PROFILER OPERATIONS MANUAL (POM) FOR MDT PROFILERS

JUNE 2006

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ACRONYMS

AC	Alternating Current
ACF	Accelerometer Calibration Factor
AASHTO	American Association of State Highway and Transportation Officials
DC	Direct Current
DCF	Distance Calibration Factor
DMI	Distance Measuring Instrument
EDM	Electronic Distance Measurement
EPM	Engineering Project Manager
FGF	Filter Gain Factor
FHWA	Federal Highway Administration
HPF	High Pass Frequency
IBM	International Business Machine
ICC	International Cybernetics Corporation
IRI	International Roughness Index
LTPP	Long Term Pavement Performance
MDR	Mobile Data Recorder
MDT	Montana Department of Transportation
PCR	Pavement Condition Recorder
PMS	Pavement Management System
SCF	Sensor Calibration Factor

1.0 INTRODUCTION

1.1 SIGNIFICANCE OF PAVEMENT RIDE MEASUREMENTS

Longitudinal profile along the wheel paths of a pavement are used to evaluate its smoothness. Indices such as International Roughness Index (IRI) are computed and used for the pavement management system (PMS) as well as for construction surface smoothness specifications.

1.2 MDT RIDE DATA COLLECTION

Ride data is collected using a profiler. Each MDT District operates a profiler to collect data within its district. MDT operates and maintains profilers from International Cybernetics Corporation (ICC). The model types used are Mobile Data Recorder (MDR) 4080 and 4097.

1.3 OVERVIEW OF THE MANUAL

This manual describes procedures to be followed when measuring pavement profiles using the ICC MDR 4080 / 4097 inertial profilers. Additionally, this manual describes procedures to be followed when processing the data collected by this device.

The following items related to data collection are covered:

1. Equipment,
2. Calibration of equipment,
3. Data collection, and
4. Record keeping.

Format of this manual follows the FHWA LTPP Manual for Profiler Measurements and Processing, Version 4.1, May 2004.

2.0 ICC PROFILER

The ICC MDR 4080 / 4097 profiler is a modified truck that is equipped with specialized instruments to measure and record road profile data. The profiler contains two laser height sensors, an accelerometer coupled with each laser height sensor, a longitudinal distance measuring instrument (DMI), a computer system, data acquisition electronics, and power control equipment.

The two laser height sensors and accelerometers in the unit are mounted on a sensor bar that has been installed on the front of the vehicle. The longitudinal distance measuring system receives a signal from the truck's speed sensor on the differential of the vehicle and measures the distance traveled by the profiler.

Data recorded by the height sensors, accelerometers and DMI are stored in the computer memory (and later stored to hard disk). These data can be processed to obtain the profile along the path that was traversed by each sensor.

According to ICC, the profiler can measure road profiles at speeds ranging from 25 to 70 mph (40 to 112 km/h). Test speed is normally 50 mph (80 km/h).

This chapter describes the profiler equipment, essential operational details of the profiling system, and critical maintenance activities.

2.1 EQUIPMENT

2.1.1 COMPUTER SYSTEM

The profiler's computer and data acquisition electronics are contained in a ruggedized chassis positioned between the front seats of the profiler truck. The profiler sensors interconnect on the back side of the computer chassis. A power switch on the front side of the computer chassis switches on the computer and supplies power to all of the associated electronics. The computer chassis includes internally mounted hard disk and Zip disk drives. Additionally, a monitor, keyboard, printer, and sixteen-key eventboard connect to the computer system. An inverter converts the 12 volt DC power (alternator and batteries) to 110 volts AC to power the computer system.

2.1.2 COMPUTER SOFTWARE

The computer software necessary for operations are:

- MS DOS 6.22 (or higher) Operating System,
- ICC MDR Data Collection Software, and
- ICC Profile Data Reporting Software (RP090.EXE).

The DOS operating system is installed on the hard disk drive and is necessary for booting and operating the profiler computer. The AUTOEXEC.BAT and CONFIG.SYS files contain critical parameters for proper operation of the profiler computer. Appendix A contains copies of the necessary AUTOEXEC.BAT and CONFIG.SYS files. If it is necessary to reload the DOS operation system on the profiler computer, please refer to Appendix A to update the installed AUTOEXEC.BAT and CONFIG.SYS files to assure proper operation of the profiler.

The DOS commands DATE and TIME should be added to the AUTOEXEC.BAT file so when the profile computer is booted the operator will have the opportunity to review the computer clock and make any necessary adjustments each time the computer is booted.

The ICC MDR data collection and reporting software are contained in the directory C:\MDRSW\. The current data collection software (MD090LLW.EXE, Version 2.48, 07/25/2000) is launched by the batch file M.BAT. Appendix A contains a copy of the M.BAT file. The MTIRI.BAT and MTBUMP.BAT are batch files that configure parameters for the ICC reporting software (RP090L.EXE) to greatly simplify the creation of the profile reports. Appendix A also contains copies of the MTIRI.BAT and MTBUMP.BAT files.

At least two (2) copies of the ICC MDR data collection and reporting software (i.e., entire C:\MDRSW\ directory) should be made. One copy should be stored with the profiler and one kept at the MDT district office in case problems occur with the software installed on the computer. Diskettes should always be stored in a safe, clean area and away from direct sunlight or rain. Refer to the diskette manufacturer guide for additional instructions.

If any of these software are re-installed, the operator should go through the setup menus described in Section 2.3 of this manual to make sure that appropriate parameters have been set to the correct values.

2.1.3 LASER HEIGHT SENSORS

Laser height sensors measure vertical displacement between the vehicle and the road. The profiler is equipped with two Selcom laser sensors securely attached to a sensor bar mounted to the front frame rails of the truck.

Laterally, the laser sensors are located in the center of each wheel path and should be at a distance of 34 inches (864 mm) from the center of the vehicle. This sensor setup results in a spacing of 68 inches (1,727 mm) between left and right sensors. The sensor bar is not designed to support the weight of the operator or other persons. Do not sit or stand on the sensor bar at any time.

The two laser sensors are equipped with removable covers. The covers should be in-place when testing is not being performed to protect the sensors. The covers are removed when performing sensor checks and while collecting profile data.

Each laser sensor consists of a laser head unit mounted to the sensor bar connected by cable to a matched processing unit mounted inside the truck. If a laser head is connected to a non-matching processing unit, the laser will be damaged.

The switch for turning the lasers 'On' and 'Off' is located on the front panel of the computer chassis adjacent to the drivers seat (Figure 2-1). The computer system must be powered on in order for the laser to be turned on. Depending on ambient lighting conditions (and whether or not the laser sensor has additional colored diode), the laser spot may not be visible on the ground. The operation of the lasers can be verified using the procedures described in Section 3.1.

The laser height sensors in the profiler can malfunction at elevated temperatures. At approximately 50°C (122°F) the laser sensors will begin to produce errors and at approximately 60°C (140°F) the laser sensors will turn off to prevent damage.
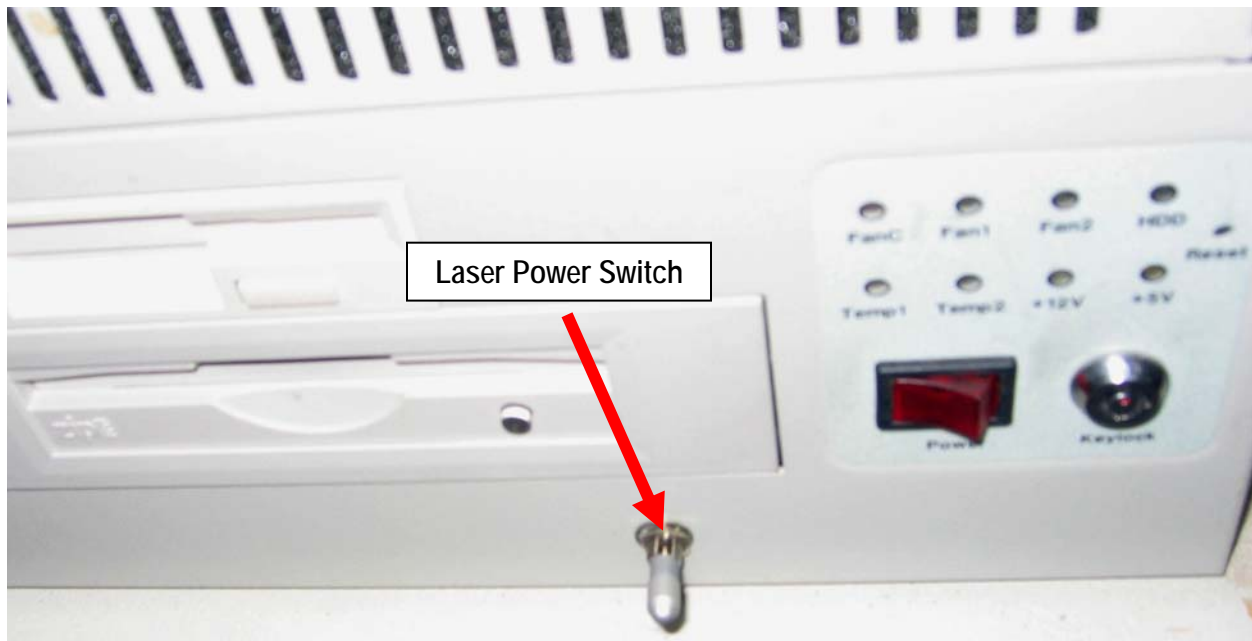
Figure 2-1. Laser Power Switch Location.

Before performing any profile data collection or calibration activities, the laser sensor lenses should be inspected and cleaned (if necessary). Always make sure that lasers are turned off when inspecting the sensor glass, cleaning the sensors or when performing maintenance on the sensors.

To clean the laser sensor lenses, the following procedure should be followed to prevent damage to the laser sensor lens:

1. Flood the lens surface with clean water or liquid glass cleaner solution.
2. Gently scrub the wet lens surface using a clean soft cloth or paper towel.
3. Wipe lens surface dry in one stroke using a clean and dry soft cloth or paper towel.

Extreme caution should be taken when cleaning the laser lens surfaces. Avoid using any cloths or cleaners that could potentially scratch the lenses. Also, avoid any gritty contaminants being rubbed against the lenses.

Additionally, operators should be warned not to let the laser beam strike their eyes. This laser is powerful enough to damage eyesight. Furthermore, the reflection of the laser beam from a surface such as a polished plate, a calibration bar or a watch may also damage eyesight. Operators should take all necessary steps to avoid a reflected laser beam coming into contact with the eye.

2.1.4 ACCELEROMETERS

The accelerometers are used in the profiler to account for the motion of the vehicle during profiling. Two accelerometers are attached to the sensor mounting bar with one located directly above each laser sensor. The accelerometers essentially determine how much the laser sensors move during profile data collection.

The accelerometers do not require special maintenance or handling. The pre-run accelerometer calibration check described in Section 3.2 should be performed to verify proper operation of the accelerometers. If an accelerometer needs replacement, the computer system should be completely powered off before detaching the accelerometer cable from the computer.

2.1.5 Distance Measuring Instrument (DMI)

The distance measuring instrument (DMI) is a system that determines how fast the profiler is moving and how far it has traveled. The DMI takes a pulse signal from the profiler's speed sensor to compute the speed and distance traveled.

Tires are a critical component of the DMI. Proper maintenance of the tires is covered under MDT maintenance policies. In most instances, the tires should be inflated following the guidelines of the truck and tire manufacturer documentation.

The tires should be sufficiently warmed up prior to testing a pavement section. The tires should be considered warmed up sufficiently if the profiler has traveled about 5 mi (8 km) at highway speeds after being parked. However, the distance for warming up tires may need to be changed depending on local weather conditions.

Warming up the tires will cause a slight increase in tire pressure versus the cold tire pressure. The DMI is affected by the tire pressure of the rear tires. The operator should note the rear tire pressures when the DMI of the profiler was last calibrated. The tire pressure of the rear tires of the vehicle for all data collection runs should be within ± 2 psi (13.78 kPa) of the tire pressure that was recorded when the DMI was last calibrated. Before performing data collection, the operator should adjust the tire pressure of the rear tires to ensure that the tire pressure is within this specified limit. The same tire pressure gauge should be used to measure tire pressure during both calibration and testing.

2.1.6 Photocell

The profiler is equipped with a photocell mounted on the sensor bar. It can be rotated around a horizontal axis. The photocell is used to create a reference reset when triggered by a reflective surface. The location where it is triggered is then stored in the event file. The positioning of the photocell is shown in Figure 2-2.

