An Enhanced Mission Dependency Index for Better Facility Renewal Funding Decisions

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Abstract

This monograph explores the transition from the widely utilized yet inherently flawed Mission Dependency Index (MDI) to an enhanced version, known as eMDI. Overcoming the limitations of the traditional MDI, the proposed eMDI serves as a more reliable tool for ensuring optimal allocation of an organization's limited resources to its key strategic priorities. The introduction succinctly outlines the purpose, design, and shortcomings of the MDI. Subsequently, the monograph identifies and addresses published flaws in the MDI, introducing corrective measures embedded in the new eMDI. A practical case study illustrates the implementation of the eMDI in a hypothetical county government, offering a simplified, robust, and credible quantitative methodology. This approach stands out as a superior alternative to previous solutions suggested by MDI critics.

Practical Application

Any public or private organization/institution relying on owned facilities to enable strategic outcomes, can adopt eMDI to improve funding decisions in facility renewal. Implementing eMDI can optimize organization-wide resource allocation, providing strategic insights that enhance decision transparency and acceptance. The quantitative, strategic insights provided by eMDI will benefit senior leaders, mission stakeholders, and facility specialists, differentiating it from the limitations of the traditional MDI..

Keywords

"Senior Leaders," "Mission Stakeholders," "User/Occupants," "Facility Specialists," "facilities renewal," "relative mission importance," "Functional Areas," "Relative Mission Importance (RMI)," "Relative Strategic Importance (RSI)," "Operational Impact Index (O2I)," Mission Dependency Index (MDI," "enhanced Mission Dependency Index (eMDI."

Introduction

The phrase "Senior Leaders" is used in this paper to mean top executives in public and private organizations who allocate resources. "Mission Stakeholders" includes "User/Occupants" of an organization's facilities and the organizational superiors of the User/Occupants. Also, the term "facilities renewal" is used, as defined by the National Academies of Science, Engineering and Medicine, to mean the sum of an existing facility's funding requirements for maintenance, repair, renovation, replacement, and repurposing (NASEM 2023). Notably, "facilities renewal" does not include expansion, demolition or new construction.

The International Organization for Standardization (ISO 55000 series) and the National Academies of Science, Engineering and Medicine (NASEM 2023) advocate several key principles of facility asset management. One of the principles is that "mission alignment" of resource prioritization requires the use of validated and verifiable metrics to link the relative importance of individual facility assets to agency missions and stakeholder performance expectations. The major benefit of quantifying relative facility importance with respect to mission and mission stakeholder expectations is the increased certainty that an organization's scarce resources are being allocated to the greatest strategic needs.

Many senior leaders mistakenly believe that they accomplish this beneficial linking by using a popular metric called Mission Dependency Index (MDI). (Citations) Despite MDI's broad adoption for guiding the expenditure of billions in public and private funds, several studies on MDI suggest it may have flaws that limit its efficacy, chief among which is that MDI does not link facilities to mission

importance. Consequently, the use of MDI may have contributed to misallocation of many scarce dollars, and replacing it with a more credible metric deserves consideration.

The next section of this paper describes the purpose, design and use of the traditional Mission Dependency Index (MDI). The section after that reviews each major flaw in traditional MDI published over the past 14 years. Included are short descriptions of the remedies incorporated in the new enhanced Mission Dependency Index (eMDI). Finally, the paper presents a case study explaining the new eMDI and illustrating a practical process for implementing it in a hypothetical county government.

Purpose, Design and Use of Traditional Mission Dependency Index (MDI)

Historic lack of credible and granular information about the relative mission importance among existing facilities has long undermined the ability of senior leaders, mission stakeholders and facility specialists to evaluate competing demands on scarce organization resources with due consideration of mission effect. Such fuzziness also lessens the ability of leaders and managers at all organizational levels to budget and allocate limited resources for optimum global outcomes.

Without current, credible, and sufficiently precise quantified information about the relative mission importance of existing facilities and/or functional areas, organizations have difficulty justifying budgets, allocating funds, and ranking repair/renewal projects and work requests according to mission benefit. They also experience difficulty in discerning which of many valid facility and non-facility demands should be satisfied with limited resources. Lack of precise information about relative mission importance also hinders organizational learning and improvement of the budget/allocation process.

To bridge this longstanding informational gap in decision support, the traditional Mission Dependency Index (MDI) was created for the U.S. Navy in the year 2000 and tested at Naval facilities located on San Clemente Island, CA. (Antelman and Pendleton, 2000) More testing and validation occurred two years later at Naval Station North Island, San Diego, CA and Naval Station Mayport, FL. (Antelman and Miller, 2002). The intent of MDI was to provide facility specialists with heuristically based, simple rules-of-thumb to determine relative mission importance as well as severity of infrastructure loss . Heuristics, play an essential role in some types of problem solving, but are not guaranteed to work. "Heuristics can provide valuable shortcuts that can reduce time and cost". (Giarratano, J. & Riley, G. 1989).

In 2003, traditional MDI was recognized by the US General Services Administration as a “Best Practice” and by the Federal Facilities Council as “a promising process indicator for prioritizing projects and funding to support an organization’s overall mission.” (Cable and Davis 2005).

Traditional MDI scores are scaled from 1 to 100 and assigned to a Facility or Functional Area within a Facility based on an expert elicitation survey of Facility User/Occupants. The more important a Facility/Functional Area is to the Mission-Function(s) performed by its User/Occupants, the higher the traditional MDI score of the rated Facility/Functional Area.

In 2008, traditional MDI was further refined. Antelman, et al (2008). Then, after more field testing, traditional MDI was deployed by the Navy, Coast Guard and NASA, where it still supports a number of facility-related decision processes. A 2011 National Research Council Report cited MDI as an example of how maintenance and repair requests can be clearly and effectively tied to mission. Since then, the use of traditional MDI has spread throughout the federal government and in public and private sectors.

Today, MDI is important because it is broadly adopted in the US government and is used to justify and prioritize huge amounts of federal expenditure. Executive Order (EO) 13377 entitled “Federal Real Property Asset Management” (2004) sets the requirement for US federal agencies to use life-cycle

cost estimations for facility planning, management, and end-of-life. In response, DoD services and federal agencies adopted MDI alongside other key metrics for justifying funding expenditure (Nichols, 2015). MDI is currently used by the US Navy (Commander, Navy Installations Command, 2018), US Air Force (USAF) (Weniger, 2018), US Army (USA) (Grussing et al., 2010), National Aeronautics and Space Administration (NASA, 2010), and US Department of Energy (DOE) (NNSA Office of Safety, Infrastructure & Operations, 2017). MDI was used among other key metrics to justify expenditure of nearly $20 billion dollars across the federal government in Fiscal Year 2021." Eisenberg, D. A., Fish, A. B., & Alderson, D. L. (2022)

Flaws of Traditional MDI and Remedies Provided by the enhanced Mission Dependency Index (eMDI)

Despite MDI's widespread use in the federal government and elsewhere, its credibility has been challenged over the past 14 years in published papers that describe many claimed flaws in the metric's design and implementation. (Kujawski and Miller, 2009), DePalmer, et al, (2021); Eisenberg, D. A., Fish, A. B., & Alderson, D. L. (2022). and (DePalmer, 2023). Eisenberg, Fish and Alderson even conclude that "MDI in its current form should not be trusted as a basis for decision making." Eisenberg, et al (2022).

The authors of this paper believe that several published flaws of traditional MDI are the result of misunderstanding among the critics. However, the critical papers do, in fact, identify at least five valid flaws that "leave room for improvement" or could cause misallocation of billions of dollars of scarce funding. As DePalmer recommends: "MDI should be updated with new methods and models or the US government should develop a new methodology that does not afford so much potential for bias." Citation

The authors of this paper mostly concur with the critics' analysis of the need to either replace traditional MDI or, at least, improve its flaws. Accordingly, this paper offers significantly improved eMDI methodology as a more robust alternative to the qualitative "ORFMEA" remedy proposed by Kujawski and Miller, as well as a simpler alternative to the math-intense, "Mamdani fuzzy inference system" proposed by DePalmer.

The following paragraphs briefly summarize traditional MDI's five flaws most needing correction. The description of each flaw is followed by a corresponding remedy, which has been incorporated in the replacement eMDI metric advocated by this paper. After that, the paper lays out a detailed process that any organization can use to create, sustain and benefit from implementing eMDI.

Traditional MDI Flaw #1: MDI does not link facilities to mission importance.

Chief among its published flaws is that traditional MDI doesn't really link facilities to an organization's overall mission. Instead, the metric links facilities to only the specific Mission-Function(s) performed by User/Occupants of the facility. Consequently, the traditional MDI metric does not account for the relative importance among Mission-Functions in terms of Mission accomplishment.

For example, a County golf course lawn mower shop with an accurate, high MDI score in terms of importance to lawnmower repair could be unintentionally misconstrued as more important to overall County mission than an Emergency Medical Station with an accurate but lower MDI score in terms of importance to emergency preparedness. Such unintended portrayals can mislead Senior Leaders to erroneously conclude that a certain high scoring Facility/Functional Area warrants more funding priority than another, lower-scoring Facility/Functional Area.

Remedy for Flaw #1 Incorporated in Proposed eMDI

The proposed eMDI combines three, new independent components into one index that actually links facilities to an organization's overall mission. The new, independent

components are: (1) Relative Mission Importance (RMI) of a Strategic Outcome, (2) Relative Strategic Importance (RSI) of a Mission-Function, and (3) Operational Impact Indicator (O2I) of a Facility/Functional Area.

eMDI Component #1: Relative Mission Importance (RMI) of a Strategic Outcome

> The RMI of an organization's Strategic Outcome captures perspectives of the organization's Senior Leaders (not Mission-Stakeholders or Facility Specialists) regarding the relative importance among all the organization's Strategic Outcomes. The higher a Strategic Outcome's RMI score on a scale of 0-1.00, the greater the Outcome's potential contribution to mission attainment. RMIs of Strategic Outcomes play a central role in calculating eMDI's second component: Relative Strategic Importance (RSI) of an organization's Mission-Function.

eMDI Component #2: Relative Strategic Importance (RSI) of a Mission-Function

> A Mission-Function's RSI captures perspectives of the organization's Mission-Stakeholders (not Senior Leaders or Facility Specialists) regarding the relative importance of the Mission-Function among all the organization's Mission-Functions in terms of mission contribution. The higher a Mission-Function's RSI score on a scale of 0-1.00, the greater the Mission-Function's intended contribution to mission attainment. RSIs of Mission-Functions, combined with the O2I(s) of the Facility/Functional Area(s) that house/enable/support User/Occupant performance of the Mission-Function play a central role in calculating the eMDI of the Facility/Functional Area.

eMDI Component #3: Operational Impact Indicator (O2I) of a Facility/Functional Area

> The O2I of a Facility/Functional Area captures perspectives of Facility User/Occupants (not Senior Leaders, other Mission-Stakeholders or Facility Specialists) regarding the potential severity of impact on performance of assigned Mission-Functions due to a Facility/Functional Area's hypothetical, complete nonavailability to house/enable/support User/Occupant performance of their assigned Mission-Functions. The higher a Facility/Functional Area's O2I score on a scale of 0-100, the greater the Facility/Functional Area's impact on User/Occupant performance of assigned Mission-Functions. O2I is similar in purpose to traditional MDI, but with changes and additions to eliminate many MDI flaws, which have been published over the last two decades.

An organization's eMDI implementation would include data-gathering and computing an RMI for each Strategic Outcome, an RSI for each organization Mission-Function and an O2I for each Facility/Functional Area. These metrics would be combined into one eMDI metric for each and every Facility/Functional Area. A Facility/Functional Area's eMDI would take into account and represent all aspects of the Facility/Functional Area's relative importance to mission accomplishment.

The process would be designed by and incorporate perspectives from Facility User/Occupants, Mission Stakeholders and Senior Leaders, thereby rendering each eMDI rating a systematically-derived consensus of a diverse base of business knowledge. Multi-level participation in implementing and using eMDI would also serve to gain top-down and bottom-up support for future Facility renewal budget requests and other uses of the eMDI metric.

Traditional MDI Flaw #2: The Scores are Vulnerable to Cognitive Biases

Traditional MDI is vulnerable to cognitive biases and, therefore, to distortions of reality that can lead to mis-allocation of scarce funds. Critics point out four separate exposures:

- "The scores are subjective and based on questions and responses that are ambiguous." (Kajawski & Miller 2009)
- The relative weighting of MDw (intradependency within an organization), MDb (interdependency between organizations) and N (number of interdependencies) means MDI scores are dominated by subjective interpretation of intradependency (of MDw), rather than by relationships among facilities to work as networks and support mission.
- There are multiple competing ways that a SME can answer MDI questions for the same mission.
- Vulnerability to cognitive biases affecting survey responses due to the use of a traditional risk matrix, (DePalmer 2023)

Remedy to Flaw #2 Incorporated in Proposed eMDI

Cognitive bias will always exist. But its negative effects on the credibility of eMDI have been minimized with:

1. Clear, unambiguous survey questions requiring objective responses.
2. Elimination of the controversial risk matrix.
3. Elimination of MDw, MDb, N and their potential for subjective interpretation.
4. Using the systematic Analytical Hierarchy Process (AHP), which is known for minimizing the effects of cognitive bias and subjective judgement in decision-making. Citation

Traditional MDI Flaw #3: Lack of resolution between MDI scores

Traditional MDI lacks resolution between scores, making the scores too general to meet the needs of decision makers who could benefit from detailed resolution. The extreme example is that, the official Mission Dependent data element of each US Government's Facility is reported annually to the Federal Real Property Profile (FRPP) as one of just 3 possible ratings: 'Mission Critical,' 'Mission Dependent' and 'Non-mission Dependent.' Consequently, decision makers could not use this MDI metric as currently constituted to distinguish relative mission importance among the thousands of facilities in each rating category. Traditional MDI was created with score range of 1-100 as an alternative to the three MDI values.(Antelman 2005)

Introduction of the traditional MDI into federal decision making expanded the ineffectual resolution of the FRPP "official MDI" into many more possible ratings. However, traditional MDI's increase in number of possible ratings, while an improvement, was still insufficient for many public and private organizations that own many more facilities than the number of available traditional MDI ratings. The resulting possibility of tied scores reduces metric value to discerning senior leaders.

