Dynatest®

Dynatest
Road Surface Profilers
including
Multi Function Vehicle options

OWNER’S MANUAL

Version 2.0.1.1

! IMPORTANT SAFETY REMARKS!

Please Read this first:

For your own safety and the safety of others, please read this advice carefully:

An RSP incorporates laser displacement sensors, which emit laser light (Class 3B)!

! WARNING !

The emitted laser light can damage a human eye if directly exposed, or if the light is reflected by a mirror or any mirror like surface directly into the eye.

The laser light may be invisible.

Follow all Warnings and Instructions in this Manual and in any referenced OEM manual!

NEVER turn on the System and thereby laser power without assuring that nobody is close to any laser sensor.

The laser light will not harm human skin.

Overview

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1 Introduction

Introduction to the Dynatest
Road Surface Profiler
Test System

In 1992 Dynatest introduced its first profiler, the Dynatest 5051 **Mark I** Road Surface Profiler (RSP). The Mark I RSP was based on technology developed by Dr. Roger Walker at the University of Texas at Arlington. The RSP has its roots in roughness measuring equipment developed for, and in use by, the Texas Department of Transportation.

In 1997, Dr. Anders Sorensen and Mr. Karsten Skrydstrup of Dynatest produced an entirely new version of the equipment, designated as the RSP 5051 **Mark II**. The RSP 5051 Mark II is designed, manufactured, and supported solely by Dynatest. The most notable component of the Mark II is the Profiler System Board (PSB), which performs all profile data collection and processing functions on one or more computer boards, which easily fit into a single computer. Another notable feature is its ability to accurately conduct IRI measurements under stop and go conditions of an urban road network environment.

Further development of the RSP technology has led to the introduction of the 5051 **Mark III** in 2003 (Figure 1). The operator interface for the Mark III now consists of a Windows-based control program typically installed on a laptop PC. A Data Processing Unit (DPU), consisting of a single-board computer and one or more PSBs mounted in a passive backplane, has replaced the desktop-style computer. The DPU handles the data collection and processing tasks, and passes the processed data to the notebook PC via an Ethernet connection.

Figure 1 - Dynatest RSP 5051 Mark III

The Mark III RSP test system can collect a wide variety of information ranging from ride quality measurements (International Roughness Index and Ride Number) to high accuracy transverse and longitudinal inertial profile elevations as well as geometric information such as grade, crossfall, and curve radius or degree of curve. The more sophisticated versions of the RSP compute, display, and store longitudinal and transverse profile as well as roughness indices, rutting measurements and crossfall in real time and at highway speeds. The RSP can also be equipped to measure pavement texture and faulting.

The **Mark IV** RSP system (Figure 2) was developed 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 only two laser height sensors as opposed to a maximum of 21 lasers on the RSP Mark III.

Figure 2 - The Dynatest RSP 5051 Mark IV

The lightweight and compact features of the Mark IV facilitate shipping and field installation of the system on almost 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 aluminium enclosure at the centre 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 of collecting the same information as the Mark III except for rut and geometric information. The Mark IV can only accommodate two lasers, and therefore cannot measure pavement rutting. 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).

This manual covers both Mark III and Mark IV models with all available options, and therefore contains information/verbiage, which may not be relevant/appropriate for your particular system.

1.1 General Description

The RSP systems have been designed to be quite flexible, incorporating a modular concept that allows for a variety of sensor combinations and configurations.

The heart of the Mark III system is the innovative DSP based Profiler System Board (PSB) that can collect and process data from a variety of sensor array combinations. These combinations may vary from one accelerometer and laser displacement sensor to three accelerometers, up to 21 laser sensors and a three-axis Inertial Motion Sensor (IMS) (incorporating solid-state gyros, etc.). The PSB is unique in the profiling industry and eliminates the need for large bulky electronic boxes typically used in profilers.

In the Mark IV, the PSB functions are incorporated into miniaturized circuits in the Electronic Processing Unit (EPU) which is housed within the RSP beam itself. The Mark IV can accommodate one or two laser/accelerometer combinations.

Both RSP models utilize a Windows laptop computer to collect and store all measured data. A Windows-based Field Program is provided to control testing and calibration operations from the keyboard. The Field Program transfers all necessary configuration settings to the electronics at start-up. It receives all processed data from the electronics, displays it on the computer screen, and stores the data on the hard disk.

The RSP systems are operable by one person, that being the driver of the vehicle. The RSP can collect data at speeds of up to 110 km/hr (70 mph).

The laser sensors, accelerometers and optional IMS unit for the Mark III system are mounted in rigid aluminium housing (Transducer Unit or “Rut Bar”) at the front of the vehicle. A basic Rut Bar is typically 1.83 m in length (or width as viewed from the front). The bar can be extended at each end with a “wing” of approx. 0.3 m in length, making a total rut bar length approx. 2.4 m. Each wing accommodates up to 4 laser sensors, one of which may be mounted vertically, but otherwise typically mounted at angles. That effectively increases the measuring width by approx. 0.3 to 0.4 m in both sides. The total effective, nominal measurement width is then typically in the range of 2.9 to 3.2 m with wings installed at both ends of the basic bar.

The laser sensors and accelerometers for the Mark IV are mounted in aluminium housing typically at the rear of the vehicle. The telescoping arms allow for transverse laser spacing adjustments from 1.5 m (60 in.) to 2.0 m (79 in.).

1.2 Measurement Parameters

In general parameters are **calculated in real time** and reported as averages over user selectable intervals from 25 mm (1 inch) to 1.6 km (1 mile). Exceptions include GPS, IMS, Event markers and Faulting measurements which are “point specific” measurements.

1.2.1 Longitudinal Profile, IRI and Ride Number

The longitudinal profile elevation measurements are obtained by using an accelerometer to monitor vertical vehicle body movement, and a laser sensor for measuring the displacement between the vehicle body and the pavement. Road profile elevation measurements are obtained by summing the vehicle body movement with the appropriate body-road displacement. Profile measurements in one or both wheel paths are possible. For the Mark III, if profile elevations are measured in both wheel paths simultaneously, it is also possible to measure profile elevations in the centre of the lane, even if only a laser sensor is installed in that position.

IRI is calculated in accordance with procedures and specifications outlined in World Bank Technical Paper Number 46 “*Guidelines for Conducting and Calibrating Road Roughness Measurements*”. Ride Number is calculated using methods outlined in "*Measuring & Analyzing Road Profiles*, National Highway Institute Short Course Manual, University of Michigan, Transportation Research Institute, October 1997".

1.2.2 Rutting (Mark III only)

With a minimum of five laser sensors, a very simple lane "cross profile" and a simple, separate rut value for each wheel path can be calculated. By adding another two, four, six or more lasers (up to a total of 21), the transverse profile can be defined in greater detail, hence the rutting can be determined more accurately.

1.2.3 Texture

Any or both wheel path laser sensors can be of a texture-capable type employing smaller spot size and higher sampling frequency. For the Mark III the centreline laser sensor can also be texture-capable. The macrotexture statistics reported are in accordance with the established standard 'Mean Profile Depth' (MPD) and Root Mean Square (RMS). Both statistics are computed continuously and can be reported as close as every 100 mm (4 inches).

Mean Profile Depth is measured according to ASTM E1845-01 "Standard Practice for Calculating Pavement Macrotexture Mean Profile Depth" and ISO/CD 13473-1 "Characterization of Pavement Texture Utilizing Surface Profiles".

The profiler can also calculate the RMS (Root Mean Square) of the profile trace, which provides additional useful information regarding pavement texture (for further information, see "*High-Speed Texture Measurement Of Pavements",* Kevin K. McGhee, P.E., Gerardo W. Flintsch, Ph.D., P.E., Virginia Polytechnic Institute & State University, Virginia Transportation Research Council, February 2003).

1.2.4 Crossfall, Grade, and Radius of Curvature (Mark III only)

By adding an Inertial Motion Sensor (IMS), collection of crossfall, grade, and highway curvature information is possible. The IMS is a microprocessor controlled, self-compensating, three-axis solid-state gyro unit.

Crossfall is computed as the slope of a linear regression line through the laser elevation measurements, adjusted for roll information obtained by the gyro. Crossfall is displayed and stored in degrees.

Grade is the longitudinal slope of the lane under test. It is displayed and stored in degrees.

Radius of Curve (km or mile) and Curvature (deg/km or deg/mile) of the lane is determined in the horizontal plane. Turn rate (degrees per second) and the vehicle velocity are the basis for these computations.

1.2.5 Laser Elevations and Accelerations

Raw laser elevation data (height of each laser above the pavement surface) and raw vertical acceleration can be stored at user-specified intervals. Elevations determine the Cross-Profile and are useful for verifying rut measurements or providing data from which to calculate rut depths using alternative procedures.

1.2.6 Vehicle Speed

The RSP can also record vehicle speed during data collection. This is useful for quality assurance/quality control purposes as well as for certain troubleshooting tasks.

1.2.7 Faulting
Faulting on jointed concrete pavements can be detected according to *"Standard Practice for Estimating Faulting of Concrete Pavements AASHTO Designation: PP39-99"*. The RSP field program provides ample flexibility for the user to specify and/or modify the definition of a fault.

1.2.8 Laser Quality
Laser quality information can be recorded in the data file at user-specified intervals. This provides valuable quality control/quality assurance feedback. Laser quality information can be useful when profiling during less-than-ideal conditions, such as on damp pavements. It can also be useful for troubleshooting RSP problems.

1.2.9 Events
Manual Events:
Any non-dedicated computer key can be used to store an "Event" character at a specific location.

Automated Events:
When the Photo-Sensor changes state an "ON" or OFF" event is recorded.
When driving speed exceeds or drops beyond preset limits a "VH" or VL" event is recorded.

1.2.10 Global Positioning System
GPS coordinate data can be collected and stored with an optional GPS receiver. A typical GPS receiver used for this purpose is the Trimble Ag-132.

If extremely high accuracy coordinates are required, the RSP can be equipped with an Applanix POS/LV system (see www.applanix.com).

1.2.11 Pictures
Still images can be stored at user-specified intervals with an optional compatible camera. The camera system must comply either with the Windows DirectX system (WDM compatible driver) or with the Halcon image software. Most Web-, USB-, Firewire- and GigE cameras can be used.

1.2.12 High Definition Cracking
Adding a Pavemetrics LCMS system to an RSP makes an MFV or Multi Function Vehicle. The LCMS produces detailed 3D imaging of the pavement surface for detection of defects like cracks.

1.2.13 Ground Penetrating Radar
This option for sampling layer properties is hardly relevant for a high speed profiler.

1.2.14 Tire Sound Intensity
Adding a Dynatest TSI system provides measurement of tire-pavement noise using the OBSI method (On-Board Sound Intensity). This method uses microphones located very close to the tire.

1.2.15 Temperatures and Air Pressure
The OBSI method requires collection of temperatures and ambient air pressure. The TSI system includes a separate networked device for this purpose.

1.3 Software

The systems are delivered with both Field- and Post-processing software packages.

1.3.1 Field Program Software

The Field Program allows the operator to enter operational parameters and other information such as:

- Beginning station of the road section being tested
- Increasing or decreasing stationing during the test run
- IRI reporting interval
- Ride Number reporting interval
- Rut reporting interval
- Longitudinal profile filter length
- Transverse profile reporting interval
- Data file names
- Etc…..

It is possible to select the IRI interval in the range of 0.3 m (one foot) to 1.6 km (one mile). The rut reporting interval can be selected independently and to intervals down to 0.10 m. The user-specified profile filter length can be 10 to 199 meters.

The standard output files produced by the field data collection software are in comma delimited ASCII format (see chapter 13). Files of this type are easily imported into popular spreadsheet programs. Other file types are supported including .XLS (Microsoft Excel), .XLSB (Microsoft Excel 2007+, Binary), .PRO (AASHTO/TxDOT), .PPF (ASTM) and .ERD (University of Michigan). See chapter 13.3 for more information on these file formats.

1.3.2 Post Processing Software

Windows®-based post processing software is available for reporting, summarizing, graphically displaying, and archiving all data produced by the RSP. Dynatest Explorer, DE a SQL database triple function program providing Import, Plotting and Export of data.

Import is used to import data from the RSP format into a Microsoft® Access® database file. This file is compatible with Dynatest's pavement management software, making it possible to transfer RSP data into a PMS in an automated fashion. Import can also be used for project level work in which a separate database is created for each road project.

The Plot function reads the database files created with Import and constructs a graphical plot of any and all data collected with the RSP. Plot produces a combination bar/line chart whereby the parameters of interest are plotted on the multiple Y-axes and distance is plotted along the X-axis of the chart.

The Export function can e.g. compute the required amount of material for *"Bituminous Levelling"* based on longitudinal and transverse profiles. The output is simple ASCII files.

2 The RSP Mark III System

For RSP Mark IV Systems, please proceed to Section 3.

2.1 Test System Components

2.1.1 System Overview

The RSP Mark III consists of some or all of the following main (standard or optional) components:

- Transducer Bar
  - Laser Sensor(s) for Elevation Measurements (optionally for Elevation as well as Texture Measurements in wheel path and/or centreline positions)
  - Laser Sensor(s) and electronics for High Definition Rut measurements
  - Accelerometer(s)
  - Inertial Motion Sensor
  - Photo-Start Sensor
  - Primary Connection Module
  - Secondary Connection Module(s) (one for RSPs equipped with more than 5 lasers, two if more than 13 lasers)
  - Power Module
- Wing Extensions with Angled Lasers (for RSPs equipped with 5 or more lasers)
- Data Processing Unit (DPU) containing:
  - One, two or three PSB(s) (Profiler System Boards) for a maximum of 5, 13 or 21 Laser Sensors.
  - One Single Board Computer.
- Wheel mounted Distance Encoder
- GPS engine
- Camera
- IBM Compatible PC, normally a portable Notebook or Desktop PC, equipped with an Ethernet connection. Optionally ruggedized.
- Ethernet Switch or Router

2.1.2 Data Processing Unit (DPU)

The Data Processing Unit (DPU) is the common term for the Profiler System Boards (PSBs) and the Embedded Processor combined in the DPU Cabinet. The DPU eliminates the need for bulky rack-mounted electronic equipment and associated housings that are typically supplied with profiling equipment.

2.1.2.1 Profiler System Boards (PSBs)

The Profiler System Board (PSB) is the heart of the RSP system. This board employs parallel processing DSP chips in the real time calculation of signal quality, inertial profiles, macrotexture, etc. and takes care of odometer processing too.

2.1.2.2 Embedded Processor

The embedded processor collects data from the PSBs and computes ride indices, rutting, faulting etc. The embedded processor is responsible for output file generation as well as communication with the host PC via Ethernet.

2.1.2.3 DPU Cabinet

The DPU Cabinet acts as a container for the Embedded Processor and the Profiler System Boards. The Cabinet has an internal Power Supply that powers the bus, into which the Embedded Processor Board and the PSBs are plugged.

2.1.3 Transducer Bar

The transducer bar is an aluminium box bar with dimensions of approximately 20 cm by 20 cm by typically 1.83 meters (without wing extensions). With wing extensions, the transducer bar length increases to anywhere from 2.33 to 2.55 m. The transducer bar is solidly mounted to the front of the vehicle and houses the laser sensors, accelerometers, IMS, photo-start sensor, power module(s) and primary/secondary connection module(s) as required. The function of the transducer bar is to provide protection to the various components housed within and to provide a straight platform for mounting of the lasers. The transducer bar is shown mounted on the front of a vehicle in Figure 3.

Figure 3 - RSP Transducer Bar with Wing Extensions (L17.2)

The transducer bar shown in Figure 3 has the optional wing extensions installed, which house angled laser sensors. Note the access cover plates on either end of the top of the bar. These plates provide access to the two wheel path accelerometers.

2.1.3.1 Laser Distance Measurement Sensors

The transducer bar will house up to 21 laser sensors. The purpose of the laser sensors is to measure the elevation of the bar over the pavement surface at various points across the lane. This information is used to develop objective statistics regarding pavement roughness, and to estimate the amount of rutting present on the pavement surface.

Selcom Model SLS 5000 laser sensors are used for profiling (except for angled lasers or lasers used for measuring texture). These laser sensors have compact, DSP based electronics that simplifies installation and enables them to occupy less space in the bar. These lasers are extremely rugged and reliable, and considered to be the finest laser sensors available for profiling pavements. A photo of an SLS 5000 laser sensor module is shown in Figure 4 below.

Figure 4 - Selcom SLS 5000 laser module

2.1.3.2 Accelerometers

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 centre of the bar. The accelerometers are attached to the top of the lasers using a magnetic base and are easily detached for calibration. The purpose of the accelerometers is to track the vertical motion of the lasers through space. The centre accelerometer is most often not applied, since the vertical centre movement can be derived from the two wheel path accelerations. The vertical displacements are subtracted from the laser elevation measurements to obtain pavement profile elevations. These elevations are used to calculate International Roughness Index, and Ride Number statistics for the pavement. These statistics are indicative of the severity of pavement roughness.

The accelerometers are state-of-the-art servo accelerometers with 1 μ**g** resolution (9.81 x 10^{-6} m/s^2). A photo of an accelerometer is shown in Figure 5.

Figure 5 - Accelerometer with Magnetic Mount

2.1.3.3 Inertial Motion Sensor (IMS) (Optional)

The IMS unit is an optional component of the RSP, which is used to collect and derive geometric data of pavement sections. Data items include:

- Grade (Pitch)
- Cross Slope (Roll)
- Turn Rate (Yaw Rate), and
- Heading

The Cross Slope (Roll) of the transducer bar is used with cross profile laser distance data for real-time calculation of the Crossfall of the pavement.

The turn rate can be used with velocity data to calculate roadway curvature (radius of curve and degrees per kilometre/mile).

The IMS currently used is a Watson AHRS-E304. It is a 3-axis solid-state gyroscope with a 3-axis accelerometer and a magnetometer to provide earth references. The IMS communicates with the RSP via an RS-232 serial port. A photo of the IMS unit is shown in the below figure:

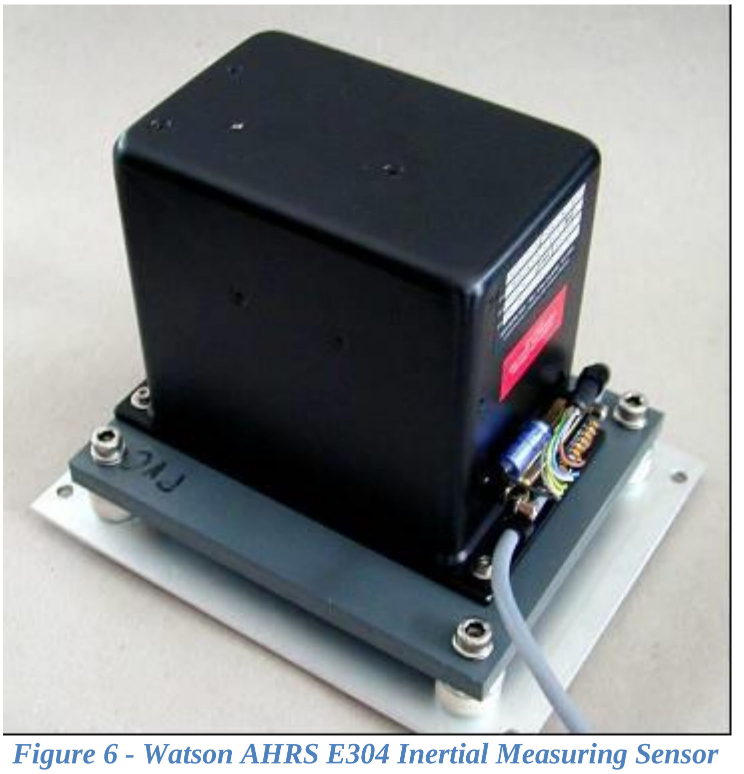


Figure 6 - Watson AHRS E304 Inertial Measuring Sensor

2.1.3.4 Photo Sensor (Optional)

A photo sensor can optionally be installed on the transducer bar. The photo sensor can be used to ensure that data collection initiates at the same point on multiple data collection runs and to perform DMI calibrations “On the Fly” (both start and stop detection). The RSP field data collection program can be triggered to begin collecting data using the input signal from this sensor. This sensor is most useful for verifying precision and bias statistics for profile elevations, which require repeated runs over the exact same test section. Precision and bias statistics may be used to determine if the equipment is working properly.

The photo sensor shines modulated, infrared (IR) light on the pavement and measures the amount of IR reflected back. It sends a signal back to the RSP system when the amount of reflected light exceeds a certain threshold. This threshold is adjustable by the user. Because the sensor employs modulated IR light, it can be used in all lighting conditions, including bright sunny days.

A typical installation location of the photo sensor is included as Figure 7 (in this case on the “inner” side of a wheel path laser sensor).

Figure 7 - Photo Sensor Mounting Location

Photo triggering can also be accomplished by “side-looking” sensors used with reflective cones placed at the side of the road.

2.1.3.5 Primary Connection Module

The primary connection module (PCM) is a proprietary circuit board that collects the signals from the various components located in the transducer bar. It sends all digital signals over a standard data (SCSI) cable to the PSB (Profiler System Board) that is located in the DPU Cabinet in the vehicle. It also performs the function of converting the analogue signals from the accelerometers into digital format. Finally, it provides power to the accelerometers, photocell, and IMS.

The primary connection module is located inside the transducer bar. The lasers, accelerometers, IMS, and photo sensor cables plug directly into this module.

Figure 8 - Primary Connection Module (PCM)

2.1.3.6 Power Module

The power module is located inside the transducer bar and supplies the 24 volts necessary to power the laser sensors.

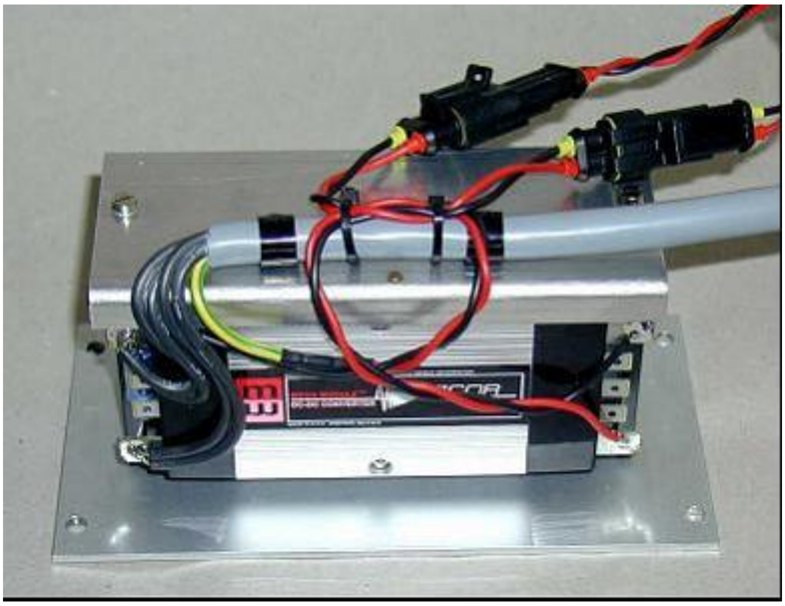


Figure 9 - Transducer Power Module (TPM)

2.1.3.7 *Wing Extensions with Angled Lasers*

The optional wing extensions typically contain Selcom SLS 6000 angled laser sensors. One or more wing lasers are provided at each end of the bar. The lasers are angled at maximum 45 degrees to the vertical axis of the transducer bar. They extend the measuring base of the transducer bar to typically 2.9 to 3.2 meters.

Figure 10- RSP with Wing Extensions and Angled Lasers

2.1.4 *Distance Encoder*

The distance encoder accurately measures distance and communicates this information to the PSB via a standard phone cable with an RJ 45 phone jack that plugs directly into the PSB. The wheel encoder produces 2,000 counts per 1 revolution of the vehicle tire making it very accurate and repeatable.

The wheel encoder is typically mounted on one of the vehicle's wheels. Figure 11 shows a typical installation.

Figure 11 - Typical Wheel Encoder Mounting

2.2 Vehicle Installation

2.2.1 General Remarks

Unless otherwise specified by the customer, RSPs are typically delivered in a fully operational state, with installation of the RSP components performed at a Dynatest facility (recommended). If circumstances require it, installation and setup can be performed at the customer's premises provided adequate workshop facilities are available. Nonetheless, vehicle selection guidelines, important installation instructions, and vehicle preparations instructions are provided in this chapter for the sake of completeness. This section does NOT describe all the "non-permanent" connections (computer (PC and DPU) power cords, network cables, etc). In this chapter RSP components that are followed by "(provided)" are typically installed prior to delivery to the customer.

2.2.2 Guidelines for Vehicle Selection

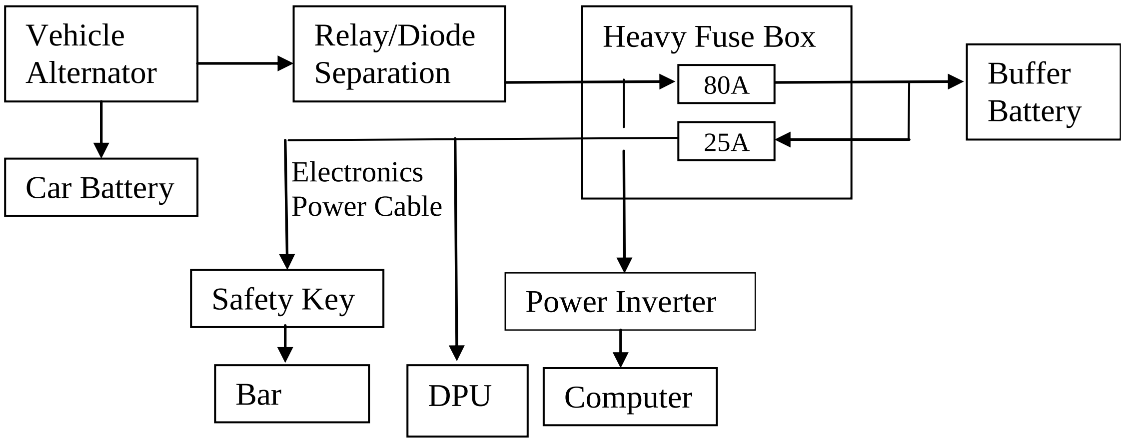
Dynatest recommends a van or mini-bus or station wagon as a platform for RSP systems. Passenger cars, due to windshield visibility restrictions, are not recommended. The vehicle wheelbase (distance from front to rear axle), should preferably be some 2.70 meters or greater. Vehicles with excessively stiff suspensions should be avoided, in particular for a towing hook mounted Mk-IV.
Minimum recommended vehicle width is 1.7 meters.

2.2.3 Warning Signs / Flasher Lights

The RSP can operate at normal traffic speeds, but warning signs and flashing lights are still recommended as a safety factor. Flashing lights should be mounted on top of the vehicle, while suitable warning signs may also be mounted on the rear of the vehicle. Due to variations in local regulations the RSP System does not include any warning signs and/or flasher lights. We recommend you to consult the local authorities concerning guidelines for selection and positioning of signs.

2.2.4 System Powering

The entire RSP Test System is powered exclusively by 12VDC, normally supplied from the vehicle alternator. Overview:



2.2.4.1 Buffer Battery

To ensure a stable 12V supply for the RSP electronics, an electronics buffer battery is provided. The buffer battery, mounted inside the vehicle, is connected to the alternator via fuses and a separation relay (or diode) combination. Heavy gauge wires are used for the positive as well as Ground connections. A maintenance-free (“add-no-water”) 12V battery of typ. 40-60 Ah capacity (standard size in most small passenger vehicles) is preferred.

2.2.4.2 Relay or Diode Battery Separator (optional)

A heavy relay or diode setup will be necessary to ensure a stable power supply for the RSP electronics. This relay/diode provides separation from the vehicle electrical system, thereby preventing voltage surges and sags during engine start. This also provides protection for the RSP electrical circuits in the event of a malfunction in the vehicle electrical system.

2.2.4.3 Heavy Fuse Boxes (provided)

Two heavy fuse boxes (provided) are installed, one between the alternator and the heavy separation relay (or diode) setup, and another close to the electronics buffer battery. Each fuse box contains two fuses, an 80 amp and a 25 amp fuse.

2.2.4.4 Electronics Power Cable

The Electronics Power Cable (provided) is used for 12VDC power connection from the fuse box to the safety key box. The wire is shortened as much as possible to reduce the voltage drop between the battery and the transducer beam. The wiring is described in the table shown below.

Wire	Connect to:
1, 2 and Yellow/Green	25A fuse (‘open’ end)
3, 4	Battery GND (negative) terminal

2.2.4.5 Safety Key Switch Box (provided)

A safety key switch controls power supply to the transducer beam. For convenience, this box is normally located near the operator (dash mount).

2.2.4.6 Power Inverter (optional with RSP-IV)

A 12VDC-to-110(220) VAC inverter (typ. 300W) powers the PC and DPU. It produces a sinusoidal (or modified sinusoidal) waveform. Square wave inverters are NOT used.

The Inverter produces considerable heat and is therefore located in an area where sufficient airflow is available.

The 12V input terminals of the inverter are connected to the electronics battery/fuse box as follows, using heavy wires (provided, 4 sq. mm (No 10 AWG) or heavier):

Terminal	Connect to:
Positive	80A fuse (‘open’ end)
Negative	Battery GND

Wire length is minimized to reduce voltage drop.

With an MFV, the Inverter is of higher power (typ. 1600W) and is normally combined with a charger (of typ. 70A capacity).

2.2.5 Transducer Bar Mounting Brackets

The transducer bar is mated to the front of the vehicle using a set of custom-made steel brackets. The brackets are attached directly to the vehicle frame. The height of the transducer bar is adjusted so that approximately 290 mm of ground clearance is obtained.

2.2.6 Cable Access Opening

An opening is installed in the front of the vehicle, through which the Signal Cables are passed from the Transducer Bar into the vehicle cab. Cables should never be routed through the vehicle door as damage by squeezing/clipping may result.

2.2.7 Distance/speed Encoder Mounting

For distance/speed measurement, a digital encoder is installed on one of the vehicle wheels. A custom-made bracket and flexible arm are necessary to prevent rotation of the encoder housing and for guiding the connecting cable.

2.2.8 Computer and DPU Installation

The Data Processing Unit (DPU) and the computer are placed anywhere inside the vehicle, subject to a few precautions:

The computer should be situated for operator convenience and the DPU should preferably be placed so that the back-panel LED indicators are visible from the operator's position. All components are situated to prevent bumping and/or tilting while driving, e.g. using rubber straps and foam rubber padding. **Care is taken to avoid restricting cooling vents and fans on the computer and DPU.**

The maximum ambient temperature limit for the Data Processing Unit and the computer is 40°C (105°F), if placed IN SHADE, so if the temperature in the vehicle approaches this limit, then direct sunlight on the two units should be avoided! Note also that the computer and the Data Processing Unit should not be OPERATING below 5°C (40°F). Storage temperature range is -40 to +65°C (-40 to 150°F).

Condensing moisture adversely affects electronic components, as this introduces creep currents on circuit boards etc. Moisture condensation often occurs when equipment is moved from a cold environment to a warm one. Periods of high relative humidity can intensify the problem. It is therefore recommended that the PC and the DPU not be exposed to large shifts in temperature. Typical problem scenarios include:

Moving the components from a cool air-conditioned room to a vehicle with a hot interior.
Leaving the components in the vehicle during a cold night, then rapidly warming the vehicle's interior.

2.2.9 Air-Conditioning

RSP vehicles are typically air-conditioned to maintain a cool vehicle interior and prevent dust from entering the vehicles windows. A white roof, tinted glass and/or curtains can reduce solar heating.

2.3 Connecting the Electronics

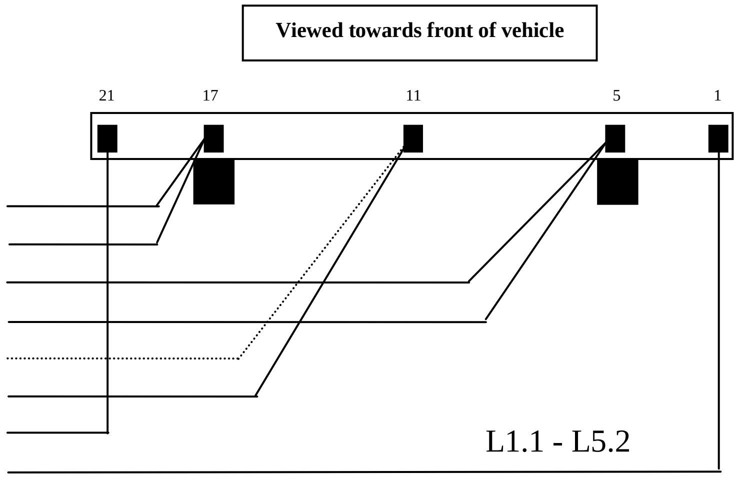
The DPU can be equipped with a maximum of three Profiler System Boards (PSBs), each of which capable of handling eight signal channels. The distribution of signals is laid out so that PSBs cover setups as follows:

PSBs	RSP Model
One Master Board	L1.1 - L5.2

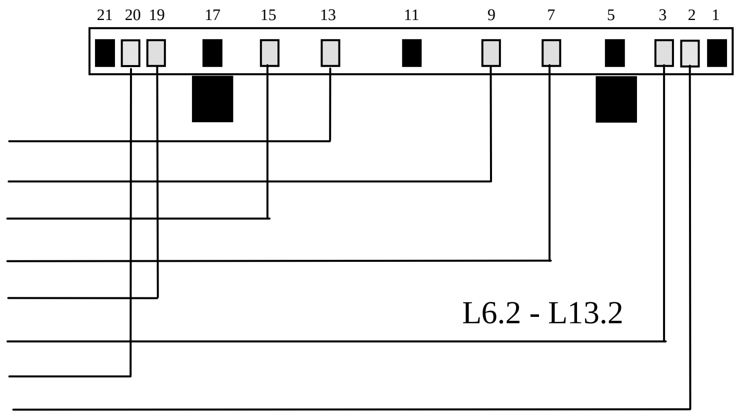
Master + one Slave	L6.2 - L13.2
Master + two Slaves	L14.2 - L21.2

2.3.1 PSB Channel Assignments

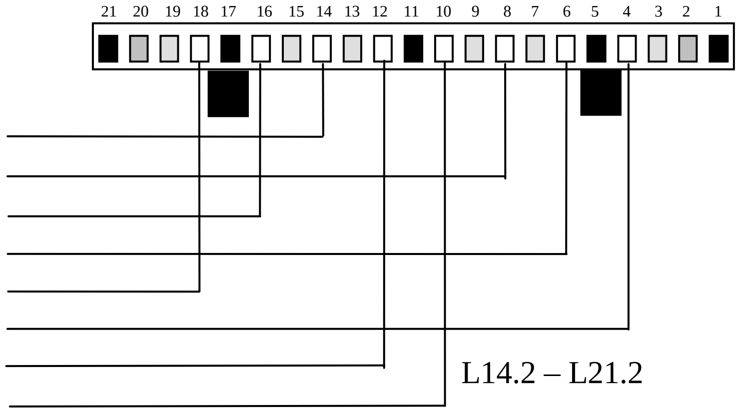
PSB	*Signal*	*Laser Channel*
1	Right Wheel Acc	
	Right Wheel Laser	17
	Left Wheel Acc	
	Left Wheel Laser	5
	(CL Acc for LX.3)	
	Centre Line Laser	11
	Right Outermost	21
	Left Outermost	1



PSB	*Signal*	*Laser Channel*
2	Right of Centreline	13
	Left of Centreline	9
	Right Wheel Inner	15
	Left Wheel Inner	7
	Right Wheel Outer	19
	Left Wheel Outer	3
	Right Wheel Outer 3	20
	Left Wheel Outer 3	2

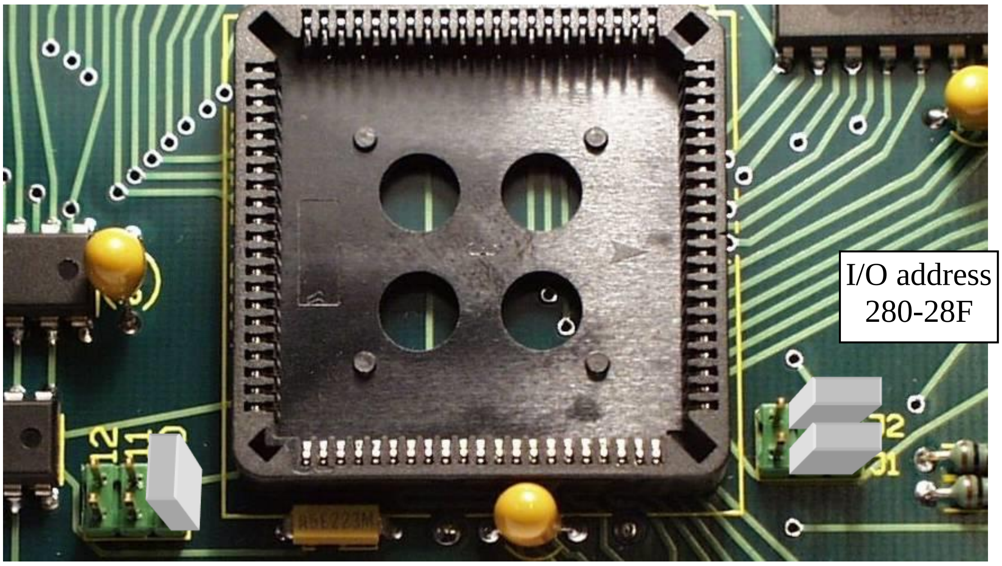


PSB	*Signal*	*Laser Channel*
3	Right of Centreline 3	14
	Left of Centreline 3	8
	Right of Centreline 4	16
	Left of Centreline 4	6
	Right Wheel Outer 2	18
	Left Wheel Outer 2	4
	Right of Centreline 2	12
	Left of Centreline 2	10



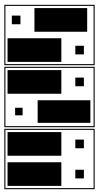
2.3.2 *Setting Jumpers on the Profiler System Boards*

The interrupt line and I/O port address jumpers on the PSBs must agree with the settings shown in the RspWin field program menu "Setup - Equipment".



IRQ 10
This jumper must be in the same position on ALL PSB boards

Alternatives:



290-29F

2A0-2AF

2B0-2BF

NOTE: If you install more than one PSB, then the I/O port addresses must differ!

INTERRUPT Setting

10	11	12
*		

I/O Port Settings

	280-28F	290-29F	2A0-2AF	2B0-2BF
Master	*			
Slave 1		*		
Slave 2			*	

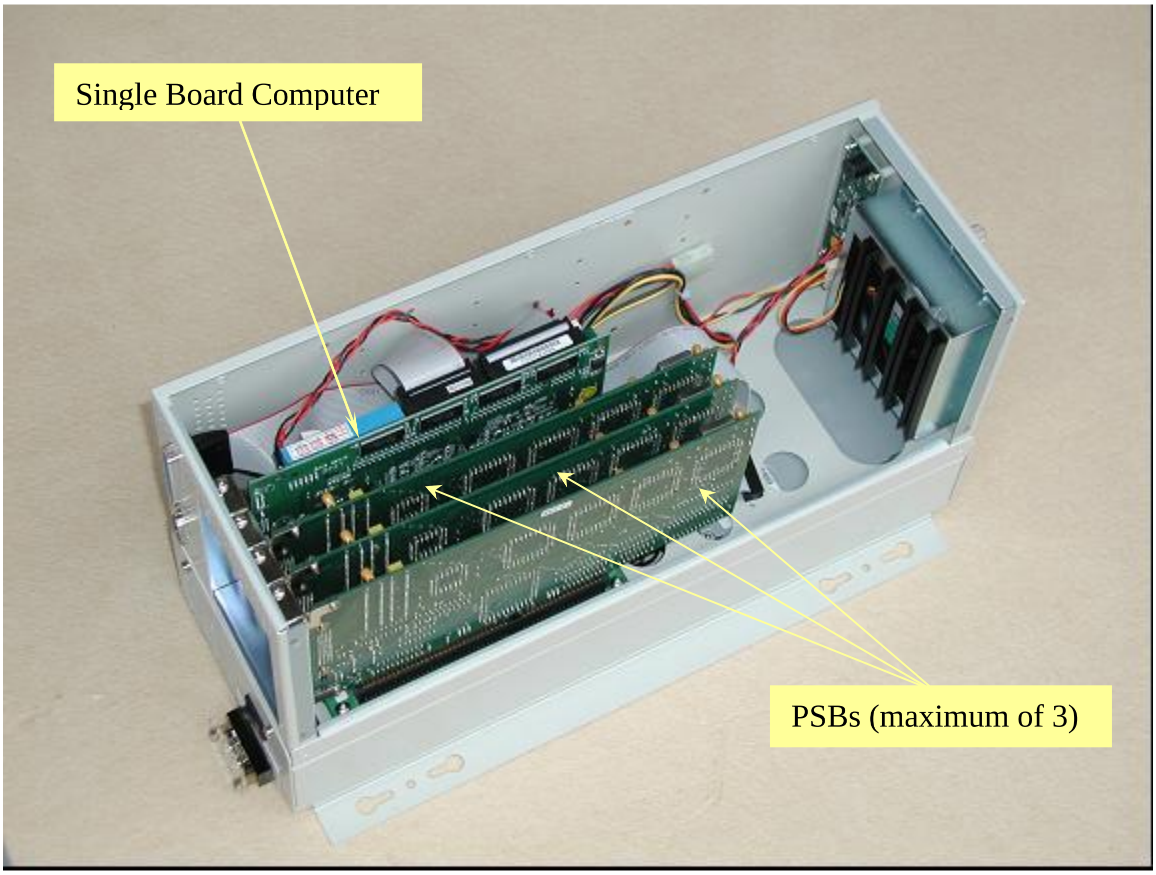
For DPUs equipped with an "Advantech" computer board the port settings must be as follows:

	280-28F	290-29F	2A0-2AF	2B0-2BF
Master	*			
Slave 1				*
Slave 2			*	

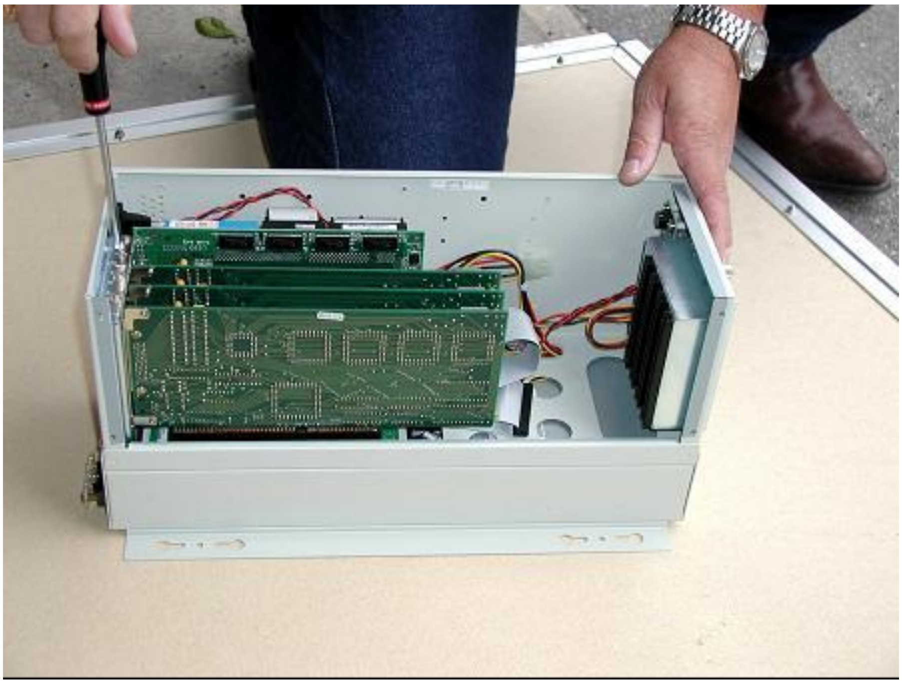
It is important that you write down the I/O addresses that you have selected for the PSBs, since you will need these for equipment setup in the RspWin Program!!

2.3.3 Installing the PSBs in the DPU

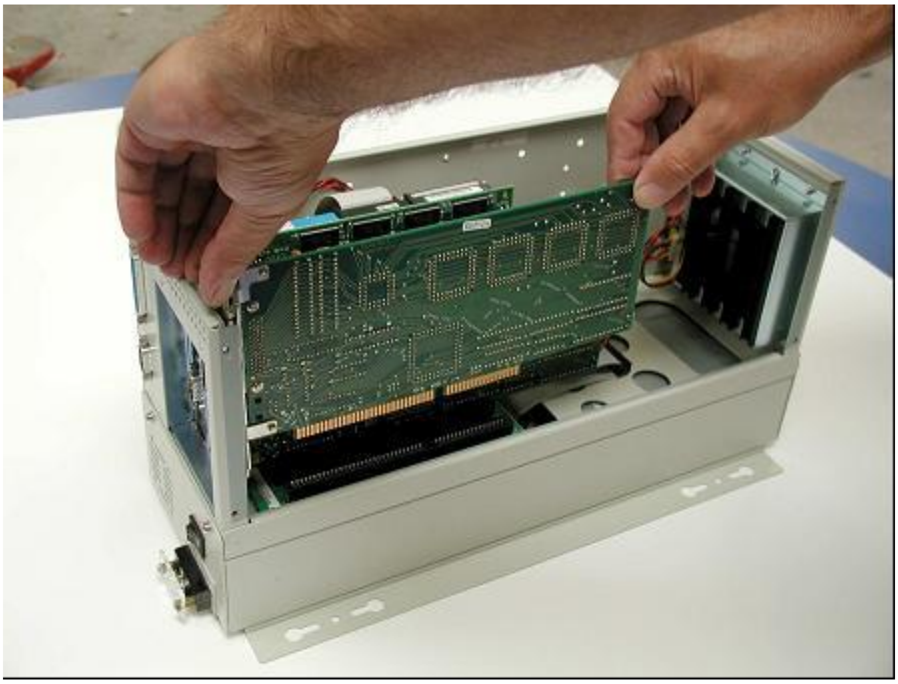
The DPU cabinet contains four slots, one for the single board computer and three for PSB installation.



Once the PSB has been configured, it can be installed in one of the ISA slots. Simply remove the DPU cover, and then remove the screw and slot cover-plate from the back of the DPU.



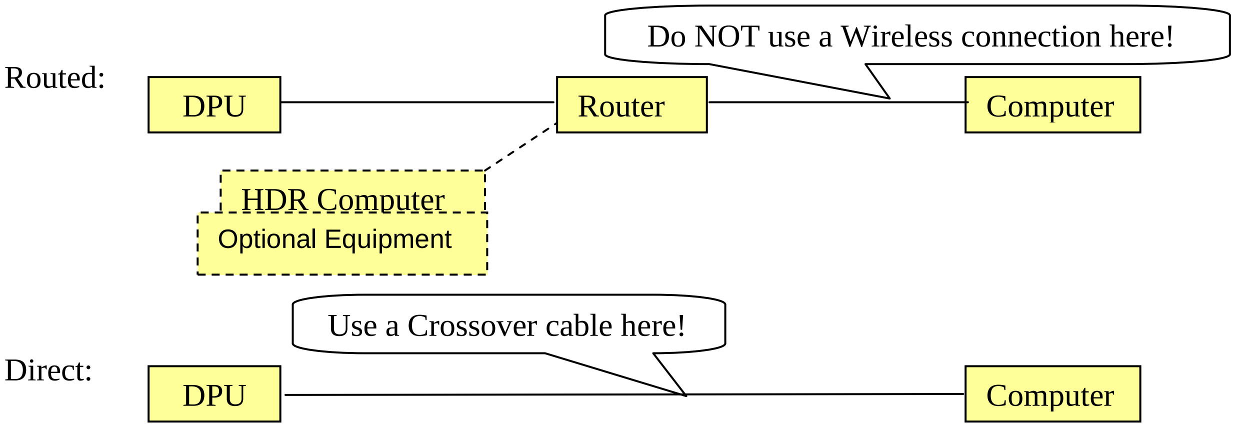
Press the PSB into the open slot. Secure the PSB with a screw.



Mount the DPU cover and attach the SCSI connector to each PSB. Attach the DMI cable to the master PSB and also connect the serial cable from the GPS (COM1) and the IMS (to COM2), if the RSP is so equipped.

2.3.4 *Completing the Installation*

To complete the installation, the computer, switchbox and optional router must be placed inside the vehicle at a suitable location and inter-connected in either 'Routed' or 'Direct' fashion:



The Router setup is preferred because it immediately satisfies the computer's initial network browsing.

3 The RSP Mark IV System

3.1 Test System Components

3.1.1 System Overview

The RSP Mark IV consists of some or all of the following main (standard or optional) components as shown in Figure 12:

- Mounting bracket with expandable insert (fits 2” x 2” “receiver” style hitch mounts)
  - Transducer Bar
  - Electronics Processing Unit (EPU)
  - EPU housing
  - Adjustable tubes or “arms”
  - Laser/Accelerometer housings
  - Laser Sensor(s) for Elevation Measurements (optionally for Texture Measurements as well)
  - Laser Sensor(s) and electronics for High Definition Rut measurements
  - Accelerometer(s)
  - Photo-Start Sensor
- IBM Compatible PC, normally a portable Notebook or Desktop PC, equipped with an Ethernet connection. Optionally ruggedized.
- Switch box
- Cables
  - Power
  - Ethernet (2)
- Calibration Hardware
- Base Plate
- 25 x 50 x 75 mm measuring block
- Bobble level
- Mounting bolts
- Wheel encoder assembly
  - Disk
  - Optical encoder
  - Tether arm
  - Magnetic or threaded mounting cups or custom-made wheel lug nuts or bolts.

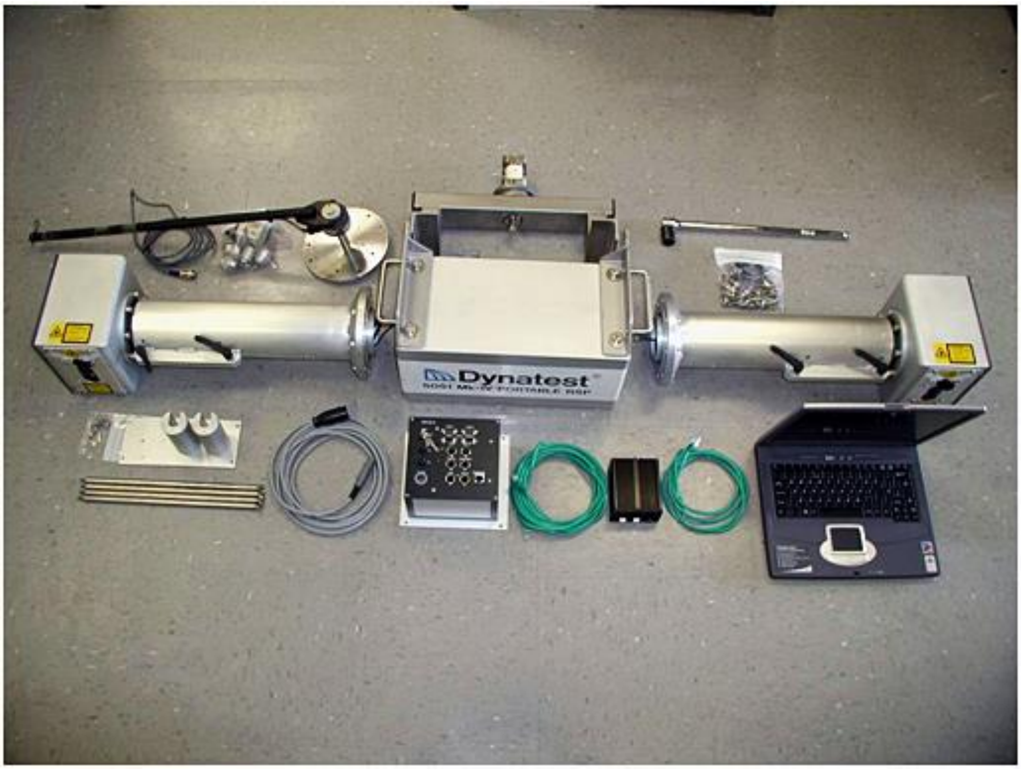


Figure 12 - RSP Mark IV Components

3.1.2 The Electronics Processing Unit (EPU)

The EPU is a fully functional, stand-alone single board (PC-104 Industrial) computer with additional electronics hardware containing DSP chips for real time calculation of inertial profile elevations, macrotexture, signal quality, distance travelled, etc. The single board computer calculates ride indices, faulting, etc. The EPU is equipped with an Ethernet port for transmitting data to the notebook computer using the TCP/IP network protocol. The EPU is contained in the EPU housing which serves as the "mechanical hub" for the mounting frame and adjustable arms. As shown in Figure 13, the EPU and cover plate have been lowered down from the EPU housing to allow inspection of the electrical connections. On recent units, an access cover in the top of the housing can be removed to serve this purpose.

Figure 13 - The EPU lowered from its housing

The EPU is the connection point for all electrical components (lasers, accelerometers, photocell, wheel encoder, local area network, system power).

A close up of the EPU front panel is shown in Figure 14 below.

Figure 14 - The EPU Front Panel

As seen in Figure 14, the following controls and connections are provided:

- On/Off switch (normally the switching is accomplished with the external switch box which is placed inside the vehicle).
- amp fuse (for protection against reverse polarity).
- 2 amp fuse.
- Input (source) power connector (12 volts).
- Com1 serial port for GPS (and for trouble shooting functions).
- Com2 serial port (not assigned).
- Left (15 PIN VGA Female Connector) – left laser connection.
- Right (15 PIN VGA Female Connector) – right laser connection.
- SW3 and SW4 – these are provided for pendants (also see 3.1.7, Switch Box) to be used for starting/stopping data collection, marking events, etc.
- Photo – photocell connector. The photocell is used for automated starting/stopping of data collection and automated marking of events.
- Encoder – The wheel encoder (DMI) connector.
- Left – left accelerometer connector.
- Right – right accelerometer connector.
- Ethernet – local area network cable connector.

Note that each type of device has a specific connector type, reducing the possibility of connecting the devices improperly **(you can still reverse the left and right lasers and accelerometers so be careful! No damage will result but your profile data will be all wrong!)**

The following describes devices inside the EPU.
Please Note: Do not open the EPU unless requested to do so by a Dynatest technician. Access to these devices (and information regarding their purpose) is solely to facilitate troubleshooting.

Since the EPU "brain" is a single board computer, running its own operating system, connectors are provided so that a monitor and keyboard can be connected for troubleshooting purposes. These connectors are located inside the EPU and are shown in Figure 15.

Figure 15 - Auxiliary Connectors inside the EPU

The auxiliary connectors from left to right in Figure 15 are:

- Local Area Network (LAN)
- Keyboard
- VGA monitor

LAN activity lights are also provided as well as a reset (red) button.

The operating system and RSP software for the EPU are stored on a flash disk that is configured as a bootable drive. Because the flash disk is solid state, the EPU has no moving parts and is therefore very reliable. The flash disk is not accessible by the user. Updates for the programs residing on the flash disk are accomplished by placing them on a shared directory on the notebook computer. The EPU will automatically transfer the updates through the local area network. The flash disk is shown in Figure 16.

Figure 16 - Flash disk inside the EPU

3.1.3 The Transducer Bar

The transducer bar is made up of the following main hardware components:

- EPU housing
- Adjustable (telescoping) arms
- Laser/accelerometer housing
- Mounting bracket

A complete transducer bar is shown in Figure 17.

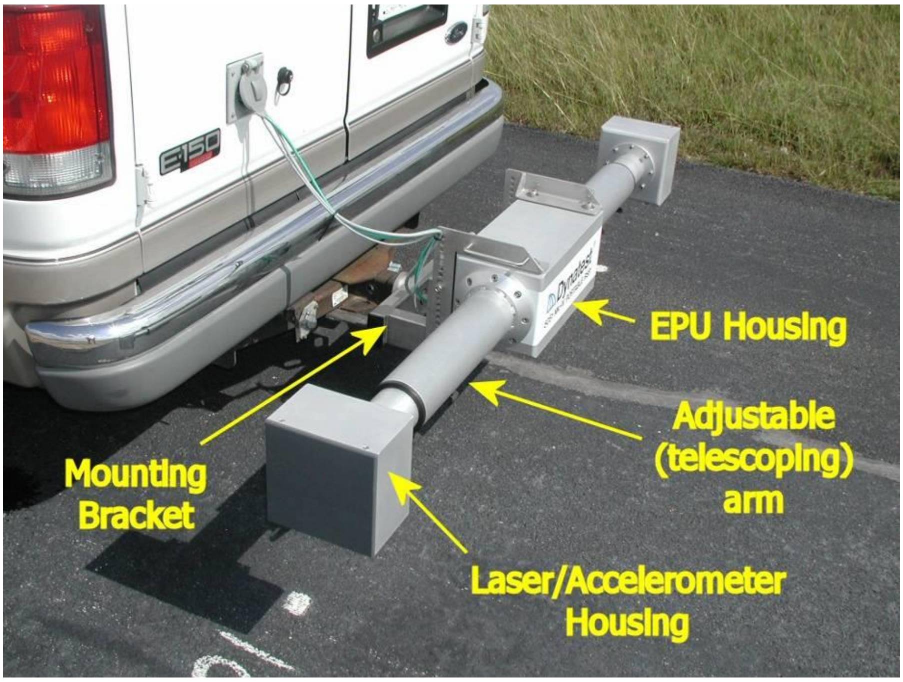


Figure 17 - Mark IV Transducer Beam Components

The transducer bar is designed to be easily and quickly installed and removed from the vehicle. The vehicle end of the mounting bracket is equipped with a specially-designed expandable steel insert that secures the transducer bar into a standard 2 inch by 2 inch (51 mm by 51 mm) receiver hitch. Expansion of the insert is accomplished by tightening a single bolt which extends through the centre of the insert using a 32 mm (1¼ inch) wrench or socket (see Figure 18). The transducer bar can be removed from the vehicle simply by loosening the single bolt.

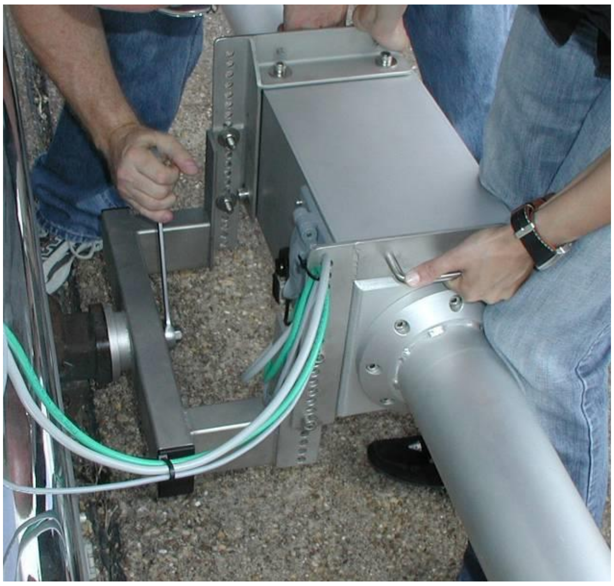


Figure 18 - Securing the RSP to the hitch

The transducer bar is constructed of aluminium and is therefore fairly light and easy to handle. Each adjustable arm has an overall travel of 0.25 m (8 inches). Two handles are provided on the underside of each arm for securing them in the desired position. The arms allow the laser enclosures to rotate so they can be adjusted to a vertical orientation with respect to gravity. Rotation of the arms also facilitates calibration of the lasers.

Laser and accelerometer cables are routed inside the arm and connected to the EPU inside the EPU housing. The transducer bar can therefore provide environmental protection for all components.

By loosening the adjustable arms, they can be “telescoped” to their most inward position, thereby reducing the overall length of the transducer bar to approximately 1.5 meters. The bar can then be easily removed from the vehicle and placed inside for transport to the next testing location.

The transducer bar will house two laser sensors. The purpose of the laser sensors is to measure the elevation of the bar over the pavement surface typically in the wheel paths. This information is used to develop objective statistics regarding pavement roughness and optionally texture.

3.1.4 Laser Distance Measurement Sensor

Selcom Model SLS 5000 laser sensors are used for profiling. These laser sensors have compact, DSP based electronics that simplifies installation and enables them to occupy less space in the bar. These lasers are extremely rugged and reliable, and considered to be the finest laser sensors available for profiling pavements. A photo of an SLS 5000 laser sensor module is shown in Figure 19 below.

Figure 19 - Selcom SLS-5000 Laser Module

3.1.5 Accelerometers

Up to two accelerometers may be provided with the portable RSP. The accelerometers are attached to the top of the lasers using a magnetic base. The purpose of the accelerometers is to track the vertical motion of the lasers through space. The vertical displacements are subtracted from the laser elevation measurements to obtain pavement profile elevations. These elevations are used to calculate International Roughness Index, and Ride Number statistics for the pavement. These statistics are indicative of the severity of pavement roughness.

The accelerometers are state-of-the-art servo accelerometers with 1 μ**g** resolution (9.81 x 10^{-6} m/s^2). A photo of an accelerometer is shown in Figure 20

Figure 20 - Accelerometer with Magnetic Mount

3.1.6 PhotoSensor

Figure 21 - Mark IV Photocell Mounting Location

A photo sensor can optionally be installed on the transducer bar (see Figure 21). The photo sensor can be used to ensure that data collection initiates at the same point on multiple data collection runs and to perform DMI calibrations "On the Fly" (both start and stop detection). The RSP field data collection program can be triggered to begin collecting data using the input signal from this sensor. This sensor is most useful for verifying precision and bias statistics for profile elevations, which require repeated runs over the exact same test section. Precision and bias statistics may be used to determine if the equipment is working properly.

The photo sensor shines modulated, infrared (IR) light on the pavement and measures the amount of IR reflected back. It sends a signal back to the RSP system when the amount of reflected light exceeds a certain threshold. This threshold is adjustable by the user. Because the sensor employs modulated IR light, it can be used in all lighting conditions, including bright sunny days.

Photo triggering can also be accomplished by "side-looking" sensors used with reflective cones placed at the side of the road.

3.1.7 Switch Box

The switch box has multiple purposes including:

- Enabling the operator to switch power to the transducer beam from inside the vehicle
- Provides two buttons for starting/stopping data collection and/or marking events
- Provides connectors for two pendants (in parallel with buttons).

Figure 22 shows the front and rear view of the switch box.

