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MassDOT Performance Dashboard

A Major Qualifying Project

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By

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Abstract

The objective of this MQP was to provide District 3 of the Massachusetts Department of Transportation Highway Division with a one-page report of performance. The rational for doing this was to equip management with district specific, monthly data for risk management and improve operational outcomes. We applied current research and technology, like Axiomatic Design to understand organizational functioning, Risk Management to determine weights and probabilities of not achieving target performance goals and the Balanced Scorecard to guide the development of a simple visual graphic. The methods we employed were client-facing meetings with upper management, in person, direct consultation for assigning relative weighting to specific measures, extensive decomposition and analysis of the organization, case studies of comparable systems within government and transportation, and interweaving best practices in change management to lead us to clear recommendations for their organization. We provided a District Health Report dashboard, we validated management's perspectives and suggested change management methods going forward.

Acknowledgements

We would like to thank to Professor Walter Towner for his contribution to this project as the main advisor. We also would like to thank Professor Helen Vassallo, the co-advisor of this project. Their combined input was invaluable.

Furthermore, we want to extend a special thanks to the members of the management of District 3 of the Massachusetts Department of Transportation Highway Division for their cooperation and contribution to this project:

Jonathan Gulliver, Highway Director

Barry J Lorion, Operations Engineer

Eric Nascimento, Assistant Operations Engineer

Arthur Frost, Head of Projects

Michael Hartnett, Head of Construction

Mohammed Nabulsi, Head of Bridges

Bernie Plante, Head of Administration

Chuck Mistretta, Head of Maintenance

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

We worked with the Massachusetts Department of Transportation Highway Division's District 3. The Massachusetts Department of Transportation (MassDOT) is composed of four agencies: Registry of Motor Vehicles (RMV), Aeronautics, Transit, and the Highway Department. This project was completed with the Highway Division, specifically District 3, which encompasses the Central Massachusetts region.

In 2009, Governor Deval Patrick signed landmark transportation reform legislation that integrated all the transportation agencies of the Commonwealth into a "streamlined" MassDOT that would take effect November 1st. This brought the Massachusetts Turnpike Authority under the jurisdiction of the Highway Division and divided all state roadways into regions for district oversight (Ref 1.1).

The Highway Division is comprised of the roadways, bridges, and tunnels of both the previous Massachusetts Highway Department and the Massachusetts Turnpike Authority. As of January 1, 2010, the Tobin Bridge came under the Highway Division, which also includes many bridges and parkways formerly under the authority of the Department of Conservation and Recreation. The Highway Division is divided into five subsections; Bridges, Projects, Construction, Maintenance and Administration. Through the combined efforts of these five sections, the Highway Division designs, constructs and maintains the Commonwealth's state highways and bridges. They also oversee traffic safety and engineering activities to ensure safe travel conditions on all roadways.

As part of their reorganization, the Office of Performance Management and Innovation was created to monitor and enhance MassDOT's achievement of the five performance goals: safety, customer service, financial responsibility, employee engagement and innovation. Below

is a graphic to show the steps of the process used by the Performance Management team to develop the new management system (Ref 1.2).

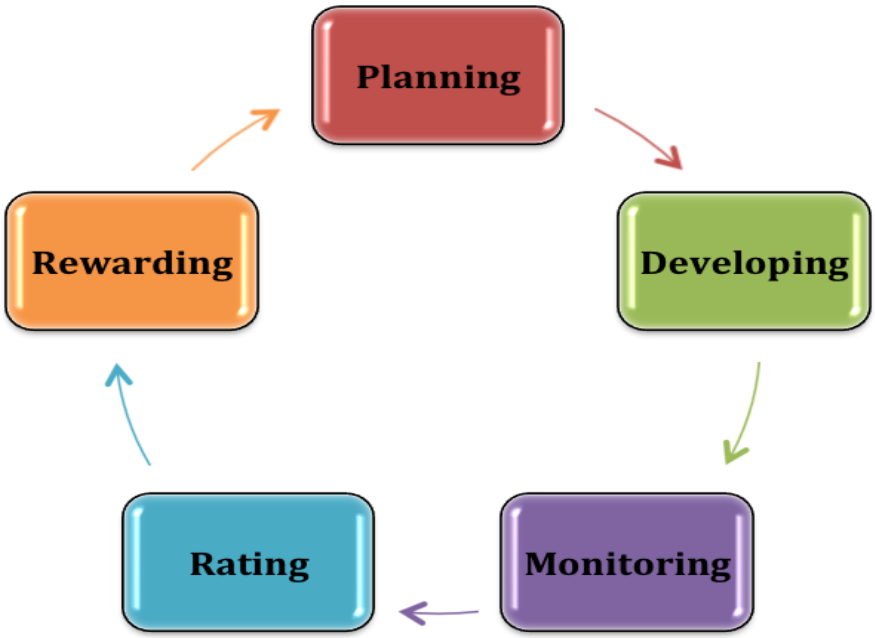


Figure 1- 1: Performance Management Process

The annual performance report highlights each MassDOT division's performance as compiled into a statewide number. This is represented visually, with three levels: red, yellow and green. The actual Performance Measure (PM) is described for the specified reporting time period along with the current, prior and target measurements. Figure 1-2 below is a snapshot of the first page of the Highway Division's annual standing statewide (Ref 1.2).

PERFORMANCE DASHBOARD

Highway Division

Highway sub-goals	Status	Measured period	Current	Prior	Target This Period	Notes
Safety						
Decrease the number of structurally deficient bridges		Monthly	447	454	≤ 463	-
Increase the system-wide Bridge Health Index		Monthly	82.66	82.49	≥ 82	-
Maintain all MassDOT-owned pavement in good or excellent condition (PSI)		Yearly (FFY)	64.1%	63.3%	≥ 65%	-
Continue to have the nation's lowest fatality rate		Yearly (CY)	1 of 50	1 of 50	1 of 50	Most recent data is from 2011
Customer Service						
Projects are completed on-time		Yearly (SFY)	75%	71%	≥ 80%	-
Accelerated Bridge Program projects are trending to finish on-time		Quarterly	74.3%	74.7%	≥ 80%	-
Maintain all MassDOT-owned pavement in good or excellent ride quality (CRSI)		Yearly (FFY)	81.8%	82.9%	≥ 80%	-
Roll-out RTTM system to major routes across the state		Monthly	On-track	New	Project benchmarks	-
Conduct a user satisfaction survey to assess driver attitudes and priorities	⦿	Monthly	Under development	Under development	Project benchmarks	-

Figure 1- 2: State Performance Dashboard

Chapter 2: Methodology

2.1 Project Beginnings

In September, we made an initial contact with multiple organizations to find a project sponsor. We sent each a general introduction of the MQP project parameters. One of those was through Celia Blue, who at the time held the position as Assistant Secretary in the Office of Performance Management and Innovation for the Massachusetts Department of Transportation (MassDOT). Finally, in late October, we received confirmation that our team was approved to proceed with the MQP with Massachusetts Department of Transportation's District 3 offices in Worcester. We were put in touch with Jonathan Gulliver, District 3 Highway Director. We spoke with his assistant to set an initial meeting with the DOT team on November 5th at 403 Belmont Street in Worcester.

In that meeting, we met several of the engineers, all but one a WPI alumni, who we would be working with later. The basics of the scope and schedule of our MQP were defined, and the DOT personnel introduced us to the Performance Management (PM) system with its many metrics, and the resulting yearly report broken down into five performance categories, then further broken down by divisions. We began to understand the expectations placed on District 3 to measure and report large amounts of data. We also heard them touch on the changes and challenges brought about by the legislative reorganization of MassDOT. It was decided in that meeting, that we would work alongside the District 3 Operations Engineering department who were implementing the PM changes. We were to come back and talk with that group for further project definition.

Our second meeting was in mid November with Barry Lorion, Operations Engineer, and Eric Nascimento, the Assistant Operations Engineer, who helped us to determine what direction

the project might take from the District 3 perspective. Through this, we identified where we might come alongside their efforts to concentrate on monitoring PM metrics that were the most important overall. Furthermore, they were interested in creating a simple one page monthly report that would visually show district specific data for management's reference in monthly meetings. The report would not list data by section, such as Bridges or Construction. Instead, the data would be compiled under the categorical headings of Safety, Customer Service, Fiscal Responsibility, Employee Engagement and Innovation.

On January 8th, we visited District 3 headquarters a third time and met with Mr. Lorion and Mr. Nascimento to further clarify what information we would need for the dashboard and to define how to proceed. It was determined that we would conduct consultation interviews with each District 3 section head to determine the relative weights of the most important metrics. Based on their subjective expert experience, together we could filter and weight the metrics for the District 3 dashboard.

2.2 Axiomatic Design

During the weeks leading up to this third meeting, our team was employing a design framework in order to fully understand the District 3 Highway Division. This was necessary to ensure that (1) we developed a design for the DHR that would meet their needs, and (2) we understood their process well enough to be able to offer potentially valuable insights. The method we employed was Axiomatic Design, developed in 1990 by Professor Suh of Massachusetts Institute of Technology. We used AD design to build the system for achieving the main goals of MassDOT Highway Division District 3 which we will discuss more details in the next Chapter.

2.3 Active Risk Management

In our second meeting, MassDOT management thought that this project had similarities to risk analysis and management. We were directed to look at the work of Allen Marr of Geocomp, who developed what is called Active Risk Management. There are many styles and methods of risk management. We focused on using foundational techniques as laid out in Active Risk Management. That is risk is the combination of the likelihood (probability) of an uncertain event multiply by the impact (weight) of said even occurring (Ref 2.1)

During our third meeting with District 3 we all agreed that data would be necessary for analysis of the probability of risk. At the conclusion of our consultation interviews, the next steps would be to follow up with Mr. Lorion and Mr. Nascimento, and see how much past data they would be able to collect through their resources. The focus was on the historic data regarding only these specific performance measures for which we had assessed weights. This would allow us to do some interpretation based on distribution of the probabilities or likelihoods of these events occurring.

Following the meeting, our team received the contact information for the five section heads. We emailed Mr. Lorion an updated electronic copy of the spreadsheet of the abridged list of PM metrics along with meeting minutes on January 10th. This was to ensure we understood their priorities and directives for our team. We concluded by confirming that we were drafting a consultation script and indicated when they could expect it from us. On January 15th, we emailed Mr. Lorion a rough draft of the consultation question script. He responded favorably, indicating that he felt the script was ready for use.

During the next week, our consultation team, consisting of Dee Angwafo and Alicia Manley, was formed and our availability coordinated. The following is the list of those persons

we met. Michael Hartnett in Construction, Mohammed "Mo" Nabulsi of the Bridges Section, Arthur Frost in Projects, Bernie Plante in Administration, and Chuck Mistretta in the Maintenance section.

In preparation for these appointments scheduled January 28th and 29th, our team conferred further to detail the exact approach. We emailed the Mr. Lorion for his feedback to ensure we continued to stay in sync with the purposes, politics and priorities of District 3. We wanted to be sure we got enough experience-based information without overstepping or overlapping DOT efforts. More details of the process can be found in Chapter 4.

Following these interviews, we continued our analysis using Axiomatic Design for the development of recommendations and reporting while we awaited data. In an effort to achieve some level of Cost/Benefit Analysis, we realized we would need to inquire directly about budget and schedule overruns and their costs and causes. In the interest of time, we would conduct a second set of consultation interviews to determine the probability of District 3 achieving below the performance goal target values. The events that would have the largest impact would involve safety, schedule and budgetary. We determined that the Projects and Administration sections would more familiar with examples of risk events and their historical frequency. This was also consistent with their self-reported weighting of performance metrics in safety and fiscal responsibility. From this we might be able to create case studies to measure and use as reference points. These studies could aid us in either confirming or refuting the couplings we observed during the Axiomatic Design.

In the interest of time, we had to conduct a second set of consultation interviews to determine the probability of District 3 achieving below the performance goal target values. The events that would have the largest impact would involve the areas of safety, schedule and budget.

A couple of the sections more familiar with these and their historical frequency we determined would be Projects and Administration. This was consistent also with their self-reported weighting of performance metrics in safety and fiscal responsibility. Dee Angwafo and Alex Freilich met with the Heads of both the Projects section, Arthur Frost, and the Administration section, Bernie Plante. The resulting information and analysis of safety and fiscal responsibility based on these inquiries are developed in Chapter 7 and Chapter 4 respectively. Chapter 7 is about safety concerns as they relate to hazards in the workplace and Chapter 4 combines the quantitative information gathered in this second round of interviews to provide the probability dimension to the Active Risk Management equation.

2.4 Performance Dashboard

We considered various visual performance reporting methods to guide the development of our deliverable. Some of these included the Balanced Scorecard, Microsoft Excel spreadsheets and Primavera. We selected the Microsoft Excel framework to create an easily updatable performance dashboard that combined the weight and probability concepts of Active Risk Management. The details of that process and examples of the spreadsheets can be found in Chapter 4.

2.5 Change Management

As we neared the conclusion of our project, we considered again the potential correlations that we observed during our decomposition of the District 3 organization using Axiomatic Design. We determined where correlations between employee engagement and safety and fiscal responsibility could be better understood and turned into an opportunity. Methods for supporting employees and engaging them in the process of change have been developed into a field called change management. We have included information about the various best practices

and tools of change management at length in Chapter 6. We recognize that MassDOT has included this employee engagement and innovation as performance goals because they likewise understand the importance of leveraging people by increasing employee engagement. If District 3 implements change management, this will help them achieve outstanding performance in two of the five goal categories.

Chapter 3: Axiomatic Design

3.1 Axiomatic Design

3.1.1 Introduction

Axiomatic design is a design method that was created and popularized by Professor Nam Suh of the Massachusetts Institute of Technology (Ref 3.1, 3.2). It is a general design framework, rather than a design theory (Ref 3.3).

Axiomatic design is based on two axioms: the Independence Axiom and the Information Axiom. A good design should satisfy the two axioms while poor design does not. Axiom 1 states an optimal design always maintains the independence of the functional requirements of the design. The design parameters (DPs) and functional requirements (FRs) are related in such a way that a specific DP can be adjusted to satisfy its corresponding FR without affecting other functional requirements. Axiom 2 states the best design is a functionally uncoupled design that has the minimum information content. It is considered a secondary rule for selecting good designs among others. If there is more than one design alternative that meets Axiom 1 and has equivalent performance, then the design with the lesser amount of information should be selected based on Axiom 2 (Ref 3.3).

3.1.2 Axiomatic Design Process

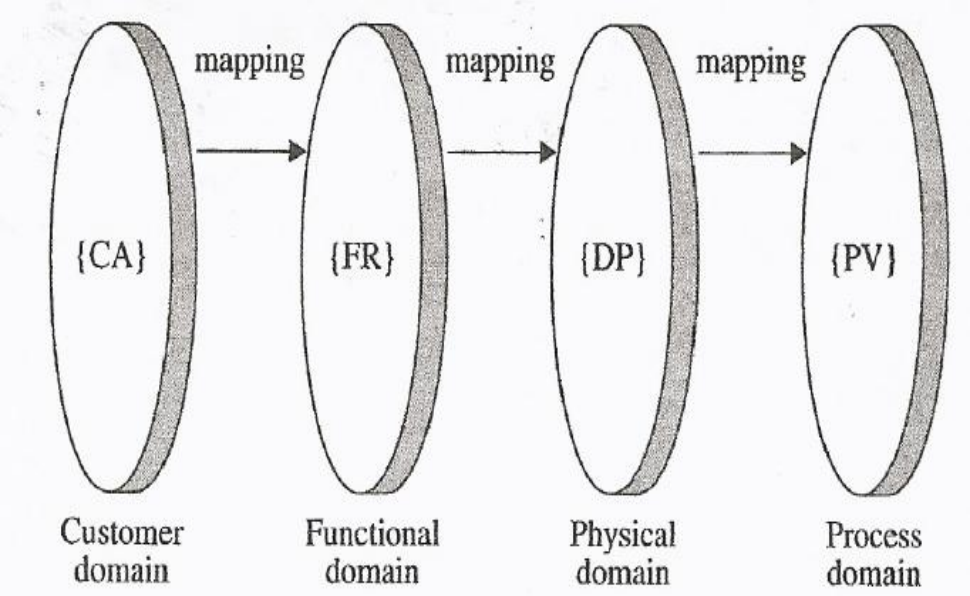


Figure 3- 1: Axiomatic Design Process

The Axiomatic Design process interrelates four domains that include the customer domain, the functional domain, the physical domain, and the process domain. The domain structure is illustrated schematically in Figure 3.1 above. The domain on the left represents "what we want to achieve," and the domain on the right represents the design solution of "how we want to achieve them".

