IMPLEMENTATION OF RESEARCH FINDINGS AND PRODUCTS

Guidelines for the Readiness and Implementation of RFID and Wireless Technologies

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Guidelines for the Readiness and Implementation of RFID and Wireless Technologies (GRIT)

Overview

Advancement in sensing and transmitting technologies, such as radio-frequency identification (RFID), barcodes, e-ticketing, global positioning systems, and other associated technologies, has significantly increased the capabilities of these technologies to assist in construction and asset management. Projects where such devices were used reported beneficial outcomes through improved resource and quality management. Wireless transmission technology enables sensing, counting, measuring, documenting, identifying, locating, tracking, and transmitting information in real time. These features can assist in significantly improving construction performance and infrastructure asset management. However, the beneficial outcomes have not yet attracted the highway construction industry to adopt these technologies to their fullest potential compared to other construction sectors.

The technologies evaluated and reported on through this research project are:

1. Radio Frequency Identification (RFID);
2. Barcodes and Readers;
3. Global Positioning System (GPS);
4. Geographic Information System (GIS);
5. Unmanned Aircraft System (UAS);
6. Ground Penetrating Radar (GPR);
7. Light Detecting and Ranging (LiDAR);
8. e-Ticketing;
9. Object Recognition; and
10. Infrared (IR)

The findings and products of NCHRP Project 03-140 address the significant gaps between the capability of existing wireless transmission technologies and their implementation. This techbrief presents the major contributions of the research and then (1) recommends how to best implement the research products; (2) identifies who to assist in applying the products; (3) identifies potential issues with implementation and recommendations to address them; and (4) recommends methods of measuring the impacts with the implementation of the research products.

NCHRP Project 03-140 Products Overview

The primary research products developed from NCHRP Project 03-140 were:

1. Technology Readiness Factsheets;
2. Department of Transportation (DOT) Case Examples;
3. DOT Implementation Criteria; and
4. The Technology Implementation Evaluation (TIE) Tool

The Technology Readiness Factsheets are quick reference factsheets for DOTs to gain a quick understanding of the representative technology's readiness for DOT applications, use cases in the construction and asset management phases, and their advantages and disadvantages. This product was informed through surveys, case example interviews, and a national workshop of leading DOTs.

The DOT Case Examples are extensive interviews with leading DOTs on specific technologies seeking to identify implementation success in different categories. These also report on specific project examples, specifications, and other important considerations for use of the technologies.

Criteria were defined and developed along six implementation factors; organization structure, IT infrastructure, data security, information workflows, personnel training, and stakeholder engagement. Each implementation factor contains a series of criteria with a descriptive ranking on a five-point scale. The criteria are meant to be a self-evaluation for DOTs in their consideration of how ready the agency is to successfully implement a sensing or wireless technology. These criteria are informed through a national workshop of representatives with hands-on experience with leading DOTs.

The products described so far combine to create an electronic tool referred to as the Technology Implementation Evaluation (TIE) tool. The TIE tool is a self assessment, Excel based product that asks users to select a particular sensing and wireless technology, select a project phase, and then self-rate their DOT's current status with each one of the implementation criteria described previously on a 5-point scale. Various analyses are performed and visually presented for DOT's to gain an understanding of their readiness to successfully implement a desired technology. The TIE tool has also been vetted and evaluated at a national workshop of DOT experts.

Guidance Structure

Each of the aforementioned research products seek to provide measurable value to DOTs to assist in successful technology implementations. The subsequent sections of this technical memorandum describe the research products in more details and then follow with suggestions on how to make each research product useful. Those suggestions are broken down into four distinct areas on how to implement, who should be responsible for implementation, potential barriers, and how to measure the impact of the research products.

Specifically the implementation suggestions are described in the following categories:
(1) Recommendations on how to best put the research products into practice (henceforth **Product → Practice**);
(2) Identification of who to assist in applying the products (henceforth **Champion**);
(3) Identification of potential issues with implementation and recommendations to address them (henceforth **Barriers**); and

(4) Recommendations on methods of measuring the impacts with the implementation of the products (henceforth **Measuring Impact**).

