NRRA National Road Research Alliance

Meeting Minutes: NRRA Intelligent Construction Technologies (ICT) Team

(Agency & Associate Member Meeting)

Date: March 4, 2021
Minutes prepared by: Rebecca Embacher
Location: Microsoft Teams
NRRA Team Webpage: http://www.dot.state.mn.us/mnroad/nrra/structure-teams/intelligent-construction/index.html

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Other Attendees: Jim Schneider (MnDOT), Raul Velasquez (MnDOT)

Decisions Made

- Finalized top 5 priorities to request funding for from the NRRA Executive Committee.

Action items

- Complete Executive Committee standardized document for top 5 priorities by April 1, 2021 meeting.
- Discuss Intelligent Construction Technologies to use during MnROAD re-construction at April meeting.

NRRA National Road Research Alliance

Agenda

- General NRRA Phase II Funding Updates
- Results of Project Priority Survey
- ICT to use during MnROAD reconstruction

Next Meeting

Date: April 1, 2021
Time: 10:30-11:30AM Central Time
Location: Microsoft Teams
Agenda items: General Updates
Top 5 priorities standardized summary documents
ICT technologies to use during MnROAD reconstruction
GPR User Group Meeting

Meeting Notes

Welcome and Introductions

There were a large number of new attendees at this meeting, and therefore, quick introductions were held.

NRRA Phase II Update (Worel)

Focus research and/or project needs on MnROAD and non MnROAD activities.

Currently trying to coordinate what research/project ideas are associated with given test sections.

A friendly reminder that efforts may relate to other NRRA teams. Conversations are currently being held with other teams to show how other activities connect to each other.

By April meeting, need to have top 5 priorities finalized. Please note that partnerships are welcome with any of these initiatives.

The top 5 items from each team (i.e., ICT, flexible, rigid, geotechnical, preventative maintenance) will be brough to the executive committee who will discuss which items to move forward with funding. There are 2 members per state on the executive committee.

The ICT team will be required to complete the "2021 Initial Idea Development Form" before the next meeting. This will be used for review by the Executive committee.

Expecting approximately $1 million to be available each year of this pooled fund (for 5 years).

Working on providing a “NRRA 101” hour meeting to allow new partners do better understand the NRRA initiatives.

Results of the Project Priority Survey (Embacher)

Discussed the project ideas included in the survey, as there were many new attendees at this meeting.

About 25 individuals completed the survey. See slides below for survey results.

The following lists the top 5 priorities:

1. ICT-7. Converting Veta from Desktop Platform to Web-Based Platform
2. ICT-6. Standardized Platform for Material Delivery Management System (MDMS) - Expanded form of E-Ticketing
3. ICT-5. AMG (3D) Milling & Paving - Independent Verification of As-Built Surface Models (digital terrain models) Recorded by AMG systems during operation with respect to Design (Milling Depth or Paving) Surface Model. (conformance with 23 CFR Part 637)
4. ICT-8. Independent Verification of IC and PMTP Measurements - Conformance with requirements of 23 Code of Federal Regulations (CFR) Part 637
5. ICT-9. Real-time Use of ICT Measurements to Address Workmanship Issues

The following individuals are willing to assist with completion of the “2021 Initial Development Form”:

- Rebecca Embacher
- George Chang
- Kyle Hoegh
- Curt Dunn
- Soheil Nazarian

A question was included in the survey to allow individuals to list additional project ideas that may have come to mind since the previous meetings. These items were discussed. See slides below.

The ICT team did not have adequate time to discuss ICT technologies to use during the MnROAD reconstruction. This item was tabled for the next meeting.

Veta Software (Embacher / Chang)

It was determined that a large number of states believe the Veta is solely a software for intelligent compaction technology. Consequently, Embacher and Chang put together a document to provide clarity that it is the standardized platform for intelligent compaction, paver mounted thermal profiling and dielectric profile system data sets. In the future, it might possibly also house MDMS and AMG data. Please help spread the word about this, as we think additional states would join NRRA Phase II if there was better understanding. Please see document at the end of the notes.

Veta Web (Embacher / Chang)

A document was also created to better describe the vision for converting Veta from a desktop software to a web-based platform. See document at the end of these notes.

Other General Comments

(Kliethermes) Shared the link for QA 23 CFR 637 Part B: https://ecfr.io/Title-23/sp23.1.637.b. The link for A/Q is: https://www.fhwa.dot.gov/pavement/materials/qanda637.cfm. These links are in reference to priority #4 above.

(Garcia) Provided further clarification on what is recorded by AMG systems. He reminded individuals that the measurements are taken at the surface and any paving or milling depth calculations have to be completed later by overlaying the 3D design and as-built surface tins together.

(Nazarian) One of his graduate students is researching the state of the practice with the use of digital twins in transportation infrastructure. He has put a questionnaire together. The link to the questionnaire is https://utep.questionpro.com/t/ASDiSZk2xs . Please help out by completing this survey.

(Angerhofer) Asked if the NRRA ICT will have access to the progress of standardization of the MDMS and the flexibility in the program.

