Multi Function Vehicle, Modular System

The Dynatest Multi Functional Vehicle (MFV) combines the functionality of the Dynatest Road Surface Profiler (RSP) with the Laser Crack Measurement System (LCMS) from Pavemetrics

Dynatest®

Introduction to the Dynatest Multi-Function Vehicle (MFV).

The Dynatest MFV consists of a number of subsystems added on top of a basic system. The term basic system is defined by Dynatest to include: a suitable vehicle, a ruggedized computer mounted in a rack, and measurement equipment which could be: a Road Surface Profiler (RSP) system equipped with 1 to 21 lasers, a Distance Measuring Instrument (DMI), up to 8 cameras, a GPS system, or a Laser Crack Measuring System (LCMS).

Each Dynatest MFV is outfitted with the appropriate combination of these technologies based on the end-user's pavement data collection goals and objectives.

Key benefits:

- Operating at traffic speed precludes the need for traffic management.
- Data can be collected day or night, at speeds up to 62 mph (100 km/h).
- Rapid evaluation and screening of all sections of the network.
- The crack detection and crack classification procedures allow for rapid, objective and accurate identification of cracks.
- The 3D capability of the LCMS allows for automatic detection of distresses according to International Standards.
- Pavement inspection 4 m wide, producing a continuous image of the pavement surface in a single run.
- Detects cracks as narrow as 1mm.
- Distress Rating Module (DRM) allows for manual distress analysis of the pavement surface to be performed quickly and efficiently.
- Safer roads both for the engineer and the public.
- RSP-III with the LCMS option can collect IRI, RN, longitudinal profile, transverse profile, rutting, macrotexture, crossfall, gradient, radius of curvature, automated crack data, raveling, Right of Way Imaging, and 2D & 3D pavement images in a single pass
- Road Surface profiler with total flexibility with 1 - 21 deflection lasers.
- RSP unique "Stop & Go" feature permits roughness data to be collected in urban areas within traffic

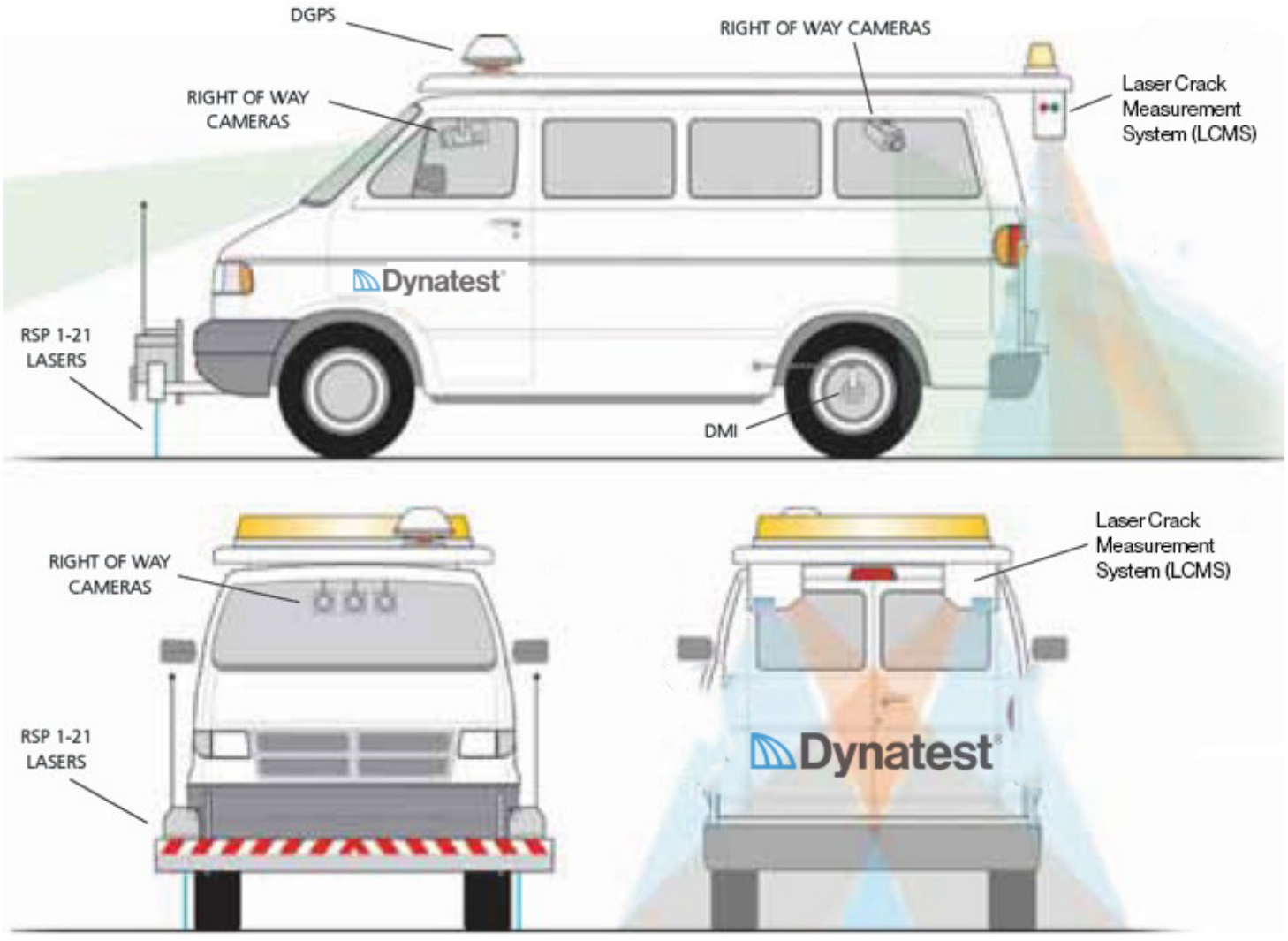
A closer look at the Dynatest Multi-Function Vehicle (MFV).