Technology Readiness Factsheets

As previously noted, the technology readiness factsheets are quick reference tools to describe the readiness, use cases, advantages and disadvantages of different sensing and wireless technologies. Surveys to the AASHTO Committee on Construction, Committee on Maintenance, and Subcommittee on Transportation Asset Management, case example interviews, and a national workshop led to the creation and refinement of the technology readiness factsheets. The work from NCHRP 03-140 led to the development of one factsheet for each of the ten studied technologies. Figure 1 shows the technology readiness factsheet for RFID as an example.

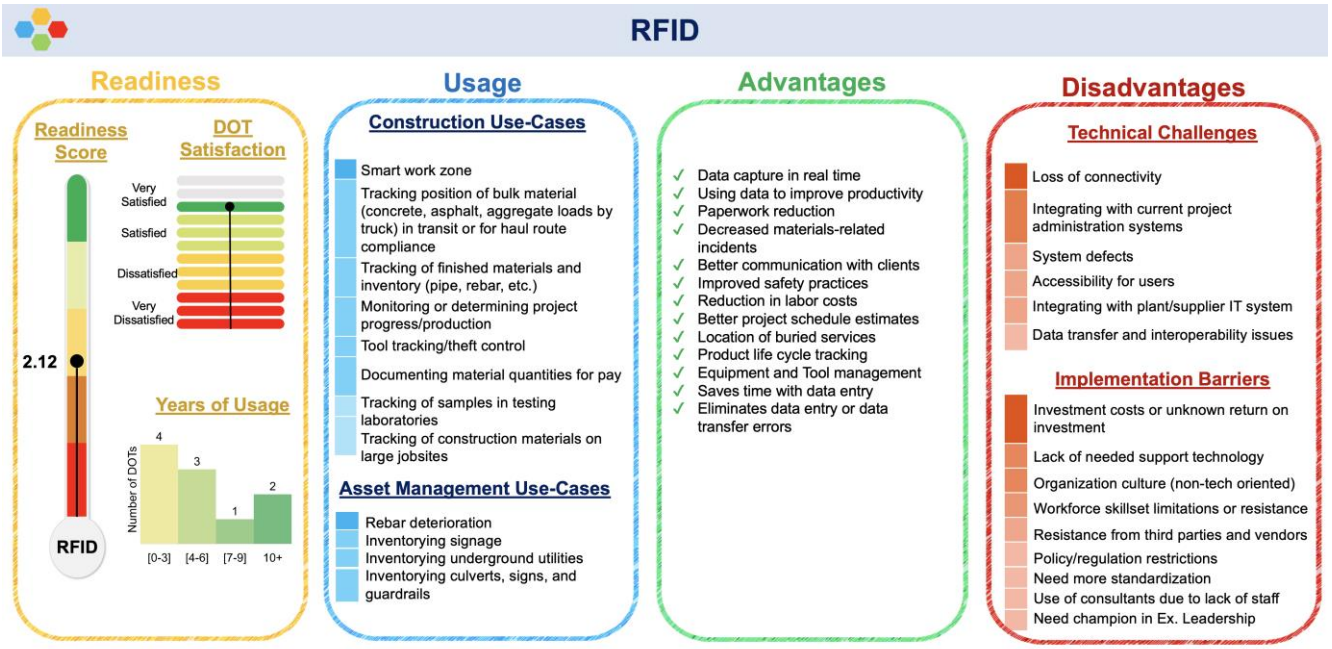

Figure 1. RFID Technology Readiness Factsheet

To assist the usefulness of this tool, the following suggestions are presented:

(1) **Product → Practice:** The Factsheets area useful reference tool for executive level decision-makers who are responsible for the appropriate selection and resource allocation for technology use. Should DOTs have a technology review process or technology review group, these factsheets could also be consulted as support documentation in the evaluation process of new implementations. They are intended to provide an awareness of capability and an alert to potential implementation concerns.

