To: TPF-5(354) Improving the Quality of Highway Profile Measurement **Memo No.** 217001-1 (V15)

From: The ProVAL Project Team   **Date:**   12/3/2025

Re: ProVAL – Future Enhancements

Recommended Enhancements for ProVAL

BACKGROUND

State highway agencies use inertial profilers to assess the smoothness of existing highway pavements and to accept new concrete and asphalt pavements. In 2001, the Federal Highway Administration (FHWA) released an engineering software application called Profile Viewing and Analysis (ProVAL) that allows users to analyze longitudinal profiles more easily from any inertial profiler manufactured in the US. State highway agencies, paving contractors, researchers, and academics depend on Profile Viewing and Analysis (ProVAL) for convenient, reliable, and consistent analysis of longitudinal pavement profiles.

Since 2001, ProVAL has become the most widely used tool in the profiling industry worldwide. Furthermore, it establishes profile-related standards that help the profiling industry keep pace with the rapid advancements in profiling technologies. Its impact is enormous, considering many implementations would not even be possible without ProVAL, such as the following ProVAL modules:

- ProVAL Standard Data Format for ASTM E2560: standardized profile data format.
- Ride Quality Module for AASHTO R54: localized roughness-based smoothness assurance with grinding simulation.
- Profiler Certification Module (PCM) for AASHTO R56 and ASTM E950: cross-correlation-based profiler certification.
- Automated Fault Measurement (AFM) for AASHTO R36: automated joint faulting measurements and
- Optimal weight-in-motion site locators (OWL) for AASHTO MP14: optimal weight-in-motion (WIM) site locators, etc. (NB: The implementation of OWL was funded through an FHWA IDIQ contract)

The Transtec developers have been logging a long list of users' wishes for new and improved features. With software applications increasingly integrated with maps (such as Google, OpenStreetMap, and Bing), ProVAL users found those map-based features intuitive and robust. Therefore, Map Support was integrated to meet the ProVAL users' start demands. During ProVAL development, the project team gathered numerous software enhancements and improvement suggestions. Most of these are based on feedback from active ProVAL software users. The effort required to develop and integrate these ideas varies and depends on the feature's maturity and complexity.

This ProVAL enhancement list has been updated regularly. The Transtec developers will also work closely with the upcoming pooled fund study (Solicitation no. 1605 – Improving the Quality of Highway Profile Measurement) that merges the longitudinal profile (TPF-5(354)) and distress pooled fund studies (TPF-5(399)) to update this list.

This Tech Memo summarizes the current version of the recommended ProVAL enhancements gathered from DOTs and end users.

Table 1. List of Proposed ProVAL Enhancements.

No.	Titles
01	Support Speed Profiles and Stop-and-Go Exclusions
02	Support for Stationing
03	Support for Modern Pavement Grinder Simulation
04	Leveling Simulation Module
05	Milling Simulation Module
06	Replace Deprecated Services
07	Convert Visual Basic Code
08	Convert Fortran Code
09	Upgrade from .NET Framework to .NET 8
10	Web version of ProVAL

01: Support Speed Profiles and Stop-and-Go Exclusions

FEATURES

Conventional high-speed inertial profilers (HSIP) implement the South Dakota inertial profiler (SDIP) design that uses a single-axis accelerometer, a laser, and a distance measurement instrument (DMI) (https://rpug.org/history/). This implementation functions well for high-speed longitudinal pavement profile measurements for highway applications. Most vendors' systems can collect valid profiles between 25 and 60 MPH. However, the SDIP design cannot collect valid data during stop-and-go or low-speed operations, such as during urban profile measurements.

Therefore, some vendors developed a solution with stop-and-go and low-speed profilers that use an augmented Global Positioning System (GPS) and a compensation algorithm that uses profiler speed/gravitational force sensor measurements to detect deceleration, stops, and acceleration. The next round of AASHTO R56 profiler certification specification revisions will include the options to certify the stop-and-go and low-speed profilers. Therefore, ProVAL will need to support speed profiles when implementing such new profiler certification modifications. Also, such a new modification may identify a valid speed range for SDIP-type profilers. Furthermore, the proposed ProVAL's new features to support speed profiles and stop-and-exclusions would provide a stop-gap solution to agencies and users who do not have the funding and resources to upgrade their SDIP-style profilers to the modern stop-and-go and low-speed ones – as one example, upgrading from the existing "conventional" profilers to "modern stop-and-go" would cost approximately $100,000 for just one profiler.