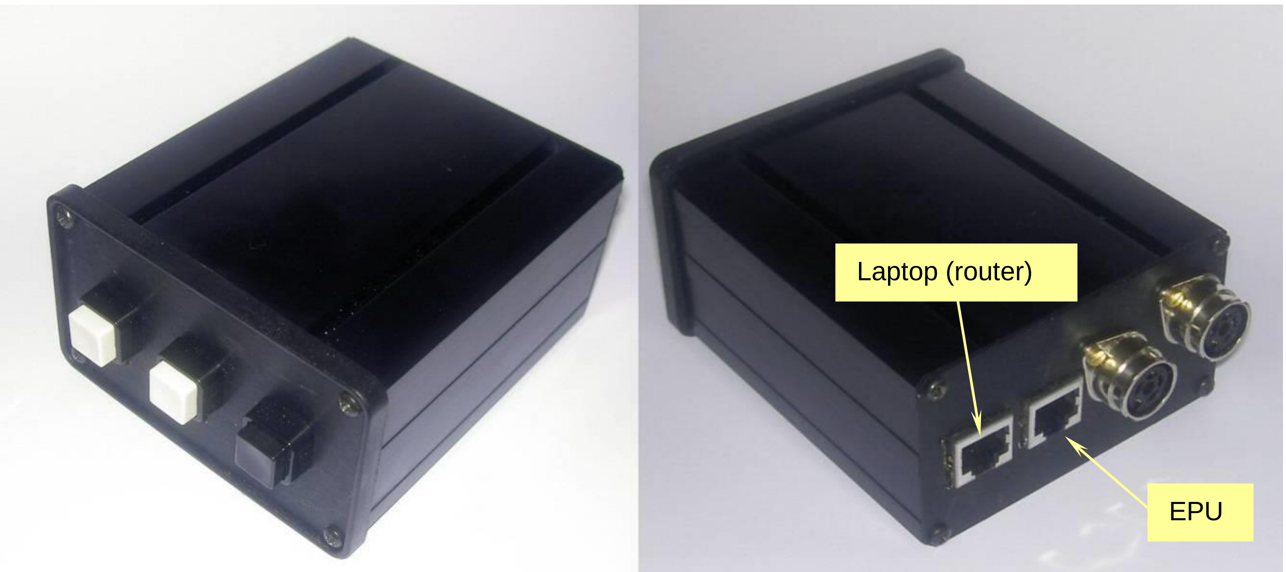


Figure 22 - Front and Rear View of the Switch Box

The front of the switch box has 3 buttons. The two first buttons from the left function as event markers and are designated “Switch 1” and “Switch 2” from left to right respectively. The rightmost switch button controls power to the EPU.

The rear of the switch box has two RJ45 Ethernet connectors. One is used to connect the laptop, the other is connected to the EPU. The two DIN (round) connectors allow the use of pendants, which are “push-button” controllers for marking events, suspending/resuming data collection, and/or starting and stopping data storage (in parallel with front panel buttons).

3.1.8 Calibration Verification Hardware

The calibration verification hardware is normally used solely for verification of the factory laser sensor calibration, but as some agencies may require a demonstration of a calibration procedure, the same hardware can be used for this purpose. The hardware consists of a base plate and a calibration block, 25 x 50 x 75mm or 1” x 2” x 3”. In case the calibration block is too shiny, a thin, flat target plate may additionally be supplied.

3.1.9 Distance Encoder

The distance encoder accurately measures distance and communicates this information to the EPU. The encoder produces 2,000 counts per 1 revolution of the vehicle tire making it very accurate and repeatable. Distance resolution is typically on the order of 0.04 in. (1 mm).

The wheel encoder for the portable profiler is typically mounted on one of the vehicle's wheels as shown in Figure 23. Because the Mark IV profiler is intended to be portable (able to mount on a wide variety of vehicles), the distance encoder hardware must be mountable on many types of wheels.

Figure 23- Typical Portable Wheel Encoder Installation

A slotted aluminium disk is provided which accommodates many common wheel bolt patterns in use today. This particular configuration uses 4 magnets to hold the aluminium disk to the wheel studs. The tether arm is also held to the vehicle body using magnets.

Note that the plastic arm is mounted in the vertical direction and the steel rod is oriented in the horizontal direction. This is critical to proper operation of the encoder. This configuration prevents vehicle suspension movements from creating unwanted rotations of the wheel encoder body which would create “noise” in the distance measurements.

The encoder cable is secured to the tether arm, then routed back to the EPU housing, passed through an access hole, and connected to the EPU via a DIN plug.

3.2 Vehicle Installation

3.2.1 General Remarks

Unless otherwise specified by the customer, RSP Portables are typically delivered in a fully operational state, with installation of the components performed by a Dynatest technician (recommended). Vehicle selection guidelines, important installation instructions, and vehicle preparation instructions are provided in this chapter for the sake of completeness.

3.2.2 Guidelines for Vehicle Selection

Figure 24 - Receiver Style Hitch for RSP IV Mounting

Dynatest recommends a van, pickup truck, mini-bus or station wagon as a platform for RSP systems. Passenger cars are not recommended due to windshield visibility restrictions. Vehicles with excessively stiff suspensions should be avoided. Minimum recommended vehicle width is 1.7 meters.

The vehicle must be equipped with a heavy duty 2"x2" receiver-style hitch as shown in Figure 24.

3.2.3 Warning Signs / Flasher Lights

The RSP can operate at normal traffic speeds, but warning signs and flashing lights are still recommended as a safety factor. Flashing lights should be mounted on top of the vehicle, while suitable warning signs may also be mounted on the rear of the vehicle. Due to variations in local regulations the RSP System does not include any warning signs and/or flasher lights. We recommend you to consult the local authorities concerning guidelines for selection and positioning of signs.

3.2.4 System Powering

The RSP Mark IV uses 12 volt DC power with a maximum of 3 amps draw on the system. Power is supplied to the system through a connector on the EPU front panel (see Figure 14). The power source is dependent on the vehicle but a list of potential sources is provided below:

- Vehicle battery
- Vehicle cigarette lighter receptacle
- Trailer wiring harness or plug

A power cable with the appropriate connector is supplied with the RSP.

3.2.5 *Mounting the Transducer Bar*

The transducer bar is designed to mount in the receptacle of a receiver-style trailer hitch. This facilitates installation and removal of the bar. The receiver hitch receptacle should be 2x2 inches (approximately 51 x 51 mm).

When properly installed, the bottom of the laser enclosures should be approximately 290 mm (11½ inches) above the pavement surface. The mounting bracket has been constructed to allow for height adjustments in 15 mm (5/8 inch) intervals over at least 300 mm (12 inches), as the mounting bracket can be rotated 180 deg.s to extend the adjustment range.

A specially designed expandable insert, tightened with a single bolt, is provided to secure the bar to the inside of the hitch receptacle. The insert is shown in Figure 25

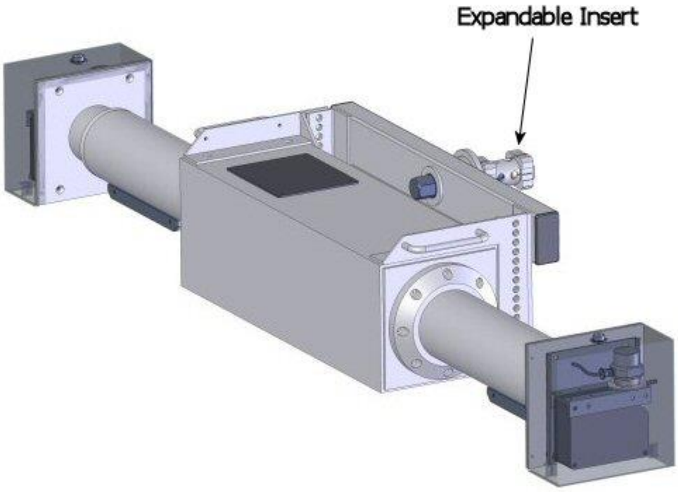


Figure 25 - Transducer Beam with Insert

The beam weighs approximately 70 lbs when configured for installation, so it is recommended that at least two persons be used to install the system on the vehicle.

The bar is installed on the vehicle using the following steps:

- While supporting the transducer bar, guide the expandable insert into the hitch receptacle (see Figure 26).
- Check that the insert is completely inside the receptacle.
- While supporting the bar, tighten the mounting bolt with a 32 mm (1¼ inch) wrench until the expandable insert snugly fits in the receptacle as shown in Figure 27.
- Check that the bar is not tilted. Usually, it is sufficient to align the bar with the rear bumper. Do not align the bar with the pavement surface unless you are sure you are on a level surface.
- Continue tightening the mounting bolt until the bar cannot be rotated.

Figure 26 - Installing the Transducer Bar

Figure 27 - Tightening the Mounting Bolt

3.2.6 Connecting the Cables

The following components should be connected to the front panel of the EPU, including:

- System power cable
- Left and Right Lasers
- Left and Right Accelerometers
- LAN (Ethernet) cable
- Wheel encoder
- Photocell (if applicable)
- GPS in COM1 (if applicable)

A view of the front panel is shown in Figure 29.

Place the RSP transducer bar near the intended mounting point.

The wheel encoder, photocell, system power, and GPS (if applicable) cables should be routed into the EPU housing via the access hole shown in Figure 28.

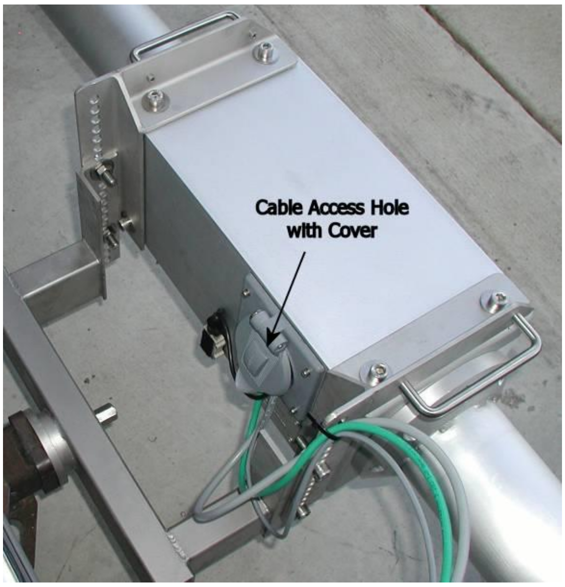


Figure 28 - Cable Access Hole with Cover

Figure 29 - EPU Front Panel

EPU connections can on newer units be accessed by removing the access cover on top of the EPU housing, otherwise by removing the EPU base plate screws from the bottom of the EPU housing and allowing the EPU to drop down as shown in Figure 30.

Figure 30 – Dropping down the EPU

Note that the various connectors are specific to each device reducing the possibility of plugging a component into the wrong location. It is still possible to reverse the left and right lasers and accelerometers. This will not cause damage, but will result in erroneous data.

The free ends of the wheel encoder, GPS, photocell, pendant (if applicable), and LAN cables should be routed outside the EPU housing through the access cover shown in Figure 28.

Once all connections have been completed, reinstall the access cover (or the EPU into the housing) and secure it with the appropriate screws.

3.2.7 Mounting the Wheel Encoder

At this point in the mounting process, the wheel encoder cable should already be routed inside the EPU case and connected to the front panel of the EPU (see previous section).

The wheel encoder assembly consists of the following components:

- 1 Slotted aluminium disk
- 1 optical rotary encoder
- magnetic cups or custom made wheel lug nuts or bolts
- 1 plastic tether arm
- 1 steel lateral support arm
- 1 magnetic clamp

To install the wheel encoder assembly using magnetic cups, these must first be fastened to the appropriate slots on the aluminium disk. The disk is able to handle a wide variety of wheel bolt patterns. The magnetic cups secure the aluminium disk to the vehicle wheel (typically the left rear wheel). Each magnetic cup fastens to the disk with an Allen bolt. Once the magnetic cups are secured to the disk, place the disk on one of the vehicles rear wheels ensuring that each magnetic cup fits over a wheel bolt and nut.

Alternatively, the lug nuts (or bolts) of the wheel can be replaced with custom made, extended lug nuts (or bolts), onto which the slotted aluminium disc can then be fastened with M6 bolts to each extended nut or bolt.

Next, place the magnetic clamp at a suitable location on the vehicle fender (preferably aft of the wheel to facilitate cable routing). Ensure that the plastic tether arm is vertical and that the lateral support arm is parallel to the pavement surface. This ensures the vehicle suspension movements will not cause the encoder to rotate (i.e. generate distance errors) when the wheel traverses a bump in the road.

Secure the encoder cable along the plastic tether arm and lateral support arm. Secure any excess cable underneath the vehicle body in a protected area.

A schematic of the installation is shown in Figure 31.

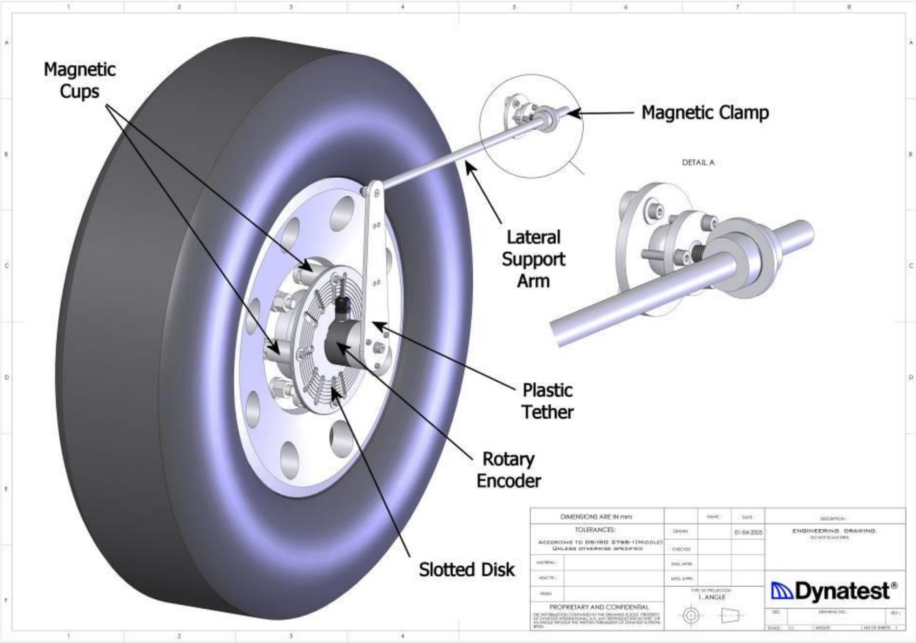
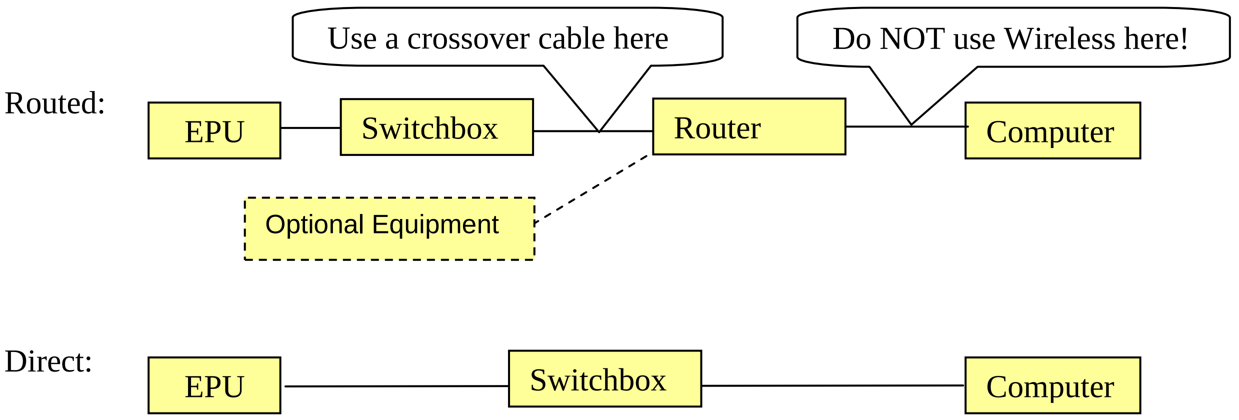


Figure 31 - Wheel Encoder Schematic

A photo of an actual encoder installation is shown in Figure 23.

3.2.8 *Completing the Installation*

To complete the installation, the computer, switchbox and optional router must be placed inside the vehicle at a suitable location and inter-connected in either 'Routed' or 'Direct' fashion:



The Router setup is preferred because it immediately satisfies the computer's initial network browsing.

Finally, power for the computer is provided with a manufacturer supplied automotive power adapter or through a 12 volt DC to 110 or 220 volt AC power inverter.

4 Optional Equipment

The following optional equipment can be used with all RSP models.

4.1 GPS

A GPS unit may be connected directly to the DPU/EPU or to the PC using a COM (serial RS232) port. The DPU/EPU connection is preferred because it provides best distance tagging and because most modern laptops require a "Serial to USB" converter due to lack of built in COM ports.

The GPS unit must be set to 2400, 4800, 9600, 19200 or 38400 baud and send the NMEA standard message "GGA". The maximum reporting rate is 10 Hz. At this rate you must assure that no other messages are sent from the GPS unit.

Some typical GPS receivers are shown here:

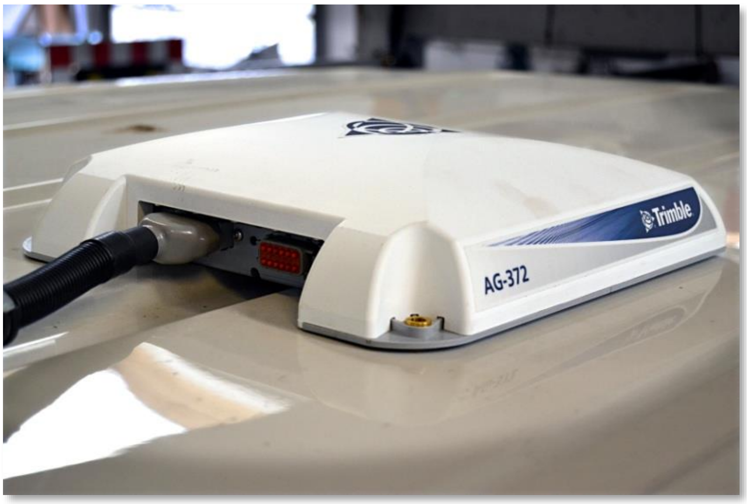


Figure 32 - Trimble AG-372 GPS Receiver

4.2 Cameras

Windows compatible camera(s) may be connected to the computer. The typical interfaces are Firewire, USB and GigE. The camera system must comply with the Windows DirectX system (WDM compatible driver) or the Halcon image software.

The figure below shows a windshield mounted Unibrain Fire-i 980c digital camera installed in the RSP for capturing digital images of the right-of-way (ROW).

Figure 33 - Digital Camera for Capturing Right of Way Images

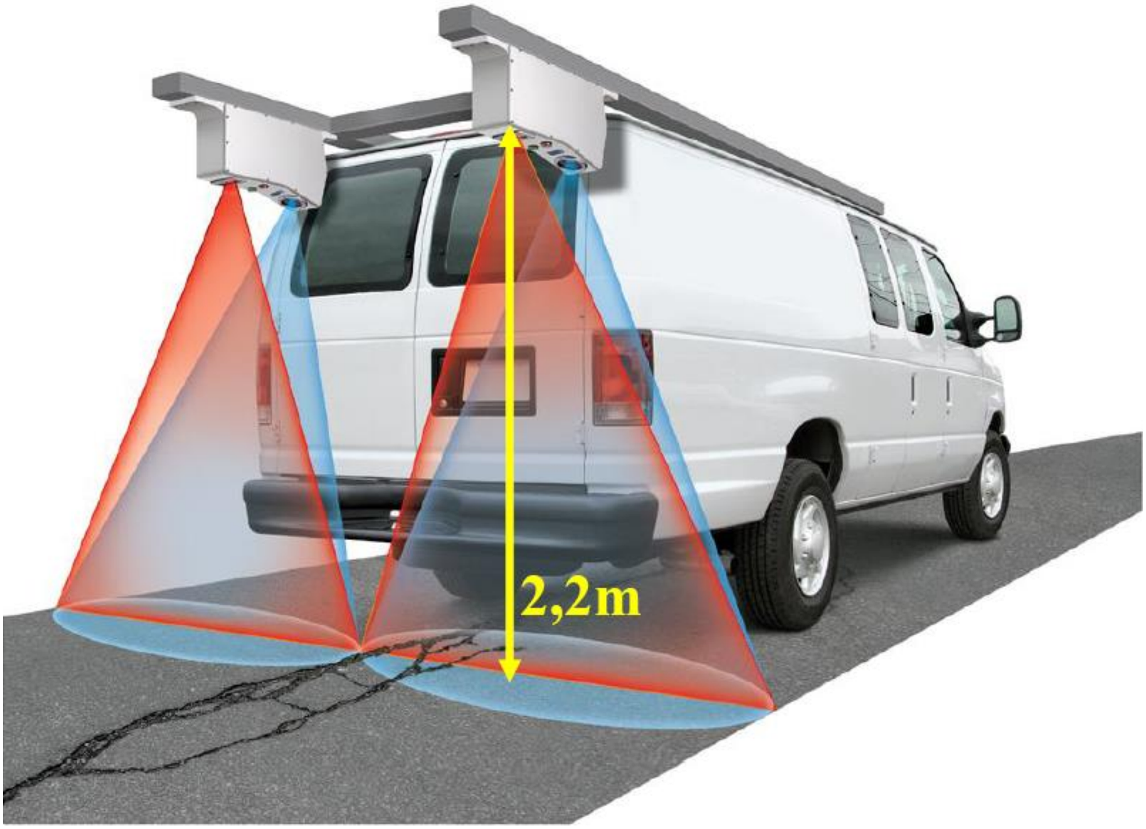
4.3 High Definition Cracking (HDC)

Cracking, Imaging, Rutting and Texture measurements

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

Pavemetrics Laser Crack Measurement System (LCMS) is a high-speed and high-resolution transverse profiling system.
Capable of acquiring full 4-meter width 3D profiles of a highway lane at normal traffic speed, the system uses two laser profilers that acquire the shape of the pavement.
Both the resolutions and acquisition rate of the LCMS are high enough to perform automatic cracking detection, rut measurements and texture measurements.

Custom optics and high power pulsed laser line projectors allow the system to operate in full daylight or in night time conditions.



Pavemetric LCMS System

4.4 Tire Sound Intensity

The Dynatest TSI system provides measurement of tire-pavement noise using the OBSI method (On-Board Sound Intensity). This method uses microphones located very close to the tire.

5 Computer Configuration

The RSP field computer must be considered an integral part of the data collection equipment. It should not be used for any other purposes. Therefore we recommend that Dynatest supply and configure the computer for the equipment. If the customer supplies the computer, then it must be open for modifications to Computer Name, Workgroup/Domain membership, Security Setup, User accounts, Network Setup, Power Options and Virus Protection.

Configuring the computer consists of

- Verifying that requirements are fulfilled
- Installing the program packages
- Establishing a network connection between the computer and the DPU/EPU
- Running the program to setup initial parameters

Dynatest personnel normally handle this task. However, this information is supplied in the event that the end-user may need to reconfigure or replace the computer.

5.1 Requirements

For an RSPIII or RSPIV without LCMS the requirements are as follows:

Core i5, 2 GHz
4 GB memory
256 Gigabyte System Disk
1280 by 1024 Monitor
1 GB LAN connection
Windows 10 Professional, 64 bit
DirectX 9 (for camera support)

5.2 MFV Installation

Regarding the Dynatest MFV, a more powerful, customized rack-mounted computer will be included. All software and hardware setups will have been finalized by Dynatest, before delivery.
See 10.3 for details on COM ports for EncIf and EnCam devices.

5.3 Installing Programs

The programs are available from ftp://ftp.dynatest.com/downloads/DDC2 as two packages named DDC Prerequisites 2.n.n.n.exe and DDC 2.n.n.n.exe, where 2.n.n.n is the version number.

If you are upgrading, please **Backup existing files and folders, then uninstall the previous DCC/DDC** (Dynatest Control Center/Dynatest Data Collection)**.** Your equipment information and setups are preserved.

Prior to installation, please close any running programs.
Failure to close all programs may result in failure of the installation process. This is not a serious problem, but the user may have to restart the installation process.

It is recommended to have Internet access during installation.

If this installation requests that a Dynatest program be uninstalled, then please do so (equipment information and setups are preserved) and then re-run the installation.
Locate the installation packages and then launch DDC Prerequisites 2.n.n.n.exe first. This package contains general system modules. Launch DDC 2.n.n.n.exe next. Just use common sense and click [Next] [OK] [Allow] etc to accept the defaults where appropriate.

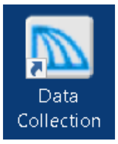
The installation will result in the following folder structure:

C:\Program Files (x86)\Dynatest\Elements	Start application and various applets
C:\Program Files (x86)\Dynatest\FwdWin	Falling Weights (FWD/HWD)
C:\Program Files (x86)\Dynatest\RspWin	Road Surface Profilers
C:\Program Files (x86)\Dynatest\Survey	Manual Survey
C:\Dynatest\...	Additional working folders

In addition to the program installation package, you may have received a file specifically for your equipment. The filename is composed of the equipment serial number and the extension MDB (e.g. 5051-001.MDB). Copy this file to C:\Dynatest\RspWin\MDB.

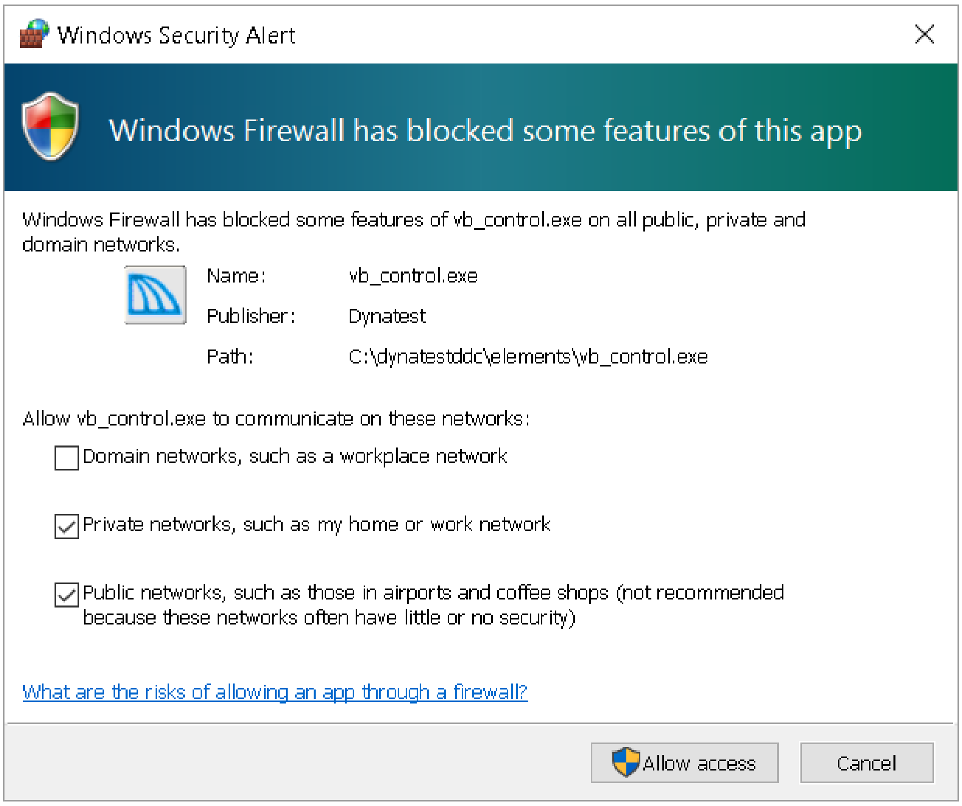
Initial execution of Dynatest Data Collection (DDC) showing that RSP 5051-080 is available:

Your desktop should now have an icon for the Dynatest Data Collection (DDC):



Windows Firewall may show a message saying it is blocking certain functionality of the DDC. You will have the option to remove the blocking. Please do so (see below).

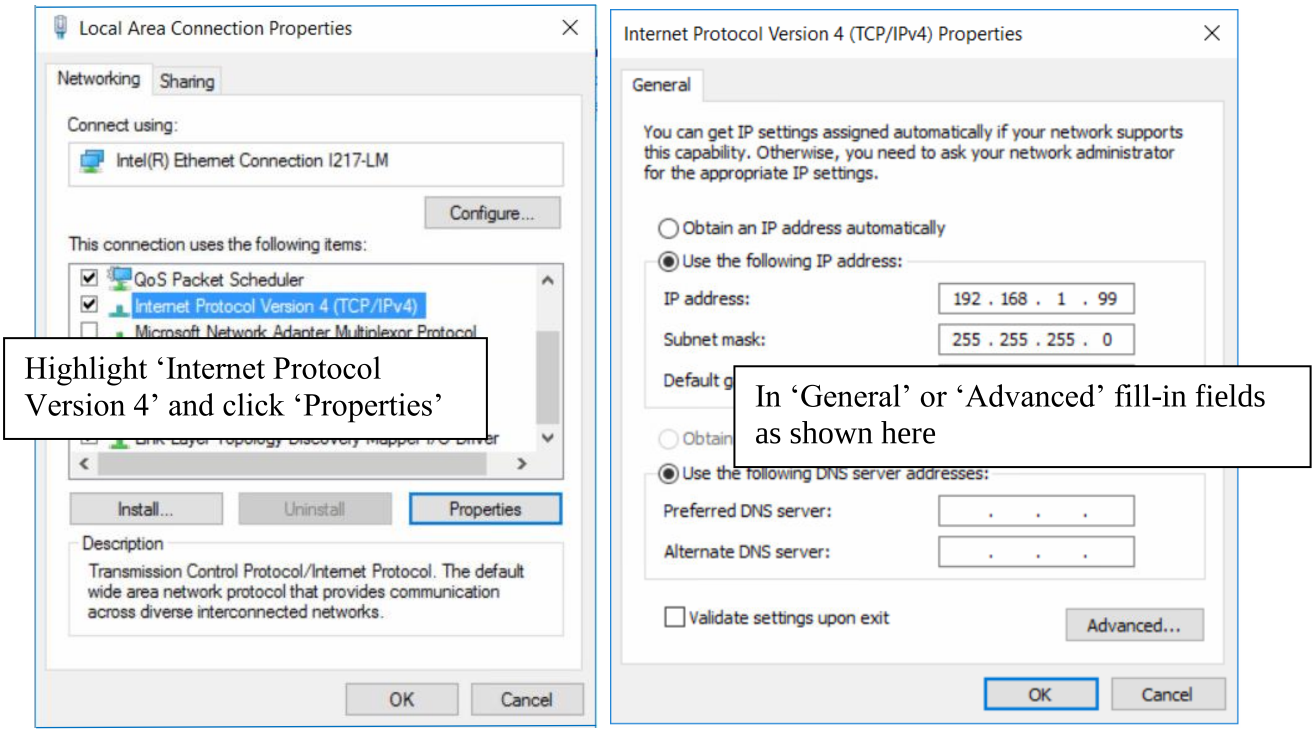
Make sure both **Private** and **Public** are checked, then click **Allow Access**:



5.4 Network Settings

RSP Mark III's delivered after august 2006 and all Mark IV's utilize the TCP/IP protocol over Ethernet hardware. If a standard router with base address 192.168.1.1 is used, then there is nothing to configure. The Router will provide the IP address. For a direct connection setting up the network depends on the computer Operating System, but the Windows 10 procedure below gives the general picture.

Right click the Windows icon (bottom left) and choose '**Network Connections**', then right-click the '**Local Area Connection**', then choose **Properties**:



5.5 *Virus Protection*

Antivirus software can significantly degrade the performance because it intercepts all file transfers between DPU/EPU and the computer. This can in some cases “Stall” the computer.
Dynatest has selected to use the (free) Microsoft Security Essentials (Windows Defender) antivirus software.

In any case, please

EXCLUDE the C:\Dynatest folder and all sub-folders from automatic protection.

EXCLUDE the following image/picture file types from automatic protection.
Extensions: *.JPG, *.BMP

5.6 *Backup*

In order to preserve your work in case the computer is damaged, you should regularly backup a number of files. Assuming that the default location was used during installation then backup all MS Access database files found in the following two folders:

C:\ Dynatest\RspWin\MDB
C:\ Dynatest\Elements\MDB

In particular:

TestSetup.MDB	Test Setups
5051-080.MDB	Equipment calibrations (sample file name shown here)
Sections.MDB	Roadway Sections

5.7 Software Upgrades

Updates to the Dynatest DDC program suite are periodically posted to, and may be downloaded from, the following location (simply type the address in your internet browser or click the hyperlink): ftp://ftp.dynatest.com/downloads/DDC2

Always un-install any previous version before updating!
The equipment file 5051-080.mdb (example) and all other working MDB databases are preserved.

If the existing hardware information was found and imported successfully, the RSP serial number(s) will be accessible in the introductory screen.

If DDC finds information for multiple RSPs, it will import information for all of them. The user can then select the appropriate RSP setup by clicking on the serial number box.

To the extent possible when upgrading database files the program attempts to keep the users previous settings (window positions, language support, hardware settings, test setups etc.).

5.8 Cameras

The software package includes two applets for camera support:

Camera	General support for Windows compatible DirectX cameras
HCamera	Halcon (MvTec) based camera support (hardware triggered)

5.8.1 Camera Applet

Go to the manufacturer's software support site and look for "DirectX Drivers" or a proprietary "Capture" program. Follow installation instructions and check that the capture program can connect to the camera and show images. Shut down the capture program and check that the camera appears in the Camera Applet's "Pick Camera" list.

5.8.2 HCamera Applet

This applet is used with the Dynatest MFV (Multi Function Vehicle) and all preparations are performed by Dynatest prior to delivery.

6 Program Configuration

This section provides the necessary information for configuring the field program for first time use. Information regarding program operation is presented in Section 8 of this manual.
If the software is already configured upon delivery, this configuration information will prove useful in the event that the present configuration is somehow lost.

This process should preferably take place with the electronics and any additional hardware connected, powered up, and ready.

6.1 Dynatest Data Collection (DDC)

When "Dynatest Data Collection" is first started, this screen appears.

This sample shows that you will run tests with RSP 5051-080 and activate the following Applets: Network (roadway section database), DMI, Speedometer, GPS, IMS Inertial Motion Sensor (Gyro), Camera(s) and HDC (3D Crack Detection).

There are various controls on this screen that affect program functionality. These controls and their functions will be discussed in the next few sections.

The first step in setting up the program is to enter vehicle identification (e.g. license plate number), the driver name and operator name or initials. This enables the field program to identify the vehicle and operators in the data files. It also enables the program to place the operator's name in any log files. These log files are written to disk whenever changes are made to test setups, equipment calibration factors, or component operating parameters.

6.1.1 Vehicle ID

Use this field to enter a "Vehicle Identification" (license plate number or other identification). The program maintains a list of several Vehicle IDs if required.

6.1.2 Driver

Use this field to enter a Driver name. The program maintains a list of several Drivers if required.

6.1.3 User

Initially there are three users each having different levels of access.

Administrator allows changes to layout and calibrations
Dynatest is for Dynatest personnel, only
Operator is for general data collection

To create another Operator, SysOp or Administrator entry, first choose the appropriate level from the list and then type the desired name (replacing the level). Then use e.g. TAB to leave the control.

6.1.4 Administrator

Administrative access is required for changes to calibration and operating parameters of critical components. It is important to note that this feature has nothing to do with the Windows “Administrator”. Its purpose is merely to avoid accidental deletions or changes to important operating parameters. You may optionally require a password for administrators. It is recommended to choose Administrator for at least the first few runs.

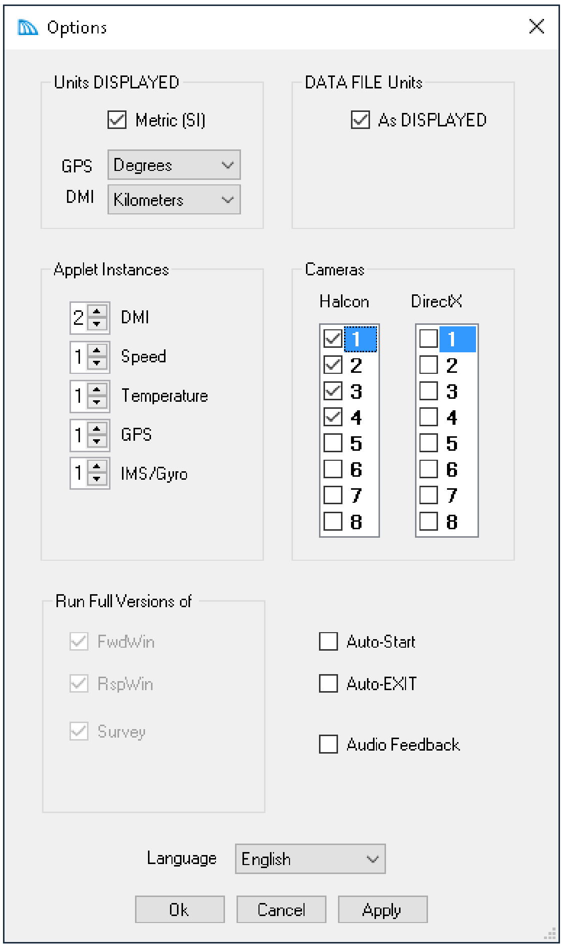
The Administrator can make changes to the setup of the following components:

- Lasers
- Accelerometers
- High Definition Rutting / Cracking
- Distance Measuring Instrument
- Inertial Motion Sensor
- GPS

If the operator *needs* to make changes to any of the above components, he needs only pick the “Administrator” entry and optionally enter a password.

6.1.5 *Settings*

 Click the Settings icon to show the DDC Options window.



Units DISPLAYED
Set the default units for your displays here.

DATA FILE Units
Usually the units used for data files are the same as what you see on the display. Un-check the "As DISPLAYED" if you want specific units in the data files.

Applet Instances
Allows you to run several instances of the Applets.

Cameras
Up to eight cameras can be run simultaneously. You can freely mix Halcon and DirectX cameras.

Run Full Version of
Presently not an option

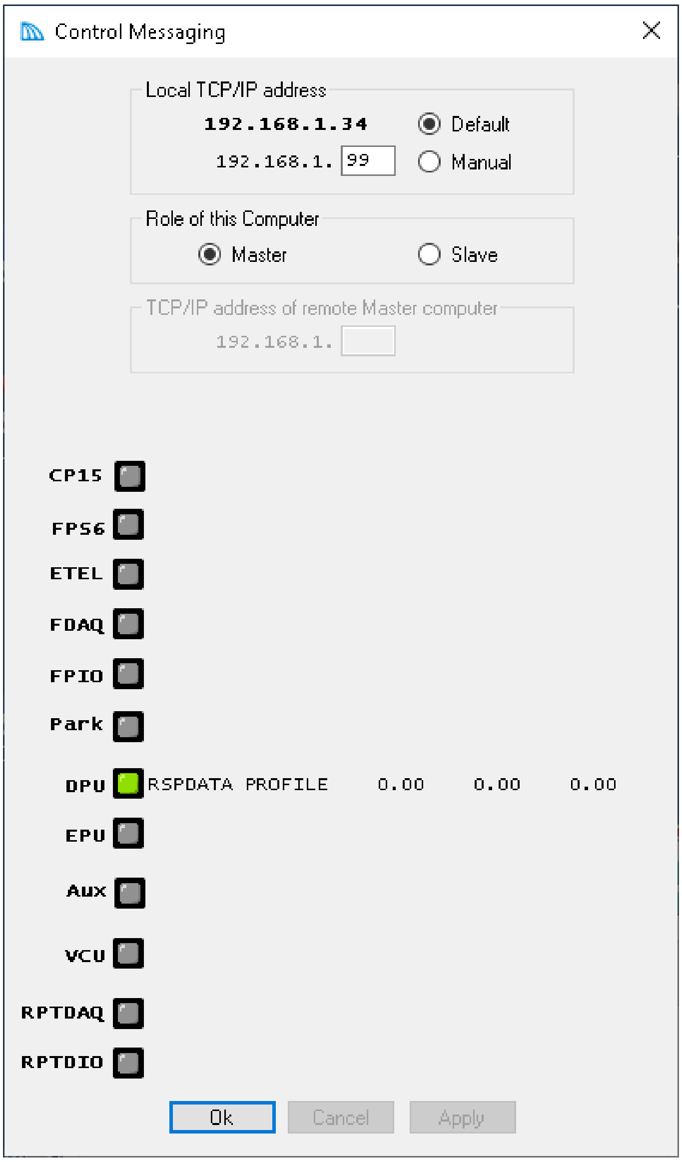
Auto-Start
Check Auto-Start to make DDC start as soon as it detects that the electronics are ready.

Auto-EXIT
Check Auto-EXIT to close the opening DDC window when the main program is terminated.

Language
All programs support English. If the chosen language is not available in a programs database then the user interface will be English.

6.1.6 *Network Connections*

 Click the Network icon to show the DDC Network Connections window.



Local TCP/IP address
The local subnet for Dynatest electronics must be 192.168.1.XXX

Default: Suggested (detected) address
Manual: For a specific NIC

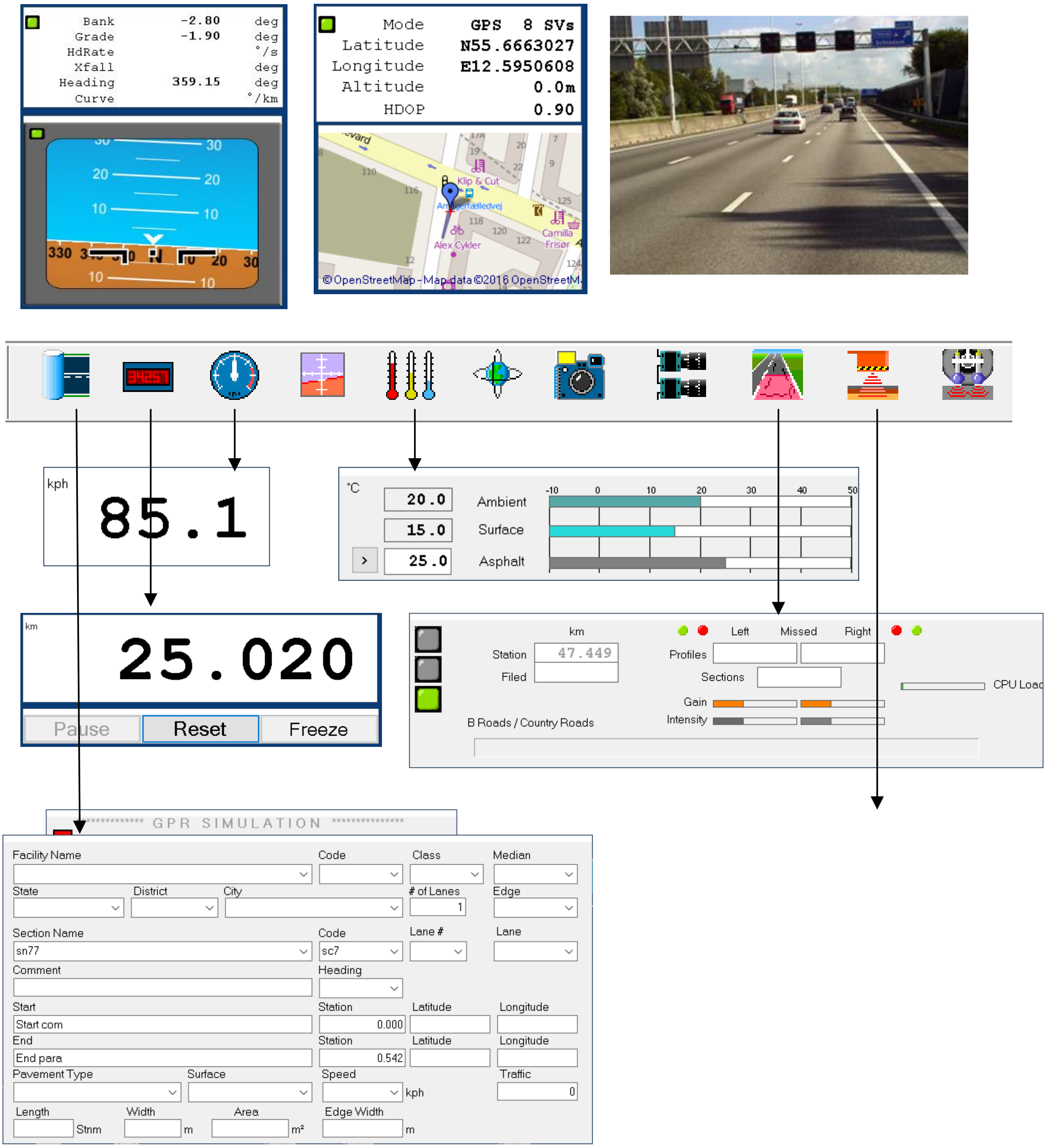
Role of this Computer
Master: The main computer
Slave: Secondary computer

TCP/IP of remote Master computer
A slave computer must know the TCP/IP of the Master

Dynatest Electronics
The remaining icons show the status of Dynatest electronics.

6.2 Applet Overview

Applets are programs providing specific functionality to the main applications. Most applets appear in resizable floating windows. The Administrator can arrange the windows but the resulting layout is locked for the Operator. This page shows the typical appearance of each.



6.3 *Completing the Setup*

This section shall address setup of the RSP hardware components. Note that some of the components are optional and may not be present in your equipment:

RspWin:
- General Equipment Parameters
- Lasers
- Accelerometers
- Options

Applets:
- Distance Measurement (DMI)
- Global Positioning System (GPS)
- Inertial Motion Sensor (IMS)
- High Definition Cracking (HDC)

In order to complete the setup, the user must be "Administrator".

! IMPORTANT!

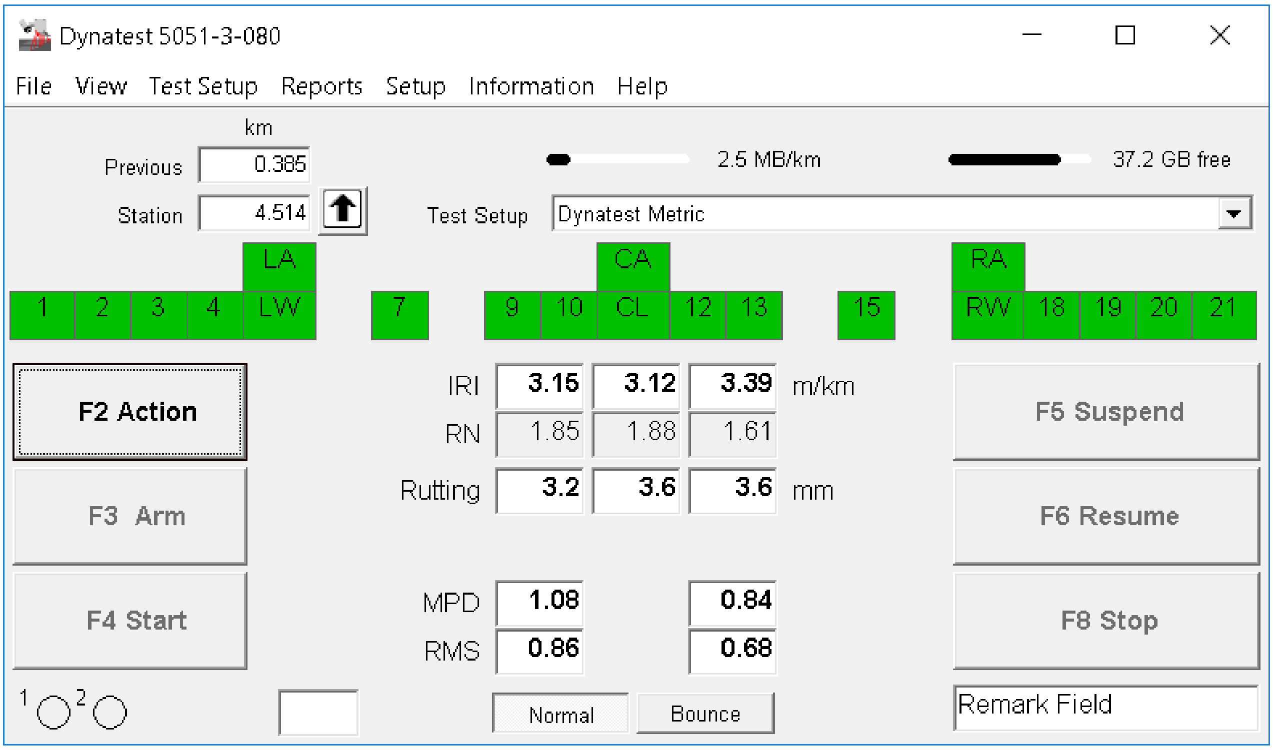
Hardware parameters (like all other parameters) are stored in a database file in order to better manage multiple RSP setups.

Before making changes to Hardware parameters make sure that you have activated the correct equipment S/N in the introductory screen (5051-NNN).

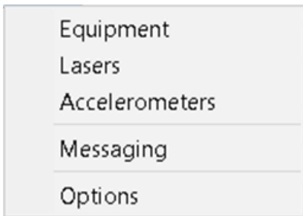
Any changes you make to the hardware setup – be it calibration or otherwise - will be stored in the equipment information file you selected in the introductory screen.

6.3.1 *Entering the Data Collection Screen*

Configuration of the hardware is accomplished from a menu item at the top of the data collection screen or through the dedicated applets DMI, GPS etc. The data collection screen opens automatically when the user clicks the **Start** button on the introductory window. This screen is the primary user interface for operating the RSP. The data collection screen interface, in its simplest form, is shown next.



To make changes to the hardware setup, the user should click the **Setup** menu item along the top of the data collection screen. A drop down list of configurable items will appear as shown here:



Each item opens a dedicated window with options and variables and the three common function buttons:

The **OK** button saves the changes and closes the window.

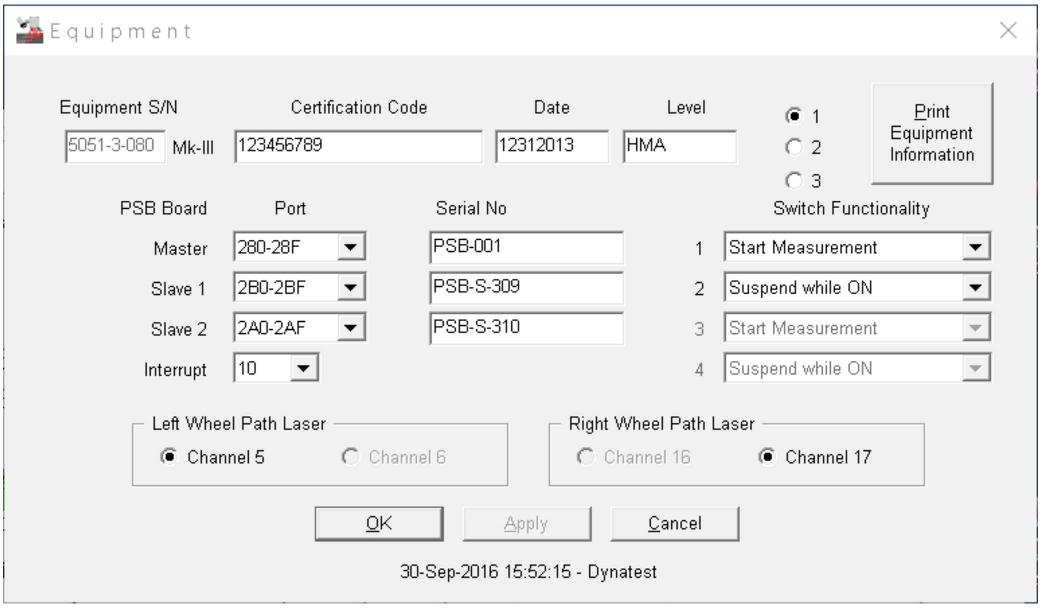
The **APPLY** button saves the changes but leaves the window open.

The **CANCEL** button discards changes and closes the window.

The **Apply** button is disabled (greyed out) until the user makes a change to one of the fields.

6.3.2 *Equipment*

To configure the equipment, select **Setup**, then **Equipment** from the data collection screen. This will open the equipment setup window.



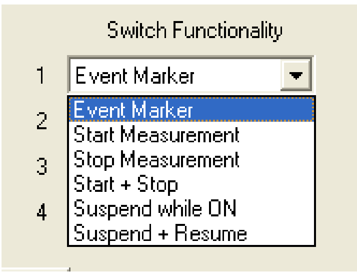
The first item to verify is the **Equipment Serial Number**. The serial number can be found on the nameplate located at the RSP transducer bar. If the serial number does not match your RSP, then you must restart RspWin. At the introductory screen, click on the correct equipment serial number, and then return to the above window. The equipment serial number should now be correct.

Mark III: The next items to verify/change are the ports assigned to each of the Dynatest PSBs. The ports must correspond to the (unique) jumper settings on each of the Profiler System Boards. Refer to "2.3.2, Setting Jumpers on the Profiler System Boards" to see which jumper settings correspond to which port addresses.

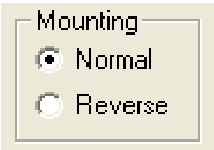
In the interrupt drop-down list you set the interrupt line for the PSBs to use when communicating with the Embedded Processor Board in the DPU. The interrupt line you select must not be occupied by other hardware (internal or external) connected to the embedded processor. Which interrupt lines that are 'free' (not occupied by other hardware) depends on the Embedded Processor used. Normally Mark III uses interrupt=10 whereas Mark IV uses 11. Contact your nearest Dynatest office should you experience any problems.

The Certification Code and Date fields provide required information for the *.PRO file format.

Print Equipment Information provides a hardcopy of all available equipment information.



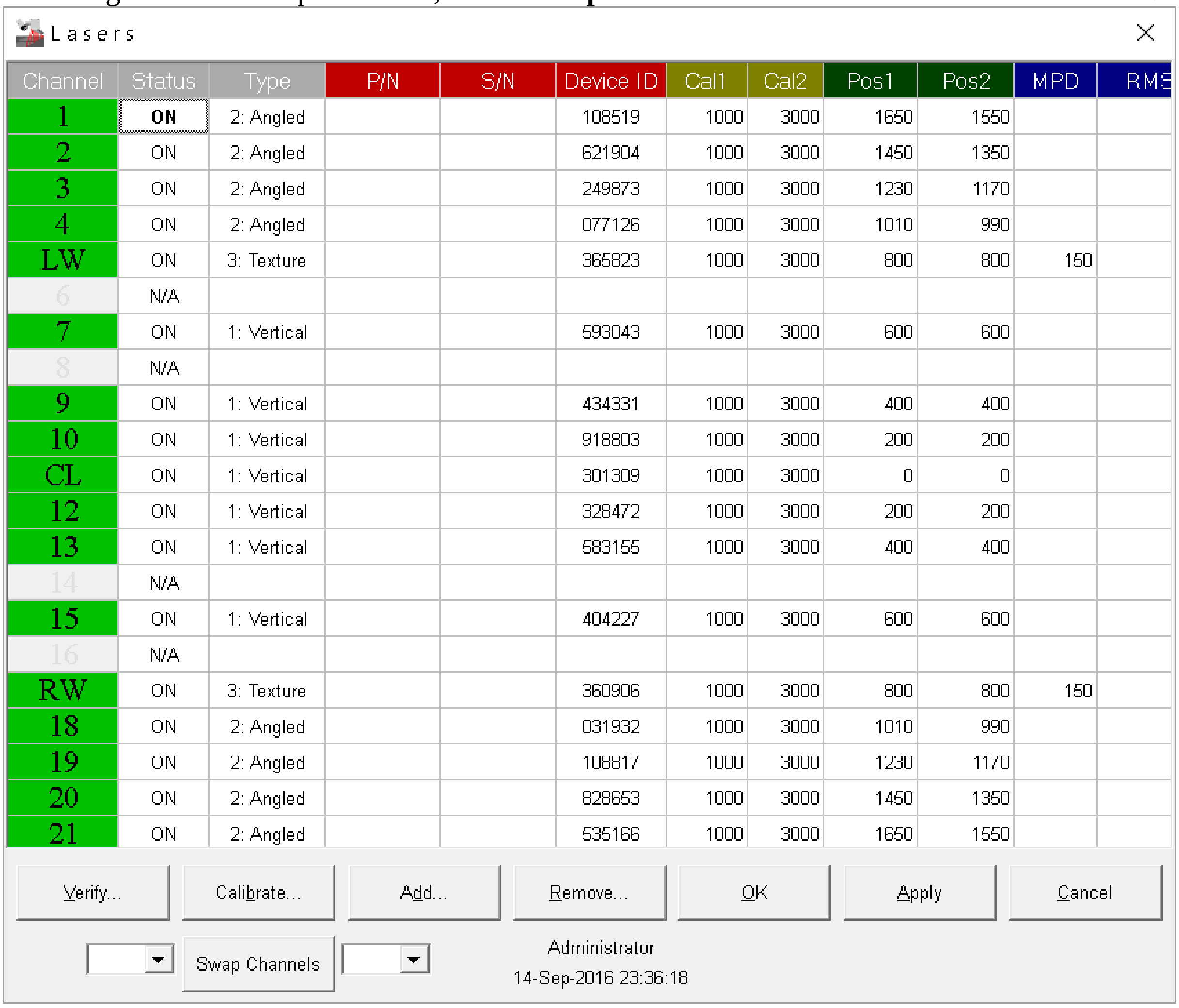
Mark IV: "Switch Functionality" is used to define the function of each pendant (available on Mark IV Portable profiler only). Up to four pendants can be used. Two plug into the Switch box while two plug into the EPU. In lieu of the pendants that plug into the switchbox, two buttons on the front of the switch box are provided. These are referred to as Switch 1 and 2. As can be seen in the diagram to the left, there are up to 6 assignable functions for each pendant/switch.



Mark IV: The Portable RSP Mark IV was intended for mounting at the back of the vehicle. If you occasionally mount the RSP at the front, then this option provides a convenient software swap of the Left and Right side data. There is no need to rearrange plugs or adjust other settings in RspWin. Just mount the RSP at the front and click the “Reverse” radio button. When you later re-mount at the back you must remember to reset this to “Normal”.

6.3.3 Laser Sensors

To configure the **Laser** parameters, select **Setup** then **Lasers** from the data collection screen.



Channel	Status	Type	P/N	S/N	Device ID	Cal1	Cal2	Pos1	Pos2	MPD	RMS
1	ON	2: Angled			108519	1000	3000	1650	1550		
2	ON	2: Angled			621904	1000	3000	1450	1350		
3	ON	2: Angled			249873	1000	3000	1230	1170		
4	ON	2: Angled			077126	1000	3000	1010	990		
LW	ON	3: Texture			365823	1000	3000	800	800	150	
6	N/A										
7	ON	1: Vertical			593043	1000	3000	600	600		
8	N/A										
9	ON	1: Vertical			434331	1000	3000	400	400		
10	ON	1: Vertical			918803	1000	3000	200	200		
CL	ON	1: Vertical			301309	1000	3000	0	0		
12	ON	1: Vertical			328472	1000	3000	200	200		
13	ON	1: Vertical			583155	1000	3000	400	400		
14	N/A										
15	ON	1: Vertical			404227	1000	3000	600	600		
16	N/A										
RW	ON	3: Texture			360906	1000	3000	800	800	150	
18	ON	2: Angled			031932	1000	3000	1010	990		
19	ON	2: Angled			108817	1000	3000	1230	1170		
20	ON	2: Angled			828653	1000	3000	1450	1350		
21	ON	2: Angled			535166	1000	3000	1650	1550		

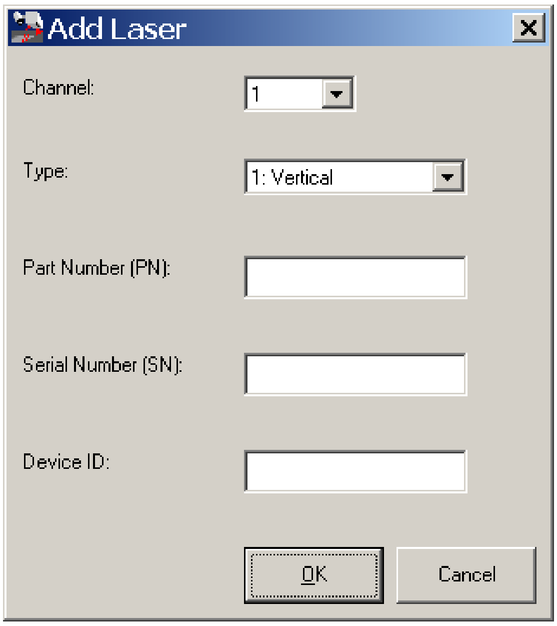
The **Lasers** window shown above displays information regarding the lasers on the RSP transducer bar. There is one row for each of the signal channels available for installing lasers.

The first column indicates the **Channel No.** to which each Laser is connected. The laser positioned at the centre of the RSP transducer bar occupies Channel No. 11 (CL – Centre Line). The right wheel path (RW) Laser occupies Channel No. 17 (optionally 16), and the left wheel path (LW) Laser occupies Channel No. 5 (optionally 6). Perhaps also see “PSB Channel Assignments”.

If a channel is NOT occupied by a laser the text in the Status field says “N/A” (not available).
The Status of populated channels is normally ON. You can set the status to OFF, meaning that output values from this laser are excluded from calculations done by the field program. This may be handy if you e.g. want to test without the wings attached.
The Part Number (P/N) and Serial Number (S/N) shown in columns 3 and 4 uniquely identify each laser installed on your system. Each laser sensor is physically labelled with a part and serial number for easy identification. It is important that the operator visually inspects the laser part and serial

numbers and physical positions in the RSP transducer bar to ensure that the information in the table is correct, especially after maintenance activities. Channel numbers are labelled in the Primary Connection Module (and Secondary Connection Module(s) if present) of the transducer bar.

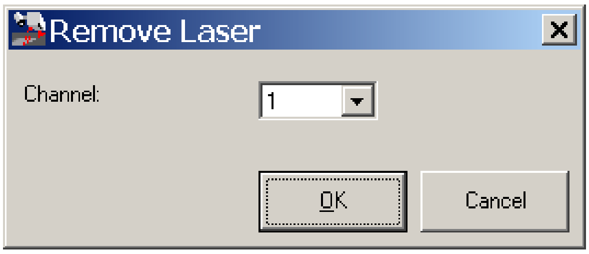
The **Type, Part Number (P/N), Serial Number (S/N)** and **Device ID** columns are not directly editable in the table by the user. They are automatically filled in when the user chooses to install a new laser. Clicking the **Add…** command button opens up a secondary window allowing the user to enter information regarding a new laser that has been installed in the transducer bar:



The Type, Part Number (P/N), Serial Number (S/N) and Device ID needed to install a new laser is provided by Dynatest upon delivery of the equipment or delivery of a replacement (or additional) laser. If you add a new laser to your equipment you will need to recalibrate the lasers, see "9 Calibration".

A laser can be disabled by clicking its status field in the table and select OFF. This enables running tests without data from some of the laser(s), like e.g. testing without "wings" or (temporarily) ignoring a defective laser.

The **Remove…** command button opens up a window to completely remove a laser from the setup:

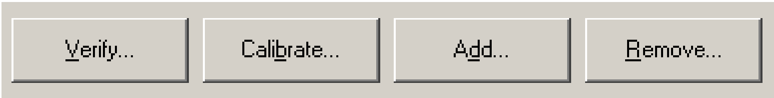


Be careful when completely removing a laser from the setup, since this procedure also removes the information needed to (re)connect the laser to your system. However there ARE situations when a user might want to remove a laser in order to reinstall it into a different channel. In that case, please remember to write down the Type, Part Number (P/N), Serial Number (S/N) and Device ID for the laser so that this data is available for the reinstallation.