(2) **Champion:** DOTs with technology review groups responsible for evaluation and implementation of existing and emerging technologies would be the ideal champion of the Factsheets. These groups could also support the management and updating of the factsheets. For DOTs without technology review groups, logical champions could be leadership of central oversight groups in construction or asset management as end users. Certainly if a DOT has a division or team that is generally a source for technology

piloting whether as direct responsibility or through organic innovation, that would be a recommended champion.

(3) **Barriers:** The primary concern for the Factsheets are their static nature. While the research made continual updates to all aspects of the Factsheets throughout the extent of the research project, they become static tools once published. However, as a template, they can be updated or created for new technologies as well.

(4) **Measuring Impact:** An ideal way to measure the impact of this research product would be in the number of technology evaluation procedures that incorporate the Factsheets. Many agencies have a form, team, or holistic technology review process, and thus, if the Factsheets are informative to that process, that would measure out to be high impact.

DOT Case Examples

The DOT Case Examples provide a holistic understanding of how leading DOTs have successfully implemented each of the ten studied technologies. Each case example is structured similarly by discussing an overview and applications, organization structure, IT infrastructure, data security, information workflows, personnel training, stakeholder engagement, other considerations, and then a discussion on readiness. Figure 2 presents a screenshot of the first two pages of the e-ticketing case example.