> (Embacher) Yes, the NRRA ICT will be kept up to date on the progress of publication of the MDMS provisional practice, along with the ability to assist with future modifications. The practice is currently be submitted as a "provisional", so yes, there will be flexibility to make modifications to this document as the technology changes/grows.

(Chang) Provided additional details on the history of the past technology rodeos. These were funded by the FHWA. This money sunset in September of 2017. Between 2013 and 2017 there were approximately 40 rodeos. Funding included covering expenses associated with coordination, travel, hosting location, equipment delivery, etc. Rodeos were geared towards local agencies and contractors that could not travel out of state.

(Salman / Kottke) There was general discussion regarding Digital Twin Applications and how these might be intertwined with NRRA initiatives. Digital Twin Applications are a visual replica of an asset, how to control and monitor through this visual background. Approach to manage.

Proposed Project Ideas

- ICT-5. AMG (3D) Milling & Paving - Independent Verification of As-Built Surface Models (digital terrain models) Recorded by AMG systems during operation with respect to Design (Milling Depth or Paving) Surface Model. (conformance with 23 CFR Part 637)

- ICT-6. Standardized Platform for Material Delivery Management System (MDMS) - Expanded form of E-Ticketing

Proposed Project Ideas (Cont.)

- ICT-7. Converting Veta from Desktop Platform to Web-Based Platform

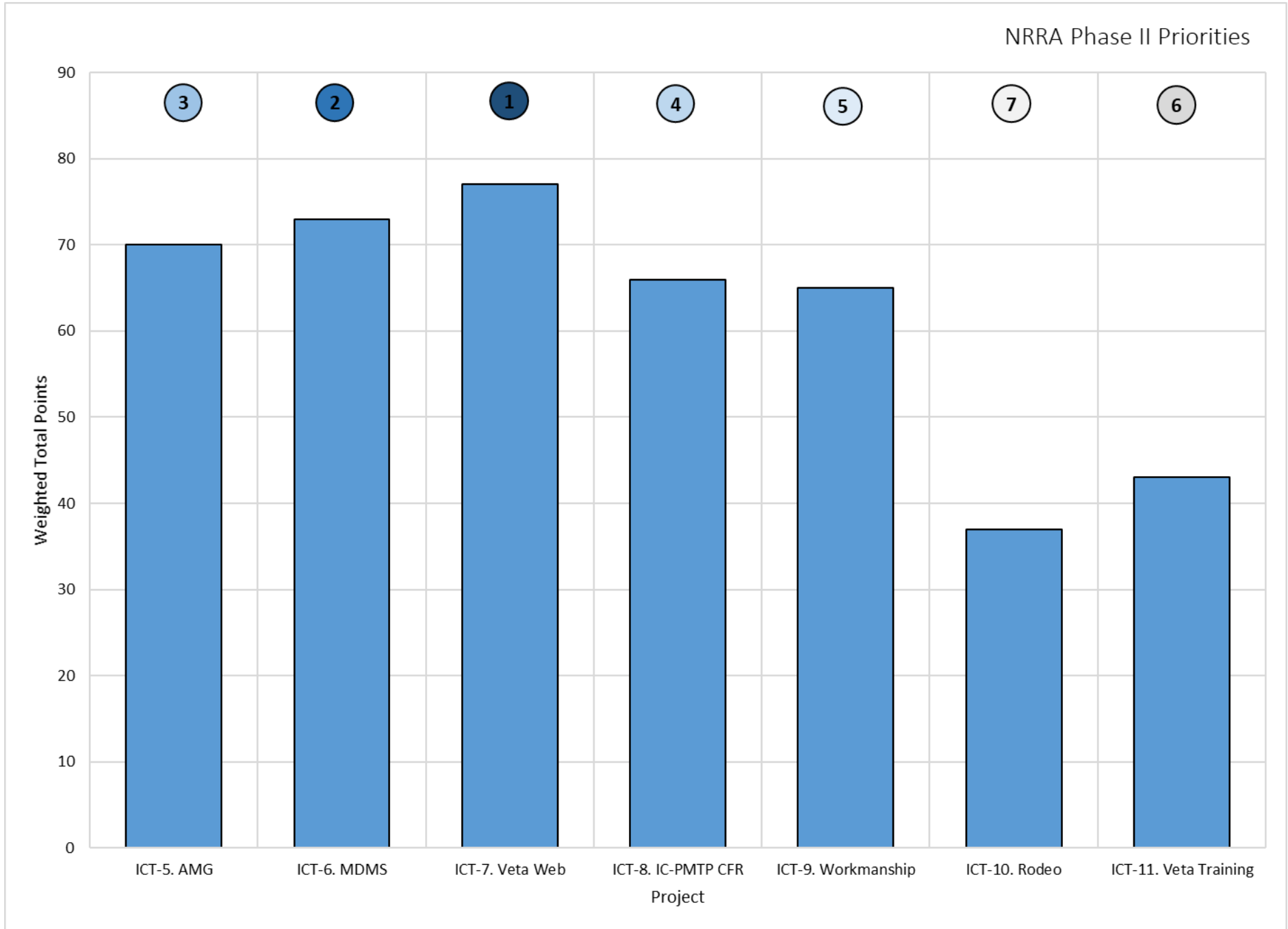
- ICT-8. Independent Verification of IC and PMTP Measurements - Conformance with requirements of 23 Code of Federal Regulations (CFR) Part 637

Proposed Project Ideas (cont.)

