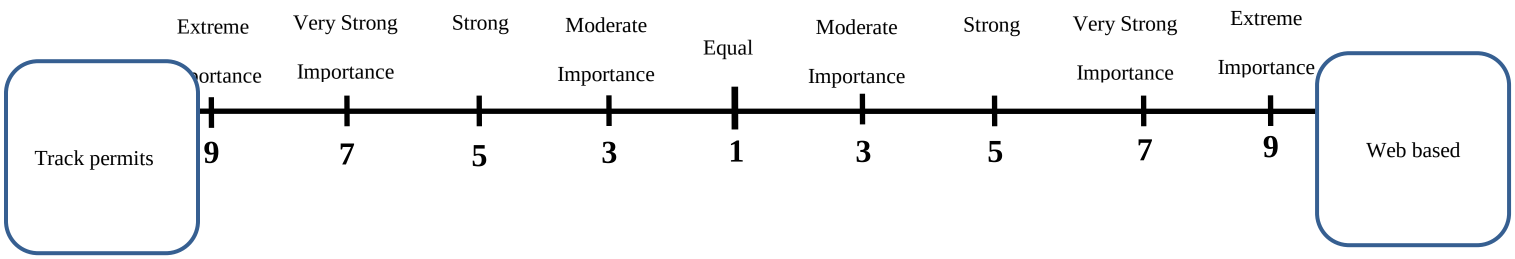

Standard Reports
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments


Standard Reports
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits


Standard Reports
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based


Store data in a single centralized file
Extreme Importance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track deleted or modified commitments


Store data in a single centralized file
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits
Store data in a single centralized file
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based
Track deleted or modified commitments
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Track permits
Track deleted or modified commitments
Extreme
ortance
Very Strong Importance
Strong
Moderate Importance
Equal
Moderate Importance
Strong
Very Strong Importance
Extreme Importance
9 7 5 3 1 3 5 7 9
Web based


Track permits
Extreme
portance
9
Very Strong
Importance
7
Strong
5
Moderate
Importance
3
Equal
1
Moderate
Importance
3
Strong
5
Very Strong
Importance
7
Extreme
Importance
9
Web based

An overview of Analytic Hierarchy Process (AHP)

AHP is a systematic procedure that will enable us to find the relative importance of the metrics developed for this study. Such a task is performed by forming a panel of expert decision makers (of the relevant field) to investigate the most influencing factors. AHP allows for the application of data, experience, insight, and intuition in a logical and thorough way. **The main purpose of AHP is the development of a vector of weights indicating the relative importance of the factors under investigation**. For this purpose, AHP consists of the following steps.

1. Structuring the elements under analysis (e.g., metrics for this study)
2. Assessment made by the decision makers through pairwise comparisons of such elements
3. Obtaining the weights (indicating the relative importance) of the elements

The critical step is the second step at which the matrices of pairwise comparison are formed. Humans are more capable of making relative rather than absolute judgments. By using the AHP pairwise comparison process, weights or priorities are derived from a set of judgments. Pairwise comparisons are basic to the AHP methodology. When comparing a pair of factors, a ratio of relative importance of the factors can be established. Usually, ratio scales (i.e. the integers 1-9 and their reciprocals) are utilized to represent the judgments of decision makers in each pairwise comparison.

Appendix IV: Email Letter Sent to State DOTs

Dear Mr./Ms. ----

My name is Andrew Fillion and I am a graduate research assistant in the Construction Management Department at Colorado State University. I am part of the research team from the University working with the Colorado Department of Transportation (CDOT) on a study titled "The Evaluation of Environmental Commitment Tracking Programs for Use at CDOT."

As CDOT is looking to update its environmental commitment tracking system, the goal of the project is to evaluate other state DOTs' tracking systems, which will allow the research team to make a recommendation to CDOT as to which existing system currently being used by another state DOT best matches CDOT's needs.

I have come across your contact information while researching and performing literature reviews of other states' environmental commitment tracking systems. We are reaching out to a few states in an effort to gain a better understanding of their environmental commitment tracking systems' features.

Within this context, I was wondering if you could take a few minutes to fill out the attached excel spreadsheet survey, by marking with an X in the appropriate box next to each feature indicating whether your state's environmental commitment tracking system has that feature or not and email it back to me by 3/11/11. I have also included a word document as an attachment that can be referred to for further explanation of each feature included in the survey.

The individual at CDOT that we are working with is the Environmental Research Manager, Ms. Vanessa Henderson. I have included her contact information in the case you have any additional questions regarding this research project.

Sincerely,

The Colorado State University research team:

Principle Investigator: Caroline Clevenger, Assistant Professor

Co-Principal Investigator: Mehmet Ozbek, Assistant Professor

Co-Principle Investigator: Andrew Fillion, Graduate Student

Vanessa Henderson, CDOT's Environmental Research Manager

Email:

Phone:

Appendix V: State DOT Surveys

Features	**Yes**	**No**	**Comments**
Allow ALL state DOT employees to view information			
Allow external stakeholders to view information			
Allow multiple state DOT employees to input/edit information			
Allow external stakeholders to input/edit information			
Control which state DOT employees can input/edit information			
Control which state DOT employees can view information			
Differentiate between CAT X, EA, & EISs			
Document Management			
GIS compatible			
Generate notifications			
Integrate with ProjectWise			
Integrate with SharePoint			
Sort and filter data			
Standard Reports			
Store data in a single centralized file			
Track deleted or modified commitments			
Track permits			
Web based			