Figure 2-2. Photocell Mounted on Sensor Bar.

The photocell has some limitations to its working range (e.g., distance and reflectivity). The photocell can be positioned to sense reflections from pre-placed marks on the road surface and sense reflective markings on pre-placed cones along the roadside.

Reflective tapes can be placed on the road surface to trigger the photocell. However, these tapes can be expensive and may have the tendency to not stick to the road surface.

Cones should be placed on the shoulder of the road in a position to avoid being hit by traffic or blown over by vehicle generated turbulence. Additionally, the photocell should be rotated around its pivot to align its beam with the reflective material on the cone. The operator should consider the photocell /cone alignment and compensate to avoid false triggering of the photocell by existing reflective markers and surfaces along the road being profiled.

Some trial and error should be expected to get the cones and photocell positioned for error free operation at some projects. The operator should also be aware that at certain times of day low sun angles have the potential of interfering with the photocell and causing either false triggers or non-triggers.

Before performing any data collection, the photocell lens should be inspected and cleaned if necessary. To clean the photocell lens, the following procedure should be followed to prevent damage to the lens:

1. Flood the lens surface with clean water or liquid glass cleaner solution.

2. Gently scrub the wet lens surface using a clean soft cloth or paper towel.

3. Wipe lens surface dry in one stroke using a clean and dry soft cloth or paper towel.

Extreme caution should be taken when cleaning the photocell lens. Avoid using any cloths or cleaners that could potentially scratch the lens. Also, avoid any gritty contaminants being rubbed against the lens.

2.1.7 EQUIPMENT MAINTENANCE & REPAIR

Decisions required for proper maintenance and repair should be based on the testing schedule and expedited as necessary to prevent disruption of testing. Maintenance activities on the profiler should be performed prior to mobilization for testing. Operators should be familiar with specific, detailed MDT maintenance requirements for the profiler.

2.2 POWER-UP, BOOTING AND SHUTDOWN PROCEDURES

2.2.1 POWER SOURCES

There are two batteries in the profiler, one located under the hood of the vehicle, and one located in the truck bed in the forward left corner. The rear battery supplies power to the computer and the electronic equipment in the profiler through an inverter. The computer and the electronic equipment in the profiler can also be powered through an external AC power source (house power) by connecting a battery charger to the rear battery. Both batteries in the profiler are charged when the vehicle engine is running.

During data collection, power will be supplied through the inverter. When the engine is turned off (e.g., while performing calibration checks, troubleshooting, or operating the computer when parked in the shop), an external battery charger should be used to supply power.

2.2.2 POWER SWITCH LOCATION

The primary power switch for powering the profiling system is located on the front panel of computer chassis located between the front seats as indicated in Figure 2-3. This switch in the 'On' position will power the computer system with or without the vehicle engine running; however, leaving the switch in the 'On' position with the engine turned off will cause the batteries to discharge completely.

The laser power switch is located next to the main computer power switch on the front of the computer chassis. The main power switch must be in the 'On' position in order for the lasers to be powered. It is recommended that the computer system be fully booted with the MDR software running before the laser power is switched on.
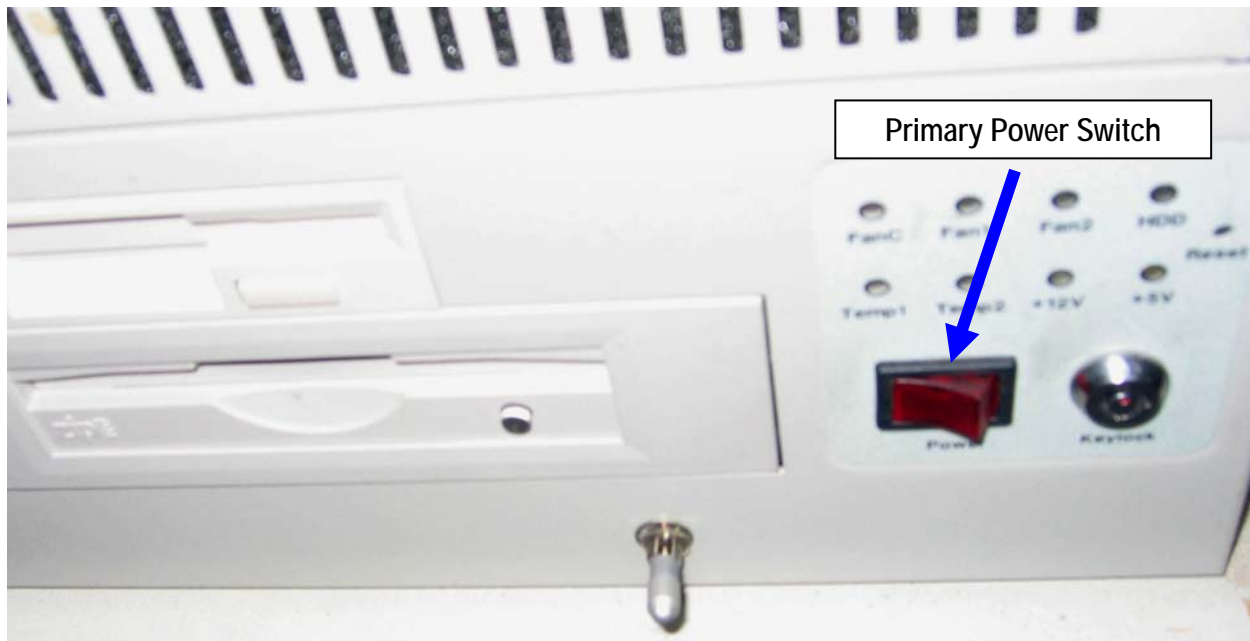
Figure 2-3. Primary Power Switch Location.

2.2.3 PROFILER POWER SUPPLY

The profiling computer and equipment can be powered in two ways. While the engine is running, the alternator provides enough power to keep both batteries sufficiently charged to provide the inverter the necessary voltage to run the computer and profiling electronics. Otherwise, the battery charger (plugged into a standard wall outlet) can be connected to the rear battery to power the computer and profiling electronics when the engine is turned off.

While the computer is running, it is imperative that the batteries have sufficient charging either with the engine running or the battery charger connected. If the inverter is unable to draw enough voltage from the batteries, it will stop producing the AC voltage that operates the computer and the computer will power down. Sudden power loss to the computer could cause damage to delicate internal components.

2.2.4 COMPUTER BOOTING PROCEDURE

The following procedure should be followed when starting the computer and profiling systems. Before powering the computer, there should be an adequate supply of power to the inverter. Either the engine should be running or the battery charger should be connected to the rear battery.

1. Remove covers from laser lenses and inspect laser lenses (clean if necessary).

2. Switch the main power switch to the 'On' position.

3. Allow the computer to boot up.

4. Check the system date and time and adjust if necessary.

5. At the C:\ prompt, type 'M' and then press the Enter key to launch the MDR data collection program.

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6. The main menu of the MDR program will show on the computer monitor (Figure 2-4).

7. Switch the laser power switch to the 'On' position.

```
System & User Options
Options   Parameters   Calibration   Run   File   Quit
```
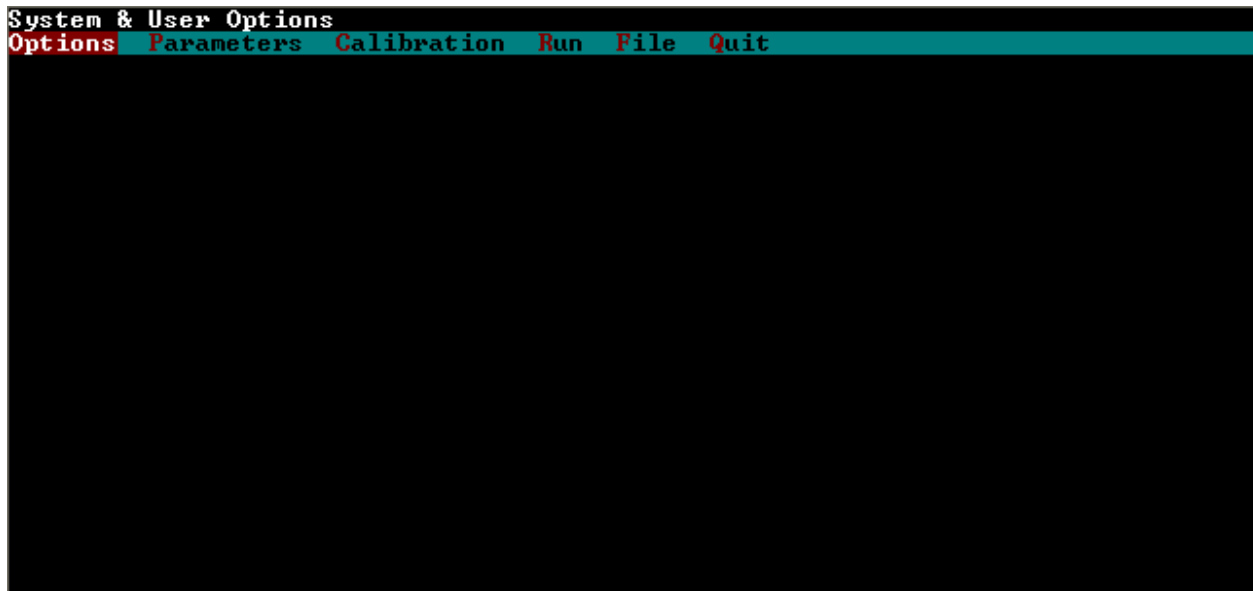
Figure 2-4. MDR Software Main Menu.

2.2.5 SHUTDOWN PROCEDURE

The following procedure should be followed when turning off the computer and profiling systems:

1. Remove any Zip disks remaining in the Zip drive.

2. Switch the laser power switch to the 'Off' position.

3. If the MDR program is running, select Quit from the Main Menu, and then enter 'Y' to confirm the quit request. The C:\ prompt will then be displayed on the screen.

4. Switch the main power switch to the 'Off' position. The power to the computer has now been turned off.

5. For shutting down when powered by house power, disconnect the battery charger from the profiler's battery.

6. Re-cover the laser sensors.

2.3 SOFTWARE SETUP

The MDR software, MD090LLW.EXE, is started with the M.BAT batch file. It is used to collect and save the profile data. The reporting software, RP090L.EXE, is used for bump and IRI (International Roughness Index) report generation. Settings in the MDR program and reporting program that need to be verified and/or updated are presented in the following sections.

The settings in the MDR software should be checked to ensure that they are set with the correct values. These settings should be checked if the software is re-installed or if problems are encountered. There are some settings that the operator will have to set or update once the software is installed.

The following steps take the operator through the different settings that need to be checked and/or updated.

1. Launch the MDR software by entering 'M' at the command prompt.

2. MDR main menu should now be displayed on the screen.

3. Options Menu Settings:

   In the MDR main menu, select 'Options'. The drop down menu shown in Figure 2-5 will be displayed on the monitor.

   The Reference Post Display Mode should be set to 'Mile' or 'Meter' and the Output File Size should be set to 'Hard Disk'. The User should show 'MTDOT_LW' and Version should correspond to the current version. If either of these two fields is different, ICC should be contacted.