The customer domain is characterized by the consumer attributes (CAs). These are the customer needs that the completed design must fulfill. The customer domain is built from collecting all consumer needs about the design.

The functional domain, as the customer needs are specified, is transformed in terms of functional requirements (FRs). Functional requirements are a minimum set of independent requirements that completely characterize the functional needs of the product. In functional domain, each FR should be independent of every other FR at the time the FR is established.

The physical domain includes design parameters (DPs), which are variables that describe the design in the physical solution space. DPs are the physical characteristic of a particular design that has been specified through the design process.

Last, the process domain contains process variables (PVs).They are the variables of the processes that will result in the physical design described by the set of Design Parameters.

In summary, the Axiomatic Design Process Method proceeds horizontally in the map. Once we identify and define the perceived Customer Attributes, those needs must be translated into Functional Requirements. After the Functional Requirements are chosen, they are mapped into the physical domain to conceive a design with specific DPs that can satisfy the FRs. For a given FR, there can be many possible DPs. The right design parameter must be chosen by making sure that other FRs are not affected by the chosen DP and that the FR can be satisfied within its design range. Last, the process variables are selected based on completing choosing design parameters (Ref 3.4).

3.1.3 Benefits

Design methods guide a designer to one or more solutions for solving the problem at hand. The Axiomatic Design method is used in engineering and business, especially in complex and large systems. It provides a systematic way of designing products and business systems. It facilitates human designers to be more creative. It reduces the random search process. It minimizes the iterative trial-and-error process. It determines the best designs among those proposed. It creates systems architecture that completely captures the construction of the system functions and provides ready documentation. Last, it endows the computer with creative power (Ref 3.5). There are some other helpful things resulting from Axiomatic Design such as correct decisions, shorten lead time, and improving quality of products and systems (Ref 3.6).

In our project, we used the Axiomatic Design method to an optimal solution for Performance Management in Mass DOT District 3 – Highway Division. The method enables us to fully understand the current status of the whole performance management system at District level. Also, the method helped us track, monitor and produce the Health District Report in Performance Management so that the managers can access and identify directly any cause of performance problems. Then, they can change, edit or make the right decision for solving the issues quickly. It reduces a lot of time for managers to investigate problems which relate to performance management. Thus, it is a useful tool for them to manage all business activities at their District better. Last, it helps them achieve the goals of performance management at District level by avoiding risks or serious problems in future.

3.2 Axiomatic Design in MassDOT District 3

3.2.1 Main Target (FR0) of MassDOT District 3

Related to our project, as we contacted with MassDOT District 3 – Highway Division, specialty with Jonathan Gulliver – Highway Director, Barry J Lorion – Operations Engineer, and Eric Nascimento – Assistant Operations Engineer, they all pursuit the main target for their office that is "Achieve outstanding performance management for MassDOT District 3 – Highway Division" by tracking, monitoring and maintaining its performance through Health District Report. This is the major functional requirement (FR0) of their needs as we use the Axiomatic Design method when we analyze and build a performance management system for them.

3.2.2 Five Goals of MassDOT State

The MassDOT District 3 – Highway Division operates under the control of the State. Therefore, its performance management belongs to the State level. Currently, the State has five goals of performance management. They are Safety, Customer Service, Fiscal Responsibility,

Employee Engagement, and Innovation as shown in the Figure 3.2 below. As a result, the MassDOT District 3 – Highway Division also has these five goals under its performance management system.

Figure 3- 2: Five Main Goals of MassDOT State

Safety is the first require and most important goal of Mass DOT at State level. It is required by law that the State needs to prepare a Strategic Highway Safety Plan (SHSP) to reverse the trend of increasing fatal crashes and reduce severe injuries. The purpose of an SHSP is to identify the State's key safety needs and guide investment decisions to achieve significant reductions in highway fatalities and serious injuries on public roads. In our State, the Massachusetts Strategic Highway Safety Plan has been implemented in 2006. The plan has helped the State a steady decline in the number of traffic-related crashes throughout the Commonwealth (Ref 3.7). According to the 2013 -2015 strategic plan of Mass DOT draft, they

pursuit their safety goal as this strategy “Work with unwavering commitment to maximize the safety of the public and employees. Minimize risks and injuries through thoughtful design, construction, oversight, enforcement, and employee empowerment” (Ref 3.8). Thus, safety is the most important goal at both State and District level.

Customer Service is the second goal that MassDOT pursuits as their strategy “Deliver superb service that both anticipates and responds to customer needs. Move people in ways that give them time back by cultivating system wide efficiencies”. MassDOT’s Customer Service goals place heavy emphasis on operational excellence. They recognize the need to engage with customers, and empower their employees to be effective ambassadors for MassDOT. Their employees are trained to be responsive to customers. Managers take hands-on responsibility to coach and develop employee awareness of excellent service. Through Mass DOT University, they offer an increasing number of training courses that hone their employee’s abilities to address customer needs (Ref 3.8).

Fiscal responsibility is the third goal that MassDOT pursuits as their plan “Invest and manage public funds and other resources wisely. Instill a dedication to thrift across organization. Carefully plan and prioritize projects” They aim to be prudent stewards of those funds and of the office oversees rigorous financial management practices and public’s trust. Their budgeting practices businesses, how they prioritize funding, and how they connect their carefully target the most vital needs of their system and ensure work to the broader goals of supporting and creating meaningful efficient use of funds. They work closely with the Auditor’s office and monitor spending constantly, use economic development for the modern project management approaches. Their leadership is focused on reducing costs and instilling a dedication to thrift by rigorously managing their budgets and driving best practices throughout the organization (Ref 3.8).

Employee engagement is the fourth goal that MassDOT pursuits as their direction "Maintain a work environment that is diverse, challenging and accommodating. Support and encourage employees. Treat employees as the internal customers and give them the tools necessary to excel at their jobs" Their workplace brings together employees from divergent backgrounds and their managers work tirelessly to ensure that MassDOT is a place that is inclusive and welcoming to all. In hiring, promotions, training, coaching, and performance appraisal, their employees will learn that diversity is an organizational backbone which strengthens their work processes and services. Therefore, working at MassDOT should be challenging and rewarding. They aim to ensure that employees' roles and responsibilities are clearly defined (Ref 3.8).

Innovation is the last goal that MassDOT pursuits as their slogan "Pursue constant improvement in the work and services. Create an environment where employees are eager to use their talents to find better ways to do business and delivery service." The Office of Performance Management and Innovation coordinates their continuous improvement process and drives their innovation campaign. Collaboration across the many models of transportation creates opportunities for dramatic improvements in their business operations, greater cost efficiency and new solutions to their transportation challenges (Ref 3.8).

3.2.3 Sections of MassDOT District 3

The office structure of MassDOT District 3 - Highway Division has five main sections. They are Project Development, Administration & Operations, Construction, Bridges, and Maintenance as shown in the Figure 3.3 below:

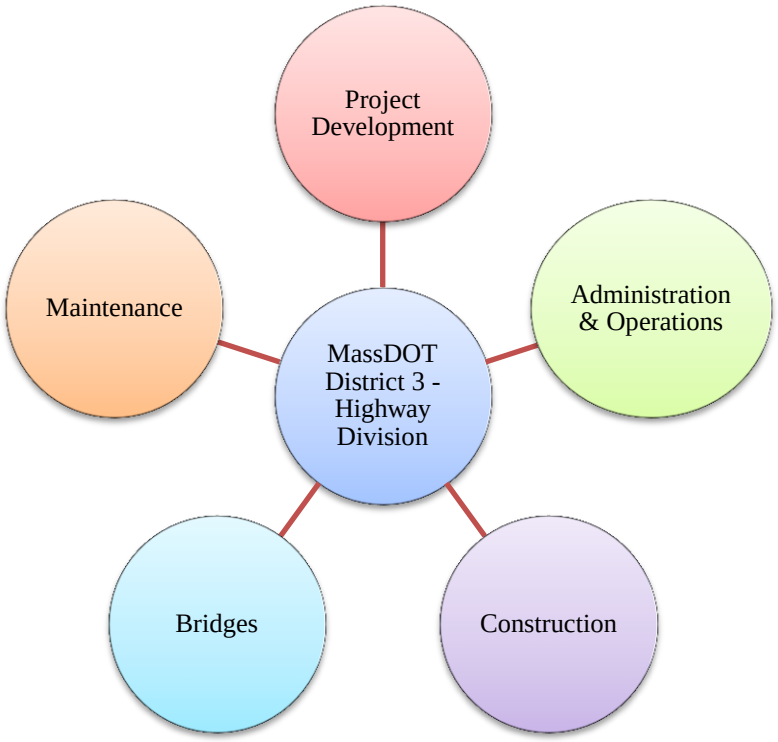


Figure 3- 3: Five Sections of MassDOT District 3 - Highway Division

As we interviewed Arthur Frost, the Section Head in Project Development, they manage the proposals from public and private entities who want the DOT District 3 Highway Division to do some work in their town or on their property. They distinguish between smaller and larger projects because of the relative amount of work for their office, and the need to turn around initial "25 Percent" for any necessary clarification and further work in a timely matter so that the entire project is not delayed unduly.

For the Administration & Operations section, we interviewed Bernie Plante, the Section Head, he runs on a balanced budget. He makes sure of that, applying his personal values to the District 3 administrative duties. As part of the new DOT ordering, his section has taken on more payrolls. This has caused some additional work, but they are managing well, and they are proud of their hard work paying off for D3 budget achievement.

For the Construction section, we interviewed Michael Hartnett, the Section Head, they work with a very varied group of individuals, from all walks of life and experience level. In the interest of keeping everyone working on the worksite, the workers report directly to the worksite, rather than meeting at headquarters daily. This presents some challenges to managing the crew.

For the Bridges section, we asked Mohammed Nabulsi, the Section Head, they are headed by longtime employee, "Mo" Nabulsi, an engineer who is professional and poised. He was cooperative and thoughtful of what measures would help management keep a close eye on key indicators of developing issues. There are seasonal influences in all sections, but this department focuses heavily on handling "structurally deficient" bridges. From timely inspection and important calculations to budget allocation, the concept of marking trends and comparing to last year, is very important in the Bridges section. Knowing if the rate of repair is meeting or exceeding the rate of deterioration of bridges is crucial to their success. This is where budget modification may be necessary.

Last, we interviewed Charles Mistretta who is the Section Head of Maintenance; they all do work well in their job. For instance, "Chuck" takes great pride in his work, especially when he talks about the minimal amount of complaints from drivers that they have not answered concerns quickly. One example of a maintenance issue would be when there is a traffic light out. How efficient they are in meeting this emergency need, while still managing everyday vandalism and theft of signage and other sectional concerns, is a matter of confidence for Chuck.

3.2.4 Performance Measures of MassDOT District 3

The MassDOT District 3 – Highway Division currently tracks over one hundred performance measures. However, there are some most important performance measures which

affect significantly to MassDOT District 3 performance. Below are the tables of their most important performance measures which we organized into their own five sections:

Goals	Performance Measures
Fiscal Responsibility	Complete 100% of design reviews within 30 days for the current year STIP projects
	Complete 100% of design reviews within 60 days for second year STIP projects
Innovation	Completeness review of 25% design submission within 10 days
Employee Engagement	Conduct a staff meeting monthly

Table 3- 1: Performance Measures in Project Development

Goals	Performance Measures
Employee Engagement	Reduce district employee work place injuries from the previous Calendar year
	Ensure 100% of staff is notified of the requirement for 100% compliance with Mass DOT mandatory training initiatives
	Ensure 100% of staff is notified of the requirement for 100% of Highway employees to attend diversity training
	Ensure 100% of personnel are in compliance with the personal protective equipment directive
	Ensure 100% of managers are notified that MassDOT encourages diversity when hiring
Fiscal Responsibility	Spend less than the annual district budget (operating) by the end of the Fiscal year
	Ensure that Payroll stays within budget

Table 3- 2: Performance Measures in Administration & Operations

Goals	Performance Measures
Customer Service	Process 100% of payments to contractors within 30 days after signature by contractor
	Ensure that 100% of construction projects use the EBO system to report M/W/DBE participation
	Complete 70% of contracts "on-time" (prior to original contract completion date)
Fiscal Responsibility	Complete 80% of contracts "on-budget" (final cost is less than original encumbrance)
	Submit minimum of 100% "final records" to district completion level within 120 days

Table 3- 3: Performance Measures in Construction

Goals	Performance Measures
Safety	Complete 100% of Bridge inspections on-time (no later than original assigned completion date)
	Track the number of structural deficient bridges added or removed
Customer Service	Process 100% of payments to contractors within 30 days after signature by contractor
	Submit a minimum of (%) final records within 120 days of contract completion
	Submit a minimum of (%) final records within 121-180 days of contract completion
	Submit a minimum of (%) final records more than 180 days of contract completion
	Complete 70% of contracts "on-time" (prior to original contract completion date)
Fiscal Responsibility	Complete 100% of design reviews within 30 days for projects up to $20 million for the current year STIP projects
	Complete 100% of design reviews within 45 days for projects over $20 million for the current year STIP projects
	Complete 100% of design reviews within 60 days for future year STIP projects
	Complete 100% of design reviews within 120 days for projects not on the STIP
	Complete 80% of contracts "on budget"(final cost less than original encumbrance)

Table 3- 4: Performance Measures in Bridges

Goals	Performance Measures
Customer Service	*Process 100% of payments to contractors within 45 days after signature by contractor
Safety	Monitor District Employee Injuries
	Track Non-compliance with personal protective equipment use
	Track number of recommendations for driver training school due to risky driving
	Snow Overs (Moving Projectile incidents)
Innovation	Labor Hour Reporting (Maximo)

Table 3- 5: Performance Measures in Maintenance

3.2.5 Decomposition of Performance Management System in MassDOT District 3

In order to fully understand the whole system of performance management for MassDOT District 3 – Highway Division, we step by step decompose the system from the main functional requirement (FR0) into five sub-goals of the State level as shown in the Figure 3.4 below. It means when all the five-sub goals under the main FR0 are achieved, they are added up and equal to the main FR0.