- ICT-9. Real-time Use of ICT Measurements to Address Workmanship Issues
- ICT-10. ICT Vendor Rodeo
- ICT-11. Veta Training to Participating NRRA States

Future Items not Included in Survey

Research Idea	Future (2022 or later)
ICT-1. Phase II: Evaluation of Levels 3-4 Intelligent Compaction Measurement Values (ICMV) for Soils Subgrade and Aggregate Subbase Compaction (Phase II may include the development and field validation of an IC certification procedure for soils and subbase compaction.) (Phase I still being completed now)	x
ICT-2. Phase II: Seismic Approach to Quality Management of Asphalt Pavement (Phase I still being completed now)	x
ICT-3. Phase II: Continuous Moisture Measurement during Pavement Foundation Construction	x
ICT-4. Phase II: Asphalt Real-Time Smoothness (ARTS) (Phase II may include the development and evaluation for the analysis procedures/software tools for ARTS data and other related data (e.g., PMTP/IC/DPS and final smoothness) (Phase I still being completed now)	x
ICT-12. Construction Project to Support Development and Verify Web-Based Veta (includes AMG, MDMS, DPS, IC, PMTP, Ride, etc.)	x
ICT-13. Veta Enhancements (General - Wish List Items) - After Veta Web completed (ICT-7)	x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70
60
50
40
30
20
10
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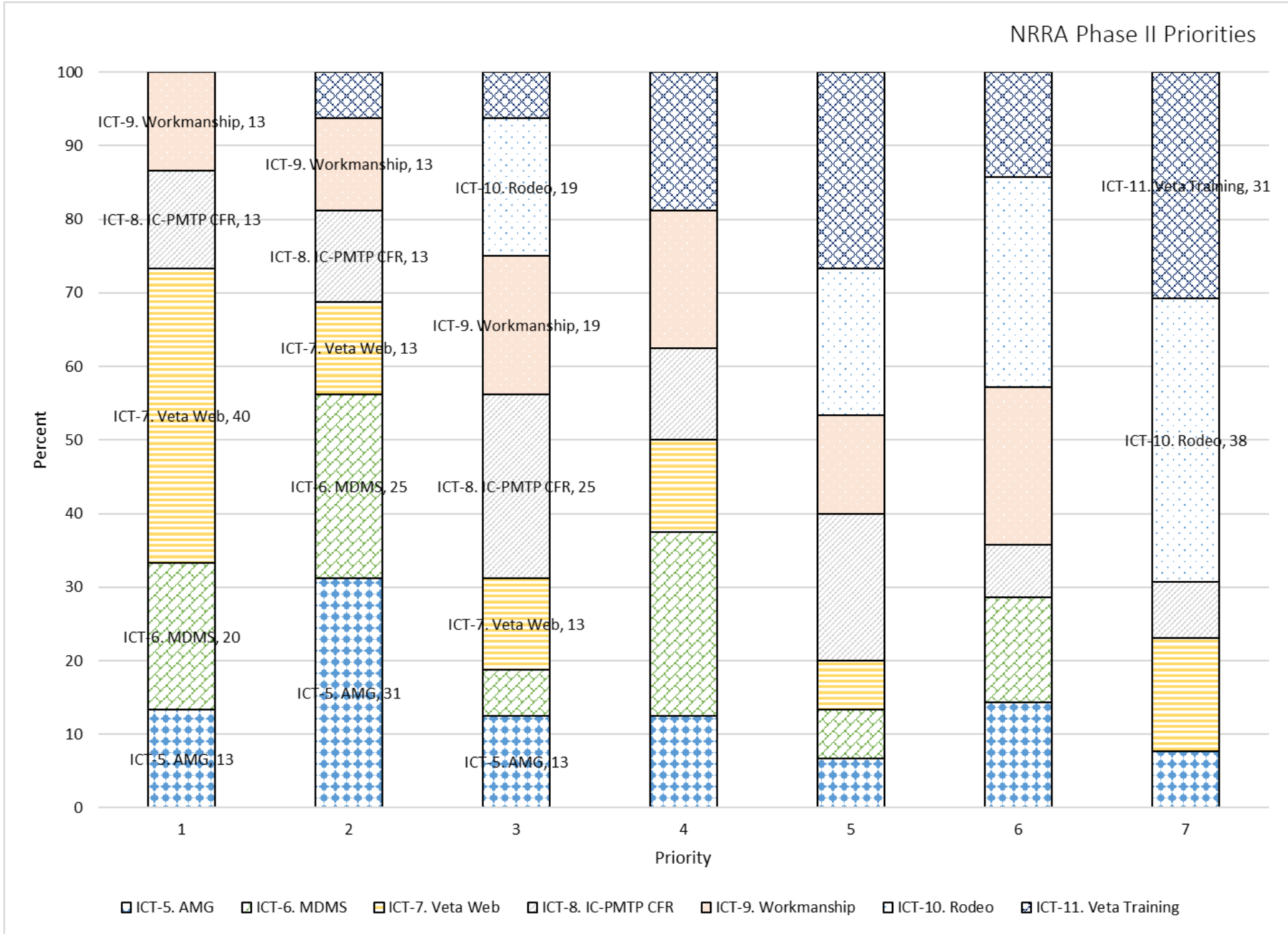
Weighted Total Points
3
2
1
4
5
7
6
ICT-5. AMG
ICT-6. MDMS
ICT-7. Veta Web
ICT-8. IC-PMTP CFR
ICT-9. Workmanship
ICT-10. Rodeo
ICT-11. Veta Training
Project