   Please note in Figure 2-5, if the available memory shows '0 Pgs', the system will not collect and store data.


```
Save System & User Options to Disk
Options  Parameters  Calibration  Run  File  Quit

   Save Options
   Reference Post Display Mode               Mile
   User...                                MTDOT_LW
   Colors...
   Output File Size                      Hard Disk
   ICC System Parameters...
   Avail Mem / Est. Collect. Dist.    1966 Pgs 285ml
   Version            MD090LLW 2.48 - 25 JUL 2000
```
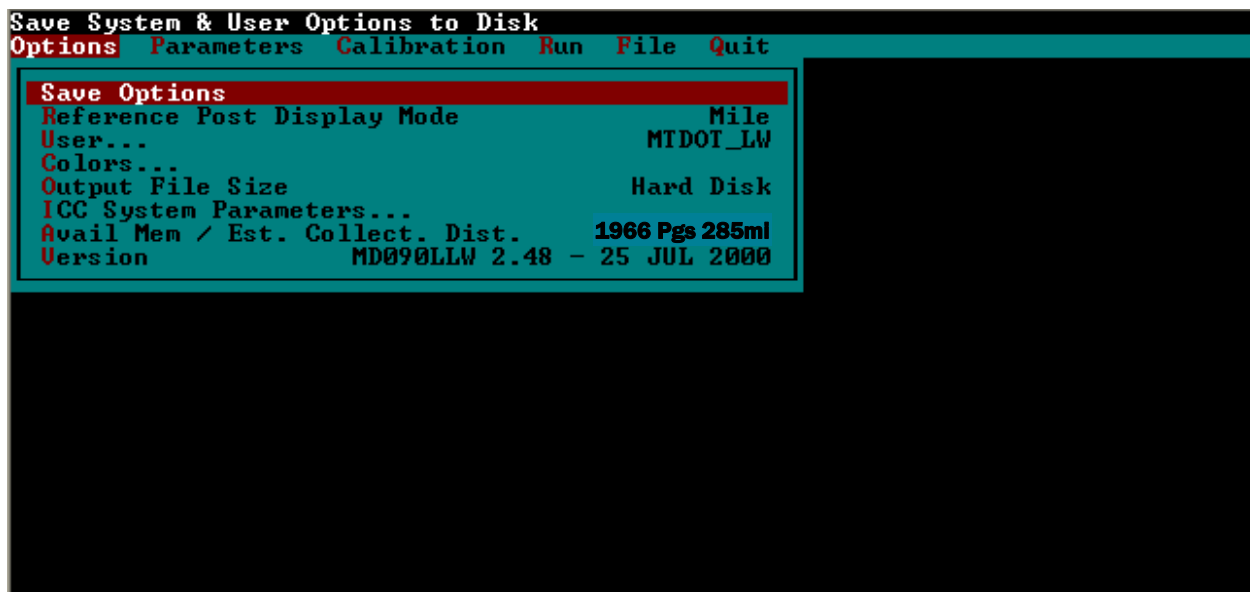
Figure 2-5. MDR Software Options Menu.

4. ICC System Parameters Menu Settings:

   In the Options Menu, highlight 'ICC System Parameters' and press Enter key. The parameters should match the values shown in Figure 2-6. Additional parameters are set in the 'morE' submenu and should match the values shown in Figure 2-7. The parameter settings should match the following values and if any of the parameters shown are different, check with ICC.

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'ICC System Parameters…' Submenu

Ref Sen Pos	6				
DAS-80 Mode	SINGLE				
Profile Sensors	1	2			
Faulting Sensors	0	0			
send GPS Init Msgs	Off				
com2 Mode	On				
1 Com1 Port Setup	9600	FA	Com1	On	
2 Com2 Port Setup	9600	FA	Com2	On	
3 GPS Port Setup	4800	83	Aux1	Off	
4 Video Port Setup	19.2	9B	Aux2	Off	
5 LCD Port Setup	9600	9F	Com1	Off	
6 Cmd Port Setup	115K	83	Com2	Off	
7 Las5200 Port Setup	38.4	83	Aux1	Off	
8 Image1 Port Setup	9600	83	Aux4	Off	
9 Image2 Port Setup	9600	83	Aux4	Off	
A Image3 Port Setup	9600	83	Aux4	Off	
Target…	1-F2	2-F9	3-F9	4-F9	5-F9

'morE…' Submenu

Laser1 Address	280	
Laser 2 Address	282	
Laser 3 Address	284	
Laser 4 Address	286	
Laser 5 Address	288	
C – Select 1ms Accelerometer Rate		Off
X-distance to GPS antenna	0.0	
Y-distance to GPS antenna	0.0	
Z-distance to GPS antenna	0.0	
MDR Prog Files Dir	C:\MDRSW\	
Report List	C:\MDRSW\MDRRPT.LS	

After the parameter settings have been checked, press Escape key twice to get back to the MDR main menu.
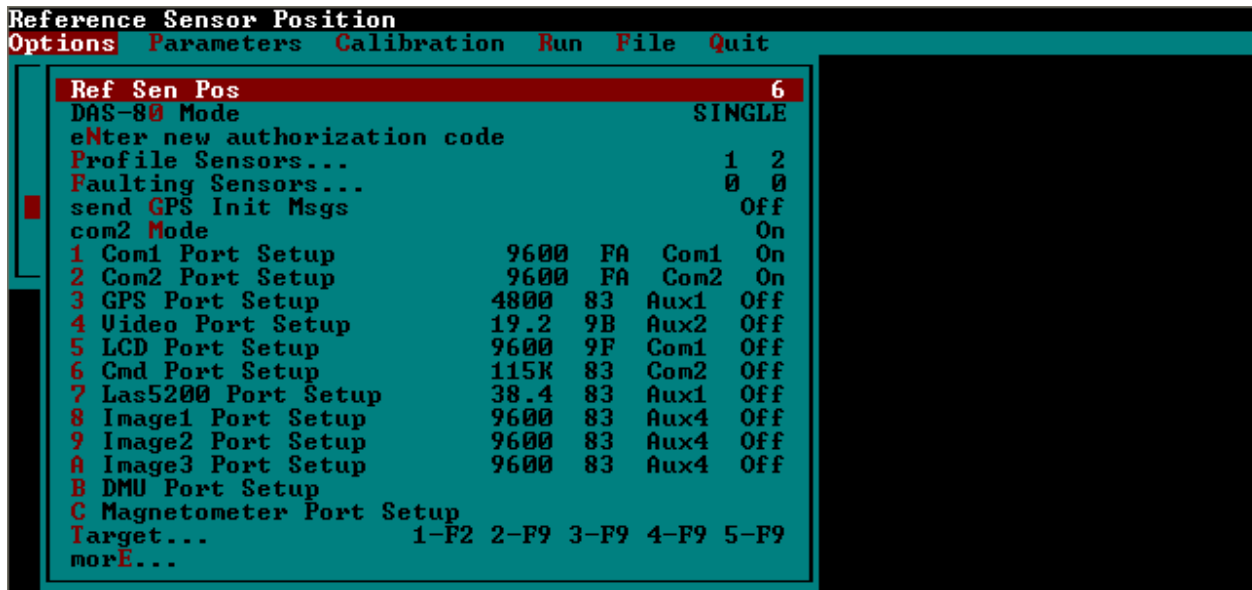
Figure 2-6. MDR Software ICC System Parameters Menu.
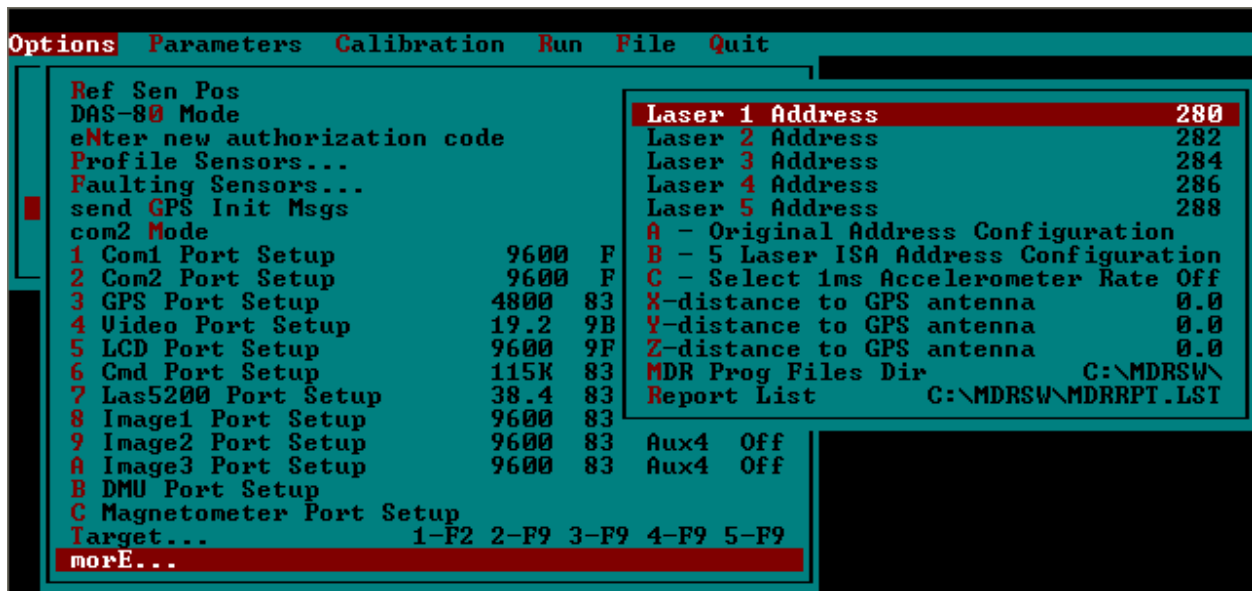
Figure 2-7. MDR Software More ICC System Parameters Menu.

5. Parameters Menu Settings:

    The 'Operator' and 'Driver' entries should be set for the names of the operator and driver using first initial and last name for each individual. As shown in Figure 2-8, the 'Vehicle' should be set to the appropriate MDT vehicle number for the profiler: 07-121X, where X is the appropriate district number (e.g., 1 for Missoula, 2 for Butte, etc.).
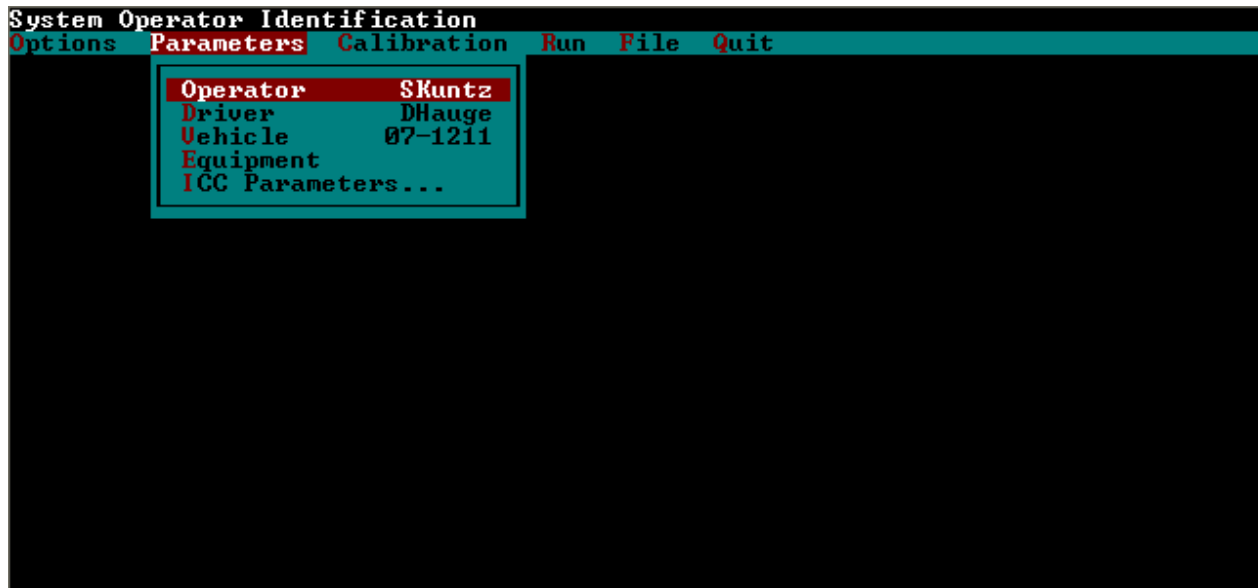
Figure 2-8. MDR Software Parameters Menu.