For example, MDI category "Significant" is 70-84. So, the facility with a traditional MDI score of 75 is in the same category as the facility with a score or 82. Therefore funding could go to a less importance facility simply because of the lack of relative importance.

Remedy to Flaw #3 Incorporated in Proposed eMDI The proposed eMDI dramatically increases the number of possible rating scores in traditional MDI by increasing the granularity of **O2I** and concatenating the two separate and independent scores (**O2I** and **RSI**) for each Facility/Functional Area's eMDI score.

Traditional MDI Flaw #4: Mathematical Issues

Traditional MDI relies on multiplication and addition of ordinal numbers. This is mathematically as well as logically meaningless. Additionally, Eq. (1) includes a term Ln(n), which is undefined for the possible situation where n = 0.

Remedy to Flaw #4 Incorporated in Proposed eMDI

Unlike ordinal numbers, the cardinal numbers used in the proposed eMDI methodology (see the Case Study) can be used in all arithmetic operations. Also the proposed eMDI methodology does not include any formulas involving the term Ln(n).

Traditional MDI Flaw #5: Deviation from the Principles of Classical Risk Management

"Unknowing decision-makers may rely on these flawed aids and misallocate funds. It is important . . . . to be wary of methods that claim to quantify complex concepts like risk using single numbers. Given the importance of properly assessing risk and taking corrective actions, there is little excuse for relying solely on MDI. Citation

Remedy to Flaw #5 Incorporated in Proposed eMDI

The proposed eMDI does not attempt to quantify risk. Instead, it is a single number to quantify potential severity of business impact of an unavailable Facility/Functional Areas.

Case Study: A Practical Process for Implementing eMDI in a Hypothetical County Government

eMDI can be implemented either as a replacement for MDI or as a new undertaking. A proposed process for implementing eMDI is presented now in the context of a hypothetical U.S. County. Our Imaginary County is governed by an appointed County Executive who reports to an elected Board of Supervisors. All County department heads and agency chiefs report directly to the County Executive. The County relies on collective performance of approximately 200 full-time, employed staff members who use/occupy 20 County Facilities.

Annual budgeting for all County departments is orchestrated by the Department of Financial Management under direction of the Chief Financial Officer, who also reports to the County Executive. Annual budgets of all County Departments and agencies collectively incorporate all County operating expenses except for facility operations and renewal. The Facility Management Department, whose Director reports to the County Executive, centrally budgets for, and executes, all Facility operating and renewal funding for the 20 County-owned facilities as well as for operation and renewal of public pavements and utilities.

Identification And Descriptions Of Specific Links Between Facilities And Mission

Figure 1 is a graphical representation of the links between County Facilities and County Mission. The approach proposed by this paper, requires a comparable representation (at least in data elements, if not in detailed graphics) for every Facility in a portfolio.

The figure depicts four key focus levels in the domain of our example County. The same four levels apply in principle to any Facility owned by any organization that depends on one or more facilities for housing, enabling and supporting desired strategic outcomes. The focus levels in the context of this example are:

(1) County Mission, (2) County Strategic Outcomes, (3) County Mission-Functions and (4) County Facilities/Functional Areas. The following sections explain working terminology used in this case study to describe each key focus level and their interrelationships.

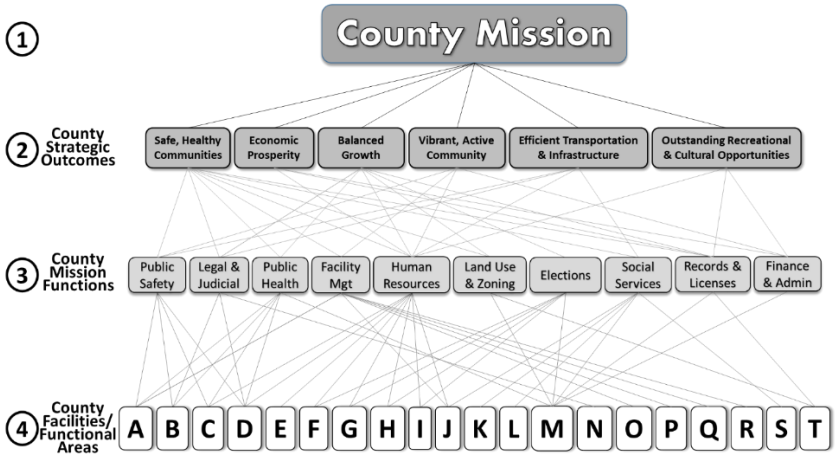


Figure 1: The Links between County Facilities/Functional Areas and County Mission
Source: Authors

Level 1 - County Mission is a very broad, top-level description of an organization's global purposes, directions and goals. The Mission of the hypothetical County in this case study is:

> *" To deliver quality, customer-focused County services with an emphasis on public safety, neighborhood livability, job creation, responsible planning for economic growth, infrastructure improvements, transportation systems, public health, and the environment."*

Level 2 - County Strategic Outcomes - for purposes of governance, organizations typically partition their Missions into subsets of Strategic Outcomes (also called Strategic Goals, Strategic Outcomes, Strategic Initiatives or Critical Success Factors). This paper uses the term "Strategic Outcomes" to refer to whatever terminology and interrelationships an organization has chosen to describe its desired high-level performance targets. Collective accomplishment of an organization's Strategic Outcomes contributes to accomplishment of the organization's Mission.

Many different types of Strategic Outcomes are adopted by the senior leaders of various organizations. Level 2 of Figure 1 shows six Strategic Outcomes adopted by the hypothetical County in this case study.

Level 3 - County Mission-Functions – *These* are the human activities that collectively and directly contribute to accomplishing specific Strategic Outcomes. For example, County employees performing the Public Safety Mission-Function help the County attain its Strategic Outcomes of "Safe, Healthy Communities," "Vibrant Active Communities" and "Efficient Transportation & Infrastructure."

A Mission-Function usually is comprised of sub-functions. For instance, the Public Safety Mission-Function encompasses sub-functions performed by County employees engaged in Law Enforcement, Emergency Fire and Rescue, and Disaster Response. Another example: the Legal and Judicial Mission-Function is comprised of subfunctions performed by County employees who bring civil and criminal cases to trial, defend accused parties, conduct trials and provide probation services. County employees performing any of these sub-functions contributes to performance of the Public Safety Mission-Function, which helps the County attain its Strategic

Outcomes of “Safe, Healthy Communities,” “Vibrant Active Communities” and “Efficient Transportation & Infrastructure.”

Level 4 – Facilities/Functional Areas – these are the buildings, utility systems, pavements, transportation infrastructure, etc. which organizations rely on to house/enable/support the human activities (Mission-Functions), which achieve Strategic Outcomes and organizational Mission. Collectively, Facilities/Functional Areas must adequately house/enable/support User/Occupant performance of designated Mission-Functions in order for the organization to achieve its Strategic Outcomes and, thus, its Mission.

A Facility usually houses/enables/supports a single Mission-Function. But, when a single Facility houses/enables/supports User/Occupant performance of multiple Mission-Functions, the Facility can be sub-divided into Functional Areas. A Functional Area is a room or space or a group of like-purposed rooms and spaces that is designed and/or designated to house/enable/support human activity that contributes to accomplishment of one or more Mission-Functions. For example, our County’s courthouse contains Functional Areas for Records & Licenses and Land Use & Zoning as well as for Legal and Judicial activities.

The Links between County Facilities/Functional Areas and County Mission

Facilities/Functional Areas house/enable/support User/Occupant performance of Mission-Functions assigned to the User/Occupants. User/occupant performance of a Mission-Function contributes to attainment of one or more County Strategic Outcomes. Achievement of all County Strategic Outcomes, collectively contributes to attainment of County Mission.

It's important to note that achievement of a County Strategic Outcome usually requires concurrent performance of multiple Mission-Functions assigned to many various organizational units throughout the County. For example, attainment of the County Strategic Outcome “Safe, Healthy Community” requires successful performance of Mission-Functions assigned to employees of the County Departments of Police, Public Health & Safety, and Facilities Management, as well as to employees of the County Fire and Rescue Department. For this reason, County Senior Leaders who want to allocate resources on the basis of strategic importance would be well-advised to extend the processes advocated by this paper to all Mission-Functions, organization-wide, regardless of Department that performs them or the budget line item that funds them. Ascertaining the relative importance among all County Mission-Functions gives Senior Leaders a benchmark for allocating all budget line items on the basis of relative strategic importance.

Figure 1 illustrates typical, upward paths of support that link County Facilities/Functional Areas with County’s Mission-Functions, County Strategic Outcomes and, ultimately, with County Mission. Examples of upward support paths are graphically depicted by lines stretched between a supporting entity at any given level and one or more supported entities in the next level above. Support links in Figure 1 may have various degree of importance (as determined with the method proposed in this paper’s following sections). Thus, a single Mission-Function may provide multiple and varying degrees of support to one or more Strategic Outcomes, while receiving multiple and varying degrees of support from one or more Facilities/Functional Areas.

Links from Facilities/Functional Areas to Mission-Functions

The upward support links from Facilities/Functional Areas to Mission-Functions illustrated notionally as lines in Figure 1 must be specifically identified and further analyzed to determine each link’s relative degree of importance to upward support. The identified links, their relative degree of importance and some additional situational awareness information from User/Occupants can be used to logically prioritize Facilities/Functional Areas and guide their associated fund allocation decisions in

terms of relative mission importance. Information about the upward links from Facilities/Functional Areas to Mission-Functions is collected from User/Occupants in structured interviews conducted by mission stakeholders and SMEs (rather than by Facility Specialists). See this paper's case study for process details.

Each "X" in Table 1 represents an upward support link from one specific Facility/Functional Area to one specific Mission-Function. Each County Facility/Functional Area supports its User/Occupant's performance of one or more assigned Mission-Functions, as determined by mission-stakeholders and SMEs (not facilities specialists) and marked by each "X" in the table.

For example, "Facility/Functional Area "A" is shown to house/enable/support performance of three User/Occupant Mission-Functions: "Public Safety," "Public Health" and "Facility Management." These links are initially identified by mission stakeholders and SME's and later rated according to relative importance by User/Occupants of relevant Functional Areas in Facility A. Link identification and structured interviews of User/Occupants are conducted by mission stakeholders and SMEs (rather than by Facility Specialists). Then the links are periodically reviewed and re-confirmed/updated, all in conjunction with the process proposed by this paper.

Table 1: Identified Links from County Facilities/Functional Areas to County Mission-Functions
Source: Authors

		COUNTY FACILITY/FUNCTIONAL AREAS																				
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
		Operation Impact Index **O2I** of each Facility/Functional Area																				
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
COUNTY MISSION FUNCTIONS																						
Relative Strategic Importance **RSI**	**Title**																					
0.00	Public Safety	X	X	X		X		X		X												
0.00	Legal & Judicial		X			X		X		X					X							
0.00	Public Health	X	X	X		X		X		X												
0.00	Facility Management	X			X						X					X	X	X	X			Support Links & Their Relative Importance
0.00	Human Resources			X	X	X	X	X	X	X	X	X										
0.00	Land Use & Zoning					X		X		X				X							X	
0.00	Elections				X				X			X		X								
0.00	Social Services										X		X	X						X		
0.00	Records & Licenses																				X	
0.00	Finance & Admin													X								

Upward Support Links from Mission-Functions to Strategic Outcomes

The upward support links from Mission-Functions to Strategic Outcomes, illustrated notionally as lines in Figure 1, also must be specifically identified and further analyzed to determine each link's relative degree of importance to upward support. The identified links and their relative degree of importance can be used to logically prioritize funding requests and guide fund allocations in terms of mission importance. Information about the upward links from Mission-Functions to Strategic Outcomes is collected from organizational mission-stakeholders and senior leaders in structured interviews conducted by mission-stakeholders and SMEs (rather than by Facility Specialists). See this paper's case study for process details.

Each "X" in Table 2 represents a support link from one specific Mission-Function to one specific Strategic Outcome. Each assigned User/Occupant Mission-Function supports one or more of the County's Strategic Outcomes, as marked by each "X" in the table. For example, User/Occupant performance of Mission-Function "Public Safety," supports four Strategic Outcomes: "Outstanding Recreational & Cultural Opportunities," "Safe, Healthy Community," "Efficient Transportation & Infrastructure" and "Vibrant, Active Community." These upward links are initially identified and rated

according to relative importance by mission-stakeholders and senior leaders in structured interviews conducted by SMEs (rather than by Facility Specialists). Then the links are periodically reviewed and re-confirmed/updated by mission-stakeholders and senior leaders in conjunction with the process proposed by this paper.