NRRA Phase II Priorities
Percent
Priority
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ICT-9. Workmanship, 13
ICT-8. IC-PMTP CFR, 13
ICT-7. Veta Web, 40
ICT-6. MDMS, 20
ICT-5. AMG, 13
ICT-9. Workmanship, 13
ICT-8. IC-PMTP CFR, 13
ICT-7. Veta Web, 13
ICT-6. MDMS, 25
ICT-5. AMG, 31
ICT-10. Rodeo, 19
ICT-9. Workmanship, 19
ICT-8. IC-PMTP CFR, 25
ICT-7. Veta Web, 13
ICT-5. AMG, 13
ICT-11. Veta Training, 31
ICT-10. Rodeo, 38
ICT-5. AMG
ICT-6. MDMS
ICT-7. Veta Web
ICT-8. IC-PMTP CFR
ICT-9. Workmanship
ICT-10. Rodeo
ICT-11. Veta Training

Do you have any other ideas?

Comment 1

Training app such as U-Tube videos on how to use ICT and how it makes the user more efficient, e.g. if the equipment is on the machine why everyone from the machine operator to project managers [contactor and DOT, that is the overall QMT (Quality Management Team)] should being using the real time data to improve the final paving product.

NRRA ICT Team Agrees

This was discussed as a phase II item for ICT-9 “Real-Time use of ICT Measurements to Address Workmanship Issues”.

Added to master spreadsheet.

Do you have any other ideas? (Cont.)

Comment 2

I believe at one point we discussed "Cost-Benefit of Advance Quality Management Techniques."

Correct

NRRA ICT Team had tabled that item due to the complexity and costs that would be associated with doing this correctly (i.e. basically needing to set up long term pavement performance (LTTP) sections).

Any changes in thoughts?

Do you have any other ideas? (cont.)

Comment 3

Recommend requesting ISIC to lead the ICT Vendor Rodeo.

Thoughts?

Lowest priority on list.

ISIC-NA meeting with in-person Vendor presentations 2 years ago successful

Interim = Virtual vendor presentations put on by ISIC-NA chapter?

Do you have any other ideas? (cont.)

Comment 4

Bringing DPS data into Veta

Done

Import of Dielectric Profile System (DPS) data into Veta was completed under NRRA Phase I. This version of Veta will be released around June 2021.
Additional DPS enhancements will be needed in the future.

Do you have any other ideas? (cont.)

Comment 5

Creating and maintaining a website or app that could be accessed on people's phones that contains up to date training videos and/or short documents for IC technologies. Could even host traditional technology too.

NRRA ICT Team Agrees

See Comment 1

Do you have any other ideas? (cont.)

BIM for Infrastructure, Digital Twin Applications for Lifecycle Management

More Details Needed

States are piloting the use of Digital Twin Applications on select construction projects now. More details would be needed for this request.

Required ICT during MnRoad Construction

Intelligent Construction Technology (ICT)	Yes / No	Applications
Dielectric Profile System (DPS)	Yes	• Asphalt Pavement • All Lifts • Minimum of 3 longitudinal passes = 9 longitudinal profiles

Intelligent Compaction (IC)	Yes	• All Lifts, All Roller Passes
		  • Asphalt, Bases, Reclamation (e.g., SFDR, FDR, CIR),
		• Final Top of Surface (e.g., grading grade)
		  • Top of Unbound Surface
		  • All Roller Passes

Paver Mounted Thermal Profiling (PMTP)	Yes	• Asphalt Pavement • All Lifts
Material Delivery Management System (MDMS) – Expanded form of E-Ticketing	Yes	• Asphalt • ?

Required ICT during MnRoad Construction (cont.)