6. Sensor Configuration Menu Settings:

In the MDR main menu select 'Calibration' and the drop down menu shown in Figure 2-9 will be displayed. Highlight 'Sensors…' in this menu, and press Enter key. The Sensor Calibration menu shown in Figure 2-10 will be displayed on the monitor.
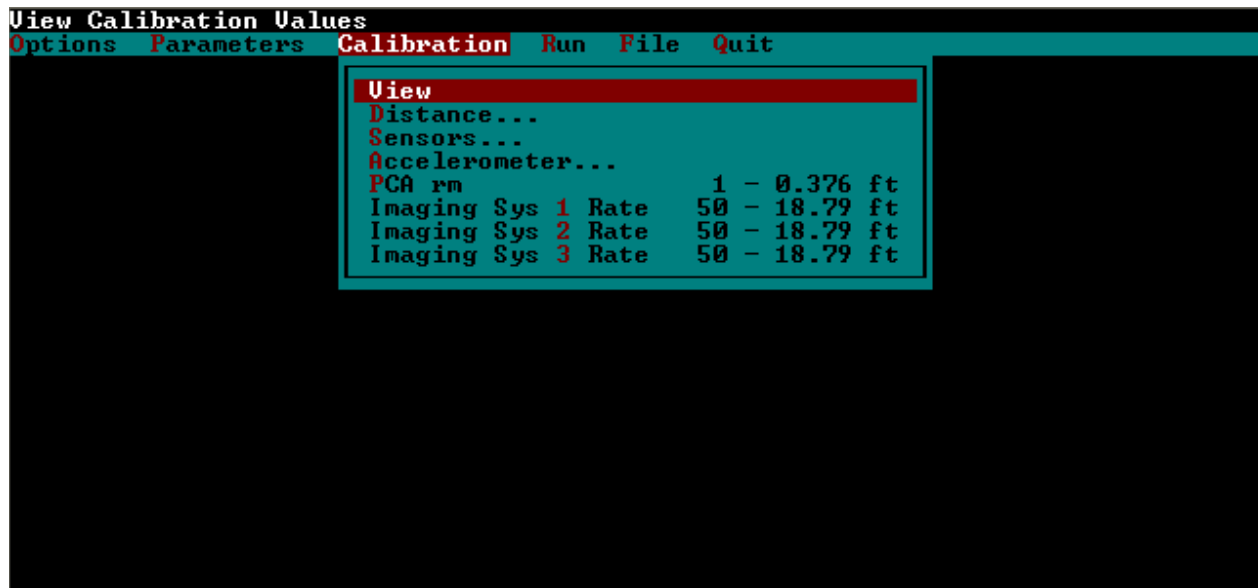
Figure 2-9. MDR Software Calibration Menu.

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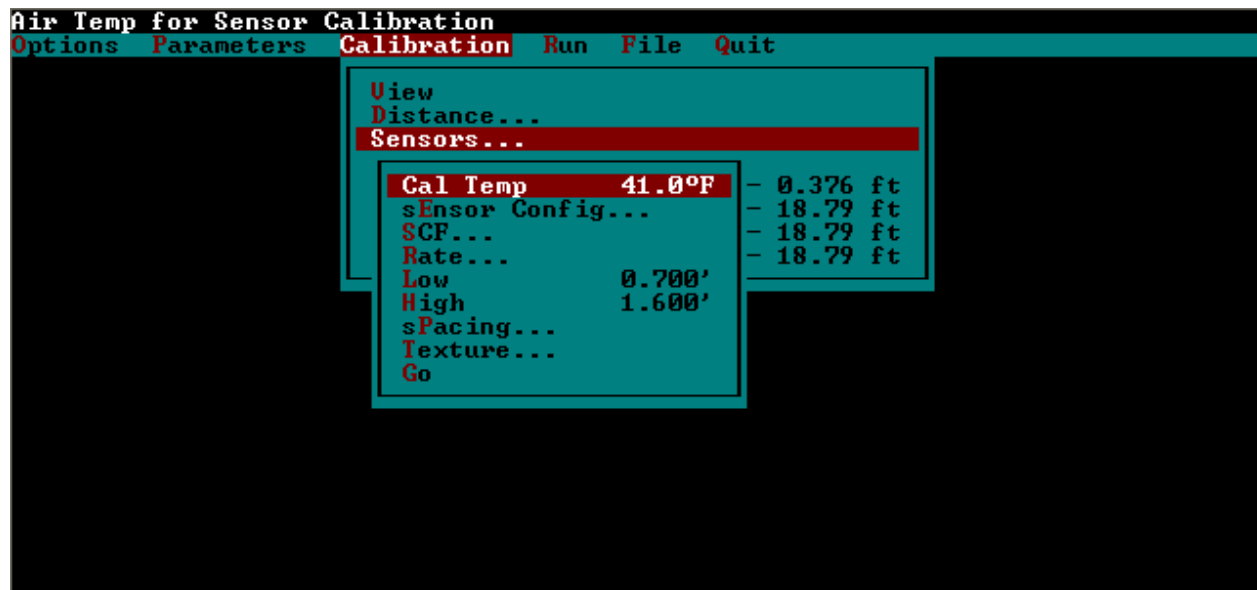
Figure 2-10. MDR Sensor Calibration Menu.

In Sensor Calibration Menu, highlight 'sEnsor Config…' and press the Enter key. The sensor configurations will be displayed on the monitor as shown in Figure 2-11. Parameter settings shown on the monitor should match the values shown below:

'sEnsor Config…' Submenu

Height Sensor(s)	2 of 2
1 – Pos 1 – Lt Wheel Path	Selcom200
2 – Pos 2 – Rt Wheel Path	Selcom200
3 – Pos 3 – Sensor	None
4 – Pos 4 – Sensor	None
5 – Pos 5 – Sensor	None
6 – Pos 6 – Sensor	None
7 – Pos 7 – Sensor	None
8 – Pos 8 – Sensor	None
9 – Pos 9 – Sensor	None
A – Pos 10 – Sensor	None
B – Pos 11 – Sensor	None
C – Pos 12 – Sensor	None
D – Pos 13 – Sensor	None
E – Pos 14 – Sensor	None
F – Pos 15 – Sensor	None

If the parameters shown are different, check with ICC and set parameters to appropriate values. After checking the parameters, press the Escape key to return to the Sensor Calibration Menu.
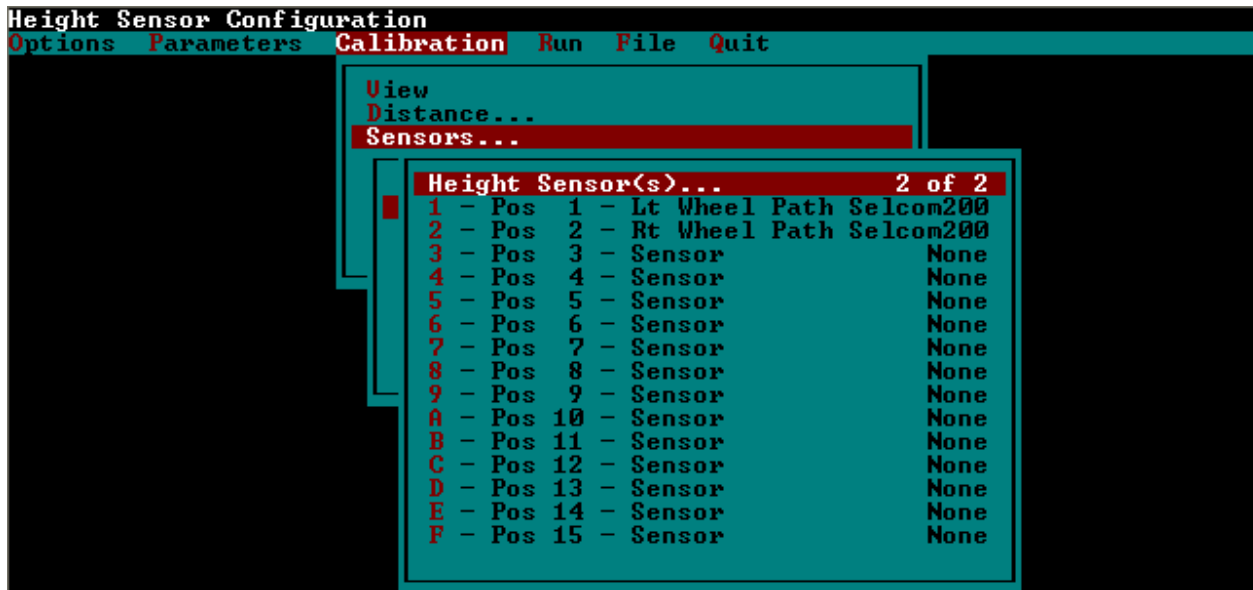
Figure 2-11. MDR Software Sensor Configuration Settings.

7. Sensor Rate Settings:

In the 'Rate...' submenu of the Sensor Calibration Menu, the Profile Rate should be set at value 1 (0.376 ft), the Rutting Rate should be set at value 1 (21 MPH), and the Ser5200 Rate should be set at value 1 (0.376 ft) as shown in Figure 2-12. The Profile Rate should be set at value 1 (0.115 m), the Rutting Rate should be set at value 1 (34 KPH), and the Ser5200 Rate should be set at value 1 (0.115 m) when the Reference Post Display Mode is set to 'Meter' in step 3 for projects with metric stationing.
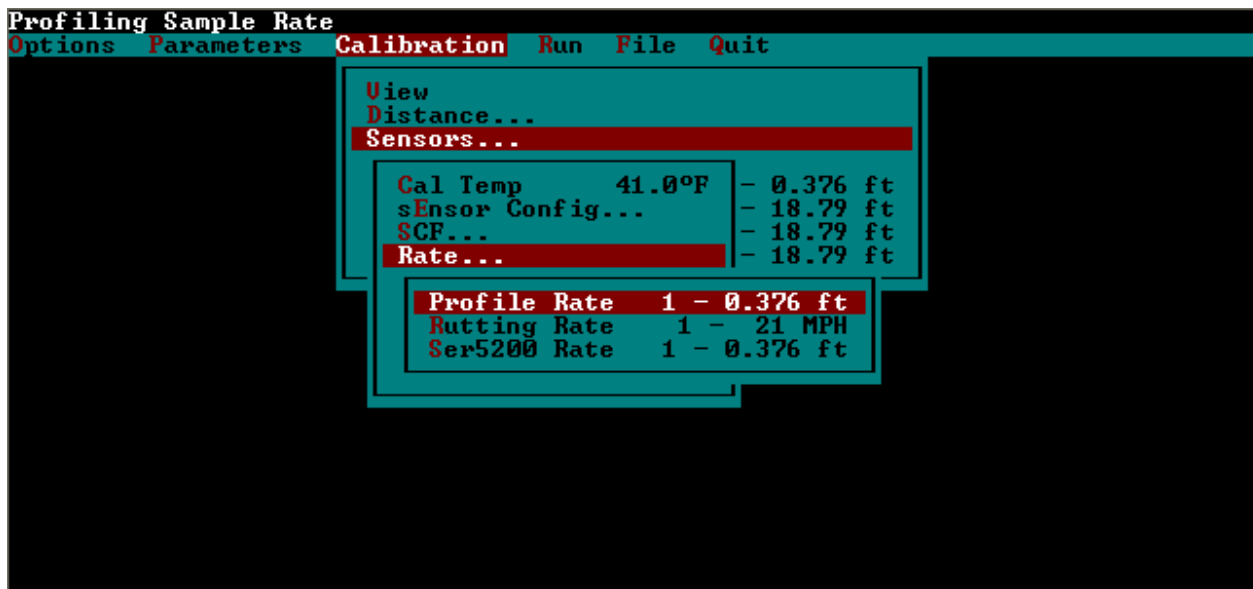
Figure 2-12. MDR Software Sensor Rate Settings.

8. Sensor Spacing Settings:

    In the 'sPacing…' submenu of the Sensor Calibration Menu, the values should be set to the following values as shown in Figure 2-13.

    'sPacing…' Submenu
    1 – Spacing   1 - 1   0.000"
    2 – Spacing   1 – 2   68.000"

    If any of the parameters are different, set parameters to the indicated values by highlighting parameter, pressing Enter, entering correct value in window that opens, and pressing Enter key again to close window. After checking the parameters, press the Escape key twice, to get back to the Calibration Menu.
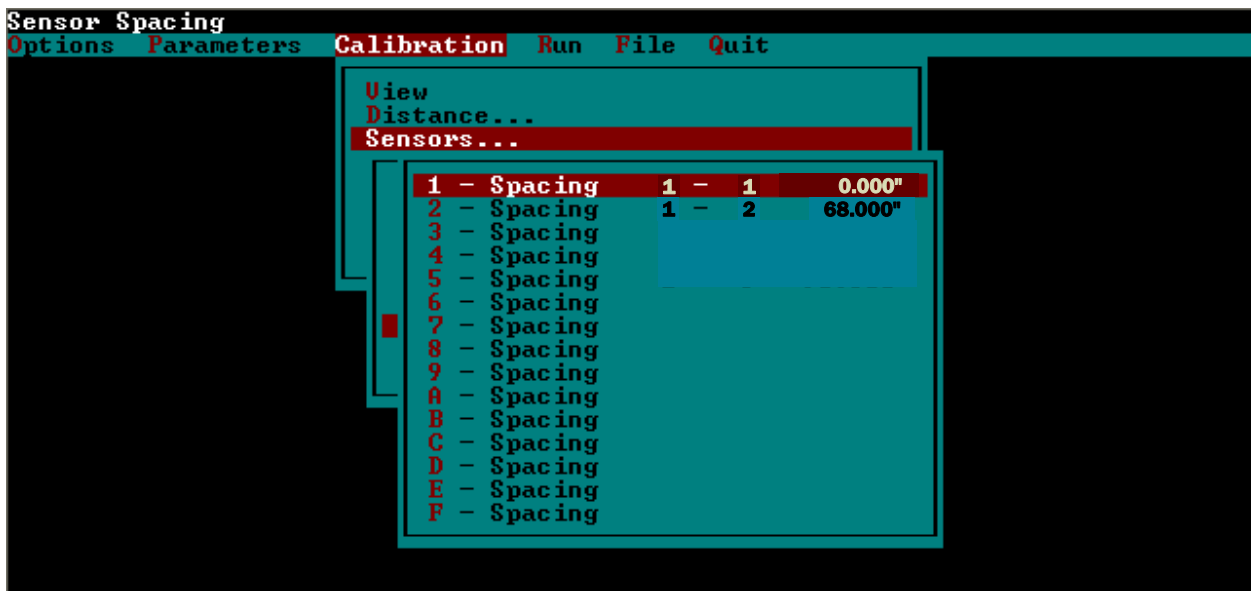
Figure 2-13. MDR Software Sensor Spacing Settings.