Table 2: Identified Links from County Mission-Functions to County Strategic Outcomes
Source: Authors

	COUNTY STRATEGIC OUTCOMES						COUNTY MISSION FUNCTIONS	
	Safe, Healthy Community	Economic Prosperity	Balanced Growth	Vibrant Active Community	Efficient Transportation & Infrastructure	Recreational & Cultural Opportunities	Relative Strategic Importance RSI	Title
	Relative Mission Importance RMI of Strategic Outcomes							
	0.00	0.00	0.00	0.00	0.00	0.00		
Support Links & Their Relative Importance	X			X	X	X	0.00	Public Safety
	X		X	X			0.00	Legal & Judicial
	X						0.00	Public Health
	X					X	0.00	Facility Management
	X	X	X	X	X	X	0.00	Human Resources
	X		X				0.00	Land Use & Zoning
			X				0.00	Elections
	X		X		X		0.00	Social Services
	X	X	X				0.00	Records & Licenses
		X	X		X		0.00	Finance & Admin

Quantitative Measures Of Relative Importance Among Functional Area in Terms of Mission

As recently affirmed by the National Academies of Science, Engineering and Medicine: "Mission alignment of resource prioritization requires the use of validated and verifiable metrics to link the relative importance of individual facility assets to agency missions and stakeholder performance expectations." (NASEM 2023) The following case study describes a proposed metric for gauging the relative importance of any specific Facility/Functional Area among all the organization's Facilities/Functional Areas from a strategic, mission performance perspective. The metric, called the enhanced Mission Dependency Index (eMDI), is based on the relative strategic importance among the Mission-Functions and Strategic Outcomes linked to the scored Facility/Functional Area, as well as on the relative importance of the various support links.

A Practical Process

This case study is set in the context of the hypothetical County described earlier in this paper. It illustrates the authors' recommended eMDI methodology for any organization that would like to increase the amount and quality of relevant, mission-centric information available to senior leaders for allocating scarce resources among all valid, competing budget requirements. The eMDI metric links a Facility/Functional Area to the organization's mission and has several, general characteristics:

1. The eMDI methodology is an adaption of the Analytic Hierarchy Process (AHP) (Saaty 2008). AHP is widely used in practical decision making and scientific study of preferences, attitudes, voting systems, social choice, and public choice. It is also extensively used in decision making for complex scenarios, where people work together to make decisions when human perceptions, judgments and consequences have a long-term repercussion (Bhushan & Rai, 2004).
2. The eMDI methodology is easily implemented at low cost and can be used in any organization, provided the organization's Senior Leaders fully support its implementation and mandate its use in decision making.

3. Implementation of eMDI methodology must be organized and administered by Facility User/Occupants, mission-stakeholders and business-savvy SMEs appointed by Senior Leaders (rather than by Facility Specialists).
4. The eMDI methodology can use, but does not require special software. Microsoft Excel works quite nicely, especially when made accessible to participants and users on the Internet or via an organization's internal network.
5. The eMDI methodology consists of four sequential phases: Planning, Data Collection, Data Analysis and Metric Utilization.

Phase 1. Planning

Senior Leaders decide to use eMDI and appoint an eMDI Implementation Team (the "Team") to prepare the organization for adapting the process described in this paper to the organization's unique needs and conditions.

Phase 2. Data Collection

a. Senior Leaders participate in a 5-minute, structured Survey of County Strategic Priorities, and
b. Facility User/Occupants participate in a 30-minute, structured Survey of Mission-Function Vulnerability by answering specific questions about the Mission-Functions assigned to the respondents.

Phase 3. Data Organization and Analysis

The Senior Leaders' eMDI Implementation Team uses Phase 2 survey data to calculate an eMDI metric for each Facility/Functional Area owned by the organization. The calculation is run in four sequential steps, as explained in the following sections.

Phase 4. Metric Utilization

Senior Leaders initiate, monitor and adjust the use of eMDI in the organization's decision-making processes.

PHASE 1: Planning

In the Planning phase, County Senior Leaders (the County Executive and Board of Supervisors) reviewed this paper, conducted additional research and decided to implement and use eMDI. A crucial aspect of this Phase 1 was the organization's Senior Leaders convincing themselves to sponsor and support the effort. They knew that, without their sustained backing and participation, the effort to implement and use eMDI will fail, regardless of any expert planning behind the process.

After the Senior Leaders decided to implement and use eMDI, they established a working group called the County eMDI Implementation Team (the "Team"). Team membership included facility User/Occupants, mission stakeholders and business savvy SMEs and they were charged with creating a plan for adapting eMDI to the organization. The starting point for the plan was identification and listing of every County Mission-Function, the County organizational units assigned to perform each Mission-Function and the Facilities/Functional Areas that house/enable/support the functional units.

The plan was also required to lay out specific arrangements for collecting and analyzing the data, then calculating an eMDI for each of the organization's Facilities/Functional Areas and recommendations for Senior Leaders on how to apply the metric in budget and funding allocation decisions.

PHASE 2: Data Collection

In this Data Collection phase, County Senior Leaders (the County Executive and Board Members) participated in a Survey of County Strategic Priorities organized and administered by the Team. Concurrently, the leaders of all Facility User/Occupant units participate in a separate Survey of County Mission-Function Vulnerability. One or both surveys could have been done on-line, but the Team decided to conduct personal interviews.

a. Senior Leader Survey of County Strategic Priorities

The process of quantifying relative importance of County Facilities/Functional Areas in terms of County's Mission and Strategic Outcomes required obtaining County Executive and Board Member consensus on the relative importance among County Strategic Outcomes in terms of contribution to County Mission.

> *Note: senior leaders' eager and full participation in this modest but critical task is vital to the success of eMDI implementation. Senior Leader degree of participation in this survey also is an indicator of future willingness to use eMDI for informed decision making. It's best to obtain Senior Leader commitment to such willingness before investing in eMDI implementation.*

The process began with the County Executive and Board Members jointly evaluating the County's six Strategic Outcomes so as to determine the relative importance between them in terms of County Mission. As prescribed by the AHP method, County Strategic Outcomes were compared just two at a time. This is called "pairwise comparison" and there are n(n-1)/2 comparisons required, with "n" being the number of items to be compared. For example, six (6) County Strategic Outcomes required 15 pair-wise comparisons: 6(6-1)/2 = 15.

Table 3 summarizes the results of the Senior Leader Survey of County Strategic Priorities. Note that the table contains an "E" rating for every comparison of a Strategic Outcome with itself, These "E" ratings were entered by the Team prior to the Survey and the Survey did not take up Senior Leader time by asking for Senior Leaders to compare relative importance of a Strategic Outcome with itself.

For each of the 15 actual pairwise comparisons of the six Strategic Outcomes, the Senior Leaders assigned one consensus letter from the survey's Rating Key (also in Table 3). The selected letters (A thru I) represent the leaders' consensus opinion regarding the rated Outcome's mission importance relative to each the other five Strategic Outcomes.

Table 3: Results of Senior Leader Survey of County Strategic Priorities
Source: Authors

Results of Senior Leader Survey of County Strategic Priorities

STRATEGIC OUTCOMES		1 Safe, Healthy Community	2 Economic Prosperity	3 Balanced Growth	4 Vibrant Active Community	5 Efficient Transportation & Infrastructure	6 Recreational & Cultural Opportunities
1	Safe, Healthy Community	E	D	D	B	C	A
2	Economic Prosperity		E	E	D	C	C
3	Balanced Growth			E	E	D	D
4	Vibrant Active Community				E	D	D
5	Efficient Transportation & Infrastructure					E	D
6	Recreational & Cultural Opportunities						E

Rating Key
A- Extremely More Important
B- Far More Important
C- Significantly More Important
D- Slightly More Important
E- Equally Important
F- Slightly Less Important
G- Significantly Less Important
H- Far Less Important
I- Extremely Less Important

For example, Senior Leaders concurred that the Strategic Outcome #1 "Safe, Healthy Community" is FAR MORE IMPORTANT than Strategic Outcome #4 "Vibrant, Active Community." So, the Leaders assigned letter "B" to Cell (1, 4) in the survey. The Team helped Senior Leaders make their choices by giving them copies of the County Mission Statement and detailed descriptions of the County Strategic Outcomes.

b. User/Occupant Survey of Mission-Function Vulnerability

The process of linking the relative importance of County Facilities/Functional Areas to the County's Mission also requires obtaining User/Occupant input about the vulnerability of each County Mission-Function to the possible unavailability of the Facilities/Functional Areas that house/enable/support the Mission-Function. The process begins with each leader of the functional unit that uses/occupies a Facility/Functional Area independently answering the same set of three questions for each County Facility/Functional Area. The three questions are:

Question 1.

What are the normal operating hours/week and weeks/year of the Mission-Functions housed/enabled/supported by this particular Facility/Functional Area?

Answer 1.a: ___ hours per week (range of allowable answers is 1-168 hours/week)

Answer 1.b: ___ weeks per year (range of allowable answers is 1-52 weeks/year)

Question 2. What is your best estimate of the maximum number of normal operating hours over a 4-week period that the Mission-Function supported by this particular Facility/Functional Area can be completely unavailable without adversely impacting performance of the Mission-Functions assigned to your department, division, or functional unit? Note: if this Facility/Functional Area supports more than one Mission-Function, answer the question with the hours of the Mission-Function least tolerable to Facility/Functional Area nonavailability.

Answer: _____ hours/4-week period (range of allowable answers: 0-672 hrs/4-week period)

Level of Difficulty	Criteria for Difficulty Level
Level-6	* No funds/resources available to relocate or replicate mission-function. * Unacceptable disruption to daily operations. * Critical dependencies on highly specialized infrastructure/technology. * No available, suitable alternative locations * Insummountable legal or regulatory hurdles for relocation.
Level-5	* Severe budget constraints with minimal financial flexibility. * Prolonged and severe disruption to daily operations. * Critical dependencies on highly specialized infrastructure. * Limited or no availability of suitable alternative locations * Significant legal or regulatory hurdles for relocation.
Level-4	* Severe budget/resource constraints, but some flexibility. * Extensive disruption to daily operations during the transition. * Critical dependencies on unique or proprietary infrastructure. * Limited or no availability of suitable alternative locations. * Difficult, but resolveable legal or regulatory issues
Level-3	* Limited resources and budget for relocation. * Significant disruption to daily operations during the transition. * Critical dependencies on specialized infrastructure or technology. * Limited availability of suitable alternative locations. * Concerning legal or regulatory issues
Level-2	* Adequate resources available, but budget constraints exist. * Moderate disruption to daily operations during the transition. * Some dependencies on specialized infrastructure or technology. * Alternative locations may require modifications or adjustments. * Concerning Legal or Regulatory Issues
Level-1	* Ample resources and budget available for relocation. * Minimal impact on daily operations during the transition. * Limited dependencies on specific infrastructure or technology. * Accessible alternative locations with suitable facilities. * Trivial Legal or Regulatory Issues
Level-0	* Ample resources and budget available for relocation. * Zero disruption of transition on daily operations * Zero dependencies on specific infrastructure or technology. * Alternative locations vacant or on divestiture list. * Zero legal or regulatory Issues

Question 3. If this particular Facility/Functional Area were to be completely unavailable during normal operating days/hours for longer than the maximum time period identified in your answer to Question #2 (T_{MAX}), which of the seven levels of difficulty defined on Table 4 would be encountered to continue performing your Mission-Functions in another permanent or temporary Facility, or by outsourcing to a service provider? Note: select the highest Level of Difficulty meeting at least one of the criteria specified for that level.

Answer: Highest Level of Difficulty ___ (allowable answers 0, 1, 2, 3, 4, 5 or 6).

Table 4: Levels of Difficulty to Relocate/Replicate a County Mission-Function
Source: Authors

PHASE 3: Data Analysis

Senior Leadership's appointed Team of User/Occupants, mission-stakeholders, and SME's uses Phase 2 survey data to calculate an eMDI metric for each of the organization's Facilities/Functional Areas.

The eMDI calculation is made in the following, four sequential steps.

Step 1. Compute Relative Mission Importance (RMI) of Each County Strategic Outcome

Step 2. Compute Relative Strategic Importance (RSI) of Each County Mission-Function

Step 3. Compute an Operational Impact Index (O2I) for Each County Facility/Functional Area

Step 4. Compute an eMDI for Each County Facility/Functional Area

Figure 3 is a roadmap for computing an eMDI for each County Facility/Functional Area. The same roadmap also can be used for computing any Facility's eMDI in any organization. The roadmap is an overview of the four, above-listed eMDI computational steps within the definitional context of Figure 1 of this paper. The roadmap, therefore, employs the precise terms and relationships established in Figures 1. The text sections following Figure 3 explain the details of each computational Step 1-4. Explanation of each step is accompanied by an expanded image of the relevant section of the Figure 3 roadmap.