The multi functional vehicle is a van or pick-up truck specially designed to mount different equipment and technologies to carry out pavement surveys on roads and airports. The MFV is designed to carry out different types of test's at the same time. The choice of van or truck is almost free within the specifications and is at the user's own expense.

The main modules of the MFV consist of:

- Road Surface Profiler (Dynatest RSP).
- Laser Crack Measuring System (LCMS)
- Right Of Way cameras (ROW) or omnidirectional cameras
- Distance Measuring Instrument (DMI).
- GPS (geo-referenced)

Each of the above components will be explained further on the following pages.



Road Surface Profilometer, Mark III, fix mounted

The RSP installed on the MFV is the model Mark III, a system developed in 2004 designed to provide advanced, automated, high-quality pavement longitudinal and transverse profile measurements for engineers, construction superintendents, and pavement network managers. The system is able to acquire data driving at a max speed of 150 km/h. The suggested minimum speed of test is 30 km/h, but the system has a unique “Stop & Go” functionality enabling the equipment to operate in an efficient manner in urban areas, at traffic lights, stop signs, junctions, and roundabouts, making it an ideal tool for data collection on both urban and rural networks.

The Dynatest Mk-III Road Surface Profilometer can measure a number of indices and characteristics including the longitudinal profile, International Roughness Index (IRI), Ride Number (RN), transverse profile, rutting, macrotexture, and geometrics (crossfall, gradient, and radius of curvature). For airport use, it can also provide data for the Boeing Bump Index (BBI) calculation. The equipment meets the ASTM E950 Class 1 precision, AASHTO R 56-14 and R 57-14 and independently verified State road standards such as the TxDOT Tex-1001-S, ensuring high accuracy and repeatability under a variety of conditions that ensure the data can be used for project and network evaluation and in Pavement Management Systems. The RSP-III is a fully upgradeable system offering up to 21 laser sensors, ideal for precise rutting measurements.

The purpose of the laser sensors is to measure the elevation of the bar over the pavement surface at various points across the lane and one or more accelerometers are used to obtain vertical vehicle body movement. Road profile measurements are obtained by summing the body movement with the appropriate body-road displacements allowing calculation for roughness and international indexes like IRI and RN.

Up to three accelerometers may be provided with the RSP. Typically, these would be placed in the wheel paths with the third placed in the center of the bar. The accelerometers are attached to the top of the lasers using a magnetic base and are easily detached for calibration.