This new function would support the speed profile data stored in the latest ASTM E2560-23 standard pavement profile data format (*.ppf). This would allow users to identify stop-and-go locations where conventional inertial profilers collect invalid data and decide whether to exclude that data from ProVAL's analyses and reports. Manual methods can be used in the ProVAL Editor/Sections to view speed profiles and identify stop-and-go areas to exclude as sections.

Alternatively, ProVAL may suggest the sections based on the speed profiles as exclusions. Then they can decide to accept or modify the sections, as suggested by the grinding locations in the ProVAL SAM module.

If the vendor's systems can use event markers to identify the stop-and-go locations in the profile data, ProVAL would import the event markers and create the exclusions based on a pre-set rule for event marker naming convention. If the vendor's systems can directly create exclusions based on their event markers and store them in the ppf files, ProVAL can automatically import those exclusions.

ProVAL will then include the speed profile and exclusions in the report.

BENEFITS
- Implementing a stop-gap solution to exclude stop-and-go areas will allow agencies and industries more time to upgrade their profilers to the latest stop-and-go technologies.
- Implementing a tool to allow agencies to evaluate the candidate profilers with stop-and-go technologies.

ESTIMATED COST
Transtec will provide an estimated cost if TPF selects this item.

02: Support for Stationing

<u>FEATURES</u>

It is well understood that the distance between Stations does not reflect the actual distance traveled by vehicle tires. Therefore, the Profile Pooled Fund has long opposed supporting stationing in ProVAL. However, there are high demands from users, agencies, and paving contractors for ProVAL to support stationing for general "reporting purposes," such as fixed-interval reports at 0.1-mile intervals that may not be significantly affected by DMI errors.

With the recent advancements of the global positioning system (GPS) and widespread use of all-purpose pavement survey vehicles, it is now possible to relate the "lots" or "sub-lots" in pavement profiles to corresponding stations knowing the GPS measurements in the profile data and those for stationing stakes (e.g., locating a projected point in profile data perpendicular to a segment between adjacent stations). That is, the ride indices for profile data points can be grouped or dissected into a tabular report using stationing, say, 100+00 to 101+00 ft. To prevent the misuse of stationing support (such as identifying locations for grinding), the display of profile data vs. stationing will not be included.

The proposed stationing support is to:

- Allow GPS data or other means for referenced stations and profile data,

- Allow users to define a stationing system within given data (starting stationing in the data and direction w.r.t. profiling direction, forward or reverse),

- Allow users to define a reporting interval with stationing references and

- Produce ride index reports using the above-defined stationing system.

Stationing support will be implemented in the RideQuality and SAM modules.

<u>BENEFITS</u>

This enhancement would greatly benefit agencies and contractors by enabling them to achieve consistent measurement, reporting, and payment schedules through the stationing system.

<u>ESTIMATED COST</u>

Transtec will provide an estimated cost if TPF selects this item.

03: Support for Modern Pavement Grinder Simulation

<u>FEATURES</u>

The current ProVAL grinding simulation has been used by agencies and industries since 2005 to optimize the grinding operations and benefits. The core algorithm of the ProVAL is based on the US Patent 6,682,261 B1 "Method for Correcting the Roughness of Pavement" in 2004, which expired.

Figure 1. The US Patent for ProVAL's Grinding Simulation.

The above grinding simulation algorithm was based on the grinders available in the early 2000s for non-articulated grinders. Since then, grinder technologies have advanced to include full-size, effective, articulated grinders. An example is the PC6000EC model exhibited at ICART during the RPUG 2023 conference. During the TPF-5(354) meeting on May 4, 2023, Larry Scofield of IGGA/ACPA recommended an upgrade for the ProVAL grinding simulation for such modern grinders.