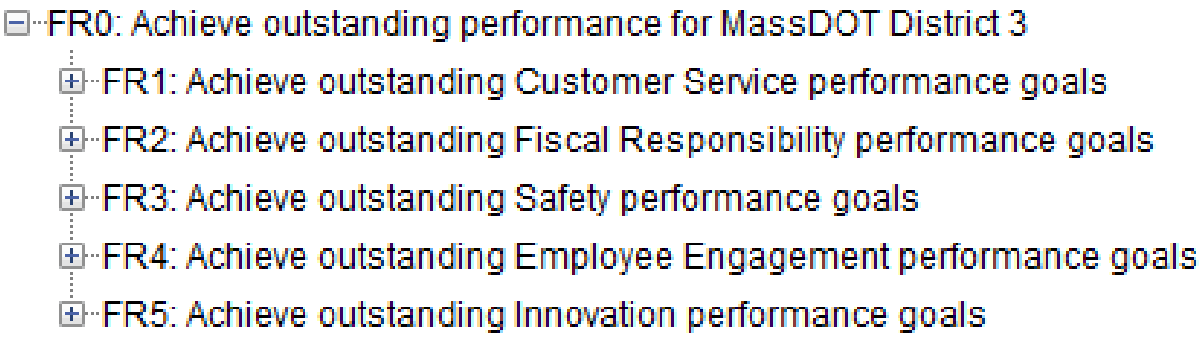
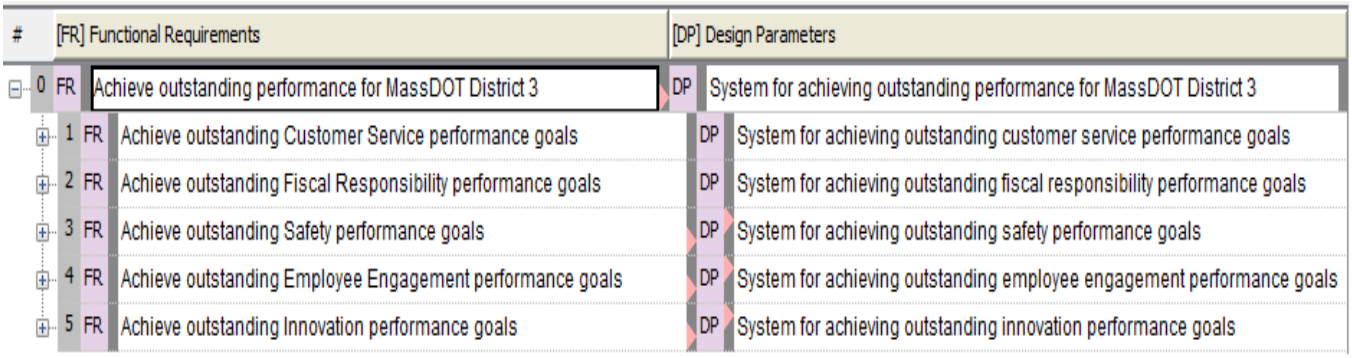


Figure 3- 4: Decomposition Main Functional Requirement (FR0) of MassDOT District 3

The functional requirements show what we want in our system. The next step of AD process is to setup our design parameters that satisfy each functional requirement respectively. It looks like we answer the two questions: “What do we want? And “How do we achieve it?” The first question is already answered by its functional requirement. The second question will be answered by its design parameter. In our project, to answer the second question, we choose our design parameters as the systems to achieve these functional requirements respectively. The figure 3.5 below shows design parameters for each functional requirement for FR0, FR1, FR2, FR3, FR4, and FR5:



#	[FR] Functional Requirements	[DP] Design Parameters
0	FR Achieve outstanding performance for MassDOT District 3	DP System for achieving outstanding performance for MassDOT District 3
1	FR Achieve outstanding Customer Service performance goals	DP System for achieving outstanding customer service performance goals
2	FR Achieve outstanding Fiscal Responsibility performance goals	DP System for achieving outstanding fiscal responsibility performance goals
3	FR Achieve outstanding Safety performance goals	DP System for achieving outstanding safety performance goals
4	FR Achieve outstanding Employee Engagement performance goals	DP System for achieving outstanding employee engagement performance goals
5	FR Achieve outstanding Innovation performance goals	DP System for achieving outstanding innovation performance goals

Figure 3- 5: Design Parameters for Functional Requirements

Similarly, we further decompose the goals for all five sub functional requirements underneath of the main functional requirement (FR0) based on the five sections of MassDOT District 3 – Highway Division as the following Figure 3.6. However, there is not always each sub functional requirement of the main FR0 which are FR1, FR2, FR3, FR4, and FR5 have all goals of five sections of District 3 – Highway Division. The further decomposition structure from FR1 to FR5 varies and depends on the availability of the most important performance measures of each section which they are tracking on.

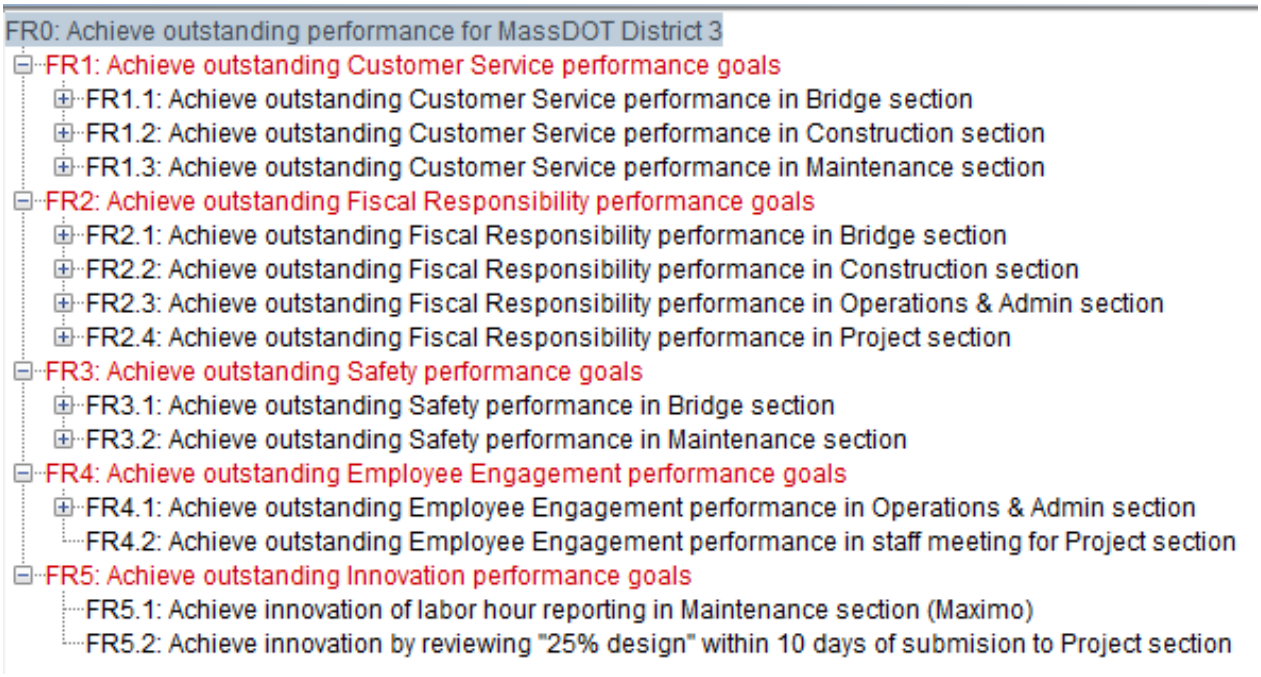


Figure 3- 6: Further Decomposition for FR1, FR2, FR3, FR4, and FR5

Furthermore, we continue to decompose each functional requirement until we reach its sub-functional requirement that can't decompose further. It means we have our functional requirement which contains minimum information and no more decomposition. In our project, the minimum functional requirement is related to its current performance measure. The minimum functional requirement shows the goal of performance measure. One example of the minimum functional requirement for FR1.1.1 is shown in the Table 3.6 below:

Component	Description
FR1.1.1	Achieve minimum final record submission for 120 days of contract completion
DP1.1.1	System for achieving minimum final record submission for 120 days of contract completion
FR Measurement	Minimum final record submission for 120 days of contract completion

Table 3- 6: Minimum Functional Requirement FR1.1.1 and Its component

Last step, we obtain the optimal design for MassDOT District 3 Performance Management System by checking couple designs and reorganizing the matrix. One example is shown in the Figure 3.7 below for checking the coupling between one functional requirement (FR1.1.1) and one design parameter (DP1.1.4). Other checking for coupling design we can see in Appendix C. Our analysis reviews potential coupling between employee engagement and both safety and innovation. There could be an opportunity or an obstacle for us that we recommend to study further.

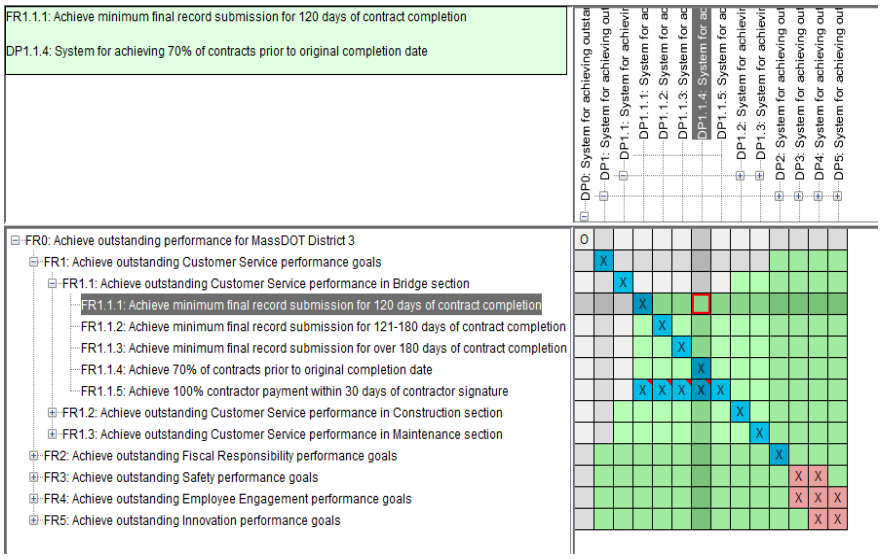


Figure 3- 7: Checking Uncouple Design

Chapter 4: Risk Management

4.1 Risk Management

For effective Risk Management, the definition of the term “risk” must be clearly understood. Risk is the combination of the likelihood of an uncertain event times the impact of said event occurring. This uncertain event can either have a positive or negative effect on the various parts of an organization. Thus risk management is the systematic process of identifying, analyzing, planning, monitoring and responding to diverse risk factors that are intrinsic to the operation of established systems. Therefore, Risk Management is an ongoing process of periodically monitoring identified risks over the life of a project, or self-sustaining system.

The goal of risk management in general is to maximize the efficiency and effectiveness of a system or project. The basic process of risk mitigation involves the identification, analysis, and response to events, which may affect the efficiency or effectiveness of a working system. Using a top-down approach to risk management, it is wise to anticipate known risks, which are system specific from the systems inception. After these risks are identified, understood and documented, a qualitative and quantitative approach to analyzing them should follow. Qualitative Risk Analysis involves the prioritization of risks by assessing, and combining their probability of occurrence and relative impact. Quantitative Risk Analysis takes this one step further, by showing the effect of the identified risks on the overall system. Following these methods of analysis comes an integral part of the process: Risk Response. During this stage of risk management, managers develop solutions, which reduce the number of risks identified, and improve the efficiency and effectiveness of the system. Subsequently, the system should be monitored in order to track risks that were already identified, and to isolate new risks that may have been unaccounted for in the earlier stages of the risk mitigation process (Ref 4.1, p5)

4.1.1 Risk Management Plan

The Risk Management Plan (RMP) describes the different levels at which risk management will be performed in an organization or project, and determines the frequency of risk management meetings. It also lists the members of the Risk Management Team (RMT) according to various positions involved in the organization, and creates a budget for risk management activities. The RMP should be completed early in a system's organization, as it is crucial to the success of the processes which are inherent to the system. Preparing a thorough RMP ensures that the appropriate resources are allocated to the proper risk management activities, and a basis for risk evaluation is established (Ref 4.1, p11).

The RMP should incorporate (Ref 4.1, p12):

- Frequency schedule for risk management meetings.
- Sufficient time to allow the RMT to prepare and review identified risks.
- Milestones for communication and accountability checkpoints.

Organization/roles and responsibilities:

The RMT is a core group within an organization, qualified in Risk Management, which performs, updates and reviews risk events under the direction of the Risk Manager, who has been trained in the process of risk mitigation. Management and resources involved in the development of an overarching system plan as well as an RMP, should consider the physical and personnel resources needed and ensure that it is built into the organizational budget and schedule (Ref 4.2, p1.1). Conducting risk management meetings as a team has value, as team members openly discuss risks, and may provide insight from different viewpoints. Thus, creating an arena where the ideas of an individual can have a large impact on the overall process is highly beneficial. This increases the likelihood that risk events will be properly assessed and prevented (Ref 4.1, p8).

Risk Register:

A risk register or "risk log" is mostly used for prescriptive planning in relation to project, operational or financial aspects of an organization. Management uses risk registers to easily identify, analyze and mitigate uncertain events. This register also communicates risks events in terms of cost and schedule impacts and enables the RMT to better understand their status through out the progression of the organization's life cycle (Ref 4.1, 13). A useful risk register should be a table with certain dimensions including a summary of planned responses in the event of a materialized risk, as well as a summary of actions to be taken to reduce future risk. In a project setting, a risk register needs to be prepared with the first cost and schedule estimate, and then repeatedly be reviewed during each subsequent phase of the project (Ref 4.1, p14).

System scale identification:

Before beginning the risk management process, the size of the system being assessed should be identified and classified according to the estimated costs of system implementation. The reason for this preparatory step is because different risk analysis assessment techniques may be called for depending on the size and complexity of a system.

Within District 3, scalability levels and requirement costs are subject to change as based on their system implementation cost ranges

Scalability Level	Estimated Cost	Risk Management Requirements
	<$1Million	Risk register encouraged
1	<$5Million	Risk register
2	$5Million<x>$100Million	Risk register with qualitative analysis
3	>$100Million	Risk register with quantitative analysis

Table 4- 1: System Scale vs. Analysis Method

These requirements per system scale are merely rudimentary. The RMT may choose alternative system requirements based on type, location, duration, stakeholders and political sensitivity. Any one of these factors will warrant a change in the system scale (Ref 4.1, p6).

4.1.2 Risk Identification

Risk Identification determines what uncertainties might affect a system, and how they occur (Ref 4.1, p13). The outcome of the risk identification phase should be the risk register, which documents each risk, its probability and its impact (Ref 4.1, p14). Subsequently, the register should either be analyzed quantitatively or qualitatively, based on the systems scale, followed by the risk response and monitoring process. This is an iterative process, as new uncertainties may become more apparent over the life of the system. This gives a rise to new risk factors, while previously identified risks, which have already been dealt with, may be disposed of (Ref 4.1, p13).

A common challenge in risk identification is avoiding confusion between the causes and effects of risks. The causes of risk are definite events or circumstances, which exist in the system environment, that create uncertainty. Although they may create uncertainty, causes themselves are certain, and hence are not a main focus of the risk management process (Ref 4.1, p14). Effects of risk are positive or negative unplanned deviations from system objectives, which could arise as a result of an uncertain event. The concept of uncertainty has two sides, and it may contain both positive and negative impacts. The positive aspects of risk may be beneficial, while negative aspects harm the system. The harmful and beneficial aspects of risks are described as "threats" and "opportunities" respectively.

One way to clearly distinguish between the causes and effects of risks is their use in a descriptive three-part structured "risk statement". "As a result of <definite cause>, <uncertain event>, may occur, which would lead to <effect on objectives>."

Amongst other methods, the RMT members identify potential shocks to a system using any combination of brainstorming, assumption questioning, consultation series, and knowledge of past systems (Ref 4.1, p15). After risk identification, this information is input into the risk register, and each risk is assigned to a member of the RMT, who becomes its "risk owner". The risk register is then reviewed and updated throughout the meaningful phases of the system lifespan (Ref 4.1, p16).

Column	Contents
Status	Select "Active" or "Retired" (A risk is retired when it has no further possibility of impacting the project).
ID#	Enter a unique identifying number for the risk.
Risk Type	Identify and name as either a "threat" or an "opportunity".
Category	Categorize the risk in a singular category
Threat/Opportunity Event	Provides a descriptive title for the risk
Description	Write a complete description of the event and its potential impacts on the project if the risk were to occur.
Current Status/Assumptions	If applicable, describe what is currently known about the risk and list any assumptions made.
Risk Owner	Enter the name of the RMT member responsible for the risk
Updated	Enter the date the risk was created.

Table 4- 2: Risk Register Basics

4.1.3 Methods of Analysis

Qualitative:

Qualitative Risk Assessment prioritizes the identified risks for further action such as risk response. The RMT can improve the system performance by focusing on high impact risks first. This assessment should be revisited during the system's life to monitor the possible emergence

of a pattern among risk factors. This may demonstrate a need for more or less risk mitigation or may be a proof that the management plan is working.

The first tier of system scale assessment requires a qualitative risk rating be assigned to each event in the register. This risk rating determines the priority of each event, and denotes where resources should be allocated in the response to each event. A "high risk" rating denotes a first priority for risk response. A "medium" risk rating allows a response if resources permit. A "low" risk rating doesn't require an immediate response. Subsequently, a rationale for each rating should be provided (Ref 4.1, 19).

For the second tier in qualitative system scale assessment, the priority of identified risks are found using their probability of occurrence and their corresponding impact on project objectives in the event of the risk. The RMT then assesses the rating for the probability of the risk occurring as well as the cost and time impact of each risk, should it occur. Each risk is then assigned a word descriptor, from "very low" to "very high", and each word descriptor is associated with a number.