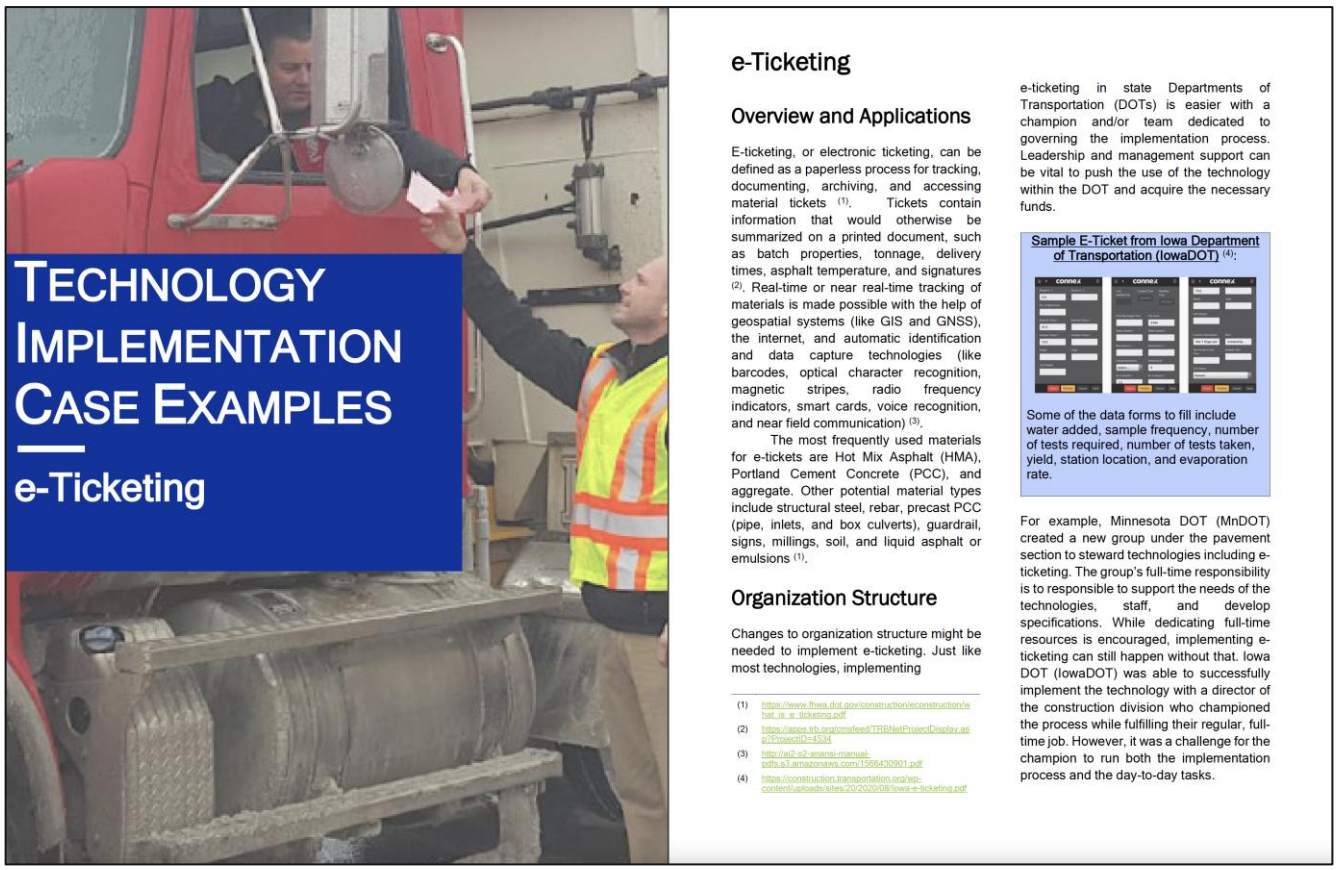

Figure 2. e-Ticketing Case Example Sample

To assist the usefulness of this tool, the following suggestions are presented:

(1) **Product → Practice:** This particular research product is a useful reference tool for individuals or groups responsible for the implementation of the referenced sensing and wireless technologies. The documented case examples should help end users understand how to use the technology, what training may be needed, what stakeholders to engage and how to engage them. The case studies help IT groups understand what needs may be required in terms of hardware, software, workflows, and data management.

(2) **Champion:** Ideal champions for the case examples would be implementation teams assigned for particular technologies. Generally speaking, the existence of implementation teams can improve the likelihood of success of technology implementation in lieu of that responsibility falling on a particular individual.

(3) **Barriers:** Similar to the Factsheets, the static nature of the case examples can be of concern. To mitigate that concern, the case examples can also guide the champions or implementation teams to contacts in other DOTs that have successfully used the technology. There are specific use cases highlighted and external links provided, so additional outreach can lead DOTs to the most up to date information.

(4) **Measuring Impact:** As DOTs lean on reference materials to assist with technology implementation, the impact of the case examples can be measured as being used as source material for those efforts. Thus, measurement could come in the form of the number of times the case examples are included in technology evaluation processes or the number of times another DOT is contacted for implementation advice through information from the case examples.

DOT Implementation Criteria

Specific technology implementation criteria were developed through NCHRP Project 03-140 to provide a checklist and evaluation opportunity for DOTs. Based on the research's data collection and analyses, these implementation criteria propose five evaluation levels for each criteria under the six implementation factors previously identified; organizational structure, IT infrastructure, data security, information workflows, personnel training, and stakeholder engagement. Figure 3 presents a portion of these criteria focused under the organizational structure implementation factor.

Implementation Success Factor: Organizational Structure					
Criteria	**Level 1: Initiating**	**Level 2: Developing**	**Level 3: Defining**	**Level 4: Managing**	**Level 5: Optimizing**
Criterion 1: Organizational Vision & Objectives	Basic technology **vision** is established.	Basic **objectives** to achieve the vision are established.	**Strategic plan** is established with a defined path to	**Implementation plan** with specific activities, schedule and measures are in place.	**Strategic plan is revisited** on a regular basis to update as needed.
Criterion 2: Management Support	**Management interest** in exploring technology.	**Limited management support** with funding for pilot project.	**Full management support** with limited budget commitment.	**Full support for full technology implementation** with appropriate budget for implementation.	**Full support for continued enterprise technology management** with appropriate program budget.
Criterion 3: Technology Oversight	Technology champion **exploring** technology at project level.	Technology champion at the project level **piloting** technology.	Part-time technology champion with small **ad-hoc committee interested** in technology (grass-root movement).	**Dedicated technical champion and formalized TAC** implementing technology at the enterprise level.	**Dedicated technical champion and formalized TAC managing** technology use.