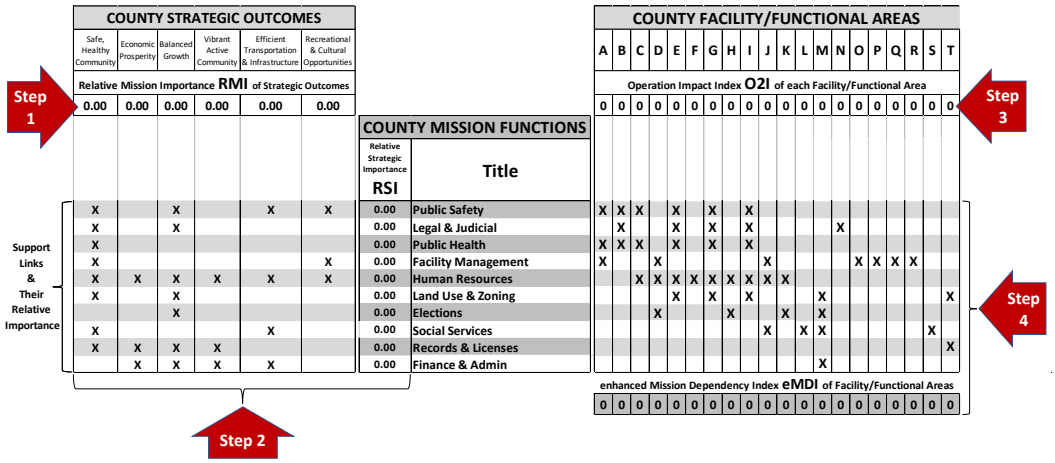


Figure 3: Roadmap for Computing an eMDI for Each County Facility/Functional Area
Source: Authors

Step 1. Compute Relative Mission Importance (RMI) of Each County Strategic Outcome

Step1 begins by converting the pairwise comparison letter ratings (A thru I) from the ***Senior Leader Survey of County Strategic Priorities*** (Table 3 to numerical ratings called Relative Mission Importance (RMI). The conversion can be done in different ways (Triantaphyllou & Mann, 1995). However, the pairwise relative importance scale suggested by Saaty (Saaty, 2005) and shown in Figure 4 is the most widely used.

Rating Key	Numerical Rating
A- Extremely More Important	**9.00**
B- Far More Important	**7.00**
C- Significantly More Important	**5.00**
D- Slightly More Important	**3.00**
E- Equally Important	**1.00**
F- Slightly Less Important	**0.33**
G- Significantly Less Important	**0.20**
H- Far Less Important	**0.14**
I- Extremely Less Important	**0.11**

Figure 4 Pairwise Relative Importance Scale
Source: Saaty (2005)

Using numerical values that vary from 0.11 to 9 for the letter ratings, the scale quantifies the relative importance of an item when compared to another item in terms of a named criterion. Table 5, Rows 1-6 and Columns 1-6 contain the results of using Saaty's scale to

convert the pairwise comparison letter ratings from the Table 3 **Senior Leader Survey of County Strategic Priorities** to numerical ratings.

Table 5: Step 1-Using AHP to Compute Relative Mission Importance (RMI) of Each County Strategic Outcome
Source: Authors

		1	2	3	4	5	6	7	8	9
	STRATEGIC OUTCOMES	Safe, Healthy Community	Economic Prosperity	Balanced Growth	Vibrant Active Community	Efficient Transportation & Infrastructure	Recreational & Cultural Opportunities	**Average**	**RMI**	**RMI times SUM**
1	Safe, Healthy Community	**1**	**3**	**3**	**7**	**5**	**9**	**4.67**	**0.42**	**0.88**
2	Economic Prosperity	**0.33**	**1**	**1**	**3**	**5**	**5**	**2.56**	**0.23**	**1.31**
3	Balanced Growth	**0.33**	**1.00**	**1**	**1**	**3**	**3**	**1.56**	**0.14**	**0.93**
4	Vibrant Active Community	**0.14**	**0.33**	**1.00**	**1**	**3**	**3**	**1.41**	**0.13**	**1.60**
5	Efficient Transportation & Infrastructure	**0.20**	**0.20**	**0.33**	**0.33**	**1**	**1**	**0.51**	**0.05**	**0.82**
6	Recreational & Cultural Opportunities	**0.11**	**0.20**	**0.33**	**0.33**	**1.00**	**1**	**0.50**	**0.04**	**0.98**
	SUM	2.12	5.73	6.67	12.67	18.00	22.00	11.20	1.00	6.51
									CI	**0.10**
									CR	**0.08**

Note the following about Table 5:

- The 15 pair-wise ratings in the upper, right half of the matrix (the cells in Columns 2-6 above the shaded diagonal cells) are the Rating Key conversions to numeric ratings of the 15 Senior Leader letter ratings (A thru I) in Table 3. For example, the "9" in cell Row 1, Column 6 is the Senior Leader assignment of relative mission importance of achieving a "Safe, Healthy Community" compared to the relative mission importance of achieving "Outstanding Recreational & Cultural Opportunities." The "9" is the number prescribed by the Rating Key for the Senior Leaders' letter rating in cell Row 1, Column 6 of "**A**-Extremely More Important."
- The 15 pairwise ratings in the lower, left half of the matrix (the cells in Columns 1-5 below the shaded diagonal cells) are the reciprocals of the numeric rating appearing in the mirrored cell in the upper right, above the shaded cells. For example, the 0.14 in cell Row 4 Column I gives the relative mission importance of "Vibrant, Active Community" in respect to "Safe, Healthy Community." The 0.14 was not directly assigned by Senior Leaders. Instead, it is the reciprocal of the "7" in cell Row 1, Column 4, which is Senior Leader assignment of relative mission importance of "Safe, Healthy Community" in respect to "Vibrant, Active Community."
- The sum of the ratings in each column (1 thru 6) is also included at the bottom of each column in Table 5. These sums were used later in this Step 1.

The Relative Mission Importance (RMI) of each Strategic Outcome is determined by calculating the arithmetic mean of each row of ratings in Table 5. Column 7 of the Table contains the calculated arithmetic mean for each row. For example, the "4.67" in Row 1, Column 7 is the arithmetic mean of Row 1, Columns 1-6. To convert the arithmetic mean of each Strategic Outcome to the Outcome's RMI, the numbers in column 7 were normalized and placed in Column 8. Normalization was done by dividing a Strategic Outcome's arithmetic mean by the sum of all arithmetic means in Column 7 and placing the result in Column 8.

For example, the calculated RMI for Strategic Outcome #1, "Safe, Healthy Community" is "0.42." This was computed by dividing the arithmetic mean for that row, "4.67," by "11.2," which is the sum of all arithmetic means in Column 7. Note that the sum of all RMIs in Column 8 is equal to one ("1.00"), thus verifying that normalization has been achieved in the RMI calculations.

Also note that the normalization of arithmetic means to compute the RMI's of Strategic Outcomes is an approximation in order to simplify the original AHP calculation process. The exact value of a Strategic Outcome's RMI would be determined by calculating the Eigenvector of each Outcome's six normalized ratings (Saaty 2005). However, Eigenvalue calculations are complex and the difference between the Eigenvector value and the arithmetic average value is less than 10%, an acceptable difference for purposes of AHP. (Kostlan 1991)

The Team's final action in Step 1 was to determine whether the Senior Leaders had been consistent in their survey choices (Teknomo, 2006). For example, if the Senior Leader Survey initially affirmed that the "Safe, Healthy Community" Outcome is more important to County Mission performance than the "Balanced Growth" Outcome, and that the "Balanced Growth" Outcome is more important to County Mission performance than the "Efficient Transportation" Outcome, it would be inconsistent for Senior Leaders to affirm that the "Efficient Transportation" Outcome is more important to County Mission performance than the "Safe, Healthy Community" Outcome (if A>B and B>C it would be inconsistent to say that A<C).

As a check on Senior Leader consistency, a Consistency Ratio for the matrix was calculated as follows:

- Multiply the RMI for Strategic Outcome #1 (Safe, Healthy Community) found in Row 1, Column 8 of Table 5 by the sum of the ratings in Table 5, Column 1, which is labeled "Safe, Healthy Community." The product of "0.42" times "2.12 is 0.88, which is entered in Cell (1,9) of Table 5, in the column labeled "RMI times Sum."
- Repeat the same multiplication for each of the other Strategic Outcomes, e.g., multiply the RMI of Row 2 in Table 5 (0.23) by the sum of Column 2 in Table 5 (5.73) and enter the product (1.31) in Cell (2,9) of Table 5, etc., etc.
- And then, sum the numbers in Column 9 of Table 5 and enter the total of "6.51" in the "Sum" row below column 9 of Table 5.
- Next, calculate the matrix Consistency Index (CI) with the equation in (Saaty 2005):

  CI= [(Column 9 total) – n)]/(n-1),

  where n = the number of County Strategic Outcomes (6)

  CI= (6.51-6)/(6-1)= 0.43/5= 0.10.

Therefore, the Consistency Index (CI) for the Senior Leader Survey of County Strategic Outcomes was 0.10.

In order to verify whether the Consistency Index (CI) was adequate, Saaty (2005) suggests using the Consistency Rate (CR), which is determined by the ratio between the computed Consistency Index and a Random Consistency Index (RI). The matrix will be considered consistent if the resulting ratio is less than 10%, and Saaty gives the calculation of the Consistency Rate by the following formula:

Consistency Rate (CR) = Consistency Index (CI)/Random Consistency Index (RI)

CR = 0.10/1.24 = 0.08

Where the RI value is fixed and is based on six (n=6) Strategic Outcomes, as shown in Table 6.

Table 6: Random Consistency Indices (RI)
Source: Saaty 2005

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Therefore, the Consistency Rate (CR) for the initial Senior Leader Survey of County Strategic Priorities was 0.08. And, since the CR of the matrix was less than 10%, the matrix was considered to be consistent. If the CR had turned out to be 0.10 or greater, the matrix would have been considered inconsistent and would have to be returned to Senior Leaders for more discussion and adjustment.

The Team entered Senior Leaders' consistent assignment of Relative Mission Importance (RMI) among the six County Strategic Outcomes in the Step 1 Portion of the Roadmap for Computing eMDI (Figure 5).

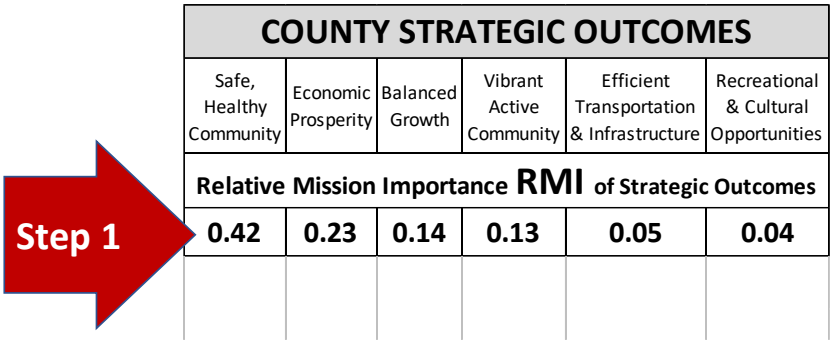


Figure 5: Completed Step 1 Portion of the Roadmap for Computing eMDI
Source: Authors

Figure 6 is a graphical representation of Figure 5. It shows, among many things, that County Senior Leaders believe that achieving a Safe, Healthy Community (RMI=0.42) is at least ten times more important" in terms of County Mission than providing Recreational and Cultural Opportunities (RMI=0.04). These RMIs of Strategic Outcomes play a central role in the following steps of calculating an eMDI metric for each County Facility/Functional Area.

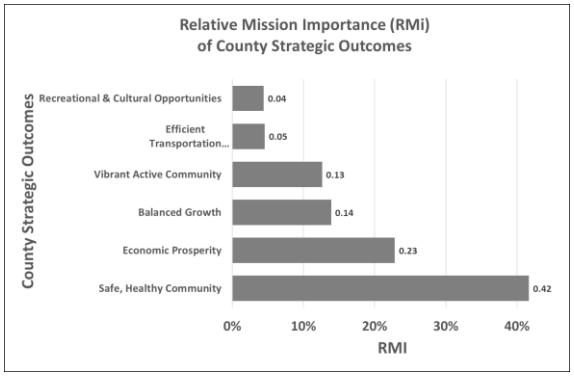


Figure 6: Relative Mission Importance (RMI) of County Strategic Outcomes

Source: Authors

Step 2. Compute Relative Strategic Importance (RSI) of Each County Mission-Function

After having established Relative Mission Importance (RMI) of each County Strategic Outcome in Step 1, it was now possible for the Team to determine relative mission importance among the ten (10) County Mission-Functions in terms of prioritized County Strategic Outcomes. In the same manner that the Relative Mission Importance (RMI) among County Strategic Outcomes was computed in terms of contribution to County Mission, County Mission-Functions were pair-wisely compared in terms of contribution to each County Strategic Outcome.

The ten (10) different County Mission-Functions in our hypothetical example, which must be assigned Relative Strategic Importance (RSI), were listed in Figure 7, which is the Step 2 portion of the Roadmap for Computing eMDI.