9. Accelerometer Calibration Menu:

    From the 'Accelerometer…' menu, the HPF value should be set to 0.020 as shown in Figure 2-14. In the 'FGF…' submenu, the 1st and 2nd FGF values should be set to 1.00 as shown in Figure 2-15. Please note that accelerometer line on top of menu should read "2 of 2".

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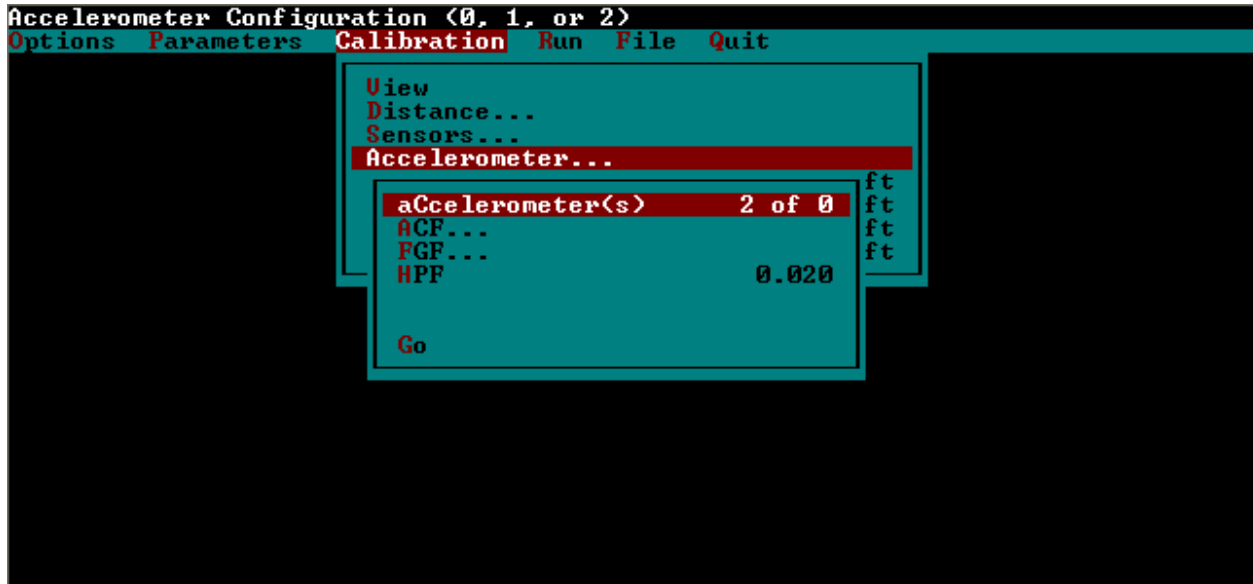
Figure 2-14. MDR Software Accelerometer Calibration Menu.
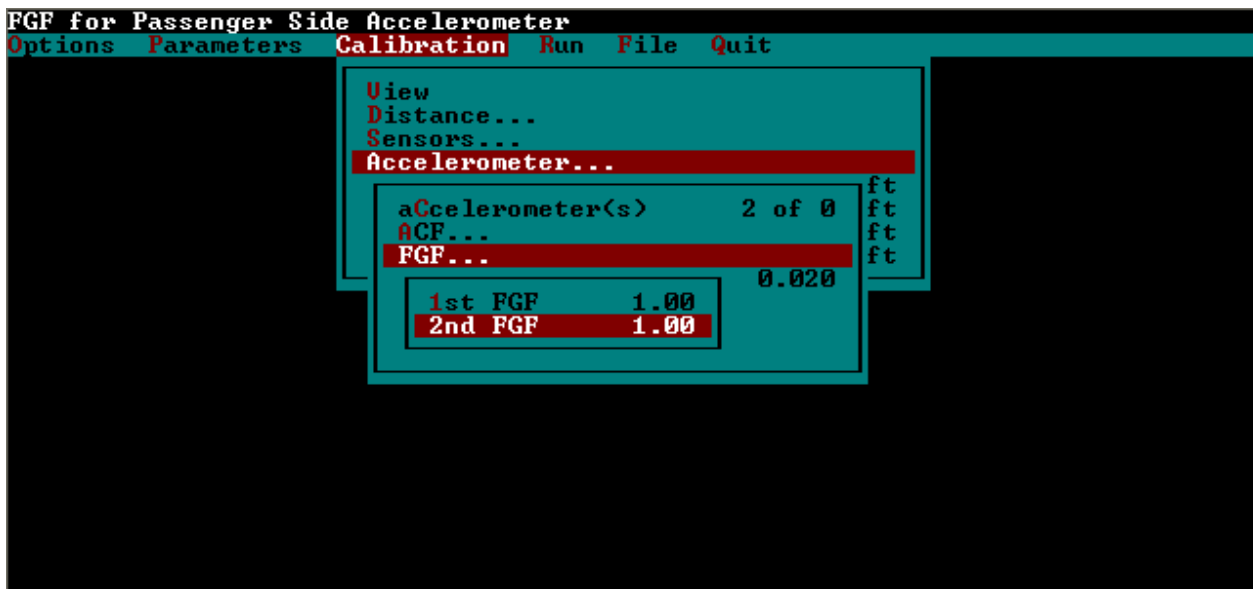
Figure 2-15. MDR Software Filter Gain Factor (FGF) Settings.

10. Run Menu Settings:

In the MDR Main Menu, select 'Run' and the Run Menu shown in Figure 2-16 will be displayed on the monitor.

County should be set to the county where the project is located, spelled out in all capital letters (e.g., MISSOULA). Route should be set to the highway or road designation for the road where the project is located, spelled out in all capital letters using a description that will not cause confusion with similarly numbered roads (i.e., INTERSTATE 90, STATE ROUTE 200, etc.). Direction should be toggled by selecting the first letter of the direction for the lane being profiled (i.e., E for East, W

for West, N for North, or S for South). Asc/Dsc Ref Point should be set to '+' for normal profiling operations. Lane should be set for the lane being profiled, spelled out in all capital letters (i.e., DRIVING, PASSING, or TURNING). Start Ref and End Ref can be used by the profiler operator to designate the project stationing values. Line 7 is a general comment field that lists the EPM and contractor who witness the profiling activities.

Figure 2-16. MDR Software Run Menu.

11. Run Options Menu Settings:

In the MDR Run Menu, highlight 'Options…' and press the Enter key. The Run Options Menu shown in Figure 2-17 will be displayed on the monitor.

*Figure 2-17. MDR Software Run Options Menu.*

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The values for the parameters shown on the monitor should match the following:

DMI Simulator	Off			
User Mode	SINGLE			
Mays	Off			
Profile	On			
GPS…	Aux1	Off		
lcd Display…	Com1	Off	1	
speed Collect	On			
speed Limit	±1.0			
secTion incr…	Off			
target…	Com1	On/Com2	Off	
tracKing	Off			
cOmmand mode	Com2	Off		
Imaging… 1-Aux4 Off	2-Aux4	Off	3-Aux4	Off
iRi…	On			
las5200 com port	Aux1	Off		
3 Remote SLD	Off			

The DMI Simulator is used strictly to demonstrate the equipment is working properly. This is not an option that should be on when collecting data. This option simulates DMI pulses and allows the RUN functions to be demonstrated without moving the profiler. Trying to collect data with the simulator on will result in extremely high speed and distance readings. This error results from the system receiving distance pulses from two sources. If the profiler is not moving but showing a speed in the RUN screen, most likely the simulator is on and must be turned off.

12. IRI Settings Menu:

From the Run Options Menu, select 'iRi…' and the IRI settings shown in Figure 2-18 will be displayed on the monitor. The IRI settings should be adjusted to match the following list:

'iRi…' Submenu	
Mode	On
HCS/avg IRI	Avg
iri Scale	63360
Negative rut	On
Filter	On
Wavelength	300.0
Moving Average	1
section Control	Off
interval Control	On
Interval	0.1
interval Reset	Off
speed Limit	15.0
ride Number	Off
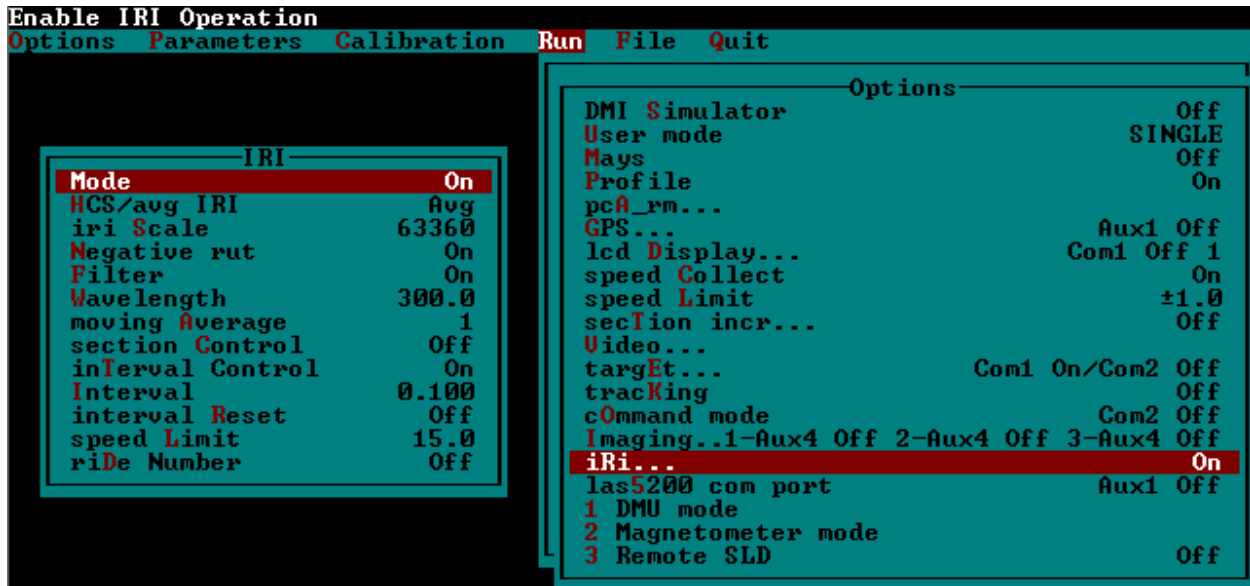
Figure 2-18. MDR Software IRI Options Settings.

3.0 CALIBRATION OF EQUIPMENT

Calibration is used to establish and adjust the transducer operating characteristics of the MDR system. There are three types of transducers in the system: linear distance measuring system (i.e., DMI), the vertical height sensor (i.e., laser sensor), and the vertical position accelerometer. The following sections describe the calibration and checks of these components.

A comprehensive calibration and sensor check will be performed at an interval of thirty (30) days, during construction season. There are four components to the calibration and sensor check procedure described in this chapter. The four components in the order that they should be performed are: 1) full calibration check of laser sensors, 2) calibration of accelerometers, 3) bounce test profiling system verification, and 4) calibration of DMI.

3.1 FULL CALIBRATION CHECK OF LASER SENSORS

The laser sensors are calibrated and sealed by the manufacturer. The operator cannot calibrate these sensors; however, the lasers can be checked. A comprehensive check of laser sensors should be performed at an interval of thirty (30) days during construction season, which will check the accuracy of the laser sensors over a 1 inch (25.4 mm) measuring range. This check is referred to as the Full Calibration Check of laser sensors and is different from the Pre-Run Check described in Chapter 4. A full calibration check of the laser sensors must also be performed whenever laser sensors problems are suspected or when a sensor is repaired or replaced.