Each risk receives three scores; a risk score, a cost core and a time score. The product of the probability number and risk impact number defines the risk score, while the cost score equals the product between the probability number and the cost impact number. Finally, the time score is equal to the product of the probability number and the time impact number (Ref 4.1, p20-21).

Impact Definitions					
Rating -->	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
Cost Impact of Threat (CO + COS)	Insignificant cost increase	<5% cost increase	5-10% cost increase	10-20% cost increase	>20% cost increase
Cost Impact of Opportunity (CO + COS)	Insignificant cost reduction	<1% cost decrease	1-3% cost decrease	3-5% cost decrease	>5% cost decrease
Schedule Impact of Threat	Insignificant slippage	<1 month slippage	1-3 months slippage	3-6 months slippage	>6 months slippage
Schedule Impact of Opportunity	Insignificant improvement	<1 month improvement	1-2 months improvement	2-3 months improvement	>3 months improvement
Probability	1–9%	10–19%	20–39%	40–59%	60–99%

Table 4- 3: Probability Matrix

Risk Matrix						
Probability Rating	**5 – Very High**					
	4 – High					
	3 – Moderate					
	2 – Low					
	1 – Very Low					
		1	**2**	**4**	**8**	**16**
		Very Low	**Low**	**Moderate**	**High**	**Very High**
		Impact Rating				
				Impact Scores		
			Low Risk	x<8		
			Moderate Risk	8<x<12		
			High Risk	x>12		

Table 4- 4: Impact Matrix

Quantitative:

For projects in the third tier, quantitative risk analysis should be employed. This is a method of numerically estimating the probability that a system will meet its cost and time objectives. It is based on a simultaneous evaluation of the impact of identified and quantified system risks, using the Monte Carlo simulation by specific project simulation software. The result is a probability distribution of the project cost and completion date based on identified project risks. Quantitative project risk analysis begins with the model of the project and its schedule or cost estimate, depending on the objective. The degree of risk in each scheduled activity and cost element is represented by a probability distribution. This distribution is usually determined by finding the "3-point Estimate" of the optimistic, most likely and pessimistic values of the activity or cost-element. Project simulation software iterates the schedule or cost

estimate model for the project hundreds or thousands of times. From these iterations, the software randomly draws duration or cost values per iteration from the probability distribution derived from the 3-point estimates of each element. Based on this distribution, one may see how likely the current plan will be with regard to schedule or budget. It will be clear how much contingency is needed to provide a cushion in terms of base cost and schedule allowance.

The risk manager leads the RMT team in quantifying cost and schedule risks. The probability of risks occurring is expressed by the "low" and "high" values derived by using the 3-point estimates for cost and schedule impacts. Probable Cost is calculated by multiplying the average value of the probability range by the average value of the cost impact range. Probable Time is calculated by multiplying the average value of the probability range by the average value of the time impact range. Risks are then prioritized for risk response in descending order of their "Probable Cost" and/or "Probable Time" (Ref 4.1, p23). This method of risk analysis is especially useful for very larger projects where cost and schedule are heavily impacted, therefore it is not necessary for the scope of this project.

4.1.4 Risk Response

Risk response is the process of developing strategic options and actions aimed at enhancing system opportunities and reducing related risks threats, while assigning each risk to a member of the RMT. Generally speaking, threats can be avoided, transferred or mitigated. On the other hand, opportunities may be exploited, shared, or enhanced. Each method for handling threats and opportunities is explained in more detail below.

When handling threats to a system, avoidance should be the first response strategy. By avoiding a risk, it may be removed by simply eliminating it, or working around it to achieve

system objectives. Not all risk can be avoided, and this step is usually expensive and time consuming.

Transference of risk involves finding a party willing to bear the liability of the risk, should it occur. When using this response mechanism, the organization must make sure risk is delegated to a party best suited to deal with it. A premium payment is usually involved, therefore the cost-effectiveness of this mechanism should be considered.

Risk mitigation reduces the probability or impact of a risk to an acceptable level, which is naturally more effective than damage control, should the risk event occur. This response method may require resources and time, but is usually the most cost effective solution.

On the other hand, when an opportunity arises, exploiting can be considered as a response to risk event. This event must be a once in a lifetime opportunity, for this is a very aggressive response strategy. This allocates the priorities of the RMT to ensure that this opportunity with a very high likelihood of occurrence definitely happens.

In sharing an opportunity, risk ownership of this positive uncertain event is allocated to a party who is best able to maximize its potential and increase its chances of realization. Therefore, it is only natural for this party to share in the potential benefits of this opportunity as well.

Risk opportunities may also be enhanced, in order to "modify" the size of positive risk by increasing its probability and impact of occurrence. By doing so, the system maximizes the benefits from this particular event.

Occasionally, risk managers may choose to "accept the potential threat or opportunity". This strategy is adopted when it isn't possible or practical to respond to the risk using other strategies, or a response is not warranted by the risk rating scale. Acceptance is an agreement to

deal with the risk if and when it occurs, using a contingency plan, which should be developed for such a scenario (Ref 4.1, p27).

4.1.5 Monitoring

Continuous monitoring by the risk manager and RMT ensures that new and changing risks are detected, managed and that the risk response actions are implemented and effective. Risk monitoring tracks identified risks, residual risks and new risks that may have arisen since the system's inception.

By implementing this phase:

- Planned risk responses are monitored and evaluated for effectiveness.
- Risk ratings and prioritizations may change during the life of the project.
- Risk meetings should be recurring to update the status of the risk register.
- Periodic risk reviews repeat the risk mitigation process.
- Upon risk retirement, the RMT will review the risk history.
- Record lessons learned regarding the processes used (Ref 4.1, p30)

4.2 Risk Management in MassDOT District 3

In order to assess risk, we needed to determine the relative importance of the many metrics that we were to analyze for a dashboard report. To do this, we conducted direct interviews to gather the subjective, experience–based "weights" for each particular measure in each specific goal category, one at a time. This was repeated in each section to canvas the entire top level of District 3 management. In Table 2-1 below, the steps of our process are delineated. The actual script can be found in Appendix A.

FIRST – *Preface*	We thought to give a preface to begin each appointment. This would introduce the project and give them an overview of the purpose of the consultations.
SECOND – *Equip*	Gave them a sheet with the measures that are identified for each of the 5 goals (safety, employee engagement, etc) as pulled directly from the one page excel worksheet, the "short list", that Mr. Nascimento sent over after our last meeting.
THIRD - *Ensure Complete List*	We asked them if there were other measures that they were already measuring that would need to be included on this list.
FOURTH - *Rank Within Category*	We would ask them to rate one category at a time from 1, (most important and top level priority reporting) to last (4 or 5, whatever number there is in each). If some measures shared equal importance, they would repeat the rank for those.
FIFTH - *Correlation Discovery*	Next, we asked the questions that had been agreed upon ahead of time with feedback from Mr. Lorion et al. These would add detail and depth, to gain insight into relevance and importance (weighting) to allow best dimensioning and development of Dashboard DHR. We systematically worked through the category in question, asking if the measure ranking number one correlated to another category, and so on. Discussion was encouraged.

SIXTH – *Weighting Measures*	We asked them according to their expert experience in this section, what weight would they assign to the most important as part of all measures listed adding to a 100% of impact if an out of standard event occurred.
SEVENTH – *Iterations*	We repeated these steps to work through each category fully and then through all 5 categories fully. Each appointment lasted about 45 minutes to one hour. We were very thankful for Mr. Lorion and Mr. Nascimento's assistance and presence in these meetings to add direction and understanding for our team.

Table 4- 5: Consultation Format Steps

The results of the interviews and the weight assignments were recorded in Microsoft Excel spreadsheets format and one example is inserted below. Other examples can be seen in Appendix D.

Bridges section	**Performance Measures**	**Rank**	**Weight**
Safety			
	Complete 100% of Bridge inspections on-time (no later than original assigned completion date)	1	0.5
	*Track the number of structural deficient bridges added or removed	2	0.5
Customer Service			
	Process 100% of payments to contractors within 30 days after signature by contractor	1	0.5
	Submit a minimum of (%) final records within 120 days of contract completion	2	0.125
	Submit a minimum of (%) final records within 121-180 days of contract completion	2	0.125
		2	0.125
	Submit a minimum of (%) final records more than 180 days of contract completion	2	0.125
	Complete 70% of contracts "on-time" (prior to original contract completion date)		
Fiscal Responsibility			
	Complete 100% of design reviews within 30 days for projects up to $20 million for the current year STIP projects	2	0.125
	Complete 100% of design reviews within 45 days for projects over $20 million for the current year STIP projects	2	0.125
	Complete 100% of design reviews within 60 days for future year STIP projects	2	0.125
	Complete 100% of design reviews within 120 days for projects not on the STIP	2	0.125
	Complete 80% of contracts "on budget"(final cost less than original encomberance)	1	0.5

Table 4- 6: Weight Assessment for Bridge Section

4.3 Case Studies

We conducted an interview with the projects department in order to determine if there were any specific instances where their performance measures were not met for whatever reason. They talked about two specific instances in recent history.

4.3.1 Case Study 1: Millbury Route 146 Bridge - Project ID#: 605964

The superstructure and substructure of the bridge carrying Route 146 over West Main Street, Interchange 8, on Route 146 is being widened by the MassDOT to accommodate four travel lanes and therefore the interchange will have to be reconfigured. The anticipated cost of the entire project was $13 million, and the MassDOT planned to advertise the project for construction in November 2013 (Ref 4.3, 2013).

The project was not ready for advertisement in 2013. The project plans were not ready in time to meet the Federal Aid deadline, and the proposed cost exceeded the Non Federal Aid spending requirement. This was due in large part to insufficient Right Of Way (ROW) planning requirements concerning environmental permitting, flood storage and utilities relocation.

The original construction budget for the project was $12,008,531. However, due to missing the advertising deadline, some federal aid was lost. The congestion mitigation and air quality program funded by both federal and non-federal aid set aside a budget of $2,015,000 for the project. The non-federal funded Accelerated Bridge Program initially set aside $6,500,000 for the project, but had to increase their budget to $11,330,354 in order to replace lost federal funding (Ref 4.4, 2011). That is an additional cost burden on the state and local budgets of almost $5,000,000.

4.3.2 Case Study 2: Leominster Route 13 - Project ID#: 605651

This project consists of reconstructing Route 13 from Haws Street to approximately 450 feet north of Prospect Street in Leominster. The proposed project includes improving six intersections with lane use modifications, pedestrian access improvements and traffic signal upgrades (Ref 4.5, 2012).

Issues surrounding the ROW planning delayed public hearing due to a demand for multiple design reviews. At the community planning organization hearing, concern was expressed about certain aspects of the design. Due to this, the schedule was not maintained, and the project needed to be re-evaluated and re-advertised.

In 2011, the project was estimated at $6,330,987, with a two-year implementation schedule. In 2012, its estimate was $4,056,000, reducing it to a one-year implementation plan. As of April 16th 2014, the master planning organization for the community Montachusett finally approved the most recent design review. This includes STP, HSIP and CMAQ funding, at $1,013,884, $613,189, and $2,118,288 respectively, for a combined total project cost of $3,745,361 (Ref 4.6, 2013).

In both of these case studies, individuals not under the direct control of District 3 handle aspects of the projects. Therefore, the performance of District 3 is impacted by many external factors, such as ROW, and community planning organizations. We recommend the implementation and use of the performance dashboard, along with other risk management techniques, for better meeting performance goals for ROW or other large projects.

Chapter 5: Performance Dashboard

5.1 Balanced Scorecard

We consider some methods for producing a performance report such as Balanced Scorecard, Microsoft Excel spreadsheets and Primavera. Primavera is in limited use in District 3, and we decided to move ahead using the Microsoft Excel products for several reasons, however, the Balance Scorecard was useful as a guide during the early stages of concept development.

The Balanced Scorecard is a valuable tool that gives managers a simplified overview of the business from four basic perspectives: customer perspective, internal business perspective, innovation and learning perspective, and financial perspective. The customer perspective gives the answer to the question of how customers view the current business service. This measure takes the company's mission statement, as provided to the customers, and brings real analytical measures to these goals. This provides a better relationship with the customers because it forces management to deliver what customers value (Ref 5.1).

The internal business perspective provides what measures give the company excellent customer service or what the company must excel at in order to differentiate themselves in the eyes of the customer. These customer-based measures stem from the areas that have the most direct connection with customer satisfaction i.e. quality, time, and employee skill. The ability to deliver excellent service comes from the ability to identify what aspects satisfy customers and which do not. Optimizing a company's ability to deliver to its target market allows for overall positive growth as the system is perfected (Ref 5.1).

The innovation and learning perspective indicates whether a business can continue to improve and create value using the current business model or business plan. This measure takes into account all historic methods, both effective and ineffective, that were utilized to compete in

industry. Improvement through innovation is how companies grow, penetrate new markets, and increase revenue (Ref 5.1).

The financial perspective is the final measure to the balanced scorecard that analyzes how a company's overall performance looks to shareholders in terms of a shareholder value analysis. The delegation of a proper financial control system enhances the company's operating abilities. This analysis forecasts future cash flows and discounts them back to a rough estimate of current value in an attempt to a make a forward-looking financial analysis (Ref 5.1).

5.2 Performance Dashboard Using Excel Spreadsheets

During our first two interviews with the district's five department heads, we identified the most important factors in regards to employee engagement, innovation, fiscal responsibility, customer responsibility and safety that caused them some degree of uncertainty. These performance management metrics were entered into an Microsoft Excel spreadsheet, where weights, or relative importance, were subjectively assigned to each systematically. Following this, we proceeded to create a system by which we could perform a qualitative analysis on each risk event. We did this by creating a probability/impact matrix, based on cost and schedules. The risk events were turned into risk statements, which were entered into a risk register. Table 5-1 is an example from the Bridges section of District 3.

LEVEL 2 - RISK REGISTER				System Name:	Bridges		DIS-3	08-1234	Project Manager	PM Person	
Risk Identification							Risk Assessment				
Status	ID #	Type	Category	Title	Risk Statement	Current status/assumptions	Probability	Cost Impact	Cost Score	Time Impact	Time Score	Rationale
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not complete within 30 days for projects up to $20 million for the current year STIP, <>, which would lead to a schedule overrun.		3-Moderate	16 - Very High	48	1 -Very Low	1	
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not complete within 45 days for projects over $20 million for the current year STIP projects, <>, which could lead to a schedule overrun.		1-Very Low	2 -Low	2	2 -Very Low	2	
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not completed within 60 days for future year STIP projects<>, would occur which would lead to<>		3-Moderate	8 -High	24	16 - Very High	48	
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not completed within 120 days for projects not on the STIP<>, may occur which would lead to <>		1-Very Low	4 -Moderate	4	4 -Very Low	4	
Active		Threat	Construction	Contract Fiscal Responsibility	If 80% of contracts are not completed "on budget"(final cost less than original encomberance), we may run out of funding, which would lead to not respecting the design construction budget.		1-Very Low	5 -Very Low	5	5 -Very Low	5	

Table 5- 1: Risk Register

A time score and a cost score were developed through the use of the probability/impact matrix, as these would determine the response to a certain risk statement, and in turn be monitored by the assigned risk owner. More examples can be found in Appendix E.

Chapter 6: Change Management

6.1 Introduction

MassDOT is an organization undergoing many changes that translate to an initial increase of workload affecting all levels. From increased data gathering and entry demands of Performance Management to learning new technologies for asset management, Massachusetts is making many innovations. These changes are especially demanding on employees during the preparation and implementation stages. That is why we are recommending that MassDOT utilize change management techniques to increase employee engagement. This chapter delves into Change Management, its development, from early workplace stress management to today's specific management best practices. Figure 6.1 below gives an excellent overview of the process of change and the steps for achieving organizational cooperation rather than only perfunctory compliance (Ref 6.22).