Road Surface Profiler, Mark IV, mobile version

The Mark IV RSP system was initially introduced in 2004 to address market desires for a portable, vehicle-independent system that can be quickly and easily moved between various vehicular platforms. The portable RSP has essentially the same capabilities and operator interface as the Mark III platform with the exception that it can be equipped with a maximum of two laser height sensors as opposed to a maximum of 21 lasers on the RSP Mark III.

The lightweight and compact features of the Mark IV facilitate shipping and field installation of the system on almost in front or in the back of any vehicle equipped with a 2x2 inch receiver-style trailer hitch. The telescoping “arms” of the Mark IV facilitate adjustments of transverse laser spacings. The “brain” of the profiler, a single board computer with supporting electronics, otherwise known as the “Embedded Processing Unit”, or EPU, is housed in the aluminum enclosure at the center of the beam. An Ethernet cable connects the EPU to an industry standard notebook computer running Microsoft Windows®

The Mark IV portable profiler is capable, as the Mark III profiler, of collecting the longitudinal profiles and the related roughness indexes on the wheel paths thanks to the height sensor lasers (that can also be upgraded to measure macrotexture) and the accelerometers. This also make it compliant to the industry standards (ASTM E950 Class 1 Profiler, AASHTO R 56 and 57 and TxDOT Tex-1001-S).
Its “Stop & Go” functionality enables the equipment to operate in an efficient manner in urban areas, at traffic lights, stop signs, junctions, and roundabouts, making it an ideal tool for data collection on both urban and rural networks.

The main difference to the Mark III equipment is that the Mark IV can only accommodate two lasers, and therefore is not suitable for rutting calculation. Also, due to the way the Mark IV is mounted to the vehicle, the beam is not considered to be a stable platform for an Inertial Measurement Unit (gyro), hence the impossibility to get geometry data.
Both RSP models utilize an IBM-compatible notebook PC to collect and store all measured data. The Dynatest Data Collection (DDC) software is provided to control testing and calibration operations from the PC keyboard. Dynatest Data Collection transfers all necessary configuration settings to the electronics at start-up. It receives all processed data from the electronics, displays it on the PC screen, and stores the data on the PC’s hard disk.

Laser Crack Measuring System (LCMS-2)

The Dynatest Multi Function Vehicle can be equipped with a Laser Crack Measurement System (LCMS®) from Pavemetrics® for high resolution imaging and crack detection.

The Laser Crack Measurement System (LCMS-2) uses laser line projectors, high speed cameras and advanced optics to acquire high resolution 3D profiles of the road. This unique 3D vision technology allows for automatic pavement condition assessment of asphalt, porous asphalt, chip seal and concrete surfaces. The LCMS-2 acquires both 3D and 2D image data of the road surface with 1 mm resolution over a 4 m lanewidth at survey speeds up to 100 km/h during day or night. LCMS-2 data is acquired and compressed in real time in the survey vehicle so as to minimize storage needs.

The LCMS-2 is able to automatically geo-tag, measure, detect and quantify all key functional parameters of pavement in a single pass, including (but not limited to): cracking, rutting, texture, potholes, bleeding, shoving, raveling and roughness. Options to measure longitudinal profiles, IRI and slope and crossfall are available with the built-in IMUs

The LCMS-2 delivers standards-compliant and industry-proven results on more surfaces than any other sensor in the market; from hotmix asphalt to chipseal, porous pavement, and both standard and grooved (tined) concrete.

LCMS-2 outputs include detailed distress data in XML format and geo-tagged pavement-view images in JPEG format, which can be viewed and verified in the Dynatest Explorer software.
The Dynatest design offers a flexible roof rack that allows a free choice of vehicle, which only need to fulfill some basic requirements to vehicle/roof height, rails for load bar installation and a standard tow bar.

The Dynatest roof-rack uses the commercially available load bars from THULE that comes with installation kits suitable for most common vehicles (vans and trucks) available in the commercial vehicle market.