Figure 2. Modern Articulate Grinder.

The proposed modern grinder simulation support is to:

- Develop a new algorithm to simulate modern articulated grinders,

- Code the new algorithm into a prototype program and validate it with field data,

- Convert the validated prototype program to a new ProVAL simulation feature and verify it with field data.

The support for modern grinder simulation will be implemented in the SAM and OWL modules.

BENEFITS

This enhancement would greatly benefit agencies and contractors in achieving effective and optimized grinding with modern articulated grinders.

ESTIMATED COST

Transtec will provide an estimated cost if TPF selects this item. Note that this item would include research efforts.

04: Leveling Simulation Module

For years, ProVAL users have been using grinding simulation in SAM to remove localized roughness, improve ride quality, and avoid penalties in many cases. Because grinding can only remove "bumps" or make "dips" wider, many users suggest a "leveling simulation" to explore other options to improve ride quality. This is also useful for the pre-bid investigation to optimize the proposed rehabilitation.

The following figure illustrates leveling courses applied to an originally uneven surface to create a smooth surface, accounting for the compaction effects of a roller. That is, the applied level course would need to be 15% higher than the final desired surface when laid down, and the compacted surface will meet the final surface's evenness requirements.
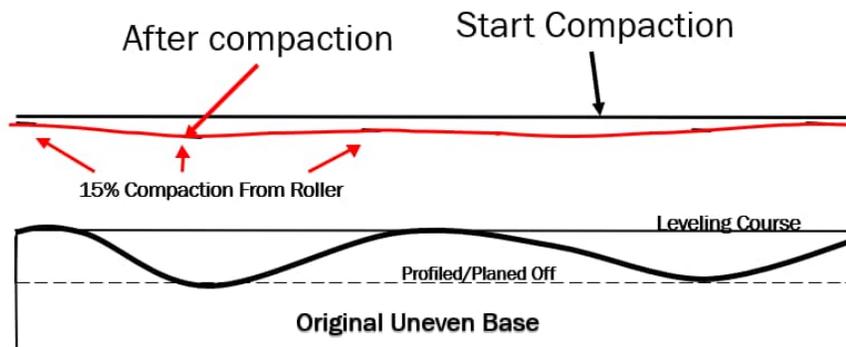

Figure 3. Concept of the Leveling Module.

During the RPUG 2024 conference, Jeff McGowan presented a semi-manual method for determining the leveling course for a bridge approach to improve ride quality in the presentation "Using ProVAL as a QC tool in profile milling." The proposed tool automates this manual process. Similar to the suggested grinding locations in SAM, this tool will suggest the locations and thicknesses for the leveling course. Then, users can decide to accept or modify them to optimize ride quality and leveling efforts.

Implementing the ProVAL level simulation would require a study to develop algorithms for simulating real-world leveling operations and validate them with field data. The GUI and report for the leveling simulation will be decided during this work's requirement and design phase.

BENEFITS

Implementing a tool to evaluate how the leveling course would improve ride quality.

Implementing a tool as the pre-bid investigation to optimize the proposed rehabilitation.

ESTIMATED COST

Transtec will provide an estimated cost if TPF selects this item.

05: Milling Simulation Module

<u>FEATURES</u>

For years, ProVAL users have been using grinding simulation in SAM to remove localized roughness, improve ride quality, and avoid penalties in many cases.

As users seek any opportunity to improve smoothness, a milling simulation would be beneficial for mill-and-fill projects. Therefore, optimized milling would improve the smoothness of the overlay. Since the milling machines behave differently from the grinding machines, it is proposed that a milling simulation module be developed to create an optimized platform for subsequent paving. This is also useful for the pre-bid investigation to optimize the proposed rehabilitation.