Intelligent Construction Technology (ICT)	Yes / No	Applications
Automated Machine Guided (AMG) – Relative Milling Method	? Depends on Staging & Length	• Milling existing asphalt surface for M&OL, Thinlay, Reclamation
Automated Machine Guided (AMG) – Robotic Total Station Method	? Depends on Staging & Length	• Milling asphalt surface for whitetopping and when using the existing pavement as a bond-breaker for an unbonded concrete overlay

NRRA – Veta Phase II Activities

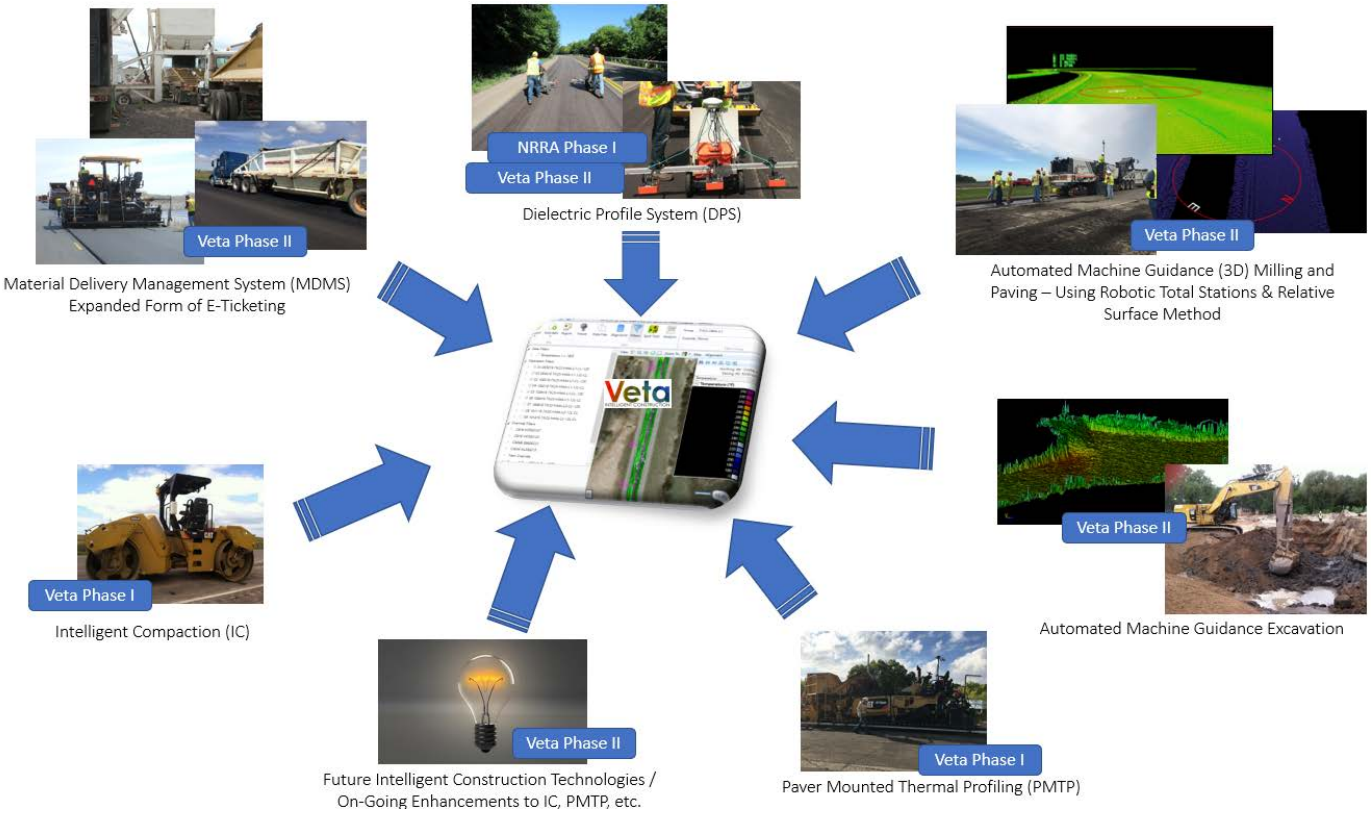
National Road Research Alliance (NRRA)

Due to the overlapping initiatives between NRRA and the Veta Phase I pooled fund TPF-5 (334), it was decided to incorporate phase II of the Veta pooled fund under phase II of NRRA (TPF-5 (466), https://www.pooledfund.org/Details/Study/693). States can become full members of NRRA (which also includes Veta Phase II) or solely join the intelligent construction team (ICT) and Veta Phase II.

Additional information regarding NRRA can be found at: http://www.dot.state.mn.us/mnroad/nrra/index.html.

Veta Phase II

As part of the NRRA Phase II mission of sustainability and intelligent construction, Phase II of the Veta pooled fund will include enhancements for the following ICTs (that were considered high priority items) depending upon funding availability. See the image below illustrating potential Veta Phase II activities.



Dielectric Profile System (DPS)

Dielectric Profiling System (DPS) is the focus of TPF-5 (443), "Continuous Asphalt Mixture Compaction Assessment Using Dielectric Profiling System."Veta will be the national, standardized platform for viewing DPS data. However, TPF-5 (443) does not include funding to support the needed enhancements in Veta to allow for import, viewing, and analyses of DPS. Consequently, as part of NRRA Phase I, funding was procured to create an importer to bring DPS data into Veta and allow for mapping and analysis of DPS data. Additional enhancements will be required within Veta to support the DPS analysis (e.g., generation of calibration curves, core density to dielectric measurement comparisons, system calibration verifications, etc.). These needed enhancements are proposed for completion under Veta Phase II.