Additional components

Cameras
Up to 8 ROW or omnidirectional cameras can be mounted on the MFV. These can either be mounted externally, generally well protected on the roof, or internally, looking through the windscreen. The cameras can be set up to point in any direction based on customer wishes.
All cameras will be securely mounted so that they remain correctly aimed during normal operation. Power will be provided through Ethernet (PoE).

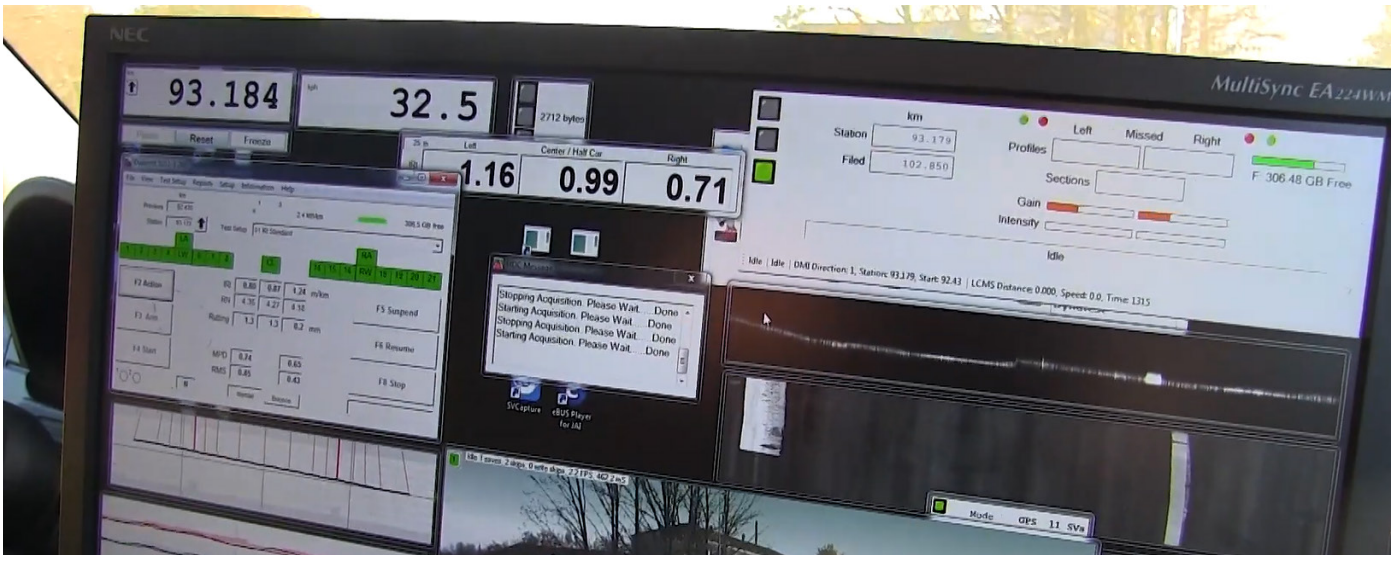
Future advantages will include adding the images to any available Geographic Information System (GIS), which will offer further opportunities for geographical visualization and analysis .
Furthermore, a new Dynatest AI platform will in the future be able to offer intelligent analysis of the imaging data.

Digital Camera looking through the windscreen

GPS and Gyro
A GPS is part of the defined Dynatest standard MFV setup. The GPS will be able to output location (degrees, minutes and seconds of latitude and longitude) via serial communication.
The GPS is mounted in the computer cabinet while its antenna uses a magnetic base to attach externally to the vehicle roof. The antenna is easily removable so that it can be stored in the vehicle while not in use. A gyro is an optional addition to the MFV. It will be mounted as close to the vehicle's center of gravity as possible. An Applanix GPS can be installed, gaining high precision also inside tunnels and in mountains environment where the satellite reception is bad.