The **Cal1, Cal2, Pos1 and Pos2** columns are filled in by the calibration procedure which opens in a secondary window, if the user activates the **Calibrate**… command button.

The **MPD** column is directly editable allowing the user to enter an MPD bias (Mean Profile Depth). MPD values only apply to texture type lasers (see 9.5 Texture Bias (Optional)

The **RMS** (Root Mean Square) column should not be used (see 9.5 Texture Bias (Optional)



Besides the ordinary **OK**, **Apply** and **Cancel** buttons, the Laser setup window contains four additional command buttons (shown above):

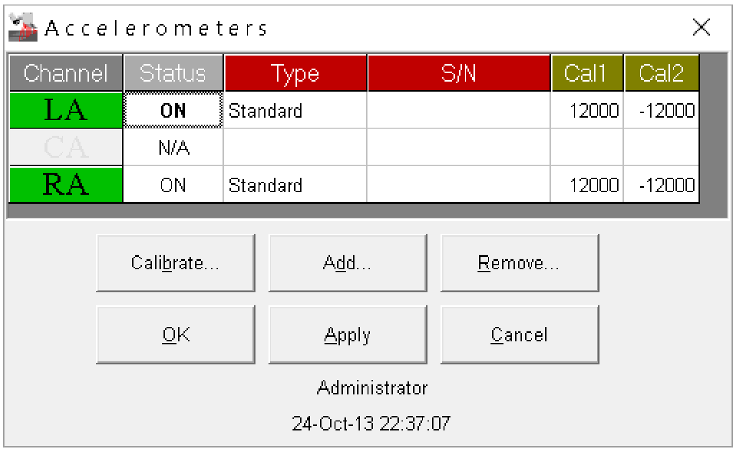
- The **Verify…** button opens up a secondary window to verify the last calibration.
- The **Calibrate…** button opens up a secondary window to perform a calibration.
- The **Add…** button opens up a secondary window to add a new laser to the system.
- The **Remove…** button opens up a secondary window to remove a laser.

For a detailed description of how to go about the calibration procedure, see the Calibration chapter (9.4.1). The calibration procedure will make changes to the Cal1/Cal2 and Pos1/Pos2 columns in the table.

MarkIII:
It is sometimes desirable to exchange two laser devices. The two drop down channel selectors and the “Swap Channels” button shown here accomplish that.

6.3.4 Accelerometers

To configure the accelerometers, select **Setup** then **Accelerometers** from the data collection screen.



The Accelerometers setup window is operated exactly like the Laser setup window, except in the Accelerometer setup window the **Type** and **Serial Number (S/N)** columns are directly editable.

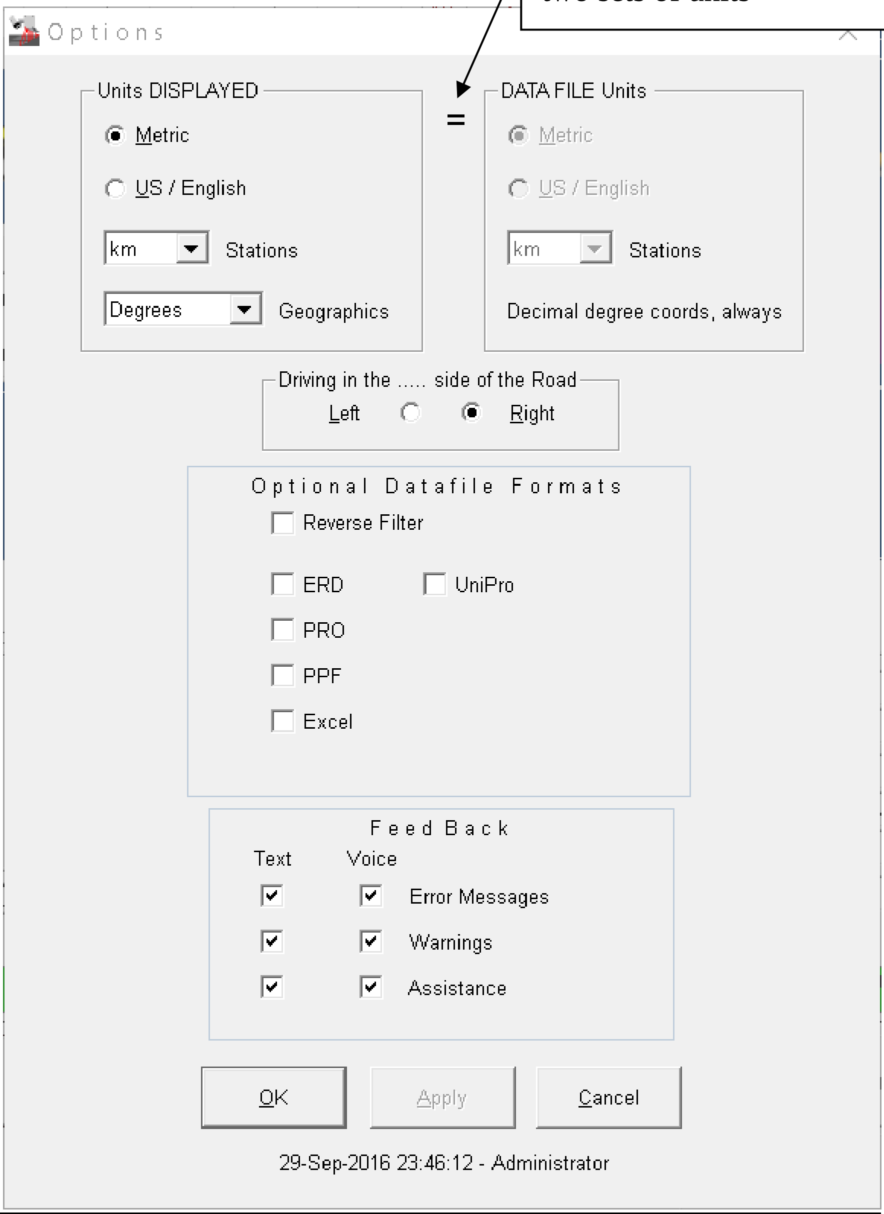
The calibration procedure initiated by the **Calibrate…** button will make changes to the values in the Cal1/Cal2 columns. For a detailed description of how to go about the calibration procedure, see the Calibration chapter.

LA, CA and RA are for Left Accelerometer, Centreline Accelerometer and Right Accelerometer.

6.4 *Program Options*

This section provides guidance for setting up miscellaneous options including measurement units, driving conventions, file formats, messaging behaviour, and screen appearance. The operator can access these options by clicking **Setup**, then **Options** from the main data collection screen.

The equal sign [=] may be toggled to [#] to separate the two sets of units



6.4.1 *Display and Storage Units*

The operator can specify the display (screen) units in the upper left corner of the window (shown above) and the data file units in the upper right corner. **This means that the computer can be configured to display test results on the screen in the Metric system while storing data in English Standard units (and vice-versa).** Furthermore, it is possible to e.g. configure the DMI display to show distances in meters while storing these distances to data file in units of kilometres.

6.4.2 Driving Conventions

The user can also indicate which side of the road he is driving on – left or right. This affects lane designations as shown in the section **Lane Designations**. This is done by checking the **Left** or **Right** button in the **Driving in the…. side of the Road** box.

6.4.3 Optional Datafile Formats

RspWin stores real-time data in its native Dynatest RSP ASCII format (see chapter 13). When a file is closed RspWin may optionally produce various additional formats (see chapter 13.3).
The **Reverse Filter** option filters each profile in the opposite direction to obtain zero phase lag (this cannot be applied to Excel output).

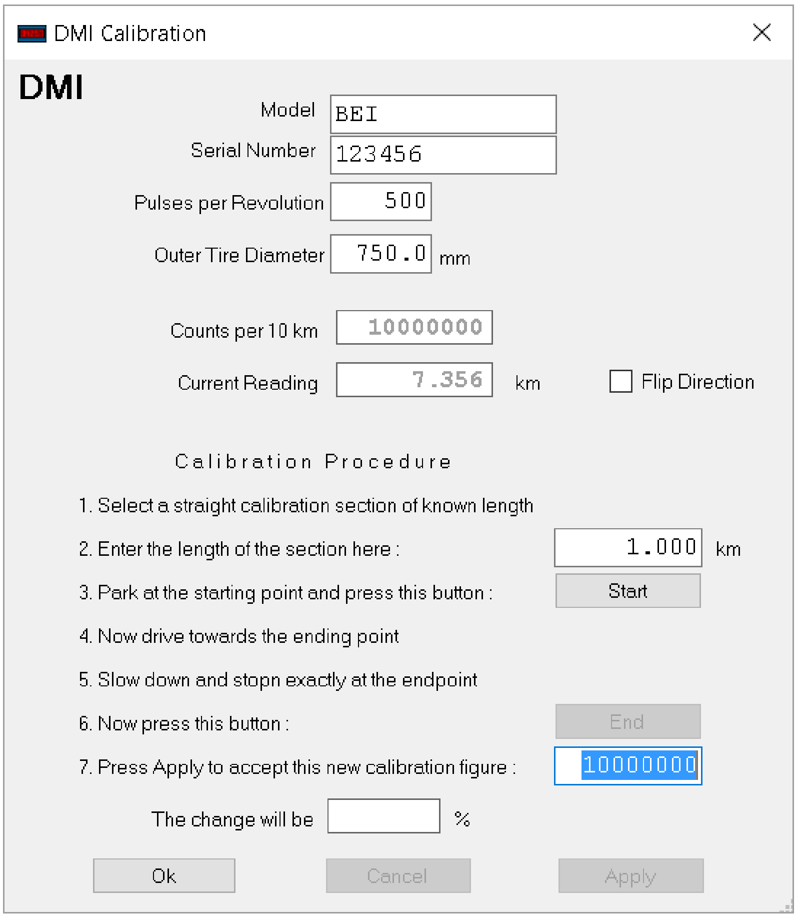
- ERD, RoadRuf and ProVal compatible
  The **UniPro** option saves each profile in a separate file
- PRO, TxDot and AASHTO compatible
- PPF, ASTM compatible
- Excel, a standard Excel spread sheet with data sorted by type

6.4.4 Feedback Type

The **Feedback** box allows the operator to control the way messages are issued by RspWin. The computer (if suitably equipped) can issue audible warnings, error messages, and assistance if desired. Each type of message can be set to **Text** (messages displayed on the computer screen) and/or **Voice** (audible messages played on the computer sound system).

6.4.6 *Distance Measuring Instrument*

Right click the DMI applet and choose **Calibration.** This window shows the Model, Serial Number, Pulses per Revolution (Advertised PPR), measured tire diameter, Calibration figure and a Calibration Procedure.



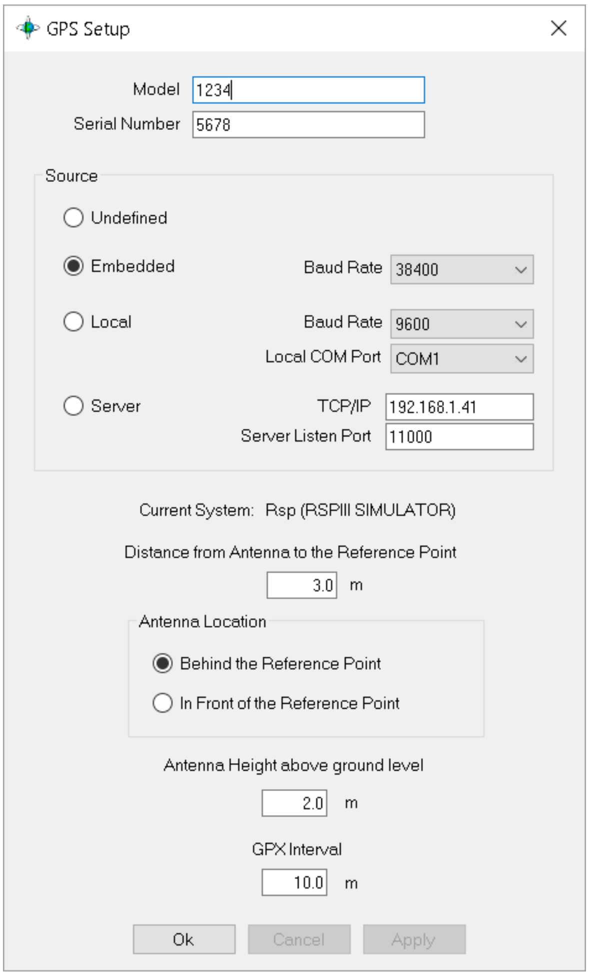
The calibration figure for the DMI is shown in the box labelled **Counts per 10 km**. This represents the expected total number of counts that would be accumulated over a distance of 10 km. The calibration figure is always displayed in units of **Counts per 10 km** regardless of the distance unit selected by the operator.

The current value of the measured distance is shown in the **Current reading** box. The value displayed here depends on the distance unit selected by the operator.

The **Flip Direction** should be toggled if the reading decreases while driving forward.

6.4.7 *Global Positioning System (Optional)*

Right click the GPS applet and choose **Setup.** This window shows the Model, Serial Number, Source options, geometric parameters and GPX option:



Embedded means that the GPS device is connected to DPU/EPU electronics. This is the recommended setup and achieves the best synchronization of DMI distance and GPS.

Local is for a GPS connected directly to the computer.

Server is for Ethernet-enabled GPS servers (e.g. an iPhone).

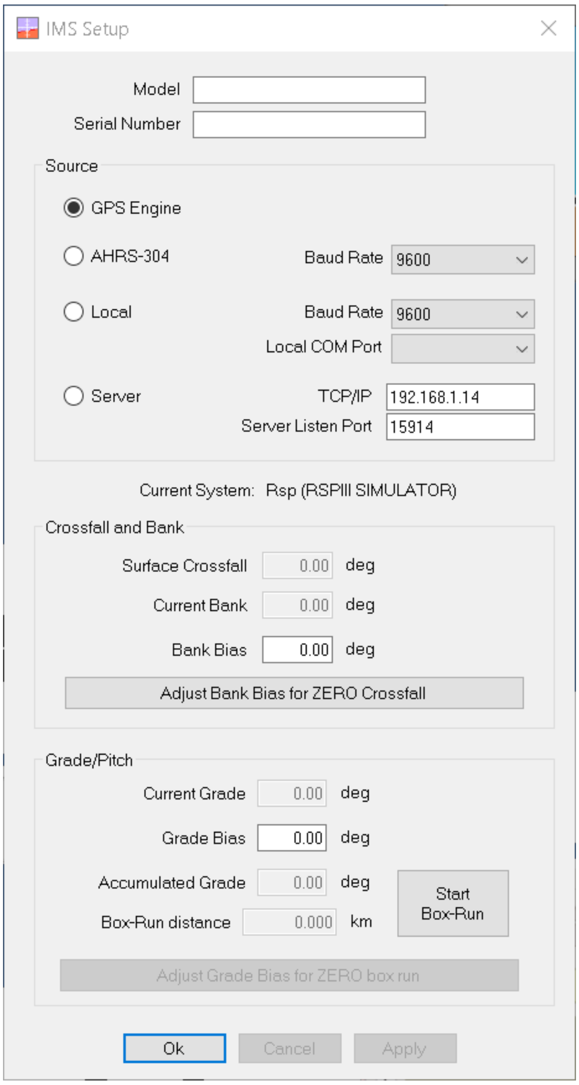
The **Reference Point** is typically a point in the center of the laser bar.

NOTE: An Applanix system allows you to choose its reference point freely. I.e. you can place the "Antenna" (the reference point) at the center line laser spot and ignore the two measures above (set both to zero).

For preparation of maps see 10.1.1 Prefetch Maps.

6.4.8 *Inertial Motion Sensor (Mark III only) (Optional))*

Right click the IMS applet and choose **Setup**. This window shows the Model, Serial Number, Source options, Crossfall, Bank and Grade parameters.



GPS Engine is for combined GPS/IMS systems like Applanix

AHRS-304 is the supported Watson model

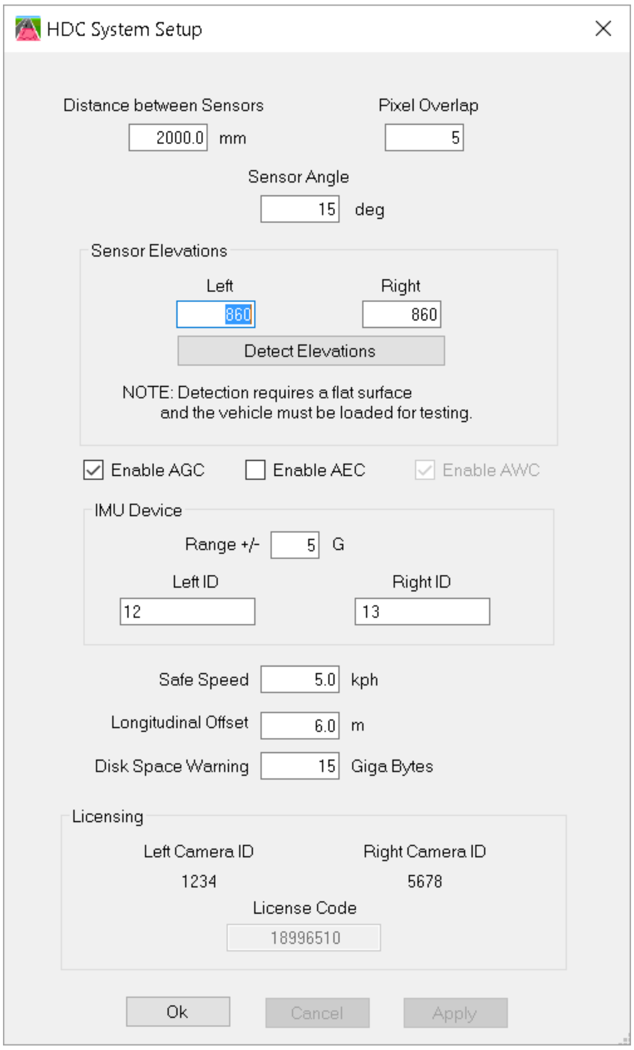
Local is for an IMS connected directly to the computer

Server is for an Ethernet enabled IMS

For adjustment of Bank Bias see chapter 9.4 below Inertial Motion Sensor (IMS) page 117.

6.4.9 *HDC 3D Crack Detection (Optional))*

Right click the HDC applet and choose **System Setup.** These parameters are setup by Dynatest at delivery of an MFV system.



7 Running the Program

7.1 Switch ON

If you are going to use the program in non-simulator mode (i.e. hooked up to the equipment) please follow below procedure:

NOTE:
If the system is equipped with an IMS then the vehicle should not be moving during power up.

High Definition Cracking (Optional)

- Take safety precautions and remove the covers from the light sources and the cameras.
- Switch ON the Pavemetric Controller key.

Mark III RSP

- Verify that the safety power key switch for the Transducer Bar is in the "OFF" position
- Verify that the computer is off
- Make sure that wing lasers are mounted and plugged in
- Connect the DPU, Router (optional) and the computer with appropriate Ethernet cables
- Plug the RJ11 connector from the distance encoder into the PSB
- Plug the 9-pin serial cable from the (optional) IMS unit into the serial COM2 port of the DPU
- Plug the 9-pin serial cable from the (optional) GPS/Applanix unit into the serial COM1 port of the DPU
- Switch ON the Computer and let it boot up
- Switch ON the DPU and wait for flashing Ethernet indication
- Start “Dynatest Data Collection”
- Turn the safety key ON to power up (activate) the Transducer Bar

Mark IV RSP

- Verify that the computer is off
- Connect the EPU, Router, switch box, and the computer with appropriate Ethernet cables
- Switch ON the computer and let it boot up
- Turn the Key on the switch box to power up the transducer bar and EPU
- Start “Dynatest Data Collection”

Windows Firewall

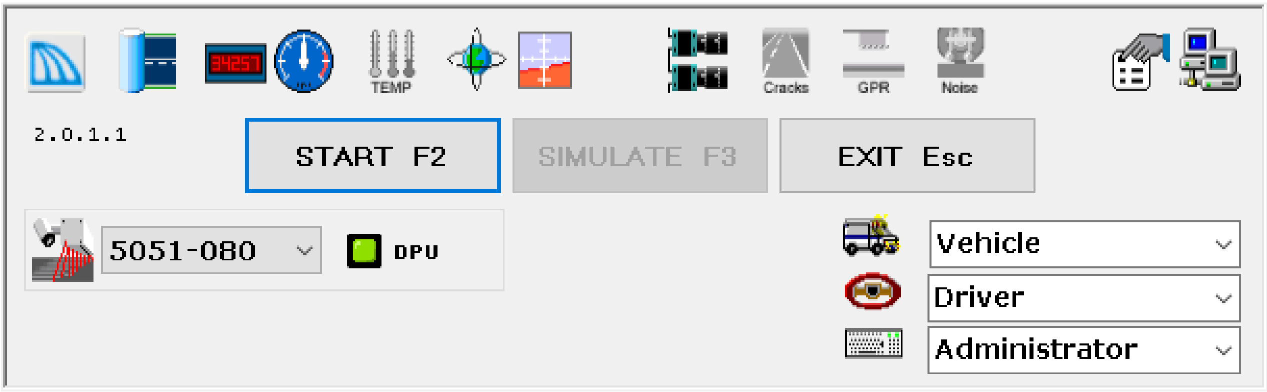
The first time you run “Dynatest Data Collection” the Windows Firewall may show a message saying it is blocking certain functionality of the DDC. You will have the option to remove the blocking. Please do so.

Network Timeout

If you get a “Network Timeout” error, then check the 12V power, Network cables and Router/Switch and then re-sequence power.

7.2 Dynatest Data Collection (DDC)

When the “Dynatest Data Collection” is first started, this window appears:



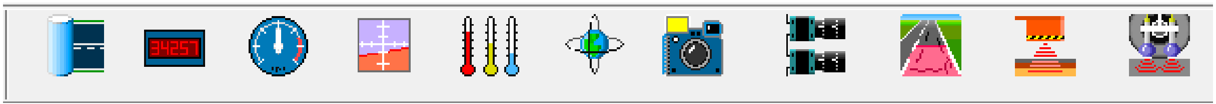
This sample shows that you will run tests with RSP S/N 5051-080 and the Network, DMI, Speed, , GPS, Gyro and Camera(s).

Check Vehicle ID, Driver Name and Operator Name

If the DPU “LED” stays pale, then check the 12V power, Network cables and Router/Switch and then re-sequence power.

7.2.1 Applets

Applets are programs providing specific functionality to the main applications. Most applets appear in resizable floating windows. The Administrator can arrange the windows but the resulting layout is locked for the Operator.

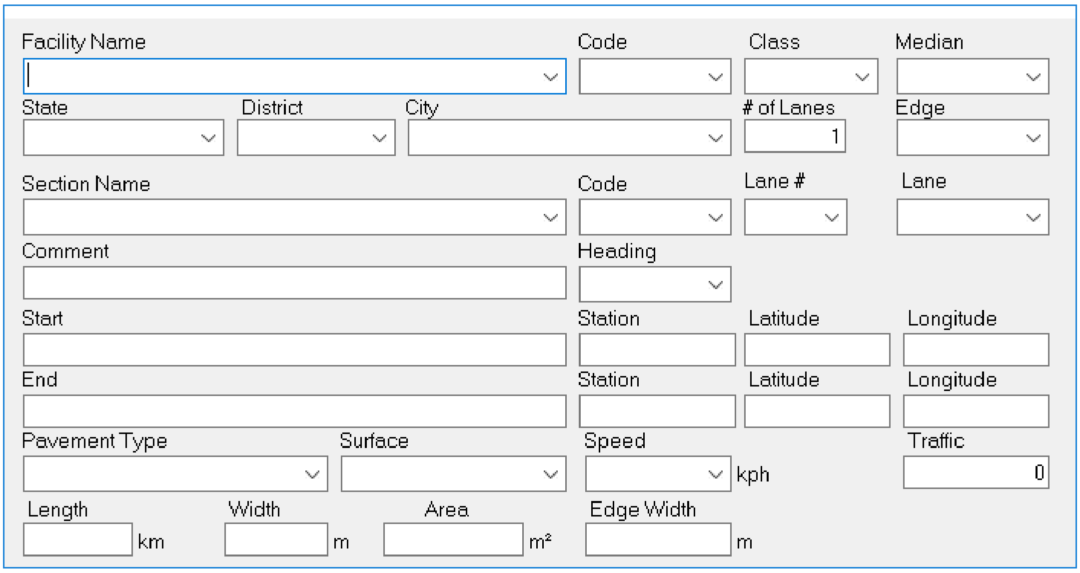


Click an icon to toggle between coloured and gray icons. When you press [Start] then all coloured applets are launched together with the main program, RspWin. After this the opening window “Dynatest Data Collection” minimizes, but must be left running during the mission.

The menus shown in the following appear when you right click the applet.

7.2.1.1 *Network*

The Network applet manages Section information. The entered information is saved in a SectionLog database for each test run. Some of the fields are also saved in the RSP data file.

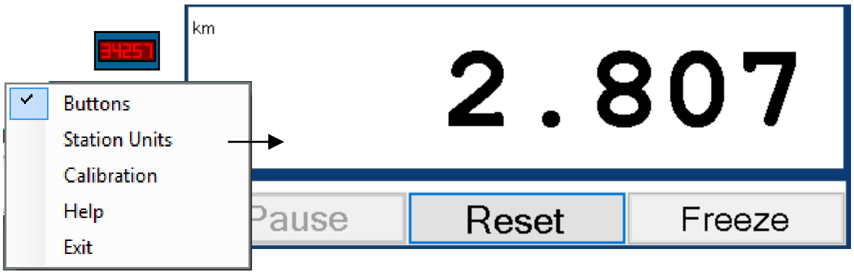


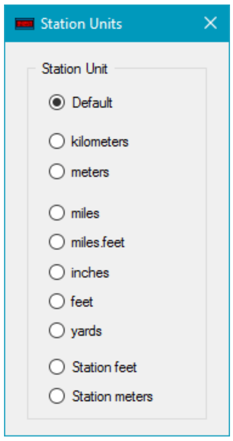
A "Facility" can be anything from roadways, runways and streets to parking lots or even railways. Often a facility is identified by both its common name and a code, which links into a pavement management system.

A single facility is often composed of sections of varying construction. This "Sectioning" can be both longitudinal and transverse. The latter is appropriate for multilane roadways where traffic load varies across the construction.

7.2.1.2 *DMI*

The DMI applet displays the current DMI reading.



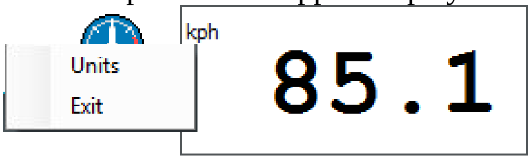


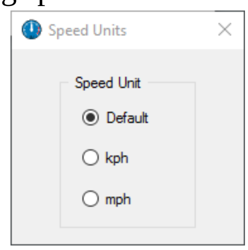
Uncheck "Buttons" to hide the Pause, Reset and Freeze buttons.

The unit can either track the unit used in RspWin (Default) or be set to any other desired format.

7.2.1.3 *Speedometer*

The Speedometer applet displays the current driving speed

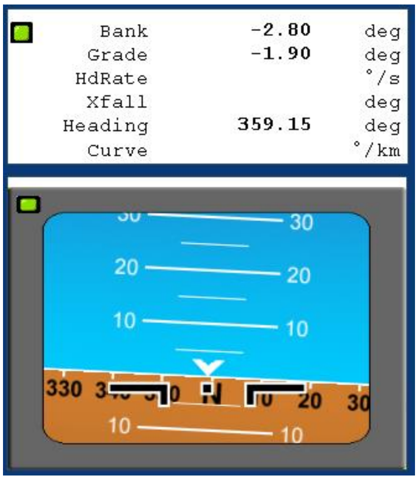


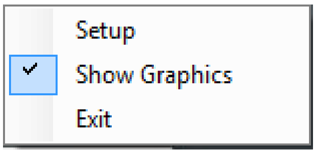


The unit can either track the unit used in RspWin (Default) or be set to kph or mph.

7.2.1.4 IMS

The IMS applet displays Bank, Grade, Heading, Crossfall and Curvature data.
IMS (Gyro) equipment is optional.

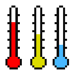




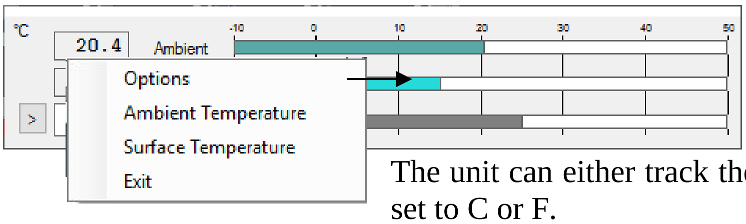
Uncheck "Show Graphics" to hide the graphical attitude display.

The attitude indicator may seem backwards at first. If the RSP leans clockwise, the artificial horizon will rotate counter clockwise. If the RSP is travelling uphill, the artificial horizon will move below the origin of the plot. This is normal, as the artificial horizon shows the orientation of the RSP with respect to a level surface.

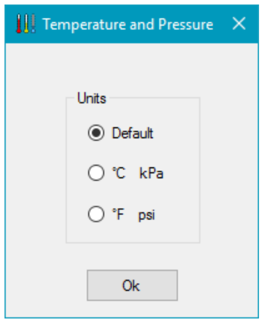
7.2.1.5 Thermometers



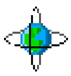
The Thermometer applet displays three temperatures and colorizes Air and Surface temperature relative to the Asphalt temperature.



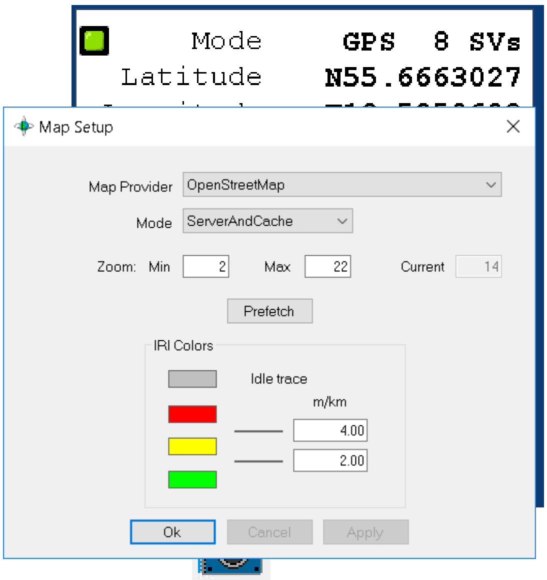
The unit can either track the unit used in RspWin or be set to C or F.

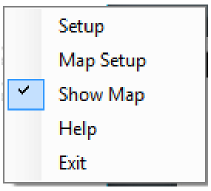


7.2.1.6 GPS



The GPS applet displays the current geographical coordinates and a map.





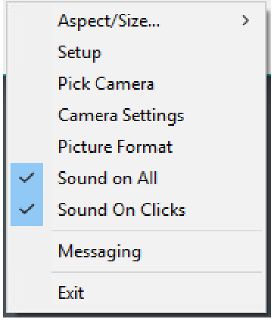
Uncheck "Show Map" to hide the map window

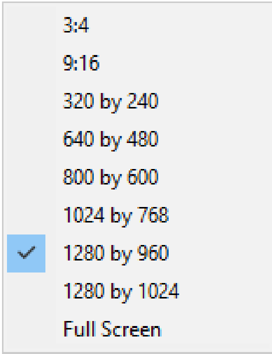
Chose the desired map provider and the maximum zoom level

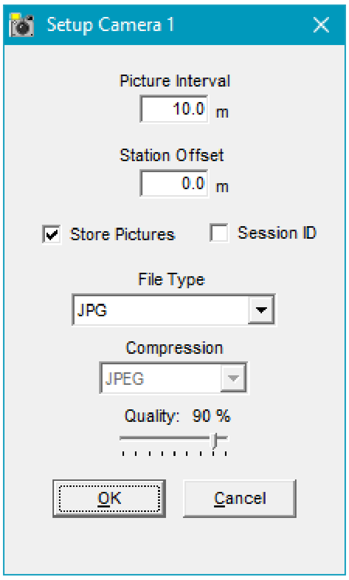
For IRI traces chose the desired colors and limits.

7.2.1.7 Camera

The Camera applet displays and saves images from DirectX cameras.







Setup:

Picture Interval:
This example shows 1 image stored every 10 meters.
Station Offset:
Adjustment of your distance reading. (Part of the image file name).
Session ID:
Ad Session ID No to image file name. (For FWD and Survey testing only).
File Type:
BMP, JPG, TIFF or PNG.
Quality:
100% is least compressed ~bigger files.

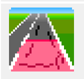
Pick Camera
Lists available DirectShow devices
Camera Settings and **Picture Format**
These windows are supplied by the camera manufacturer
Sound
Uncheck to shut off the shutter sound

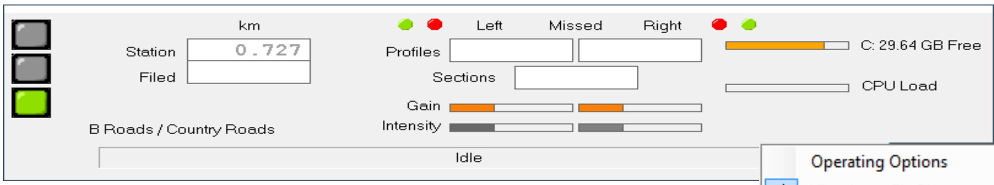
For detailed setup of specific camera models see chapter **Error! Reference source not found.**

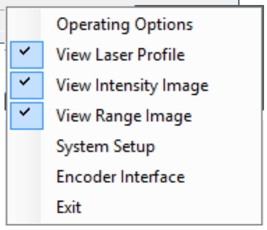
Unibrain
The following items must be performed for each camera after camera power-off!

1. Right-click on the ROW picture and select “Camera Settings” and then “Exposure”
2. For “Shutter” as well as for “Gain”, check the “at” box
3. Click the “Basic” tab.
4. In the “Basic” window, adjust “Gamma” to 1 or 2 and “Sharpness” to 16 _

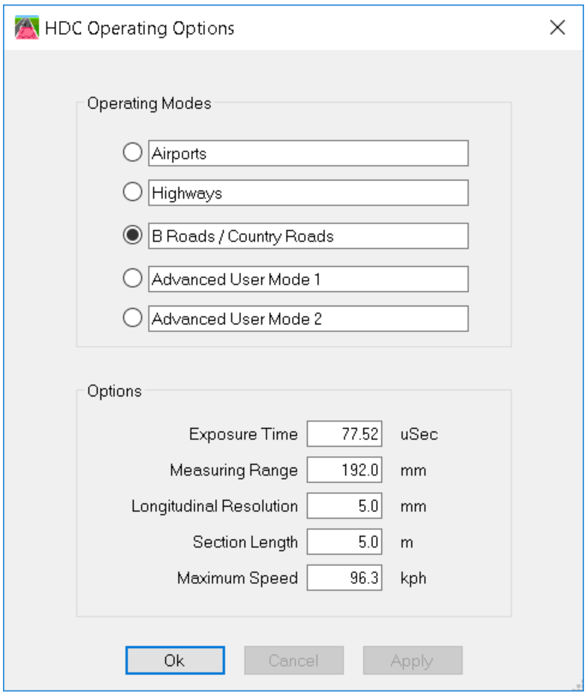
7.2.1.8 *High Definition Cracking (HDC)*







Uncheck the "View" options to hide the images below.



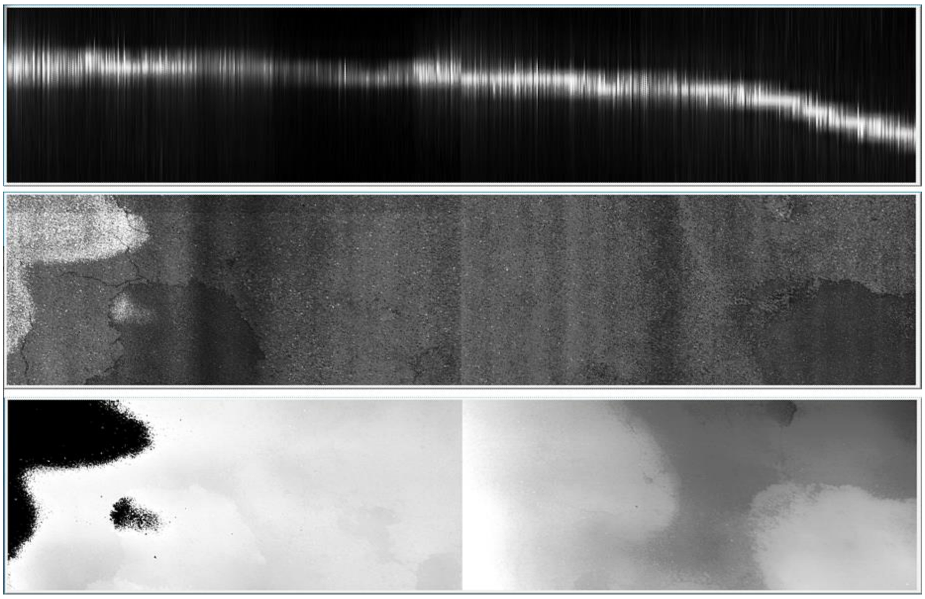
Five Operating Modes have been prepared.
Make sure you have chosen the best fit for your mission.

You can modify the descriptive labels

These parameters are interrelated, so changing one may affect others. In particular the Maximum Speed is sensitive to the other four parameters.

In the main window:

Station	The offset position of the LCMS cameras (typically 6 m behind the RSP)
Filed	Shows Station of last section (FIS file) stored
Missed Profiles	Number of profiles (lines) missed from each LCMS Unit
Missed Sections	Number of sections missed
Gain	Displays the current Auto Gain Control (AGC) value
Intensity	Light intensity level.



Crossprofile

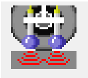
Intensity Image

Range Image / 3D Image

7.2.1.9 Ground Penetrating Radar

The GPR option is very unlikely to combine with an RSP, so we will skip this here.

7.2.1.10 Tire Sound Intensity



TSI according to the OBSI

7.2.2 Simulation Mode

If the Data Collection cannot detect the presence of RSP hardware (EPU or DPU) you can still run the system in Simulation Mode.

Simulation mode allows the user to run RspWin even when the equipment is not connected. In this mode artificial data is fed into the program at the appropriate times to create the appearance that an RSP is actually connected.

Simulation mode is useful for training purposes. Using simulation mode, an instructor can conduct classroom training with one or more computers and operators (no hardware is needed). The operator can also “practice” running the equipment in the office.
In simulation mode you can use the following key combinations to get a more realistic training situation:

- **Ctrl** + **Shift + P** toggles the Photo signal so PhotoStart/Stop can be demonstrated.
- **Ctrl + Shift + UpArrow** increases speed (up to 115 kmh max).
- **Ctrl** + **Shift + DnArrow** decreases speed (down to –5 kmh backing up).

7.2.3 Reporting

In addition to the *.RSP data file itself, the program can generate various printed and/or filed reports like IRI Average, Localized Roughness, Section Statistics etc. both real-time, during data collection, and later in the office running DDC in Simulation Mode.
See chapter 8.2“Reports”.

7.2.4 Entering the Main Program

Once everything in the “Dynatest Data Collection” screen is configured, the user may click the “Start” button (choose “Administrator” for the first few runs). The data collection screen should appear and the user can now complete the setup process.

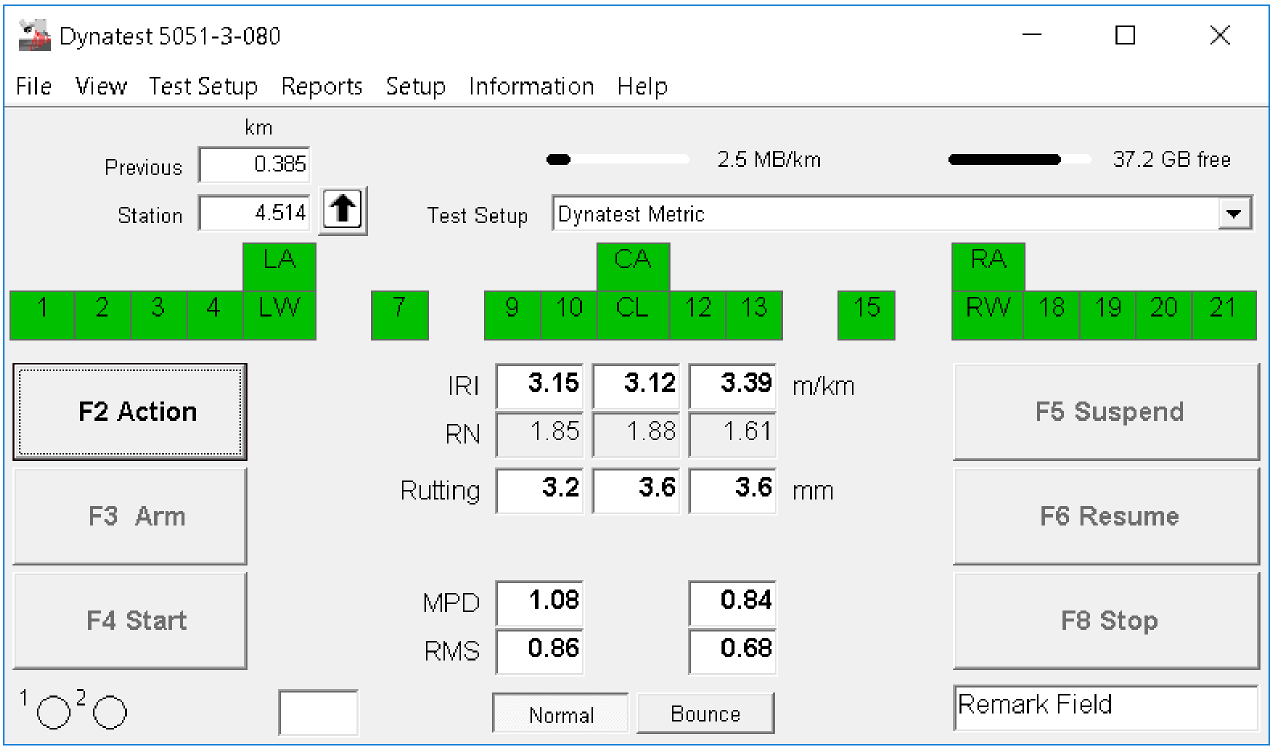
NOTE: Some of the features shown in the following may not apply to your system.

7.3 The Data Collection Screen

The data collection screen opens when the user clicks the “Start” button in “Dynatest Data Collection”. The following screen shot was obtained with a Mark III RSP running with 17 lasers.

The screen consists of a Main window, sub-windows and applets. The large Main window is the primary interface or “mission control” for operating the program, i.e. all RSP functions are controlled from here. Each of the sub-windows and applets tend to mimic a real-life instrument like, for instance, a GPS navigator, Distance Measuring Instrument etc. Sub-windows and applets may be resized and moved around independently by simple drag operations using the mouse pointer. They may even be moved to a secondary monitor.

7.4 *Main Window*



As mentioned earlier the Main window is the "mission control" for operation of the RspWin program. From this window the additional sub-windows can be toggled on and off by clicking the **View** menu item on the menu bar. Applets can be turned off from their individual menus.

7.4.1 *Navigating with the Keyboard*

Often, when using the program within a confined space (like in a testing vehicle), it is impossible or – at its best – inconvenient to use a mouse to operate the program. Therefore it may be a good idea for the user to brush-up the basics of navigating with the keyboard.

Actually, most of the operations you can do using a mouse (except drag-and-drop operations) can be done using the keyboard instead. The key to navigating with the keyboard is using the **TAB** (↔) key to put the focus on a *control* in the active window (controls are all the items that a window contains, like command buttons, textboxes, drop-down lists etc.).

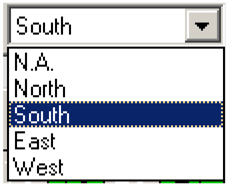
When a control has the focus it has a *focus rectangle* around it as shown below (the **Apply** command button has the focus):

Each control in a window has been assigned a tab order, so that when the user presses the **TAB** key the focus rectangle is moved to the next control in the tab order, and when **TAB** is pressed while simultaneously holding down the Shift key the focus rectangle is moved to the previous control in the TAB order.

When a control has focus the user can manipulate it using the keyboard. Here is a quick overview of how to manipulate the most common of windows controls using the keyboard:

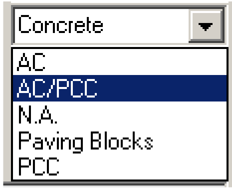
- Command Buttons:
  To activate a command button simply press the Enter key on the keyboard.

- Drop-down lists:



To make a drop-down list drop down or retract simply press the up- or down arrow while at the same time holding down the **Alt** key. To navigate in the drop-down list simply use the up- and down-arrows WITHOUT pressing the **Alt** key. When an item in the drop-down list is highlighted the user can select it by pressing the **Enter** key on the keyboard.

- Combo Boxes:



A combo box is a combination of a textbox and a drop-down list. The text portion of a drop-down list can only display items from the list, whereas a combo box allows the user to directly enter an input into the text portion as if it was a plain textbox as well.

In the combo box shown above the user has been allowed to enter the word “Concrete” into the text portion of the combo box although “Concrete” doesn’t appear in the list of pavement types to choose from.

- Check Boxes:

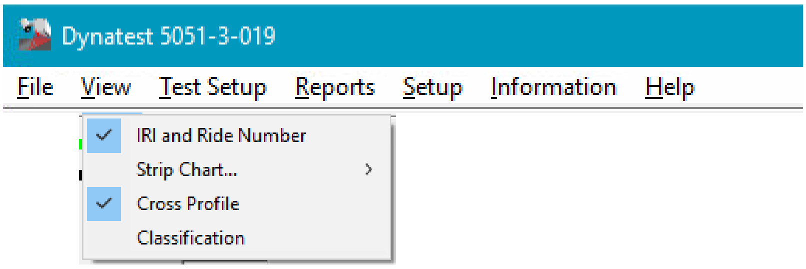
The checkmark in a checkbox can be toggled ON and OFF by pressing the **Enter** key.

The menu bar (along the top of the main window) is accessed in a rather special way. Actually there are two ways a user can access the menu bar using the keyboard:

The user can shift the focus between the menu bar and the rest of the window by pressing the **Alt** key. When the menu bar has the focus one of the headline items is “depressed” as shown below (the **View** headline item is highlighted):

Use the left- and right arrows to highlight the desired headline item. Each headline item conceals a list that the user can drop-down by pressing the **down-arrow**. To navigate in the drop-down list simply use the up- and down-arrows. When an item in the drop-down list is highlighted the user can select it by pressing the **Enter** key.

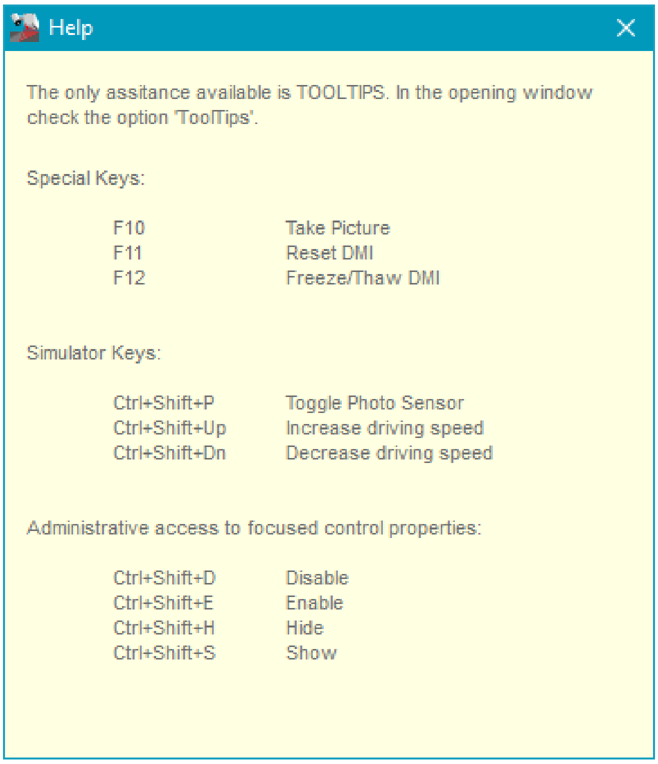
The user can navigate the menu bar using *short-cuts*. Each of the items in the menu bar has an underscored letter in their name. A menu item can be selected by pressing the underscored letter in combination with the **Alt** key. For instance, pressing **Alt + V** would be a direct way to select the **View** menu and make it drop-down at the same time:



Note: Short-cuts not only apply to menu bars, but can be used for ordinary control items as well. For instance an **OK** button like the one shown elsewhere in this chapter can be focused and activated (pressed) in a single keyboard operation by pressing **Alt + O**.

7.4.2 Special Keys

Some Function Keys and key combinations are allocated for various special purposes. Some of the functions are available for the Administrator, only.



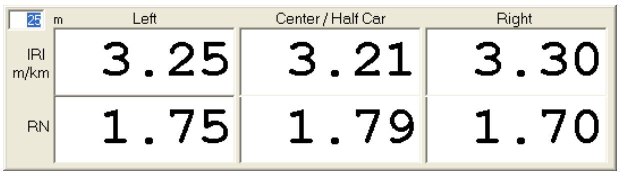
The Help entry in the menu item Help displays the full list of special keys

7.5 Sub-Windows

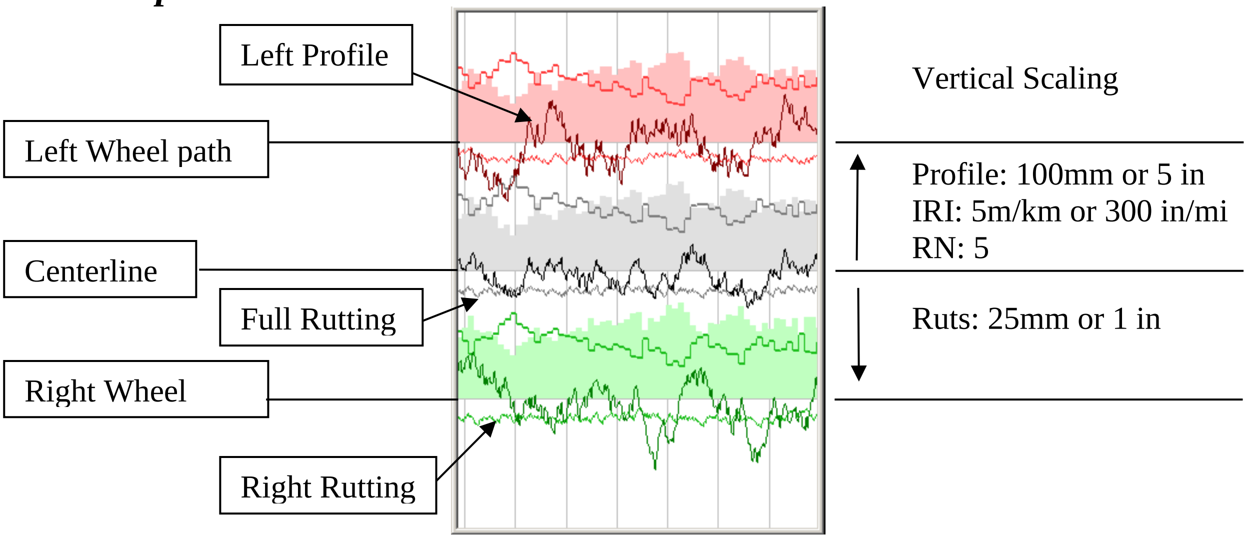
The sub-windows listed here are RSP dedicated windows. General functions are handled by the previously described applets.

7.5.1 IRI and Ride Number

This is for ease of checking the IRI and Ride Number during data collection.
The little text field in the upper left corner indicates the averaging distance.



7.5.2 Strip Chart

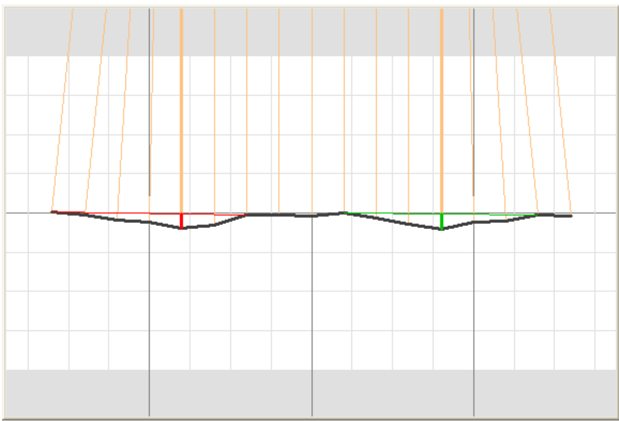


The Strip Chart rolls left across the window displaying Longitudinal Profile, IRI, Ride Number and Rutting. The filled column bars represent IRI values; the merely outlined column bars represent Ride Number. The vertical grey lines are spaced 0.1 km or 0.1 mile apart.

Which of the abovementioned quantities that are to be shown on the Strip Chart, can be selected in the View menu.

7.5.3 Cross Profile

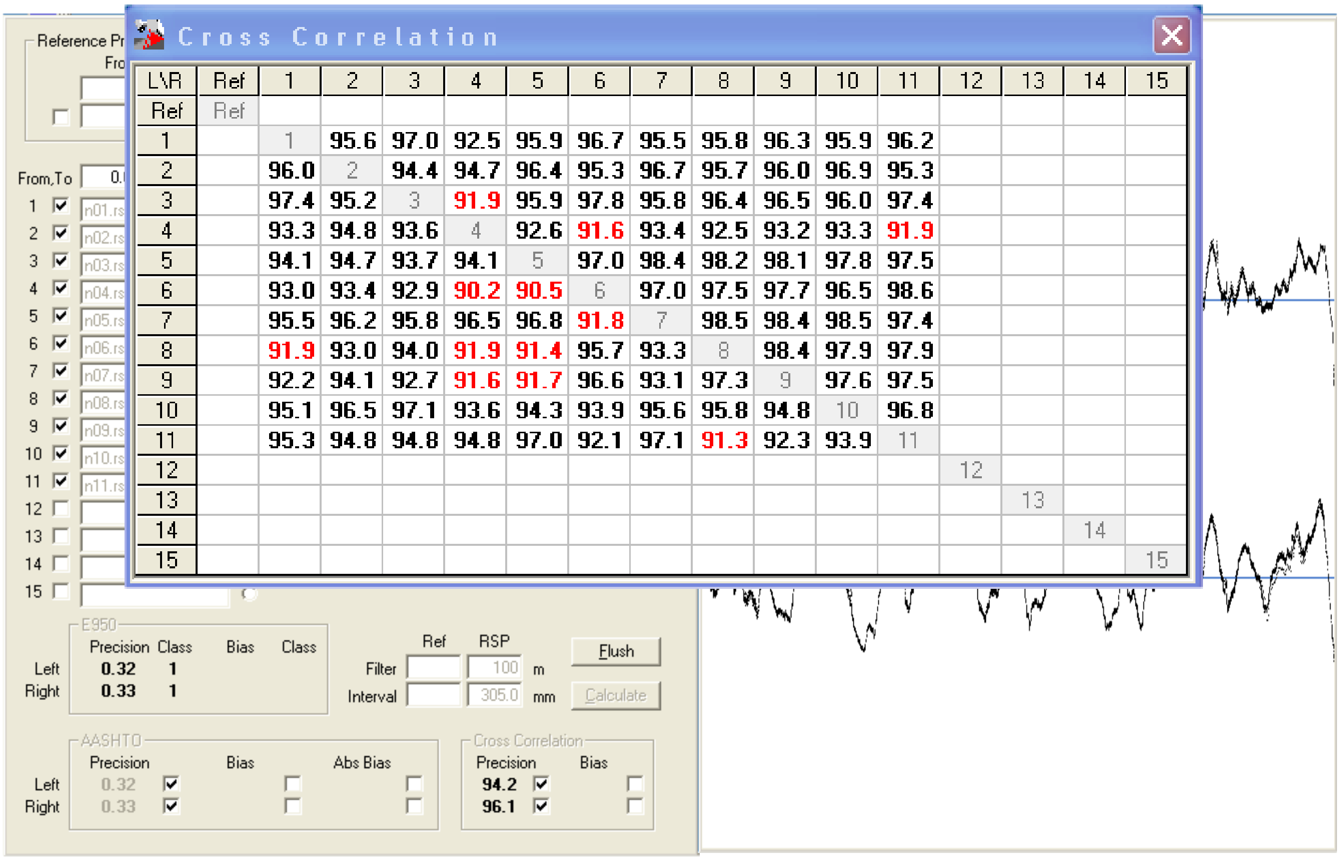
The Cross Profile window shows a cross profile as viewed through the front window of the vehicle. The orange lines indicate the laser beams (notice the angled beams from the (optional) wing extensions with angled lasers). The thick, black line shows the cross profile as measured by the lasers. The red and green rutting lines show how the string line algorithm works. The grey areas indicate the valid measuring range of the lasers, which is typically from 200 to 400 mm, with a nominal standoff distance of 300 mm.



7.5.4 Classification

The Classification windows are used during precision (repeatability) and bias testing to classify the RSP according to E950 and AASHTO specifications and also for estimation of Cross Correlation performance according to AASHTO PP49. Note that the results should be double checked by independent software like the free ProVal (www.roadprofile.com).

The main window shows summary data from repeated runs; including bias and the overall IRI from each run. A graph shows the longitudinal profiles and a table shows the Cross Correlation figures.



L\R	Ref	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ref	Ref															
1		1	95.6	97.0	92.5	95.9	96.7	95.5	95.8	96.3	95.9	96.2				
2		96.0	2	94.4	94.7	96.4	95.3	96.7	95.7	96.0	96.9	95.3				
3		97.4	95.2	3	91.9	95.9	97.8	95.8	96.4	96.5	96.0	97.4				
4		93.3	94.8	93.6	4	92.6	91.6	93.4	92.5	93.2	93.3	91.9				
5		94.1	94.7	93.7	94.1	5	97.0	98.4	98.2	98.1	97.8	97.5				
6		93.0	93.4	92.9	90.2	90.5	6	97.0	97.5	97.7	96.5	98.6				
7		95.5	96.2	95.8	96.5	96.8	91.8	7	98.5	98.4	98.5	97.4				
8		91.9	93.0	94.0	91.9	91.4	95.7	93.3	8	98.4	97.9	97.9				
9		92.2	94.1	92.7	91.6	91.7	96.6	93.1	97.3	9	97.6	97.5				
10		95.1	96.5	97.1	93.6	94.3	93.9	95.6	95.8	94.8	10	96.8				
11		95.3	94.8	94.8	94.8	97.0	92.1	97.1	91.3	92.3	93.9	11				
12													12			
13														13		
14															14	
15																15

Right Wheel Path

Left Wheel Path

For calculating precision, 5 or more repeat runs over a pavement section are recommended.
For calculation of bias, a reference profile is needed. If only precision is of interest, no reference profile is required. A reference profile can be any profile elevation data taken with a device other than the particular RSP you are operating. It can be another RSP, a Dipstick, or a Walking Profiler. The reference profile elevation data must be filtered with the same filter type and wavelength used when the RSP data was recorded. The reference profile elevation data must also have been collected using the same distance interval between elevation points. The reference profile data must be formatted as a standard *.RSP file. To open a reference profile, double-click in the filename box at the top of the window next to the Ref check box. Also, make sure the "Ref" box is checked. This will activate the bias calculations. Once a reference file is opened, the "From" and "To" fields will show the beginning and ending chainage for the reference profile data.

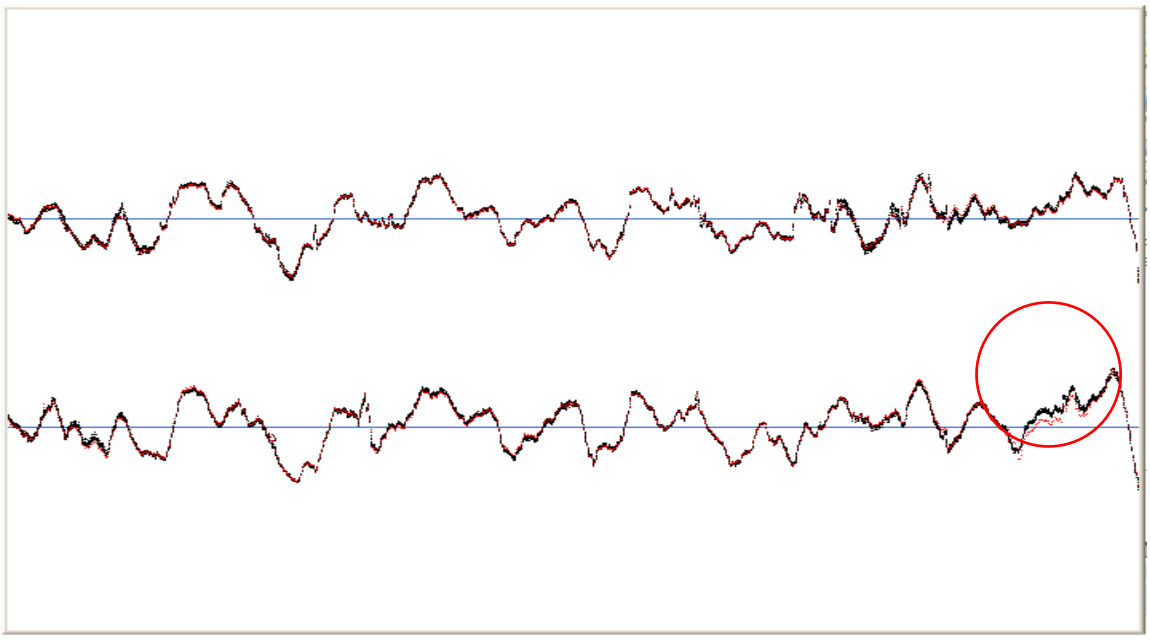
The filter lengths for both the .RSP and reference data files are shown in the "Filter" fields. Also shown is the data storage interval for both the reference and RSP profile files.