Power to the electronic equipment should be turned on for about 15 minutes prior to performing any calibration or calibration checks so that the electronic equipment is allowed to warm up and stabilize.

The results of the full calibration check of the laser sensors will be recorded under the "LASER SENSOR CALIBRATION CHECK" section on the MDT Profiler Calibration Record Sheet (Appendix B) and kept in the profiler log book.

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Once a year, before the beginning of the construction season, each calibration block's thickness will be measured using micrometers. Each block's thickness with the value converted to feet is recorded in the "Actual Block Thickness" line of the Profiler Calibration Record Sheet each time the full calibration check is performed.

The full calibration check of laser sensors should be performed in an enclosed building with a level concrete floor using external power (house power) to power the profiler system. If the full calibration check is performed in the field, the location where the check is performed should protect profiler from wind and other vibrations. The pavement surface should be as level as possible and lighting conditions should be consistent from sensor to sensor (i.e., face profiler away from the sun). An external power source should be used, whenever possible.

The following procedures should be used to set up the profiler to perform the full sensor calibration check.

1. Check Sensor Height: Make sure the laser sensors are powered off. Remove sensor covers. Measure distance from floor to glass face of the laser sensor. This distance should within 13 in ± 0.5 in (330 mm ± 10 mm). The distance from ground to face of the sensor should not change between calibration checks that are performed monthly, unless the sensors have been moved or replaced since the previous calibration check. Adjust the sensor if required so that the height from glass face of sensor to ground is 13 in ± 0.5 in (330 mm ± 10 mm). Record these measurements in the appropriate boxes in the "Lens to Ground Measurement" line under the "LASER SENSOR CALIBRATION CHECK" section on the Profiler Calibration Record Sheet.

2. Clean Sensor Glass: Gently clean each lens following the guidelines described in Chapter 2. When cleaning the lenses, extreme care should be taken to prevent scratching of the lenses. Always make sure that lasers are turned off when inspecting the sensor glass, cleaning the sensors or when performing maintenance on the sensors. Additionally, operators should be warned not to let the laser beam strike their eyes. This laser is powerful enough to damage eyesight. Furthermore, the reflection of the laser beam from a surface such as a polished plate, a calibration bar or a watch may also damage eyesight. Operators should take all necessary steps to avoid a reflected laser beam coming into contact with the eye.

3. Warm Up Electronics: Power the computer system and lasers. Let equipment warm up for at least 15 minutes.

4. The operator should be outside of the profiler when the calibration check is performed. Adjust the computer monitor so that it can be seen from outside the vehicle, and the keyboard should be placed on the seat of the profiler. Do not enter the profiler, bounce or bump the profiler, or lean on the profiler during the calibration check.

5. In the MDR main menu, select 'Calibration' to display the Calibration Menu. Highlight the 'Cal Temp' selection and press Enter key.

6. Enter an accurate air temperature value ± 3°F and press the Enter key.

7. In the Calibration Menu, make sure that all parameters match the settings described in Section 2.3.

8. In the Calibration Sensor Menu, highlight 'Go' and press the Enter key. The monitor will display the sensor calibration screen similar to Figure 3-1.

The items on the screen are as follows:

Number of Samples	The number of sensor readings.
Sensor	The height sensor position number on the test vehicle (1 for Left and 2 for Right).
Count	The count the sensor required for the last height sample.
Height	The height of the last sample.
Avg. Height	Average height of all samples.
Gate/Zero	Number of hardware errors detected.
Low	Number of sensor readings that are below the Low limit.
High	Number of sensor readings that exceed the High limit.
Dif	Number of samples where differences in successive samples are greater than 15 inches (381 mm).
Total	Total number of errors detected.

```
============================= Sensor Calibration =============================
Sensor          #1     #2
Count          1600   1675
Height        0.262  0.275
Avg Height    0.263  0.274

Gate/Zero
Low
High
Dif
Total

Sensor
Count
Height
Avg Height

Gate/Zero
Low
High
Dif
Total
                            973 Samples
                        Press BkSp To Stop
```
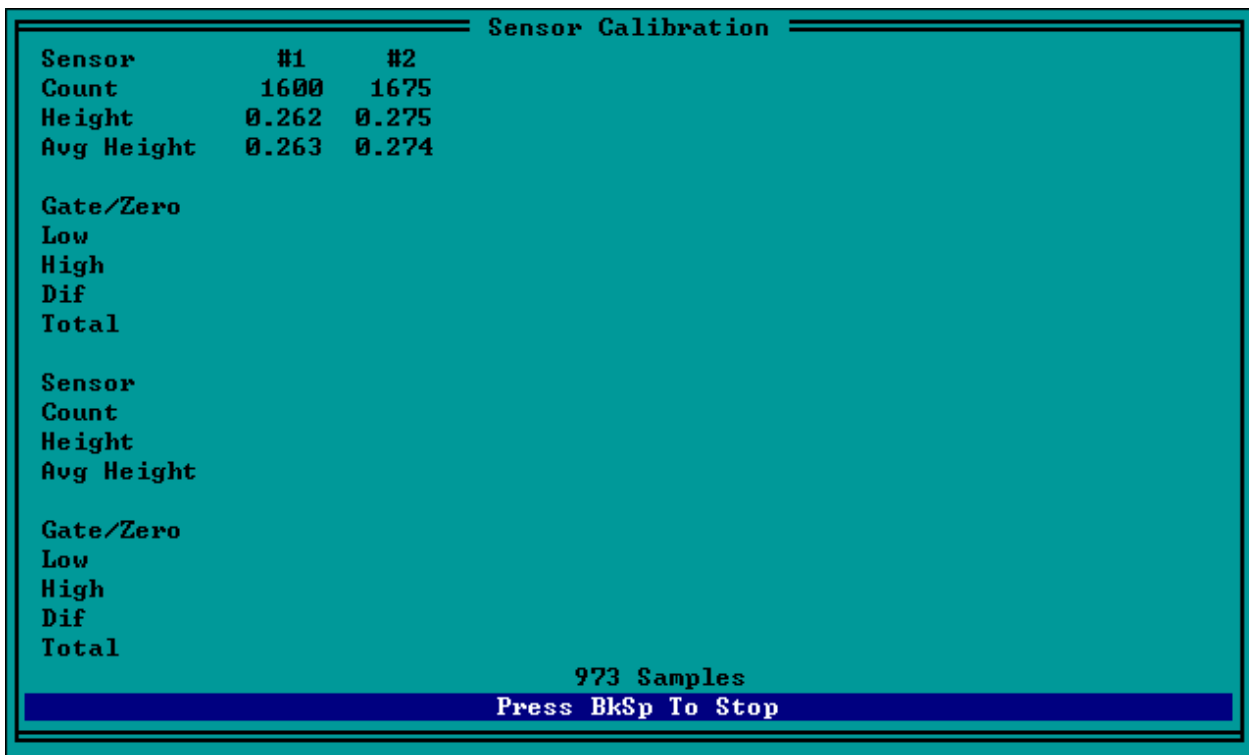
Figure 3-1. MDR Software Sensor Calibration Screen.

9. Record the actual ¼″, ½″, and 1″ calibration block thicknesses (in feet units) in the appropriate spaces on line 1 (Actual Block Thickness) under the "LASER SENSOR CALIBRATION CHECK" section of the Profiler Calibration Record Sheet.

10. Verify that no blocks, objects, or debris are directly under the laser sensors. Press the Enter key to start reading the laser values. After a minimum of 1000 samples, press backspace to stop. From

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the Sensor Calibration Screen, record the left laser (sensor 1) Avg Height value for the floor height measurement in the appropriate space on line 2 (Height: Floor) under the "LASER SENSOR CALIBRATION CHECK" section of the Profiler Calibration Record Sheet.

11. Place the ¼" calibration block on the floor under the left laser sensor, and position the block so that the laser will reflect approximately at the center of the block. Press the Enter key to start reading the laser values. After a minimum of 1000 samples, press backspace to stop. From the Sensor Calibration Screen, record the left laser (sensor 1) Avg Height value for the block height measurement in the appropriate space on line 3 (Height: Block) under the "LASER SENSOR CALIBRATION CHECK" section of the Profiler Calibration Record Sheet.

12. Repeat steps 10 and 11 using the ½" calibration block.

13. Repeat steps 10 and 11 using the 1" calibration block.

14. Using the Height values recorded on the "LASER SENSOR CALIBRATION CHECK" section of the Profiler Calibration Record Sheet, compute the "Height: Floor - Block" values for each of the ¼", ½", and 1" calibration blocks by subtracting the "Height: Block" value from the "Height: Floor" value.

15. Using the "Height: Floor - Block" values recorded on the "LASER SENSOR CALIBRATION CHECK" section of the Profiler Calibration Record Sheet, compute the "Difference: Actual - Height" values for each of the ¼", ½", and 1" calibration blocks by subtracting the "Height: Floor - Block" value from the "Actual Block Thickness" value.

    The computed value should be less than or equal to 0.002 ft for the laser sensor to be considered working properly. If the value is greater than 0.002 ft, the trouble shooting procedure below is a suggested guide to verify and resolve any issues with the laser sensor.

16. Repeat steps 9 through 15 to perform the laser sensor calibration check on the right laser (i.e., sensor 2).

17. Press the Escape key to return to the MDR Main Menu.

If any of the "Difference: Actual – Height" values computed for the left and right sensors are greater than 0.002 ft, the following items are suggested to verify that there is an actual problem with the laser sensor. If these procedures do not successfully rule out a problem with the laser sensor(s), ICC should be contacted to assist and resolve sensor problems.

- Verify that all recorded values and computations are accurate.

- Repeat the laser sensor calibration check for the block(s) and laser that produced an unacceptable difference greater than 0.002 ft. It is possible that the block was not positioned under the laser sensor properly, or that the block was not sitting squarely on the floor. It is not necessary to repeat the calibration check for any blocks that satisfy the acceptable criteria.

- If the laser sensor calibration check was performed with the engine running, attempt to perform the calibration check (in its entirety) with the engine switched off and the profiling system plugged into house power (if possible).

- Move the profiler to another location and redo the laser sensor calibration check in its entirety.

3.2 CALIBRATION OF ACCELEROMETERS

The accelerometers in the profiler should be calibrated at an interval of thirty (30) days during construction season or whenever problems are suspected. The accelerometers should be calibrated if the accelerometer check indicates accelerometer calibration factor(s) are outside the allowable range or if the bounce test indicates a potential problem with the accelerometer(s). The operator may elect to calibrate accelerometers daily prior to performing the bounce test. The accelerometers should be calibrated when repairs are performed on the accelerometer(s) or on computer cards associated with the accelerometer(s). The accelerometers should be calibrated when a full calibration check is performed on the laser sensors.

Calibration of accelerometers should be performed while the profiler is parked on a level surface. The location, where calibration is being performed, should be free of any vibrations and shielded from any environmental conditions such as gusty winds. The calibration of accelerometers can be performed when the engine of the profiler is running but ideally the engine should be turned off while the calibration is being performed. The calibration can be performed with the operator and driver sitting in the profiler seats. Alternately, the operator can stand outside of vehicle when calibration is performed and the computer monitor should be adjusted so that it can be seen from outside the profiler with the keyboard placed on the seat. Do not enter the truck, bounce or bump the profiler, or lean on the profiler during calibration. The power to the system should be turned on for about 15 minutes for the system to warm up prior to calibrating the accelerometers. The following procedure should be used to calibrate accelerometers:

1. Boot up computer following procedures described previously in Section 2.2. The MDR main menu should now be displayed on the monitor.