Material Delivery Management System (MDMS)

Material Delivery Management System (MDMS) is an expanded form of E-Ticketing, an EDC-6 Initiative.Many States have been piloting the MDMS since 2015. The increased use of this technology has been accelerating due to the impact of COVID-19 since 2020. A draft AASHTO provisional practice has been established to assist with the standardization of data block naming conventions, data elements, data exports, addressing centralized suppliers' needs, and more. There are currently more than 15 vendors providing varying levels of solutions for the MDMS technology. As with ride quality (smoothness), intelligent compaction (IC), paver mounted thermal profiling (PMTP), a standardized platform is needed to view the MDMS data regardless of the MDMS vendors used on the contracts. There could potentially be multiple MDMS platforms that an inspector is required to navigate on a given contract depending upon which MDMS each subcontractor elects to utilize (e.g., a different MDMS for asphalt, concrete, aggregate, milling, etc.).

Veta will be the national, standardized platform for viewing MDMS data. Consequently, the following enhancements are proposed for completion under Veta Phase II:

- Mapping of the numbers of trucks at the source, transit, construction site, and return to the source.
- Map features to allow the user to click on any given truck symbol to view the associated E-Ticket.
- Overlaying of material dump locations on ICT data maps, including DPS, IC, and PMTP data for Agencies collecting dump latitude and longitude coordinates.
- Identification of mix changes with respect to dump placement locations.
- Tabularization of the ticket status summary (e.g., ticket number, loaded, in transit, dumped).
- Estimate of the arrival time to the dump location and on-site wait-time of trucks before dumping.
- Calculation of flow/feed rates and display of these results on maps.
- Tying of QA sample identifications and test results for a given load of material to the dump locations.
- Determination of an appropriate calibration curve (related to mix design changes) to associate with the DPS measurements.
- Generation of as-built asphalt heat loss curves for troubleshooting workmanship issues using MDMS temperatures collected at the source and Jobsite, PMTP measurements behind the paver screed, and IC temperature measurements during compaction.
- Identification of remove-and-replace limits based on dump locations collected by the MDMS and DPS/IC/PMTP/spot test data.
- Contractor and Agency user interface to allow for data entry of split loads, rejected loads, and other quality assurance (QA) information.

Veta Web

Converting Veta from a desktop platform into a web-based system would allow the realization of the following essential items.

- Viewing ICT data (e.g., IC, PMTP, MDMS, DPS, AMG, etc.) near-real-time, using a standardized web-based viewing and analyses platform.
- Allow real-time entry of needed agency data for auto-creation of Veta projects by contractors, including:
- Start and end station limits of production areas
- Production dates
- Centerline offsets for use in automation of location filters
- Exclusion limits
- DPS Calibration Equations
- MDMS agency data (e.g., split load quantities/pay items, sample IDs, air and source temperature measurements at source and in the field, etc.).
- Spot tests (QC/QA test results) – for use in overlaying on top of other ICT data.
- And other emerging technologies and data.

- Improved Submittal Timeline – Currently, with the IC and PMTP technologies, states have not been able to get Veta project submittals daily. Typically, the Veta projects are not submitted until after completion of the work. This is not an option with the DPS. The web-based platform will help support daily submittals' ability by making the software live (i.e., allowing real-time, automated import of vendor data into Veta vs. manual, real-time entry of agency data, live viewing of data, etc.).
- Allow ICT to be used in near real-time as a construction monitoring tool instead of as post-processed data.

Consequently, conversion of Veta from a desktop platform to a web-based application is proposed for completion under Veta Phase II.

Automated Machine Guidance (AMG) Milling and Paving Operations

Independent verification measurements are collected during AMG milling and paving operations. However, the density of measurements is limited by the number of resources available and technical abilities. These measurements often require surveyor experience. Therefore, often a minimal number of QA measurements are typically collected each day. Consequently, in addition to these measurements, it is recommended that a denser and more frequent verification process is also completed using the as-built measurements recorded by the AMG equipment. The digital terrain model (DTM) generated for the as-built surface is then compared to that for the Model of Record (i.e., milling depth and/or pavement thickness design models). The density of measurements significantly impacts the percent of measurements that are considered within tolerance. Therefore, the daily production should also be reviewed per sublot and at a set node frequency. Most survey software cannot automatically split the data per sublot, easily remove excluded areas, and provide ease in dealing with shifting centerline offsets and tapers. Additionally, inspectors often do not have the expertise to use survey software to complete these operations. Consequently, the following enhancements are proposed for completion under Veta Phase II:

- Overlaying of the as-built and model of record surfaces for calculation of volumes of cut and fill.
- Calculation of the delta (differences) milling/paving depths between the as-built and model of record surfaces.
- Calculation of the percent of DTM nodes exceeding required tolerances.
- Filtering of data by date, location, offsets from milling head (e.g., 1-ft inside the left and right edge of the milling operation), etc.
- Creation of sublots for better understanding of areas of concerns.