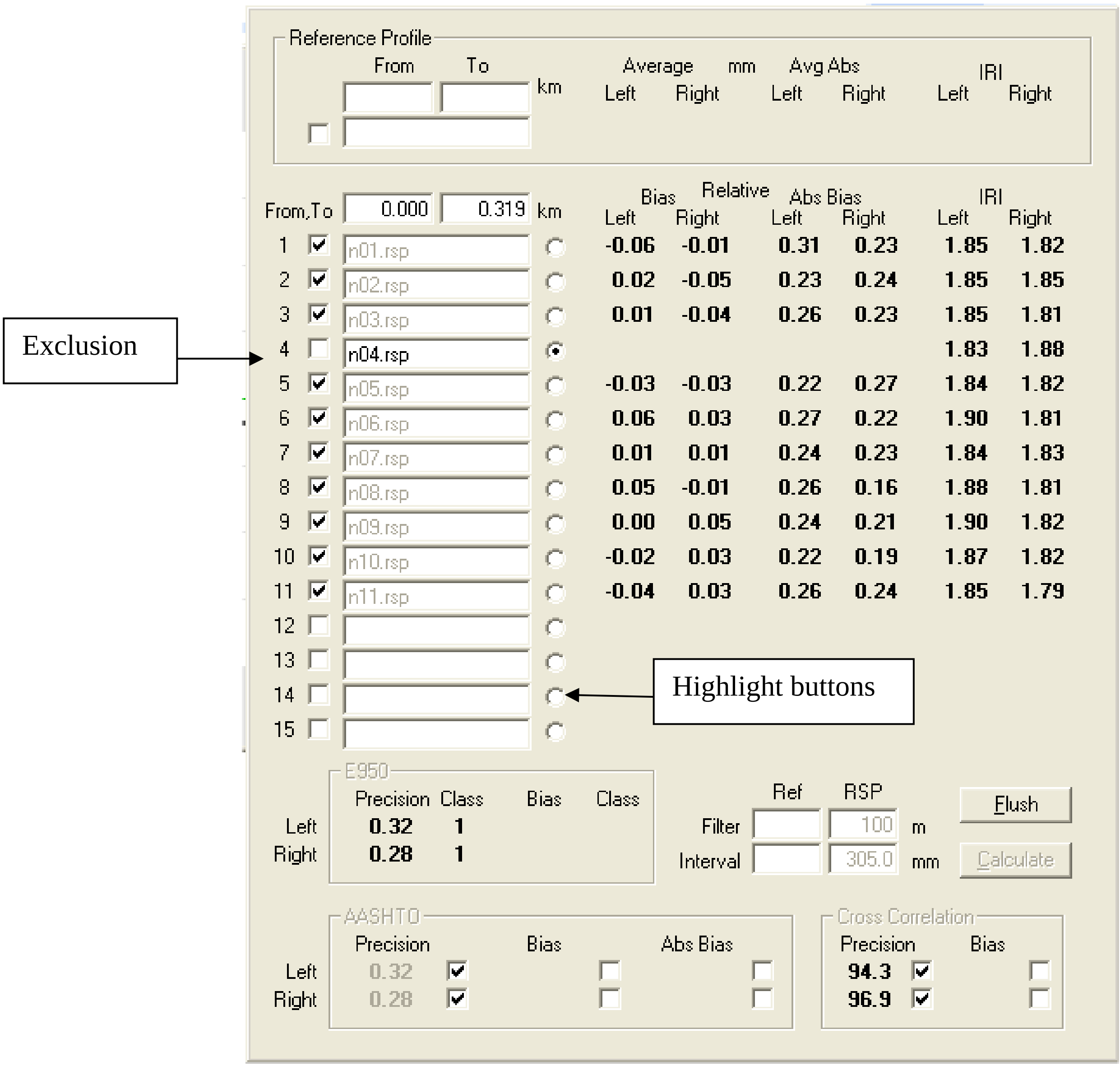
The "Relative" "Bias" and "Abs Bias" compare an individual profile file to the average of the group. This can be used to determine if one particular run is a statistical outlier.

Procedure for conducting classification runs in the field:

1. Prepare the test section for Photo Start and perhaps also Photo Stop.
2. In menu View check Classification to show the windows.
3. Click "Flush" to clear all fields.
4. Load a reference profile if available
5. Choose an appropriate Test Setup among:
   - E950, repeatability tests
   - AASHTO Certification
   - PP49, Classification
6. For each run the Classification window will load the new file and recalculate.

In the following example a suspect run is highlighted in red by selecting one of the radio buttons. Subsequently that run is excluded by un-checking the particular file and the pressing calculate.

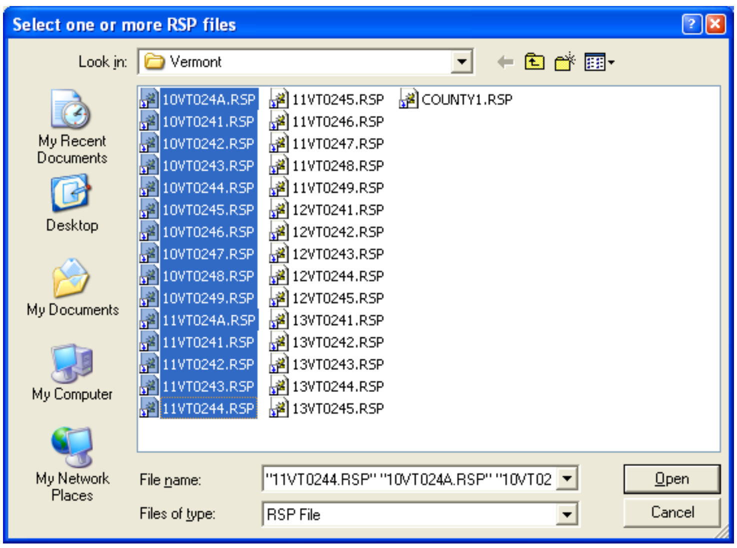




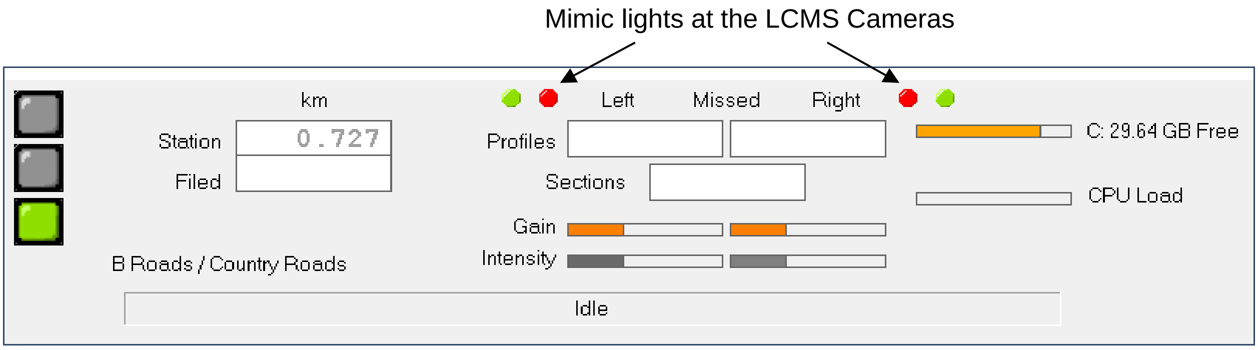
The Classification windows can also be used to compute precision and bias from any existing set of repeat runs (e.g. in the office).

To open a series of RSP files, just double-click on the filename fields. You can import up to 15 files at a time by highlighting all 15 filenames in the dialog box.

Once the files are selected, click "Open". Next, click "Calculate". The precision and bias calculation results are shown at the bottom of the form.



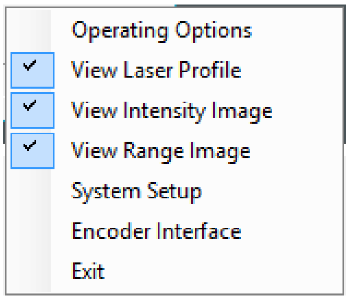
7.5.5 *High Definition Cracking (HDC)*



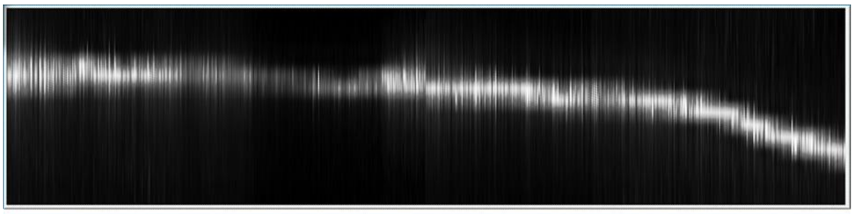
HDC High Definition Cracking Main Window

Red light	When system is not initialized or not ready to collect data Flashing when sections are lost during data collection
Yellow Light	Just before starting measurement.
Green Light	OK
Station	Longitudinal position of the LCMS cameras Offset is specified in “System Parameters”
Filed	Shows beginning Station of the last LCMS images captured and stored
Left Right	Number of profiles (image lines) missed from each LCMS Unit
Sections	Number of sections (FIS files) missed
Gain	Displays the current Auto Gain Control (AGC) value.
Intensity	Light intensity level.
Storage	Remaining space on Main drive (and Back-up drive)

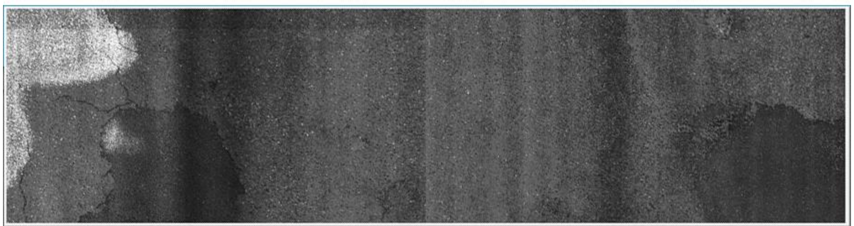
Right-click the HDC window for Options Menu.



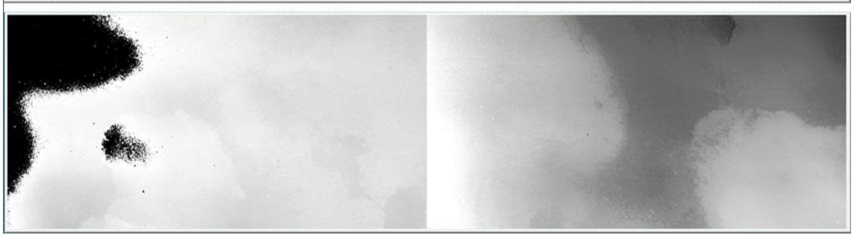
View Options:



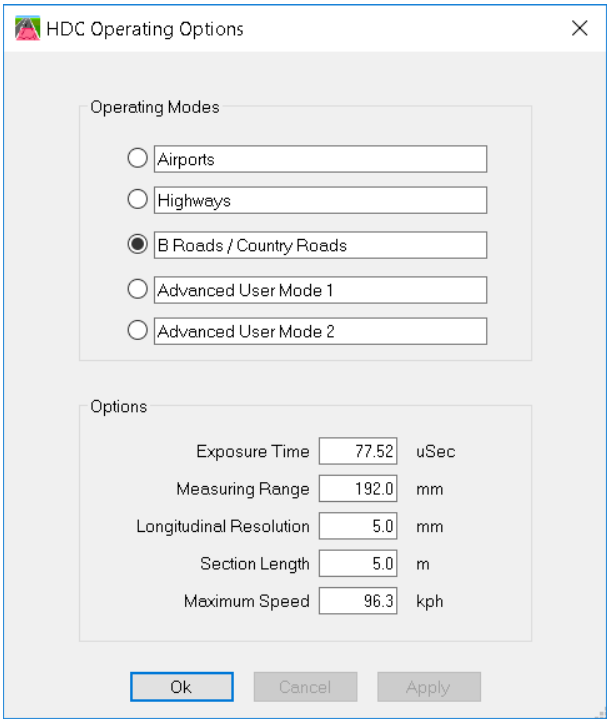
Laser Profile



Intensity Image



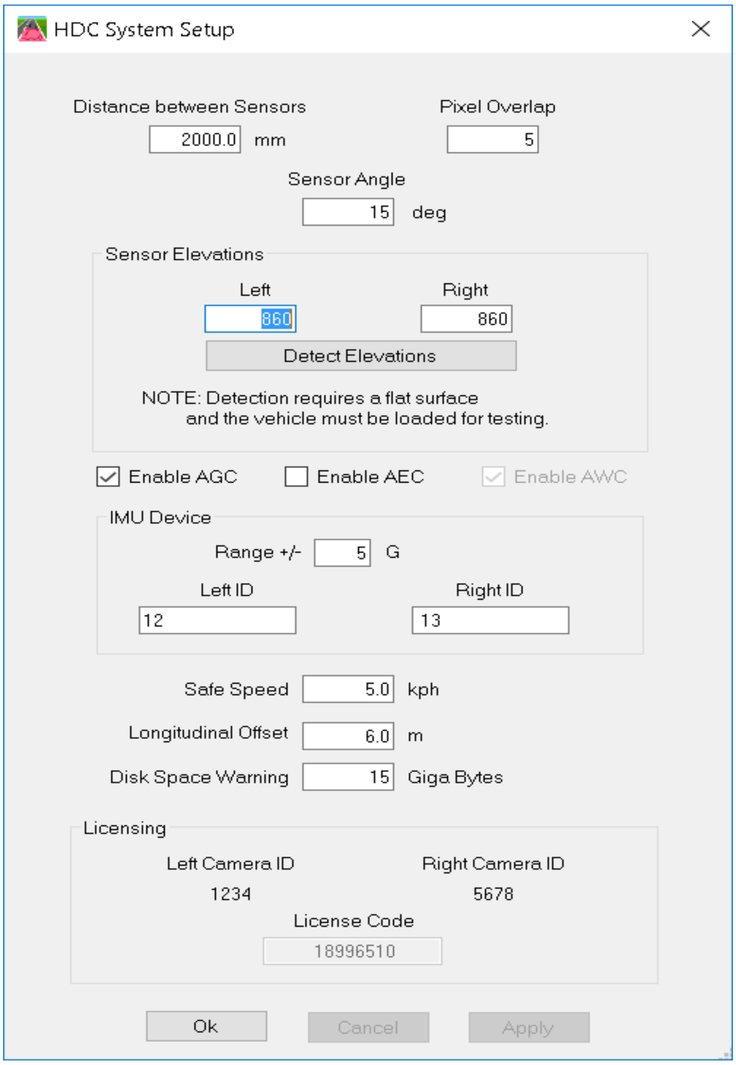
Range Image (3D Image)



Picking List

Three settings with preset parameters.
Similar to “Test Set-ups” in RspWin.
Two customizable set-ups.

Exposure Time: Changes here affect maximum speed.
Measuring Range: Changes affect longitudinal resolution.
Longitudinal Resolution: Changes affect Section Length and Maximum Speed.
Section Length: Limit is Longitudinal Resolution times 2000.
Maximum Speed: Changes affect Longitudinal Resolution. An alert box “Slow Down” will pop-up when exceeding the Max. speed.



Distance between Sensors: 2m.is standard. No change.
Sensor Angle: 15 degrees is standard setup. Don’t change.

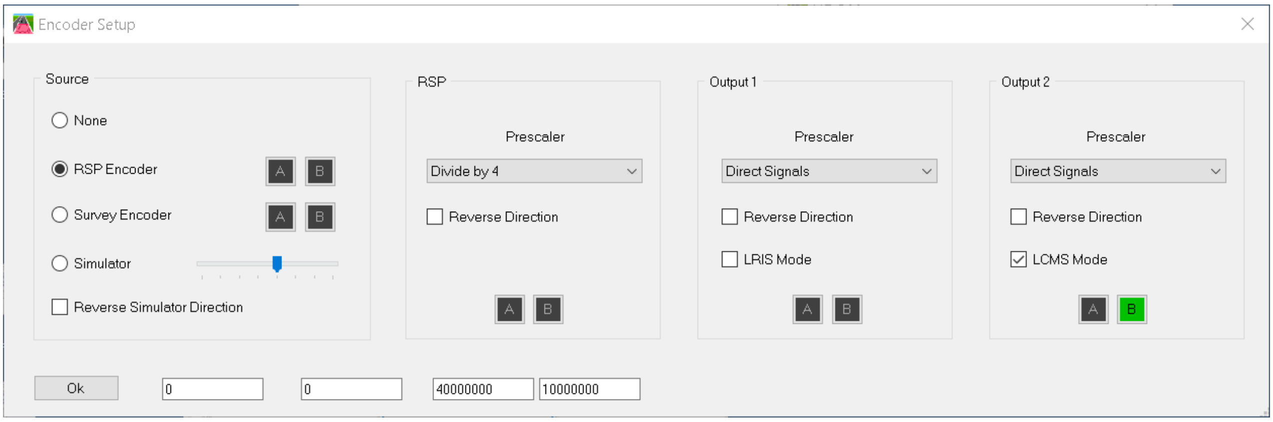
Sensor Elevations: Left and right average CCD row number of laser projections.
Use Detect Elevations to automatically detect and save these figures.

AGC = Automatic Gain Control. Recommended “On”.
AEC = Automatic Exposure Control. For very dark airport runway surfaces. For daily use it is recommended “Off”.

IMU Device: Range and IDs delivered

Safe Speed: Minimum. speed with active laser light.
Longitudinal Offset: The distance between the RSP in front and the LCMS cameras.
Disk Space Warning: 50 Giga means space for approx. 50 km. An alert is given when space is below the limit

Licensing: License code delivered



Source: None: For testing purposes.
RSP Encoder: Distance Encoder mounted to the wheel of test van.
Survey Encoder: Relevant for the Survey program only.
Simulator: Generates artificial distance pulses.
Reverse Simulator Direction: Corrects the simulated counting direction.

RSP Prescaler: Enables use of various Encoder PPR (512, 1024, 2048).
Reverse Direction: Corrects the counting direction for the DPU/EPU.

Output 1 This output typically drives encoder signals for Applanix
Prescaler: Enables use of various Encoder PPR (512, 1024, 2048).
Reverse Direction: Corrects the counting direction.
LRIS Mode: Check this when output is routed to LRIS.

Output 2 This output typically drives encoder signals for LCMS
Prescaler: Enables use of various Encoder PPR (512, 1024, 2048).
Reverse Direction: Corrects the counting direction.
LCMS Mode: Check this when output is routed to LCMS.

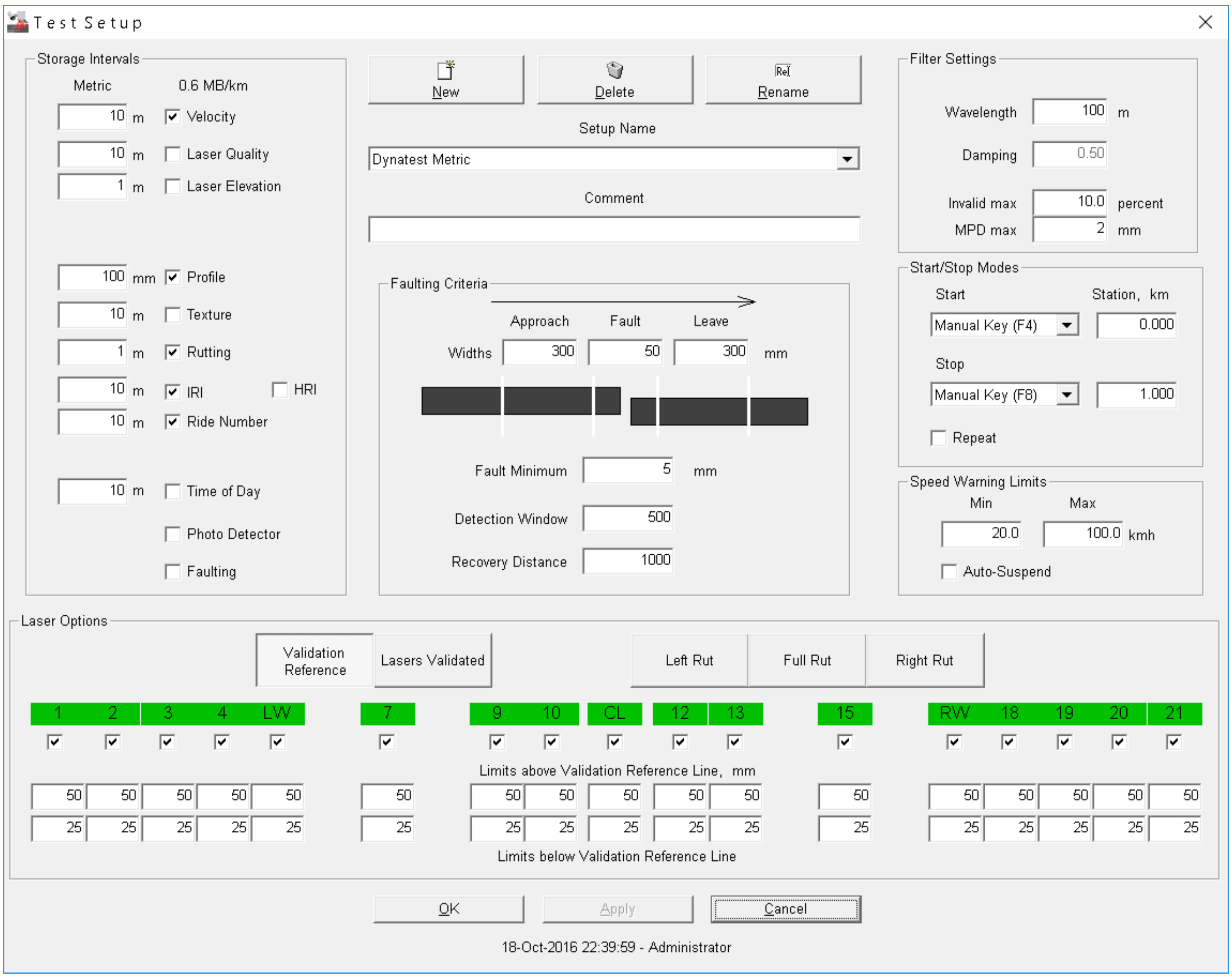
8 *Performing the Measurements*

8.1 *Test Setups*

The first step in preparing for measurements is to make sure that the Field Program is using the correct test setup. A "Test Setup" is a collection of software settings that tell RspWin which values to include in the output file and what parameters to use when calculating these values. For example you might want RspWin to report Texture values every 10 meters or specify which lasers are to be used for the calculation of a validation reference line. A test setup can be created to do this.

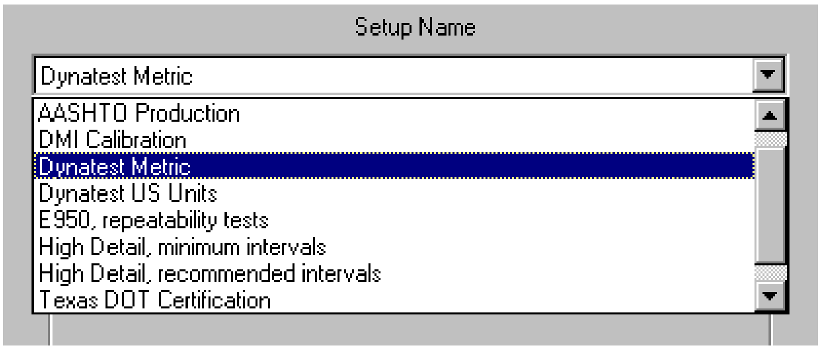
The name of the active test setup is displayed in the drop-down box in the Main window. To select a different test setup, click the down arrow. To access the test setup parameters click the **Operation → Test Setup** menu item along the top of the Main window OR click the Test Setup label (hyperlink, shown below):

The test setup window, shown below, displays information regarding the chosen test setup:



To select a different setup click the Setup Name combo box at the top of the test setup window.

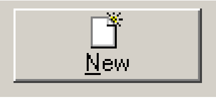
The drop-down list that appears contains a list of all setups stored in the test setup database. Clicking on one of the setups loads it into the test setup window. There are both Metric and US Units style setups to choose from. “DMI Calibration” is for On-The-Fly calibration of the distance encoder.



If you are happy with the selected setup click **OK** to exit the test setup window. If you would like to create a new setup or edit an existing one, you need to follow the guidelines below. Any changes you make will be stored in the active test setup displayed in the Setup Name field (if you press the **OK** or **Apply** command button).

New

Creates a new test setup based on the present test setup, so, BEFORE you press this button you should select the Test Setup that best matches your needs from the Setup Name combobox (shown above) . The operator must specify a new name in the Setup Name field then click the **Apply** button. The operator can then make changes to the test setup. Once changes are complete, the operator should then click the **OK** button to save the changes.



Delete

This deletes the present Test Setup. The operator will be prompted to confirm that he/she wishes to delete the setup.

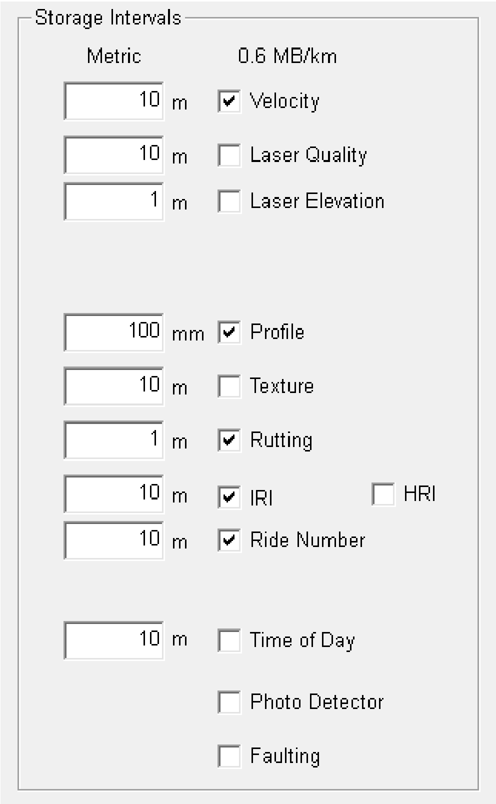
Rename

This allows the operator to rename the present Test Setup. The operator must enter a new name in the **Setup Name** field, then click **OK**.

Note that the Test Setup screen is divided into different areas that control specific operational aspects of the RSP. These will be discussed in detail below.

Comment

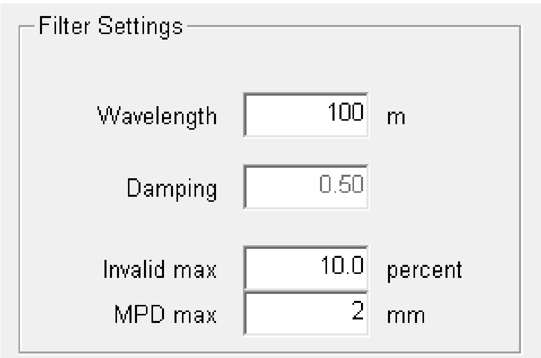
The operator can use this line to include additional descriptive information regarding the present test setup.



Storage Intervals
The Storage Intervals portion of the test setup window is used to specify which quantities you would like to store in the output file (the check marks). Also you can specify how often you would like the program to report each quantity to the output file (the storage intervals). For instance, a storage interval of 10 meters for IRI, means that every 10 meters the average IRI value is stored in the output file.

Metric intervals are integer meters or millimetres.
US Units are feet with one decimal or integer inches.
Clicking a unit label will toggle between the two choices (m↔mm or ft↔in).

Check the HRI option to store Half-Car IRI (replaces Centreline IRI).



Filter Settings
The longitudinal profile filter Wavelength can be specified from 10 to 199 meters (33 to 650 feet).
The filter Wavelength setting should be 100 meters.
This is the standard in the industry and should generally not be changed unless the operator is specifically instructed to do so.

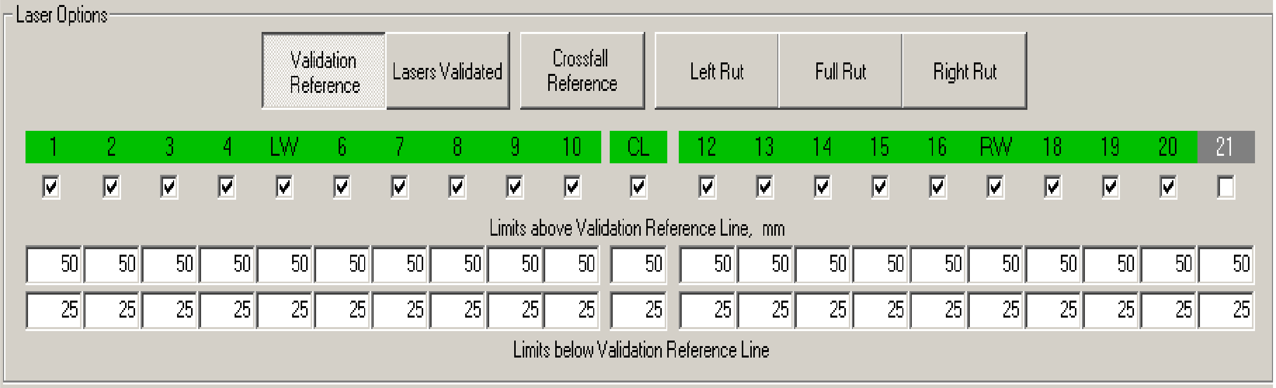
Filter Damping Fixed at 0,5.

Invalid max: Texture readings are discarded when the number of invalid laser shots exceeds this limit

MPD max: Texture readings are discarded when MPD readings exceeds this limit

Discarded texture data are substituted by the last valid readings

Laser Options (Mark III only)

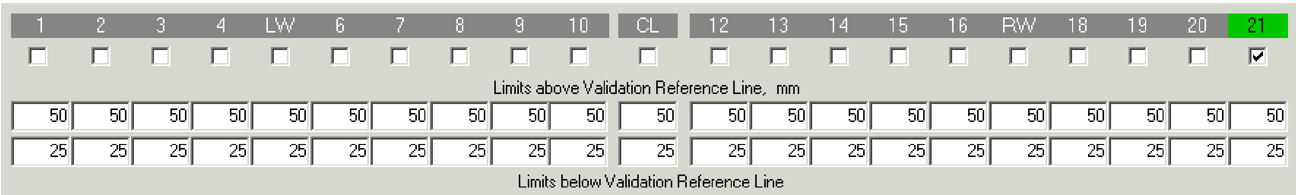


The Laser Options part of the test setup window has 6 "radio buttons" (only one button at a time can be activated). Each button represents a value/regression line that the program calculates. When a button is activated the transducer bar indicates which lasers take part in the corresponding calculation. When a laser channel is selected it is green, otherwise it is grey.

<u>Validation Reference</u>

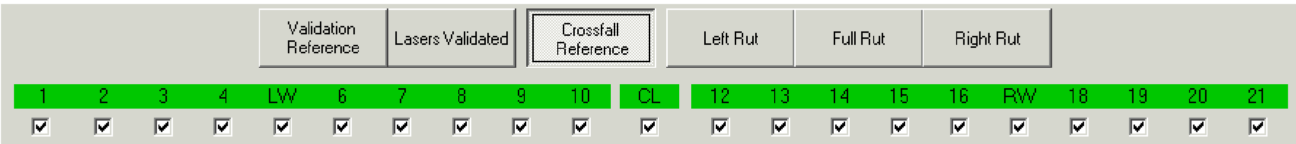
It is sometimes necessary to test close to the edge of the pavement, hence running the risk that the outermost angled laser beam hits the curb, fences, vegetation etc. Such false elevations would significantly increase the rut readings. To avoid this, the remaining laser elevations are used to establish a linear regression cross "Validation Reference" line. If the outermost elevation reading falls a certain amount above or below this line it is considered false and will be substituted by a point on the line (for rutting and crossfall calculations, only). To set this up you must first decide which lasers will generate the reference line. In the above figure showing validation reference (driving in the right side of the road) only the rightmost angled laser is excluded (grey) from the calculation of the regression line.

<u>Lasers Validated</u>



If you activate the **Lasers Validated** button you can specify which lasers you would like to be tested against the "Validation Reference" and set the individual limits above and below the line as shown in the above figure. Here, only the rightmost angled laser will be validated (green) and the limits are 50 mm above and 25 mm below the reference line.

<u>Crossfall Reference</u>

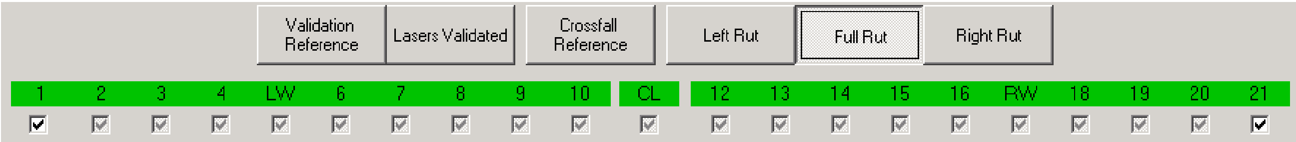


It is possible to determine the roadway crossfall by combining the Bank reading from the (optional) IMS and a best-fit line through the laser elevations. Activating the "Crossfall Reference" button makes it possible to specify which lasers will take part in the calculation of the slope or angle between the transducer bar and the pavement. Here, all lasers are "greened" but you might want to exclude the outermost angled lasers in e.g. urban areas where curbs might be disturbing.

Left Rut

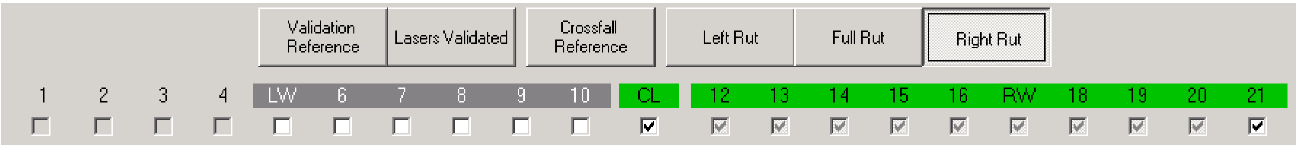
In the above figure Left Rut extends from channel 1 to 11 (from left side angled laser until centre laser). In all, channel 1 to 17 (from left side angled laser until right wheel (RW) laser) are available for the calculation of Left Rut.

Full Rut



Full Rut may take all lasers into account as shown above.

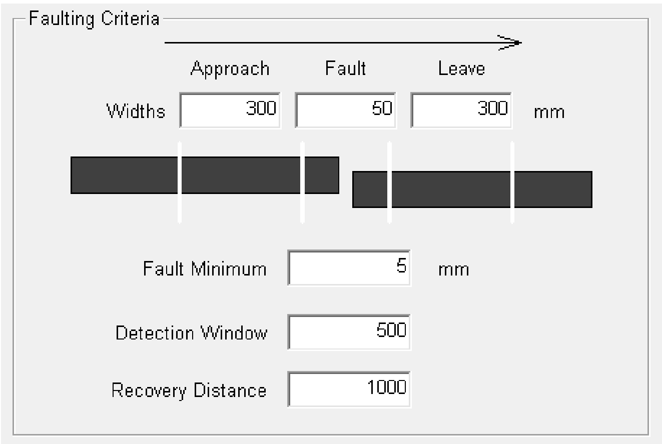
Right Rut



In the above figure Right Rut extends from channel 11 (centre) to 21 (rightmost angled laser). In all, channel 5 to 21 (from left wheel (LW) laser until right side angled laser) are available for the calculation of Right Rut.

Faulting Criteria

Some pavements are constructed by laying down slabs/segments (concrete or other material) closely together.



Faulting is the phenomenon of bumps caused by difference in height between two successive slabs.

Dynatest’s fault detection method is compatible with AASHTO’s “Standard Practice for Estimating Faulting of Concrete Pavements”.

The detection algorithm has three phases: Approach (Lead), Fault (Drop zone) and Leave (Tail).

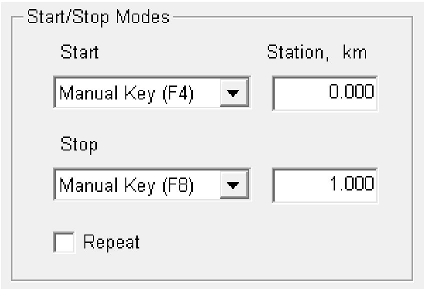
Profile excursions in the Fault phase are disregarded (cracks or fill may occur).
The average height of the Approach and Leave phases are computed. The height difference is the Fault height.

The values for width of each phase and the minimum fault height shown here comply with the AASHTO standard.

Detection window: The above figure indicates that the algorithm will wait 500 mm to see if there are faults in the other wheel path or centre line in order to store faults together in one line in the data file.

Recovery: The above figure indicates that the algorithm will pause for 1000 mm when fired.

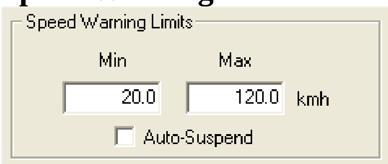
Start/Stop Modes



In this portion of the test setup window you specify the default Start/Stop modes to be used when initiating a test session. When you press the **Activate** button in the Main window (in order to initiate data collection), the program will prompt you asking if you would like to use the Start/Stop modes predefined in the test setup.

Repeat: Check this for repeatability runs. This will aid in sequencing filenames.

Speed Warning Limits



If the operator does not keep the vehicle's speed within the limits defined in the Speed Warning Limits section of the test setup window (shown above), a warning signal will be issued.

Normally the Speed Warning limits are set to the recommended values according to the RSP specifications. Generally the driving speed should be between 25 km/h (16 mph) and 110 km/h (70 mph).

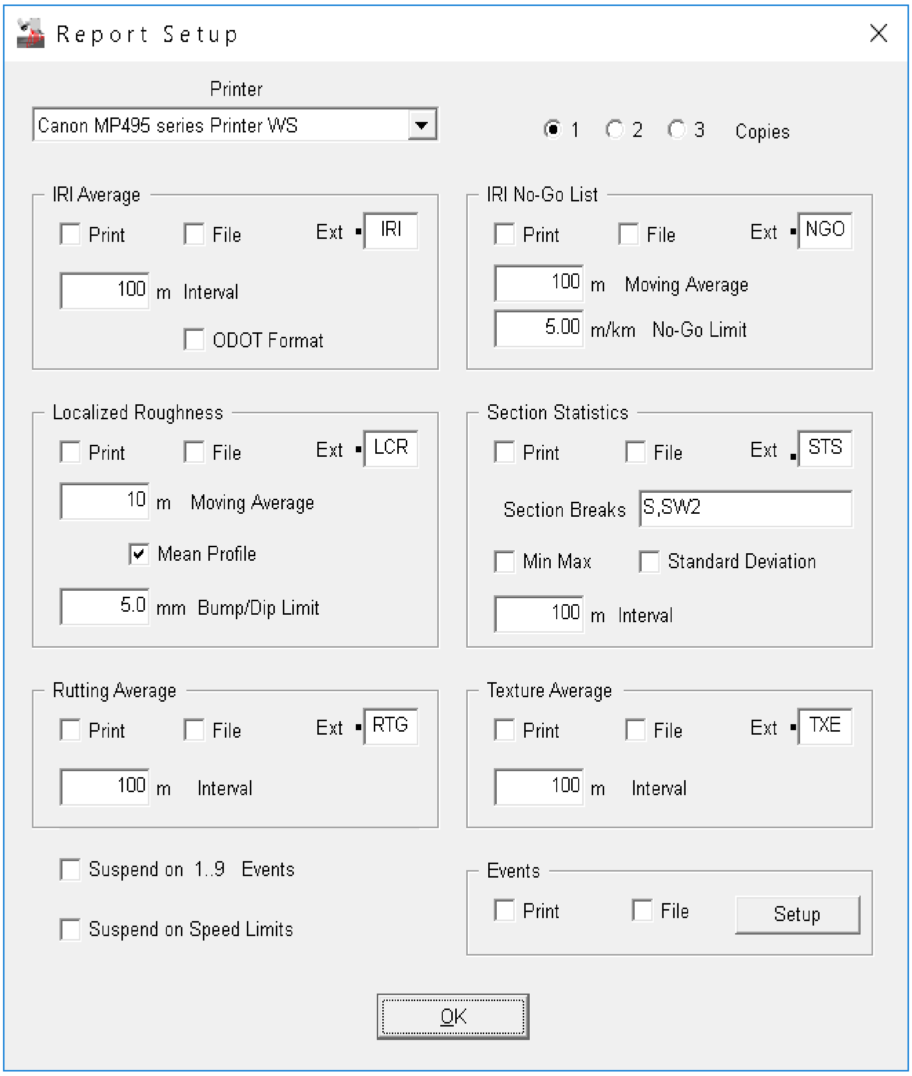
Sometimes, however, it is desirable to be able to define these values freely. For instance, the specifications for a particular testing job could require that the vehicle speed be as close as possible to 60 km/h, setting 55 km/h as lower limit and 65 km/h as upper limit.

The **Auto-Suspend** option will suspend accumulation of IRI, Ride Number, Rutting and Texture data while the speed is too low or too high.

8.2 *Reports*

In addition to the *.RSP data file itself, the program may generate various printed and/or filed reports. These reports can be generated automatically every time an RSP file is closed or post-processed through the Menu File → Report.

To setup reporting choose the Menu → Reports



IRI Average is based on tightly recorded IRI values.

IRI No-Go List first runs the recorded IRI values through a moving average, and then finds areas above the No-Go limit.

Localized Roughness first runs the left and right profiles or the mean profile through a moving average, and then localizes areas above and below the Bump/Dip Limit.

Section Statistics lists the average IRI, Rutting and Texture per section.
Any Event record may act as a section break point. Optionally lists Standard Deviation and Min Max.

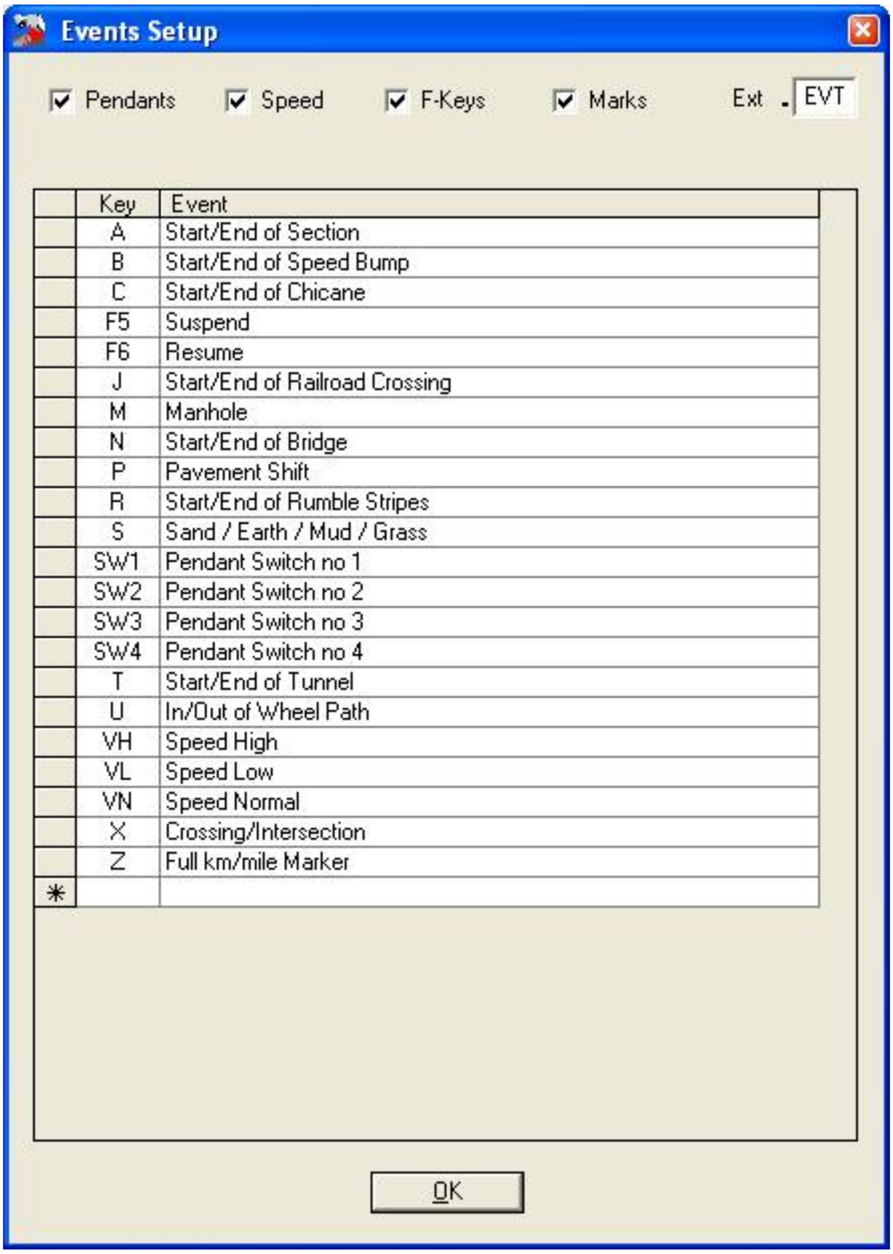
Rutting Average and **Texture Average** are based on tightly recorded values.

Events produce a list where single keys are associated with text through the [Setup].

The two **Suspend** options allow exclusion or inclusion of IRI, Rutting and Texture data.

Note: Checking any Print option requires that the printer is connected and ready in the field.

For examples of output files see chapter 13.3, ‘ Optional RSP Data File Formats’.



DDC File Reports – "Events Setup"

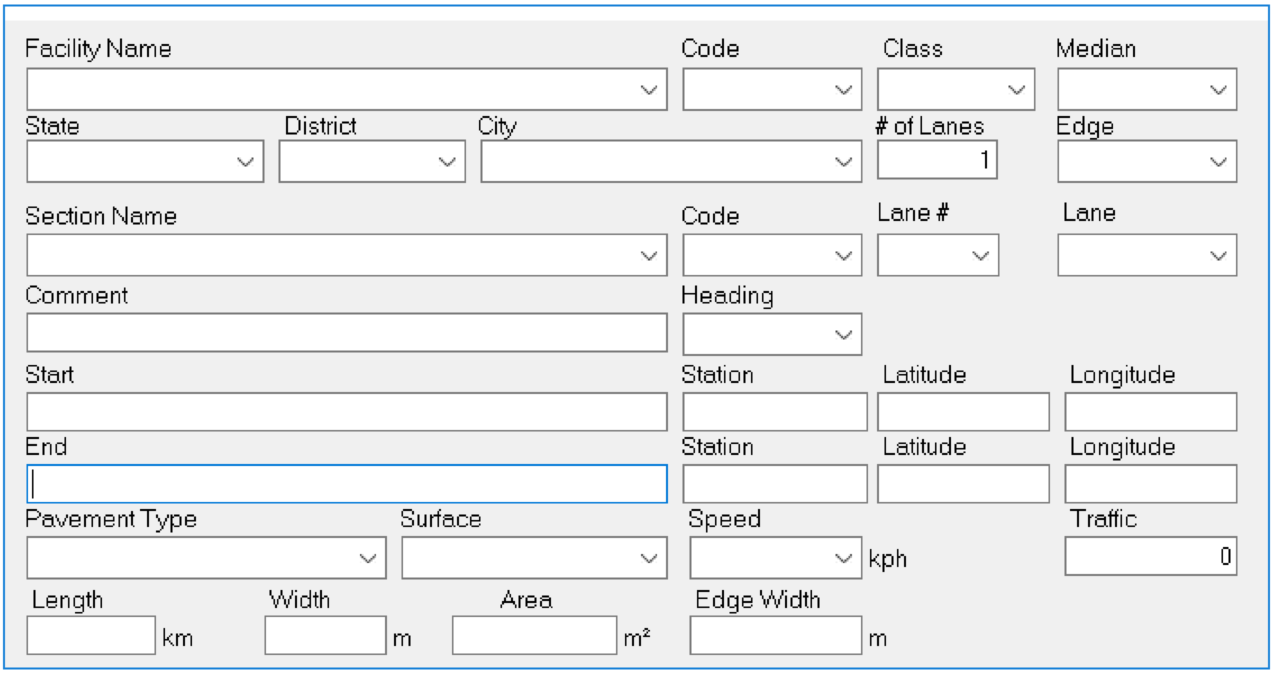
Click "Events" -> "Setup" for list with example of events.

To be used with the DDC Reports. (File -> Report)

8.3 *Test Section*

Before initiating a data collection you also need to specify the test Section information.

The Network applet provides a wealth of opportunities to incorporate section information in your data files. In addition, many attributes, such as your start location, end location, pavement type, lane, and other useful bits of information can be included as seen below:



All fields default to plain text entry mode, however there are a few features that make it easier for the operator to incorporate location and other information in the datafile.

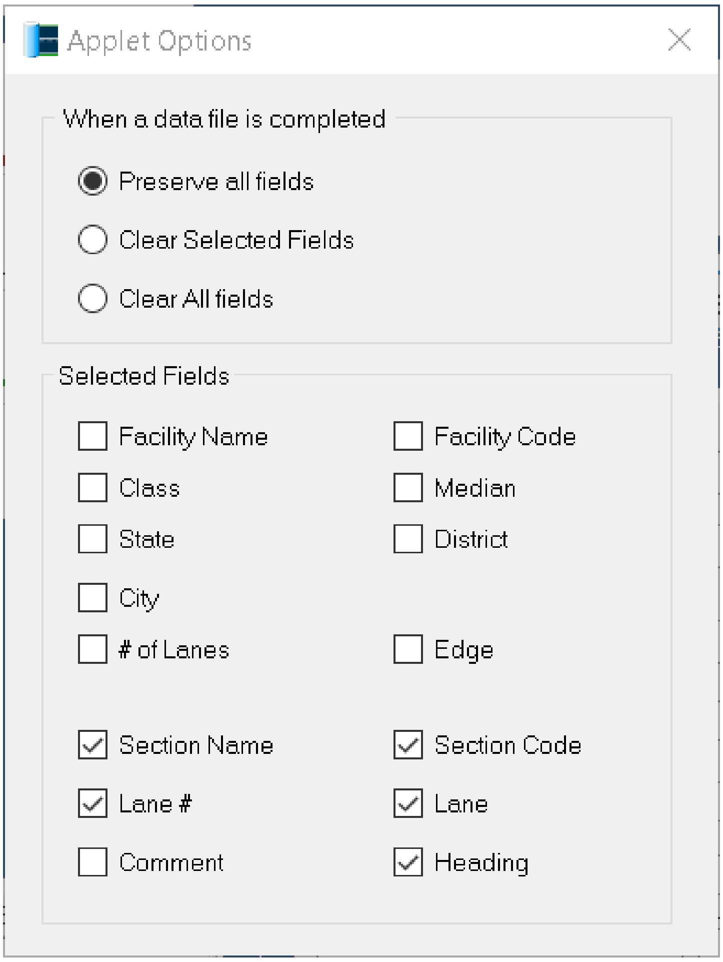
All fields with a drop down arrow provide access to previously used information.

Districts
Most highway agencies subdivide their networks into Districts for more efficient management.

Facilities
Various attributes of the facility under test can be entered by the operator. A “Facility” can be anything from roadways, runways, streets to parking lots or even railways. Often a facility is identified by both its common name and a roadway code.

Section
A single facility is often composed of sections of varying construction. This “Sectioning” can be both longitudinal and transverse. The latter is appropriate for multilane roadways where traffic load varies across the construction.

When a data file is closed you have the following options to act upon the fields in the Network window:



8.4 *Leaving Base*

8.4.1 *System Checks*

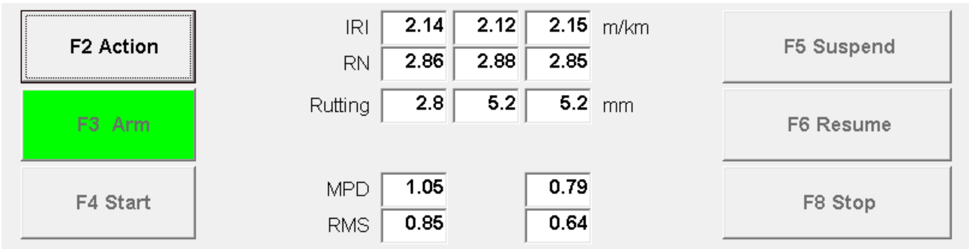
The data collection screen in idle mode is useful for checking the status of all systems prior to initiating data collection.

If the vehicle is moving the following checks can be made:

- Chainage should be increasing or decreasing.
- Velocity should reflect current speed
- The active accelerometers blocks should be green
- The active laser blocks should be green
- Longitudinal profile, transverse profile and artificial horizon should be plotted and updated continuously
- IRI, Ride Number, Rutting and Texture fields should be updating
- GPS coordinates should reflect current location (if equipped)
- IMS data should reflect reasonable values for current conditions (if equipped).
- HDC (if equipped) shall display pavement images when vehicle Speed>"Safe Speed"

If you are going to use a photo detector to initiate and/or terminate a data collection, you may verify that the sensor is working by observing the **Arm** button in the Main window. The photocell is activated by reflective material such as aluminium tape or, if the sensitivity is adjusted accordingly, pavement markings such as white paint will also activate it.

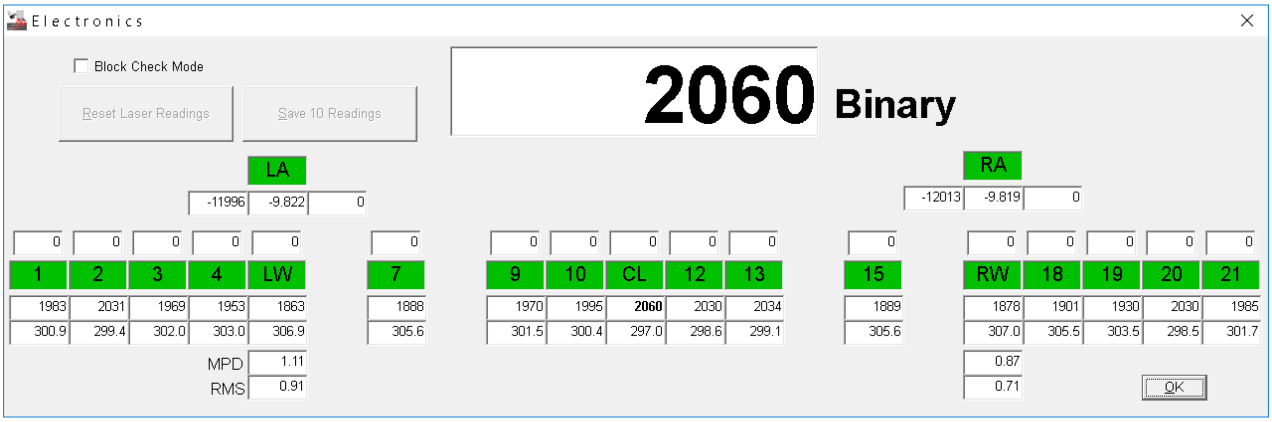
When the photo detector is triggered the **Arm** button will shift from grey to green, as shown below:



Once you remove the trigger material from the sight of the photo detector it should turn back to grey.

8.4.2 *Checking the Status of the Sensors*

The program provides an interface that can be used to monitor the status of the RSP system's sensor units (lasers and accelerometers) including raw output readings from the sensors along with the physical quantities calculated by the program using these readings. To enter the Electronics window shown below you must choose **Information** in the Main window's menu bar:



The fields below the accelerometer text boxes (LA, CA and RA) displays the raw accelerometer output readings (-12000), the accelerations as calculated by the program by making use of these readings (-9.81m/s²), and the percentage of bad/missing readings (0).

The row above the laser text boxes displays the percentage of bad/missing readings (0).
The first row below the laser text boxes displays the raw laser output readings (typ 2050). The next row displays the laser elevations as calculated by the program by making use of these readings (300.0).

Clicking on a text box in this window causes the reading to be displayed on the large readout at the top of the window as well as being bold faced in the text box. This aids in troubleshooting as the reading can be seen from some distance.

Pressing the **OK** button closes this screen and returns to the data collection window.

8.4.3 Block Check Mode

The **Block Check Mode** is provided to facilitate verification that the lasers are measuring accurately throughout their measuring range.

Block Check means working with reflective surfaces close to the laser sensors

WARNING: TAKE EYE SAFETY PRECAUTIONS

Normally, the "Electronics" window displays the current readings for the lasers (bit readings and total height above the pavement surface. When the block check mode is activated, and the **Reset Laser Readings** button is pushed, each laser is reset to "zero", i.e. the reference point for the distance measurements is changed from the laser aperture to surface being measured. For example, when a laser is reset to zero and a 25 mm block is placed under the laser, the display should read 25.0 mm. Pressing **Save 10 Readings** writes the currently highlighted reading to an ASCII file named 5051-XXX.BCK (where XXX is the actual serial number).

The readings revert to normal operating when the "Block Check Mode" box is unchecked.

8.4.4 Bounce Test

WARNING: For an RSP system with High Definition Cracking (LCMS) the Laser Cameras may start firing!

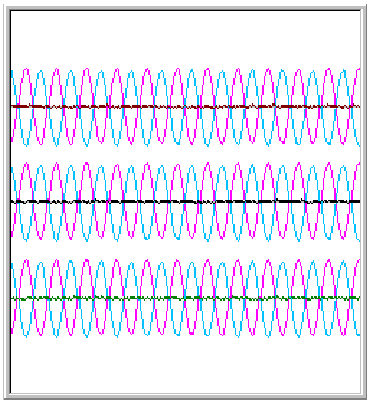
TAKE SAFETY PRECAUTIONS

To put the program into “Bounce” mode, click the **Bounce** button at the bottom of the Main window:

Bounce mode fools the program into thinking that the vehicle is moving steadily forward although in reality the vehicle is stationary (not moving). This enables the program to paint the profile traces in the Strip Chart window as if the vehicle was moving. The profile traces should be virtually flat, since the longitudinal profiling laser sensors are seeing fixed pavement spots all the time.

To perform the Bounce test, you must do as follows:

1. Make sure that the vehicle is stationary (hand brake pulled!).
2. If the target surface spots under the longitudinal profiling laser sensors are textured, then place flat and smooth, non-glossy plates under each.
3. Bounce the vehicle up and down by stepping on the front of the vehicle. Perhaps also try rocking the vehicle from side to side.
4. If the bouncing is strictly vertical, and the laser sensors and accelerometers are functioning properly, then the accelerometers shall compensate for the movement of the laser sensors, leaving the profile traces shown in the Strip Chart window virtually flat during the bouncing.



The cyan and magenta traces represent the lasers and accelerometers, which should be in opposite phases.

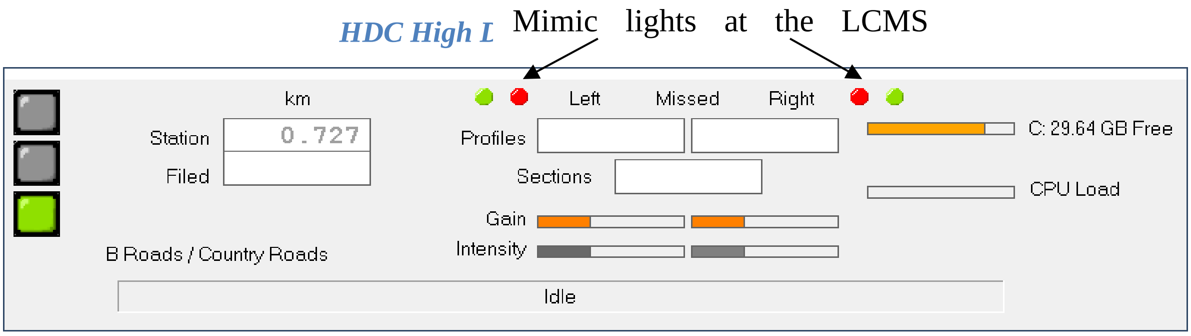
The red, black and green traces are the resulting profiles.

Scaling is one inch or 25mm between axes.

The Bounce test should be performed at the beginning of each working day, before starting the measurements.

To put the program back to “Normal” mode, click the **Normal** button. If you forget to re-activate the **Normal** button, the program will warn you when initiating a data collection and suggest that you return to Normal mode.

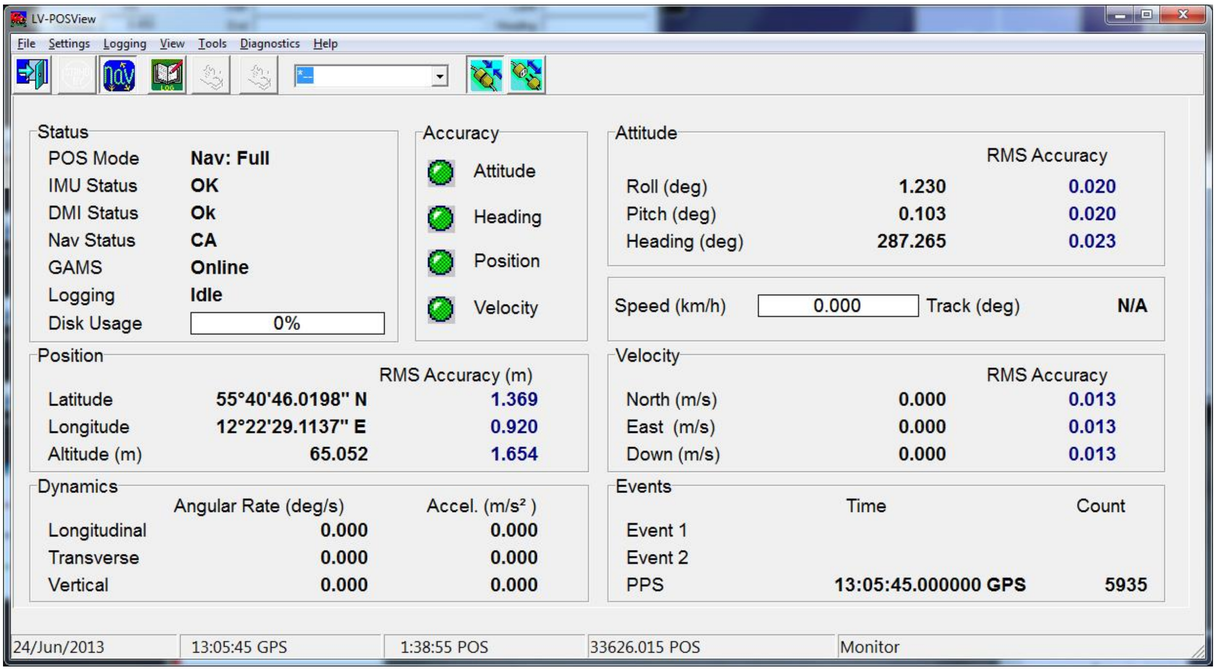
8.4.5 Checking Status of the (optional) HDC System



Red light	When system is not initialized or not ready to collect data Flashing when sections are lost during data collection
Yellow Light	Just before starting measurement.
Green Light	OK
Station	Longitudinal position of the LCMS cameras Offset is specified in “System Parameters”
Filed	Shows beginning Station of the last LCMS images captured and stored
Left Right	Number of profiles (image lines) missed from each LCMS Unit
Sections	Number of sections (FIS files) missed
Gain	Displays the current Auto Gain Control (AGC) value.
Intensity	Light intensity level.
Storage	Remaining space on Main drive (and Back-up drive)
CPU Load	Percentage CPU Load

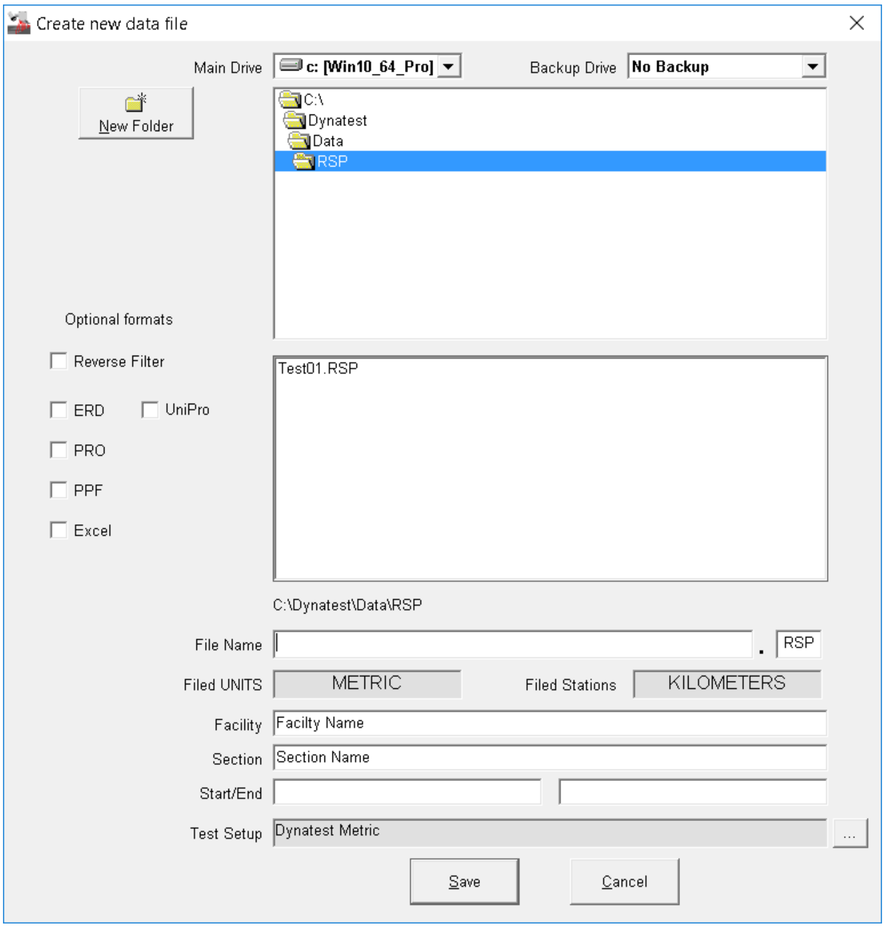
HDC Images shall be displayed when Vehicle Speed > “Safe Speed” (Defined in HDC sub-menu “System Setup”).