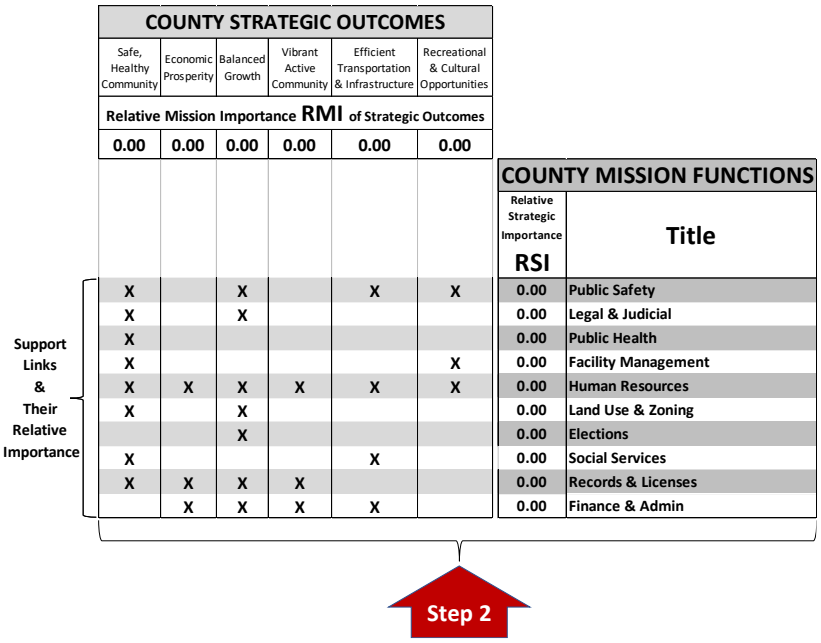


Figure 7: Step 2 Portion of the Roadmap for Computing eMDI
Source: Authors

The Team appointed by Senior Leaders to implement eMDI could now compute a Relative Strategic Importance (RSI) of each County Mission-Function. Applying the AHP method, they first, pair-wisely compared the specific Mission-Functions supporting each County Strategic Outcome, as identified by the "X's" in Figure 7. For example, since County Strategic Outcome #1 ("Safe, Healthy Community") is enabled by eight of the ten Mission-Functions, only the eight Mission Functions were pair-wisely compared with respect to contribution to a "Safe, Healthy Community." The Saaty Risk Key was used again to assign numbers to the pair-wise comparisons. Table 7 is the matrix the Team used to pair-wisely compare the relative importance of the eight Mission-Functions contributing to Strategic Outcome #1 in terms of Strategic Objective #1.

Table 7: Step 2- Computing Partial RSIs of the 8 Mission-Functions contributing to Strategic Outcome #1
Source: Authors

		1	2	3	4	5	6	8	9	11	12	13
	MISSION FUNCTIONS	Public Safety	Legal & Judicial	Public Health	Facility Mgt	Human Resources	Land Use & Zoning	Social Services	Records & Licenses	Average	Partial RSI	RMI times SUM
1	Public Safety	1	5	1	5	5	7	7	7	4.75	0.31	0.94
2	Legal & Judicial	0.20	1	0	1	1	1	3	3	1.30	0.08	1.24
3	Public Health	1.00	5.00	1	5	5	7	7	7	4.75	0.31	0.94
4	Facility Management	0.20	1.00	0.20	1	1	3	3	1	1.30	0.08	1.24
5	Human Resources	0.20	1.00	0.20	1.00	1	1	3	1	0.99	0.06	1.05
6	Land Use & Zoning	0.14	1.00	0.14	0.33	1.00	1	1	1	0.64	0.04	0.96
8	Social Services	0.14	0.33	0.14	0.33	0.33	1.00	1	0	0.45	0.03	0.82
9	Records & Licenses	0.14	0.33	0.14	1.00	2.00	2.00	3.00	1	1.20	0.08	1.59
	Sum	3.03	14.67	3.03	14.67	16.33	23.00	28.00	20.33	15.38	1.00	8.77
											CI	0.11
											CR	0.08

Partial RSI's of each Mission-Function with respect to County Strategic Outcome #1 ("Safe, Healthy Community") are then determined by calculating the arithmetic average of each row of ratings in the eight Columns of Table 8. Column 11 of the Table contains the calculated arithmetic average for each Mission-Function. For example, the "4.75" in Row 1, Column 11 is the arithmetic average of Row 1, Columns 1 – 6, 8 & 9. To convert the arithmetic average of each Mission-Function to the Mission-Function's RSI, the numbers in column 11 are normalized and placed in Column 12. Normalization is done by dividing a Mission-Function's arithmetic average by the sum of all arithmetic averages in Column 11 and placing the results in Column 12.

For example, the calculated RSI for Mission-Function #1, "Public Safety" is "0.31." This was computed by dividing the arithmetic average for Mission-Function #1, "4.75," by "15.09," which is the sum of all arithmetic averages in Column 11. Note that the sum of all Partial RSI's in Column 12 is equal to one ("1.00"), thus verifying that normalization has been achieved in the Partial RSI calculations.

The final action in computing the Partial RSI's in terms of Strategic Outcome #1 is to determine whether Senior Leaders have been consistent in their survey choices. For this purpose, a Consistency Ratio (CR) for the matrix is calculated, as follows:

- Multiply the Partial RSI for Mission-Function #1 (Public Safety) found in Row 1, Column 12 of Table 8 by the sum of the ratings for Mission-Function #1 in the bottom row of Table 8, Column 1 which is labeled "Public Safety." The product of "0.31" times "3.03" is 0.94, which is entered in Cell (1,13) of Table 8, in the column labeled "RSI times SUM."

- Repeat the same multiplication for each of the other Mission-Functions in Table 8; e.g., multiply the Partial RSI of Row 2, Column 12 of Table 8 (0.08) by the sum of Column 2 in Table 8 (14.67) and enter the product (1.24) in Cell (2,13) of Table 8, etc., etc.

- Then, sum the numbers in Column 13 of Table 8 and enter the total of "8.77" in the "Sum" row below column 13 of Table 8.

- Next, calculate the matrix Consistency Index (CI) with the equation:

CI = [(Column 13 total) – n)]/(n-1), (Saaty 2005)

where n is the number of County Mission-Functions being compared in terms of Strategic Outcome #1 (8)

CI= (8.77 - 8)/(8-1)= 0.77/7= 0.11

Therefore, the Consistency Index (CI) of pairwise comparisons of relevant Mission-Functions in terms of Strategic Outcome #1: Safe, Healthy Community is 0.11.

In order to verify whether the Consistency Index (CI) is adequate, compute the Consistency Rate (CR), which is determined by the ratio between the computed Consistency Index (CI) and the Random Consistency Index (RI) for n=8 from Table 6.

Consistency Rate (CR) = Consistency Index (CI)/Random Consistency Index (RI)

CR = 0.11/1.41 = 0.08

Therefore, the Consistency Index (CI) of pairwise comparisons of relevant Mission-Functions in terms of Strategic Outcome #1: Safe, Healthy Community is 0.08. And, since the CR of the matrix is less than 10%, the matrix can be considered to be consistent. If the CR had turned out to be 0.10 or greater, the matrix would be considered inconsistent and would have to be returned to those appointed by Senior Leaders to implement eMDI for more discussion and adjustment.

Since the Consistency Rate for this matrix checks out to less than 10%, the matrix can be considered consistent, and the Partial RSI's of each Mission-Function with respect to County Strategic Outcome #1 ("Safe, Healthy Community") are entered in the Step 2 portion of the Roadmap for Computing eMDI, replacing the appropriate "X's" in the column marked "Safe, Healthy Community." See Figure 8, below.

Repeating the same process, all Partial RSI's of all relevant Mission-Functions with respect to each of the other five County Strategic Outcomes are then calculated. See Appendix A for details. Then, the Partial RSIs are substituted for the relevant "X's" in the Roadmap for Computing eMDI (Figure 8).

Note the following about Figure 8:

- Partial RSI's for Squad Mission Functions were calculated only for the existing links to County Strategic Outcomes as indicated by the "X's" in Figure 7. The "X's" were pre-determined by mission owners and program SMEs (not facilities specialists).
- No calculations were needed, or performed for non-existent links from any Mission-Function to the two County Strategic Outcomes "Economic Prosperity" or "Efficient Transportation and Infrastructure."
- In Figure 8, the column sums of Mission-Function Partial RSI's for each County Strategic Outcome linked to one or more Mission-Function is 1.00, thus verifying that normalization has been retained in the Partial RSI calculations. It also serves to illustrate that the value of a Partial RSI represents the percent of total support given by a Mission-Function to a specific Strategic Outcome. For example, the Mission Function "Public Safety" is 31% of the total Mission-Function support for County Strategic Outcome "Safe, Healthy Community."

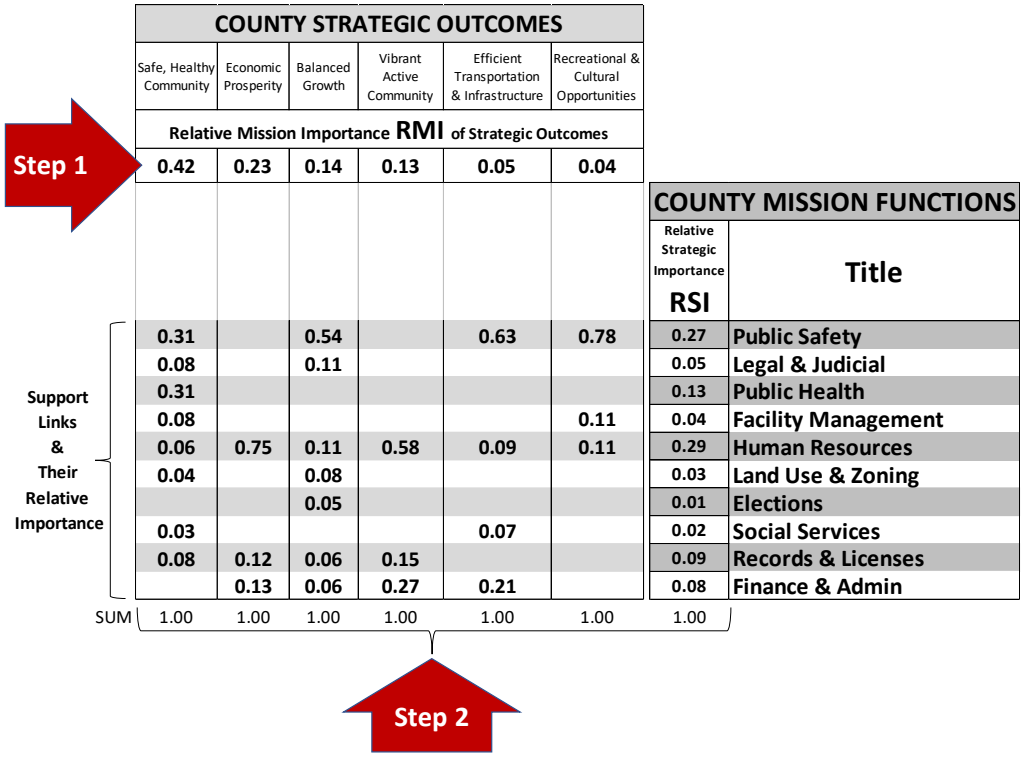


Figure 8: Completed Step 1 & 2 Portions of the Roadmap for Computing eMDI
Source: Authors

The Total Relative Strategic Importance (RSI) of each Mission Function is calculated by multiplying each Partial RSI for the Mission-Function by the RMI of the relevant Strategic Outcome and then summing up the values of each product. For example, Total RSI for the Mission-Function "Public Safety" is computed as follows:

*Total RSI (Public Safety) = (0.42*0.31) + (0.14*0.54) + (.05*0.63) + (.04*0.78) = 0.27*

Figure 9 is a graphical representation of Figure 8. It illustrates that mission stakeholders and County Senior Leaders believe that the most important County Mission Functions in regard to County Mission Accomplishment are Human Resources and Public Safety. All these RSIs together play a central role in the following steps in calculating an eMDI metric for each County Facility/Functional Area.

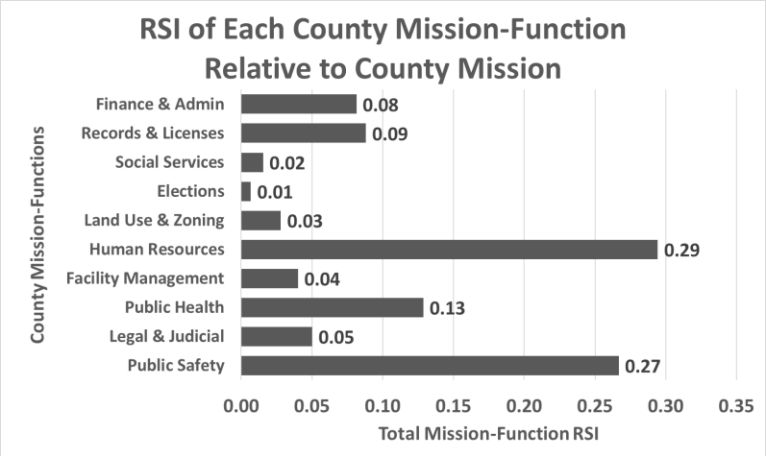


Figure 9: Relative Strategic Importance of County Mission-Functions
Source: Authors

Step 3. Compute an Operational Impact Index (O2I) for Each County Facility/Functional Area

The O2I of a Facility/Functional Area captures perspectives of Facility User/Occupants (not of Facility Specialists). The metric gauges severity of potential impact on User/Occupant performance of assigned Mission-Functions due to a Facility/Functional area's complete nonavailability. O2I is similar in purpose to traditional MDI, but with changes and additions to eliminate many inherent flaws, which have been published over the last two decades.

In concept, the O2I of a Facility/Functional Area is computed by mathematically conjoining User/Occupant estimated values of three indicators: T_{MAX}, L_D and H_O.