Automated Machine Guidance (AMG) Excavation Operations

Currently, there are multiple vendors that provide solutions for AMG excavation activities. This makes it difficult for construction staff to use different software to view excavation activities out on the jobsite. Consequently, the following is proposed for completion under Veta Phase II:

- Import of AMG excavation coordinates (X, Y, Z)
- Mapping of excavation elevations.
- Ability to filter by lowest elevation, date, locations.
- Calculation of excavation volumes by overlapping surface model with bottom of excavation model.

Future Intelligent Construction Technologies

During this technology era, it is anticipated that additional technologies may rapidly arise that warrant inclusion within the Veta software, such as what recently occurred with the MDMS. Consequently, a placeholder exists to allow these technologies to be incorporated into the Veta software should the pooled fund participants address the given technology needs.

On-Going Veta Enhancements

Additional enhancements may be warranted for inclusion with respect to the technologies incorporated into Veta during Phase I. Consequently, a placeholder exists to allow pooled fund participants to address the given enhancement needs.

NRRA National Road Research Alliance

Benefits of Veta Web for MDMS

The Need for a Web Platform to Implement MDMS

Many States have been piloting the Material Delivery Management System (MDMS) (an expanded form of E-Ticketing) since 2015. The increased use of this technology has been accelerating due to the impact of COVID-19 since 2020. A draft AASHTO provisional practice has been established to assist with the standardization of data block naming conventions, data elements, data exports, addressing centralized suppliers' needs, and more. There are currently more than 15 vendors providing varying level of solutions for the MDMS technology. As with ride quality (smoothness), intelligent compaction (IC), paver mounted thermal profiling (PMTP), a standardized platform is needed to view the MDMS data regardless of the MDMS vendors used on the contracts. There could potentially be multiple MDMS platforms that an inspector is required to navigate on a given contract depending upon which MDMS each subcontractor elects to utilize (e.g., a different MDMS for asphalt, concrete, aggregate, milling, etc.).

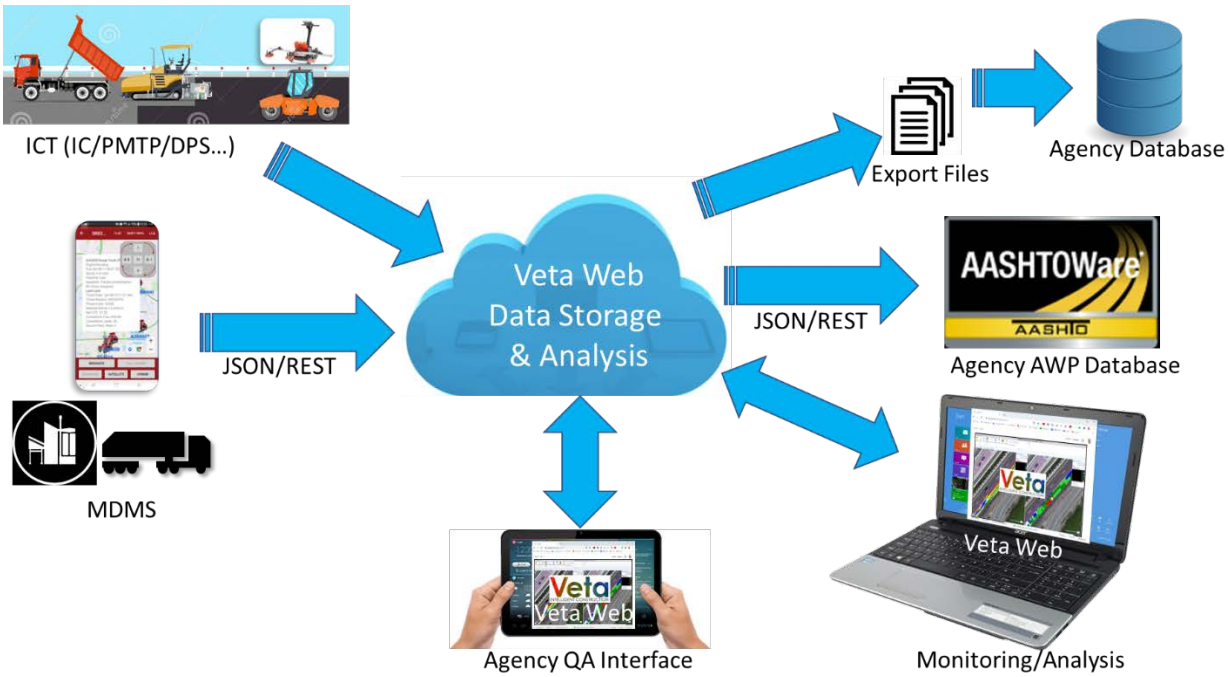
Additionally, an agency interface is needed (independent from the Contractor's MDMS) to allow for data entry of split load, rejected loads, and other information. Also, MDMS data and analysis results will need to be transferred into AASHTOWare® Project and other state database systems. However, this will not address the standardization of the geospatial needs that the MDMS currently provides.