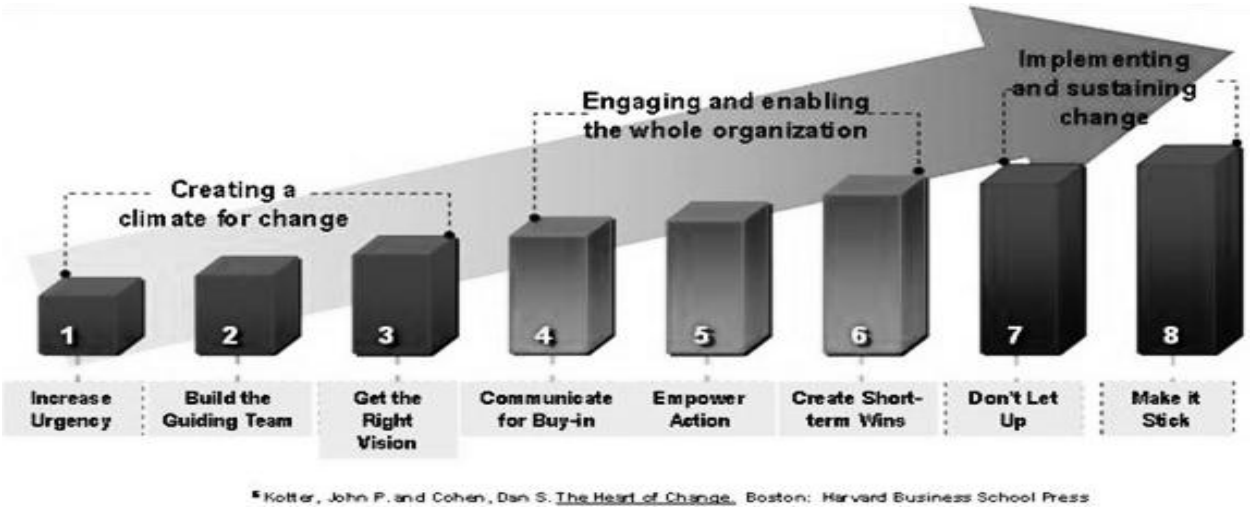


Figure 6- 1: Kotter's Eight Steps of Change

Today there is a branch of management specifically called Change Management that commonly refers to a "set of basic tools or structures intended to keep any change effort under

control" (Ref 6.1). The intent is to mitigate the "distractions and impacts of the change" (Ref 6.1). Since change is only one aspect of stress (Ref 6.2), the larger concern is managing stress. The fields of psychology and business management have studied stress extensively and have shown there is a correlation between the environment created by those in authority and the resulting stress levels experienced by employees within the organization. This is how *best practices* were developed.

When management implements change well, positive associations can occur which benefit the individual, group and the corporation as a whole. However, workers can have a very difficult time when change is not managed well. It is important to consider the impact of efficiency measures on the people involved. Much of the impact can be tracked as the health effect under the category of stress-related illnesses. The scientific community has a clear understanding of the effect that negative stress can have on a person. Decades of research have found direct correlations between management practices and the resulting employee experience. The results can be either positive or negative depending heavily on the level of engagement. Engagement is a feeling of importance, relevance and mutual concern. High levels of engagement result in reduction of stress and the illnesses associated with stress (Ref 6.2).

Research of workplace dynamics draws strong correlations between high demand jobs that do not offer high levels of control for their employees, and the increased incidence of work-related stress. In 1981, a study defined seven factors of stress, of which time constraints, productivity emphasis, and heavy workload are only three (Ref 6.3). All three of these aspects can be dramatically affected when a routine is interrupted during a process change.

6.2 Stress in the Workplace

The modern work environment has been long suspected as a cause of stressors that are related to adverse health effects. Through decades of research, experts have developed best practices for employers to follow to minimize workplace stress and thereby reduce stress-related illnesses. These techniques become even more necessary during times of change, as change at any level produces stress. This study considers first the effects of stress, and then the two key contributing factors of environment and change, with the purpose of considering what can or cannot be done to reduce stress in the workplace.

6.2.1 Types of Stress

Webster's dictionary defines stress as "a physical, chemical, or emotional factor that causes bodily or mental tension and may be a factor in disease causation" (Ref 6.4). There are two types of stress: distress and eustress. Distress is defined as "pain or suffering affecting the body, a bodily part, or the mind; a state of danger or desperate need" (Ref 6.5). The term "eustress," also referred to as a "good stress" that comes with a challenge and during a time of growth, is used to describe stress that is deemed healthful, giving one a sense of fulfillment (Ref 6.6).

6.2.2 Fulfillment vs. Stress

In 1943, psychologist Abraham Maslow put forth his five-part model known as the Hierarchy of Needs (Ref 6.7). Maslow stated that people are motivated to meet certain needs. When one need is fulfilled, a person seeks to fulfill the next one, and so on. This is a good evaluative starting point because of how integral a workplace environment is to the provision of these needs, from the lowest level of providing food and shelter all the way potentially to self-esteem and status.

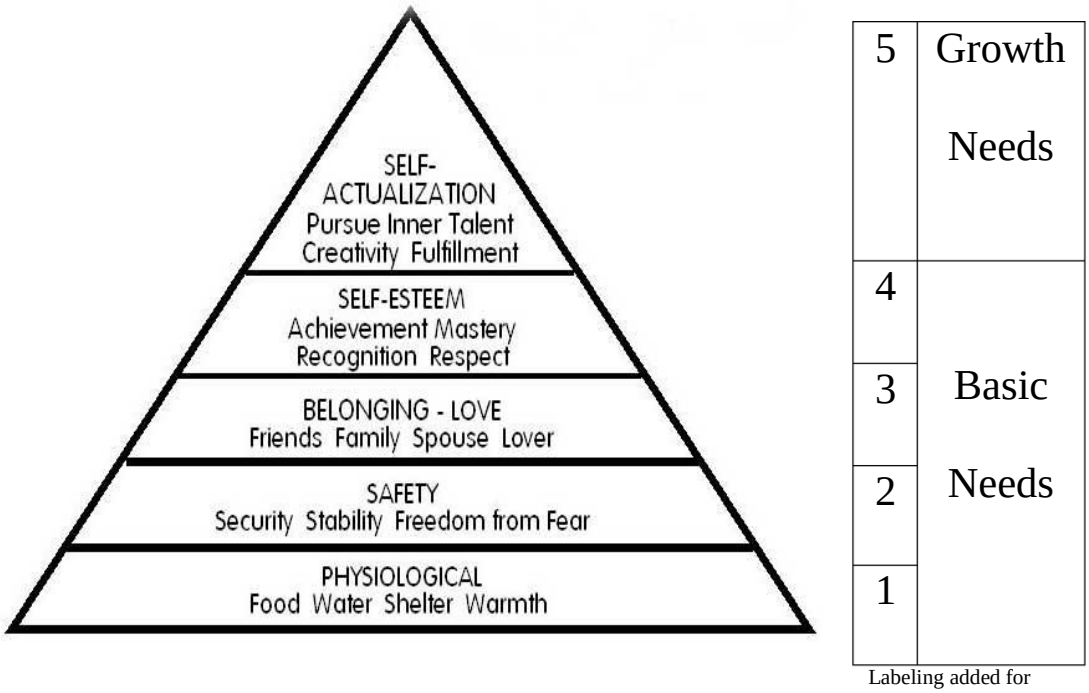


Figure 6- 2: Maslow's Hierarchy of Needs reprinted

(Ref 6.23)

Below is a list wherein each level is defined.

*1. Biological and **Physiological** needs - air, food, drink, shelter, warmth, sex, sleep.*

*2. **Safety** needs - protection from elements, security, order, law, limits, and stability.*

*3. **Belongingness** and **Love** needs - work group, family, affection, relationships.*

*4. **Esteem** needs - self-esteem, achievement, mastery, independence, status, dominance, prestige, and managerial responsibility.*

*5. **Self-Actualization** needs - realizing personal potential, self-fulfillment, seeking personal growth and peak experiences.* (Ref 6.7)

This version of Maslow's needs uses words and phrases like "work group" with "relationships" under level 3, which is labeled as Social Needs in some versions. Maslow calls all need levels except the highest level, Self-Actualization, "basic needs".

The top most level contains what are called growth needs. These needs are only important to us when the lower levels are satisfied. When looking at Figure 6.1 above, it is clear that all needs have the possibility of being fulfilled in the workplace. According to Maslow's theory, only when the lower levels are satisfied will a desire to achieve progressively higher levels be demonstrated. In the workplace, just having a job is most important, and then feeling secure in that job is more important than forming alliances. This can explain why office politics becomes so cutthroat during layoffs. If an employee is unclear about expectations, this represents job insecurity to them. If they lose their job, their physiological needs are threatened.

6.2.3 Measuring Stress

Responses to stress are shown to vary based on several factors. Different researchers may call a factor by various names, however they are very consistent in their framing of human needs and how those needs relate to workplace experience.

Stress, in the workplace as in the laboratory, has been found to be a product of two factors: the elasticity of the material and the percentage of change. For the purposes of this discussion, the material is the workplace *environment*. This environment can be defined further as a construct of job *demands* and job *control*. Demands from a job can be constant or changeable. Likewise, personal control over time management, for instance, may be relatively consistent as part of the company culture or it may be more or less flexible depending on the project. This creates a continuum of possible stress level outcomes felt by the employees.

Job Strain Model

In 1979, Robert Karasek published his model, Figure 2, showing how differing levels of job demands and employee control resulted in stress, either positive or negative. It is called the Job Strain Model (JSM), also called the Demand-Control Model.[1] Other models discussed later have expanded this model by dividing each of the original two factors into subcategories that focus on the personal interactions and their effect on workplace stress. They are therefore better able to measure the entire workplace environment, so they are explained under the "Measuring the Workplace Environment" section to follow.

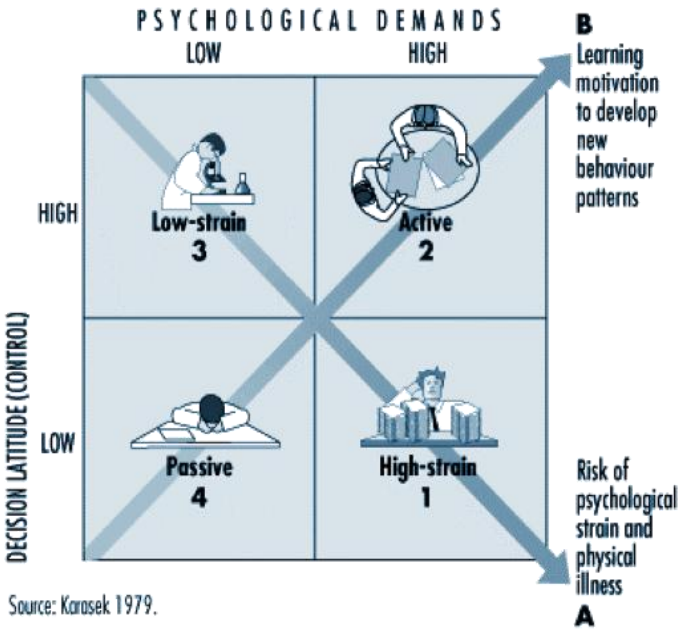


Figure 6- 3: Job Strain Model developed by Robert Karasek

In the above figure, Point A is where both the demand is highest and personal control is lowest. In this model, demand and control (aka decision-making latitude) are set on different axes, therefore an increase in either factor results in a change in stress.

6.2.4 Effects of Stress

Stress-Related Illnesses

[1] Johnson and Hall (1988) added social support to the two main aspects, demand and control.

In Figure 2, section 4 relates to a work situation where even though there is low demand, there is very little control given to the employee. Even though this might represent low stress to many, there are negative health effects even at this “Passive” level. This was confirmed by a Harvard School of Public Health study in 1990 that concluded that a person unable to control the demands of their environment could become depressed. It also stated that depression has been recognized as the second worst cause of “life reduction and loss of productivity”, following ischemic heart disease (Ref 6.8). Heart disease is the indicator used in many studies on stress-related illnesses. While estimates vary greatly between studies, in 1990, Karasek, joined by Theorell, estimated that up to 23 percent of heart disease might be prevented if the level of "job strain" in jobs with the highest strain levels was reduced (Ref 6.9).

Stress has been found to be not only a direct cause of illness, but also an indirect cause when other related unhealthy habits and risk increase. In one study, these secondary risks are referred to as “lifestyle risks”, which are the unhealthy changes in lifestyle that occur as a result of stress in the workplace. For example, smokers may smoke more because they are under increased stress. Another lifestyle risk is associated with employees eating unhealthily at work due to pressures to grab something quickly. This in turn can increase obesity and its associated costs, such as absenteeism and lowered productivity (Ref 6.10).

In the Whithall II Study, Paul Tearle showed that an increased incidence of coronary heart disease “could not be explained by conventional risk factors, such as smoking, being overweight and having high blood pressure” (Ref 6.11). The research showed that the stress factors of high levels of job demand, low levels of job control, and imbalances in effort to reward, were related *directly* to an increased incidence of coronary heart disease. The conclusion

is that stress alone has a negative impact on health. This further supports the correlation between the two factors of demand and control proposed by Karasek's JSM.

Reduced Productivity

Since stress can have serious health consequences, monitoring levels of demand and increasing workplace flexibility (control) are imperative to keeping the modern worker healthy. This is a concern that goes beyond the individual employee and their family. In 1999 the US Department of Health and Human Services' Surgeon General stated the ability of an employer to prevent mental illness and promote wellbeing was compatible with the mission of the public's health. The HSE reported 10.4 million days of work lost to stress within one year within the UK (Ref 6.2). Improvements to workplace environment have been shown to have a profound impact on increasing employee productivity in large part by reducing the number of sick days (Ref 6.12). The result is a cost benefit to the corporation and ultimately society.

Increased Autonomy

There is also a positive outcome that can be brought about by stress. Point "B" in Figure 2 would illustrate eustress as a challenging growth environment at work. Sometimes when pressures increase in a workplace, new collaborations form and different methods of time management are employed. Professionals generally enjoy more autonomy in the workplace, perhaps because of attributes such as self-discipline (Ref 6.13). According to the Health and Safety Executive (HSE) website, a UK national risk control organization, the employees more likely to feel stressed are managers, professionals, women and middle aged workers (ages 35-54) and those employed within large corporations (>250 employees) (Ref 6.2). Therefore, professionals would generally fall into the "active" category in Figure 2, enjoying more control

over how they meet a high level of demand. This higher level of autonomy is a practical response to workplace stress.

There are different ways to effectively implement changes in a work community. Not all employees are capable of being responsible with high levels of autonomy. However, there are many techniques comprising best practices that can be highly effective for stress management. Any means that can minimize the negative stress effects will have a beneficial effect on the organization overall. Unfortunately, there are workplaces where stress management tools are not being utilized to their full capacity. As these techniques rely heavily on management styles and methods (Ref 6.14), any organization would be wise to regularly measure its stress management effectiveness.

Whether an organization prefers to employ management self-assessment or employee feedback methods, or a combination, more care and attention will be required during times of change. Surveying and comparing the stress level of the employees before, during and after a change is implemented can give a good indication of the workplace environment resiliency.

There are many website, tools and books in print to support any type of organization through change. The specific methods we suggest for their consideration can be found on the Health and Safety Executive website. This is the United Kingdom's version of the Department of Labor. Their stress management materials include surveys that question employees about their experiences with their direct managers using the Human Safety Executive Indicator tool. There are also self-assessment tools for management to utilize and supportive follow-up material as well. The HSE benchmark is the result of a lengthy study of 136 companies of all types and sizes that used the same survey tool that can be found on the website today (Ref 6.2). The correlations between differences in management and the related stress levels of employees were used to

formulate the benchmark that is now available for use by any organization. In this way, an assessment of management during change implementation can indicate the organization's performance under stress. Material and methods commonly used to improve workplace environments can be found on this website as well.

6.3 Workplace Environment

In the next section, we detail a few perspectives and supportive tools for understanding and promoting the importance of the management team in creating the workplace environment

6.3.1 Differences in Management Style

How management handles changes makes a big difference in the subjective experiences of the employees. The book "Flourishing: The Positive Person and the Good Life", pulls together many stress and health reports and statistical data (Ref 6.15). This report contains transcripts from a study involving two focus groups within a single organization undergoing both restructuring and ongoing changes. The contrast in emotions can easily be associated with the two very different management types.