2. In the MDR main menu, select 'Calibration' to display the calibration menu. In the Calibration Menu, highlight 'Accelerometer' and press Enter key, and the Accelerometer Calibration Menu shown in Figure 3-2 will be displayed on the monitor. The parameters are as follows:

aCcelerometer(s)	Number of configured accelerometers should be 2 of 2.
ACF	Accelerometer Calibration Factor
FGF	Filter Gain Factor
HPF	Integrator Filter High Pass Frequency should be 0.020.
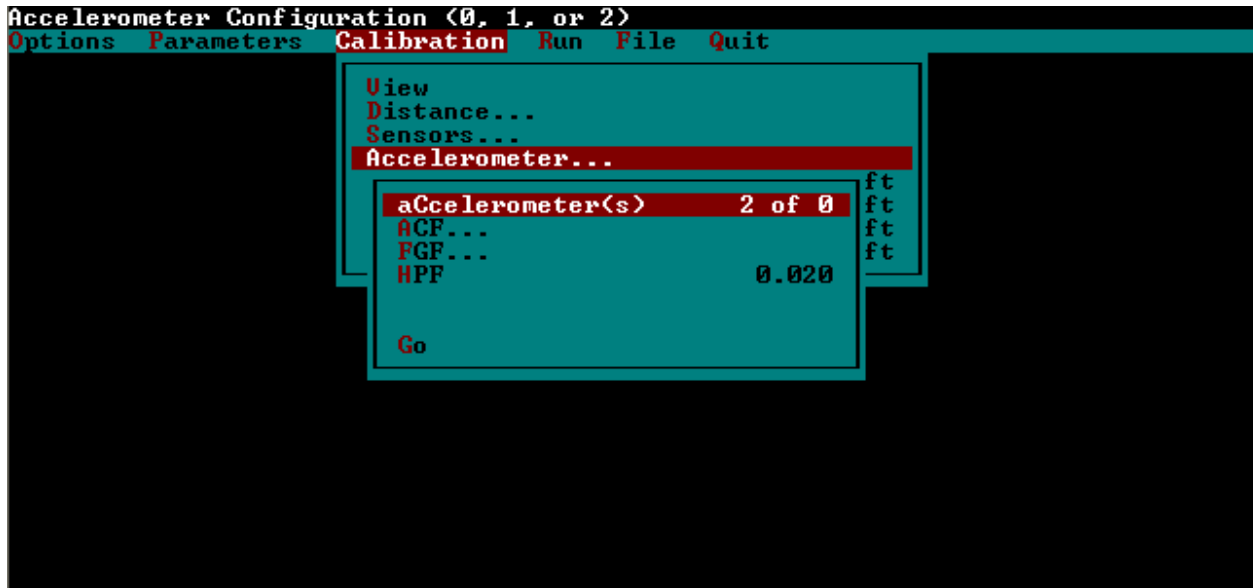
Figure 3-2. MDR Software Accelerometer Calibration Menu.

3. In the Accelerometer Calibration Menu, highlight 'Go' and press Enter key. The monitor will display an Accelerometer Calibration Screen similar to that shown in Figure 3-3.
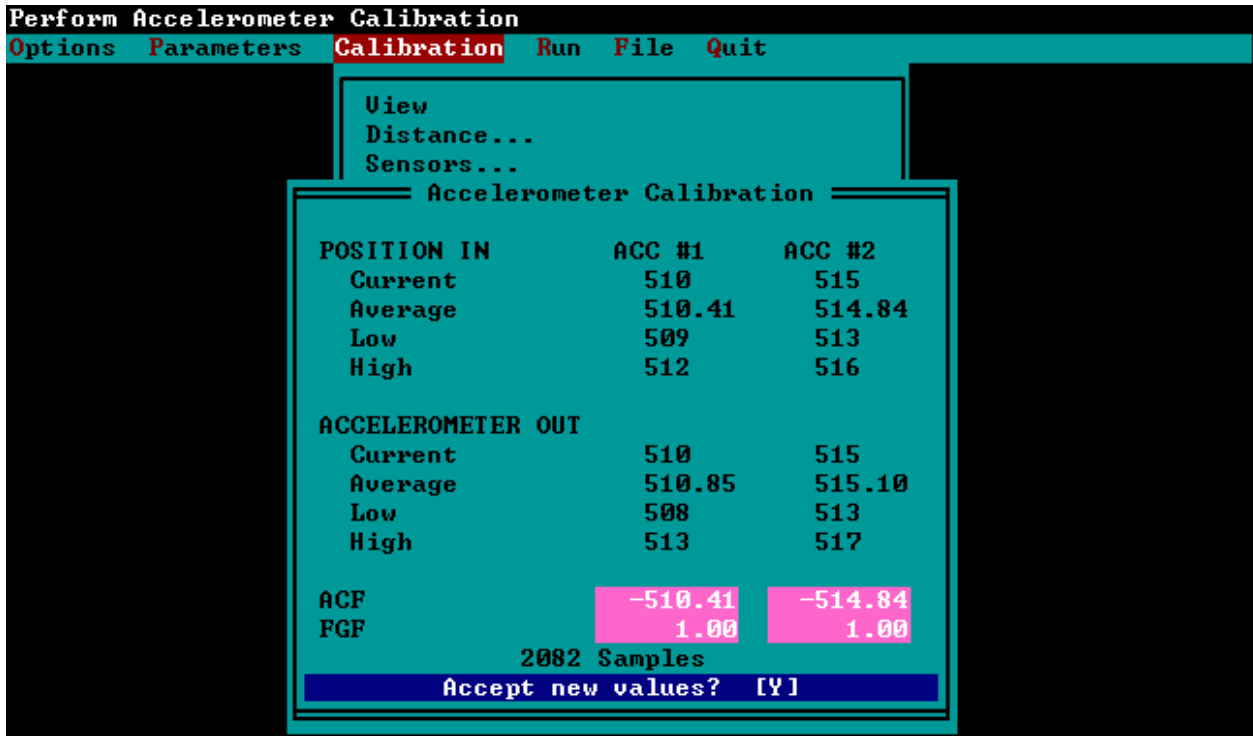
Figure 3-3. MDR Software Accelerometer Calibration Screen.

4. Press 'Enter' key and the accelerometer calibration procedure will begin to sample accelerometer measurements. After approximately 2000 samples have been taken, press 'Backspace' key to end calibration.

5. System will prompt the operator if the new ACF values should be accepted. The accelerometers are considered to be working properly if the ACF values are within the range 512 ± 10. If test appears to be valid, press 'Y' key to accept values. If test was not valid, press 'N' key to repeat the calibration procedure.

6. The results of the accelerometer calibration need to be recorded under the "ACCELEROMETER CALIBRATION" section on the MDT Profiler Calibration Record Sheet (Appendix B) and kept in the profiler log book. Record the calibration factor values for the right and left accelerometers prior to performing the accelerometer calibration. After completing the acceptable accelerometer calibration, record the new calibration factors for the right and left accelerometers

7. Press 'Escape' key to return to the MDR Main Menu.

3.3 BOUNCE TEST PROFILING SYSTEM

The bounce test is a controlled-conditions procedure that uses the profiler's built in simulation capabilities to test that the profiling system is operating properly. A bounce test will be performed every time the accelerometer calibration and laser calibration checks are performed at an interval of thirty (30) days during construction season or whenever problems are suspected. This bounce test is different than the pre-run bounce test described in Chapter 4.

The bounce test will be performed following the Laser Sensor Calibration Check and Accelerometer Calibrations described in Sections 3.1 and 3.2. Power to the electronic equipment should be turned on for about 15 minutes prior to performing any calibration or calibration checks so that the electronic equipment is allowed to warm up and stabilize.

The bounce test should be performed while the profiler is parked on a level surface. Location where the bounce test is being performed should be free of any vibrations, and shielded from any environmental conditions such as gusty winds. The bounce test can be performed when the engine of the profiler is running but ideally the engine should be turned off while the bounce test is being performed. The operator should stand outside of the vehicle when the bounce test is performed, and the computer monitor should be adjusted so that it can be seen from outside the profiler with the keyboard placed on the seat.

The results of the bounce test will be recorded under the "BOUNCE TEST" section on the MDT Profiler Calibration Record Sheet (Appendix B) and kept in the profiler log book. Additionally, the electronic data files from this bounce test will be submitted to the MDT Pavement Management Analysis Division for further analysis of the accelerometers and laser sensors.

The following procedure should be used to perform the bounce test:

1. Place brown wooden clipboards on the ground directly under the right and left laser sensors so that the lasers spots are near the center of the clipboards. Metal, plastic, or colored clipboards are not recommended as the intent of the clipboards is to have the laser sensor take height measurements off a flat neutral colored surface.

2. In the MDR Main Menu, select 'Options' to display the options menu. In the Options Menu, verify that the "Reference Post Display Mode" is set to "Mile" as shown in Figure 3-4.

Figure 3-4. MDR Software Options Menu for Bounce Test.

3. In the MDR main menu, select 'Run' to display the run menu. In the Run Menu, the entries for "County," "Route," "Direction," and "Lane" do not impact the bounce test and do not need to be changed from the last data collection project. However, the "Asc/Dsc Ref Point" should be set to "+," the "daTa Directory" should be changed to "D:\BOUNCE," and the "1 File Name" should be set as the date (e.g., "14JUL05") as shown in Figure 3-5.

Figure 3-5. MDR Software Run Menu for Bounce Test.

4. In the Run Menu, select 'Options…' to display the Run Options Menu. Highlight the "DMI Simulator" option and press 'Enter' key to toggle the distance simulator to "On" as shown in Figure 3-6. The remainder of the Run Options Menu settings are described in Section 2.3. Press 'Escape' key to return to the Run Menu.

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Figure 3-6. Run Options Menu Toggling Distance Simulator On.

5. In the Run Menu, highlight 'Go' and press 'Enter' key to begin the bounce test. The monitor will display the Run Screen similar to that shown in Figure 3-7.
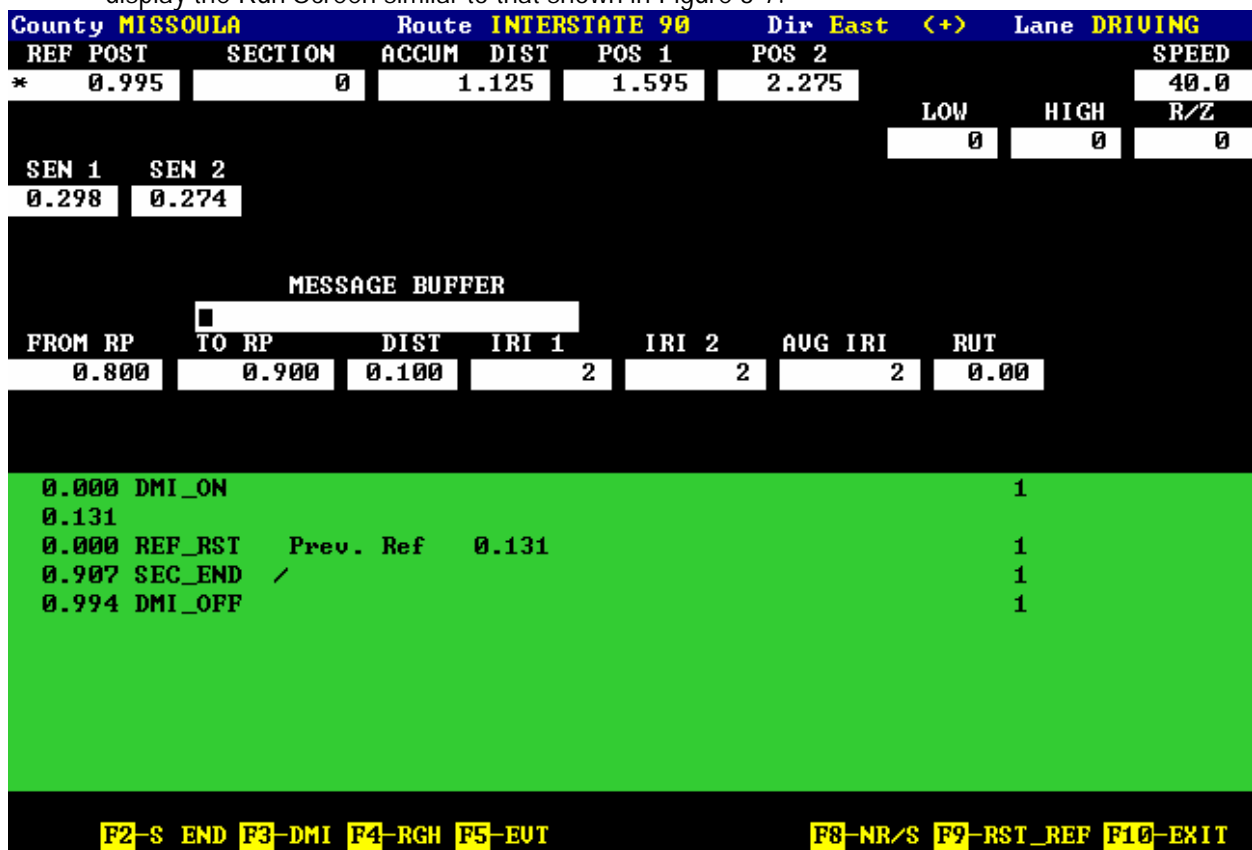
Figure 3-7. MDR Software Run Screen for Bounce Test.