The potential solution to overcome the above challenges is a public-domain, standardized web-based geospatial software system. Sponsored by the FHWA and TPF, the Veta desktop software has been a proven model for integrating and mapping data from various intelligent construction technologies (ICT) with great success since 2012. Therefore, it is recommended to develop a Veta Web that can be a standardized web platform to integrate all MDMS-related data in a standardized format (e.g., JSON).

Proposed Veta Web Platform

The proposed Veta Web platform consists of a web-based server application for MDMS data storage and computation for analysis. Being web-based, Veta Web can be run from any mobile device, laptop/desktop computers, etc., as long as the internet connection is available. The conceptual architecture of Veta Web is illustrated below.

- MDMS data can be pushed from transaction points and fleets to the Veta Web cloud database using a standard method (i.e., JSON and REST API).
- Agency inspectors can perform quality assurance (QA) and upload the data to the Veta Web cloud storage using the Veta Web agency interface. Also, agency inspectors can monitor the fleet information and paving progress using the same interface.
- Other intelligent construction technologies (ICT) (including IC, PMTP, Dielectric constant profiles methods – Dielectric Profile System [DPS], etc.) can also push their data to the same cloud storage.
- Agency and contractor office staff can monitor and perform mapping and analysis using the Veta Web.
- The MDMS data and analysis results can be transferred from the Veta Web cloud to agencies' AASHTOWare Project® database using a standard file method (i.e., JSON and REST API).
- For agencies not using AASHTOWare Project®, they can export the MDMS data and analysis results from the Veta Web cloud to local data files and upload them to the agencies' own database.



The MDMS data will be stored on the server with data security and integrity. Veta Web will be used for managing users, data-access permissions, and MDMS projects. While Veta Web will interact with the server, the time-intensive calculations will be performed on the server. This includes filtering, analyzing, reporting, and map creation similar to those in the current Veta desktop version. Specifically, the following features:

- Recreating current Veta desktop mapping GUI for the Veta Web.
- New MDMS analysis projects can be created, stored, and managed as stored in *.vetaweb files.
- MDMS data can also be downloaded by users to local computing devices on a routine basis as redundancy. In the event of data loss or corruption on the server, the user can re-upload the data, or if the data is still available from the vendor's systems, the server can re-download the data.

Anticipated Benefits of Veta Web to MDMS

The anticipated benefits of using Veta Web to the implementation of MDMS include the following:

Facilitation of Data Management

- Push MDMS data in a standardized format to the cloud server from any transaction points (at the source, construction sites) and beacon devices (GPS/cellular trackers on trucks) using the single Veta Web GUI via the internet.
- Eliminate the complexities of nested geofences within the vendor's MDMS, as the Agency's static geofences needed for reconciling quantities with respect to projects and funding categories can now be created within Veta and recorded with respect to the dump location.
- Create an agency interface where agency data does not require data entry within the contractor's MDMS.
- Push MDMS data to AASHTOWare® Project or other Agency databases through a standardized method (e.g., REST APIs, JSON).
- Export of MDMS data as an ASCII, CSV, XLSX, or text format. Agencies can then upload these files to their own database.

Near Real-Time Monitoring with Powerful Mapping Visualization

- Map the numbers of trucks at the source, transit, construction site, and return to the source.
- Show map features to allow the user to click on any given truck symbol to view the associated E-Ticket.
- Overlay material dump locations on ICT data maps, including DPS, IC, and PMTP data for Agencies collecting dump latitude and longitude coordinates.
- Identify mix changes with respect to dump placement locations.

Near Real-Time Data Analysis

- Tabularize the ticket status summary (e.g., ticket number, loaded, in transit, dumped).
- Estimate the arrival time to the dump location and on-site wait-time of trucks before dumping.
- Calculate flow/feed rates and display of these results on maps.

MDMS Data Integration with ICT Data and QA Data

- Tie QA sample identifications and test results for a given load of material to the dump locations.
- Determine an appropriate calibration curve (as related to mix design changes) to associate with the DPS measurements.
- Generate as-built asphalt heat loss curves for troubleshooting workmanship issues using MDMS temperatures collected at the source and Jobsite, PMTP measurements behind the paver screed, and IC temperature measurements during compaction.
- Identify remove-and-replace limits based on dump locations collected by the MDMS, DPS, IC, PMTP, and spot test data.
- Contractor and Agency user interface to allow for data entry of split loads, rejected loads, and other quality assurance (QA) information.

Here is a mark-up for one of the many Veta Web features described above to tie each E-Ticket with stationing on the PMTP temperature map. Comparing the PMTP temperature and IC pass count maps, a QA core data location can be tied to the asphalt truck, stationing of the dump, sublot, temperature segregation, and pass count information. Therefore, the causes of any QA noncompliance can be identified.