Figure 3. Organizational Structure Implementation Criteria

To assist the usefulness of this tool, the following suggestions are presented:

(1) **Product → Practice:** The implementation criteria are meant to serve as a self-evaluation checklist for the readiness of a particular DOT to successfully implement a particular sensing and wireless technology. For technology review groups or other technology evaluation processes within a DOT, this criteria can be readily adopted and integrated into those processes. The criteria can also be adapted to unique situations within a DOT.

(2) **Champion:** Technology evaluation teams or technology review groups should be the custodian of the implementation criteria. If a DOT does not have such resources, division leads can be the champiom for the use of the implementation criteria. While division leaders may not be involved in the evaluation process of using the implementation criteria, they can be proponents of its use as well as decision-makers based on the resulting information. They can also task individuals or teams to audit and modify the implementation criteria to specific DOT needs.

(3) **Barriers:** A potential concern for the use of the implementation criteria is that it may require effort from employees in multiple divisions. This type of cross-divisional exercise requires a clear understanding of the objectives of the exercise to lead to meaningful results.

(4) **Measuring Impact:** If DOTs have an existing return on investment (ROI) methodology for new technology deployment, tracking those results with deployments that utilize the implementation criteria could provide an impact measurement. Without an ROI methodology, impact could come in the form of perception surveys on readiness when the technology deployment is completed.

Technology Implementation Evaluation (TIE) Tool

The culmination of the research performed through NCHRP Project 03-140 is represented in the TIE Tool. The TIE Tool is an interactive spreadsheet that requires no macros nor external references. Self-contained within the TIE Tool interface is the ability for DOTs to evaluate their current readiness level with each of the implementation criteria. Those readiness levels are then benchmarked against a baseline score that was determined at a national workshop of leading DOTs. From there, gaps are visually seen and presented as well as a relative impact score for each of the implementation factors. Thus, users are able to see which factors make the greatest impact for implementation success as well as where their current level of attainment is farthest behind. A screenshot of the TIE tool introduction and instruction page can be seen in Figure 4.