8.4.6 Checking the Status of (optional) Applanix POS LV System



8.5 *Creating a Data File*

A data file is created by clicking the **File** menu item from the data collection screen, then choosing **New**. A file dialog box appears.

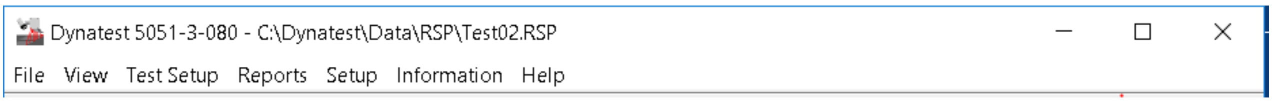


This dialog box allows the operator to navigate to an existing subfolder for file storage. It also allows the operator to create a **New Folder** and to select additional output formats and select a back-up drive (if applicable).
To create a new file, the operator merely needs to type the data file name in the **File Name** field.

This window also informs the user which system of units will be employed for storage of data. The user is also given a last chance to sort out the facility information and choose a suitable test setup. A button is provided for convenient navigation to the Test Setup window.

Once the information on the screen has been entered, the operator should click the **Save** button. The program will now prepare the disk file and then return to the data collection screen.

After creating a data file the title bar of the main window will display the name of the output file:



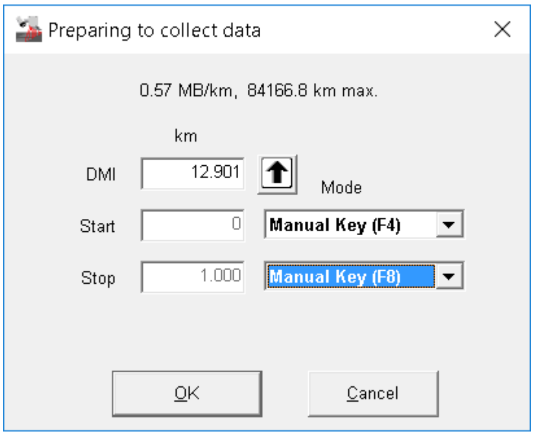
The caption in the main window's title bar will change back to normal (Dynatest 5051-XXX) once the data file is closed.

8.6 Start Data Collection

This chapter will describe the various ways to start a data collection session. The operator should be aware that, in order to obtain good measurement results, the vehicle should preferably achieve the proposed data collection speed at least 100 meters prior to initiation of data collection.

8.6.1 Prepare for Data Collection

Activate the **F2 Action** button in the Main window to prepare for data collection. You can do this either by pressing the **Enter** key (if the **Action** button has focus) or by pressing the **F2** key.
After pushing the **Action** button the "Preparing to collect data" window will appear as shown below (if a file hasn't yet been created you will be prompted to create one before continuing):

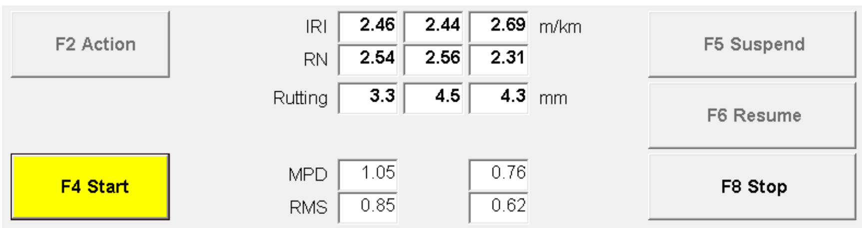


The "Start Mode" and "Stop Mode" fields are filled in according to what was specified in the test setup. However the user gets a last chance to make alterations to the Start/Stop modes and/or Start/Stop station fields (alterations made in the "Preparing …" window will be remembered by the test setup).

If you have a Watson IMS unit, then there will be a button labelled **Initialize IMS.** Before pressing the **OK** button to accept the settings, please remember to activate this button. During initialization (which lasts some 15 secs.), please make sure that the vehicle is NOT moving. Initializing the IMS unit before each data collection is vital for the IMS to be functioning properly.

8.6.2 Manual Key (F4)

To use this option the "Start Mode" combo box should be set to "Manual Key (F4)". Once you press **OK** to the settings you will return to the data collection screen. The command button "F4 Start" will start blinking yellow.

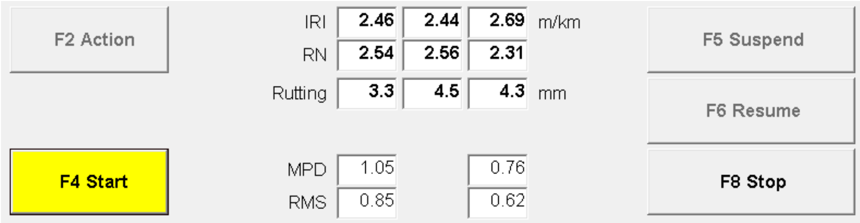


As shown above, all the command buttons, except the **Start** and **Stop** buttons, are greyed out. The focus is set to the **Start** button according to the "Start Mode" selected in the "Preparing …" window. To initiate data collection you can either activate the **Start** button by pressing **F4** OR by pressing the **Enter** key.

When data collection starts, the DMI will automatically be set to the value defined in the "Start" field in the "Preparing …" window.

8.6.3 Automatic

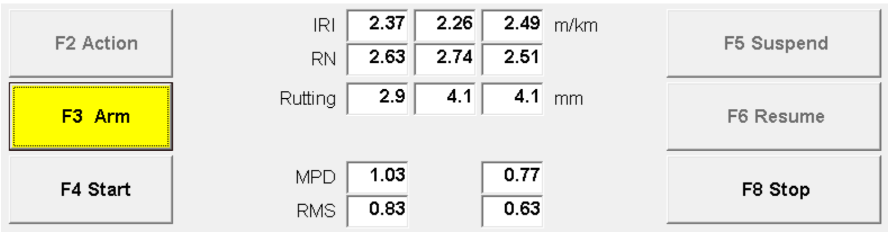
To use this option the "Start Mode" combo box in the “Preparing …” window should be set to "Automatic". Once you press **OK** to the settings you will return to the data collection screen. The command buttons at the bottom of the Main window will now look like this:



As shown above, all the command buttons except the **Start** and **Stop** buttons are greyed out. The focus is set to the **Start** button. Data collection will be initiated automatically, when the DMI reading reaches the “Start” value defined in the “Preparing …” window. Since the **Start** button is not greyed out, the operator is still allowed to start the data collection manually, should he wish to do so.

8.6.4 Photo Detector

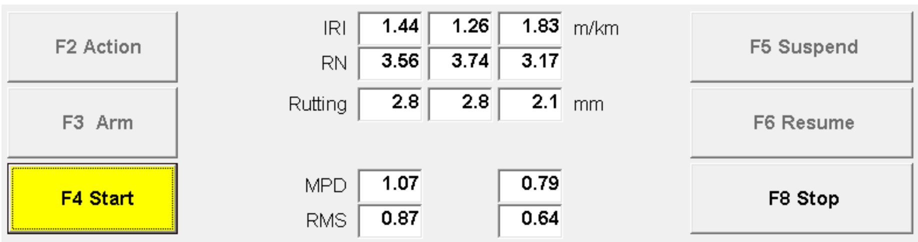
To use this option the "Start Mode" combo box in the “Preparing …” window should be set to "Photo Detector". Once you press **OK** to the settings you will return to the data collection screen. The command buttons at the bottom of the Main window will now look like this:



As shown above, the **Arm, Start** and **Stop** buttons are enabled. The **Arm** button is yellow and blinking, waiting to be activated. Since the **Arm** button has focus, you can activate it either by pressing **F3** OR by pressing the **Enter** key.

After activating the **Arm** button the system is “Armed”, i.e. data collection will begin when the Photo Detector is triggered. The Arm functionality is used to prevent any reflective road object (other than the desired) from triggering the Photo Detector prematurely. The system should be armed just before the vehicle reaches the trigger object.

When the system is “Armed” the command buttons should look as shown below:

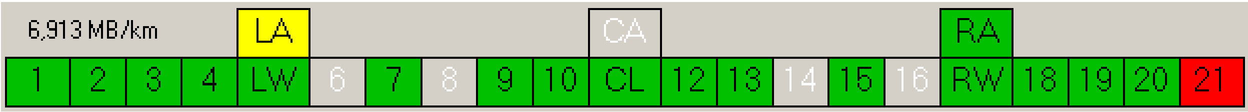


As shown above the operator still has the opportunity to initialize data collection manually by activating the **Start** button should the photo detector fail in detecting the trigger object.

8.7 *During Data Collection*

8.7.1 *Monitoring the System's Status*

The operator should occasionally glance at the screen to ensure that the accelerometer and laser blocks remain green. The blocks will shift colour towards red and an audible alarm will sound if a malfunction with any of these sensors occurs. The sensor panel shown below indicates a problem with the right-most laser (21) and the left-wheel (LA) accelerometer:



A yellow accelerometer block indicates that the accelerometer is no longer reading 1g as a long-term average. This may happen if the accelerometer is no longer firmly attached to the top of the laser sensor.

A red laser block indicates that all of the elevations measured by the laser unit are invalid. Generally speaking, the colour is used to indicate the percentage of samples that fail to fall within the unit's measurement range. The below figure shows the gradual change in colour from 0% (green) to 100% (red):

The Selcom lasers are only able to measure displacements between 200 and 400 mm (from the underside of the rut bar to the pavement surface). If the right-most laser (when driving in the right side of the road) gets too close to the edge of the pavement, then the laser-beam may hit vegetation, curbs etc. This could cause invalid laser output.

8.7.2 *Keyboard Events*

During data collection the operator may use any printable character key to indicate observations of any kind. Normally keyboard events are used to indicate observations that may have a significant impact on the output file; this could be R for railroad, B for bridge etc. Each key hit is stored in the output file along with the immediate stationing. There is no predetermined meaning of any key, but certain post-processing software interprets 1 to 9 as suspect data (suspend) and 0 (zero) as accept data (resume).

Examples of events:

Z =	Full km marker
P=	Shift in pavement type
9=	90° bend in route
B=	Speed bump (1st B Start. 2nd B End)
X=	Intersection Crossing (1st X Arrive. 2nd X Depart)
R=	Roundabout (1st R Enter. 2nd R Exit)
U=	In/Out of Wheel Path (1st U Out. 2nd U Back in)
N=	Bridge (1st N Start. 2nd N End)
A=	Section (1st A Start. 2nd A Next)
C=	Chicane (Velocity reducing) (1st C Start. 2nd C End)
J=	Railroad Crossing (1st J Enter. 2nd J Passed)
R=	Rumble Stripes (1st R Start. 2nd R End)
T=	Tunnel (1st T Enter. 2nd T Exit)
S=	Sand, Earth, Mud, Grass (1st S Start. 2nd S End)

8.7.3 Suspend/Resume
During data collection the operator may want to prevent unusual or irrelevant pavement features from affecting the output data. For instance, the output IRI could be affected when crossing a bridge or railroad track, causing output data that do not apply to the pavement you set out to measure.

"Suspend" means that accumulation of IRI, Ride Number, Rutting and Texture data is temporarily suspended. To suspend operation, activate the **Suspend** button by pressing **F5** or **Enter** (the **Suspend** button normally has focus during data collection).

When the operation is suspended the **Suspend** command button will be greyed out and the **Resume** button is in focus blinking yellow, reminding you to resume data collection.

To resume data collection press **F6 Resume** or hit the **Enter** key once again.

8.8 Stop Data Collection

8.8.1 Manual Key (F8)
To manually stop data collection press **Escape** or activate the **F8 Stop** button by pressing **F8**.

8.8.2 Automatic
In 'automatic' stop mode the data collection will stop automatically when the vehicle reaches the "stop" station defined in the "Preparing …" window. The user may still stop the data collection prematurely by activating the **F8 Stop** button.

8.8.3 Photo Detector
If you have set the stop mode in the "Preparing …" window to 'photo detector' then, during data collection, the **Arm** button is yellow and blinking, waiting to be activated.
Just before the vehicle reaches the trigger object that is supposed to stop the data collection, the operator should "Arm" the system by activating the **F3 Arm** button. To activate the **Arm** button press **F3** or hit the **Enter** key.
When the system is armed then the program will stop data collection when the trigger object activates the photo detector. If the detector fails, then the operator can stop the data collection manually by activating the **Stop** button.

8.9 Closing the Data File
When stopping the data collection (F8 or Esc), the data file is automatically closed. If you did not collect any data then you can close the data file by selecting **Close** from the **File** menu item. Closing the program (**Exit**) or creating a new datafile (by selecting **New** from the **File** menu) will automatically close the data file properly.

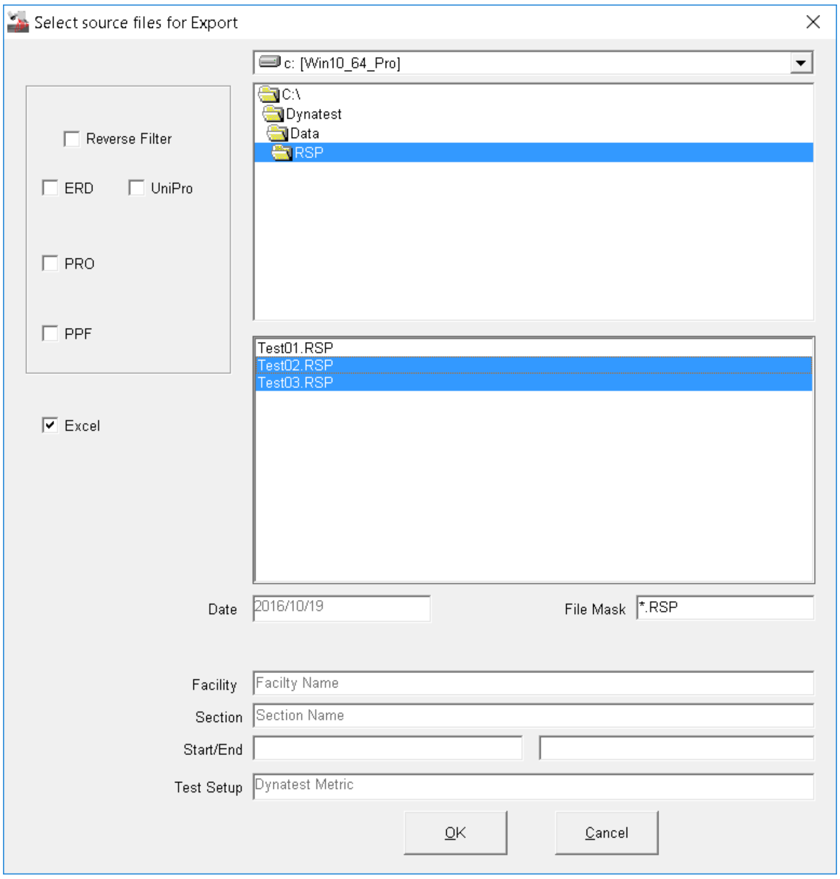
(Optional) High Definition Crack images and ROW images are stored real-time during data collection.

8.10 Post Processing

Various file formats and printed reports can be generated either immediately when an RSP file is closed or after testing in the office. Such post-processing is accessed through menu item File→Export and File→Report.

8.10.1 Export

Menu item **File** then **Export** shows the following dialog:



Select drive.

Select the source folder

Select the files

Reverse Filter: For removal of phase shifts in longitudinal profiles

Select desired output
ERD: RoadRuf
UniPro: ERD with separate files for each profile
PRO: Texas Profile Format
PPF: ASTM format

Microsoft Excel File

NOTE: Export to Excel does not support “Reverse Filter”.

For information about file formats see chapter 13.3, ‘ Optional RSP Data File Formats’.

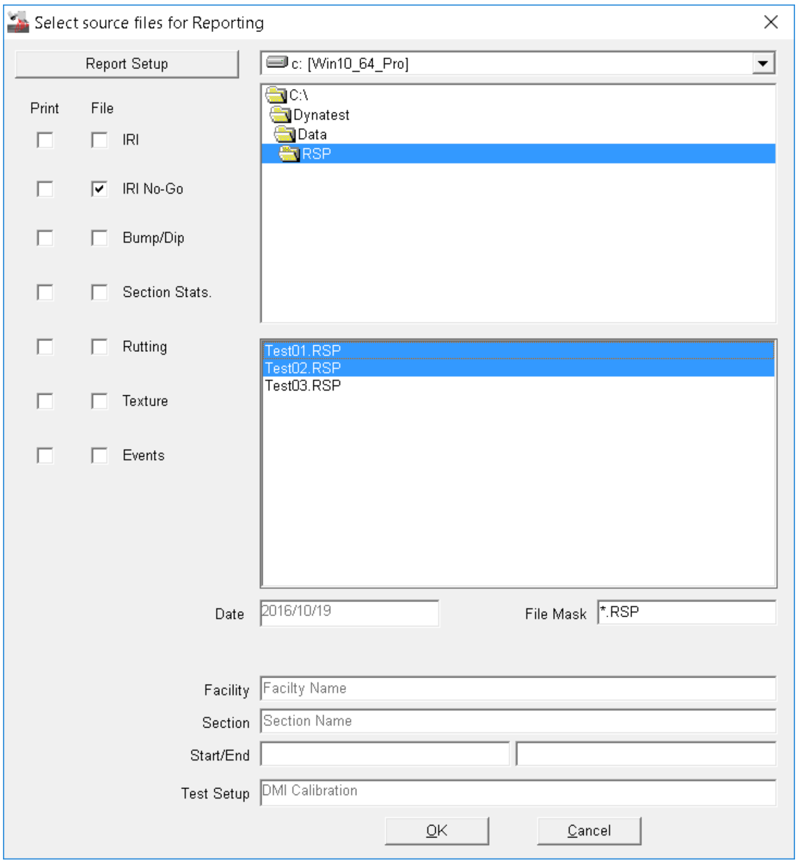
8.10.2 Report

In addition to the *.RSP data file itself, the program may generate various printed and/or filed reports.

These reports can be generated automatically every time an RSP file is closed.

Reports can also be post-processed in the office later through the Menu → File → Report.

Menu item **File** then **Report** shows the following dialog:



Select drive.

Select source folder

Select Printed output
Select Filed output.

Select the files

Report Setup: To set up reporting details.

For more information on Reports see chapter 8.2, ‘Reports’ and chapter 13.3, ‘ Optional RSP Data File Formats’.

To set up reporting details choose the Menu → File → Reports → **Report Setup**.

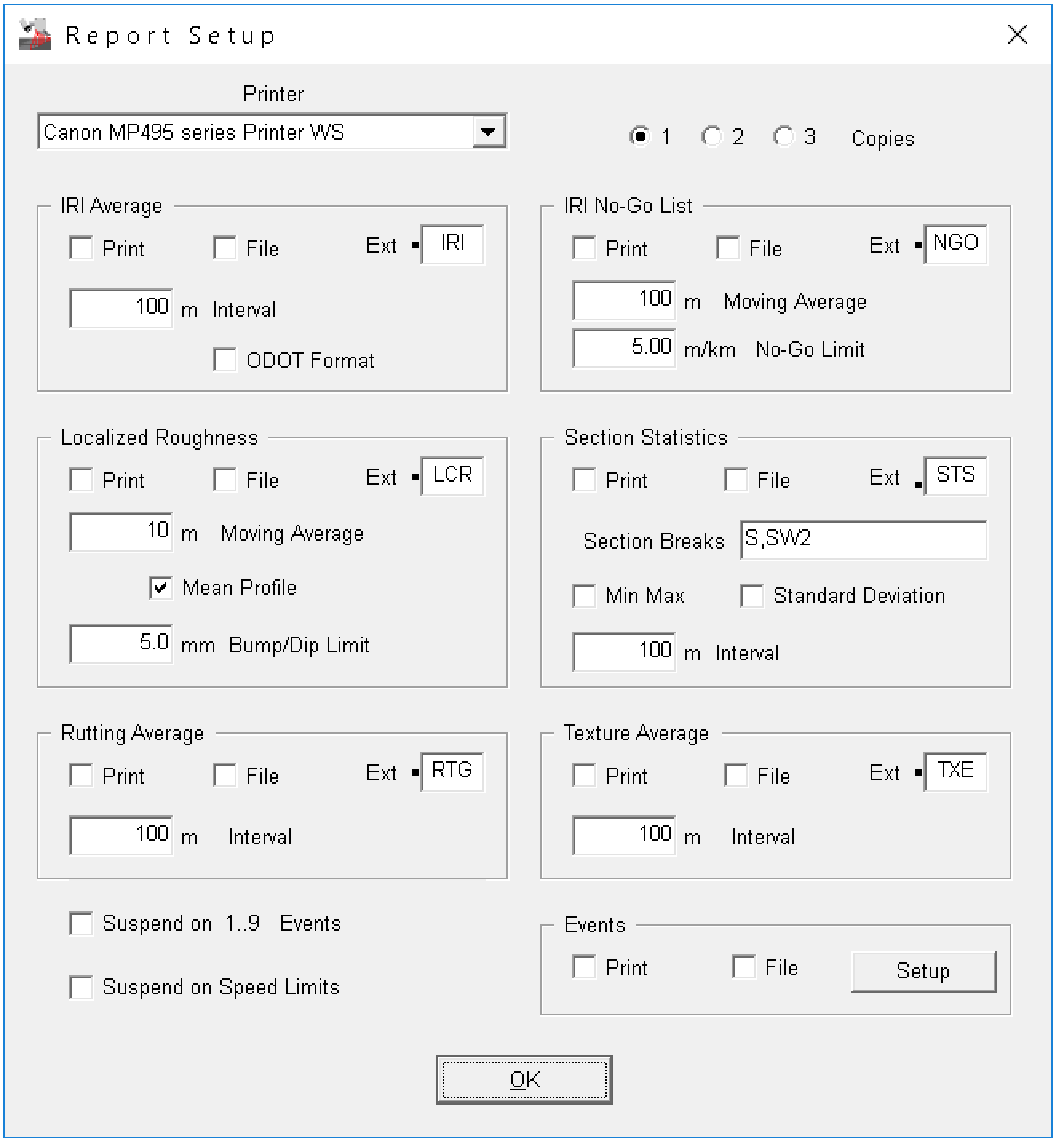


Figure 34 Report Setup

Report Setup:
Click to enter specifications and intervals on different reporting options:
IRI Average,
IRI No-Go List,
Localized Roughness,
Section Statistics,
Rutting Average and
Texture Average.

9 Calibration

Proper calibration of the RSP is of vital importance. A properly calibrated RSP can meet or exceed all of the rigorous industry standards in effect today, including ASTM E950 and AASHTO PP-52. These standards are demanding, requiring a high degree of precision and bias on both profile elevation measurements and in the case of PP-52, IRI.

Each RSP is delivered with the necessary hardware and software for periodic calibration of its various components.

The following RSP components require periodic calibration:

1. Distance measurement (DMI)
2. Accelerometers
3. Laser Displacement Sensors
4. Inertial Motion Sensor (IMS)
5. High Definition Cracking (HDC)

Longitudinal distance measurements are directly related to the radius of the vehicle tire(s), and since tire radius is dependent on pressure, temperature, and vehicle load, they suffer the most error. The error can be removed by calibrating the DMI to on-site conditions. The DMI should be calibrated at every opportunity. This does however require a section of pavement whose length is measured very accurately. This is not always easy to find, and is labour intensive to prepare.

Accelerometers and Laser Sensors are usually very stable and should not need re-calibration on a frequent basis. Calibration of these components is typically done on a monthly basis, or when a major component of the RSP has been replaced, or when a major project is about to be undertaken.

! IMPORTANT!

Hardware parameters (like all other parameters) are stored in database files in order to better manage multiple RSP setups.

Before making changes to Hardware parameters make sure that you have activated the right equipment in the introductory screen (5051-XXX).

Any changes you make to the hardware setup – be it calibration or otherwise - will be stored in the equipment information file you selected in the introductory screen.

9.1 *Preparations*

Prior to a DMI calibration, all tires should be inflated to normal operating pressures. If possible the vehicle should be driven to warm the tires to normal operating temperatures. Although not always practical, the DMI calibration runs should be done at the typical speed anticipated for data collection. The DMI calibration section should be as flat and straight and level as possible. The pavement should be free of distresses. The accuracy of the calibration increases with the length of the reference section.

Laser and accelerometer calibration is best done in an indoor shop area where feasible. Vibrations from passing vehicles, wind, and sunshine on the rut bar and calibration beam and vehicle occupants should be avoided during this calibration process. Calibration of the lasers on the Mark III RSP requires that the front of the vehicle be elevated to provide adequate clearance for the calibration hardware. Typically, the front wheels of the vehicle are driven into ramps or lifted with a floor jack.

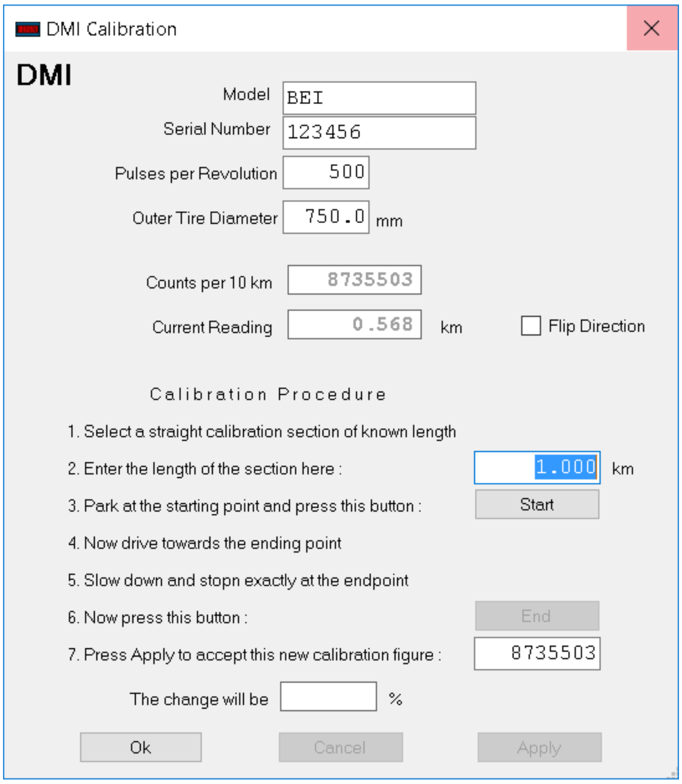
9.2 *Distance Measuring Instrument (DMI)*

DMI calibration is performed by driving the vehicle over a pavement section of known length, comparing the measured length to the actual length, and updating the DMI calibration factor to correct for the difference in the measurements.

There are two methods of doing a DMI calibration, Stop-Go-Stop and On-the-Fly, the latter requiring photo triggered start and stop.

9.2.1 *Stop-Go-Stop*

The DMI calibration screen provides comprehensive and easy to follow instructions for conducting the calibration process. To initiate the DMI calibration, right click the DMI applet and select **Calibration**.



The first fields in the screen holds the encoder Model, Serial Number and advertised Pulses per Revolution.

Enter the approximate tire diameter

"Counts per 10 km" is the calibration value currently in effect. This is the total number of counts received from the wheel encoder over 10 kilometres, giving the RSP a distance resolution of approximately 1 mm.

The field labelled "Current reading" is the distance travelled since the DMI was last reset.

The "Flip Direction" (phase reversal) should be toggled if the reading decreases when driving forward.

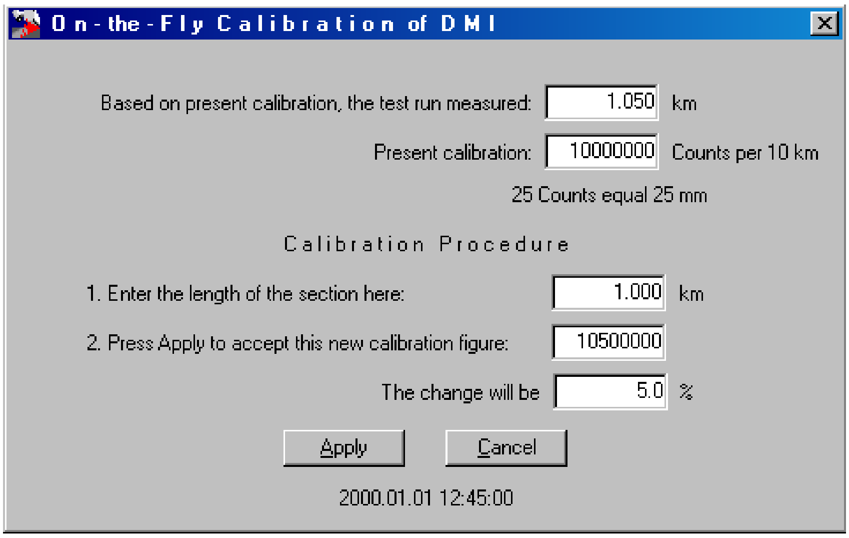
The Calibration Procedure consists of the following steps:

1. Locate a straight, smooth, accurately measured pavement section with no distresses.
2. Enter the measured length of the section.
3. Locate the starting point and stop the vehicle as close as possible, then press **Start**.
4. Accelerate gently to a constant speed, maintaining a straight trajectory over the length of the calibration section.
5. Slow down in a smooth manner and stop the vehicle as close to the end of the section as possible.
6. Click the **End** button. The program will calculate a new calibration figure and display it in the window under the **End** button.
7. If the calibration figure is within a few percent of the old figure, click the **Apply** button to accept it. Note that the box at the bottom of the window shows the percent change from last calibration.
8. Click the **Ok** button to return to close the window.
9. If the calibration figure is more than 1% different from the old figure, subsequent runs should be performed. If the calibration figure is erratic, check the system for possible problems with the tires, encoder mounting, encoder wiring, etc.
10. The calibration process can be abandoned at any time provided the **Cancel** button is pressed before the **Apply** button.

9.2.2 On-the-Fly

You must be familiar with the use of photo start and photo stop (see 8.6.4 and 8.8.3)

1. Locate a straight, smooth, accurately measured pavement section with no distresses.
2. Mark the start and stop points with reflective tape.
3. Choose the special Test Setup named “DMI Calibration”.
4. Create a new file.
5. Approach the start point at normal driving speed.
6. Arm the photocell (F3) just before the starting point and again just before the ending.
7. At the end of the section, a window similar to the following will appear

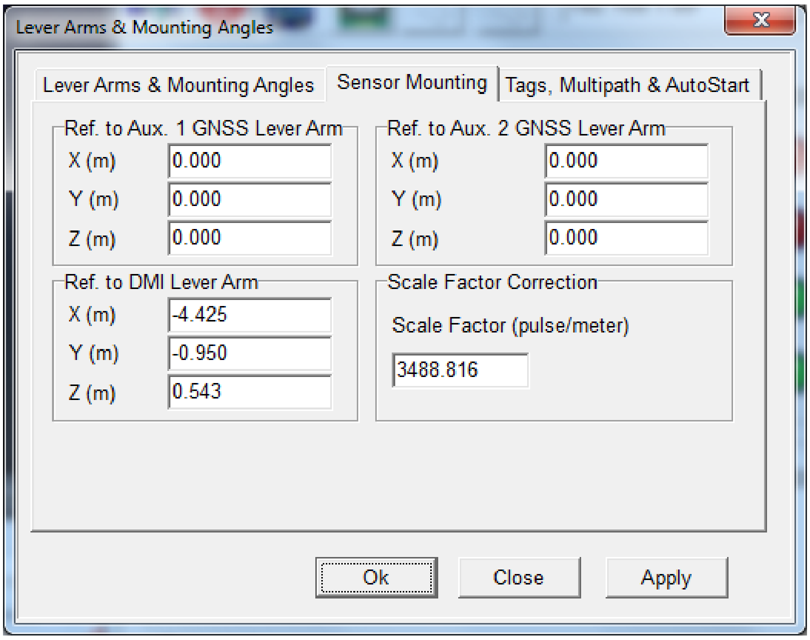


8. Press Apply to accept the new calibration or cancel to preserve the present value.

9.2.3 Applanix DMI Scale Factor Calculation

The new DMI calibration value must be updated in the (optional) Applanix software as well. The input value used by Applanix differs from the pulse number generated and used by the Dynatest DDC software.

DDC input is pulses/10 km. (in most cases giving a value around 8,000,000 to 10,000,000). Applanix utilizes pulses/meter. I.e., the amount of pulses have to be divided by 10,000 and that value entered into Applanix' LV POSView Settings→Installation→Lever Arms & Mounting Angles and select the "Sensor Mounting" tab.



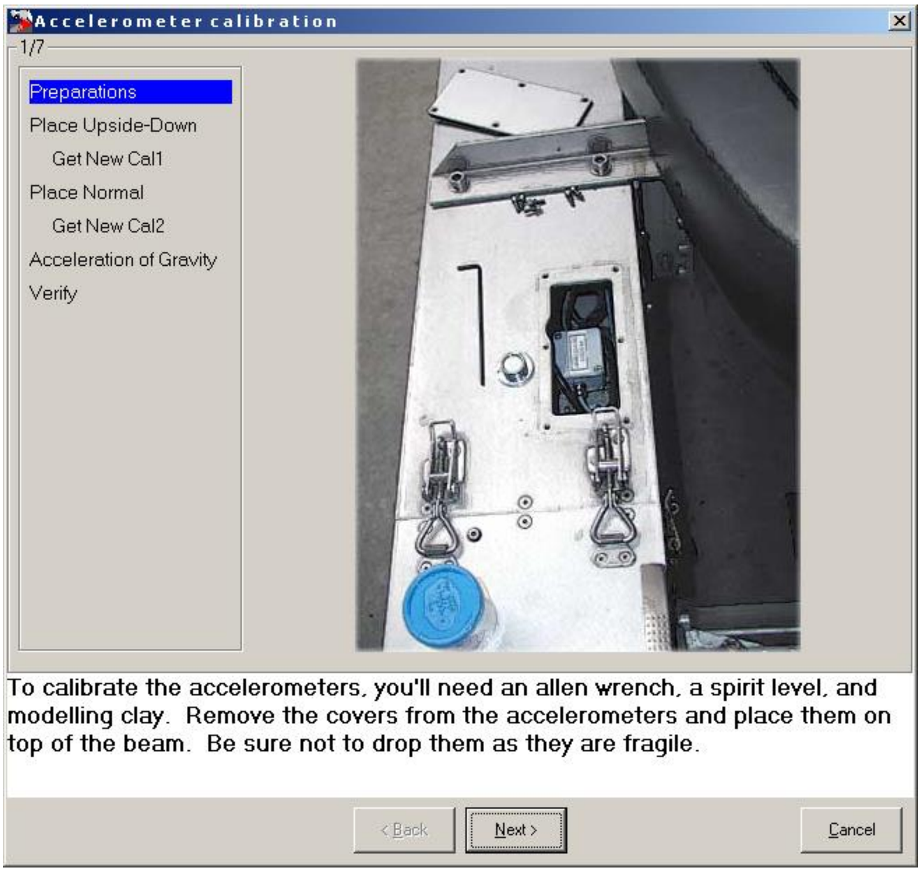
With Encoders generating 500 or 512 pulses/rev. the RSP DMI Calibration value shall be divided by 10,000 before entered into Applanix LV POSView.
With Encoders generating 2000 or 2048 pulses/rev the Calibration value from the RSP DMI calibration shall be divided by 2,500.

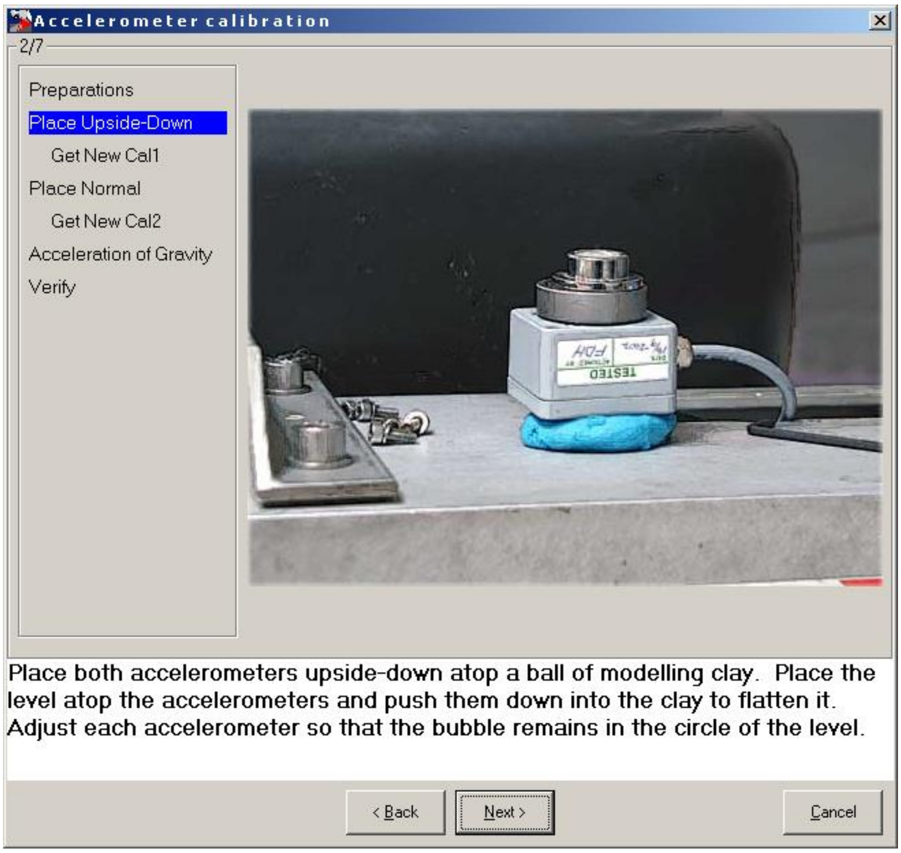
9.3 Accelerometers

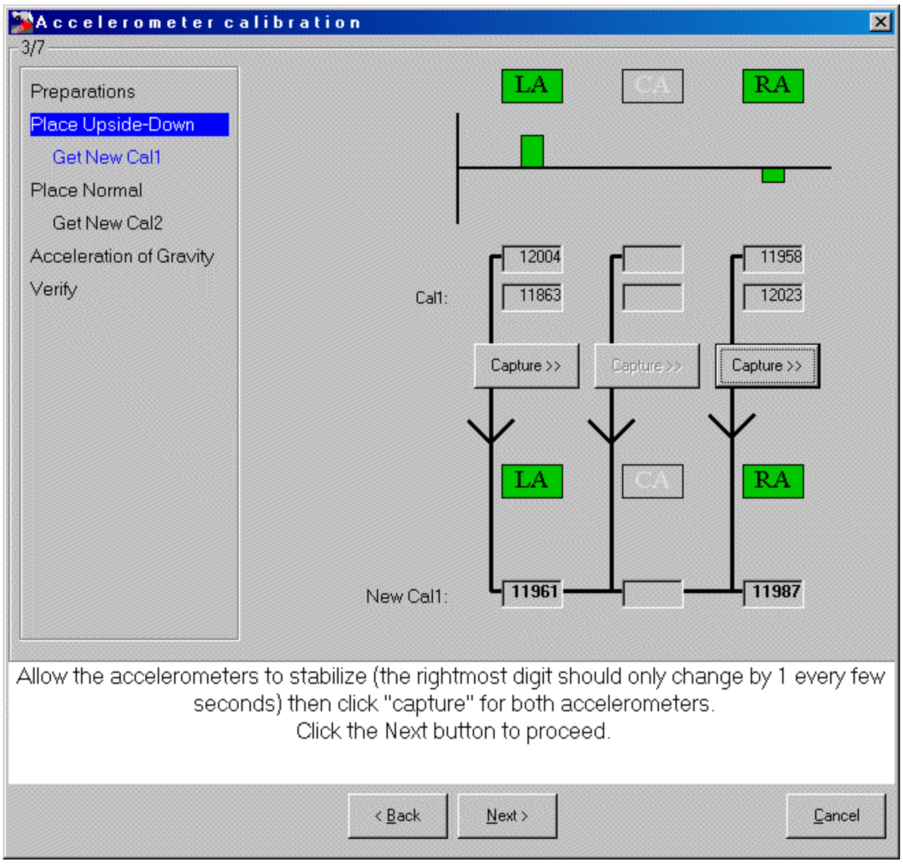
The accelerometers are calibrated statically by means of the Earth's gravity, which is equivalent to an acceleration of approx. 9.8 m/s^2 (slightly dependent on latitude). Two readings are taken, one with the accelerometers in an upside down position and another in the normal position. Since the differences between readings correspond to twice the acceleration of gravity, this information can be used by the RSP Program to establish the accelerometer sensitivities (calibration factors). The calibration factors are automatically calculated and stored in the RSP equipment database.

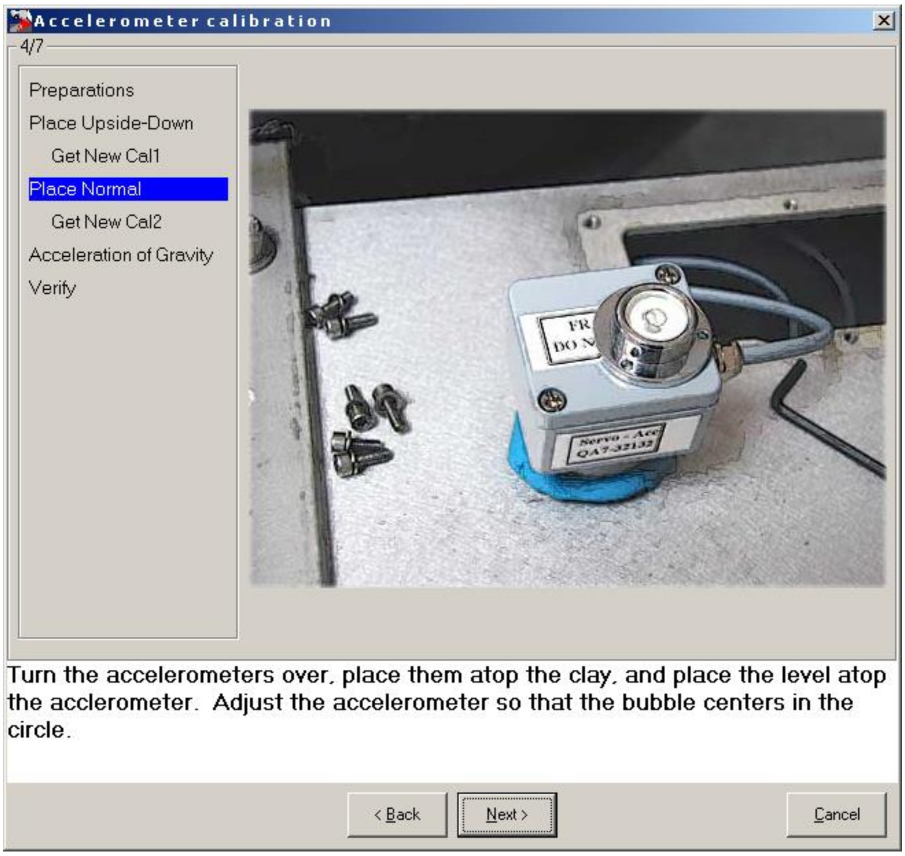
Initiation of the calibration is done by selecting **Setup** > **Accelerometers** > **Calibrate**. The process is comprised of seven steps as described in the series of illustrations that follow.

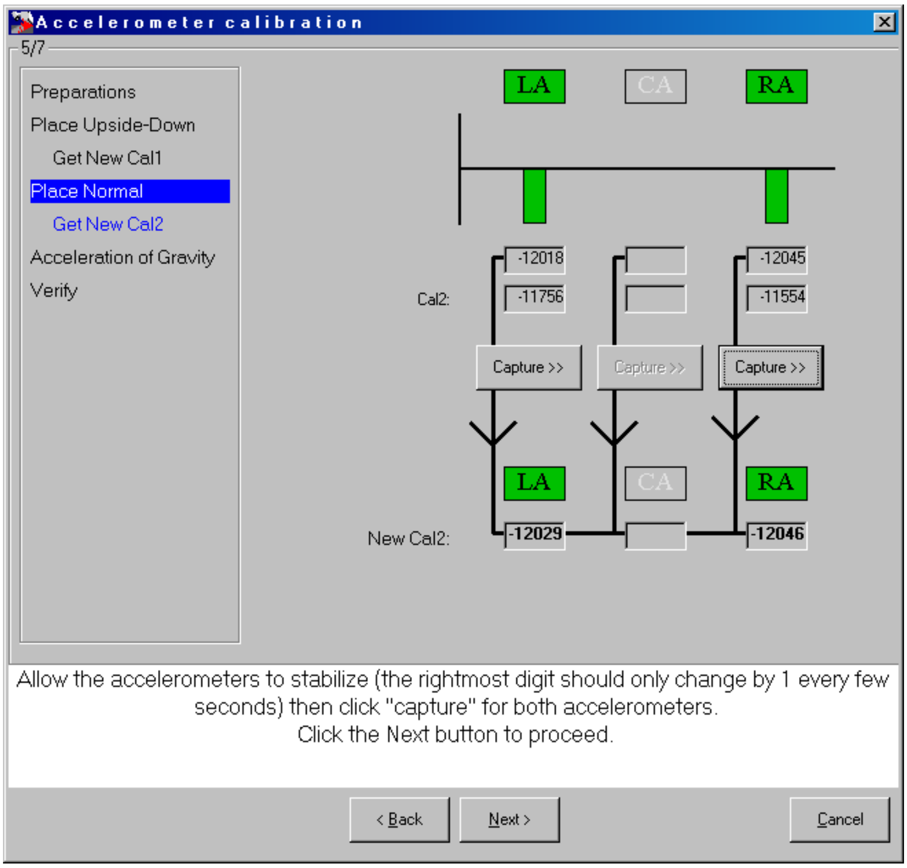
9.3.1 Mark III RSP

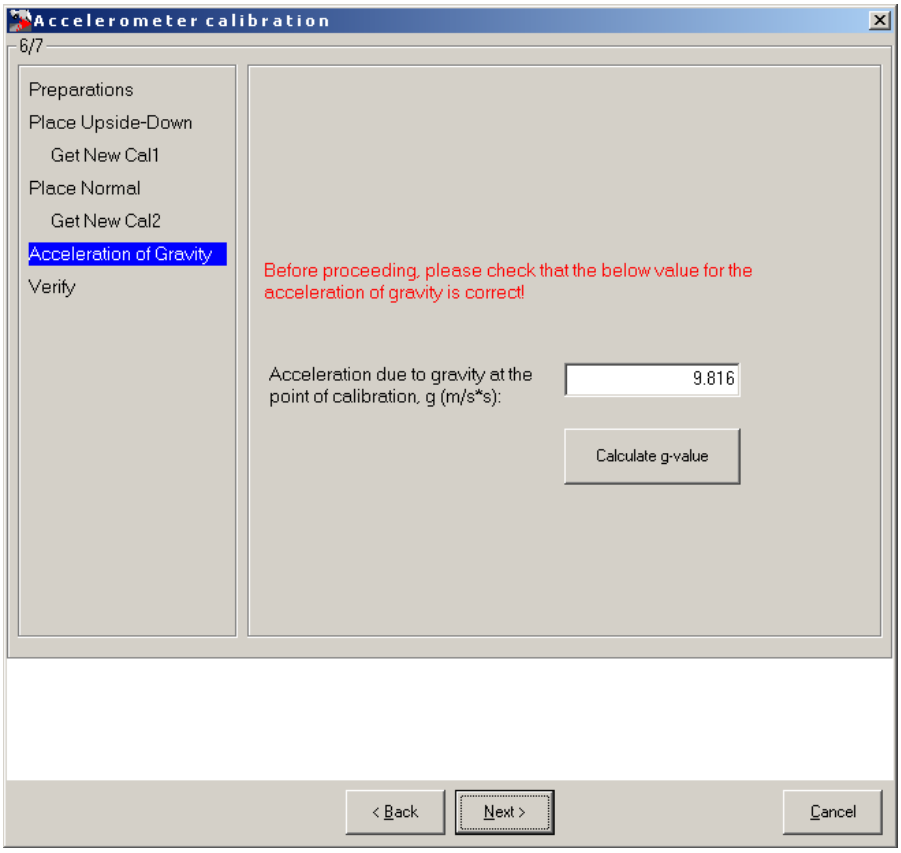



Accelerometer calibration
2/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
Place both accelerometers upside-down atop a ball of modelling clay. Place the level atop the accelerometers and push them down into the clay to flatten it. Adjust each accelerometer so that the bubble remains in the circle of the level.
< Back
Next >
Cancel


Accelerometer calibration
3/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
LA
CA
RA
Cal1:
12004
11863
11958
12023
Capture >>
Capture >>
Capture >>
LA
CA
RA
New Cal1:
11961
11987
Allow the accelerometers to stabilize (the rightmost digit should only change by 1 every few seconds) then click "capture" for both accelerometers.
Click the Next button to proceed.
< Back
Next >
Cancel

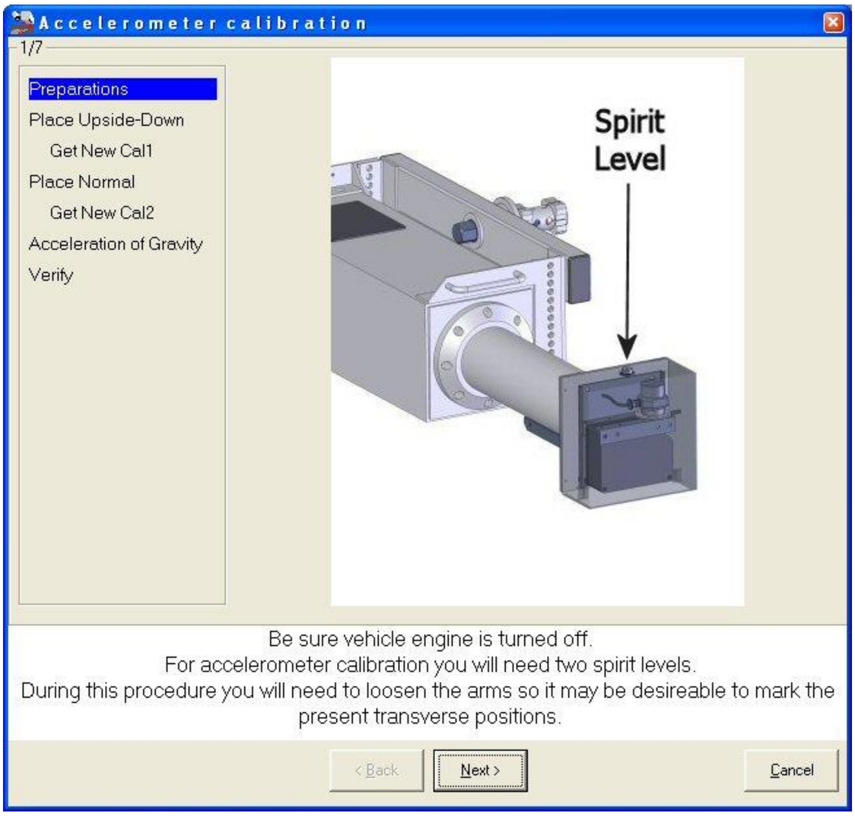

Accelerometer calibration
4/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
Turn the accelerometers over, place them atop the clay, and place the level atop the acclerometer. Adjust the accelerometer so that the bubble centers in the circle.
< Back
Next >
Cancel

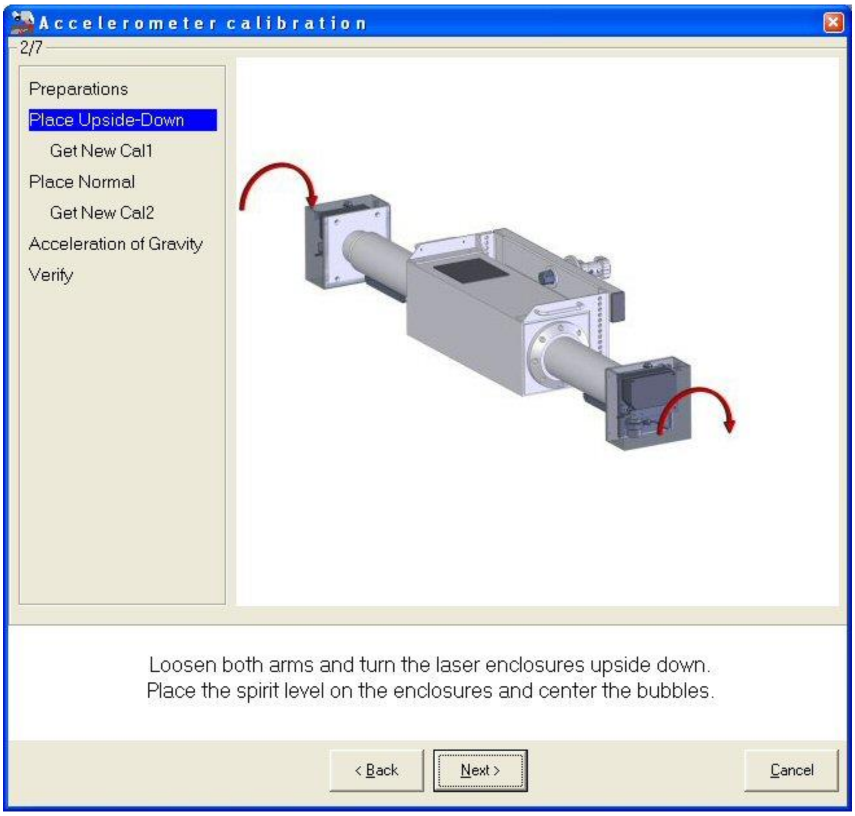

Accelerometer calibration
5/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
LA
CA
RA
Cal2:
-12018
-11756
-12045
-11554
Capture >>
Capture >>
Capture >>
LA
CA
RA
New Cal2:
-12029
-12046
Allow the accelerometers to stabilize (the rightmost digit should only change by 1 every few seconds) then click "capture" for both accelerometers.
Click the Next button to proceed.
< Back
Next >
Cancel

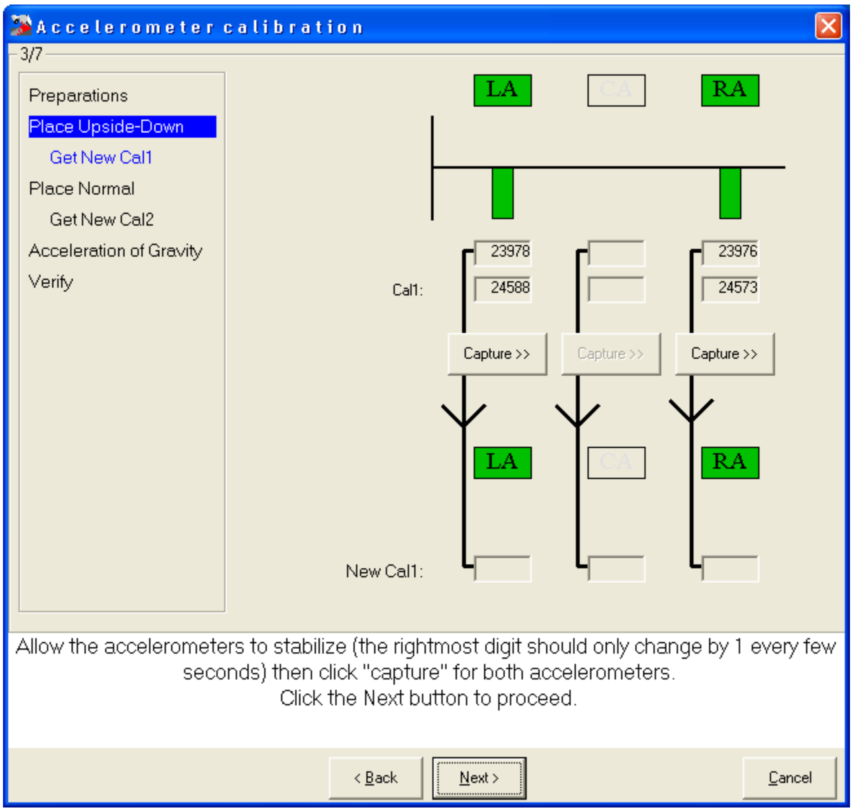


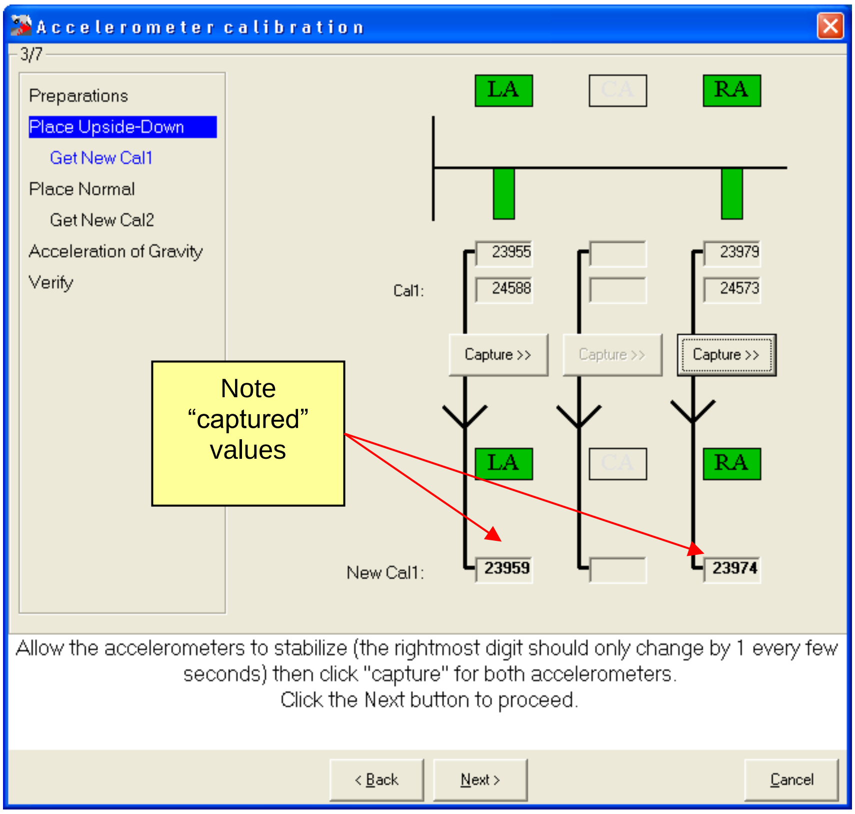
At this point the accelerometer calibration is complete. Click **OK** to return to the main Accelerometer setup window. In the Accelerometer setup window you must click **OK** or **Apply** to the changes made to the Cal1/Cal2 columns by the calibration procedure.