Variable 3D profile milling, followed by 2D paving control, is becoming popular. This would allow variable-depth milling to create a smoother platform for the subsequent overlay, improving smoothness and reducing asphalt material costs. As ProVAL begins implementing features that use 2D/3D data, such as Transverse Pavement Profiles, it is logical to propose the long-awaited function.
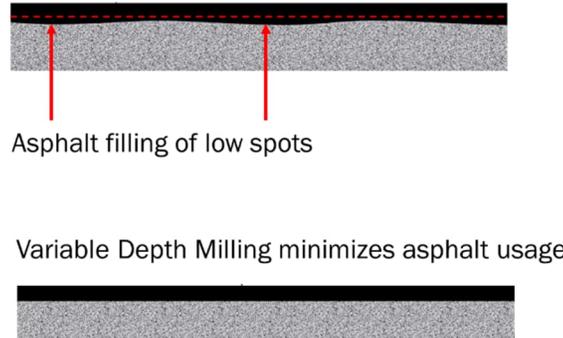

Figure 4. Fixed Depth and Variable Depth Milling.

During the RPUG 2024 conference, Jeff McGowan presented a semi-manual method for determining whether milling or cold planing improves ride quality in the presentation titled "[Using ProVAL as a QC tool in profile milling](#)." The proposed tool automates that by simulating the milling machine.

Implementing the ProVAL level simulation would require a study to develop algorithms for simulating real-world milling operations. The GUI and report for the milling simulation will be decided during this work's requirement and design phase.

<u>BENEFITS</u>

Implementing the Milling Simulation Module will help optimize milling and the subsequent paving overlay to improve smoothness and reduce costs.

<u>ESTIMATED COST</u>

Transtec will provide an estimated cost if TPF selects this item.

THE TRANSTEC GROUP

06: Replace Deprecated Services (completed in ProVAL 4.0.68+)

<u>FEATURES</u>

Mapping

ProVAL 4's map and route creation features are based on Microsoft's Bing Maps. Bing Maps is now deprecated and will be retired on June 30, 2025. It has been replaced by Microsoft Azure Maps (https://learn.microsoft.com/en-us/azure/azure-maps/migrate-bing-maps-overview).

Azure Maps is a set of mapping and geospatial services that enable developers and organizations to build intelligent location-based experiences for applications across many different industries and use cases. Use Azure Maps to bring maps, geocoding, location search, routing, real-time traffic, geolocation, time zone info, weather, and custom indoor maps into your web, mobile, and server-side solutions. Azure Maps is an Azure service, so it inherently includes many of the Azure security and compliance commitments important to enterprise customers. Azure Maps includes many of the same features as Bing Maps for Enterprise, along with more functionality (MS, 2024).

Bing Maps in ProVAL will need to be migrated to Azure Maps to prevent disruption of the map features. It is estimated that the efforts will not be too big, though it will take time to test the route creation.

Error Reporting

ProVAL 4 uses Microsoft's Visual Studio App Center to report errors automatically. This service is now deprecated and will be retired on March 31, 2025. Most bug fixes in ProVAL 4 are due to these automatic reports. Without this service, bugs will largely go unreported.

To prevent this loss of services, the error reporting code will be migrated to use OpenTelemetry. This will allow the use of any vendor that supports OpenTelemetry. Changing a vendor in the future will require only minor changes.

<u>BENEFITS</u>

This enhancement would bring ProVAL's map features up to date with modern technologies.

This enhancement is the largest contributor to increasing ProVAL 4's stability.

<u>ESTIMATED COST</u>

Transtec will provide an estimated cost if TPF selects this item.

07: Convert Visual Basic Code

FEATURES

A substantial portion of the ProVAL code is written in Visual Basic (VB) for .NET. While still usable, Microsoft is not evolving the language (March 2020). C# is a more modern language than VB, resulting in faster feature implementation and fewer coding errors. When practical, newer ProVAL code is written in C# (e.g., some new features in ProVAL 4.0). However, there remain tens of thousands of lines of VB code in ProVAL. New developers are also more likely to be fluent in C# than VB.

BENEFITS

This enhancement would make it easier to use future language enhancements, reduce coding errors, and reduce time spent on implementation and maintenance.

ESTIMATED COST

Transtec will provide an estimated cost if TPF selects this item.