Even though these two groups were within the same company during the same transitional time, the employees described two very different experiences. The first group acknowledged that many changes had occurred, but their supervisor had 1) kept them informed of what changes were happening, 2) explained why the changes were occurring, and 3) asked for their input on how to continue to succeed amongst such major changes.

On the other hand, a second group said that they were "scared" by the restructuring. They stated that many quality team members had left the organization, and those hired to replace them were described as not knowing "the business". Communication with managers had changed from

two-way to a top down style that did not incorporate input from the employees who knew best how to serve the customer's needs.

This difference in experience is a result of differing workplace environments. Stress is qualitative and subjective by nature. Therefore, comparisons can be made regarding the effect on the team members when different types of teams encounter the same change. Experts measure (quantify) the human experience so that levels of stress can be tracked and studied and therefore be mitigated.

6.3.2 Measuring the Work Environment

Research into the safety of the workplace has been conducted for over a hundred years (Ref 6.16). Since then, the American Psychology Association and other major organizations have developed tools for measuring the physical, psychological and social impacts of varying workplace conditions on those working there. Three of the many survey tools used to measure workplace competence and resulting stress levels and outcomes are described here.

GWA

Developed from 30 years of research questionnaires, the Gallup Workplace Audit (GWA) is a twelve-question survey of employee perceptions of management practices used by the trusted Gallup Organization. Some of the concise questions in the survey ask the respondents to rate their employer and managers on job clarity, sufficient work resources, job satisfaction and personal connectedness with people at work among other criteria (Ref 6.15).

OSI

Dr. Karen Belkic, along with her colleagues, has developed the Occupational Stress Index that she includes in her book "Occupational stress index: an approach derived from cognitive ergonomics and brain research for clinical practice" (Ref 6.1). This tool is an important part of

the website, www.workhealth.org that is a rich resource of collaborative information on stress in the workplace.

HSE

According to the HSE website, seven key areas of work design are primary indicators of stress in the workplace. They are described as table below as seen on the website www.hse.gov.uk/stress/standards/index.html (Ref 6.2).

Demands	- issues such as workload, work patterns and the work environment.
Control	- how much latitude the person has in the way they do their work.
Management Support	- encouragement, sponsorship and resources provided by the organization and line management.
Peer Support	- encouragement, sponsorship and resources provided by colleagues.
Relationships	- promoting positive working to avoid conflict when dealing with unacceptable behavior.
Role	- whether people understand their role within the organization and whether the organization ensures that they do not have conflicting roles.
Change	- how organizational change (large or small) is managed and communicated in the organization.

Table 6- 1: HSE "7 Assessment Factors of Workplace Design"

The HSE defines *Demands* and *Control* the same as in the JSM discussed previously. *Change* is so important that it holds its own category. *Role* refers to how well the staff understands the responsibilities as communicated by the organization. *Relationships*, *Management Support* and *Peer Support* work together to form a social environment at work. This creates an emotional connection often referred to as engagement.

6.3.3 Employee Engagement

Over and over in the research, the concept of engagement was repeated as a factor that made the difference between distress and eustress. Simon Albrecht writes in the *International Journal of Manpower*, "The science and practice of employee engagement, a key indicator of employee well-being, continues to evolve with ongoing incremental refinements to existing models and measures" (Ref 6.17). Those existing models and measures, some of which are laid out for us in "Flourishing", are based on a review of Gallup Organization findings. Chapter 9 is particularly focused on "well-being". The hypothesized model of this chapter is not a new one, but instead highlights the "reemergence of interest in the happy-productive worker hypothesis" (Ref 6.15).This theory holds that employee engagement produces a positive effect more often than without engagement. These positive effects spillover in a good way resulting in increased work efficiency, higher employee retention rates and better "business outcomes."

This text goes on to say that a feeling of engagement is a result of employees having their needs fulfilled in the workplace. Four key needs are identified as need for personal growth, a need to feel important, a need to belong, and need to be able to succeed. The ability to succeed is a result of clear expectations coupled with the materials needed to meet those goals. Even without managers being personally involved with each employee, their communication of goals and provision of necessary materials can begin to either make or break the connection between the employee and the organization.

Relationships with supportive peers and managers lead to higher work engagement that is found to mitigate perceptions of distress. In this way, managers who use best practices management styles reap results from increased employee engagement and job satisfaction.

6.3.4 Management Styles

While management is not necessarily the source of stress, research has clearly defined differences in the effects on employees based on management styles. For example, the way a manager relates to the employee with regard to communication has an effect on the employee's productivity. According to Isobel Rimmer, an expert in management training and HR management, a manager's appropriate feedback can help reduce stress-related illnesses. In 2008, Rimmer, individually trained managers at the HR department of the West Yorkshire Probation Service (WYPS). After training managers to give clear objectives and regular feedback, employee absence fell so dramatically that the HR manager reported, "it was like adding eight or nine new employees when considering the increase in efficiencies" (Ref 6.12). This is one example of where *demand* was not reduced per se, however a clearer understanding of the expectations increased the employee's feeling of *control*. This benefitted both the employees and the corporate bottom line.

S.M.A.R.T.

With over 20 years of experience, Rimmer, has developed training that incorporates best-practice techniques in performance management. She developed her S.M.A.R.T. approach that gives trainees opportunities to practice skills and incorporates at least two facilitators for groups of more than ten people. The steps to take to achieve management success begin with setting clear objectives.

"First, managers must set clear objectives, which need to specific, measurable, agreed, realistic and with a clear timeline (Smart). Managers must observe and measure their team members' performance against these impartial objectives in order to give accurate feedback on their performance" (Ref 6.12).

The second essential step to success is giving and receiving feedback with care and skill. This involves using performance data wisely. Note that receiving feedback as a manager is the second part of the two-way communication model.

The third step is management training. Managers that feel comfortable answering a variety of questions and concerns will be better equipped to be an equitable resource for the staff. This is where role-playing helps managers practice skills until they are comfortable using them even in uncomfortable circumstances.

Participative Leadership (Ref 6.18)

This method is defined by shared decision-making with team members. There are three subcategories that help classify the many positive behaviors included:

1. Consultative Leaders who get the advice of the other members before making a decision.
2. Consensus Leaders who open up discussion and then make a decision based on the general feelings of the group.
3. Democratic Leaders who leave the final decision to the team members.

Transformational Leadership (Ref 6.19)

This management technique was developed from the writings of James MacGregor Burns in 1978. It is broken into four components: intellectual stimulation, individualized consideration, inspirational motivation and idealized influence.

Intellectual Stimulation encourages questioning the "norm" and creating new solutions under the leader's visioning of the big picture and how everyone fits together to overcome any obstacle.

Seven Methods of Influence

Individualized Consideration is given to each employee in the form of mentoring, coaching and opportunities for growth, which helps fulfill the individual's needs for using their potential, feeling valuable and achieving their personal goals.

Inspirational Motivation provides challenges and meaning for employees to share in tasks and goals where they feel necessary to the forward movement of the team/company.

Idealized Influence can be described as the relationship of mutual trust that is built on high moral and ethical standards.

This type of management clearly uses eustress, or "good stress," opportunities to bring about ownership and engagement in employees. The indirect effect of this type of leadership was an increase to the subjective occupational success as a result of the direct increase in work engagement. The results showed a significant relationship between transformational leadership and work engagement, positively effecting occupational success, especially in women. Since higher levels of engagement are related to lower levels of job-related stress, these findings suggest ways for leadership to enhance the employee's work success (Ref 6.20). Further study could be helpful to suggest methods of leadership to increase employee success and decrease distress while increasing eustress.

Influential Leadership

The last method of leadership to be discussed here is from the work of our co-advisor, Dr. Helen Vassallo. She co-authored a book that put forward seven methods of influence that can help managers become true leaders of transformative change. The table below gives a brief synopsis of the seven ways to influence employees to cooperate fully (Ref 6.21).

1	Persuasive Communication	Helping people envision hope
2	Role Modeling	Showing how it's done
3	Expectancy	Using the power of self-fulfilling Prophecy
4	Extrinsic Rewards	Reinforcing transformative behavior
5	Structural Rearrangement	Shaping the work environment
6	Coercion	Legitimate use of position
7	Participation	Creating a shared reality through joint endeavor

Table 6- 2: Seven Methods of Influence

The authors go into some detail to further describe what actions would create the specific method of influence.

1. Persuasive Communication is a method for structuring and delivering information to influence another person to think or act in a way that the "sender" believes to be beneficial, desirable or preferable.
2. Role modeling is the dynamic process that begins by the leader modeling specific behaviors so the employee can learn by observing. Then the employee identifies with the leader who emulates the behavior. Dr Helen Vassallo coined the phrase, "adopt, adapt, adept" to summate this method (Vassallo).
3. Expectancy: Use and Misuse.
    i. If the leader believes in his/her people, they will live up to that expectation.
    ii. If the leader believes "people are no damn good", they will live down to that expectation.

4. Extrinsic rewards can be used effectively to enhance achievements and reinforce experimentation. Leaders can also initiate transformation change with changes to reward system such as combining reward systems.
5. Structural rearrangement must look at the whole system, include the culture in the change plan and consider carefully the domino effect.
6. Coercion can be problematic and is indicated for cases when systemic issues exist. Coercion is not the best choice when there are low barriers to exit and employees can easily vote with their feet. There can also be lingering animosity.
7. Participation strategy systems are especially necessary in organizations that experience perpetual, rapid, complex or large scale changes.

The most effective influential leadership strategy is one that integrates multiple methods for reaching all types of employees according to their particular personality.

6.3.5 Change Management in MassDOT District 3

Optimally, everyone would benefit from reducing stress by both limiting demands and by creating a work environment with more personal control for employees. Unfortunately, businesses are not always capable of minimizing both factors of workplace stress simultaneously. As we have seen above, management has a great deal of influence over reducing distress for workers.

Since MassDOT is a very large and interconnected government organization that has identified "employee engagement" as one of the five goals to improve performance statewide, they would benefit greatly from Change Management. During this exciting time of innovative improvements, change management could have a very positive effect on the other four target areas of safety, customer service, fiscal responsibility, and innovation. If they decided to follow

up this project by investigating effectiveness of management, the data could be expected to identify areas of strength and/or weakness that could assist them in applying appropriate measures.

(This chapter is edited and adapted by the coauthor from her previous original work. Shannon, G., Manley, A. Change Management in the Consumer Electronics Industry. Interdisciplinary Qualifying Project. Advised by Prof. H. Ault. Worcester Polytechnic Institute. 2012)

Chapter 7: Hazards

7.1 Hazards in the Workplace

Hazards can vary from physical, to chemical, or environmental, to societal and there are risks that can be foreseen and accounted for; however, many are simply unaccounted for. Seven of the most common injuries that occur in the workplace are musculoskeletal disorders of the neck, back, and upper extremities, struck by or against an object, fall from the same level, fall from an elevation, musculoskeletal disorders of the lower extremity, motor vehicle injuries, and caught in, under or, between an object (Ref 7.0). In order for hazards and risks to be minimized and prevented they must be identified, analyzed, and a method of prevention must be delegated throughout the departments.

7.2 Massachusetts State Employee Risk

In 2009 Governor Deval Patrick issued order 511 to address health and safety protections for Commonwealth employees because public workers were not covered by federal Occupational Safety and Health Administration (OSHA) standards and rules. This order would attempt to reduce the number of workplace related injuries that state workers experienced (Ref 7.1). Thirty-two Massachusetts workers suffered fatal injuries on the job in 2012; this is a decrease from the fifty-eight that were seen in 2011 and forty-seven in 2010. According to statistics from the article (Ref 7.2) the average age of employee was 50 years old, and these deaths came from construction job sites, maintenance workers, and other work related injuries such as falls from heights. Maintenance and Snow departments are considered to be some of the most dangerous departments to work in based on the number of hazards presented on a daily basis. Although District Utility and Construction engineers are at much less of a risk than day-to-day field employees, these engineers bring a level of risk to their jobs when they are required to enter the

field to survey land for a future project or to visit a current work-site. Although, it is assumed that employees are as careful, but unforeseen or accidental occurrences bring the element of risk on a daily basis.

7.3 OSHA (Occupational Safety and Health Administration)

OSHA defines a hazard, "as the potential for harm, in practical terms, a hazard often is associated with a condition or activity that, if left uncontrolled, can result in an injury or illness" (Ref 7.3). This serves as a more generic dictionary definition of a hazard. A hazard can be more specifically defined as "any facility, location, equipment, tool, job, task, or action that presents a potential of serious injury or death to any employee"(Ref 7.4). These types of hazards can come from working in close proximity to heavy equipment, large vehicles entering the crash site, trees or power lines falling down, improper equipment or improper equipment use. Hazards can be closely associated to risk in terms of workplace safety by definition, but risk then connects the impact of said hazards on the company. Hazards or risks cannot always be controlled; however, they can be assessed and accounted for to best protect employees in the workplace.

7.4 Maintenance Department

Although Department of Transportation (DOT) construction workers are in a very high risk position, according to Massachusetts DOT district 3 Project Development Engineer Arthur Frost, maintenance is "the most high risk position"(Ref 7.5). These types of employees are considerably more exposed to the elements of their surroundings than construction workers because their sites are hardly ever blocked off or supervised by police officers, or even fellow DOT employees. Maintenance workers are often alone during fieldwork, depending on the magnitude of the job. If a piece of debris needs to be removed from a highway or high traffic

area, usually only one employee will be sent out to run and retrieve it to clear the roadway. In these types of scenarios, risks may be taken in order to get the job done more quickly (Ref 7.5).

7.5 Snow and Ice Department

The department of Snow and Ice of the MassDOT is just as at risk as the maintenance department (Ref 7.5). Department employees venture out in any and all snowstorms throughout the state, plowing and clearing roadways. Their job often requires labor in less than optimal conditions, varying from moderate snowstorms to the worst ice storms the state had seen in a decade in 2008(Ref 7.6). Hazards present to snow and ice workers stem most frequently from the equipment that they use because it is out of date or not the best equipment for the job. Drivers do not always have trucks equipped with four-wheel drive, making it difficult to maneuver in slippery conditions. Tires are not always rotated or replaced at the proper time causing the tires to bald and provide less traction with the already slick roadways. This creates a risk of skidding out and losing control of the vehicle, and inhibits the drivers' ability to clear roads. If roads are not cleared and the department cannot complete its jobs in a time efficient manner it puts civilians at risk during poor weather conditions.

7.6 Musculoskeletal Disorders and Injuries

A MassDOT field employee is often required to lift, place, carry, hold, and lower heavy equipment from sledgehammers to concrete saws. These materials can weigh hundreds of pounds and it is usually necessary for workers to handle them long periods of time. Serious injuries of the back, shoulders, and other various upper extremities are common. It is vital for workers to understand the proper ergonomics for lifting and handling these pieces of equipment.

7.7 Muscle Strains & Ligament Sprains

Muscle strains and ligament sprains are some of the most common injuries. A ligament sprain occurs from a falling, twisting, or blunt trauma and forces a joint out of it normal position. Injuries of this type are common in the ankles, wrists, and lower back from landing improperly, falling, or overstressing weak muscles and joints (Ref 7.7). A muscle strain is similar to a sprain in that it is caused by the abnormal wrenching of a muscle or tendon resulting in this type of injury. This particular injury can either occur instantly or can gradually occur over days or weeks. When a sudden or acute strain happens, it is usually due to improper form when lifting heavy objects or overexerting muscles in a jerking quick motion. Chronic or delayed strains usually stem from repeated motion or holding an odd position. The tendons become too weak to continue. Strains cause pain, swelling, muscle spasms, weakness in the muscle, swelling, cramping, and trouble with mobility.

7.8 Lumbar Vertebral Disk Herniations

The lower back is the most susceptible area to these sprains, strains, herniated disks, and even fractured vertebrae. A human's spine is made up of 26 small bones called vertebrae, and in between each one of the individual bones is soft disk that acts as a cushion for the bones. As one ages, these cushions deteriorate, break down, and slip out of place or rupture (Ref 7.8). The result can be a herniated disk that can cause extreme pain throughout the entire lumbar of the spine, and shooting pain through the buttocks and legs (Ref 7.9).