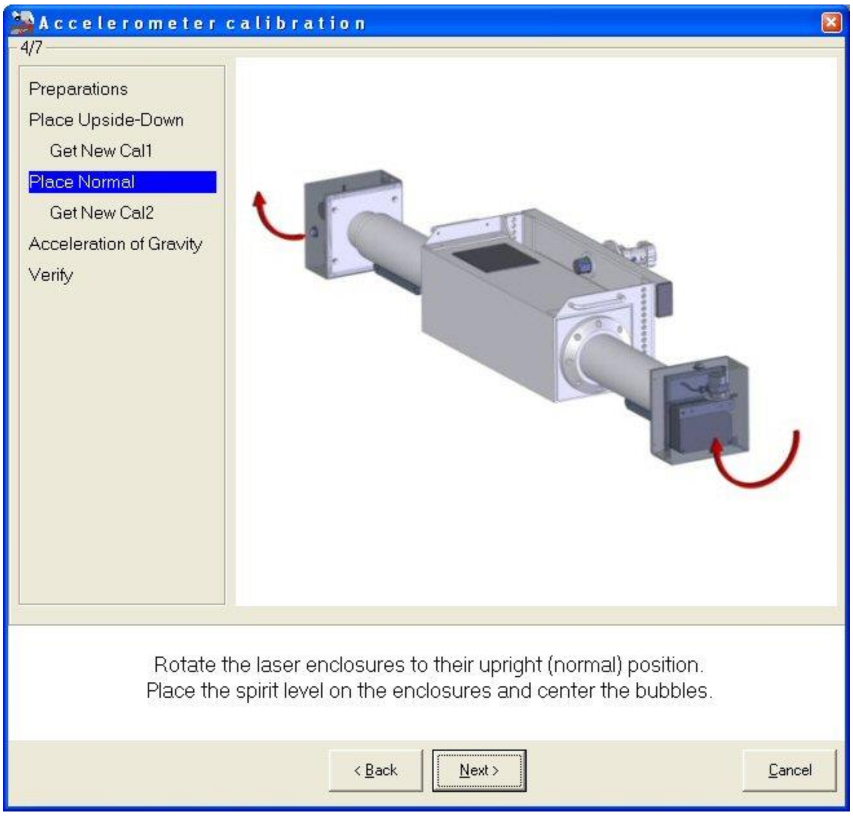
9.3.2 Mark IV RSP

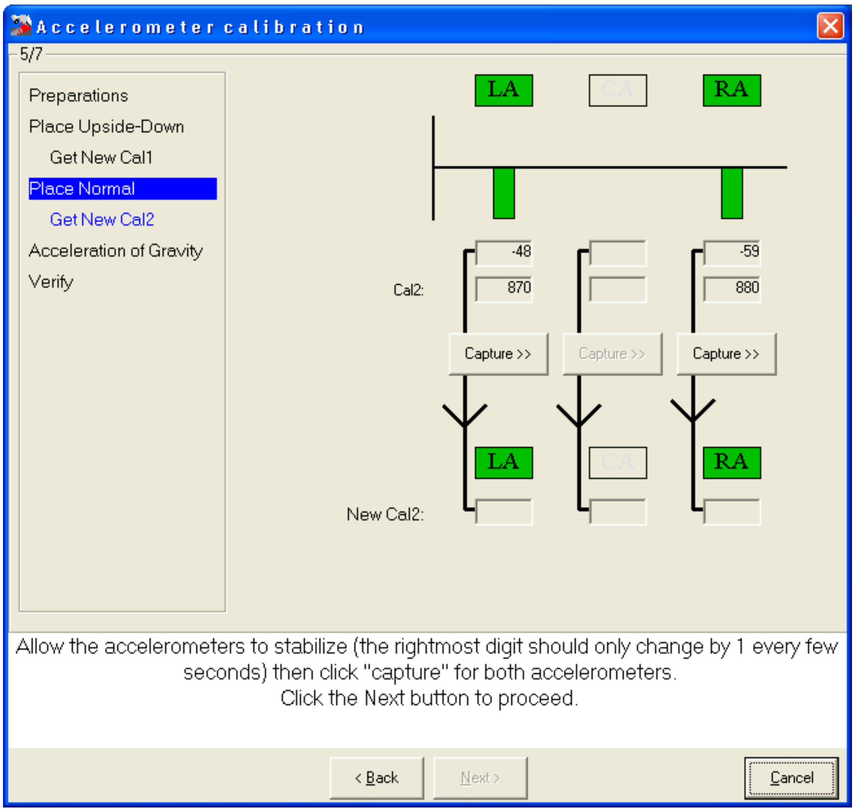


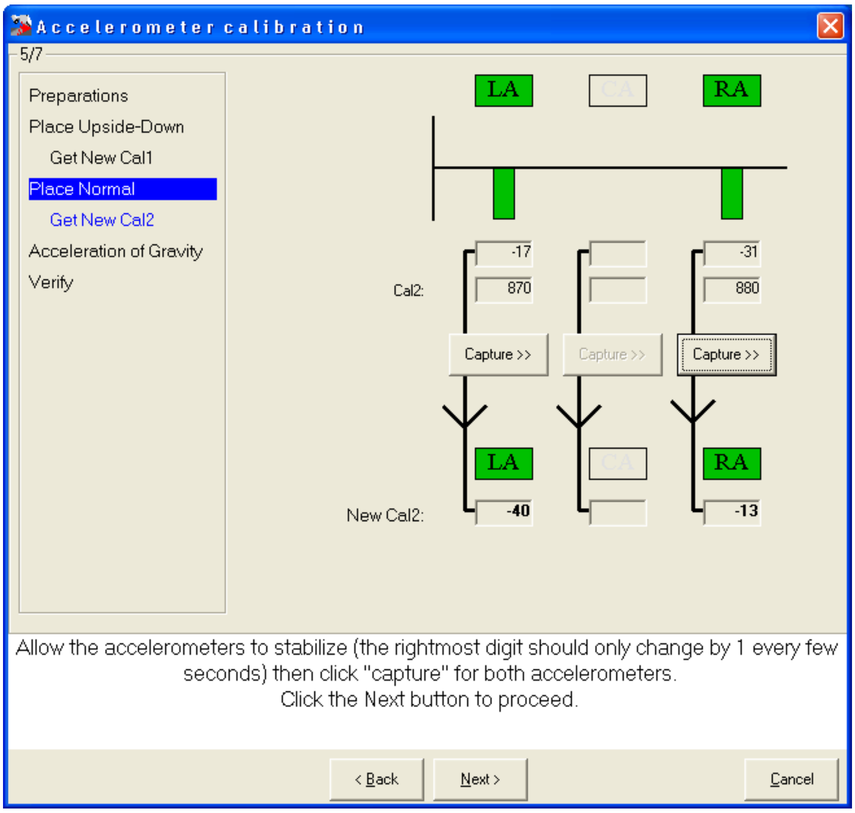


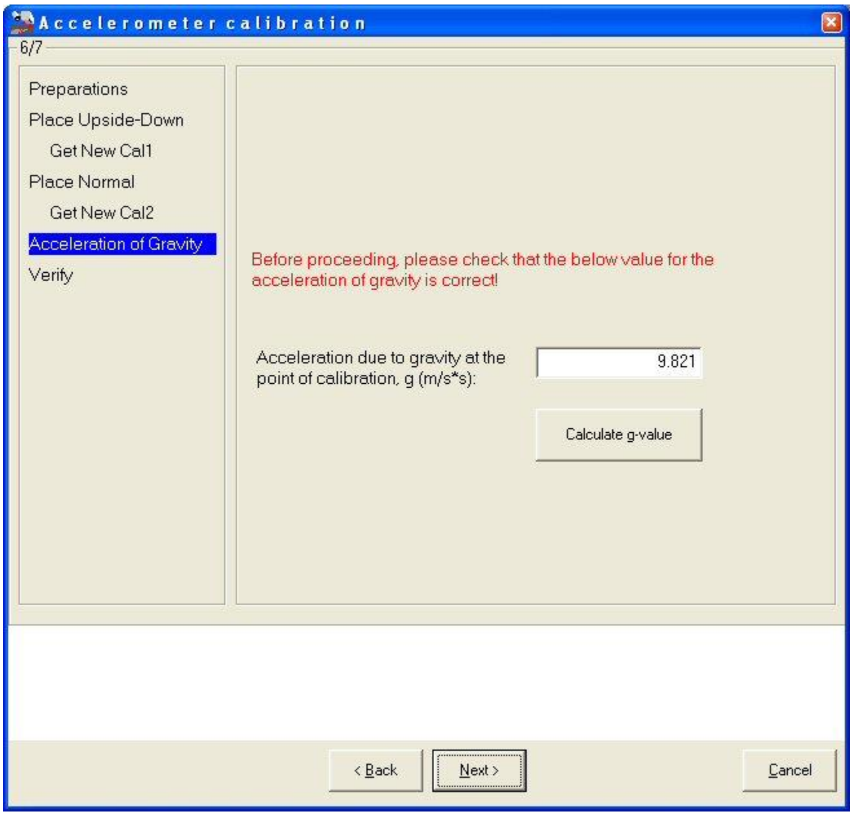

Accelerometer calibration
3/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
LA
CA
RA
Cal1:
23978
24588
23976
24573
Capture >>
Capture >>
Capture >>
LA
CA
RA
New Cal1:
Allow the accelerometers to stabilize (the rightmost digit should only change by 1 every few seconds) then click "capture" for both accelerometers.
Click the Next button to proceed.
< Back
Next >
Cancel

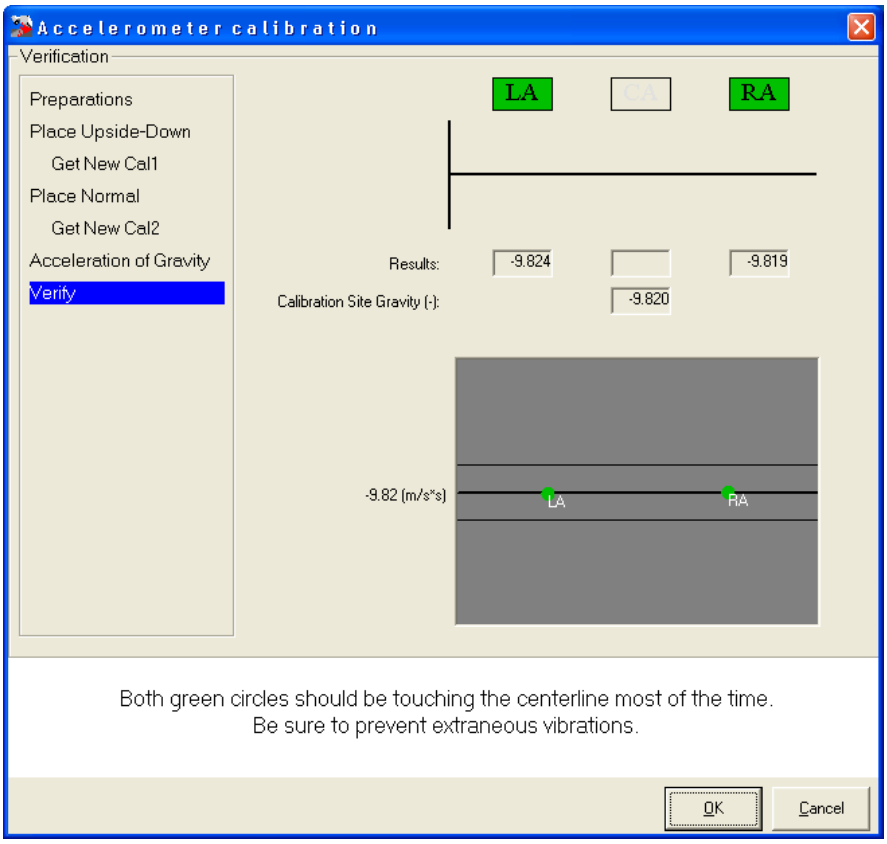

Accelerometer calibration
3/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
LA
CA
RA
Cal1:
23955
24588
23979
24573
Capture >>
Capture >>
Capture >>
Note "captured" values
LA
CA
RA
New Cal1:
23959
23974
Allow the accelerometers to stabilize (the rightmost digit should only change by 1 every few seconds) then click "capture" for both accelerometers.
Click the Next button to proceed.
< Back
Next >
Cancel


Accelerometer calibration
4/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
Rotate the laser enclosures to their upright (normal) position.
Place the spirit level on the enclosures and center the bubbles.
< Back
Next >
Cancel

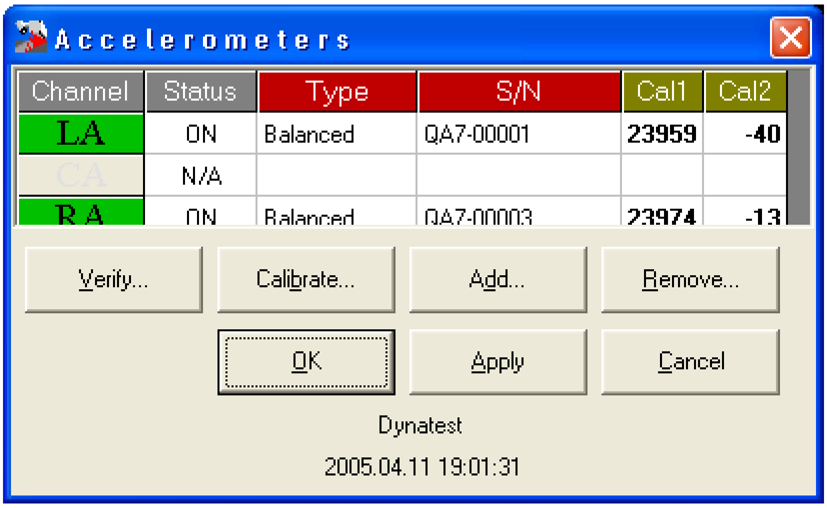

Accelerometer calibration
5/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
LA
CA
RA
-48
870
-59
880
Cal2:
Capture >>
Capture >>
Capture >>
LA
CA
RA
New Cal2:
Allow the accelerometers to stabilize (the rightmost digit should only change by 1 every few seconds) then click "capture" for both accelerometers.
Click the Next button to proceed.
< Back
Next >
Cancel


Accelerometer calibration
5/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
LA
CA
RA
Cal2:
-17
870
-31
880
Capture >>
Capture >>
Capture >>
LA
CA
RA
New Cal2:
-40
-13
Allow the accelerometers to stabilize (the rightmost digit should only change by 1 every few seconds) then click "capture" for both accelerometers.
Click the Next button to proceed.
< Back
Next >
Cancel


Accelerometer calibration
6/7
Preparations
Place Upside-Down
Get New Cal1
Place Normal
Get New Cal2
Acceleration of Gravity
Verify
Before proceeding, please check that the below value for the acceleration of gravity is correct!
Acceleration due to gravity at the point of calibration, g (m/s*s):
9.821
Calculate g-value
< Back
Next >
Cancel



Click “OK” to continue.



The bold numbers in the Cal 1 and Cal 2 fields in the windows above indicate that the net calibration values have not been stored. Click the “Apply” button to store the new values.

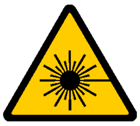
Click OK to return to the main menu.

9.4 Laser Sensors

9.4.1 RSP Mark III

The Laser Displacement Sensors are calibrated statically by means of a mechanical beam which can be positioned in the laser beam paths at two different levels exactly 100 mm apart, or more exactly, 50 mm above and below the laser sensor mid-range position. The readings at these two levels will be stored automatically and used by the Field Program to derive the laser sensor sensitivities and offsets. Dynatest provides the mechanical beam and other hardware necessary for calibration (except for jacks and jack stands used to raise and support the vehicle).

WARNING!



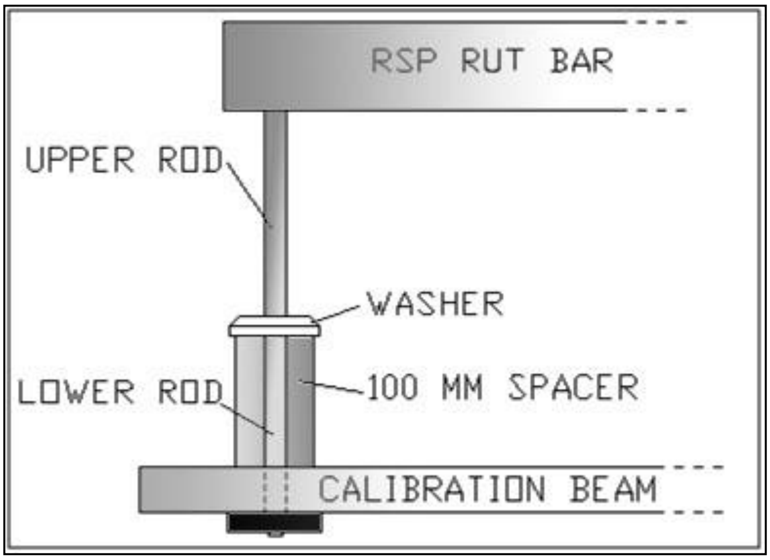
When performing any maintenance in the area of the laser sensors, OBSERVE that the laser beams *will cause serious damage to a human eye if viewed directly*! As an additional precaution, keep the safety power key switch OFF whenever possible.
NEVER switch ON power without assuring
that nobody is close to any of the laser sensors!

ALSO:

- **This procedure requires that the vehicle be raised and supported during the calibration process. The floor or pavement of the work area should smooth and level.**
- **Use a jack with the necessary capacity and configuration to safely raise the vehicle.**
- **Jackstands with the appropriate load capacity should be placed under each wheel. Lower the jack until the stands completely support the vehicle.**

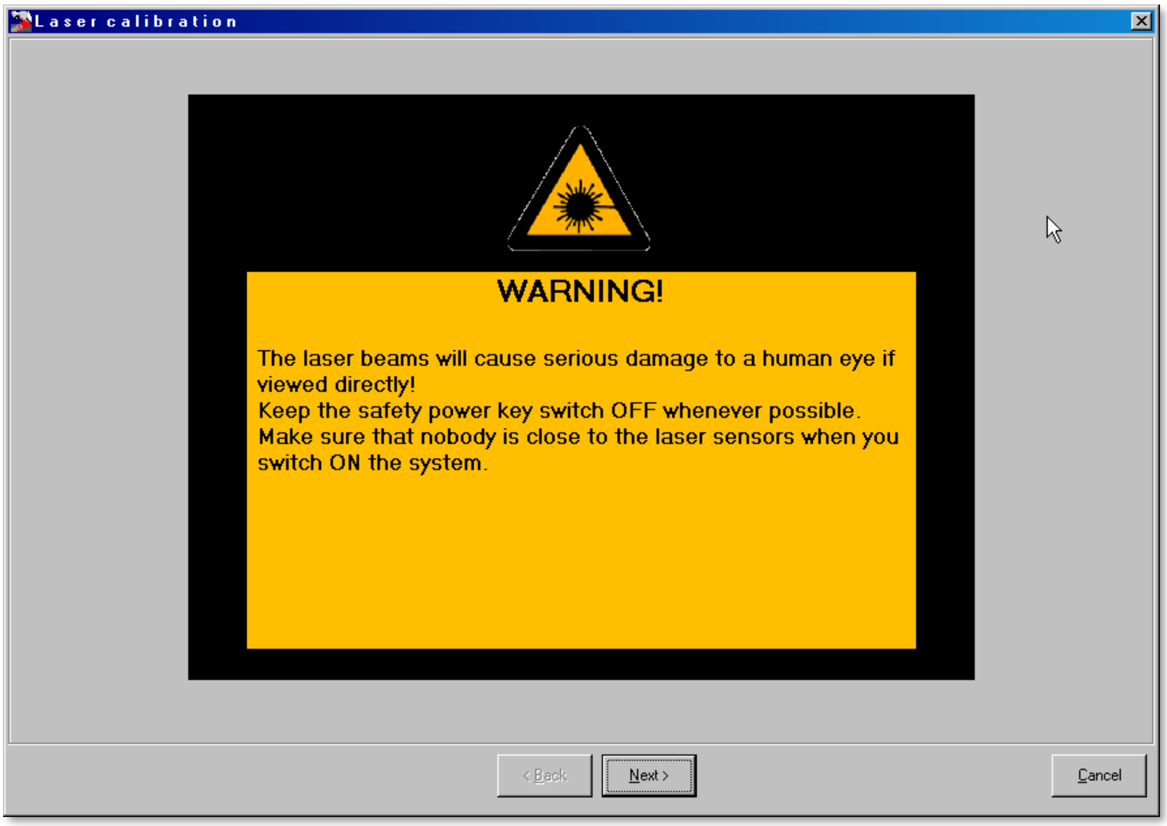
Procedure:

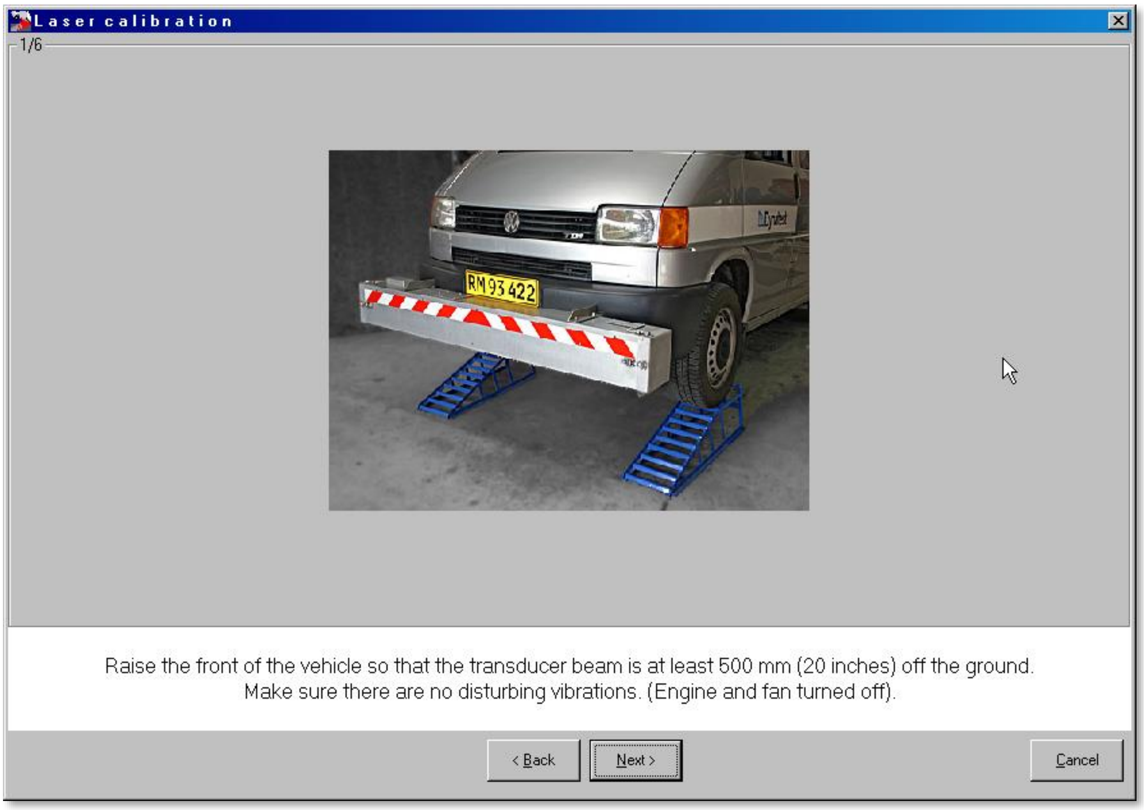
1. Raise and support the vehicle so that the bottom of the transducer beam is at least 500 mm above the ground.
2. Follow the recommendations outlined in section “9.1 Preparations”.
3. Attach the mechanical calibration assy. to the two threaded holes at the bottom of the Transducer Beam and adjust it to the “350 mm” level (lower level) in the following sequence:
    a. Following the figure below, attach the upper part of the rod first.
    b. Insert the lower rod into the calibration beam.
    c. Connect the upper and lower rods.
    d. Insert the 100 mm spacers as shown and tighten the lower rod.

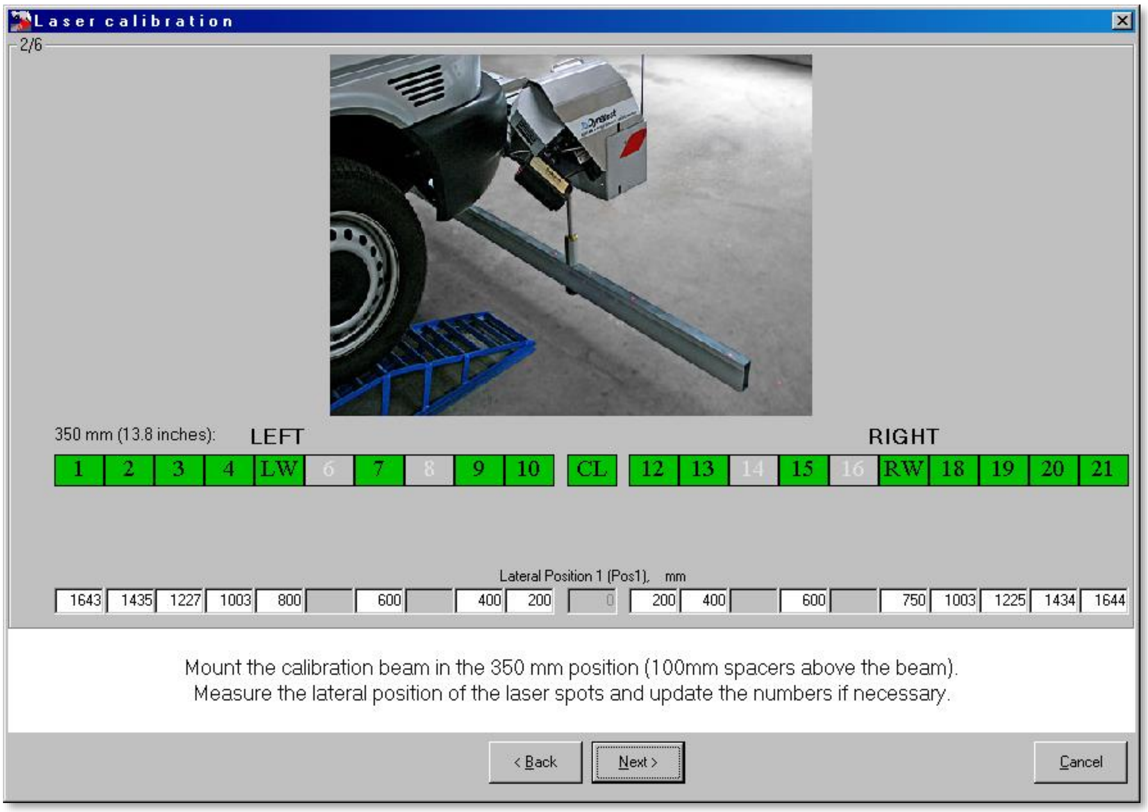


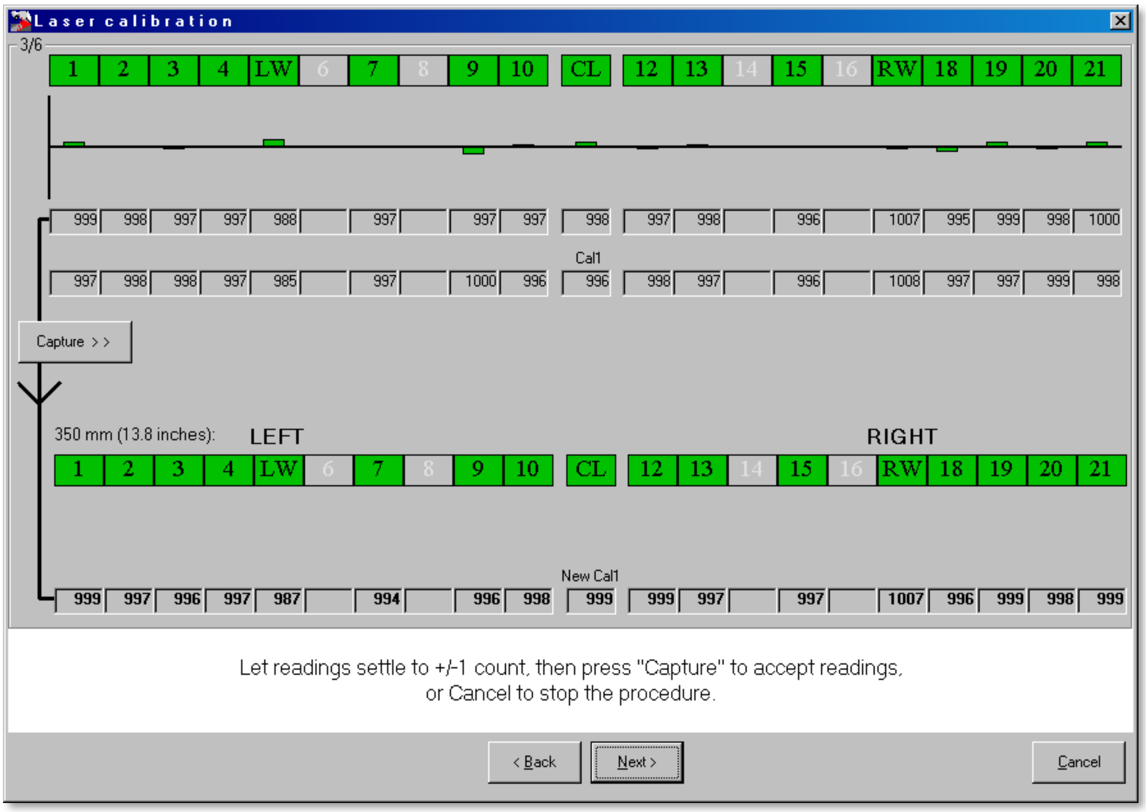
Note: The calibration should only be done where sunlight does not strike the beam - i.e. indoors if possible, otherwise in shade or cloudy weather.

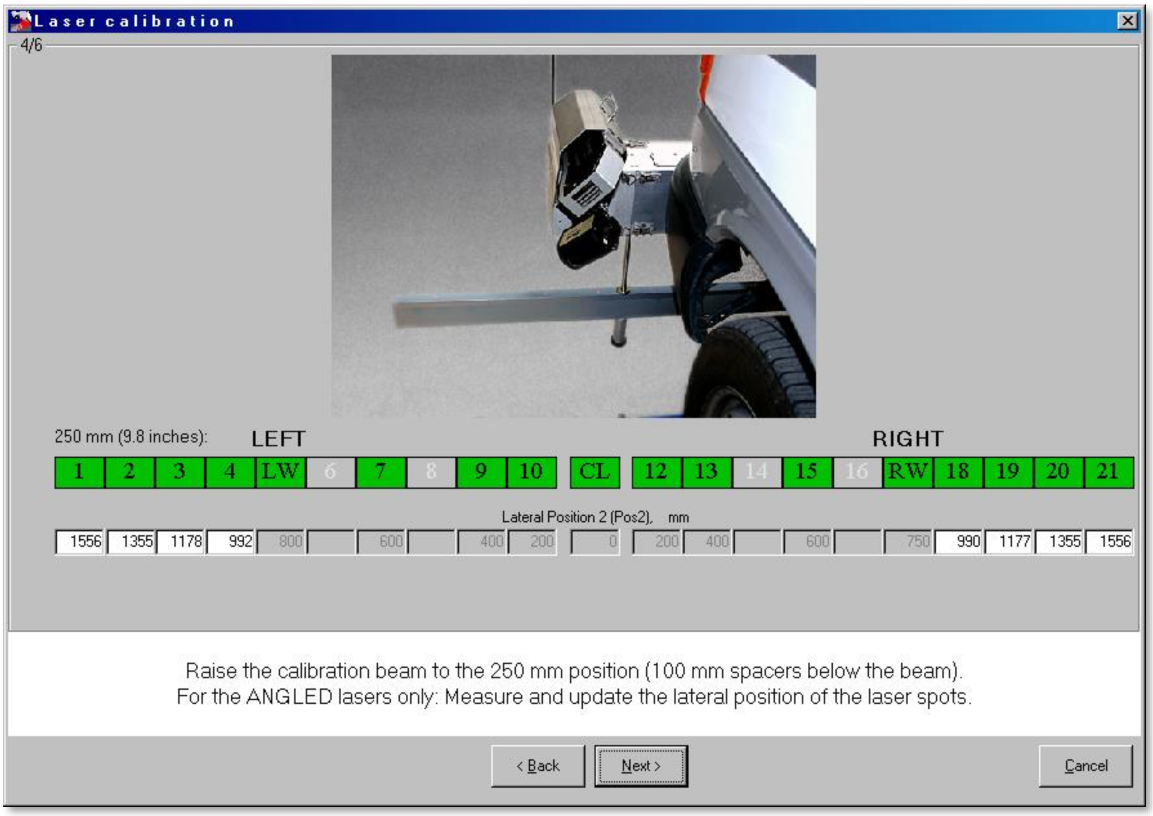
4. Click **Setup** > **Lasers** > **Calibrate** to access the calibration procedures. Follow the directions provided in each of the calibration screens shown below.

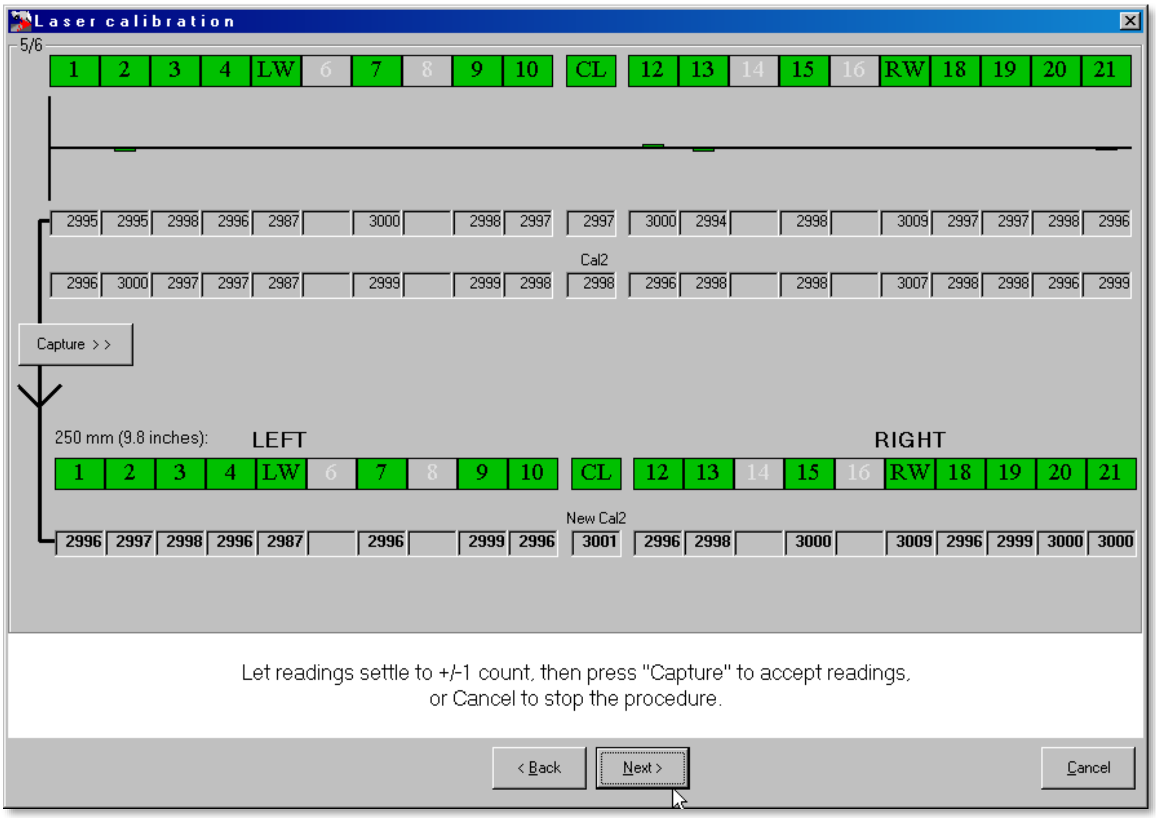


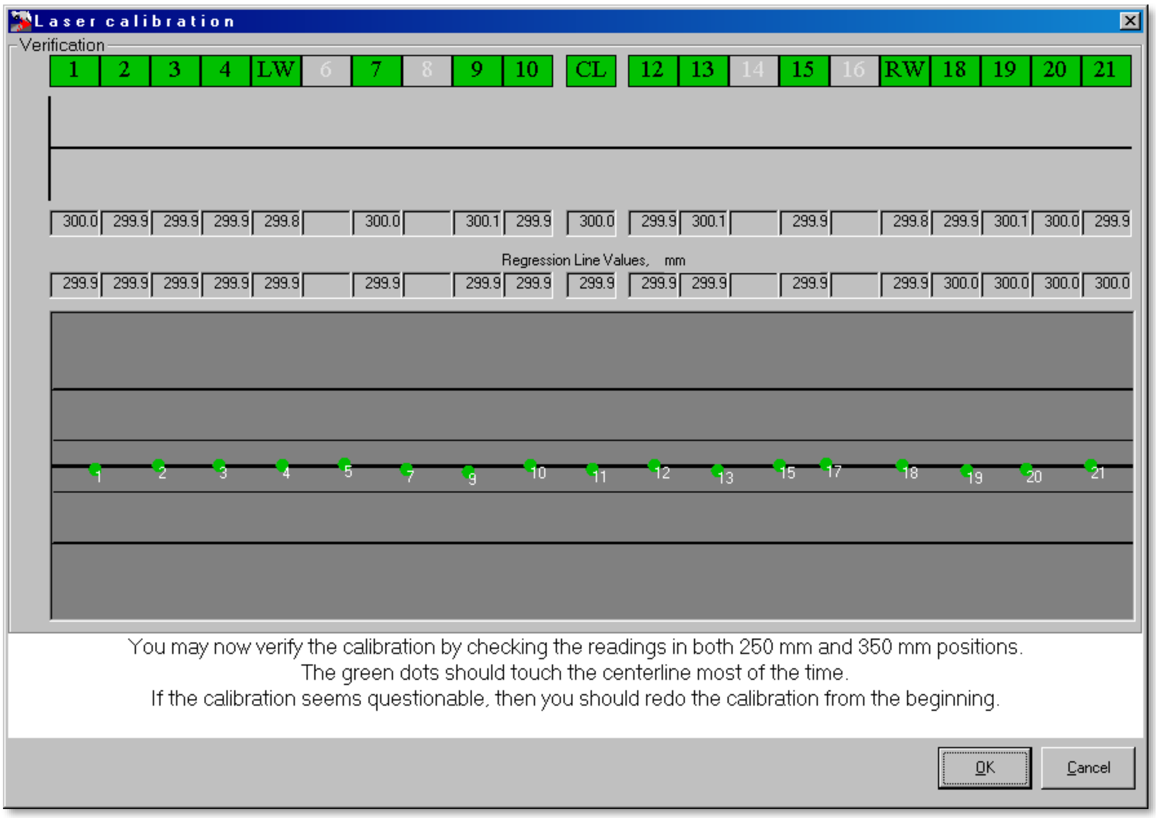

Laser calibration
1/6
RM 93 422
Raise the front of the vehicle so that the transducer beam is at least 500 mm (20 inches) off the ground.
Make sure there are no disturbing vibrations. (Engine and fan turned off).
< Back
Next >
Cancel


Laser calibration
2/6
350 mm (13.8 inches):
LEFT
RIGHT
1 2 3 4 LW 6 7 8 9 10 CL 12 13 14 15 16 RW 18 19 20 21
Lateral Position 1 (Pos1), mm
1643 1435 1227 1003 800 600 400 200 0 200 400 600 750 1003 1225 1434 1644
Mount the calibration beam in the 350 mm position (100mm spacers above the beam).
Measure the lateral position of the laser spots and update the numbers if necessary.
< Back
Next >
Cancel


Laser calibration
3/6
1 2 3 4 LW 6 7 8 9 10 CL 12 13 14 15 16 RW 18 19 20 21
999 998 997 997 988 997 997 997 998 997 998 996 1007 995 999 998 1000
Cal1
997 998 998 997 985 997 1000 996 996 998 997 996 1008 997 997 999 998
Capture > >
350 mm (13.8 inches):
LEFT
RIGHT
1 2 3 4 LW 6 7 8 9 10 CL 12 13 14 15 16 RW 18 19 20 21
New Cal1
999 997 996 997 987 994 996 998 999 999 997 997 1007 996 999 998 999
Let readings settle to +/-1 count, then press "Capture" to accept readings,
or Cancel to stop the procedure.
< Back
Next >
Cancel


Laser calibration
4/6
250 mm (9.8 inches):
LEFT
RIGHT
1 2 3 4 LW 6 7 8 9 10 CL 12 13 14 15 16 RW 18 19 20 21
Lateral Position 2 (Pos2), mm
1556 1355 1178 992 800 600 400 200 0 200 400 600 750 990 1177 1355 1556
Raise the calibration beam to the 250 mm position (100 mm spacers below the beam).
For the ANGLED lasers only: Measure and update the lateral position of the laser spots.
< Back
Next >
Cancel





At this point the laser calibration is complete. Click **OK** to return to the main Laser setup window. In the Laser setup window you must click **OK** or **Apply** to the changes made to the Cal1/Cal2 and Pos1/Pos2 columns by the calibration procedure.

9.4.2 RSP Mark IV

The RSP Mk-IV cannot operate with more than two laser sensors. This means that no pavement cross-profile can be measured with this unit, and therefore no alignment of the readings from the two sensors is needed, meaning that they can be calibrated independently.

Furthermore, since the laser sensor is producing a digital output, this output will be read directly by the EPU processor without being manipulated with any sensor specific gain adjustment. This means that as long as the factory calibration of the digital output of a laser sensor is stable, then no user calibration is necessary.

Experience has shown that the factory calibration of the laser sensors is extremely stable, so normally it will be sufficient to periodically just **verify** the calibration. The operator can do this by running a "Block Check" as described in a previous paragraph 8.4.3 'Block Check Mode'.

We therefore **recommend NOT performing any user calibration**, unless it for some reason should be demanded. In such case, it can be done as described in the following, but DDC "Administrator" is required.

9.4.2.1 Block Calibration

The Block Calibration is performed using the same hardware as supplied for the Block Check, typically a Base Plate and a precision Calibration Block, 25 x 50 x 75mm or 1 x 2 x 3". It is recommended to use the largest possible calibration height (75mm or 3"). If the Calibration Block has a shiny surface, then a thin, flat, grey painted or e.g. bead blasted and anodized target plate is needed.

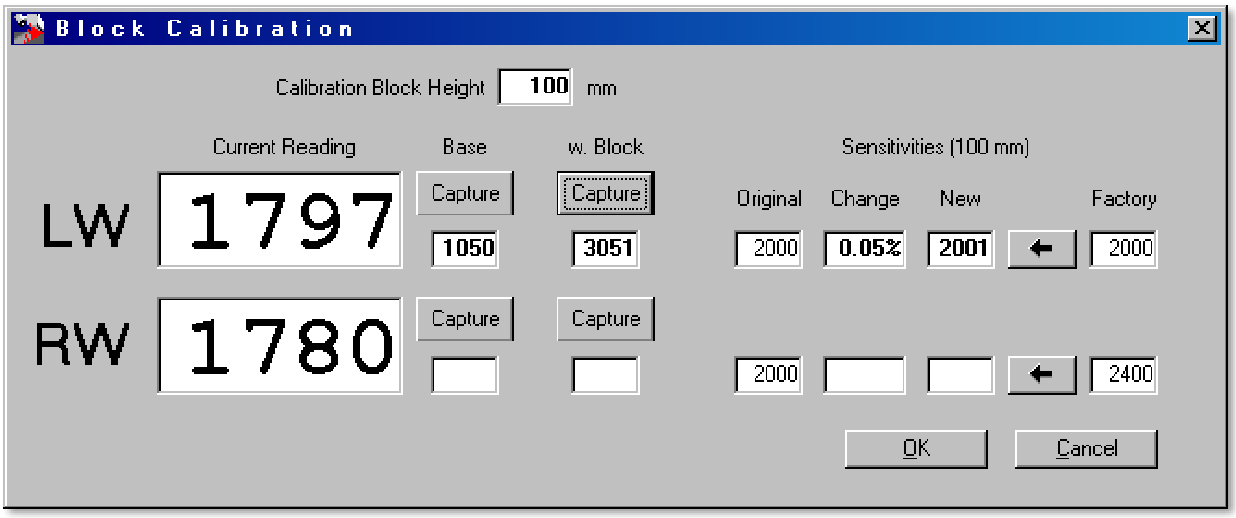
Block Calibration means working with reflective surfaces close to laser sensors

WARNING: TAKE EYE SAFETY PRECAUTIONS

As the laser sensor would typically be supported (indirectly) by a vehicle, please make sure that this is stable between readings, meaning that no person(s) should be inside or touching the vehicle during the calibration. Windy conditions should also be avoided.

From the main RspWin menu, select "Setup" > "Lasers" > "Block Calibration" (if there is no "Block Calibration" button, then select "Calibration")
Enter the desired calibration height in the text box (preferably 75mm or 3").
The following steps are carried out for one sensor at a time.
If a non-shiny Calibration Block is used, then no target plate is needed, and the steps in parenthesis should be ignored:

1. Place the base plate firmly under one sensor, so that the laser spot is close to the centre of the plate (the plate must be empty)
2. (Place the target plate firmly on top of the base plate)
3. When the reading is stable press the "Base" Capture button
4. (Remove the target plate)
5. Place the calibration block on the base plate, so the laser spot is centred on top of this
6. (Place the target plate on top of the calibration block)
7. When the reading is stable press the "w. Block" Capture button
8. The New sensitivity and the percentage change should now show



The factory-calibrated sensitivity can be entered by pressing the left-arrow.

If the Sensitivity obtained by the Block Calibration deviates more than 1% from the factory calibration value, then check that the base plate is resting firmly on the ground, and that the laser beam is perpendicular to the base plate within a couple degrees. Also make dead sure that the laser sensor is not moving at all between the two readings, and then redo the calibration. If still too much off, please contact Dynatest.

9.5 Texture Bias (Optional)

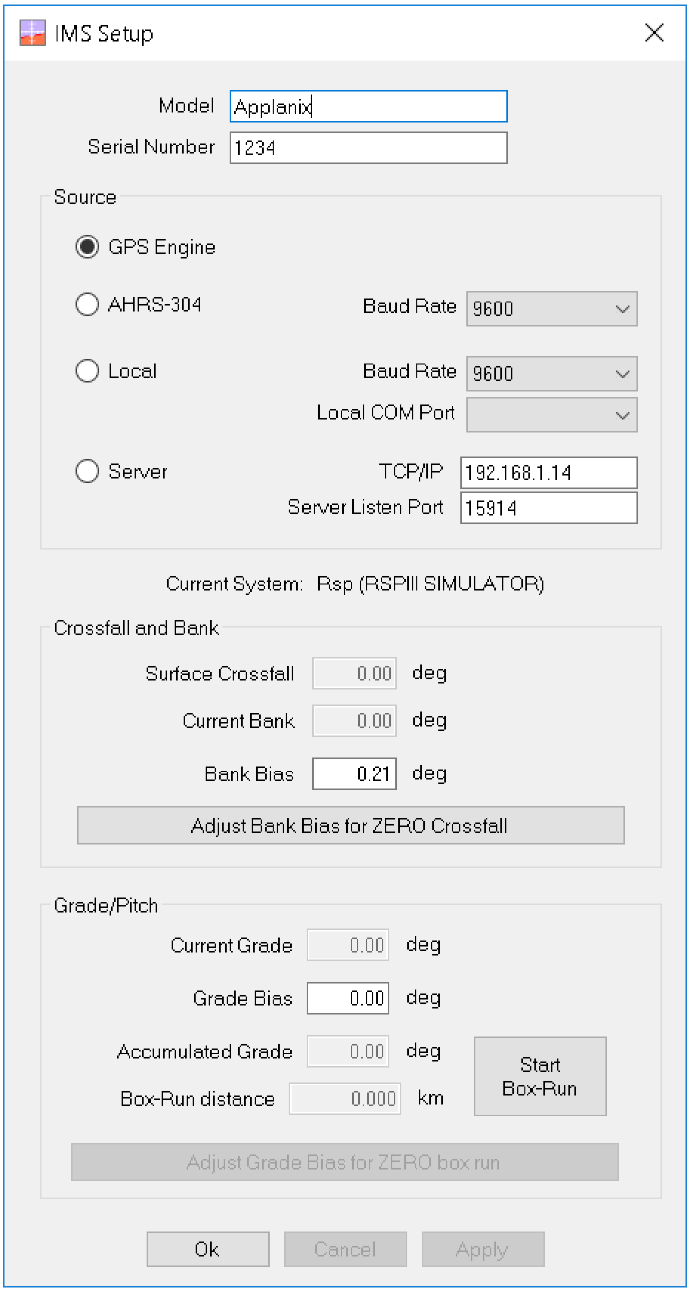
The MPD Texture algorithm tends to produce non-zero readings on perfectly flat surfaces (equivalent to a steady reading). To compensate for that, the equipment must be setup to subtract an "MPD Texture Bias" from the raw MPD reading. Determination of this bias goes like this:

1. Park on a reasonable "Roadway-Like" spot.
2. Turn off the engine and eliminate any other noise source.
3. Check that the standoff is approximately 300 mm (11.8 in)
4. Go into Setup – Lasers. Note the values in the "MPD" column and then reset those values to ZERO.
5. In the idle screen you will see MPD readings of some 0.2 to 0.6 millimetres. Readings may vary a bit depending on the surface.
6. Note the average MPD readings and enter those values in the "MPD" column of the Setup – Lasers table **in microns**, i.e., an average readout of e.g. **0.35 mm** should be entered as **350** (microns).

NOTE: The RMS bias should be ZERO, always.

9.6 *IMS (Mark III Only) (Optional)*

Right click the IMS applet and select “Setup”. **IMS Setup** window appears:



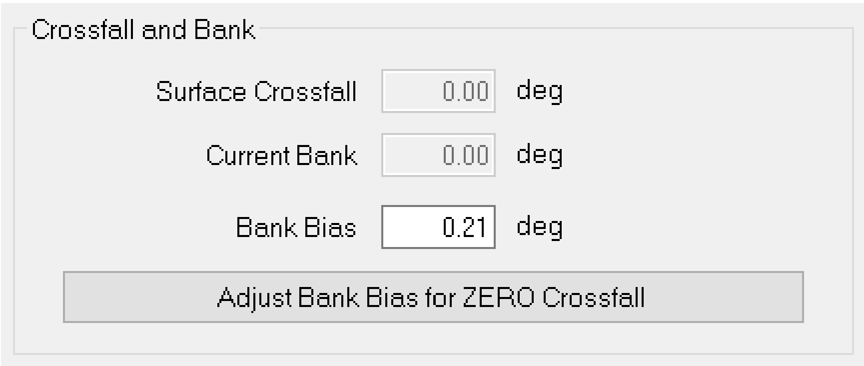
Model, Serial Number and Source parameters are all setup at delivery.

Bank Bias is determined by the procedure below.

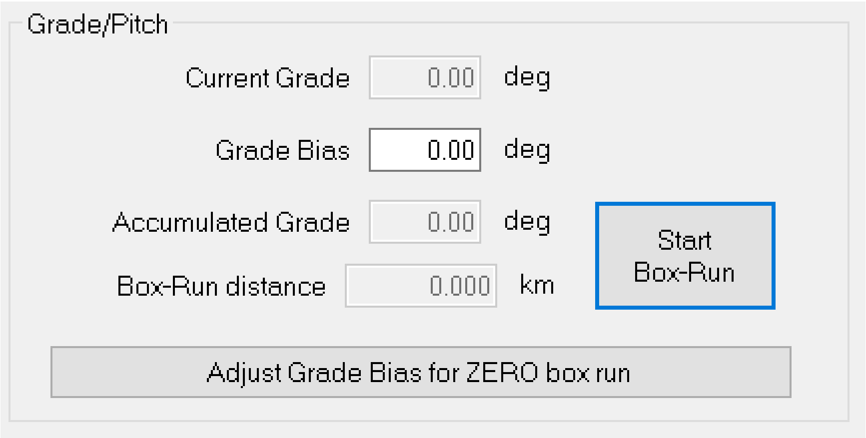
Grade Bias is determined by a so called “Box-Run” in which grade data is collected on a round trip where you return to the starting point.

9.6.1 Bank Bias Procedure

1. Boot the RSP, allow 15 min. warm-up before step 7 below is performed.
2. Raise the front end of the vehicle and attach the mechanical calibration assembly to the transducer beam. This is completely analogue to the preparations made before a laser calibration.
3. If you are not performing the crossfall adjustment right after doing a full laser calibration, please check (verify) that the lasers have been calibrated correctly before proceeding.
4. Place the calibration beam around the nominal 300 mm level, by placing it on top of the 50 mm spacers as shown in the above picture.
5. Place a spirit level on the calibration beam and adjust the tightening screws, until the beam is exactly level.
6. Remove the spirit level from the calibration beam!
7. Activate the "Initialize IMS" button. If the button is missing then your IMS is of a kind that doesn't need/support initialization, and you may skip to the next paragraph.
8. Wait a minute or so and make sure that the crossfall readout is stable.
9. When the crossfall readout has stabilized activate the "Adjust Bias for ZERO Crossfall" button. This will change the value in the "Current Bank " field, which is used by the program for crossfall bias suppression. A bias value within 1-2 degrees is normal.
10. The crossfall readout should now be very close to 0 (+/- 0.1 deg.). If the result is not satisfactory then perform step 7-9 again. Alternatively, you may edit the "Bank Bias" field directly.



9.6.2 Grade Bias Procedure



1. Select a round trip with moderate ups and downs
2. Park at the starting point and mark the start position
3. Press “Start Box-Run”
4. Drive “nicely” around the block
5. During the round trip “Box-Run distance” shows your mileage and “Accumulated Grade” shows the sum of all grade readings
6. Park at the starting point
7. Press “Adjust Grade Bias for ZERO box run”

9.7 High Definition Cracking HDC (Optional)

9.7.1 LCMS Validation

The LCMSValidationTool module uses a calibrated pyramidal object to validate the calibration of a LCMS sensor.
This optional module includes the validation object (see Figure 37) and the validation software (LcmsValidationTool).

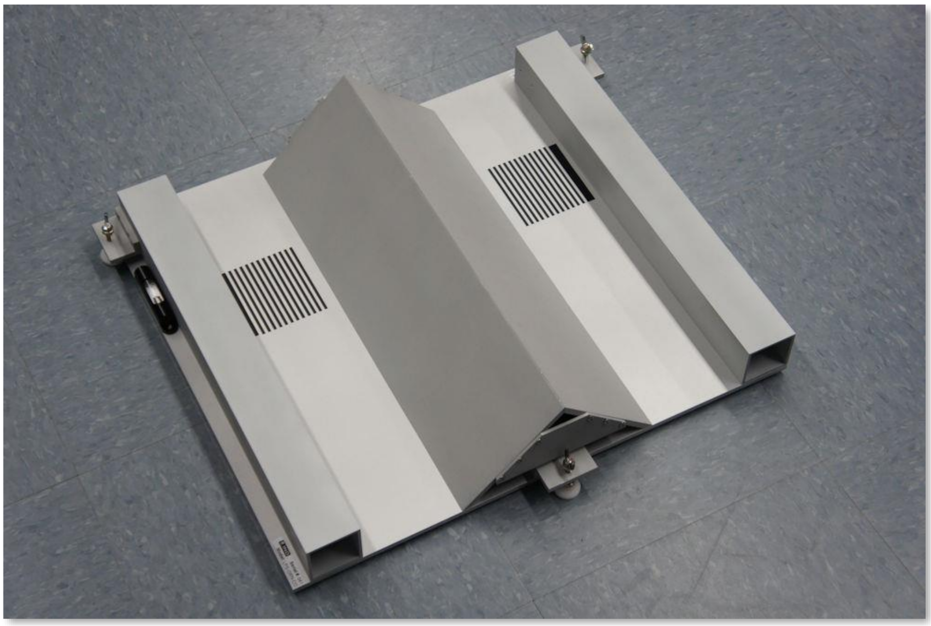


Figure 35 Calibrated Pyramidal Object for Validation

1 Software Installation

The LCMSValidationTool software is already installed on the computer. A shortcut is placed on the desktop.
If reinstalling, the installation file is named (CD_Installation3_ValidTool_VX_Y_Z) The installation procedure is straightforward: double-click on the Install.bat file in order to install all necessary software and drivers. Accept all default settings.

2 Validation procedure

Disengage the Encif (DMI) box (un-plug the USB cable) and replace the "Interlock" cable with the "Cheating-Plug" in the Pavemetrics Controller Box.
Launch the LcmsValidationTool software, initialize the system by clicking on the "Init" button and then "Start" to begin the acquisition, as shown in Figure 38.

Warning. ***From this point, make sure to take all necessary laser eye safety precautions. For more information refer to the LCMS laser safety manual.***

The validation steps are divided in two parts.
The first part **(Range Validation)** verifies the sensor alignment in order to make sure that calibration tables (.ltx and .ltz files) are still valid.
The second part **(FocusValidation)** assesses the sensors optical quality.

Different portions of the reference object will be used depending on which test is performed.
These two steps must be performed for three positions (left/center/right) in the field of view of each sensor.

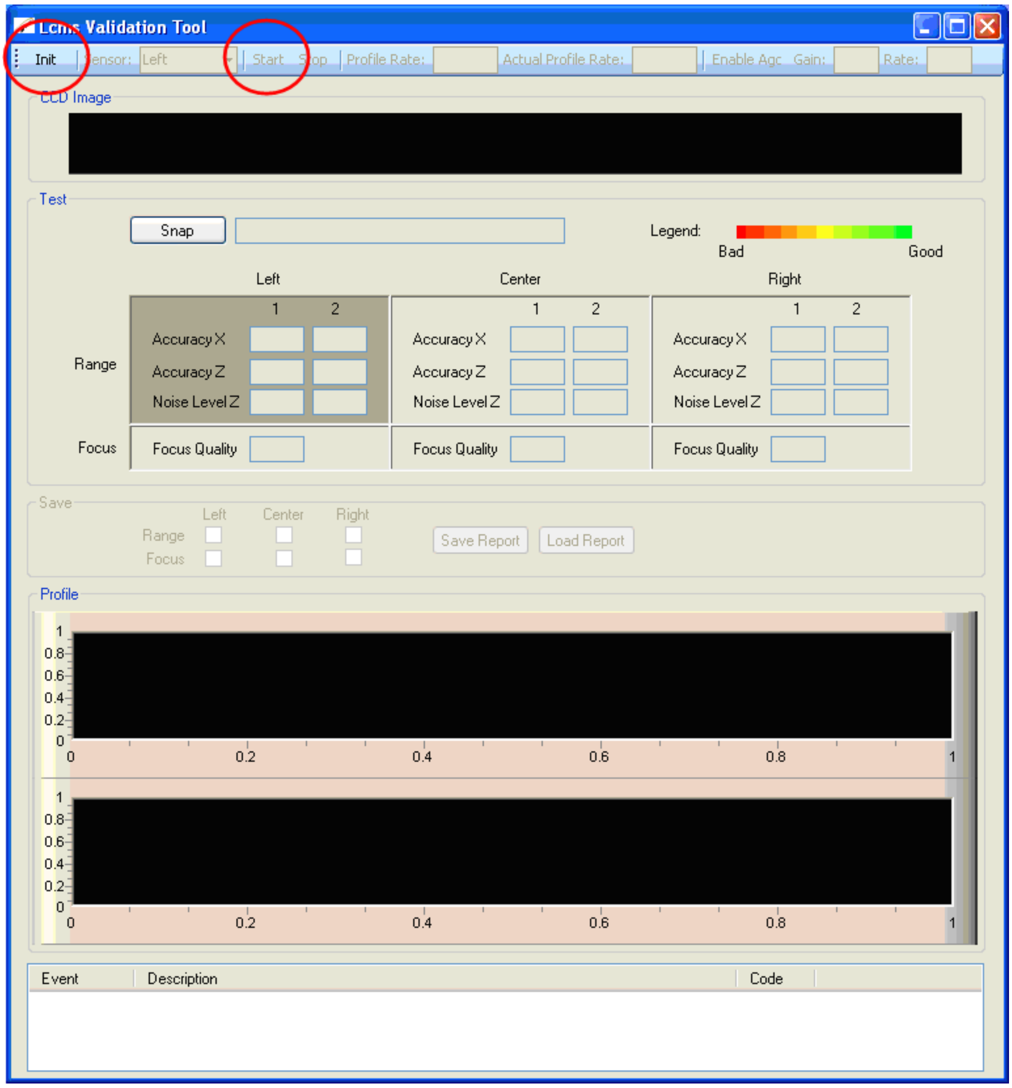


Figure 36 LCMSValidationTool graphical user interface.

9.7.2 Range Validation

To perform the range validation procedure, the calibrated pyramidal object must be placed under the sensor (left/center/right section) so the laser cuts the object transversally (see Figure 40).

For this part of the test, the laser line **must not** touch the portion of the object with the line pattern.

The user should ensure that the object is leveled. The leveling may be adjusted using the two levels installed on the sides of the object.

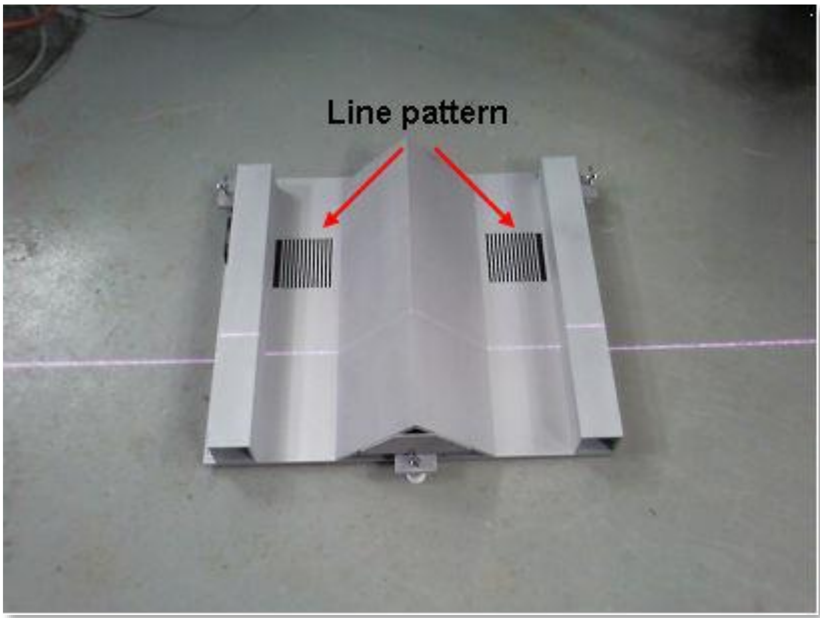


Figure 37 Laser line position on the reference object for the Range Validation Test.

The laser line is almost impossible to see with the human eye, however most basic cameras (i.e.: cell phone cameras) are sensitive in the near infrared spectrum. Using such a camera makes it very easy to position the reference object properly.

When testing for the left or right part of the field of view of the sensor, the user should position the calibrated object such that the object is always completely included within the field of view of the camera. See Figure 41 – "Profile" Window.

Figure 38 Example where the reference object is on the left side extremity

1. Choose LCMS unit. Left or Right.
2. Click “Init” and “Start”.
3. Select the test of the LCMS Unit you want to perform by clicking on the background box where the test results are displayed. The selected test, (Left, Center, Right) will be displayed in dark grey (Range – “Left” is selected in Figure 41).
4. When the Validation Object is positioned and leveled properly, Click the “Snap” button. The operation takes about 2 seconds before the validation results are displayed.
5. When done, reposition the calibrated object to a different part of the field of view of the sensor (Left, Center and Right) Click the background box to activate and turn grey and click “Snap” to capture that Range readings.

9.7.3 Focus Validation

The focus validation is performed in the same manner as the range validation, except that the calibrated pyramidal object must be position so the laser line passes through the line pattern (Figure 42).