08: Convert Fortran Code

FEATURES

The main number-crunching code for ProVAL is written in Fortran (specifically, Fortran 90). Given the potential difficulty of finding a Fortran developer in the future when the need arises, it's worth considering rewriting the technical code in C or C#. The Fortran compiler used for ProVAL also no longer supports Mac computers or ARM processors, which affects the feasibility of making ProVAL cross-platform.

BENEFITS

Replacing Fortran would allow ProVAL to be used on more platforms and improve the ability to find a developer if needed.

ESTIMATED COST

Transtec will provide an estimated cost if TPF selects this item.

09: Upgrade from .NET Framework to .NET 8

FEATURES

The current ProVAL 4's programming foundation is a snapshot of the programming technologies available 17 years ago (i.e., 2007). Note that the programming environment evolves faster than the conventional industry, such as pavement engineering. These 17-year-old programming technologies are now considered legacy (i.e., no longer updated or supported by MS. See the following for further details) or at least have newer replacements available.

A substantial portion of the ProVAL code uses Microsoft .NET Framework 4.8. While still supported, Microsoft is no longer adding features to the .NET Framework (as of May 2019). The current framework version is .NET 8 (November 2023). Even without any code changes, limited testing of a profile data file imported with .NET 8 has shown substantial performance improvements.

In addition, most of the user interface uses the Windows Forms (WinForms) technology, which was the first user interface (UI) framework released for the .NET Framework (2002). WinForms are Windows-specific. Multiple frameworks have since been released. When practical, new screens in ProVAL 4 were created using a newer framework. Newer frameworks offer better support for high-resolution and touch screens, and are more consistent with current versions of Windows. The selection of the UI framework would depend on the desirability of cross-platform and performance testing.

BENEFITS

This enhancement would allow better code enhancements, maintenance, and performance.

ESTIMATED COST

Transtec will provide an estimated cost if TPF selects this item.

10: Web version of ProVAL

FEATURES

ProVAL has been developed as a desktop application since its inception in 2000. It was designed to run efficiently on individual PCs and in Windows emulation mode on Apple computers. Over the past 23 years, the industry has used the desktop version of the ProVAL software as the de facto tool for profile viewing and analysis. However, installation and upgrade of ProVAL software have continued to be issued across FHWA departments and State agencies. In the same period, significant advancements in the World Wide Web and web applications have opened another venue for deploying ProVAL more efficiently and effectively. Therefore, it is proposed that a web version of ProVAL (ProVAL Web) be developed and run on a web browser with an internet connection.