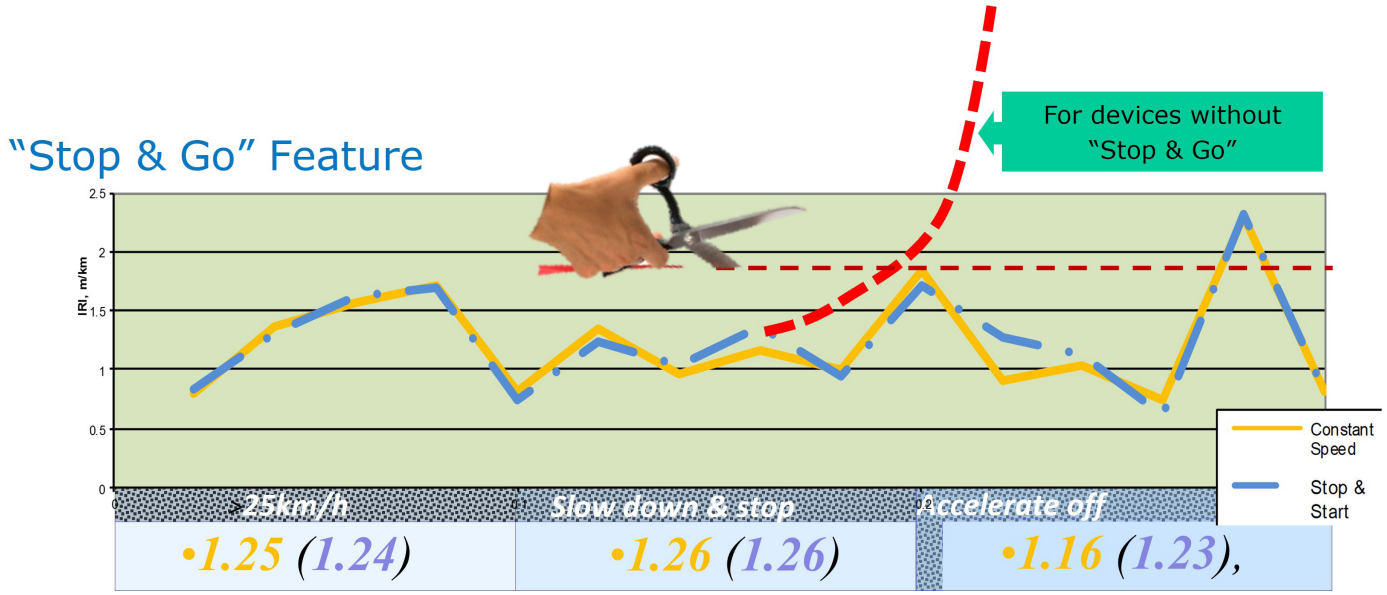
Inverter and battery
An extra 12V DC battery is mounted to power the electrical components of the MFV. This battery feeds an inverter which generates 220V AC for the equipment which requires it.

Data collection computer
The data collection computer runs the Dynatest Data Collection (DDC) software which controls the data collection from all components of the MFV and also stores the generated data.



Stop & Go Feature

The “Stop & Go” feature allows IRI and RN measurements to be taken at all traffic speeds, allowing testing at junctions, traffic lights, roundabouts and testing of short sections where it is difficult to gain enough speed, or when it is not possible to do a pre-section(tined) concrete.
This function makes it possible to drive under normal circumstances and still avoid a lot of work to cut and connect the measuring data afterwards. This saves time & money and ensures correct datasets.



Section length 320m, Two runs:

1st run at constant 70km/hr

2nd run, started at 70km/hr, came to a complete stop at junction, then accelerated back to 70km/hr

The average IRI values for the three 100 m sections are yellow (values in parenthesis are for “Stop & Go”).