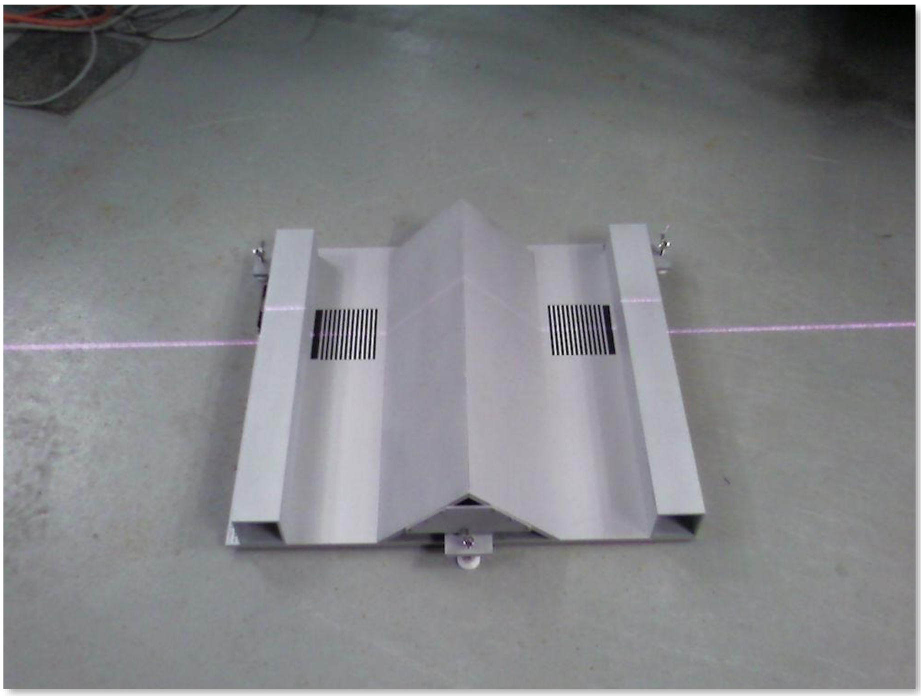


Figure 39 Laser line position on the reference object for the Focus Validation.

Once again, click on the background box that corresponds to the test to be performed (Focus – Left, Focus Center, Focus – Right) and click on the button Snap.
Repeat the same procedure for all 3 sections of the field of view of the sensors (Left/Center/Right).

When all six validation measures are completed, a report can be saved by clicking on the Save Report button.

9.7.4 Result interpretation

After each test, the different textboxes will be filled with a numerical value and the background set to a given color.
Green means the sensor passed the test successfully. On the opposite color range, red means a failure for that particular test. If the color shade is in between red and green then the sensor is acceptable.

The Table 1 gives the mapping between the numerical values for each indicator and the sensor status.

Indicator	Fail	Good	Excellent
Accuracy X 1	> 3.5	3.0 to 3.5	< 3.0
Accuracy X 2	> 3.5	3.0 to 3.5	< 3.0
Accuracy Z 1	> 1.2	1.1 to 1.2	< 1.1
Accuracy Z 2	> 1.2	1.1 to 1.2	< 1.1
Noise Level Z 1	> 1.2	1.0 to 1.2	< 1.0
Noise Level Z 2	> 1.0	0.5 to 1.0	< 0.5
Focus Quality	< 0.4	0.4 to 0.5	> 0.5

Table 1: Mapping between indicators values and sensor status

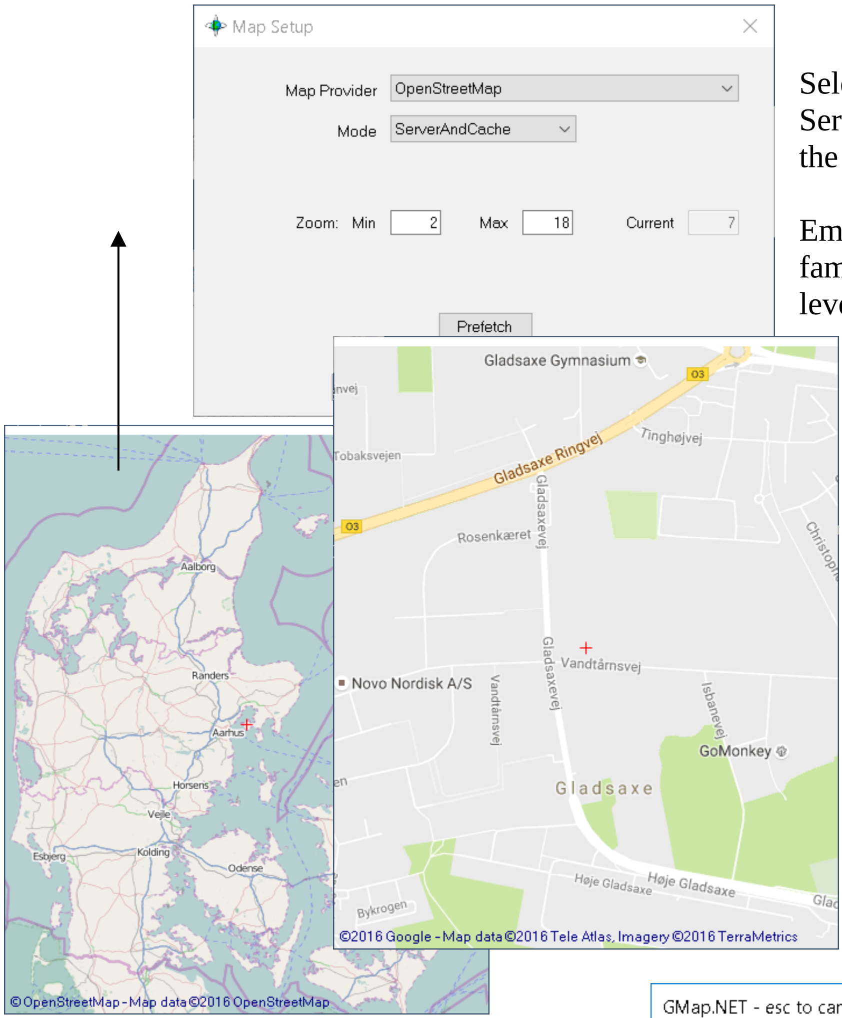
Save Reports:
Results can be saved in XML format by clicking the “Save Reports” button.
Previous Validation Tests can be opened via “Load Reports”.

10 Setup Details

10.1 GPS

10.1.1 Prefetch Maps

If you don’t have Internet connection during data collection, then you may prefetch map imagery when the Internet is available. This can be done by connecting your laptop to an office network and run DDC in simulation mode.
Right click the GPS applet and chose “Map Setup”

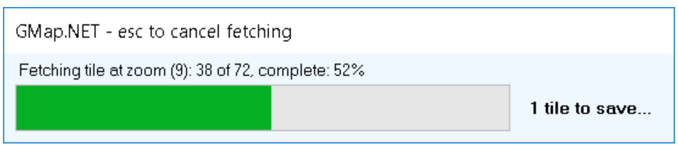


Select the desired Map Provider
ServerAndCache means that if a tile is not found in the cache, then it is fetched from the Internet

Embrace your area of interest (Denmark) and get familiar with the detail of zoom levels. This is zoom level 15 with a fair amount of detail:

Zoom out again to level 7 to embrace all of Denmark and then set Zoom Max to 15.

Press “Prefetch” to start the process. This may take several hours!

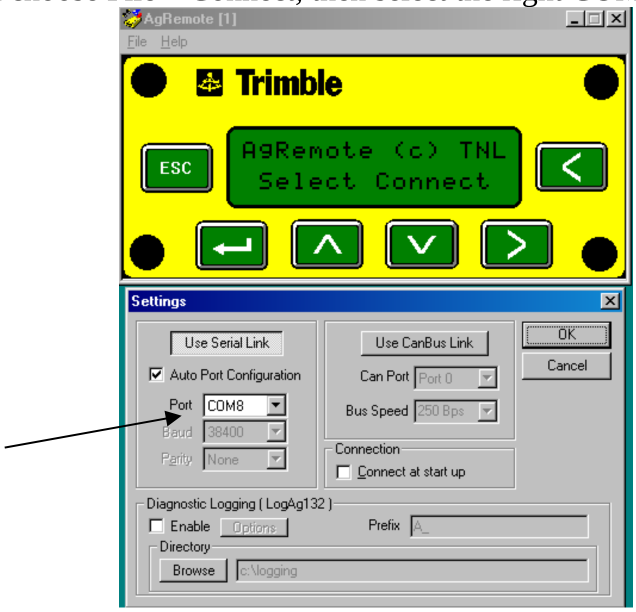


10.1.2 Trimble Ag262 Setup

We will setup the Ag262 through port B and later use the device through port A

Install Trimble's AgRemote software
Connect signal cable to port B
Connect RS232 plug to computer
Apply power

Start AgRemote and choose File – Connect, then select the right COM Port:

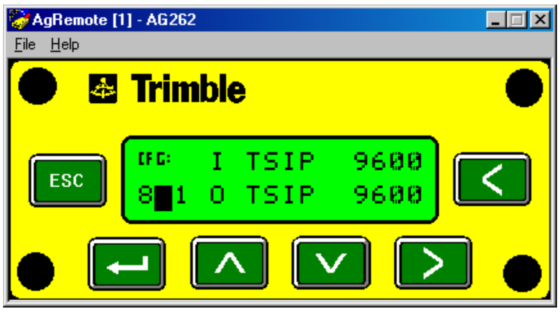


Connection is established if this comes up:

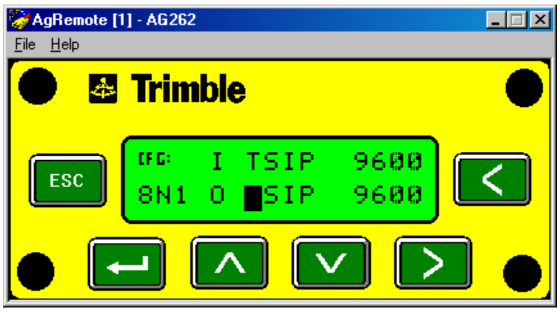
Click **>** until **`Configuration`** then **V** once, then **>** until **`Port A Config`**:

Click **V** to enter Port A configuration:

Click **>** until cursor reaches **O** in **8O1**, then click **V** once to make it **N** (no parity)

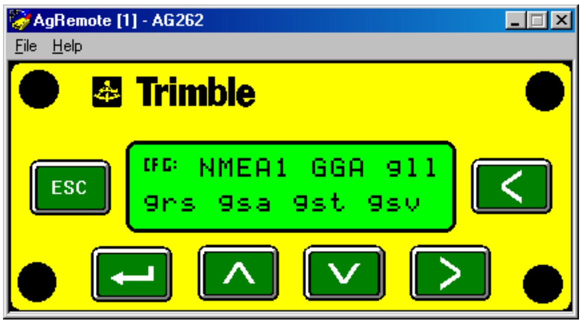


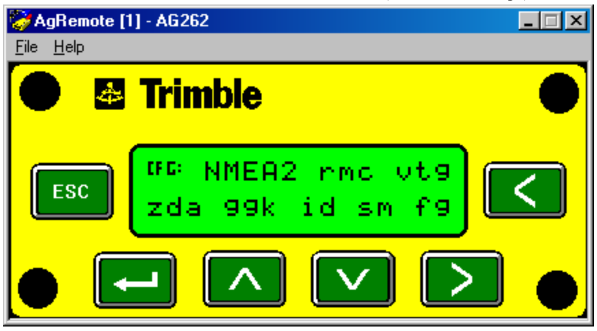
Click **>** until cursor reaches **TSIP**, then click **V** until you get **NMEA**



If the baud rate is not 9600, then change it
Press ← (Enter) to terminate edit mode

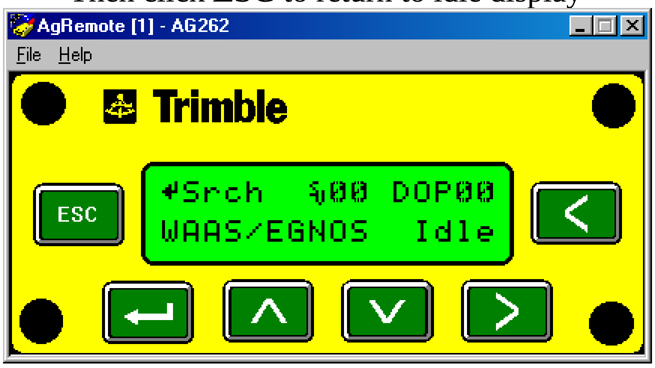
Click **V** to check the NMEA message settings, which should be as follows (GGA only):





Click **V** to get to:

Then click **ESC** to return to idle display



Then Choose [File] – [Disconnect] and exit the AgRemote program.

Switch off the GPS
Connect signal cable to port A
Check the GPS with DDC

10.1.3 Trimble BX982, Ver. 85992-01 (Basic Version) Setup

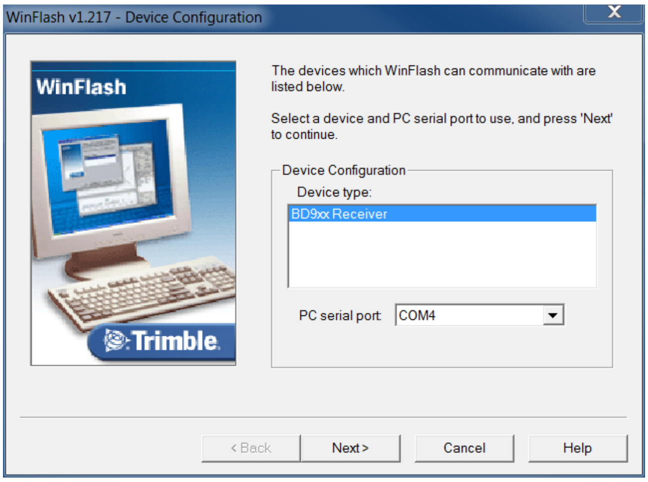
Download WFC-BD9xx-V494.exe from this web site:
http://intech.trimble.com/support/oem_gnss/trimble_bd982

Install on a computer on the usual 192.168.1.xxx network.

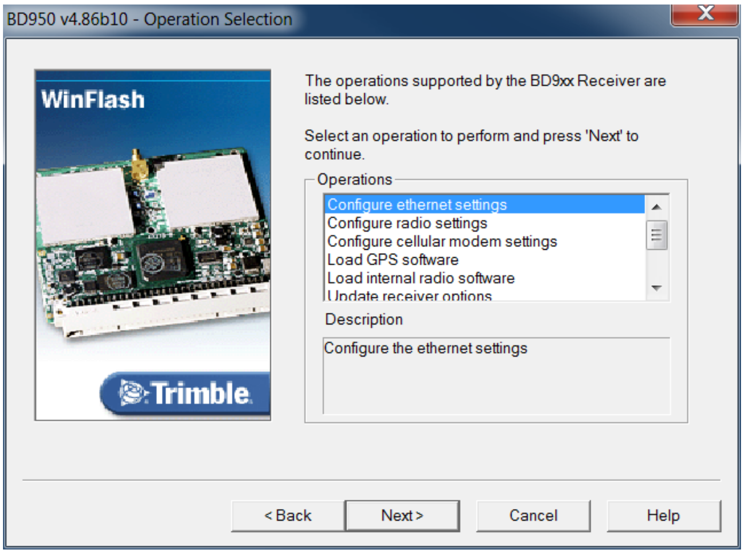
Connect a Serial cross over cable to PORT4 at the BX 982

Connect an Ethernet cable to the BX 982 “Dongle”

Start WinFlash and set the COM port for your computer:



Chose “Configure ethernet settings”:



Click “Next” then “Finish”

The program now tries to communicate via COM

The default setting is DHCP

Change that to “Static IP address”

and enter IP Address: 192.168.1.19

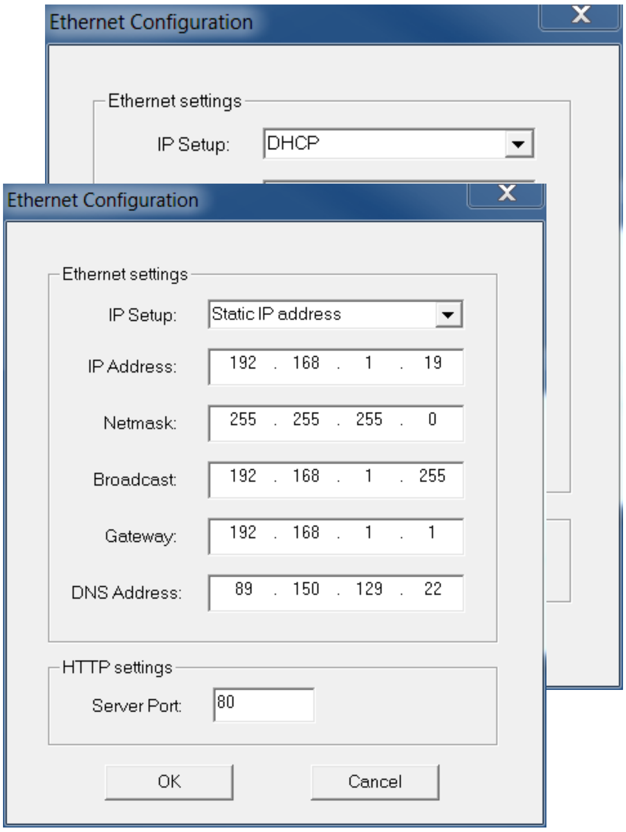
Press OK and the BX 982 will reboot

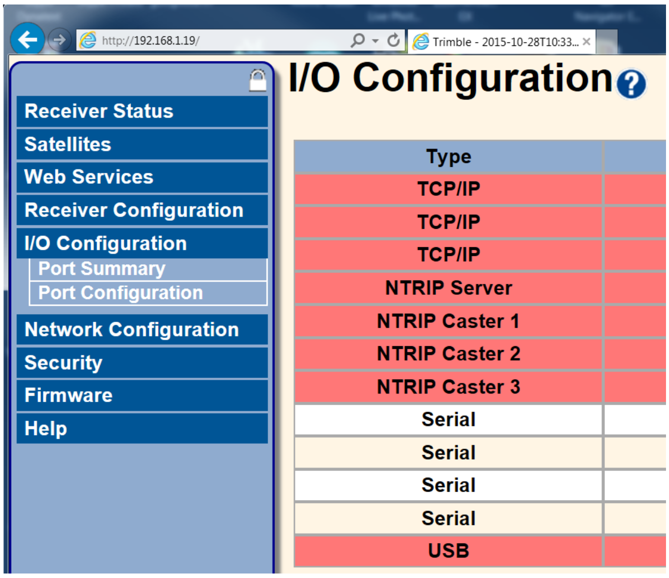
Exit WinFlash

Open an Internet browser and enter 192.168.1.19 in the address line

User name: admin

Password: password

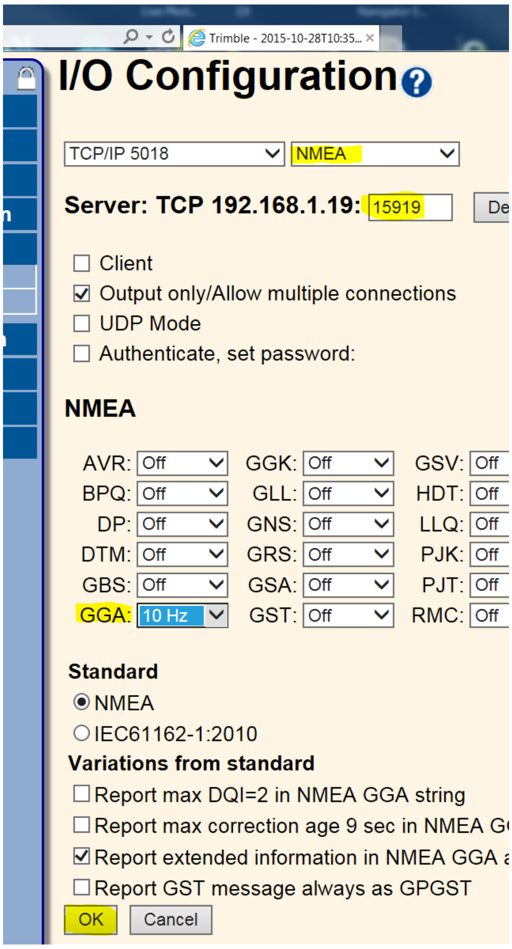




In I/O Configuration click one of the TCP/IPs

Chose: **NMEA,** Listen port: **15919, GGA** at **10 Hz**

Press OK

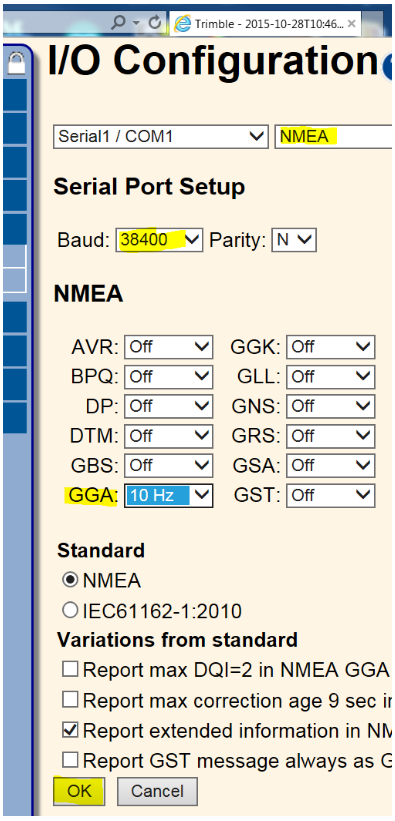


Chose Serial COM1 and setup for

NMEA, 38400 Baud, GGA at 10Hz

And Press OK

Close the browser



Start DDC with GPS applet colored

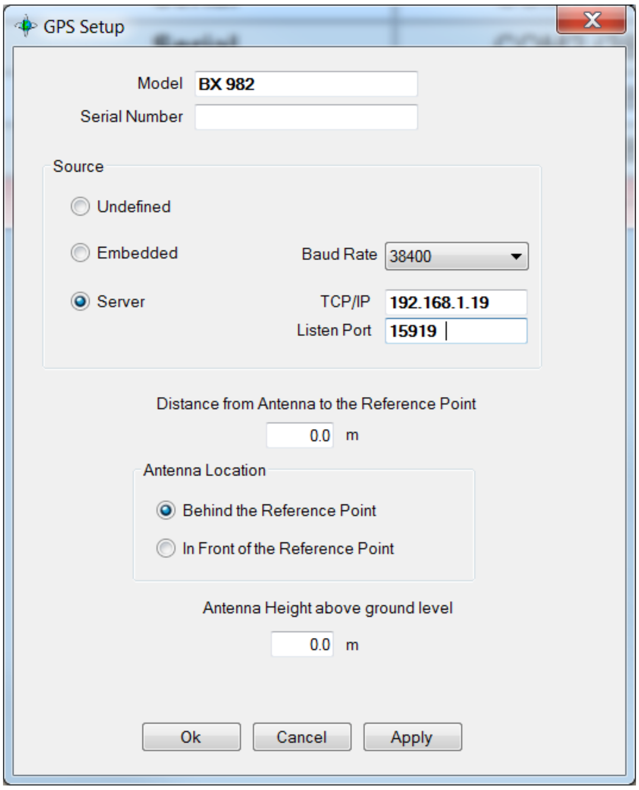
Right click the GPS window and chose [Setup]

Set Server to 192.168.1.19 and Listen port 15919

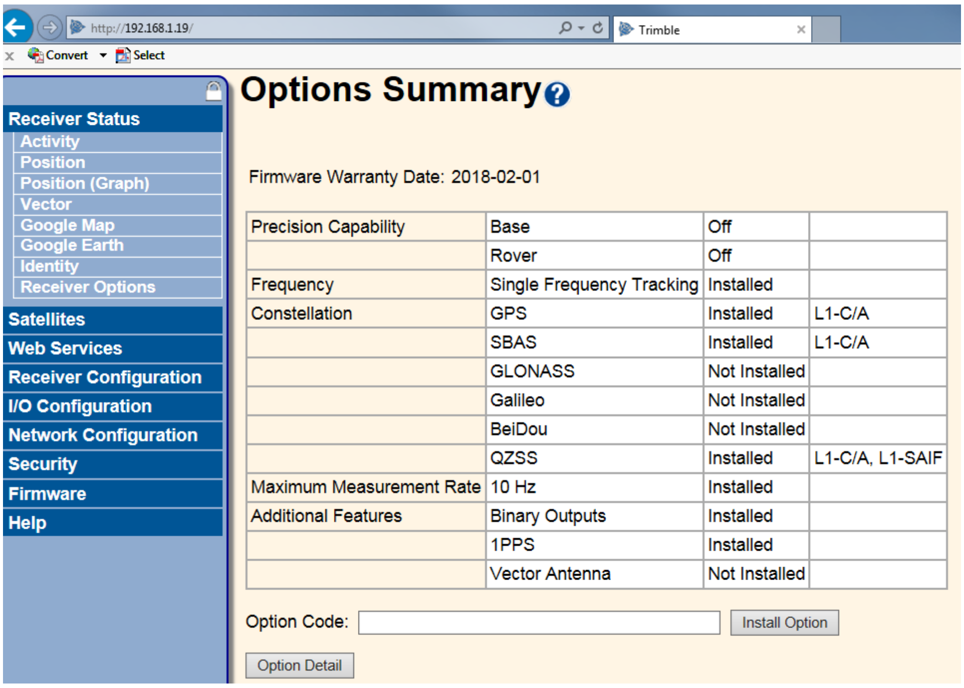
Enter figures for antenna position.

(there will be two Distance from Antenna fields, one for FWDs and one for RSPs)

For standard GPSs the “Reference Point” is the location of the Antenna. For Applanix the Reference Point can be chosen freely. For an RSP this will typically be the Laser spot produced by the Center Line laser or the center of the IMU unit.



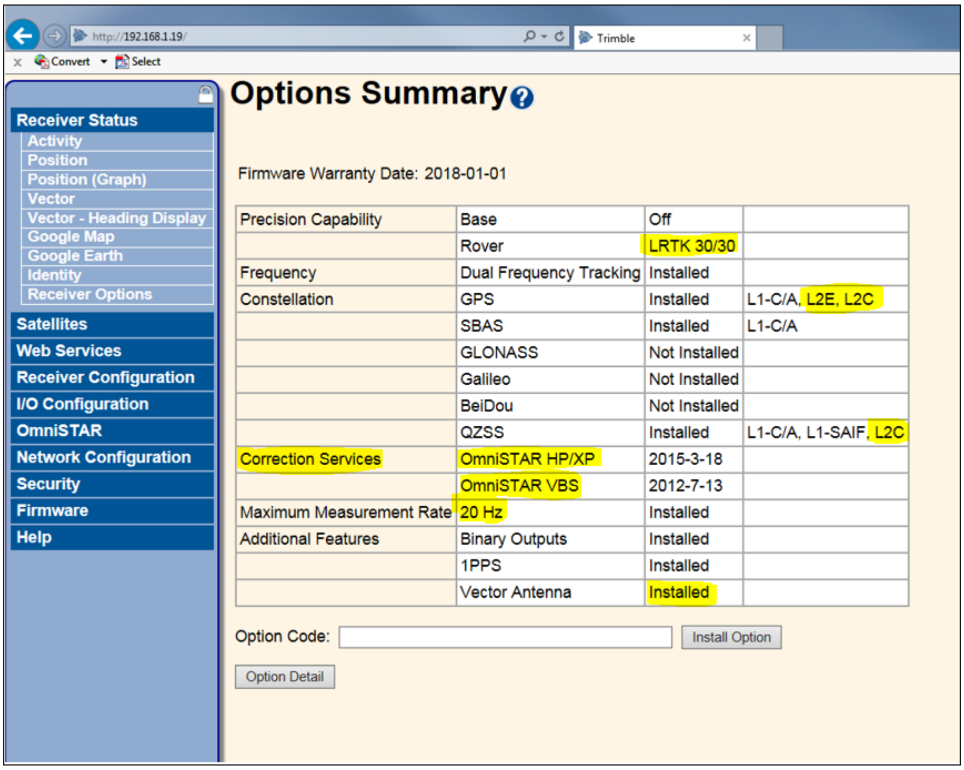
When the setup (of a standard, basic version BX982, Version 85992-01) has been completed, the Options Summary should look like this:



10.1.4 Upgrading a BX982 to Ver. 85992-02

To upgrade a ver. 85992-01 (which has been set up as described above) to a ver. 85992-02, do the following:

1. Use the equipment laptop PC (or a computer with the usual 192.168.1.xxx network)
2. Connect an Ethernet cable to the BX 982 “Dongle”
3. Open a web-browser and type 192.168.1.19 in the address field
4. Press “Enter”
5. Click “Receiver Status”
6. Click “Receiver Options”
7. Enter the supplied Password / Code in the “Option Code” field
8. Press the “Install Option” button, which should result in an updated “Options Summary” window as shown below
9. Check additions marked with yellow highlighting



Options Summary

Firmware Warranty Date: 2018-01-01

Precision Capability	Base	Off	
	Rover	LRTK 30/30	
Frequency	Dual Frequency Tracking	Installed	
Constellation	GPS	Installed	L1-C/A, L2E, L2C
	SBAS	Installed	L1-C/A
	GLONASS	Not Installed	
	Galileo	Not Installed	
	BeiDou	Not Installed	
	QZSS	Installed	L1-C/A, L1-SAIF, L2C
Correction Services	OmniSTAR HP/XP	2015-3-18	
	OmniSTAR VBS	2012-7-13	
Maximum Measurement Rate	20 Hz	Installed	
Additional Features	Binary Outputs	Installed	
	1PPS	Installed	
	Vector Antenna	Installed	

Option Code: Install Option

Option Detail

10.2 IMS

10.2.1 Watson AHRS-304 Installation

1. Connect the IMS unit to the primary connection module inside the transducer beam (‘Gyro’ socket).

2. Connect the RS232 cable from the primary connection module (‘RS232’ socket) to the computer (COM1 or higher).

3. Connect the RSP SCSI cable(s) and switch on the computer.

4. Start a terminal program like ‘Hyper Terminal’ and set the appropriate COM port for 9600 baud, eight data bits, one stop bit and no parity.

5. After switching on the RSP system, you should see a message similar to the following:

```
AHRS-BA303 INITIALIZING
    SERIAL NUMBER - 0097
    LAST CALIBRATED - 01/21/98
    SOFTWARE VERSION - AH3.4D4
    COPYRIGHT (C) 1990 THROUGH 1996
    WATSON INDUSTRIES, INC.
I +000.2 -00.4 303.1 -00.0 -00.2 -00.0 +120 +179 +402 +28
```

6. The unit must now be placed in 'Command Mode'. Switch the RSP system off, and then wait for a minimum of 10 seconds.

7. Make sure the terminal program is ready, and then switch on the RSP and immediately after the ‘WATSON INDUSTRIES, INC’ message press **SPACEBAR** twice.

8. Wait until the data line (bottom line in step 5 above) starts updating.

9. If the bottom line in step 5 shows something like: ˆñ…ªêÕ‰£• ¸†ž- , then press _ (underscore). That will change the format from binary to readable ASCII.

10. Press the ‘**&**’ key and you should see:

```
TYPE IN THE NUMBER OF YOUR SELECTION (OR 'Q' TO QUIT):
    1 = ADJUST TIME CONSTANTS
    2 = SET OUTPUT CHANNELS
    3 = LIST CURRENT OUTPUT CHANNEL SELECTION
    4 = SET NEW BAUD RATE
```

    Press ‘2’

11. The following procedure specifies which parameters or channels to output:

```
TO SET FOR OUTPUT FOR ANY OF THE FOLLOWING DATA ITEMS, PRESS Y
 TO AVOID ANY OF THE FOLLOWING DATA ITEMS, PRESS N
 TO QUIT AND DISREGARD ANY OTHER DATA, PRESS Q

 ***  DO YOU WANT TO PROCEED?  (Y/N/Q)
```

    Press ‘Y’

12. The IMS now presents several parameters of which only seven should be chosen by pressing '**Y**', for all other parameters press 'N'. The desired parameters are:

```
DO YOU WANT OUTPUT OF BANK ANGLE DATA? Y
DO YOU WANT OUTPUT OF ELEVATION ANGLE DATA? Y
DO YOU WANT OUTPUT OF HEADING ANGLE DATA? Y

DO YOU WANT OUTPUT OF Z AXIS ANGLE RATE DATA?  Y
DO YOU WANT OUTPUT OF HEADING ANGLE RATE DATA?  Y

DO YOU WANT OUTPUT OF FORWARD VELOCITY DATA?  Y
DO YOU WANT OUTPUT OF TEMPERATURE DATA?  Y

Y = GOBACK, N = INSTALL DATA & QUIT, Q = QUIT
DO YOU WANT TO TRY TO SET DATA AGAIN?  N
```

Press 'N' and then ENTER

13. Press '**&**' to enter the primary menu:

```
TYPE IN THE NUMBER OF YOUR SELECTION (OR 'Q' TO QUIT):
    1 = ADJUST TIME CONSTANTS
    2 = SET OUTPUT CHANNELS
    3 = LIST CURRENT OUTPUT CHANNEL SELECTION
    4 = SET NEW BAUD RATE
```

14. Press '3' to verify the settings

15. The list of parameters should now look like this:

```
THE FOLLOWING CHANNELS ARE CURRENTLY SELECTED:

DATA CHANNEL            F. S. DECIMAL    F. S. BINARY

BANK ANGLE              +/-180 Deg       +/-180 Deg
ELEVATION ANGLE         +/-90 Deg        +/-180 Deg
HEADING ANGLE           0 to 360 Deg     0 to 360 Deg
Z AXIS ANGLE RATE       +/-100 Deg/Sec   +/-200 Deg/Sec
HEADING ANGLE RATE      +/-100 Deg/Sec   +/-200 Deg/Sec
FORWARD VELOCITY        +/-400 Km/Hr     +/-800 Km/Hr
INTERNAL TEMPERATURE    -40 TO +88 C     -40 TO +88 C (8 BIT)
```

16. Finally choose '**Q**' to return to normal operating mode. The continuously updated output from the unit should now look like:

```
I +000.3 +00.0 027.8 +00.0 +00.0 +199.9 +33.1
```

17. Press ^ (caret) to change the data output format back to binary, like: ˆñ…ªêÕ‰£• ¸†ž-

18. **IMPORTANT:** Now press **"** (double quote) to permanently store the settings inside the IMS unit.

19. Close the terminal program.

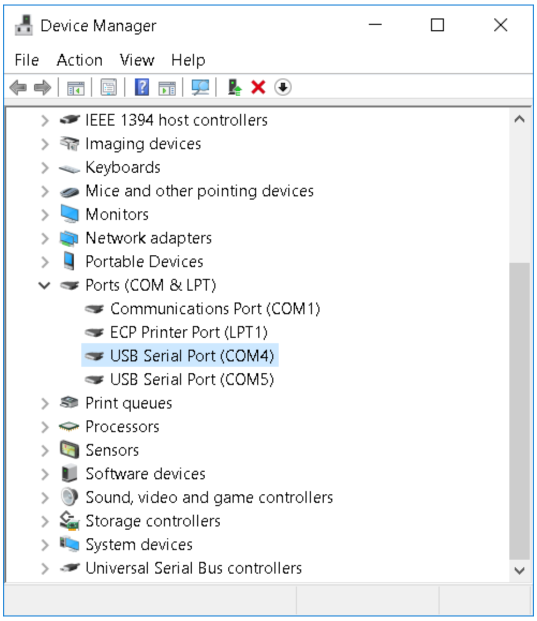
20. Disconnect the serial cable from the Computer and (re-) connect to the DPU COM2 socket.

10.3MFV

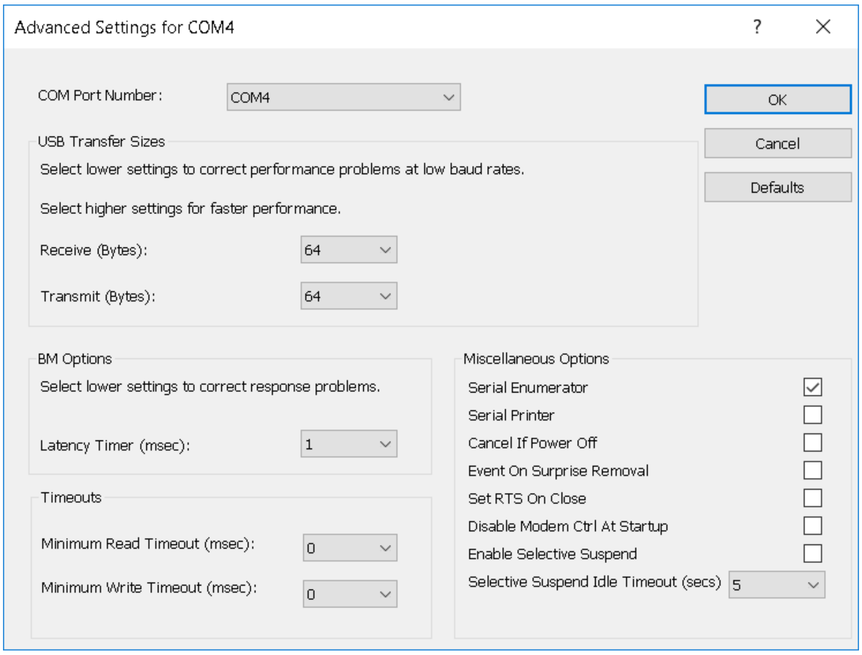
10.3.1EnCam & EncIf

A Multi Function Vehicle may include an EnCam (Camera Encoder Interface) and/or an EncIf (System Encoder Interface) device. Here both devices are in one panel:

Both devices are USB based but appear as COM ports in the computer's "Device Manager".
Open Control Panel - Device Manager and identify the COM ports allocated for the devices.



Right click each and go Properties – Port Settings – Advanced. Make sure that the Receive and Transmit bytes are set to 64 and that Latency Timer is 1 (lowest values).



10.4 Cameras

10.4.1 Mounting

Figure 40 ROW Camera Suction Disc Mount

Clean the suction disk

Clean the window

Pull back the plastic housing to protrude the rubber suction disk

Press the rubber suction disk firmly against the window.

Apply suction with the lever and lock in position.

Adjust focus and aperture.

10.4.2 Exposure

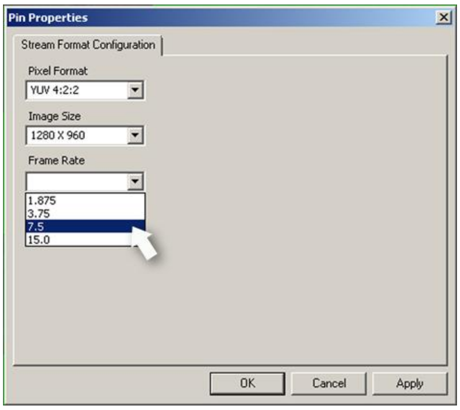
Aperture Adjustment
Shutter Speed and Field of Depth depends on the F-stop setting, the size of the aperture opening. The lens aperture ranges from F 1.4 to F 22 typically
Smaller F-stops numbers = larger opening.
Larger openings = more light.
Larger openings = faster shutter speed.
Larger openings = narrows the Field of Depth. Background and foreground becomes blurred, out of focus.

Balancing Shutter and Aperture
F stop 4 is a good all-round setting. On bright sunny days this gives fast shutter speed, to avoid motion blur, together with “full” Field of Depth.
On dark overcast days and when approaching sunset you can continue to drive as fast as the trucks do and produce good sharp images.
Shutter is defined as the integration time of the incoming light where both the Manual and Auto Shutter are supported.
The shutter range varies from 1us ~ 3600sec.

Camera Auto Exposure Control
The automatic shutter/gain mode is based on a feedback loop which calculates the average pixel luminance. Then the average is compared with the exposure reference value, adjusting shutter and gain accordingly.

10.4.3 Unibrain Camera

Unibrain Fire-i™ 780c 1394b SXGA, 2/3" CCD camera with a 12.5mm Fujinon C-mount "Megapixel lens".



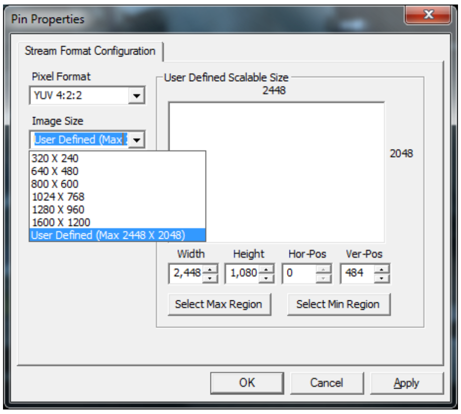
Right click the Camera applet and chose "Picture Format"

Values shall be:

Pixel Format: YUV 4:2:2

Image Size: 1280 x 960.

Fire-i 780c Frame Rate 7.5 (Frames/Sec).

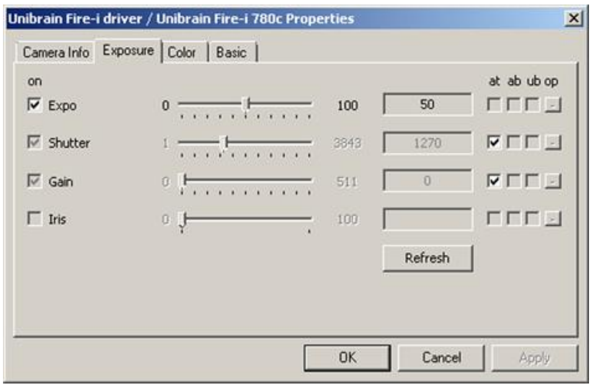


Unibrain Fire-i 980c

Max resolution 2448 x 2048 pixels.

The following items are normally "one-time adjustments" only, or should be done if any unusual problems with picture focusing or brightness occur.

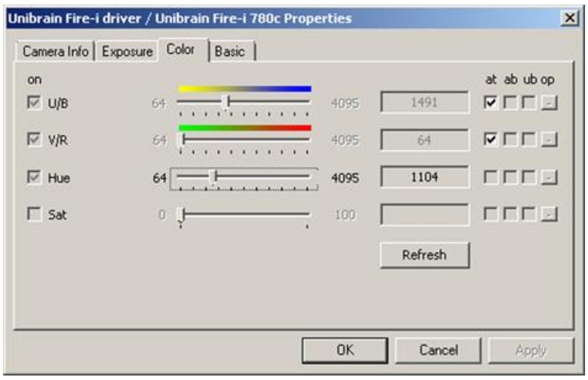
Park the vehicle and make sure to have an object (preferably vertical) with some text on it (a road sign, a paint bottle or the like) some 10-15m from the camera.
Boot the system, so that ROW pictures are shown on the monitor.
Right-click on the ROW picture and select "Aspect/Size", then select "Full Screen".
Right-click on the ROW picture and select "Camera Settings" and then "Exposure"



For “Shutter” as well as for “Gain”, check the “at” box.

Expo: Regulates the total amount of light. Can be used to regulate the overall “lightness / darkness” of the pictures.
Shutter: and Gain: With check marks in Shutter and Gain “at” the camera automatically adjusts the optimum exposure value.

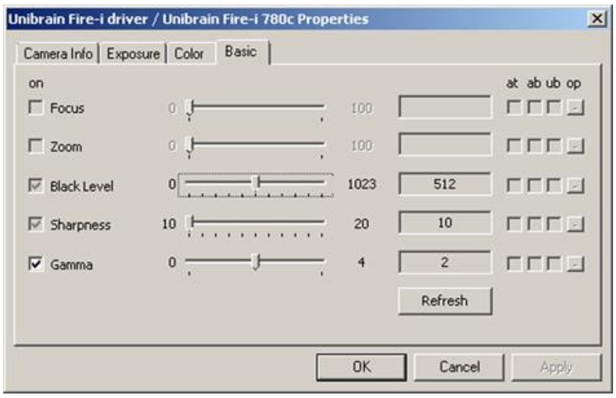
Right-click on the ROW picture and select “Camera Settings” and then “Color”.



For “U/B” as well as for “V/R”, check the “at” box

Color (White Balance):
With check marks in U/B and V/R the camera automatically adjusts correct color balance.
U/B Ultraviolet-Blue.
V/R Visible-Red.
Hue: Can be used to adjust overall color cast of the pictures.

Right-click on the ROW picture and select “Camera Settings” and then “Basic”.



Black Level: Adjust brightness and tonal range by specifying the location of complete black.
Sharpness: Sharpening enhances the definition of edges in an image. Too high setting will create “noise” in the picture.
Gamma ~ “Brightness”.
Corrects the ratio between maximum light (white areas) and minimum light (black areas) in the picture.
If too high “contrast” in your picture adjust gamma down.

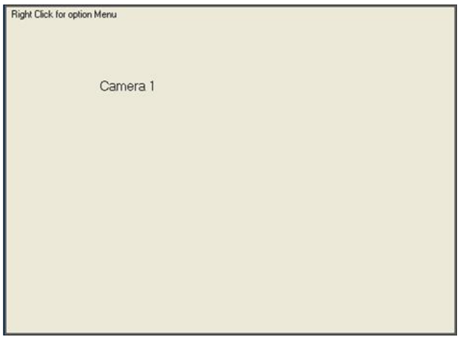
If necessary (normally a one-time adjustment), adjust the focus manually as follows:

a) Loosen the f-stop ring locking screw and set the f-stop to the minimum No. (1.4), i.e. maximum aperture opening (maximum light)
b) Then loosen the focusing ring locking screw and adjust the focusing till you get max. sharpness of the object 10-15m away
c) Lock the focusing ring lock screw
d) Set the f-stop No. to 4
e) Lock the f-stop ring locking screw

It is recommended that the Focus Adjustment is done with camera image displayed on the monitor in the camera chip’s native size.
Unibrain Fire-i 780c: 1280x960 pixels.
Unibrain Fire-i 980c: “Panoramic View”, typ. 2448x1080 pixels.

Dynatest®

10.4.4 Unibrain Troubleshooting



Empty Image Holder

Camera has not been recognized by Windows.

Is the LED on the camera on?

Check all cable connections.

Power and connection ok and still empty Image Holder?

Drivers for laptops build-in web-camera may also be listed

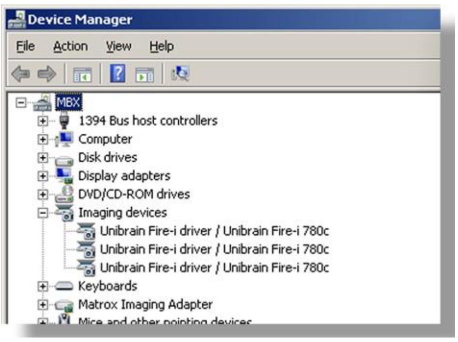
Right Click Image Holder.

In the pop-up Menu Click “Pick Camera”.

Choose “Unibrain Fire-I driver / Unibrain Fire-i 780c”.

Click OK.

Still no image?



Check Windows’ Device Manager -> Imaging devices.

Under “Imaging devices” the “Unibrain Fire-i driver…” must be listed.

If no “Imaging devices” listed, or only the laptop’s build-in web-camera?

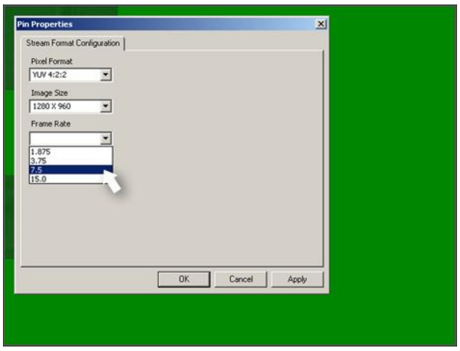
Check that the PC-card is in place.
Check cables for loose connections.
Reinstall drivers.

Scrambled / Distorted Image

Camera(s) working, signals received by DDC, but image are scrambled.

Right-Click image holder to bring up the menu.

Click “Picture Format”.



Frame Rate

Fire-I 780: Values should be:

Pixel Format: YUV 4:2:2

Image Size: 1280 x 960.

Frame Rate 7.5 (Frames/Sec).

11 Maintenance

Apart from the vehicle, the only moving/wearing parts of the RSP Test System are a ventilating fan and the distance encoder. Therefore, the need for maintenance of the RSP system itself is not extensive if it is operated and stored carefully.

On a routine basis, maintenance is normally limited to cleaning of the cover glass(es) of the laser displacement sensor(s), perhaps supplemented by a calibration check of all transducers as explained in the "Calibration" Section. Apart from this, the vehicle should of course be maintained as prescribed by the manufacturer.

The single board computer in the DPU of the RSP Mk III system holds a lithium battery that preserves the BIOS settings. When this battery runs out the RSP will stop functioning. If you experience continuous "Network Timeout" messages it may be caused by a drained battery.

11.1 Vehicle

- The vehicle should be maintained according to the manufacturer's recommendations.
- Check tire pressure regularly (to ensure minimum variation in DMI calibration.
- Keep all wheels/tires of the vehicle well balanced at all times (improper balance may affect measurement accuracy).
- Check acid level (and perhaps charging condition) of the Electronics Buffer Battery.

11.2 RSP System

WARNING!

When performing any maintenance in the area of the laser sensor(s), OBSERVE that the (invisible) laser beam(s) *will cause serious damage to a human eye if viewed directly*! As an additional precaution, keep the safety power key switch OFF whenever possible. NEVER switch ON power without assuring that nobody is close to (any of) the laser sensor(s)!

- Check that the rut-bar is level and horizontal and that all bolts etc. in the mechanical hardware connecting the Transducer Beam Unit to the front of the vehicle are tight.

- With the vehicle parked on a level and plane surface like e.g., a concrete floor, and when loaded like during testing, including the driver and possible other person(s), check that the vertical clearance between the underside of the Transducer Beam Unit and the (floor) surface is close to 290 mm. If more than 310 mm or less than 270 mm, loosen beam holding nuts and re-locate beam. Re-tighten nuts.

- Check tightness of ALL bolts in the bottom of the Transducer Beam Unit securing the laser sensor module(s) (please observe ***WARNING*** above!!), other modules and cap plates.

- Check and clean if necessary the cover glass(es) of the laser sensor module(s). Use pre-moistened Lens Cloth Wipes / Cleaning Tissues. If not available, use first a wet, then a dry, soft tissue for the cleaning (please observe ***WARNING*** above!!).

- In case of a wheel mounted distance encoder, check that the mechanical adapter connecting the encoder unit to the wheel of the vehicle is not loose. Re-tighten if necessary.

- Check that the distance encoder cannot be moved in the axial direction of the adapter.

- Perhaps also disconnect the flexible distance encoder-retaining arm from its attachment piece to the vehicle chassis and check that the encoder can be rotated easily (as far as it will go without straining the cable).

- Check all cables and connections.

- Perhaps calibrate the distance measurement (as described in the "Calibration" section).

- Perhaps calibrate the Laser Displacement Sensor(s) (as described in the "Calibration" section).

- Perhaps calibrate the Accelerometer(s) (as described in the "Calibration" section).

- Perhaps calibrate the (optional) Inertial Motion Sensor (as described in the "Calibration" section).

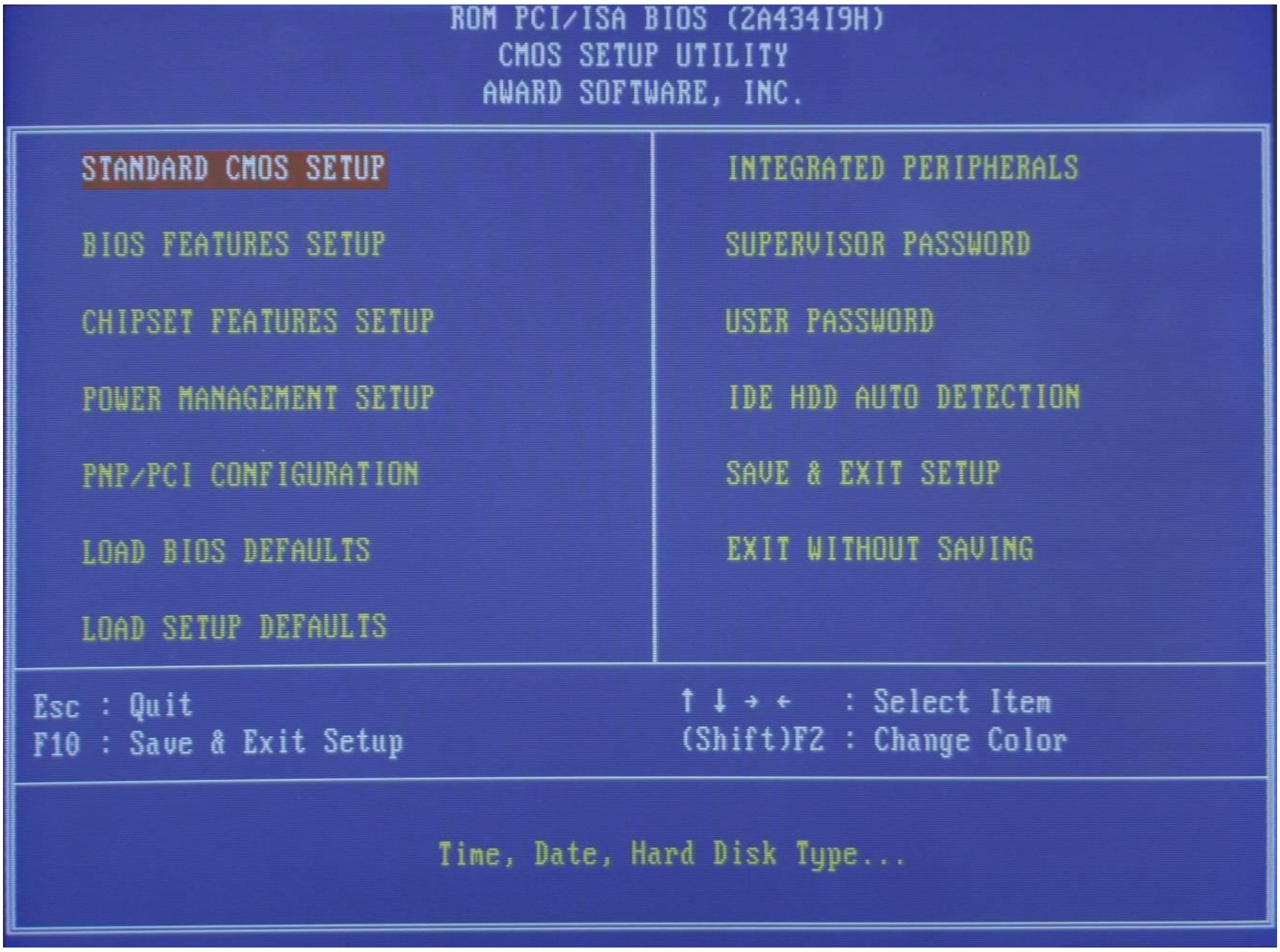
11.3DPU Lithium Battery

The single board computer in the DPU of the RSP Mk III system holds a CR2032 lithium battery. When this battery runs out the RSP will stop functioning, the symptom being continuous "Network Timeout" messages. If you suspect that the battery is drained, then

- Connect a VGA monitor and a keyboard to the DPU
- Switch on the DPU
- If you see the DOS boot up screens, then you need to exchange the CR2032

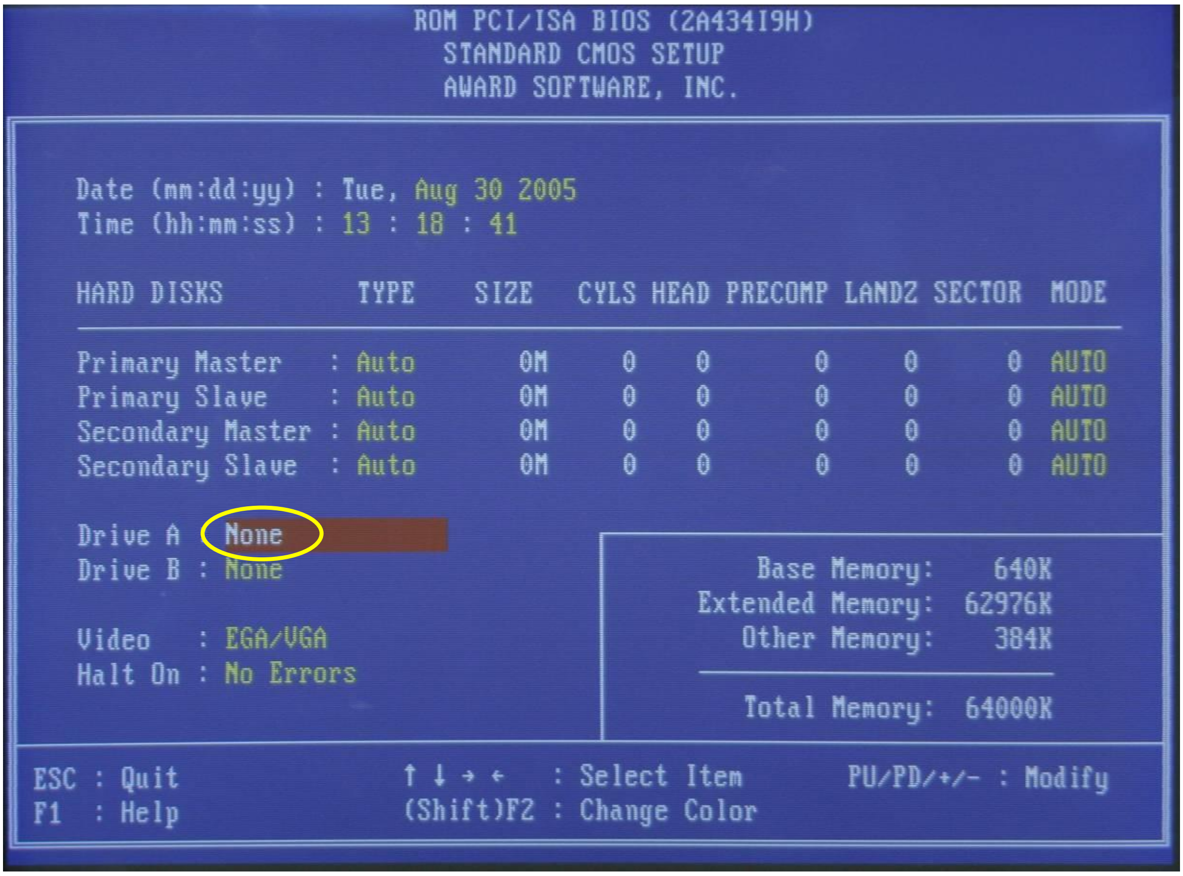
When the lithium battery is exchanged all bios settings are lost and you must reconfigure the board as follows:

- Connect a VGA monitor and a keyboard to the DPU
- Switch on the DPU
- Press the DELete key as soon as you hear a beep
- Your monitor should now show main SETUP window:

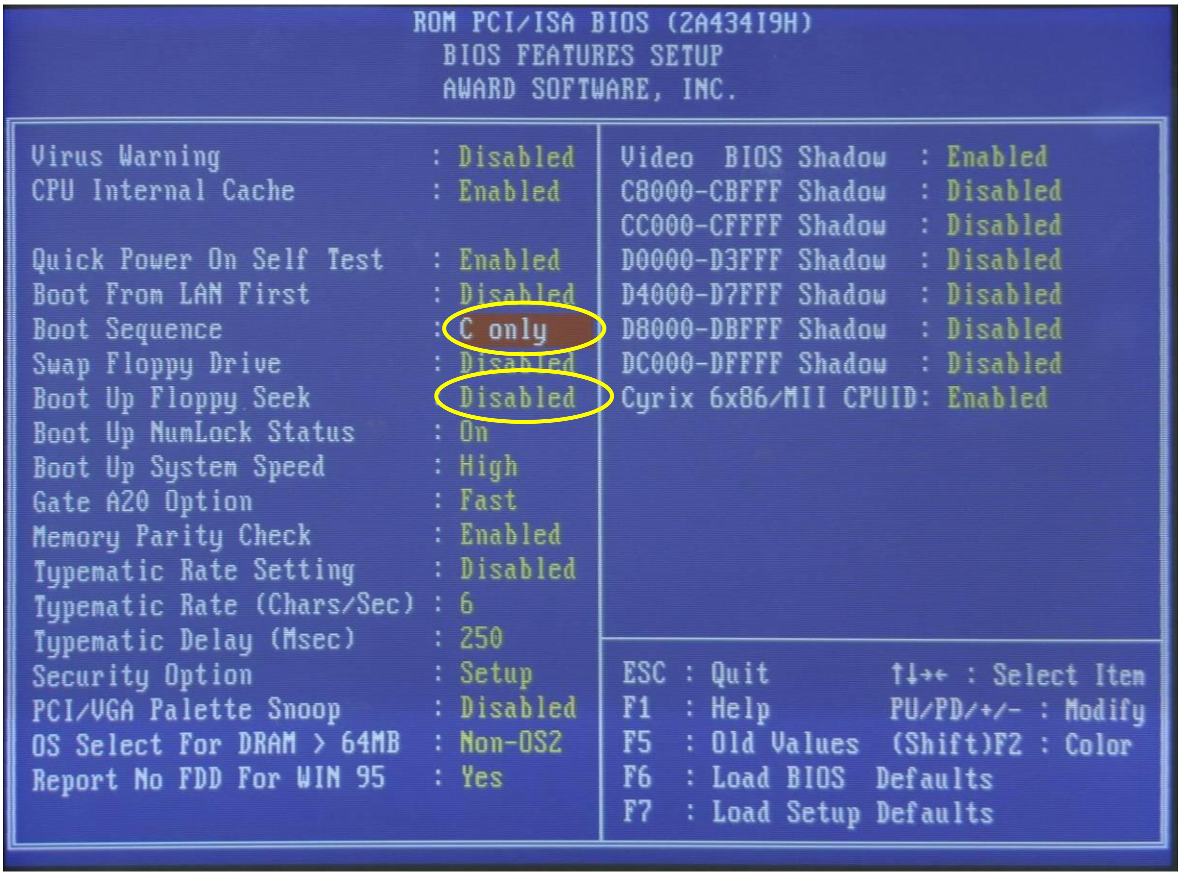


You will need to access STANDARD CMOS, BIOS FEATURES, CHIPSET FEATURES, PNP/PCI CONFIGURATION and INTEGRATED PERIFHERALS one by one and make changes as outlined in the following.