The ProVAL team has been developing another software, Veta MDMS & Web, for intelligent construction technologies under the National Road Research Alliance (NRRA) Phase II pooled fund study. Veta MDMS and Web's goal is to better manage all digital as-built (DAB) data from different parties and construction machines (e-Ticketing, agency QA, paver-mounted thermal profilers, intelligent compaction, dielectric profiling systems, ground-penetrating radar, etc.) via a web application and a web Application Programming Interface (API). The first version of Veta MDMS & Web is expected to be released in 2025. The following infographic illustrates the DAB data flow and management for Veta MDMS & Web to support Building Information Modeling (BIM). It is anticipated that we will release Veta MDMS at the end of 2024 and the full Veta Web at the end of 2025.
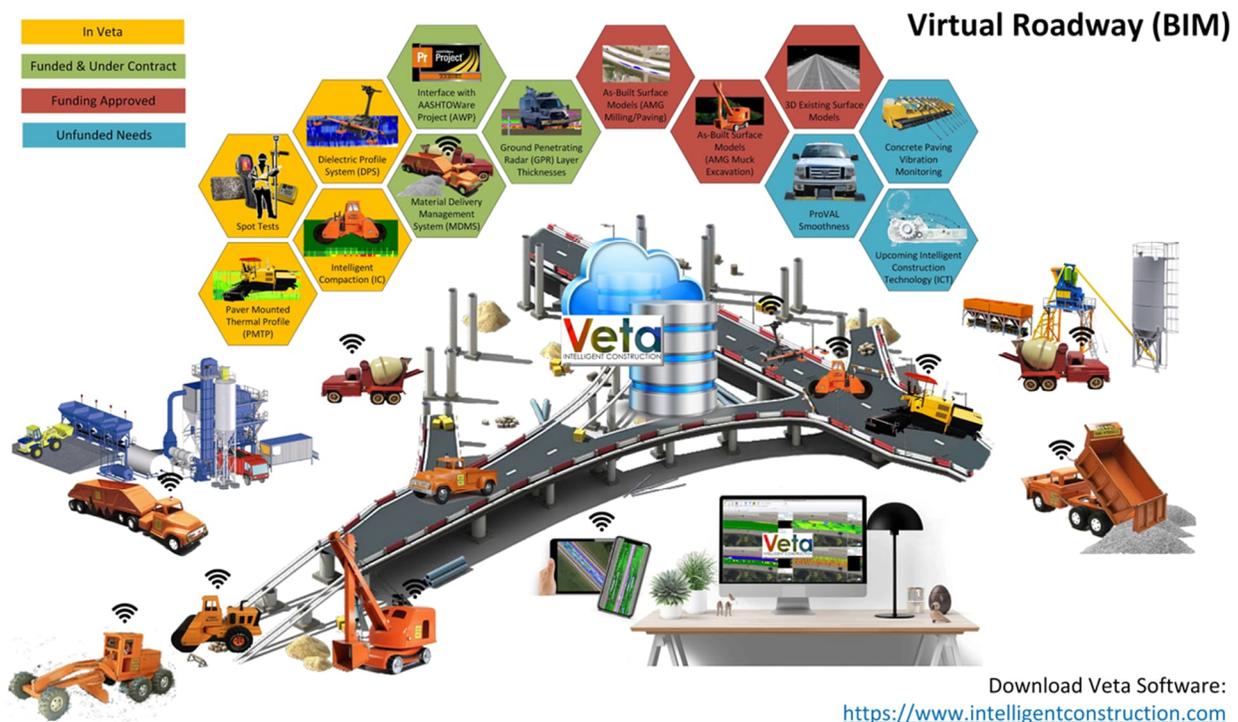

Figure 5. The Infographic of the Veta MDMS and Web.
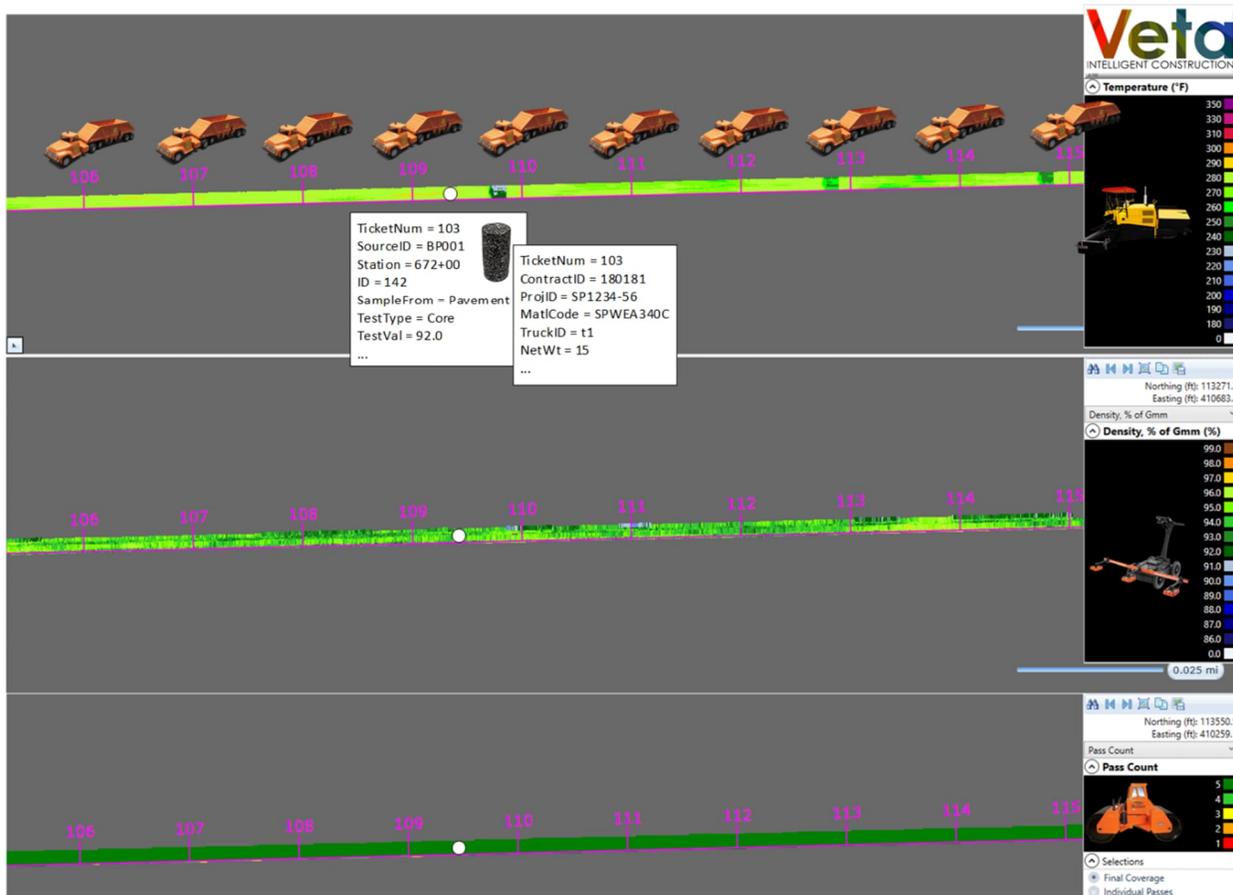
Figure 6. Veta Web GUI.