7.9 Musculoskeletal Injury Prevention

These types of musculoskeletal injuries to the upper and lower extremities of the body can be prevented by following three simple techniques: stretch, strengthen, and proper lifting. The main reason that these muscles become strained and sprained is due to tight muscles being

put stressed. Stretching before doing these types of manual handling tasks allows for your muscles to lengthen and prepare for the labor. The risk of injury due to overcompensation or overexertion due to weak muscles is therefore decreased by proper warms-ups. Proper lifting is the main way to preventing these injuries. Employees should lift with the legs not with the back, keeping the object as close to the body as possible. The ability to plan and practice ahead with the strengthening discussed previously will allow for better lifting technique (Ref 7.10).

7.10 Motor Vehicle Injuries

In the highway maintenance and construction department's, physical hazards that are accounted for are the high speed traveling vehicles in close proximity to the work sites. Work sites are meant to be safe with police supervision, traffic signs to make drivers aware of roadwork ahead, closing off as much area around the work site as possible, and working during low traffic hours. Unforeseen events can still occur when one is dealing with these types of locations, even when all these precautions are taken into account. Vehicles being operated by either pedestrian, professional drivers [i.e. truckers, or other motor vehicle operators] often crash with the sight. The recent texting and driving epidemic causes drivers to take their eyes off the road and become distracted while driving, not paying attention to the task at hand. Semi-truck drivers, who are hauling cargo for long hours do not always take the proper precautions of getting enough sleep due to long hours, the need to make a delivery early or on time, and consequently dozing in and out of consciousness behind the wheel. When something like this occurs the tractor-trailer can smash through one of these work sites causing utter devastation to the area and employees. On September 14, 2010 at approximately 10:45 pm a man drove through a MassDOT construction zone on Route 9 in Framingham, MA, striking and killing state employee Gregory Vilidnitsky (Ref 7.11). The driver was sentenced to eight years for vehicular

homicide, and operating under the influence of alcohol. Any driver operating under the influence of substances that impairs his or her ability to operate a vehicle effectively poses one of the greatest risks to these construction and maintenance workers.

7.11 Caught Under or Struck by Objects

This type of hazard on the job site occurs when an employee becomes squeezed, pinched, or crushed by materials around the work site. These materials could be machinery, trees, and power lines - anything that could cause harm to employees (Ref 7.12). Maintenance and construction workers are always in the field, constantly at risk from the environment around them, whether it is the weather or other employees working with them. Maintenance workers of the MassDOT snow and ice department were sent out in 2008 in order to clear fallen debris throughout Massachusetts. During one of the most devastating ice storms the Northeast had ever seen, workers were in heavily wooded areas such as Paxton, MA and Spencer, MA (Ref 7.5). Workers were heavily at risk for falling debris like tree branches or even entire trees that were being crushed under the weight of the ice. Serious, potentially life threatening, injuries would occur if an employee had been caught under this form of falling debris. An employee's time working in the vicinity around heavy machinery in motion in the field runs the risk of being crushed between the machinery and another piece of equipment. Employees may assume that the operator can always see them, they could become complacent, not focusing of their surrounding environment. These pieces of equipment often have many blind spots making it difficult to see all angles surrounding the operator. Broken bones, serious head trauma, and even death can be the result.

7.12 Accident Prevention

The way to prevent these types of injuries is for the individual to constantly be aware of his surroundings. The worker should not assume that that operator of a piece of machinery sees him. Make sure the work should be a safe distance away from the equipment to prevent an accident or injury. The operators should be properly trained to use the equipment properly and safely (Ref 7.12). Employees must be wearing the proper safety equipment while in the work zone at all times (i.e. helmet and safety vest). These pieces of equipment are required for employees to wear for a reason a helmet will protect your head from falling objects, the safety vest makes you make visible, this equipment could save a workers life.

7.13 Falling Injuries

Falling injuries are usually the result of the employees' failure to concentrate on what is occurring in one's surroundings. These types of hazards can cause mild injuries such as strains and sprains, but can also cause serious trauma depending of the severity of the incident. If an employee is simply walking down the embankment next to a worksite, or exiting the cab of their truck, they can slip and may only sprain an ankle or a wrist. Landing on one's tailbone or hands followed by the weight of one's entire body could cause bones to break or ligament to tear. Employees working from elevation such as ladder or from the side of a moving truck are at even more risk for serious injury. When setting up work sites employees place cones off the side of moving trucks in order to safely block off the work-site. Employees are at risk of losing their footing or leaning too far over to place a cone and falling from the truck, causing serious, even fatal injury. Falling from height occurs it is not certain how the person will land, should they land short they would be run over by the truck. If the employee extends too far they could land

on their head, causing serious head trauma, or retain a simple sprain (Ref 7.13). An employee's risk during falling is dependent on the person and their ability to react to the situation.

7.14 Falling Injury Prevention

The workers can prevent falling injuries by constantly being aware of what they are doing at that present time since these injuries are often the result workers not being fully engaged with the task at hand. Proper footwear and stabilizing equipment is a way in which workers can prepare themselves to prevent these types of slip and falls (Ref 7.14).

7.15 Public Exposure

MassDOT maintenance and construction employees are always working outside in public areas. This type of exposure leaves them susceptible to the criticism of unhappy citizens, unsavory characters, and other public threats. Citizens are often held up by these kinds of construction sites because the department has to close off areas of the roadways in order to keep employees as safe as possible. Often, the public does not understand the need for these types of set ups and becomes frustrated, taking out this frustration out on employees. Aggravated citizens have even been known to approach work zones threatening and battering employees to the point that local law enforcement have been notified.

Due to this level of exposure to the public leaves employees very open to contact with unsavory characters. This is not always necessarily an issue of the area where they are working but simply how often they are on the side of the roads throughout Massachusetts. In February 2014 a state highway worker reported seeing "a man with blood soaked jeans and a large amount of dried blood covering his face" (Ref 7.15). The man he saw had just came from attempting to murder his own mother in their Westborough home a short time after. The state employee's call to the local police department is reason that the man was found and taken into custody. This

means that state employees were close enough to a man, who just attempted to murder his own mother, to identify the stains and discoloring on his clothing as blood. This type of contact with unsavory characters is definitely a rare occurrence, but not unheard of, and therefore, must be taken into account when discussing risk.

7.16 Working Alone

Massachusetts Department of Transportation do not often operate without the company of other employees, but under some circumstances it is the case. “A person is “alone” at work when they are on their own; when they cannot be seen or heard by another person; and when they cannot expect a visit from another worker” (Ref 7.16). Maintenance employees often travel by themselves when they receive quick job phone calls, for example to go remove debris from the highway. This is detrimental to the safety of the employee and the operators driving on the road. In order to avoid hitting the worker a driver may swerve into another car causing an extremely destructive chain of events, especially during a high-density traffic hour. Even worse, the employee could trip and fall while trying to run across the street and thus get run over by one or more cars, causing traumatic injury or death.

Field employees are not the only ones in jeopardy from the risk of working alone. Project management engineers are sometime forced to survey a prospective area of land for development by themselves. Work like this sometimes requires them to walk for miles and miles over undeveloped land with unknown hazards. When working these types of project surveys alone, they are at the mercy of the environment, serious falls that could disable their ability to walk, contact with unsavory characters, or even getting lost in an unfamiliar area (Ref 7.5).

7.17 Working Alone Risk Prevention

Working alone cannot always be avoided but an attempt should be made to have it occur as rarely as possible. A procedure of checking in should be established with the employee working alone and the department they answer to. Today's cellular technology allows for easy and constant contact; however, sometimes work in remote areas prevents from cellular single. Setting a schedule of departure, arrival, and return time for the lone employee allows the department to know the location of the lone employee at all times (Ref 7.16).

Chapter 8: Conclusion & Recommendations

8.1 Conclusion

The Department of Transportation is undergoing a substantial amount of organizational change. The Office of Project Controls & Performance Oversight (OPCPO) is in charge of the performance management system roll out. We observed some difficulties with the implementation of the numerous metrics that included both measures that have historically tracked as well as the addition of many data points for tracking and entry. The system of performance management within the Highway Division District 3 subdivision is complicated and was not easy to understand. With the help of Axiomatic Design, we were able to more fully understand the whole system and the current status of performance management at the local district level.

A monthly District Health Report (DHR) will certainly make it easier to identify and monitor any performance issues before they reach the degree of a serious risk. The DHR will reduce the time required for management to investigate the problem. Therefore, it will be a useful tool for improved oversight of all business activities. This will naturally aid District 3 in achieving outstanding performance management by ideally avoiding risk or serious complications in the future.

The couplings we observed in the AD decomposition between Employee Engagement and both Safety and Innovation indicate that people are integral to the optimal functioning of any organization. It is no wonder that Employee Engagement has been identified as one of the five performance management goals. Additionally, this correlation can be optimized and result in new ideas bringing forth innovative approaches, for instance, for reducing the number of sick

days. Unfortunately, this can lead to worksites being understaffed and that, in turn, can lead to safety concerns.

8.2 Recommendations

MassDOT District 3 can use the monthly District Health Report to accomplish their performance management goals better by: (1) avoiding serious risks and (2) achieving consistently high scores on the yearly statewide goals. The DHR is innovative because it enables local managers to make more informed decisions in-house to resolve issues quickly before the yearly report is affected. For financial reasons, the DHR is a competent tool to prevent or at least minimize the incidence of budget and schedule overruns. These types of events can be costly for MassDOT District 3 and the state vicariously. By having a DHR available to District 3, district level achievements can improve the Highway Division's overall performance score while setting the bar high for others to emulate their innovative spirit and outstanding achievement.

MassDOT is a very large and interconnected government organization that has identified "employee engagement" as one of their five goals to improve performance statewide. This has brought about a great deal of change in the types, amounts and methods of data being produced and recorded. This makes them a prime candidate for Change Management. In addition, this organization is becoming more like a corporation, especially as it relates to accountability to the taxpayer and the legislature who allocates funds throughout the state. MassDOT would benefit greatly from incorporating change management best practices and self-assessment tools. If they decided to follow up this project by investigating the effectiveness of management, the data could help indicate areas of strength and/or weakness to assist them in choosing and applying appropriate improvement measures. During this exciting time of innovative improvements, change management could harness the opportunity to engage employees for moving past

reluctant compliance to the higher level of cooperation. This would then have a positive effect on the outcomes in the other four target areas of safety, customer service, fiscal responsibility, and innovation. By working together to adapt to the many changes in the system, employees can have a profound impact on the performance of the State of Massachusetts' Department of Transportation.

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Appendices

Appendix A: First Interview Script for Assigning Weight

PREFACE:

We understand that the state office has been doing a lot to measure performance. We have heard that everyone is trying to simplify this task.

We want to get your direct feedback to help us understand which measures are the most relevant. This will help management understand and best support your department as it endeavors to meet or exceed goals for safety, fiscal responsibility, etc.

To do this, this project sets out to assist your District managers to develop a dashboard reporting method for which we are using the working title "District Health Report". This DHR could allow management to better understand the health of District 3 specifically with a monthly report. Currently, the performance measures are all given equal importance when calculating overall rating for the statewide reports.

With your help, we can recognize and build upon your strengths to support areas where improvements are possible. Ultimately, the goal is to be the best. By working together to identify the most important measures, it may be possible for District 3 to prevent or head off events that would put District 3 out of standard.

Having an accurate District Health Report (DHR) will help everyone participate and be recognized as they achieve that goal.

STEP 1: COMPLETING LIST

(Place a copy of the PM metrics abridged list in front of interviewee)

Under the heading, (insert PM category name here)

Are there other measures, that you currently report, that are not on this list, that you feel would be key for calculating a "District Health Report" (DHR)? Could it indicate a developing concern? Describe.

(Write in any metrics with appropriate descriptive wording and set boundary points)

STEP 2: RATING

Looking at this now "complete" list of most important performance measures, let's take each measure under the category (PM category). Based on your experience, in your department, we would ask you to rate them in order of importance, marking the most important as number "1" and so on. If there are some measures that are equally important, please write the corresponding rank number beside each of those measures. (Be available for questions as they complete the rating column).

STEP 3: CORRELATION

Does this measure affect another measure, such as Employee Engagement? Does this measure affect Customer Service? (And so on…asking each individually to encourage depth of thought to prepare them to assign weight next)

STEP 4: WEIGHT ASSIGNMENT

Based on your experience with challenges and issues in the past, out of 100, what percent of the overall importance would you give to your top pick. This is based on the impact that an event or variation outside standard would have on the District.

{REPEAT QUESTIONS 3 and 4 for their second ranked measure, etc.}

{REPEAT FOR EACH OF 5 PM GOAL CATEGORIES}

Appendix B: Second Interview Script for Assigning Probability

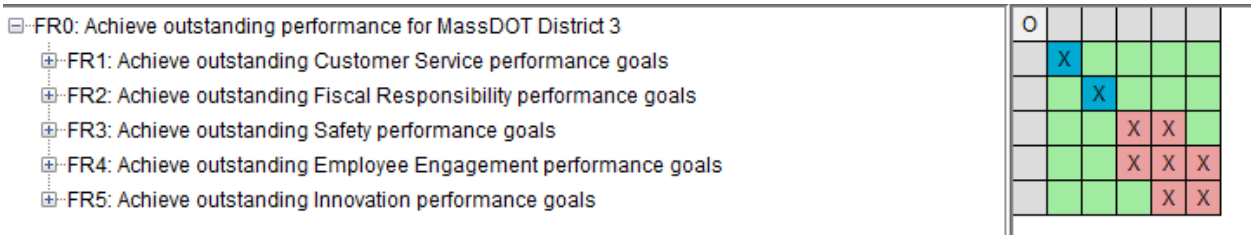
PREFACE:

As the first order of business today, it would be beneficial for us to review the format of the performance management risks gathered thus far, to ensure that they are in fact accurate, and relevant to the Project and Administration departments.

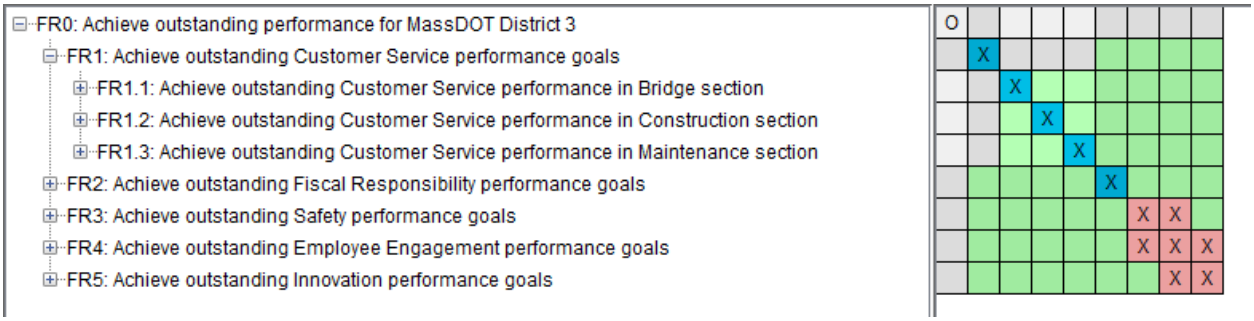
We are meeting with you with the goal of determining if there have been any specific instances where district 3 did not meet their performance goals. In recent memory, has there been any memorable moments where the projects or administration departments have not adhered to their performance standards, which has had a negative repercussion to either the cost or schedule constraints?

If you could give us more information about these specific cases, it would greatly benefit our cost/benefit analysis.