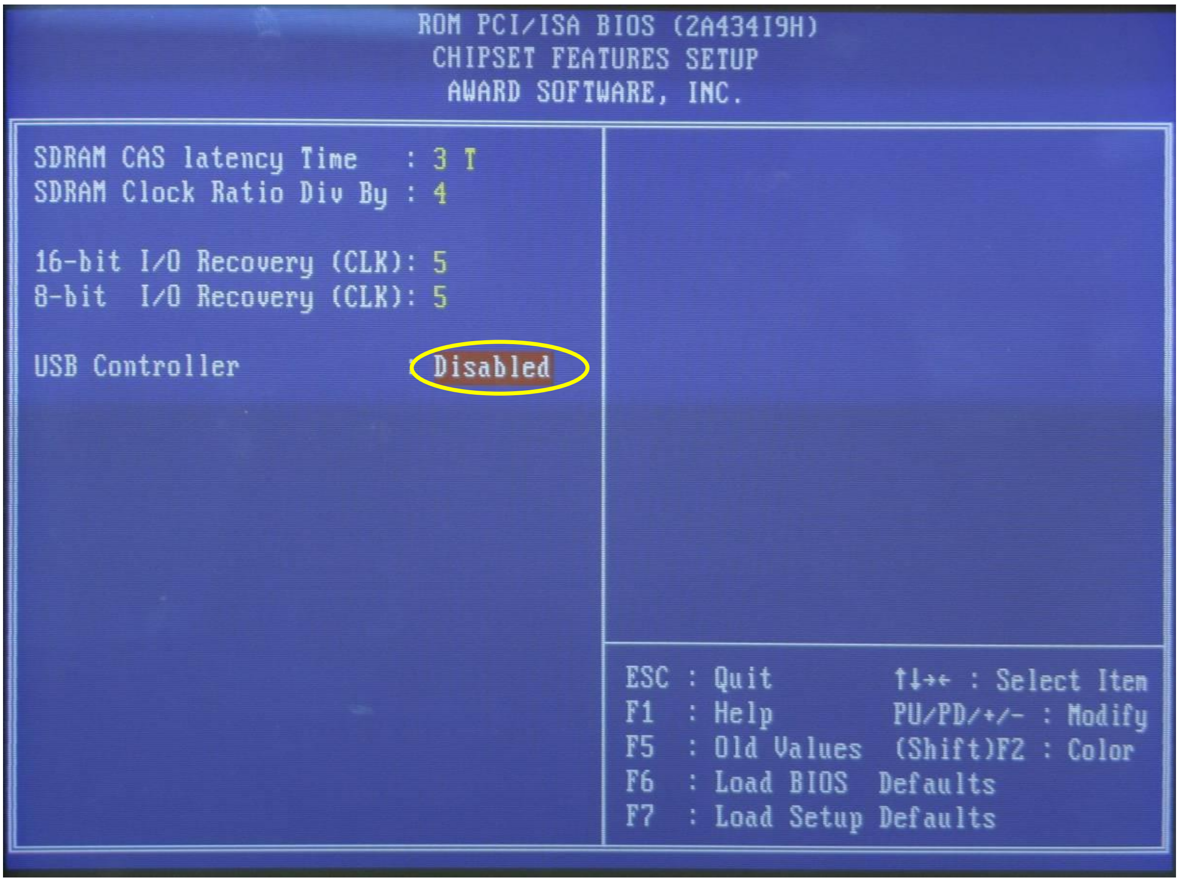
STANDARD CMOS SETUP



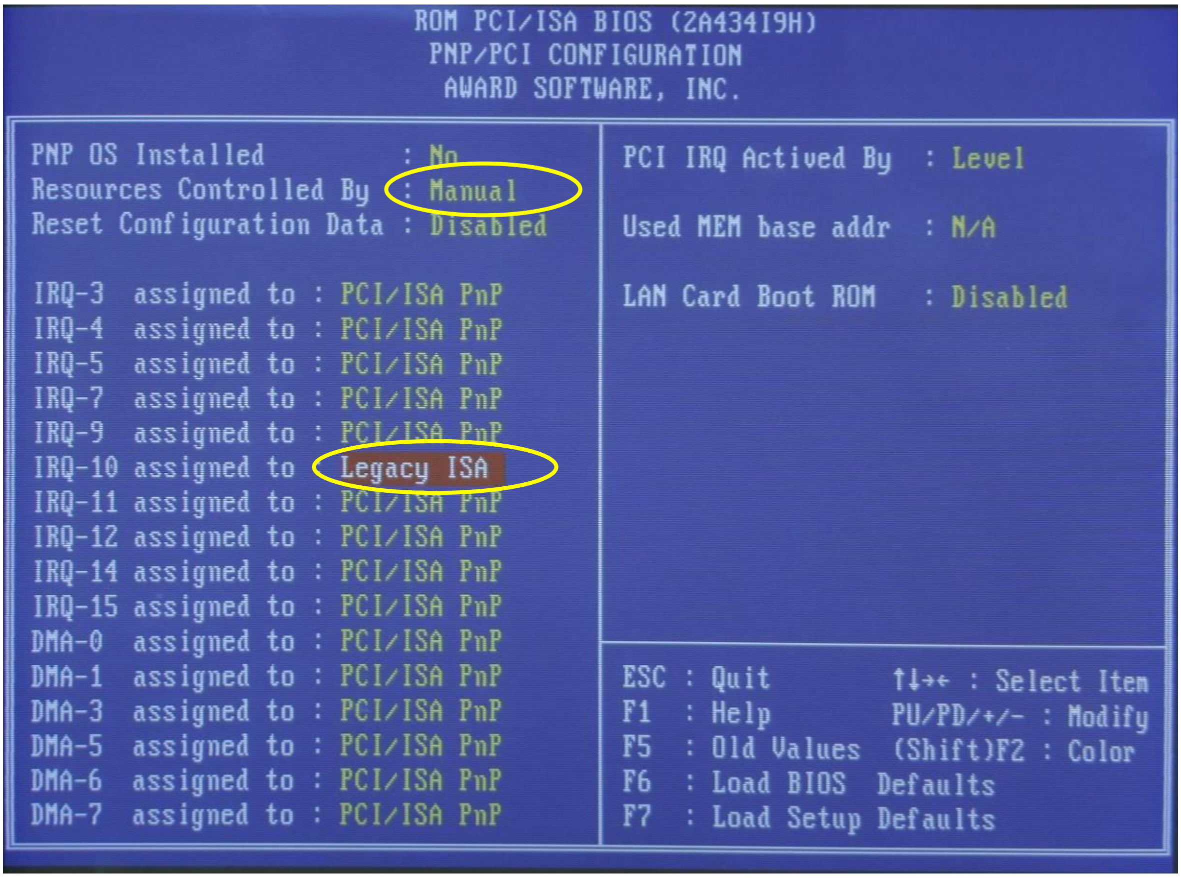
BIOS FEATURES SETUP



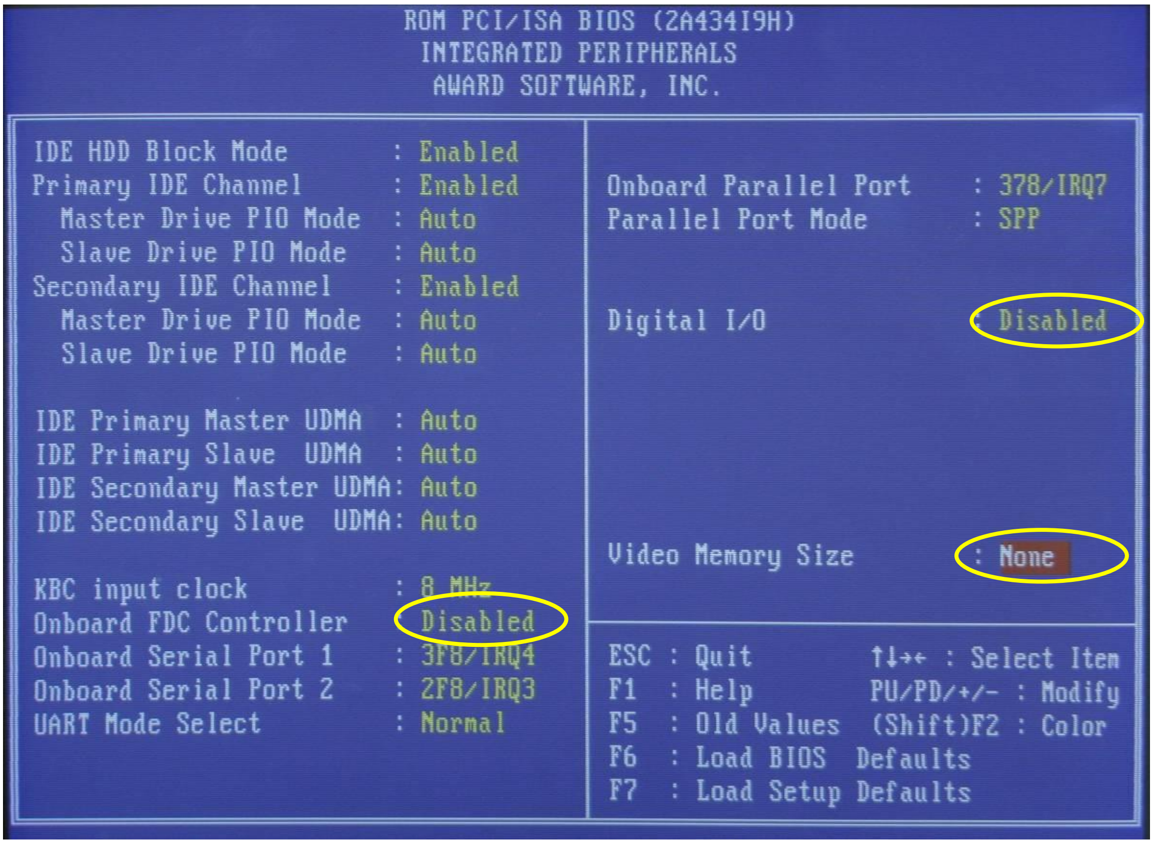
CHIPSET FEATURES



PNP/PCI CONFIGURATION



INTEGRATED PERIFHERALS



Finally choose SAVE & EXIT SETUP in the main setup window and confirm the decision. Switch off the system and then switch back on again.

IMPORTANT: Setting Video Memory Size to “None” means that the monitor will no longer show anything. If it does, then either the battery is still drained or the setup was not modified and stored properly.

11.4 Precautions for LCMS Units

Laser Heat

The plastic covers must be removed before firing the laser lights. The heat generated from the lasers will melt the plastic cover and form a smoke film on the lens, which will degrade the performance of the imaging system.

Cleaning

Lens cleaning tissues, cloths, brushes and fluids aren't harder than glass, but dust and dirt may be. Don't scratch. Don't wipe with a dry cloth. Always apply Solvents on some sort of tissue, never poured onto the glass. Distilled water, dishwasher, alcohol based or special lens cleaning fluids can be used.

12 Quick Start

This section provides abbreviated instructions to assist the operator in getting the RSP up and running quickly. This section assumes that the RSP computers and software have already been configured, that test setups have been created, and that all options have been previously configured.

12.1 Vehicle/Equipment Inspection

Prior to each data collection session, the operator should perform the following preparatory tasks:

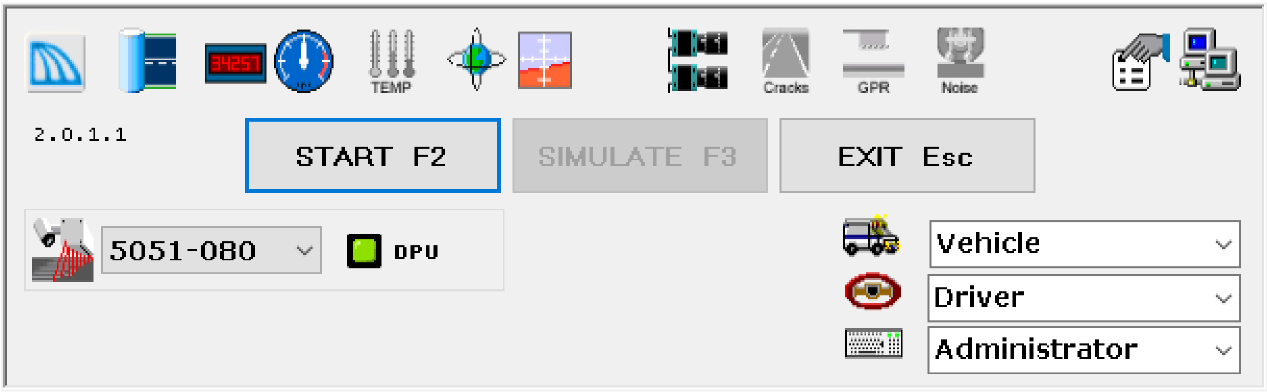
- ✓ Check tire pressures and adjust to manufacturers specifications
- ✓ Check tire condition (balance, roundness)
- ✓ Check the wheel encoder for movement. If the wheel encoder is loose, tighten the centre screw. If looseness persists, remove the wheel encoder from the vehicle hub and check mounting components for wear or damage. Looseness in the wheel encoder mount will adversely affect accuracy of profile/roughness data.
- ✓ Inspect laser sensor lenses for dirt, moisture, or damage. Clean if necessary. **Ensure that the laser sensors are POWERED OFF while inspecting and/or cleaning them.**
- ✓ Ensure that all computers are plugged into their respective power supplies
- ✓ Verify that the PC is connected to the DPU via an Ethernet cable
- ✓ Verify that the wheel encoder cable is connected to the RJ11 jack on the DPU
- ✓ Verify that the SCSI cable(s) is (are) connected to the DPU

12.2 Powering Up

- ✓ Start the vehicle
- ✓ Switch on the inverter
- ✓ Switch on the Pavemetrics Controller for the HDC Laser Cameras (optional)
- ✓ Switch on the Applanix Controller (optional)
- ✓ Boot the PC into Windows (do not start DDC at this time)
- ✓ WAIT for the PC to FINISH ALL booting work (a few minutes!)
- ✓ Power up the Data Processing Unit (DPU)
- ✓ Wait for the green link light on the Ethernet port of the DPU to appear, flashing “slowly”
- ✓ Start the Dynatest Data Collection Program
- ✓ Allow a few moments for the DPU to connect to the PC via the Ethernet cable. The activity light on the Ethernet port of the DPU should now be flashing “quickly”
- ✓ Turn the safety key switch to the “ON” position to supply power to the transducer beam
- ✓ Turn the safety key switch to the “ON” position to supply power to the LCMS Units
- ✓ Ensure transducer beam fan is running when power to the beam is switched on
- ✓ Ensure that each laser sensor projects a red spot on the pavement when power to the transducer beam is switched on

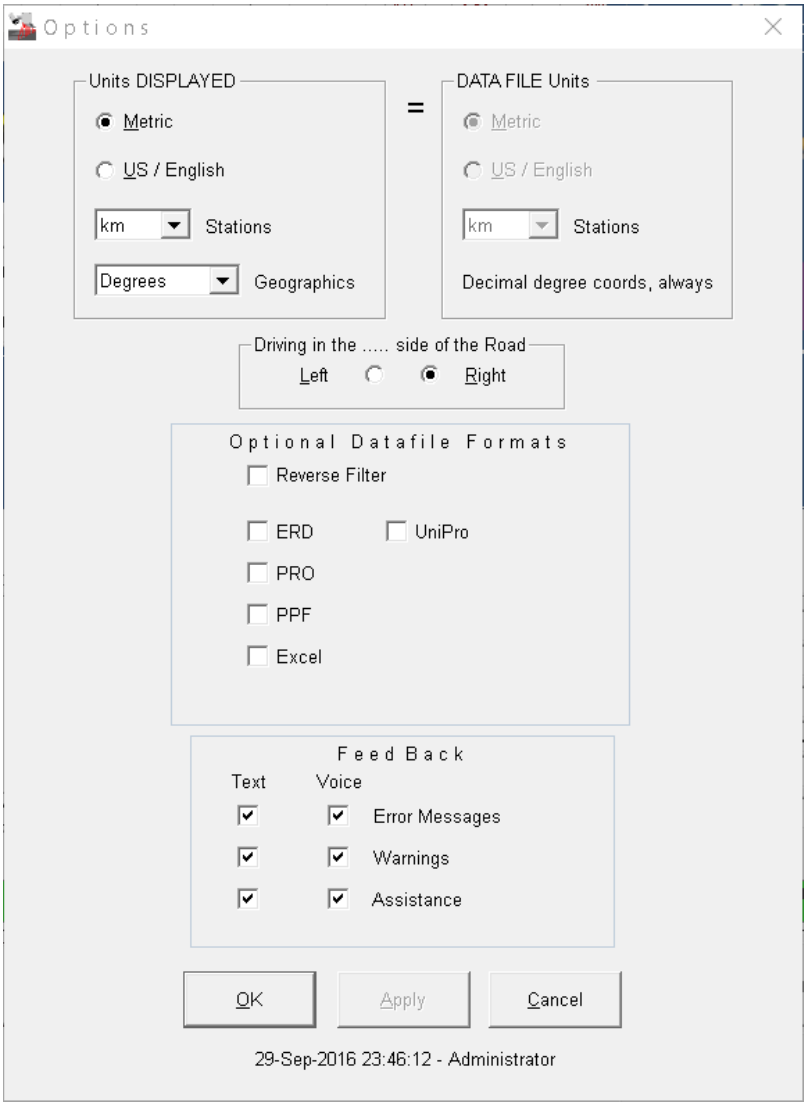
12.3 Start RspWin

- ✓ Verify that “Dynatest Data Collection” shows correct RSP equipment serial number (5051-???). Make sure the required applets are highlighted. Pick your name from the list of operators. Wait for the audio feed-back signal for the connection to the DPU / EPU before clicking “Start” to continue.

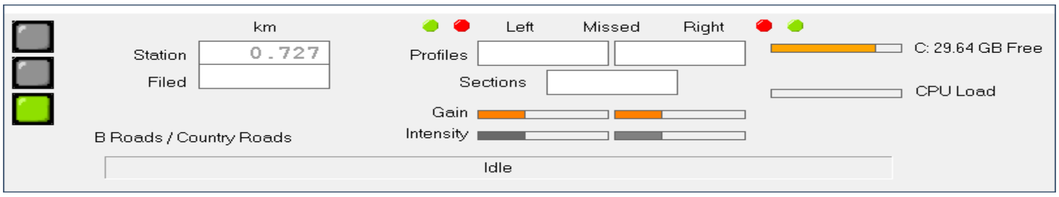


12.4 Configuring RspWin

✓ Select **Setup** > **Options** to configure the display and storage units and desired feedback modes.

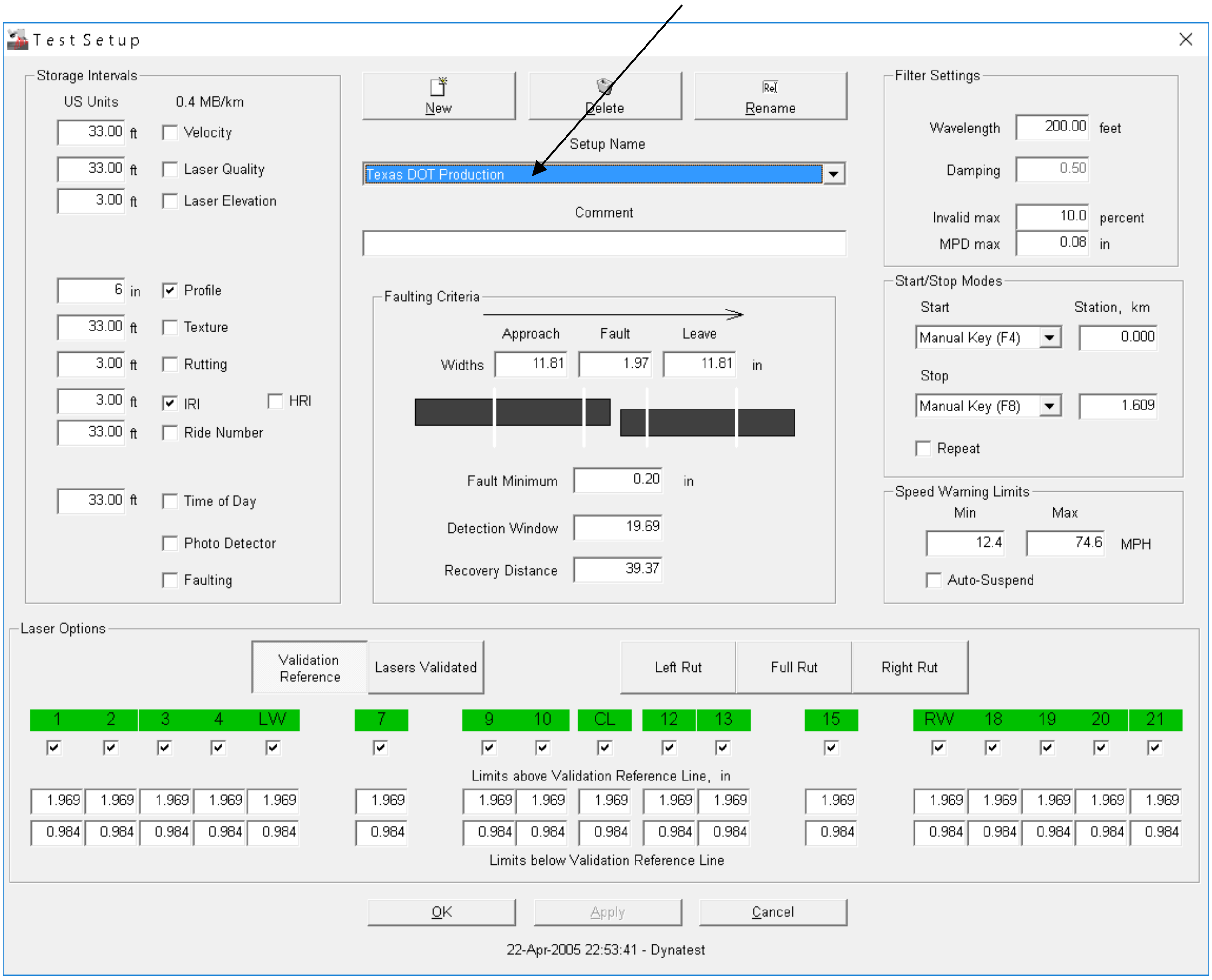


✓ If you have an HDC system, then you may also want to check the "System Parameters":



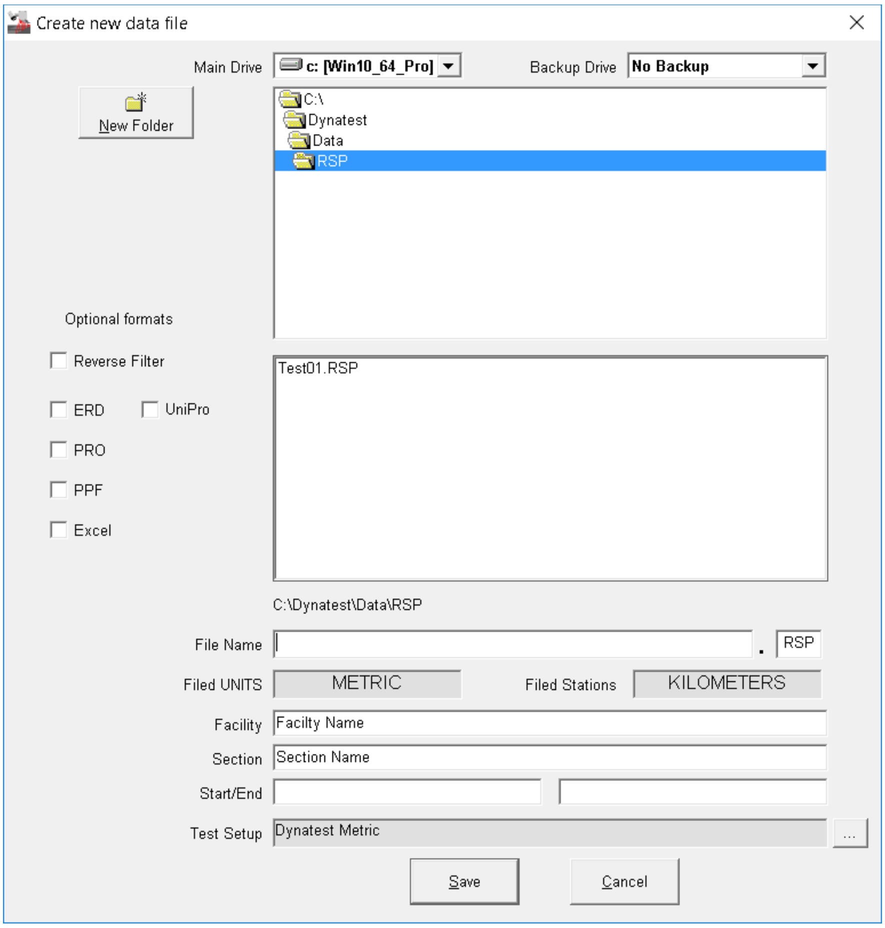
Red light	When system is not initialized or not ready to collect data Flashing when sections are lost during data collection
Yellow Light	Just before starting measurement.
Green Light	OK
Storage	Check for sufficient space on Main drive and Back-up drive.

✓ Select **Test Setup** and choose the relevant Setup Name.

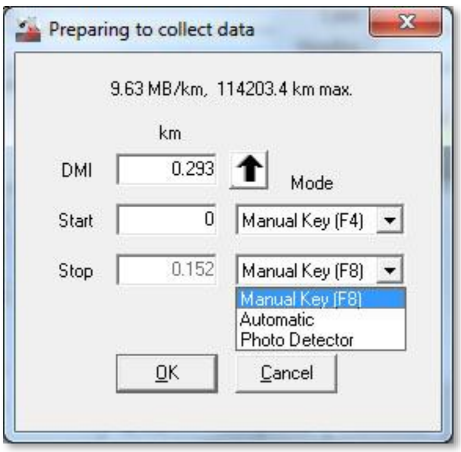


12.5 Collecting the Data

- ✓ Drive to the test site.
- ✓ Identify and physically locate the limits of the test section.
- ✓ Open a new data file by clicking the **File** > **New** menu item.



- ✓ Select a file folder for data storage
- ✓ Select, or “None”, Backup Drive
- ✓ Enter the file name and any other relevant location information.
- ✓ Click the **Save** button.
- ✓ Click the F2 “**Action**” button. The window shown below should appear.



- ✓ Select data collection start and stop modes. - Choices are Manual, Automatic and Photo Detector. If a Photo Detector is applied and selected for start and/or stop, then reflective tape or a white paint line will need to be placed on the pavement at the intended start and/or stop locations. Note that these options reflect what is stored in the active "Test Setup" but can be changed at this time.
- ✓ Enter values in the Start and Stop fields according to the following guidelines:

- **Manual Start:**
  - **DMI (Distance Measuring Instrument)** – doesn't matter. You might enter the current position (–0.200 indicating that there is around 200m to the start point).
  - **Start** – Enter the station/chainage value that you wish the RSP to assign to the start of the test section. This can be zero or any number corresponding to stationing or chainage from project plan sheets.
  - **Stop Mode**:
    - Manual:
      Stop – Doesn't matter – field is disabled
    - Automatic:
      Stop – Enter the station/chainage value for which you intend the RSP to automatically terminate data collection. This value is obtained by adding the length of the section to the Start value.
    - Photo Detector:
      Stop – Field is disabled.

- **Photo Detector** Start:
  - **DMI (Distance Measuring Instrument)** – doesn't matter. You might enter the current position (–0.200 indicating that there is around 200m to the start point).
  - **Start** – Enter the station/chainage value that you wish the RSP to assign to the start of the test section. This can be zero or any number corresponding to stationing or chainage from project plan sheets.
  - **Stop mode:**
    - Manual:
      Stop – Field is disabled.
    - Automatic:
      Stop – Enter the station/chainage value for which you intend the RSP to automatically terminate data collection. This value is obtained by adding the length of the section to the Start value.
    - Photo Detector:
      Stop – Field is disabled.

- o **Automatic** Start:
  - ▪ **DMI (Distance Measuring Instrument)** – value should accurately reflect the RSP's current location along the project.
  - ▪ **Start** – Enter the station/chainage at which RSP should initiate data collection. This can be zero or any number corresponding to stationing or chainage from project plan sheets.
  - ▪ **Stop Mode**
    - Manual:
      Stop – Field is disabled.

    - Automatic:
      Stop – Enter the distance value for which you intend the RSP to automatically terminate data collection. This value is obtained by adding the length of the section to the Start value.
    - Photo Detector:
      Stop – Field is disabled.

✓ Click OK to return to the Main window.

✓ Do the following, depending on the start method:
- o Automatic – No additional action is required. Data collection will be initiated when the DMI reading equals the intended starting value.
- o Manual – Click the F4 button or press the F4 key to initiate data collection at the appropriate location.
- o Photo Detector - arm the photo detector by left-clicking the F3 button or pressing the F3 key, then drive over reflective tape or paint stripe to initiate data collection. Take care not to arm the photo detector too early. This could cause premature start due to pavement markings.

✓ Continue driving the RSP until the end of the test section has been reached.

✓ Perform the following steps depending on the selected stop mode:
- o Automatic – No action is required to terminate data collection. Data collection will be terminated when the DMI value reaches the intended stop value.
- o Manual – Press the F8 key or left-click the F8 button at the appropriate stopping location.
- o Photo Detector – arm the photo detector by left-clicking the F3 button or pressing the F3 key, then drive over reflective tape or paint stripe to terminate data collection. Take care not to arm the photo detector too early. This could cause premature termination due to pavement markings. Data collection will be automatically terminated when the photo detector passes over the reflective tape or paint mark placed at the end of the test section.

The Esc key and the F8 key will terminate the section regardless of stop mode.

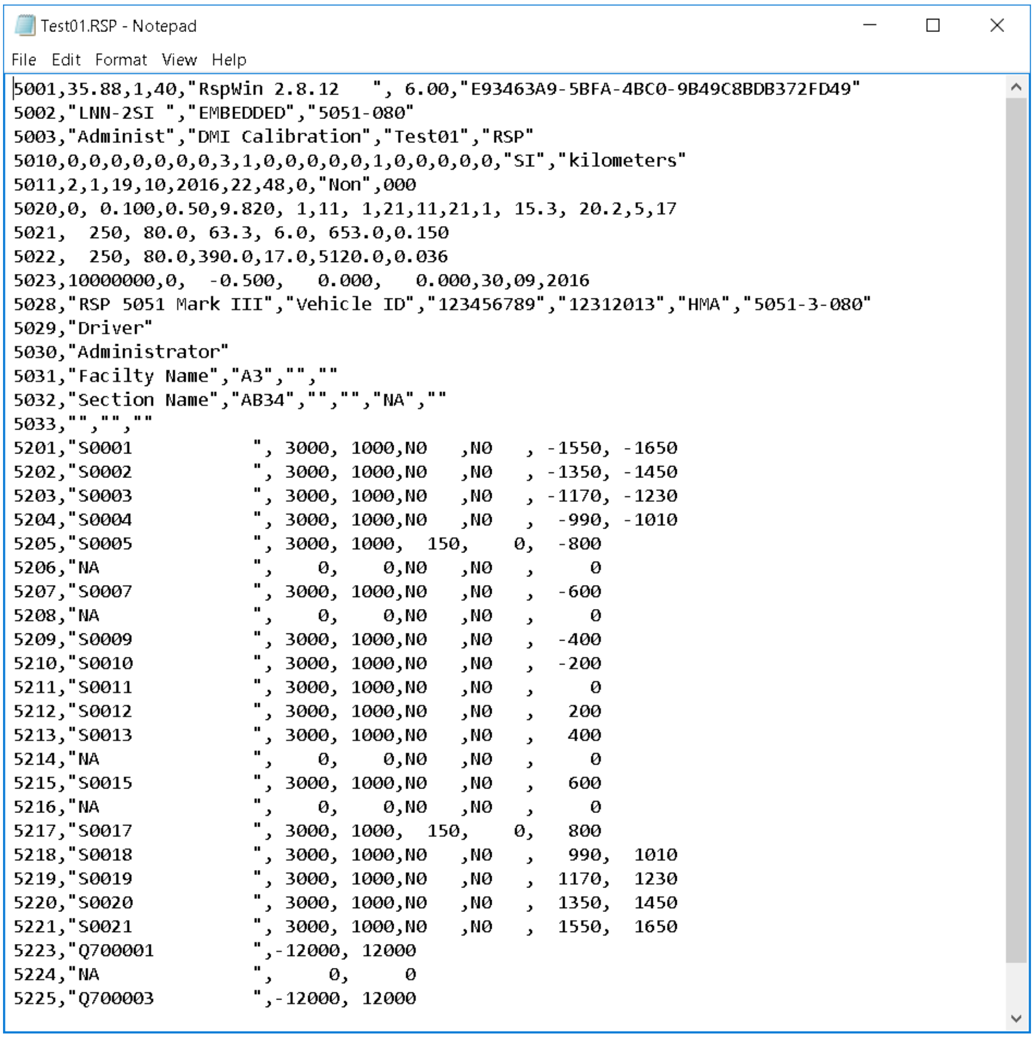
✓ With check mark in "auto Suspend" in your TestSetup, the file will automatically be closed i.e. data will be moved from the temporary location to the chosen data folder. Without check mark, a dialog box will prompt you for next action. Save or Discard. "Yes" for closing the file is recommended. Close the data file by selecting "File" then "Close" from the menu at the top of the screen. Note: The data file resides in a "working" folder until it is closed. When the file is closed, it is moved from the temporary location to the chosen data folder.

12.6 Reviewing the Data

12.6.1 RSP Data

The RSP stores its data in a comma-delimited ASCII file. This means that the file is "human readable" and that the information in each line of the file is separated by commas. This facilitates data processing and handling. The comma-delimited data can easily be imported into Microsoft Excel for ad hoc analysis and reporting.

The data file can also be reviewed in the field for completeness using Microsoft Notepad, Wordpad, or any other ASCII based text editor.

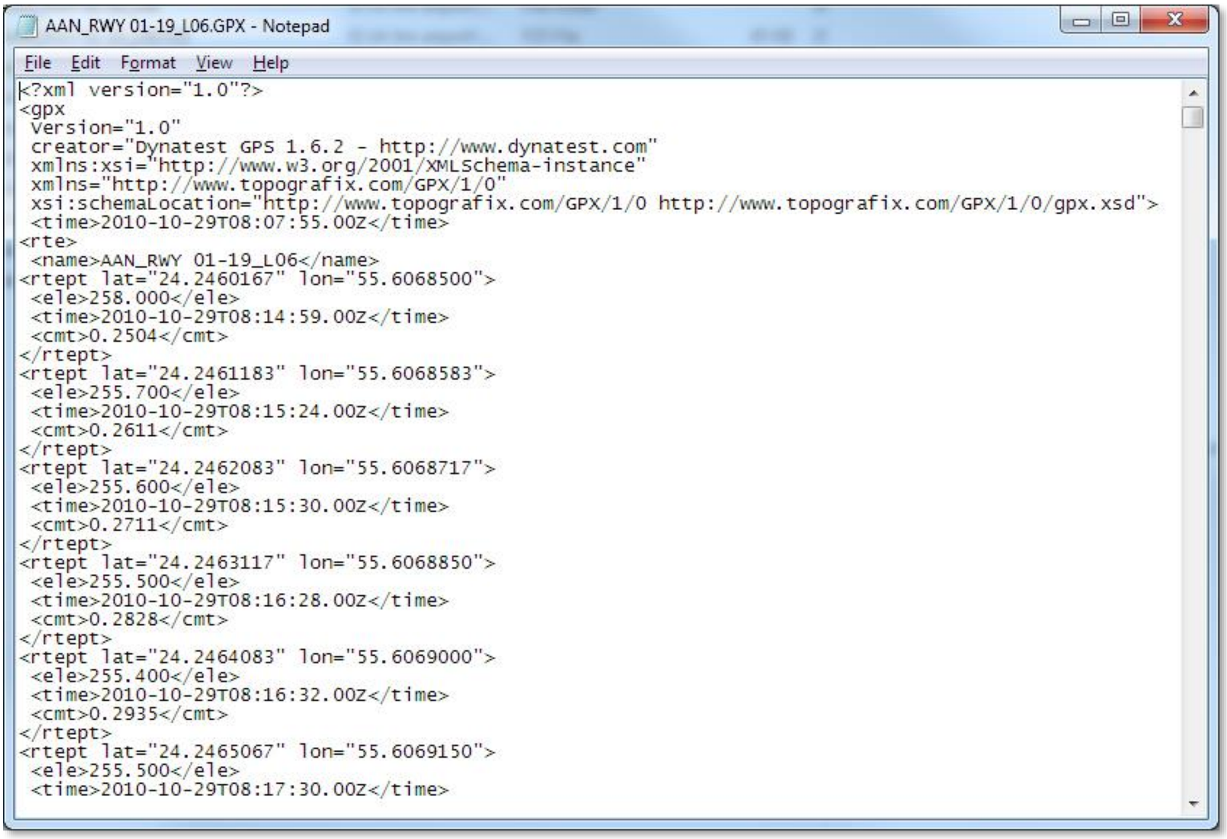



```
5001,35.88,1,40,"RspWin 2.8.12   ", 6.00,"E93463A9-5BFA-4BC0-9B49C8BDB372FD49"
5002,"LNN-2SI ","EMBEDDED","5051-080"
5003,"Administ","DMI Calibration","Test01","RSP"
5010,0,0,0,0,0,0,0,3,1,0,0,0,0,0,1,0,0,0,0,0,"SI","kilometers"
5011,2,1,19,10,2016,22,48,0,"Non",000
5020,0, 0.100,0.50,9.820, 1,11, 1,21,11,21,1, 15.3, 20.2,5,17
5021,  250, 80.0, 63.3, 6.0, 653.0,0.150
5022,  250, 80.0,390.0,17.0,5120.0,0.036
5023,10000000,0,  -0.500,   0.000,   0.000,30,09,2016
5028,"RSP 5051 Mark III","Vehicle ID","123456789","12312013","HMA","5051-3-080"
5029,"Driver"
5030,"Administrator"
5031,"Facilty Name","A3","",""
5032,"Section Name","AB34","","","NA",""
5033,"","",""
5201,"S0001           ", 3000, 1000,N0   ,N0   , -1550, -1650
5202,"S0002           ", 3000, 1000,N0   ,N0   , -1350, -1450
5203,"S0003           ", 3000, 1000,N0   ,N0   , -1170, -1230
5204,"S0004           ", 3000, 1000,N0   ,N0   ,  -990, -1010
5205,"S0005           ", 3000, 1000,  150,    0,  -800
5206,"NA              ",    0,    0,N0   ,N0   ,     0
5207,"S0007           ", 3000, 1000,N0   ,N0   ,  -600
5208,"NA              ",    0,    0,N0   ,N0   ,     0
5209,"S0009           ", 3000, 1000,N0   ,N0   ,  -400
5210,"S0010           ", 3000, 1000,N0   ,N0   ,  -200
5211,"S0011           ", 3000, 1000,N0   ,N0   ,     0
5212,"S0012           ", 3000, 1000,N0   ,N0   ,   200
5213,"S0013           ", 3000, 1000,N0   ,N0   ,   400
5214,"NA              ",    0,    0,N0   ,N0   ,     0
5215,"S0015           ", 3000, 1000,N0   ,N0   ,   600
5216,"NA              ",    0,    0,N0   ,N0   ,     0
5217,"S0017           ", 3000, 1000,  150,    0,   800
5218,"S0018           ", 3000, 1000,N0   ,N0   ,   990,  1010
5219,"S0019           ", 3000, 1000,N0   ,N0   ,  1170,  1230
5220,"S0020           ", 3000, 1000,N0   ,N0   ,  1350,  1450
5221,"S0021           ", 3000, 1000,N0   ,N0   ,  1550,  1650
5223,"Q700001         ",-12000, 12000
5224,"NA              ",     0,     0
5225,"Q700003         ",-12000, 12000
```

Please refer to the following chapter for a detailed discussion of the RSP data file contents.

12.6.2 GPS Data

Example of GPX file holding GPS coordinates.




```
<?xml version="1.0"?>
<gpx
 version="1.0"
 creator="Dynatest GPS 1.6.2 - http://www.dynatest.com"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns="http://www.topografix.com/GPX/1/0"
 xsi:schemaLocation="http://www.topografix.com/GPX/1/0 http://www.topografix.com/GPX/1/0/gpx.xsd">
 <time>2010-10-29T08:07:55.00Z</time>
<rte>
 <name>AAN_RWY 01-19_L06</name>
<rtept lat="24.2460167" lon="55.6068500">
 <ele>258.000</ele>
 <time>2010-10-29T08:14:59.00Z</time>
 <cmt>0.2504</cmt>
</rtept>
<rtept lat="24.2461183" lon="55.6068583">
 <ele>255.700</ele>
 <time>2010-10-29T08:15:24.00Z</time>
 <cmt>0.2611</cmt>
</rtept>
<rtept lat="24.2462083" lon="55.6068717">
 <ele>255.600</ele>
 <time>2010-10-29T08:15:30.00Z</time>
 <cmt>0.2711</cmt>
</rtept>
<rtept lat="24.2463117" lon="55.6068850">
 <ele>255.500</ele>
 <time>2010-10-29T08:16:28.00Z</time>
 <cmt>0.2828</cmt>
</rtept>
<rtept lat="24.2464083" lon="55.6069000">
 <ele>255.400</ele>
 <time>2010-10-29T08:16:32.00Z</time>
 <cmt>0.2935</cmt>
</rtept>
<rtept lat="24.2465067" lon="55.6069150">
 <ele>255.500</ele>
 <time>2010-10-29T08:17:30.00Z</time>
```

13 Output Files

13.1File Names and Folders

An RSP system may generate several output files. The file name you enter in preparation for a data collection run has several purposes. This example shows the maximum output of file name TEST in folder C:\Data. If you have cameras or an HDC (LCMS) then there will be a subfolder with the same name like C:\Data\TEST

C:\Data\TEST.RSP The main output from the profiler
C:\Data\TEST.GPX GPS route trace

ROW Cameras
C:\Data\TEST\Cam**1**\TEST *station* **1**.JPG 1 is the camera number
C:\Data\TEST\Cam**8**\TEST *station* **8**.JPG

HDC (LCMS)
C:\Data\TEST\HDC\TEST *station*.FIS *station* refers to the beginning (bottom)

Reports
C:\Data\TEST.IRI Average IRI
C:\Data\TEST .NGO IRI No Go List
C:\Data\TEST.LCR Localized Roughness
C:\Data\TEST.STS Statistics
C:\Data\TEST.RTG Average Rutting
C:\Data\TEST.TXE Average Testure
C:\Data\TEST.EVT Events

13.2RSP Data File

The RspWin program produces files that are directly 'Importable' to most spreadsheet software and easily readable by dedicated software. The following main features accomplish this:

- A comma character separates items.
- Each line is prefixed (the very first item on the line) by a 'Line-ID-Number', which is the key to the contents of the line.

The data file type is: SEQUENTIAL UASCII Text File (Line lengths vary).

A file consists of "Header" information followed by RSP Profiling Data and optional IMS data.

Numeric items:
May be preceded and/or padded with spaces
The special Nil value (a 'No use' number) is written as "N0"
The number of decimals shown are just examples

Text items:
The width of a text field may vary
Most text items are "Quoted"

Units	Numeric information is stored in either Metric or English systems.
Stations	Meters, km, feet, yards, miles or miles.feet
Geographic	Decimal degrees. Latitude is positive North. Longitude is positive east. Altitude is meters, always.

Common to ALL lines is the Line ID number (the first four characters).

13.2.1 RSP File Header Information

```
1. Program Version
5001,35.88,1,40,"RspWin 2.8.12", 6.00,"E93463A9-5BFA-4BC0-9B49C8BDB372FD49"
     35.88  Program Identification
           1                                    No of Headers (ONE always)
             38                                 No of Lines in Header
                 "Rsp...                        Program Comment
                                 6.00           Firmware version
                                       E93..    Unique GUID
2. Primary Setup Names
5002,"LNN-2SI ","EMBEDDED","5051-XXX"
      LNN-2SI                             Data Format
                 EMBEDDED                 Hardware system
                            5051-XXX      Equipment S/N

3. Secondary Setup Names
5003,"B-JONES","UK-MANCH","S1-L5","RSP"
      B-JONES                             Operator Name
                UK-MANCH                  Test setup name (part of)
                           S1-L5          Datafile name (the name of this file)
                                   RSP    Datafile extension
```

4. Units

```
5010,0,0,0,0,0,0,0,3,1,0,0,0,0,0,1,0,0,0,0,0,"SI","kilometers"

     0                  Temperature 0:C°  1:F°
       0 0 0 0 0 0      NA
                   3    Location    1:StnMeters 2:meters  3:kilometres
                                    5:feet 6:yards 7:miles 8:StnFeet 9:ml.feet
                     1  Angle (GPS) 1:Deg (2:Deg°Min 3:Deg°min'Sec)
                       0 0 0 0 0                       NA
                                 1                     Angle (0:Radians) 1:Deg
                                   0 0 0 0 0           NA
                                              SI       (or US)
                                                   Kilometers
```

5. Date and Time

```
5011,2,1,28,08,2003,21,45,0,"Non",000
     2            Date style (fixed)
       1          Time style (fixed)
         28             Day
            08          Month
               2003     Year
                    21       Hour
                       45    Minute
                        0  Non  000       Not used
```

6. Operating Parameters

```
5020,0, 0.100,0.50,9.820, 1,11, 1,21,11,21,0, 25.5, 26.9,5,17
     0                        0:Normal  (1:Bounce)
        0.100                 Filter Wavelength (same unit as Stations)
              0.50            Filter Damping
                   9.820      Gravity (m/s²)

The following pairs are channel numbers for Left, Full and Right Rutting
                          1       Leftmost laser for "Left Rutting"
                            11    Rightmost laser for "Left Rutting"
                                1      Leftmost laser for "Full Rutting"
                                  21   Rightmost laser for "Full Rutting"
                                     11     Leftmost laser for "Right Rutting"
                                        21 Rightmost laser for "Right Rutting"

                                           0     0:Center line Index
                                                (1:Half Car Index)
                                              25.5        Surface Temperature
                                                    26.9  Air Temperature
                                                         5    Left Wheel Path
                                                           17 Right Path
```

7, 8. Roughness Index Parameters for IRI (5021) and Ride Number (5022)

```
5021,  250, 80.0, 63.3, 6.0, 653.0,0.150
       250                              Averaging Distance (mm/inches)
            80.0                        Simulation Speed (kmh/MPH)
                  63.3                  Normalized Suspension Stiffness
                        6.0             Normalized Suspension Damping
                             653.0      Normalized Tire Stiffness
                                   0.150 Mass Ratio
```

9. DMI and Stationing

```
5023, 1709645,0,   0.000,   0.000,   0.000,30,09,2016
      1709645     DMI Calibration Figure
              0   DMI Direction  0:Increasing  1:Decreasing
                   0.000    0.000    0.000           NA
                                           30        Date of calibration
                                              09     Month
                                                 2016 Year
```

10. Name of Driver
```
5029,"Jack"
```

11. Name of Operator
```
5030,"Jones"
```

12. Facility Information
```
5031,"Dynatest Boulevard","A1","Motorway","ACC"
      Dynatest Boulevard                        Name
                          A1                    Code
                               Motorway         Type
                                          ACC   Class
```

13. Subsection Information
```
5032,"East bound","A1+1","Townhall"," Airport","Right-1","1R"
      East bound             Name
                   A1+1      Code
                          Townhall                    Start
                                    Airport           Ending
                                              Right-1            Lane name
                                                        1R       Lane code
```

14 to 34. Data for each of 21 lasers max. (5201-5221)
```
5201,"20081817",2724,1163,300,0,-59.49,-63.39
      20081817            Serial Number
                2724         Reading at reference distance 250mm
                     1163    Reading at reference distance 350mm
                          300     Mean Profile Depth Bias (mu/mill)
                              0   RMS Texture Bias (mu/mill)
                                -59.49          Lateral position (mm/inches)
                                       -63.39   Optional secondary position
```
For positions above, centreline is zero, negative to the left, positive right. TWO positions apply for ANGLED lasers only; the first is closest to the centreline (calibration beam closest to lasers) the second is farthest from the centreline.

A spare (not used) laser channel appears like this:
```
5202,"NA      ",    0,    0,N0   ,N0   ,     0
```

35 to 37. Data for each of 3 accelerometers max. (5223-5225).
```
5223,"DDK-LWA",-11936, 12135
      DDK-LWA                Serial Number
               -11936        Reading in upright position
                       12135 Reading in opposite position
```

A spare (not used) Acc channel appears like this:
```
5224,"NA      ",     0,     0
```

38. Inertial Motion Sensor.
```
5228,"WS-0123", 0.3,1.000, 0.1,1.000, 0.1,1.000
      WS-0123     Serial Number
                0.3          Bank Bias (deg)
                    1.000    Bank Gain
                           0.1           Grade Bias (deg)
                               1.000     Grade Gain
                                      0.1            Heading Rate Bias (deg/s)
                                          1.000      Heading Rate Gain
```

13.2.2 RSP Measurement Data

Measurement data is stored chronologically after the header. Most items cover an interval of some size (see "Storage Intervals" in section 8, Test Setups), e.g. IRI could be reported every 50 meters, Average Laser Elevations every 25mm. The beginning and ending Stations are the first two items in most lines. Information from the various transducers is always written in sequence with the leftmost laser first and the rightmost farthest to the right. The following examples show data from a typical "Five lasers plus two accelerometers" system.

Common to most lines

```
54XX,  0.000000,  0.000100, ……
       0.000000               Beginning of interval
                  0.010000    End of interval
```

Laser elevations and raw accelerations.

```
Distance from the lasers down to the pavement.
5401,  0.000,   0.0001,293.1,298.6,..,316.7,-9.8123,-9.8123
                      293.1                   Leftmost Laser (mm/inches)
                            298.6             Left Wheel path
                                  ...
                                     316.7    Rightmost laser
                                           -9.8123         Left acc
                                                   -9.8123  Right acc
```

Failures.

```
Percentage of dropouts/erroneous readings
5402,  0.010,   0.020,1.0,0.0,0.0,0.0,4.1,0.0,0.0
                     1.0                            Leftmost Laser
                         0.0                        Left Wheel path
                              ...
                                         0.0        Right Accelerometer
```

Velocity and Driving Acceleration.

```
5403,  0.000,   0.010, 14.0, 1.3
                      14.0        Velocity (kmh/MPH)
                            1.3   Acceleration (m/s² or ft/s²)
```

Longitudinal Profile elevation

```
5405,0.000000,0.000100,   -0.5,   -0.8,    2.1
                          -0.5                 Left Wheel path (mm/inches)
                                  -0.8         Centreline
                                           2.1 Right Wheel path
```

International Roughness Index (IRI)

```
5406,  0.000,   0.020,  4.75,  4.09,  3.69
                        4.75          Left Wheel path (m/km or in/mile)
                               4.09   Centreline IRI
                                      3.69 Right Wheel path
```

Ridenumber (RN)

```
5407,  0.000,   0.020,  1.73,  2.05,  2.69
                        1.73          Left Wheel path
                               2.05   Centreline RN
                                      2.69 Right Wheel path
```

Texture, RMS (Root Mean Square)

```
5408,  0.000,   0.001,812,845,……, 302.5, 298.4
Texture is reported in either microns or mills
                     812      First texture capable laser
                         845  Second texture capable laser
Followed by Laser Elevations (mm or inch) for each texture capable laser
```

Texture, MPD (Mean Profile Depth)

```
5409,   0.000,   0.001,436,534,……
Texture is reported in either microns or mills
                     436      First texture capable laser
                         534  Second texture capable laser
```

Rutting

```
5411,   0.000,   0.001,3.6,4.5,4.5,4.3,5.2,5.2
                     3.6            Left Rutting (mm/inches)
                         4.5        Full Rutting
                             4.5    Right Rutting
                                 4.3            Max Left Rutting
                                     5.2        Max Full Rutting
                                         5.2    Max Right Rutting
```

Faulting

```
5414,   0.007890, 5.4, 5.6, 5.4, 5.2
        0.007890   Station (average)
                 5.4                      Average Fault Depth
                      5.6                 Left wheel path
                           5.4            Centre line
                                5.2       Right wheel path
```

Photo sensor Status-change

```
5415,   0.007890,"OFF"
        0.007890        Exact station
                 OFF    New Status (ON or OFF)
```

Keyboard 'Events'

```
5416,   0.008823,"K"
        0.008823        Exact station
                 K      Ascii Key
```

Keyboard 'Events'

```
5417,   0.008823,"Just a remark"
        0.008823              Exact station
                "Just...      Text
```

Time of day

```
5418,   0.001000, 12345.6
        0.001000              Exact station
                 12345.67     HrMnSc.nn
```

Inertial Motion Sensor data

NOTE: Begin and End stations are the same. I.e this is point data

```
5420,0.001,0.001,"I",0.73,-3.53,26.9,2.6,2.6,54.6,26,-1.24,0.523,23.45
                     0.73           Bank (deg)
                          -3.53     Grade (deg)
                                26.9      Heading (N=0 E=90 S=180 V=270)
                                     2.6        Yaw Rate (deg/sec)
                                         2.6    Heading Rate (deg/sec)
                                             54.6     Velocity (kmh/MPH)
                                                  26  Temperature (C/F)
                                                     -1.24  Crossfall (deg)
                                                           0.523 Curve Radius
                                                                 23.45
                                                Deg of Curve (deg/km or deg/ml)
```

Macro Profile Elevations (RSPIV only).

Distances from the Left (5421) and Right (5422) lasers down to the pavement. Each record presents 25 (or less) elevations covering 25 mm (1 inch) of travel. Elevations are prefixed by the acc and laser contributions to the longitudinal profile.

```
5421,0.000000,0.000025,-19.1,37.7,298.1,298.6,298.7,299.3,300.5 …
                       -19.1        Acc part of inertial profile (mm/inches)
                             37.7   Laser part of inertial profile
                                  298.1       First elevation sample(mm/inches)
                                        298.6 Second elevation sample
                                                ...   25th sample (typically)
```

Geographic Positioning System (GPS)

NOTE: Begin and End stations are the same. I.e this is point data

```
5280,0.001,0.001,0,130743.5,90.0000,180.0000,50.9,2,5,416,11
                 0            0: No Failure 9: Timeout
                   130743.5   UTC Time, format hhmmss.s
                            90.0000             Latitude (degrees)
                                    180.0000000 Longitude
                                             50.9     Height (meters)
                                                  2   0:NoNav 1: GPS 2:DGPS
                                                    5        No of satellites
                                                      416    Beacon ID (DGPS)
                                                          11 Age (sec)
```

Stop flag

```
5429,   0.000,   0.774,   0,   0
        0.000           Lowest Station
                 0.774  Highest Station
      Additional parameters are for internal use by Dynatest (typ zero).
```

13.3 Optional RSP Data File Formats

In addition to the native RSP format you may optionally choose to generate other output files. These files are written when the RSP file is closed.

Export related files:

XLS	Microsoft Excel
XLSB	Microsoft Excel 2007+, Binary
ERD	See http://www.umtri.umich.edu/erd/software/erd_file.html
PRO	Texas DOT format
PPF	ASTM PPF format

Report related files:

IRI	Average IRI
NGO	IRI No-Go (Excess IRI readings)
LCR	Localized Roughness (Bump/Dip)
RTG	Average Rutting
TXE	Average Texture

13.4 Excel

This option requires that the Excel application be installed on the computer.
The RSP file is imported to Excel and then sorted by data type.

NOTE: Older Excel versions have a limitation of about 65500 rows, which is often too small for detailed data from longer sections. MS Excel 2007+ allows for a virtually unlimited number of rows in binary format (.XLSB).

13.5 ERD

This format uses "Facility" as sole indication of where the data was taken.
The "UniPro" option writes separate files for each longitudinal profile.
This example shows profiles from left, centre and right:

```
ERDFILEV2.00
      3,   6329,     -1,       1,       5, 1               ,     -1,
SURVDATE2003/10/10
PROFINSTDynatest RSP 5051-001
TITLE    P B road
XLABEL  Distance
XUNITS  m
XSTART   0
XSTOP    6328.383
UNITSNAMmm      mm      mm
SHORTNAMLElev.  CElev.  RElev.
LONGNAMELeft Elevation                  Centre Elevation                 Right…
END
-10.41 -11.72 -14.26
-10.86 -12.77 -14.93
-11.2 -13.21 -15.77
-11.65 -13.52 -15.71
-10.8 -12.91 -15.13
-10.82 -12.07 -14
```

13.6 PRO

The following data fields are used to generate the header part of PRO files:

In RspWin	In PRO	Format
Setup → Equipment	Certification Code, Date	Code,mmddyyyy
Facility	Roadway	$$####$
City/Area	District,County	##,###
Start	Beginning Ref.	####$±##.###
Lane Numbers	Lane	$#

Example showing profiles from left and right and comment code ‘0’.

```
HEAD3,10102003,__,___,P_B_roa,23.977______,0_
CMET3,,,,,,,
Dynatest,mil,LR, 1000,m
Comment
Comment
-410 ,-561 , 0
-428 ,-588 , 0
-441 ,-621 , 0
-459 ,-619 , 0
-425 ,-596 , 0
-426 ,-551 , 0
```

13.7 PPF

This is a binary file format that we cannot detail here. Please refer to ASTM documentation.

13.8 IRI

Example showing average IRIs from left, centre and right.

```
RspWin 1.1.994   S/N: 5051-001    2005.05.06  18:03
Date: 2003.10.10  File: C:\Data\RSP\RSP-DATA\HW-North\HW-North.RSP
Driver,jw
Operator,jw
Facility,P B road, 656
Beginning,23.977
Ending,26.192
Lane,0
     0.0,    500.0,  1.78,  1.66,  1.82
   500.0,   1000.0,  1.54,  1.62,  1.77
  1000.0,   1500.0,  1.51,  1.61,  1.91
  1500.0,   2000.0,  1.55,  1.72,  1.86
```

13.9 IRI No-Go

Example showing areas where IRIs are above the 1.50 m/km limit:

```
RspWin 1.1.994   S/N: 5051-001    2005.05.06  20:15
Date: 2003.10.10  File: C:\Data\RSP\RSP-DATA\HW-North\500m.rsp
Driver,jw
Operator,jw
Facility,P B road, 656
Beginning,23.977
Ending,26.192
Lane,0
    From,      To,  Left,CL/HRI, Right,  IRI Limit: 1.50 m/km
    70.0,    80.0,  1.73,      ,
    80.0,    90.0,  1.71,      ,
   230.0,   240.0,  1.99,  1.93,  1.72
   240.0,   250.0,  2.03,  2.04,  2.00
   250.0,   260.0,  2.05,  2.02,  2.00
   450.0,   460.0,  1.53,      ,  1.71
   460.0,   470.0,  1.54,      ,  1.76
   470.0,   480.0,  1.59,      ,  1.74
   480.0,   490.0,  1.66,  1.60,  1.76
```

13.10 Localized Roughness

Examples showing both 'Mean Profile' and separate left and right output:

```
RspWin 1.1.994   S/N: 5051-001    2005.05.06  21:09
Date: 2003.10.10  File: C:\Data\RSP\RSP-DATA\HW-North\500m.rsp
Driver,jw
Operator,jw
Facility,P B road, 656
Beginning,23.977
Ending,26.192
Lane,0
    From,      To,   L/R,   Ext,  Bump/Dip Limit: 3.8 mm
   293.0,   294.0,  6.63,  2.83
   351.0,   355.0, -7.63,  3.83
   356.0,   360.0,  8.01,  4.21
```

Left and right profiles handled separately:

```
    From,      To,  Left,   Ext,   Bump/Dip Limit: 3.8 mm
   237.0,   238.0, -4.59,  0.79
   327.0,   328.0,  5.62,  1.82
   351.0,   355.0, -8.25,  4.45
   356.0,   361.0,  8.57,  4.77
   372.0,   374.0, -4.68,  0.88

    From,      To, Right,   Ext,   Bump/Dip Limit: 3.8 mm
   293.0,   294.0, 10.21,  6.41
   352.0,   355.0, -9.98,  6.18
   356.0,   360.0,  7.44,  3.64
   374.0,   376.0, -5.86,  2.06
   434.0,   435.0,  3.85,  0.05
```

13.11 Average Rutting

Example showing average left, full and right Rutting and Max values. The Max values are the deepest rutting occurring in each segment.

```
RspWin 1.3.0   S/N: 5051-001    2005.09.16  21:26
Date: 2003.10.10  File: C:\Data\RSP\RSP-DATA\HW-North\500m.rsp
Driver,jw
Operator,jw
Facility,P B road, 656
Beginning,23.977
Ending,26.192
Lane,0
    From,       To,  Left,  Full, Right,  LMax,  FMax,  RMax, mm,  Average Rut
   0.000,   0.050,  3.41,  5.90,  4.31,  7.50, 27.70, 24.30
   0.050,   0.100,  3.13,  4.39,  1.93, 10.70, 13.30,  5.00
   0.100,   0.150,  3.29,  5.84,  1.84, 13.20, 13.20,  6.60
   0.150,   0.200,  5.75,  7.45,  4.35, 12.30, 12.30,  8.20
   0.200,   0.250,  8.92,  9.51,  6.01, 21.80, 22.00, 16.90
   0.250,   0.300,  9.41, 10.32,  6.38, 21.60, 23.30, 21.80
   0.300,   0.350,  9.31,  9.92,  6.10, 19.50, 19.50, 18.50
   0.350,   0.400, 10.59, 12.53,  9.39, 17.60, 25.90, 23.20
   0.400,   0.450,  8.80, 11.11,  9.01, 16.10, 18.00, 16.90
   0.450,   0.500,  8.76, 12.97, 10.51, 24.50, 29.40, 23.50

   0.000,   0.500,  7.14,  8.99,  5.98, 24.50, 29.40, 24.30
```

13.12 Average Texture

Example showing average RMS and MPD from right wheel path.

```
RspWin 1.3.0   S/N: 5051-001  VIN: RM 93 422    2005.09.16  23:19
Date: 2005.08.16  File: C:\Data\RSP\Kastrup\W0001.RSP
Model,RSP 5051 Mark III
Vehicle ID,RM 93 422
Driver,Dynatest
Operator,jw
Facility,,
Lane,NA, 0
    From,       To,  Lrms,  Crms,  Rrms,  Lmpd,  Cmpd,  Rmpd, mm,  Average Text
   0.000,   0.050,      ,      ,  0.74,      ,      ,  1.30
   0.050,   0.100,      ,      ,  0.74,      ,      ,  1.29
   0.100,   0.150,      ,      ,  0.88,      ,      ,  1.53
   0.150,   0.200,      ,      ,  0.87,      ,      ,  1.29
   0.200,   0.250,      ,      ,  0.77,      ,      ,  1.18
   0.250,   0.300,      ,      ,  0.77,      ,      ,  1.22
   0.300,   0.350,      ,      ,  0.88,      ,      ,  1.35
   0.350,   0.400,      ,      ,  0.74,      ,      ,  1.11
   0.400,   0.450,      ,      ,  0.48,      ,      ,  0.79
   0.450,   0.497,      ,      ,  0.72,      ,      ,  1.13

   0.000,   0.497,      ,      ,  0.76,      ,      ,  1.22
```

14 Error Messages

Error 603: Network time-out

```
The network connection between this PC and the Data Processing Unit (DPU) fails.
Possible causes:
    Power supply failure in the DPU, maybe only momentarily!
    Defective circuits in the DPU.
    Network Cable disconnected or damaged.
    PC Network Adapter defective.
    Defective circuits in the PC.
    Setup problem
- If all connections, supplies and cables seem OK, then close this program,
  switch OFF the Beam and DPU, shut down the PC and wait 10 sec.
  Switch ON again as follows: Boot the PC completely, switch ON the DPU
  then the Beam and wait until the green network led flashes, then
  restart this program.
- If re-starting does not help, then have the PC Network port and the Network
  cable verified by a technician.
- Check the System Setup as described in the Manual.
```

Error 604: DPU Response

```
The response from the Data Processing Unit (DPU) is not as expected.
This could be caused by mismatched versions of the DPU firmware and
this program.
To determine the DPU firmware version do as follows:
  Connect a NUL-MODEM cable from DPU-COM1 to a PC and run Hyperterm.
  In the "MAIN Monitor" display locate the Version information.
To determine this program's version:
  Choose Help - About and note the RspWin version numbers.
```