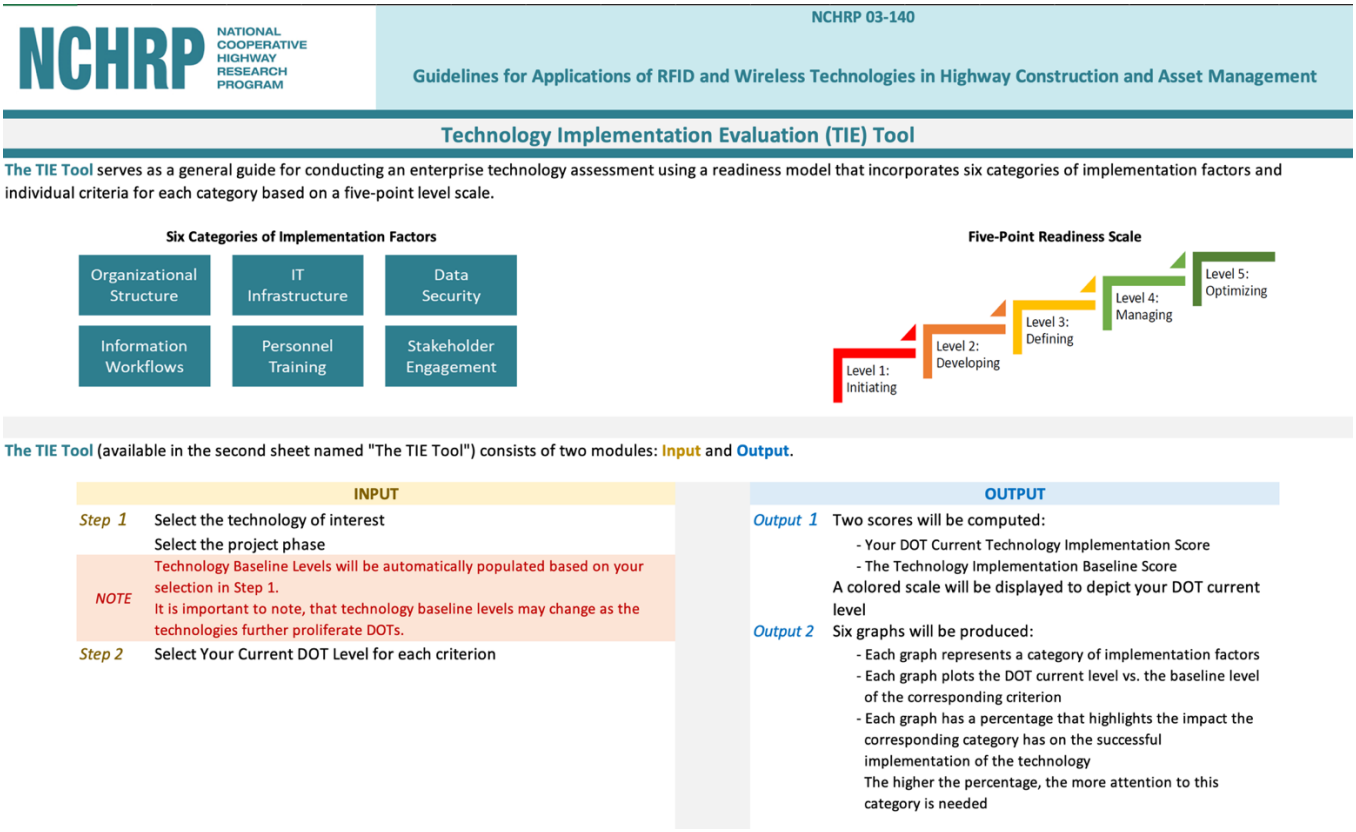

Figure 4. TIE Tool Introduction Page

To assist the usefulness of this tool, the following suggestions are presented:

(1) **Product → Practice:** The most practice ready product from the NCHRP 03-140 research is the TIE tool. To successfully integrate the TIE tool, DOTs can augment or create a technology evaluation process that utilizes the TIE tool for the ten studied technologies. It could also be modified by the DOT for a new technology.

(2) **Champion:** The group that oversees a technology evaluation process within the DOT should be the champion for the TIE tool. In the absence of such a group, each division head would be logical champions to coordinate and direct a technology evaluation process for technologies of interest. While this may necessitate involvement of multiple divisions, the end user division should be the lead champion.

(3) **Barriers:** The TIE tool was designed based on the data captured through NCHRP Project 03-140. The research was focused on ten sensing and wireless technologies noted previously. The logic behind the TIE tool is replicable but would need modifications by the DOT for an evaluation of a technology not on the study list. In addition, the implementation criteria used in the tool are written to be broad enough to be applicable across all DOTs but specific enough to provide meaningful results. However, there may be additional criteria specific to unique circumstances in a particular DOT. To address this, a DOT could modify the spreadsheet to meet their specific needs.

(4) **Measuring Impact:** If a DOT has in-place success measures (such as measured ROI or changes in bid prices, change orders, or other measures of project success) for technology deployment, tracking the change in those measures after integrating the TIE

tool would be a strong measure of impact. Other means to measure impact of the TIE tool could include response of surveying stakeholders with the new technology use or number of successful technology pilots. Depending on the type of technology deployed, other project success measures could be considered (e.g., e-ticketing leading to more timely payments to contractors and quicker project closeouts).

Conclusions

Effective technology implementation for highway construction and asset management is often a challenge for state DOTs. The advancement and proliferation of technology solutions combined with a need to manage more lane miles with staffing challenges leaves DOTs with no shortage of attractive options. However failed technology implementation has compounding negative impacts beyond the direct costs including reducing staff morale and increasing the resistance to future changes. The research efforts and products of NCHRP Project 03-140 provides DOTs with usable reference and evaluation tools to improve the effectiveness of wireless and sensing technologies for highway construction and asset management. Through an extensive literature review, readiness methodology, case examples, implementation criteria development, and a national workshop, leading DOTs and technology service providers laid the foundation for guidance towards effective technology implementation. The research culminated in the development of a self-evaluation tool called the Technology Implementation Evaluation (TIE) tool that provides an assessment and gap analysis to understand the readiness of a DOT for a particular technology implementation.