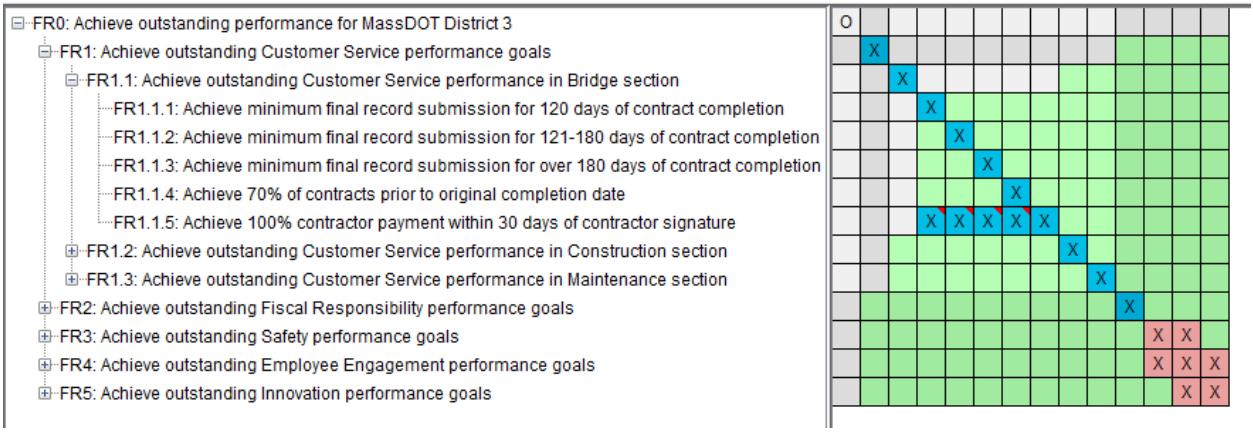
Appendix C: Check Uncouple Designs



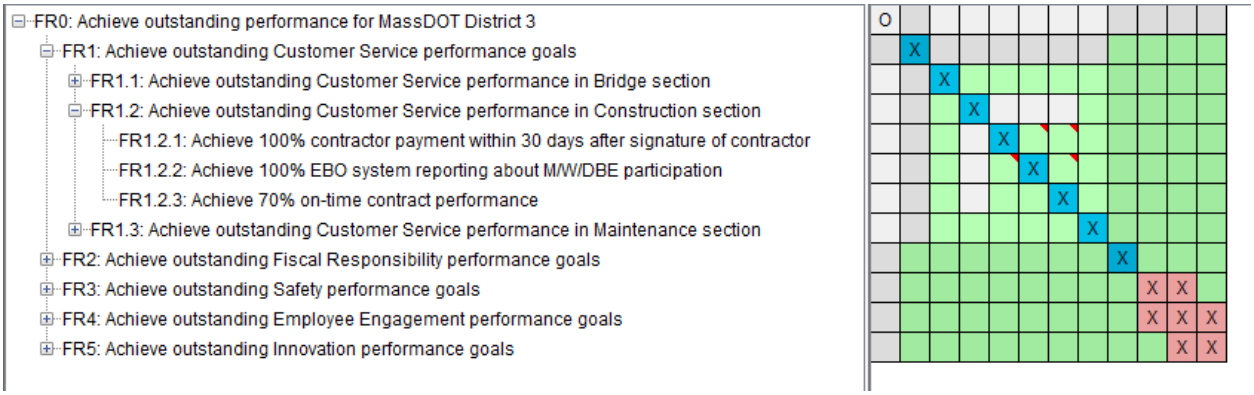
Check uncouple design for all five FR1, FR2, FR3, FR4, FR5



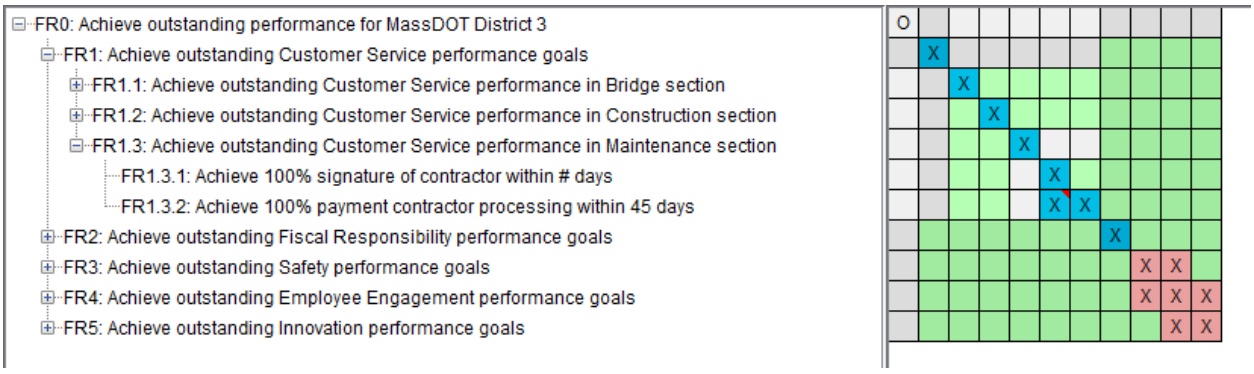
Check uncouple design for FR1.1, FR1.2, FR1.3



Check uncouple design for FR1.1.1, FR1.1.2, FR1.1.3, FR1.1.4, FR1.1.5



Check uncouple design for FR1.2.1, FR1.2.2, FR1.2.3



Check uncouple design for FR1.3.1, FR1.3.2

Appendix D: Weight Assessment for Sections

Bridges section	Performance Measures	Rank	Weight
Safety			
	Complete 100% of Bridge inspections on-time (no later than original assigned completion date)	1	0.5
	*Track the number of structural deficient bridges added or removed	2	0.5
Customer Service			
	Process 100% of payments to contractors within 30 days after signature by contractor	1	0.5
	Submit a minimum of (%) final records within 120 days of contract completion	2	0.125
	Submit a minimum of (%) final records within 121-180 days of contract completion	2	0.125
		2	0.125
	Submit a minimum of (%) final records more than 180 days of contract completion	2	0.125
	Complete 70% of contracts "on-time" (prior to original contract completion date)		
Fiscal Responsibility			
	Complete 100% of design reviews within 30 days for projects up to $20 million for the current year STIP projects	2	0.125
	Complete 100% of design reviews within 45 days for projects over $20 million for the current year STIP projects	2	0.125
	Complete 100% of design reviews within 60 days for future year STIP projects	2	0.125
	Complete 100% of design reviews within 120 days for projects not on the STIP	2	0.125
	Complete 80% of contracts "on budget"(final cost less than original encomberance)	1	0.5

Construction section	Performance Measures	Rank	Weight
Customer Service			
	Process 100% of payments to contractors within 30 days after signature by contractor	2	0.25
	Ensure that 100% of construction projects use the EBO system to report M/W/DBE participation	3	0.05
	Complete 70% of contracts "on-time" (prior to original contract completion date)	1	0.7
Fiscal Responsibility			
	Complete 80% of contracts "on-budget" (final cost is less than original encumbrance)	1	0.8
	Submit minimum of 100% "final records" to district completion level within 120 days	2	0.2

Projects section	Performance Measures	Rank	Weight
Fiscal Responsibility			
	Complete 100% of design reviews within 30 days for the current year STIP projects	1	0.6
	Complete 100% of design reviews within 60 days for second year STIP projects	2	0.4
Innovation			
	Completeness review of 25% design submission within 10 days	1	1
Employee Engagement			
	Conduct a staff meeting monthly	1	1

Maintenance section	Performance Measures	Rank	Weight
Customer Service			
	Get Signature from contractor		
	*Process 100% of payments to contractors within 45 days	1	1
Safety			
	Monitor District Employee Injuries	1	0.4
	Track Non-compliance with personal protective equipment use	2	0.2
	Track number of recommendations for driver training school due to risky driving	2	0.2
	Snow Overs (Moving Projectile incidents)	2	0.2
Innovation			
	Labor Hour Reporting (Maximo)	1	1

Operations & Admin section	Performance Measures	Rank	Weight
Employee Engagement			
	Reduce district employee work place injuries from the previous Calendar year	1	0.5
	Ensure 100% of staff is notified of the requirement for 100% compliance with MassDOT mandatory training initiatives	3	0.1
	Ensure 100% of staff is notified of the requirement for 100% of Highway employees to attend diversity training	3	0.1
	Ensure 100% of personnel are in compliance with the personal protective equipment directive	2	0.2
	Ensure 100% of managers are notified that MassDOT encourages diversity when hiring	3	0.1
Fiscal Responsibility			
	Spend less than the annual district budget (operating) by the end of the Fiscal year	1	0.9
	Ensure that Payroll stays within budget	2	0.1

Appendix E: Risk Registers

LEVEL 2 - RISK REGISTER				System Name:	Construction		DIS-3	08-1234	Project Manager	PM Person					
Risk Identification							Risk Assessment						Risk Response		
Status	ID #	Type	Category	Title	Risk Statement	Current status/assumptions	Probability	Cost Impact	Cost Score	Time Impact	Time Score	Rationale	Strategy	Response Actions	Risk Owner	Updated
Active		Threat	Organizational	Customer Service.	As a result of not processing 100% of payments to contractors withing 30 days of contractor signature, delinquency of payment may occur which would lead to a negative impact in customer service.		2-Low	8 -High	16	1 -Very Low	2					
Active		Threat	Organizational	Customer Service	As a result of not completing 70% of contracts "on-time", a delay in construction schedules, which would lead to dissatisfied drivers on the road.		1-Very Low	16 - Very High	16	1 -Very Low	1					
Active		Opportunity	Construction	Customer Service	As a result of completing 70% of contracts "on-time", we are ahead of schedule, which would lead to happier drivers on the road.		4-High	8 -High	32	1 -Very Low	4					
Active		Threat	Construction	Fiscal Responsibility	As a result of not completing 80% of contracts "on-budget", we may have budget creep and would lead to a negative impact on fiscal Responsibility		1-Very Low	1 -Very Low	1	1 -Very Low	1					
Active		Opportunity	Construction	Fiscal Responsibility	As a result of completing 80% of contracts "on-budget", we may have more capital, thus being more fiscally responsible		1-Very Low	1 -Very Low	1	1 -Very Low	1					
Active		Th	uction	Submit 100% "final records" within 120 days.	If 100% "final records"is not submitted to district completion level within 120 days,<> occurs which may lead to <>		2-Low	1 -Very Low	2	1 -Very Low	2					

Select the type of risk.

LEVEL 2 - RISK REGISTER				System Name:	Bridges		DIS-3	08-1234	Project Manager	PM Person					
Risk Identification							Risk Assessment						Risk Response		
Status	ID #	Type	Category	Title	Risk Statement	Current status/assumptions	Probability	Cost Impact	Cost Score	Time Impact	Time Score	Rationale	Strategy	Response Actions	Risk Owner	Updated
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not complete within 30 days for projects up to $20 million for the current year STIP, <>, which would lead to a schedule overrun.		1-Very Low	8 -High	8	1 -Very Low	1					
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not complete within 45 days for projects over $20 million for the current year STIP projects, <>, which could lead to a schedule overrun.		1-Very Low	2 -Low	2	2 -Very Low	2					
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not completed within 60 days for future year STIP projects<>, would occur which would lead to<>		3-Moderate	8 -High	24	3 -Very Low	9					
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not completed within 120 days for projects not on the STIP<>, may occur which would lead to <>		1-Very Low	4 -Moderate	4	4 -Very Low	4					
Active		Threat	Construction	Contract Fiscal Responsibility	If 80% of contracts are not completed "on budget"(final cost less than original encomberance), we may run out of funding, which would lead to not respecting the design construction budget.		1-Very Low	5 -Very Low	5	5 -Very Low	5					

LEVEL 2 - RISK REGISTER		System Name:	Projects		DIS-3	08-1234	Project Manager	PM Person						
Risk Identification					Risk Assessment						Risk Response			
Status	ID #	Type	Category	Title	Risk Statement	Current status/assumptions	Probability	Cost Impact	Cost Score	Time Impact	Time Score	Rationale	Strategy	Response Actions	Risk Owner	Updated
Active		Threat	Design	Design Review Completeness	If 100% of design reviews are not completed within 30 days for the current year STIP projects,Project design schedule could be impacted, which would lead to jeopardizing its advertising date and funding.		2-Low	16 - Very High	32	4 -Moderate	8					
Active		Threat	Design	Design Review Completeness	If 100% of design review are not completed within 60 days for second year STIP projects, Project design schedule could be impacted, which would lead to jeopardizing its advertising date and funding.		3-Moderate	2 -Low	6	2 -Very Low	6					
Active		Threat	Design	Design Review Completeness	If completeness review of 25% design submission is not done within 10 days, time would be innappropriately used which would lead to a negative cascading effect across internal and external resources.		1-Very Low	3 -Very Low	3	3 -Very Low	3					
Active		Threat	Organizational	Innovation	If staff meeting monthly is not conducted, critical insights may not occur, which would lead to a lack of project awareness.		1-Very Low	4 -Very Low	4	4 -Very Low	4					

LEVEL 2 - RISK REGISTER		System Name:	Maintenance		DIS-3	08-1234	Project Manager	PM Person						
Risk Identification					Risk Assessment						Risk Response			
Status	ID #	Type	Category	Title	Risk Statement	Current status/assumptions	Probability	Cost Impact	Cost Score	Time Impact	Time Score	Rationale	Strategy	Response Actions	Risk Owner	Updated
Active		Threat	Organizational	Contractor Relationships	As a result of not processing 100% of payments to contractors within 45 days, contractors may complain due to lack of payment, thus affecting customer service.		2-Low	4 -Moderate	8	4 -Moderate	8					
Active		Threat	Organizational	Safety	As a result of not monitoring District Employee injuries, there may be a rise in workplace injuries, thus affecting employee safety.		2-Low	16 - Very High	32	2 -Very Low	4					
Active		Threat	Organizational	Safety	As a result of not tracking Non-compliance with personal protective equipment use, there may be a rise in workplace injuries, thus affecting employee safety		1-Very Low	3 -Very Low	3	3 -Very Low	3					
Active		Threat	Organizational	Safety	As a result of not tracking the number of employee recommendations for driver training school due to risky driving, traffic incidents may increase, thus impacting customer safety.		1-Very Low	4 -Very Low	4	4 -Very Low	4					
Active		Threat	Environmental	Safety	As a result of not tracking Snow Overs, there may be a rise in moving Projectile incidents, thus impacting customer safety.		5-Very High	16 - Very High	80	2 -Very Low	10					
Active		Threat	Organizational	Innovation	As a result of not reporting Labor Hours , organizational deficiencies may occur, thus affecting innovation.		1-Very Low	3 -Very Low	3	3 -Very Low	3					

LEVEL 2 – RISK REGISTER		System Name:	Administration		DIS-3	08-1234	Project Manager	PM Person						
Risk Identification					Risk Assessment						Risk Response			
Status	ID #	Type	Category	Title	Risk Statement	Current status/assumptions	Probability	Cost Impact	Cost Score	Time Impact	Time Score	Rationale	Strategy	Response Actions	Risk Owner	Updated
Active		Opportunity	Organizational	Employee Engagement.	As a result of reducing district employee work place injuries from the previous Calendar year, employees feel safer, thus leading to increased employee engagement.		4-High	8 -High	32	16 - Very High	64					
Active		Opportunity	Organizational	Employee Engagement.	As a result of ensuring 100% of staff is notified of the requirement for 100% compliance with MassDOT mandatory training initiatives, there is less discrimination in the hiring process, thus resulting in increased employee		1-Very Low	8 -High	8	1-Very Low	1					
Active		Opportunity	Organizational	Employee Engagement.	As a result of ens staff is notified of for 100% of Highw attend diversity tr employees are m minded, resulting employee engag		1-Very Low	8 -High	8	1-Very Low	1					
Active		Opportunity	Organizational	Employee Engagement.	As a result of ens personnel are in the personal protective equipment directive, there is a reduction in workplace injuries, resulting in more employee		1-Very Low	16 - Very High	16	1-Very Low	1					
Active		Opportunity	Organizational	Employee Engagement.	As a result of ensuring 100% of managers are notified that MassDOT encourages diversity when hiring, the massDOT hiring policy is respected, resulting in increased employee		1-Very Low	1-Very Low	1	1-Very Low	1					
Active		Opportunity	Organizational	Fiscal Responsibility	As a result of spending more than the annual district budget (operating) by the end of the Fiscal year, there is more money available to the district, resulting in increased fiscal responsibility		2-Low	1-Very Low	2	1-Very Low	2					
Active		Opportunity	Organizational	Fiscal Responsibility	As a result of ensuring thatovertimel stays within budget, district 3 looks good compared to other districts, resulting in increased fiscal responsibility.		3-Moderate	8 -High	24	1-Very Low	3					

Risk statement in the form:
"As a result of <definite cause>,
<uncertain event> may occur,
which would lead to <effect on objective(s)>."