Dynatest MFV feature list

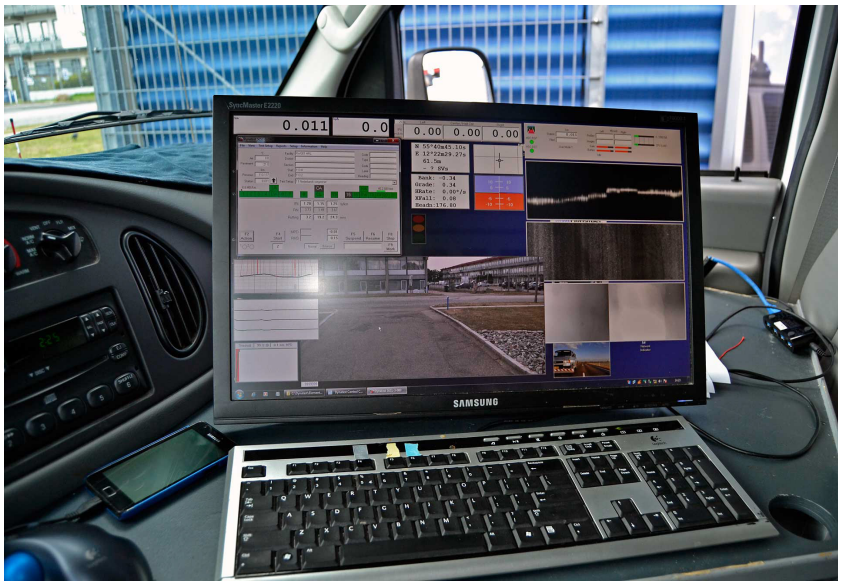
The below table gives an overview of the measuring features possible with the MFV:

Measurement Feature	RSP	LCMS
Boeing Bump Index (BBI)	•	
Geometry (grade, cross-fall, turn rate, Heading)	• (only With RSP III)	•
Longitudinal Profile Roughness	•	•
Visual of Pavement distresses with 2D and 3D Images		•
IRI/RN	•	•
Rutting	• (only With RSP III)	•
Automated PCI		• (With PCI module in DE software)
Sealed cracking		•
Cracking		•
Water entrapment		•
Potholes		•
Bleeding		•
Pop-outs and Picks-outs		•
Shoving		•
Raveling		•
Manholes and Storms Drains		•
Curb and Edge drop-off		•
Patching		•
Lane Markings		•
Texture/ Mean Profile Depth (MPD)	•	•
Location	•	•

Data Collection Software

Dynatest Data Collection (DDC)
Dynatest Data Collection (DDC) is the data collection application used with most Dynatest equipment, including the Multi Function Vehicle (MFV) solution with Road Surface Profilers and/or Laser Crack Measurement System (LCMS-2). Dynatest Data Collection is needed to operate the equipment, and it orchestrates the communication with embedded software to extract measurement data to a file.

DDC is able to detect equipment connected to the main board and activate relative tools. All devices can be set to the desired settings before testing.



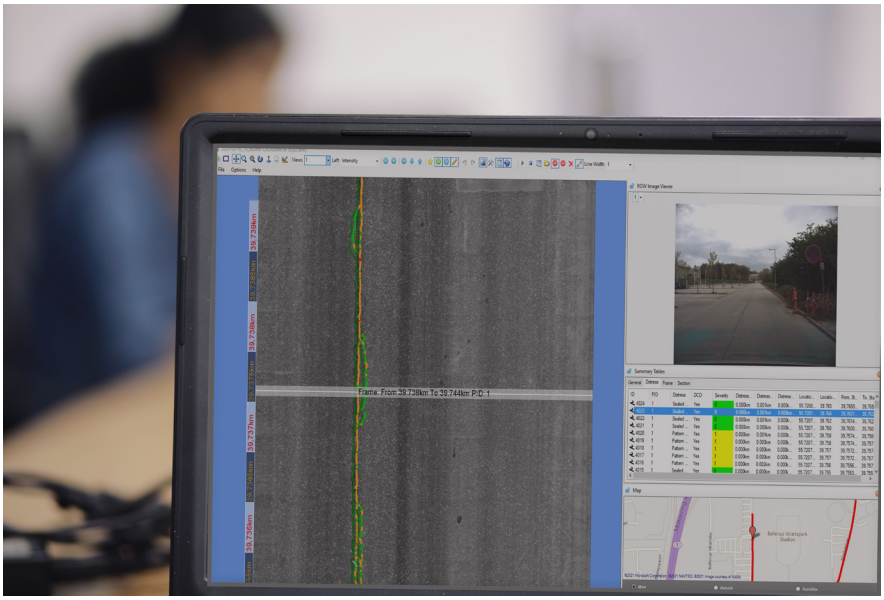
The start screen of the Dynatest Data Collection software consists of small windows (applets), which are programs providing only the required information about the connected equipment.