1. T_{MAX}: The maximum number of continuous, normal operating hours over a 1-year period (not to exceed 672 continuous hours - a 4-week period) that the most sensitive Mission-Function supported by a particular Facility/Functional Area can be completely unavailable without adversely impacting Use/Occupant performance of the Mission-Function.
2. L_D: The level of difficulty that would be encountered by the organization to continue performing a particular Mission-Function in another permanent or temporary Facility, or by outsourcing the Mission-Function to a service provider, if this particular Facility/Functional Area were to be completely unavailable during normal operating days/hours for longer than the maximum tolerable time period (T_{MAX}) identified in #1.
3. H_O: a Mission-Function's required tempo of operations in relation to required tempo of operations for other Mission-Functions. The number of continuous

An Operational Impact Index is computed for each Facility/Functional Area using Equation 1:

$$O2I = (W1 \times L_D) + (W2 \times (1 - (T_{MAX}/ P_t)) + (W3 \times H_O/8760) \quad \text{Equation 1}$$

Where:

W1 = 60, a weighting factor that assigns 60% of a Facility/Functional Area's O2I to Impact Severity due to estimated difficulty of relocating the Mission-Function.

W2 = 30, a weighting factor that assigns 30% of a Facility/Functional Area's O2I to Impact Severity due to estimated duration of the interruption.

W3 = 10, a weighting factor that assigns 10% of a Facility/Functional Area's O2I to Impact Severity due to the Mission-Function's required tempo of operations.

W1+W2+W3 = 100. Note: the 60/30/10 split of weights W1/W2/W3 were derived by consensus of members of the County Senior Leaders' Team for eMDI Implementation. Appendix B details the process used and shows how any organization can create their own split of weights, if desired, in order to reflect the organization's unique circumstances and needs.

L_D = the highest Level of Difficulty anticipated to continue performing these same Mission-Functions in another permanent or temporary Facility or by outsourcing to a service provider if the Facility/Functional Area were to be completely unavailable during normal operating days/hours for longer than T_{MAX} for Facility/Functional Area. $0 \leq L_D \leq 1$

T_{MAX} = the maximum number of hours over a 4-week period that the most sensitive Mission-Function housed/enabled/supported by the rated Facility/Functional Area can be unavailable without adversely impacting User/Occupant performance of the Mission-Function. $0 \leq T_{MAX} \leq 672$.

P_t = 672, the total number of hours in a 4-week period.

H_O = number of normal hours of actual operation per year (0-8760 hours).

The values of H_O, T_{MAX} and L_D, come from User/Occupant responses to an Operational Impact Survey of the assigned Facility/Functional Area. The responses are treated by the eMDI Implementation Team *in four calculations,* as follows:

Calculation 1 – Finalize and Record the Survey Values of H_O for Each Facilities/Functional Area

Question 1 of the Operational Impact Survey of Mission-Function Vulnerability asks the User/Occupant to state: a. the normal operating hours per week, and b. the normal operating weeks per year of the Mission-Functions that are housed/enabled/supported by the User/Occupant's Facility/Functional Area. Calculate H_O as the arithmetic product of User/Occupants' answers to Survey Questions 1.a and 1.b and transcribe the product H_O to an Excel spreadsheet similar to Figure 9. Figure 9 is an expanded and completed Step 3 Portion of the Roadmap for Computing eMDI. For example, the User/Occupants of Facility A answered Questions 1.a and 1.b with "45 hours/week" and 52 weeks/year. The Team multiplied 45 by 52 and transcribed the product, 2340, to the Q1 row in the A column of Figure 9.

Survey Question Number	COUNTY FACILITY/FUNCTIONAL AREAS																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Q1. H_o (0 to 8760 hrs/year)	2340	1188	2464	1196	5092	2484	4264	45	1960	1665	4674	702	4017	4740	7500	6192	5814	6862	2822	646
Q2. T_{MAX} (0-672 hrs per 4-week period)	40	69	214	372	52	267	582	170	39	227	392	140	94	414	654	295	131	312	518	497
Q3. L_D = Answers converted to Table 9 values	1.000	0.249	0.099	0.699	0.249	0.849	0.849	0.099	0.849	0.099	0.849	0.699	0.549	0.249	0.099	0.390	0.549	0.099	0.390	0.699
Operation Impact Index **O2I** of each Facility/Functional Area																				
	91	43	29	57	48	72	60	28	81	28	69	66	63	32	15	47	64	30	33	50

Step 3

Figure 9: Expanded and Completed Step 3 portion of the Roadmap for Computing eMDI
Source: Authors

Calculation 2- Record each Facility/Functional Area's Maximum Allowable Time of Mission-Function Interruption (T_{MAX})

Question 2 of the Operational Impact Survey of Mission-Function Vulnerability asks the User/Occupant to estimate the maximum number of normal operating hours over a 4-week period that the Mission-Function least tolerable to non-availability of the supporting Facility/Functional Area can be completely unavailable without adversely impacting performance of the Mission-Function. Transcribe the User/Occupants' answers to Survey Question 2 to the expanded Step 3 Portion of the Roadmap for Computing eMDI (Figure 9). For example, the User/Occupants of Facility A answered Question 2 with "40 hours/4-week period." So, the Team entered 40 in the Q2 row of A column of Figure 9.

Calculation 3- Ascertain each Facility/Functional Area's Highest Level of Difficulty Score (L_D)

Question 3 of the Operational Impact Survey asks the User/Occupant to select the highest level of difficulty that would be encountered if the User/Occupant's Facility/Functional Area became completely unavailable and continued performance of assigned Mission-Functions required relocating the Mission-Function to another permanent or temporary Facility, or by outsourcing the Mission-Function to a service provider.

Facility User/Occupants answer Question 3 by selecting one of seven, pre-defined difficulty levels. The survey provides a detailed verbal definition of each Level of Difficulty (Table 4) in order to help survey participants decide among the seven options, thereby reducing subjectivity of responses.

The seven, defined Levels of Difficulty are listed in the first column of Table 9, and the Senior Leaders' appointed Team for eMDI Implementation employed the corresponding numerical rating in the table as input to the O2I equation. For example, the User/Occupants of Facility A answered Question 3 with "Level 7." So, the Team entered "1.000 in the Q3 row in the A column of Figure 9.

Table 9: Key for Converting Survey Question 3 Answers to L_D
Source: Authors

Level of Difficulty	L_D
7	1.000
6	0.848
5	0.652
4	0.544
3	0.334
2	0.203
1	0.107

Note: the set of L_D values given in Table 9 were derived by consensus of members of the County Senior Leaders' Team for eMDI Implementation. Appendix C details the process used and shows how any organization can create its own set of L_D's, if desired, in order to reflect the organization's unique circumstances and needs.

Calc 4-Compute each Facility/Functional Area's Operational Impact Index (O2I)

The O2I for each Facility/Functional Area was computed simply by substituting in Equation 1 the O2I Survey values for H_o, T_{MAX} and L_D recorded for the Facility/Functional Area, and then entering in Figure 9 the results of the calculations for each Facility/Functional Area. For example, the User/Occupants of Facility A calculated O2I for Facility A as:

$$O2I = (W1 \times L_D) + (W2 \times (1 - (T_{MAX}/ P_t)) + (W3 \times H_O/8760)$$

$$= (60 \times 1) + (30 \times (1 - (40/672)) + (10 \times 2340/8760)$$

$$= 60 + (30 \times (1 - 0.059)) + (10 \times 0.267)$$

= 60 + (30 x 0.941) + 2.67
= 60 + 28.23 + 2.67
= 91

The computed value of O2I = 91 for Facility A was entered in Figure 9 to the last row in Column A and the Team repeated the process for each Facility/Functional Area.

Step 4. Compute an eMDI for each County Facility/Functional Area

Having computed the Relative Strategic Importance (RSI) of each County Mission-Function in Step 2, as well as the Operational Importance Index (O2I) of each Facility/Functional Area in Step 3, it is now possible to compute an eMDI for each Facility Functional Area. The computation uses the Step 4 portion of the Roadmap for Computing eMDI shown in Figure 10.

		COUNTY FACILITY/FUNCTIONAL AREAS																				
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
		Operation Impact Index O2I of each Facility/Functional Area																				
		86	30	28	28	14	12	52	31	16	8	19	19	13	18	55	9	7	39	11	27	
COUNTY MISSION FUNCTIONS																						
Relative Strategic Importance RSI	Title																					
0.27	Public Safety	0.27	0.27	0.27		0.27		0.27		0.27												
0.05	Legal & Judicial		0.05			0.05		0.05		0.05					0.05							
0.13	Public Health	0.13	0.13	0.13		0.13		0.13		0.13												
0.04	Facility Management	0.04			0.04	0.04					0.04					0.04	0.04	0.04	0.04			
0.29	Human Resources			0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29										
0.03	Land Use & Zoning					0.03		0.03		0.03				0.03							0.03	
0.01	Elections				0.01				0.01			0.01		0.01								
0.02	Social Services										0.02		0.02	0.02						0.02		
0.09	Records & Licenses																		0.09		0.09	
0.08	Finance & Admin													0.08								
1.00	TOTALS	0.44	0.45	0.69	0.34	0.81	0.29	0.77	0.30	0.77	0.35	0.30	0.02	0.13	0.05	0.04	0.04	0.04	0.13	0.02	0.12	
	SUM/PRODUCT	37.57	13.59	19.06	9.65	11.15	3.43	40.12	9.32	12.67	2.65	5.61	0.30	1.74	0.91	2.19	0.35	0.29	5.06	0.18	3.17	179.00 Row Total
		enhanced Mission Dependency Index eMDI of Facility/Functional Areas																				
	NORMALIZED SUM/PRODUCT	21.0	7.6	10.6	5.4	6.2	1.9	22.4	5.2	7.1	1.5	3.1	0.2	1.0	0.5	1.2	0.2	0.2	2.8	0.1	1.8	100.00 Row Total

Step 4

Figure10: Completed Step 4 portion of the Roadmap for Computing eMDI
Source: Authors

Step 4 calculates eMDI values using Equation 2:

$$eMDI_n = O2I_n + (O2I_n \times \sum \text{Relevant RSI's})$$

$$= O2I_n \times (1 + \sum \text{Relevant RSI's}) \qquad \text{Equation 2}$$

Where:

$eMDI_n$ = eMDI for Facility/Functional Area "n"

$O2I_n$ = O2I for Facility/Functional Area "n"

$\sum$Relevant RSI's = sum of RSI's for Facility/Functional Area "n"

The Team's first action in Step 4 is shown in Figure 10, which is the expanded Step 4 portion of the Roadmap. The RSI computed for the "Public Safety" Mission-Function in Step 2 (0.27) was substituted across the row in place of each relevant, pre-determined "X." This substitution was then repeated across all rows for each of the other Mission-Function RSIs.

Then, the Team added the RSIs in the Facility A column and placed the column sum (0.44) below the column. Then, as prescribed by Equation 2, the Team multiplied the sum by the Facility A O2I from Step 3 (86) to yield a Sum/Product for Facility A (37.57). This sum/product process was repeated for each of the other Facility/Functional Areas and the results placed in the appropriate column on the row marked "Sum/Product." Finally, the numbers in the row marked "Sum/Product" were normalized and multiplied by 100 to yield the eMDI for each Functional Area.

Figure11 is a graphical representation of the Team-calculated eMDIs for each County Facility/Functional Area as shown in Figure 10. It illustrates that County mission stakeholders and Senior Leaders believe that the County's 20 Facilities/Functional Areas provide varying degrees of support to mission accomplishment and that it is possible to quantify relative facility mission importance with increased certainty not provided by the flawed traditional MDI metric.

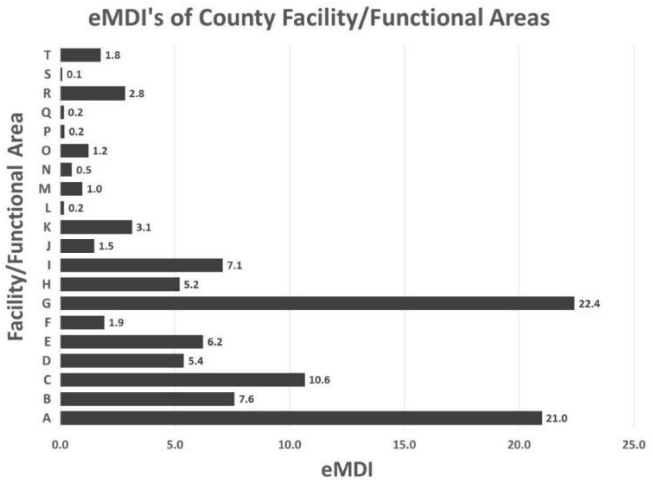


Figure 11: Computed eMDIs of County Facilities/Functional Areas
Source: Authors

Conclusion

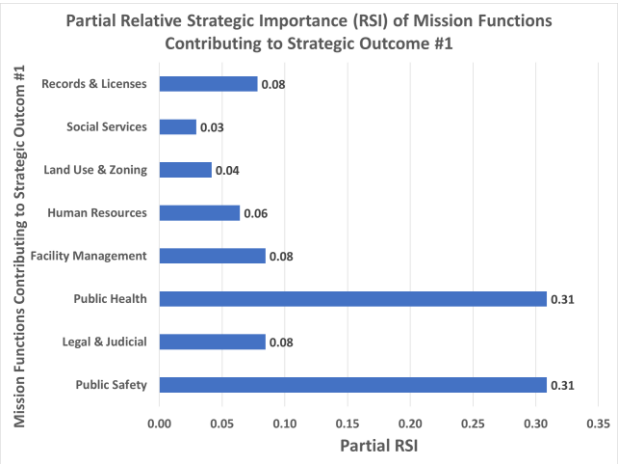
Replacing the flawed but widely-used traditional Mission Dependency Index (MDI) with a greatly improved metric called enhanced Mission Dependency Index (eMDI) is moderately easy, fairly inexpensive and can help Senior Leaders and Facility Specialists make better informed decisions about Facility renewal funding. Better informed decisions will help optimize the allocation of scarce resources to the most important, strategic needs of the organization, while increasing decision transparency and acceptance. Any public or private organization that depends on owned facilities to achieve strategic outcomes can improve funding decisions involving Facility renewal by replacing the traditional MDI metric with the proposed improved eMDI metric. Senior Leaders, Mission Stakeholders, Facility Specialists and their organizations will benefit from the quantitative, strategic insights of eMDI not available from traditional MDI.