Figure 7. Veta MDMS and Web Mark-up Display of Multiple ICT Data.

With proven experience developing the above web application, the ProVAL team proposes a web version of ProVAL that can leverage all the web app benefits detailed in the next section.

BENEFITS

The proposed ProVAL Web will provide the following benefits:

Cross Platform Compatibility

Web-based applications are more compatible across platforms or operating systems (OS) than traditional installed software. The minimum requirement to run a web application would be a web browser such as Chrome, Microsoft Edge, Firefox, or Safari. Since these web browsers are available for many OS, ProVAL

Web can be run on any web browser on Windows, Mac OS, and Linux/Unix.

Improved Manageability

ProVAL Web must be installed on a server, so it imposes minimal requirements on the client or end users' systems. Maintaining, improving, customizing, and updating the ProVAL Web can be done on the server. Any client updates, if needed, can then be deployed via the web server with relative ease.

Efficient Deployment

Due to improved manageability and cross-platform compatibility, deploying the ProVAL Web application to end users is more accessible than deploying the desktop version. The ProVAL web is also ideal when access bandwidth is limited, and the system/data is remote to users. The only thing needed to deploy the ProVAL Web is a website address. This would allow for wider access to systems, streamlined processes, and improved functionality very efficiently.

Live Data Security

Typically, in larger, more complex systems, data are stored and moved around separate systems and data sources (e.g., a laptop on a profiler, USB flash drives, a PC in the office, and a server at an agency). In web-based systems, these systems and processes can be consolidated by reducing the need for data marshaling. The ProVAL Web would provide an added layer of data security by eliminating the need for users to move or trace data across different systems.

Cost Reduction

Web-based applications can dramatically lower costs by reducing support and maintenance costs, lowering requirements for end-user systems, and simplifying architecture (e.g., cheaper PCs or other accessible web devices). The ProVAL Web can be used to further streamline operations, resulting in additional savings.

The user interface on the proposed ProVAL Web may be significantly different from the desktop version. The web GUI is expected to be much simpler, and the chart interaction may be slightly limited. The first version of ProVAL Web is proposed to implement the main modules, including Viewer, Editor, and core analyses (Ride Quality, Power Spectral Density, Profiler Synchronization, Profiler Certification, Automated Fault Measurement, and Smoothness Assurance). With this new development, the ProVAL web can be scaled to include many other features (pavement management systems, data mining, etc.) in the future. More design considerations will be optimized during development.

ESTIMATED COST

Transtec will provide an estimated cost if TPF selects this item.