The data will be shown while testing and stored for export into the post processing data program.
The system generates several output files and if you have cameras or an LCMS then the data for these will be stored separately for easy export.

Post processing of data

Post processing computer

The post processing computer can be separate from the data collection computer (which is permanently mounted in the host vehicle). It is an office computer dedicated to post processing the data collected with the MFV equipment.

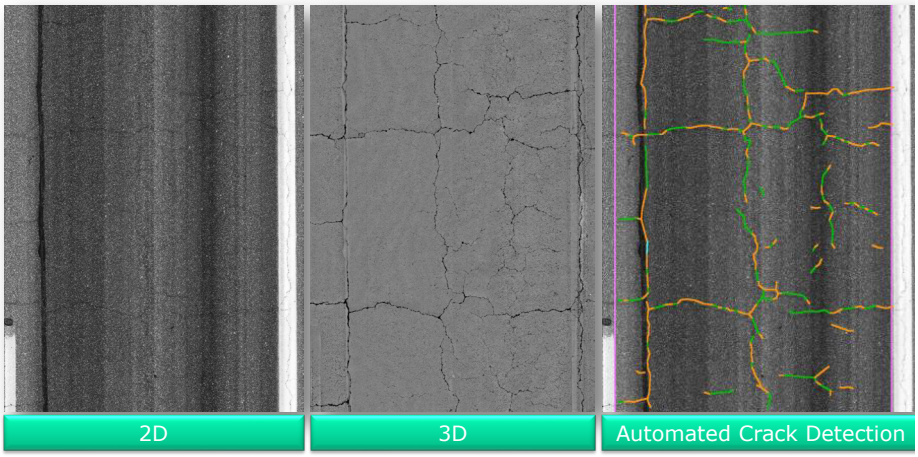


Dynatest Explorer (DE)

Dynatest Explorer (DE)
Dynatest Explorer (DE) is a comprehensive pavement analysis program that can provide the user with a complete overview of the pavement condition.

Dynatest Explorer is primarily used to evaluate the functional pavement condition with data from Dynatest Road Surface Profilers (RSP) or LCMS®. DE gives you access to all the data, images and distresses acquired during the survey, allowing for visualization, verification, reviewing and reporting of results.
Dynatest Explorer provides a long range of export options, including export of distresses to Microsoft Excel and Google Earth. Dynatest Explorer is a Desktop Application, that runs on Microsoft Windows 10 or newer (64-bit).

Distress Rating Module
For equipment with a Pavemetrics® Laser Crack Measurement System (LCMS®), the Distress Rating Module (DRM) in Dynatest Explorer can be used for both the automated and manual analysis of 3D and 2D pavement images, while simultaneously being able to see Right of Way (ROW) images and map location.



The Distress Rating Module uses the images from the LCMS® sensors and the distresses identified in the LCMS® data processing will automatically be added to the distress table. Using the tools provided in the Distress Rating Module it is possible to manually identify and classify distresses that may not have been detected in the automatic processing, while also being able to measure and edit the detected distresses.

DTMap
Using the DTMap module in Dynatest Explorer, it is possible to visualize road section data on a map. The module allows the user to set thresholds for color visualization as well as calculation parameters. The data can then be exported directly to Google Earth.

Pavement Condition Index (PCI) calculations

Automated PCI calculations for your ease

The Pavement Condition Index, as defined by the International standard ASTM D6433-20 (and the ASTM D-5340-20 for Airport) is the most used and significant index in order to have an overview of the quality of the road.
Dynatest has developed an automated PCI calculation according to standard D6433 - 20.

Pavement Condition Index	Color	Scale
100 < PCI < 85		Good
85 < PCI < 70		Satisfactory
70 < PCI < 55		Fair
55 < PCI < 40		Poor
40 < PCI < 25		Very Poor
25 < PCI < 10		Serious
10 < PCI < 0		Failed

The new PCI calculation function is part of a licensed module within Dynatest Explorer, and offers the user an accurate, safe, and fast method to achieve the PCI value of flexible pavements on roads. The automated PCI calculation function is able to give you the PCI value taking into consideration all distresses identified (both automatically and manually rated) within the sample unit that the user has defined.
The results can be shown as tables, graphs, or directly on a map.

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