Appendix A

This Appendix contains the pairwise-comparison matrices for calculating all Partial RSI's of all relevant Mission-Functions with respect to each of the six County Strategic Outcomes.

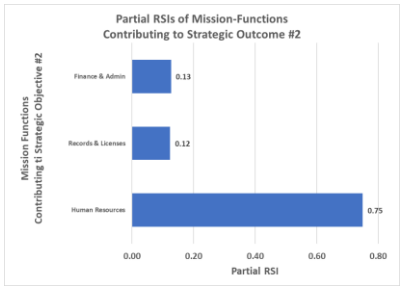
Partial RSIs of the 8 Mission-Functions Contributing to Strategic Outcome #1 : Safe, Healthy Community

	MISSION FUNCTIONS	1 Public Safety	2 Legal & Judicial	3 Public Health	4 Facility Mgt	5 Human Resources	6 Land Use & Zoning	8 Social Services	9 Records & Licenses	11 Average	12 Partial RSI	13 RMI times SUM
1	Public Safety	1	5	1	5	5	7	7	7	4.75	0.31	0.94
2	Legal & Judicial	0.20	1	0	1	1	1	3	3	1.30	0.08	1.24
3	Public Health	1.00	5.00	1	5	5	7	7	7	4.75	0.31	0.94
4	Facility Management	0.20	1.00	0.20	1	1	3	3	1	1.30	0.08	1.24
5	Human Resources	0.20	1.00	0.20	1.00	1	1	3	1	0.99	0.06	1.05
6	Land Use & Zoning	0.14	1.00	0.14	0.33	1.00	1	1	1	0.64	0.04	0.96
8	Social Services	0.14	0.33	0.14	0.33	0.33	1.00	1	0	0.45	0.03	0.82
9	Records & Licenses	0.14	0.33	0.14	1.00	2.00	2.00	3.00	1	1.20	0.08	1.59
	Sum	3.03	14.67	3.03	14.67	16.33	23.00	28.00	20.33	15.38	1.00	8.77
											CI	0.11
											CR	0.08



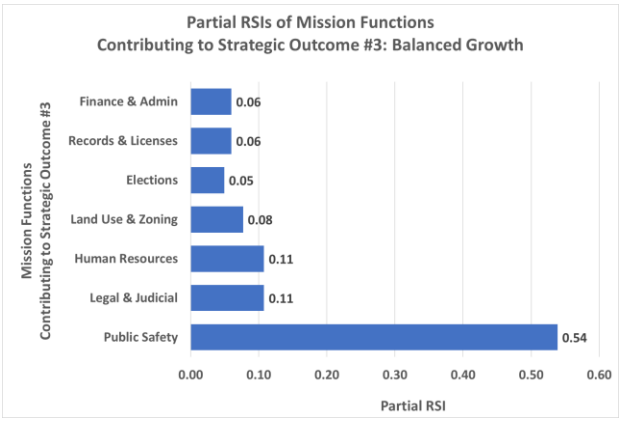
Partial RSIs of the 3 Mission-Functions Contributing to Strategic Outcome #2: Economic Prosperity

	MISSION FUNCTIONS	5 Human Resources	9 Records & Licenses	10 Finance & Admin	11 Average	12 Partial RMI	13 RMI times SUM
5	Human Resources	1	7.00	5.00	4.33	0.75	1.01
9	Records & Licenses	0.14	1	1.00	0.71	0.12	1.112
10	Finance & Admin	0.20	1.00	1	0.73	0.13	0.888
	Sum	1.34	9.00	7.00	5.78	1.00	3.01
						CI	0.00
						CR	0.01



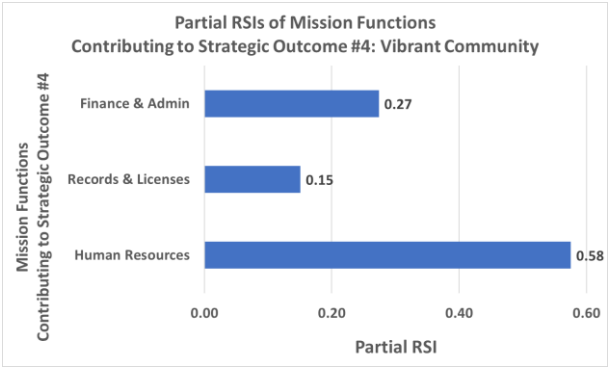
Partial RSIs of the 7 Mission-Functions Contributing to Strategic Outcome #3: Balanced Growth

	MISSION FUNCTIONS	1 Public Safety	2 Legal & Judicial	5 Human Resources	6 Land Use & Zoning	7 Elections	9 Records & Licenses	10 Finance & Admin	11 Average	12 Partial RMI	13 RMI times SUM
1	Public Safety	1	5	5	7	9	9	9	6.43	0.54	1.01
2	Legal & Judicial	0.20	1	1.0	1.4	1.8	1.8	1.8	1.29	0.11	0.96
5	Human Resources	0.20	1.00	1	1.40	1.80	1.80	1.80	1.29	0.11	0.96
6	Land Use & Zoning	0.14	0.71	0.71	1	1.29	1.29	1.29	0.92	0.08	1.01
7	Elections	0.11	0.11	0.11	0.78	1	1.0	1.0	0.59	0.05	0.83
9	Records & Licenses	0.11	0.56	0.56	0.78	1.00	1	1.00	0.71	0.06	1.01
10	Finance & Admin	0.11	0.56	0.56	0.78	1.00	1.00	1	0.71	0.06	1.01
	Sum	1.88	8.94	8.94	13.13	16.89	16.89	16.89	11.93	1.00	6.80
										CI	0.16
										CR	0.13



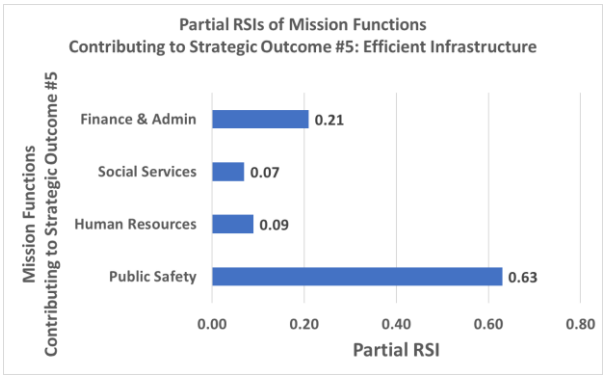
Partial RSIs of the 3 Mission-Functions Contributing to Strategic Outcome #4: Vibrant Community

	MISSION FUNCTIONS	5 Human Resources	9 Records & Licenses	10 Finance & Admin	11 Average	12 Partial RMI	13 RMI times SUM
5	Human Resources	1	3.00	3.00	2.33	0.58	0.96
9	Records & Licenses	0.33	1	0.50	0.61	0.15	0.904
10	Finance & Admin	0.33	2.00	1	1.11	0.27	1.233
	Sum	1.67	6.00	4.50	4.06	1.00	3.10
						CI	0.05
						CR	0.08



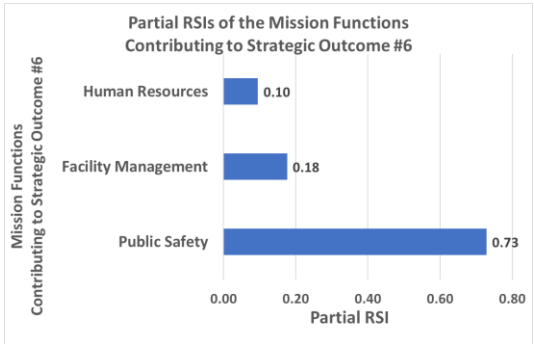
Partial RSIs of the 4 Mission-Functions Contributing to Strategic Outcome #5: Efficient Infrastructure

	MISSION FUNCTIONS	1 Public Safety	5 Human Resources	8 Social Services	10 Finance & Admin	11 Average	12 Partial RMI	13 RMI times SUM
1	Public Safety	1	7.00	9.00	3.00	5.00	0.63	1.00
5	Human Resources	0.14	1	1.29	0.43	0.71	0.09	1.000
8	Social Services	0.11	0.78	1	0.33	0.56	0.07	1.000
10	Finance & Admin	0.33	2.33	3.00	1	1.67	0.21	1.000
	Sum	1.59	11.11	14.29	4.76	7.94	1.00	4.00
							CI	0.00
							CR	0.00



Partial RSIs of the 3 Mission-Functions Contributing to Strategic Outcome #6: Recreation/Culture

	MISSION FUNCTIONS	1 Public Safety	4 Facility Management	5 Human Resources	11 Average	12 Partial RMI	13 RMI times SUM
1	Public Safety	1	7.00	5.00	4.33	0.73	0.98
4	Facility Management	0.14	1	2.00	1.05	0.18	1.497
5	Human Resources	0.20	0.50	1	0.57	0.10	0.762
	Sum	1.34	8.50	8.00	5.95	1.00	3.24
						CI	0.12
						CR	0.20



Appendix B - Calculating the O2I Weighting Factors

This Appendix details how members of the County Senior Leaders' Team for eMDI Implementation applied the pairwise comparison technique of the AHP process (Saaty, 2005) to derive the 60/30/10 consensus split of weights (W1, W2 and W3) for the O2I formula. By following these same steps, any organization can do the same, if desired, to calculate a different consensus split that better reflects the organization's unique circumstances and needs.

First, the Team constructed the simple matrix shown in Table B for pairwisely comparing the three weights (W1, W2 and W3) in terms of relative importance to potential impact on User/Occupant performance of assigned Mission-Functions due to a Facility/Functional area's complete nonavailability.

Table B: Using AHP to Compute Relative Weights of Each County Strategic Outcome
Source: Authors

			Column Numbers						
			1	2	3	4	5	6	7
			W1	**W2**	**W3**				
Row Number	O2I Weights		Due to Estimated Difficulty of Relocation	Due to Estimated Duration of Interruption	Due to Required Tempo	Row Average	Value of Weight (0 - 1.00)	Value of Weight (0 - 100)	Weight Value times Weight SUM
1	**W1**	Due to Estimated Difficulty of Relocation	**1**	**3.00**	**5.00**	**3.00**	**0.605**	**60.5**	**0.93**
2	**W2**	Due to Estimated Duration of Interruption	**0.33**	**1**	**3.00**	**1.44**	**0.291**	**29.1**	**1.263**
3	**W3**	Due to Required Tempo	**0.20**	**0.33**	**1**	**0.51**	**0.103**	**10.3**	**0.928**
4		Sum	1.53	4.33	9.00	4.96	1.00	100.00	3.12
									0.06 CI
									0.10 CR

Then, using Saaty's relative importance scale shown in Figure X, the Team made and recorded the three, required comparisons: W1 to W2 = 3, W1 to W3 = 5 and W2 to W3 = 3.

Rating Key	Numerical Rating
A- Extremely More Important	**9.00**
B- Far More Important	**7.00**
C- Significantly More Important	**5.00**
D- Slightly More Important	**3.00**
E- Equally Important	**1.00**
F- Slightly Less Important	**0.33**
G- Significantly Less Important	**0.20**
H- Far Less Important	**0.14**
I- Extremely Less Important	**0.11**

Figure 2: Pairwise Relative Importance Scale
Author: Saaty (2005)

Note the following about the Team's completed Table B:

- The 3 pairwise ratings in the lower, left half of the matrix (the cells in Columns 1-2 below the shaded diagonal cells) are the reciprocals of the numeric rating appearing in the mirrored cell in the upper right, above the shaded cells. For example, the 0.20 in cell Row 3 Column I is the relative mission importance of "W3" in respect to "W1." The 0.20 was not directly assigned by the Team. Instead, it is the reciprocal of the "5" in cell Row 1, Column 3, which is the Team rating of "W1's" relative impact importance in respect to "W3."

- The sum of the ratings in each column (1 thru 3) is also included at the bottom of each column in Table B. These sums were used later in this computation.

The Relative Weighting Factors (W1, W2 and W3) of the O2I formula were determined by first calculating the arithmetic mean of each row of ratings in Table B. Column 4 contains the calculated arithmetic mean for each row. For example, the "3.00" in Row 1, of Column 4 is the arithmetic mean of Row 1, Columns 1, 2 and 3.

To convert the arithmetic mean of each row to the Value of the Weight on a scale of 0 to 1.00, the numbers in Column 4 were normalized and placed in Column 5. Normalization was done by dividing a "Row's Average" in Column 4 by the sum of all arithmetic means in Column 4 and placing the result in Column 5. Then, each "Value of the Weight (0 – 1.00)" was multiplied by 100 and placed in Column 6.

For example, the calculated W1 on a scale of 0 to 1.000 is "0.605." This was computed by dividing the arithmetic mean for that row, "3.00," by "4.96," which is the sum of all arithmetic means in Column 4. The W1 of 0.605 on a scale of 0-1.000 was converted to 60.5 on a scale of 0 to 100 by multiplying the 0.605 by 100 and placing the result in Column 6.

Note that the sum of all W's in Column 5 is equal to one ("1.00"), thus verifying that normalization has been achieved in the W calculations. Also note that the normalization of arithmetic means to compute the W's on a scale of 0 to 1.000 is an approximation in order to simplify the original AHP calculation process. The exact value of a W would be determined by calculating the Eigenvector of the three normalized ratings (Saaty 2005). However, Eigenvalue calculations are complex and the difference between the Eigenvector value and the arithmetic average value is less than 10%, an acceptable difference for purposes of AHP. (Kostlan 1991)

The Team's final action was to determine whether it had been consistent in their pairwise comparisons (Teknomo, 2006). As a check on consistency, a Consistency Ratio for the matrix was calculated as follows:

- Multiply the Value of W1 (0 – 1.000) found in Row 1, Column 5 of Table X by the sum of the ratings in Table X, Column 1, which is labeled "W1." The product of "0.805" times "1.53" is "0.93," which is entered in Cell (1,7) of Table 5, in the column labeled "Weight Value times Weight Sum."
- Repeat the same multiplication for W2 and W3, e.g., multiply the Value of W2 (0 – 1.000) found in Row 1, Column 2 of Table X (0.291) by the sum of Column 2 in Table X (4.33) and enter the product (1.263) in Cell (2,7) of Table 5, etc.
- And then, sum the numbers in Column 7 of Table X and enter the total of "3.12" in the "Sum" row below column 9 of Table 5.
- Next, calculate the matrix Consistency Index (CI) with the equation from (Saaty 2005):

  CI= [(Column 7 total) – n)]/(n-1),

  where n = the number of W's (3)

  CI= (3.12 - 3)/(3-1)= 0.12/2= 0.06.

Therefore, the Consistency Index (CI) for the Team's pairwise comparisons was 0.06.

In order to verify whether the Consistency Index (CI) was adequate, Saaty (2005) suggests using the Consistency Rate (CR), which is determined by the ratio between the computed Consistency Index and a Random Consistency Index (RI). The matrix is considered consistent if the resulting ratio is less than 10%, and Saaty gives the calculation of the Consistency Rate by the following formula:

Consistency Rate (CR) = Consistency Index (CI)/Random Consistency Index (RI)

CR = 0.06/0.58 = 0.10

Where the RI value is fixed and is based on six (n=6) Strategic Outcomes, as shown in Table Y.

Table 6: Random Consistency Indices (RI)
Source: Saaty 2005

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Therefore, the Consistency Rate (CR) for the Team's pairwise comparisons of W1, W2 and W3 was 0.10. And, since the CR of the matrix was 10% or less, the matrix was considered to be consistent. If the CR had turned out to be greater than 10%, the matrix would have been considered inconsistent and the Team would have to continue discussion and adjustment.

Figure 6 is a graphical representation of Figure B. It shows that the County Team for eMDI Implementation believes that Impact Severity due to difficulty of relocating a Mission-Function is two times more important than Impact Severity due to duration of the interruption, and six times more important than Impact Severity due to required tempo of operations. These weights, when rounded to 60/30/10, play a central role in the steps of calculating O2I and eMDI metrics for each County Facility/Functional Area.

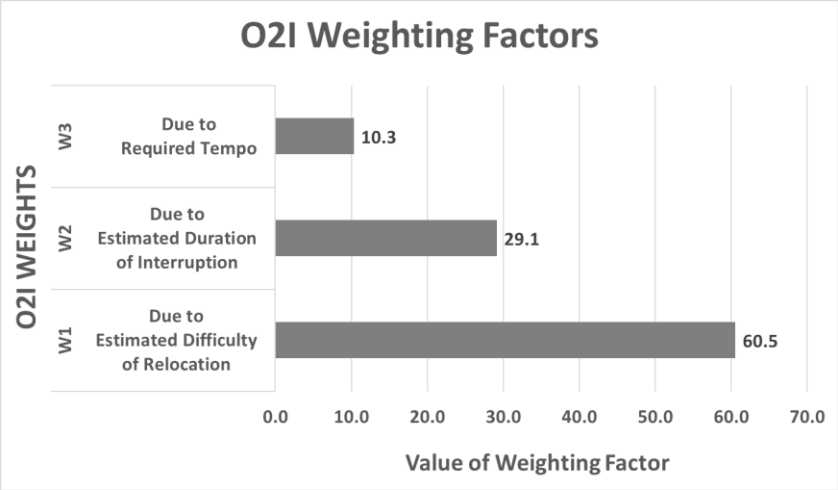


Figure X: Relative Weights of O2I Weighting Factors
Source: Authors

Appendix C – Computing Levels of Difficulty for Table 9

This Appendix details the AHP process used by members of the County Senior Leaders' Team for eMDI Implementation to derive the consensus set of L_D values given in Table 9. By following these same steps, any organization can do the same, if desired, to reflect the organization's unique circumstances and needs.

First, the Team constructed the simple matrix shown in Table C for pairwisely comparing the seven Levels of Difficulty defined in Table 4 (L-1, L-2, . . . L-7). Quantitative comparisons of Difficulty Levels then were made in terms of relative importance to potential impact on User/Occupant performance of assigned Mission-Functions due to a Facility/Functional area's complete nonavailability.

Table C: Using AHP to Compute Levels of Difficulty for Table 9
Source: Authors

								11	12	13	14
7 levels of difficulty	1	2	3	4	5	6	7	Row Avg	Weight Value (0 - 1.00)	WV times Weight SUM	L_D
1	1	0.500	0.333	0.200	0.167	0.143	0.111	0.35	0.03	0.96	0.107
2	2.00	1	0.50	0.33	0.33	0.25	0.25	0.67	0.06	0.96	0.203
3	3.00	2.00	1	0.50	0.50	0.33	0.33	1.10	0.09	1.07	0.334
4	5.00	3.00	2.00	1	0.50	0.50	0.50	1.79	0.15	1.18	0.544
5	6.00	3.00	2.00	2.00	1	0.50	0.50	2.14	0.18	1.15	0.652
6	7.00	4.00	3.00	2.00	2.00	1	0.50	2.79	0.23	1.09	0.848
7	9.00	4.00	3.00	2.00	2.00	2.00	1	3.29	0.27	0.87	1.000
Sum	33.00	17.50	11.84	8.03	6.50	4.73	3.19	12.11	1.00	7.28	3.687
									CI	0.05	
									CR	0.03	

Then, using Saaty's pairwise comparison rating key shown in Figure Y, the Team made and recorded the 21 (7 x 6/2), required comparisons in the cells above and to the right of the shaded diagonal cells.

Rating Key	Numerical Rating
A- Extremely More Important	9.00
B- Far More Important	7.00
C- Significantly More Important	5.00
D- Slightly More Important	3.00
E- Equally Important	1.00
F- Slightly Less Important	0.33
G- Significantly Less Important	0.20
H- Far Less Important	0.14
I- Extremely Less Important	0.11

Figure Y: Pairwise Relative Importance Scale
Author: Saaty (2005)

Note the following about the Team's completed Table C:

- Each of the 21 pairwise ratings in the lower, left half of the matrix (the cells in Columns 1-6 below the shaded diagonal cells) is the reciprocal of the numeric rating appearing in the mirrored cell in the upper right, above the shaded cells. For example, the 3.00 in cell Row 3 Column I is the relative difficulty of "L-3" in respect to "L-1." The 3.00 was not directly assigned by the Team. Instead, it is the reciprocal of the "0.333" in cell Row 1, Column 3, which is the Team rating of "L-1's" relative difficulty compared to "L-3."
- The sums of the ratings in each column (1 thru 7) are included at the bottom of each column. These sums were used later in this computation.

The Levels of Difficulty (L_D's) for Table 9 were determined by first calculating the arithmetic mean of each row of ratings in Table C. Column 11 contains the calculated arithmetic mean for each row. For example, the "0.35" in Row 1, of Column 11 is the arithmetic mean of Row 1, Columns 1 thru 7.

To convert the arithmetic mean of each row to the Row's "Weight Value on a scale of 0 to 1.00," the numbers in Column 11 were normalized and placed in Column 12. Normalization was done by dividing a "Row Average" in Column 11 by the sum of all arithmetic means in Column 11 and placing the result in the same row of Column 12. For example, Row 1's calculated "Weight Value on a scale of 0 to 1.00" is "0.03." This was computed by dividing the arithmetic mean for Row 1, "0.35," by "11.57," which is the sum of all arithmetic means in Column 11.

Note that the sum of all Weight Values in Column 12 is equal to one ("1.00"), thus verifying that a min-max normalization has been achieved in the Weight Value calculations. Also note that the normalization of arithmetic means to compute the Weight Values on a scale of 0 to 1.00 is an approximation in order to simplify the original AHP calculation process. The exact value of a Weight Value would be determined by calculating the Eigenvector of the seven normalized ratings (Saaty 2005). However, Eigenvalue calculations are complex and the difference between the Eigenvector value and the arithmetic average value is less than 10%, an acceptable difference for purposes of AHP. (Kostlan 1991)

The Team's next action was to determine whether it had been consistent in its pairwise comparisons (Teknomo, 2006). As a check on consistency, a Consistency Ratio for the matrix was calculated as follows:

- Multiply the "Weight Value on a scale of 0 to 1.00" for Level of Difficulty 1 (found in Row 1, Column 12 of Table C by the sum of the ratings in Table C, Column 1, which is labeled "Level-1." This product of "0.029" times "33" is "0.96," which is entered in Cell (1,13) of Table C, in the column labeled "Weight Value times Weight Sum."
- Repeat the same multiplication for the Weight Values of Level of Difficulty 2 thru 7, e.g., multiply the Value of "Weight Value on a scale of 0 to 1.00" found in Row 2, Column 12 of Table C (0.60) by the sum of Column 2 in Table C (17.50) and enter the product (0.96) in Cell (2,13) of Table C, etc.
- And then, sum the numbers in Column 13 of Table C and enter the total of "7.28" in the "Sum" row below column 13 of Table C.
- Next, calculate the matrix Consistency Index (CI) with the equation from (Saaty 2005):

$$CI = [(\text{Column 13 total}) - n)]/(n-1),$$

where n = the number of Levels of Difficulty (7)

CI = (7.28 - 7)/(7-1)

= 0.28/6

= 0.05

Therefore, the Consistency Index (CI) for the Team's pairwise comparisons was 0.05

In order to verify whether the Consistency Index (CI) was adequate, Saaty (2005) suggests using the Consistency Rate (CR), which is determined by the ratio between the computed Consistency Index and a Random Consistency Index (RI). The matrix is considered consistent if the resulting ratio is less than 10%, and Saaty gives the calculation of the Consistency Rate by the following formula:

Consistency Rate (CR) = Consistency Index (CI)/Random Consistency Index (RI)

CR = 0.05/1.32 = 0.03

Where the RI value is fixed and is based on seven (n=7) levels of Difficulty, as shown in Table Z.

Table Z: Random Consistency Indices (RI)
Source: Saaty 2005

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Therefore, the Consistency Rate (CR) for the Team's pairwise comparisons of the seven Levels of Difficulty was 0.03. And, since the CR of the matrix was 10% or less, the matrix was considered to be consistent. If the CR had turned out to be greater than 10%, the matrix would have been considered inconsistent and the Team would have to continue discussion and adjustment.

The Team's final step was to place the consistent Weight Values of Column 12 on another ratio scale of 0-1.00 with the highest Weight Value (Level 7 = 0.27) equivalent to 1.00. The Team did this simply by dividing each Weight Value in Column 12 by the highest Weight Value (Level 7 = 0.27) and placing each dividend on the appropriate row in Column14.

Figure X is a graphical representation of Table C, Column 14. These values of L_D play a central role in the steps of calculating O2I and eMDI metrics for each County Facility/Functional Area.

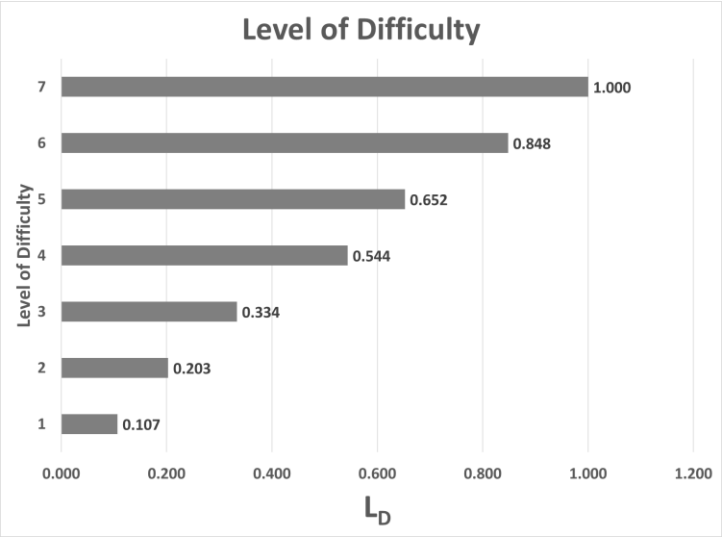


Figure X: Relative Weights of O2I Weighting Factors
Source: Authors

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Disclosure Statement

The views expressed in this paper do not purport to represent the views or policies of any person, group or organization other than the authors.

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