6. Verify that the "SPEED" indicates a reasonable simulated speed. Press Page Up key to increase the speed to 70 mph (113 km/h). If the indicated speed is zero, exit the run screen and verify that the distance simulator is turned on as described in step 4 above.

7. Press the F3 key to begin simulating distance for the bounce test. The "REF POST" should indicate an ascending distance count.

8. When the "REF POST" indicates a minimum of 0.1 miles (0.16 km), press the F9 key to initiate the reference reset.

9. The profiler should remain settled for the static portion of the bounce test for a minimum of 0.5 miles (0.80 km) indicated on the "REF POST."

10. After the "REF POST" indicates a minimum of 0.5 mi (0.80 km), the operator should begin to apply a vertical up and down motion to the center of the sensor bar on the front of the profiler. The pitching motion on the sensor bar should impart a displacement of approximately 1 in (25.4 mm) total. All efforts should be attempted to avoid any side to side or rolling motions. This dynamic portion of the bounce test should continue, without interruption, for a minimum of 30 seconds.

11. At the conclusion of the dynamic portion, press the F2 key to mark the section end of the simulated profile. The operator may elect to allow the profiler to return to a static state before stopping the simulation.

12. Press the F3 key to stop the simulated profile.

13. Press the F10 key to exit from the Run Screen. Press 'Enter' key to save the profile data file to the hard disk drive.

14. In the Run menu, select 'Options…' to display the run options menu. Highlight the "DMI Simulator" option and press the Enter key to toggle the distance simulator to "Off" as shown in Figure 3-8. Press 'Escape' key twice to return to the Main Menu.

Figure 3-8. Run Options Menu Toggling Distance Simulator Off.

15. From the Main Menu, select 'Quit' to exit the MDR software. At the "Do You Want to Exit System" prompt, press the 'Y' key.

16. At the DOS prompt, change to the directory D:\BOUNCE.

17. From the DOS prompt, type MTIRI <FILENAME> 1 and press the enter key to analyze the bounce test data. <FILENAME> is the file name set in step 4 (e.g., "14JUL05"). 1 indicates the run file number; if more than one bounce test is performed, the number of the desired bounce test should be changed to the appropriate bounce test run number.

18. When the MTIRI analysis program prompts for the IRI Report Type, enter 'E' for English.

19. When the MTIRI analysis program prompts for the IRI Report Interval, enter '1' for 100 ft and the IRI report will be created.

20. When the MTIRI analysis program prompts how to output the IRI report, enter 'P' to print the file. The report can also be displayed on the monitor by entering 'D,' but a copy of the report should be printed and attached to the MDT Profiler Calibration Record Sheet to be kept in the profiler log book.

21. Review the IRI report for Reasonableness.

The first 0.5 mi (0.80 km) of intervals on the report should contain IRI values reflecting the profiler in a static condition. The resulting static IRI values should be less than or equal to 5 in/mi (0.08 m/km) for the profiler to be considered functioning properly under static conditions. As long as no more than two static intervals have IRI values greater than 5 in/mi (0.08 m/km) in either the left or right channels the profiler is considered to have satisfied the static bounce test criteria. If more than two static intervals have IRI values greater than 5 in/mi (0.08 m/km), the bounce test should

be repeated to make sure that the profiler remained completely motionless (was not bumped, moved, or otherwise disturbed) during the static portion of the bounce test. The profiler can also be moved to a new location and the bounce test repeated if the static IRI values are not improved.

The intervals following the static portion represent the profiler in a dynamic condition and typically have IRI values much larger than the static condition IRI values. The dynamic IRI values would typically be in the range of 20 to 45 in/mi (0.32 to 0.71 m/km) for the amount of motion imparted following this bounce test procedure. If more than three intervals of dynamic IRI values are less than 20 in/mi (0.32 m/km), the bounce test should be repeated with emphasis to make sure that a displacement of 1 inch (25.4 mm) is applied at the sensor bar during the dynamic portion of the bounce test. If a majority of intervals of dynamic IRI values are significantly more than 50 in/mi (0.79 m/km), the bounce test should be repeated with emphasis to make sure that a displacement of 1 inch (25.4 mm) is applied at the sensor bar during the dynamic portion of the bounce test. The profiler can also be moved to a new location and the bounce test repeated if the dynamic IRI intervals are not improved.

22. Select one interval from the static portion of the bounce test and record the resulting IRI values for the left and right sensors in the appropriate blocks on the "Static Value" line under the "BOUNCE TEST" section of the Profiler Calibration Record Sheet (Appendix B).

23. Select one interval from the dynamic portion of the bounce test and record the resulting IRI values for the left and right sensors in the appropriate blocks on the "Dynamic Value" line under the "BOUNCE TEST" section of the Profiler Calibration Record Sheet (Appendix B).

24. The electronic data files are transferred to the MDT Pavement Management Analysis Section by copying the bounce test data files to the MDT Ride Specification Share Drive. For consistency between the districts, the files will be placed in the "Calibration" subdirectory in the appropriate district directory on the Share Drive. After copying the electronic data files to the Share Drive, the MDT Pavement Management Analysis Section should be notified of the new bounce test data requiring analysis.

If the review of the IRI report or the additional data review performed by the MDT Pavement Management Analysis Section indicates potential problems with the profiling system, ICC should be contacted for assistance in resolving any problems.

3.4 CALIBRATION OF DMI

The DMI should be calibrated at an interval of thirty (30) days during construction season or whenever problems are suspected. The DMI should also be calibrated when tires are replaced, suspension repairs are performed, or when wheels are rotated or aligned. The DMI should be calibrated when repairs are performed on the DMI or to computer cards associated with the DMI.

The DMI is calibrated by driving the vehicle over a known distance to calculate the Distance Calibration Factor (DCF). The operator enters the actual distance traveled in the calibration menu and the computer calculates the DCF. An accurately measured section that is approximately one mile long should be used to

calibrate the DMI. The section should be measured with a standard surveying tape using standard surveying procedures or laid out using an electronic distance measurement (EDM) system. Each district should have a calibration site set up. This section should be located on a straight portion of roadway that is reasonably level and has low traffic volume.

Prior to driving the profiler, the operator should check the tire pressure (cold) to ensure that the tire pressure of the rear tires are at the truck and tire manufacturers' recommended pressures. The operator should drive the vehicle for about 4 to 5 mi (6 to 8 km) at highway speeds prior to calibration so that the tires can warm up. Based on local weather conditions (e.g., cold weather) the operator may need to increase the distance the vehicle should be driven to warm up the tires.

The following procedure should be used to calibrate the DMI:

1. Power up the profile system and boot the computer using procedures outlined previously in Section 2.2.

2. Check and adjust if necessary the rear tire pressures to verify reasonable values that are consistent with the manufacturer specified cold tire pressures. The DMI calibration should only be performed when the tires have been warmed sufficiently to maintain a stable pressure throughout the time required to perform the DMI calibration.

3. In the MDR main menu, choose 'Calibration' to bring up the Calibration Menu and then highlight 'Distance' and press 'Enter' key as shown in Figure 3-9. The screen will display the current DCF. The DCF is a maximum of five (5) numbers followed by a letter. The letter represents the following:

> C   Entry was entered by completing the calibration process.
> E   DCF has been entered into the system.
> U   No calibration has been performed by operator.
>
> Note: MDT will only accept DCF values attained through the calibration process.

Figure 3-9. MDR Software Distance Calibration Menu.

4. In the Distance Menu highlight 'Go' and press 'Enter' key. The system will then prompt the operator for the Calibration Distance. Enter the length of the calibration section and press 'Enter' key (e.g., 5280). The system will then prompt the operator for the tire pressure. Enter the current, warm tire pressure and press 'Enter' key (e.g., 50). The distance calibration screen shown in Figure 3-10 will now be displayed on the monitor.

Figure 3-10. MDR Software Distance Calibration Screen Before Performing DMI Calibration.

The following steps are a coordinated effort between the operator and driver. The profiler will be driven over the distance calibration course, and the operator will manually mark in the computer when the profiler passes over the beginning and ending points of the course. During the calibration, the profiler must be driven smoothly and as straight as possible; all accelerations and decelerations must be constant; and the profiler should not be placed into reverse between the times when the start mark and end mark are noted in the computer.

5. The F3 key should be pressed to activate the Distance Calibration Test mode.

6. The profiler should be driven near the starting point of the distance calibration course. When the profiler is approximately three feet from the starting point, the profiler should be gradually rolled forward until a mark on the profiler is aligned with the mark on the pavement from the constant vantage point of the operator. At the same time as the mark on the profiler aligns with the mark on the pavement, the operator should press the 'Enter' key to begin the pulse counts for the distance calibration.

7. The profiler should be gradually accelerated until the profiler has attained a reasonable speed to traverse the distance calibration course. As the end of the course is neared, the profiler should be gradually slowed.

8. When the profiler is approximately ten (10) ft from the ending point of the distance calibration course, the profiler should be gradually rolled forward until the mark on the profiler is aligned with the mark on the pavement from the constant vantage point of the operator. At the same time as the mark on the profiler aligns with the mark on the pavement, the operator should press the 'Backspace' key to stop the pulse counts for the distance calibration. The MDR software automatically computes the DCF from the number of pulse counts and displays the values on the screen.

9. Steps 5 through 8 should be repeated five more times until six calibration attempts have been completed. When six calibration runs have been obtained, the monitor will display a screen similar to that shown in Figure 3-11.
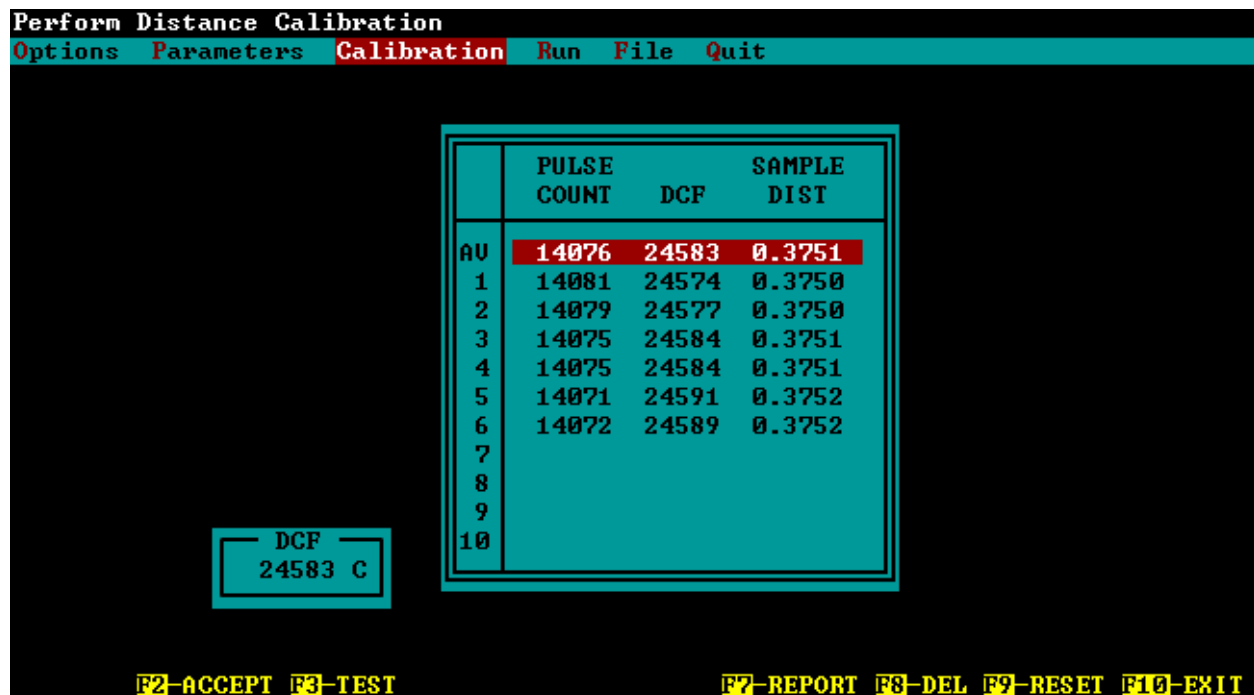
Figure 3-11. MDR Software Calibration Screen After Performing DMI Calibration.

10. Acceptability of the DMI Calibration:

    This is determined by comparing the six "PULSE COUNT" values resulting from the six calibration attempts to the "PULSE COUNT" value in the "AV" row. All six calibration attempts should have values that are within ± 10 of the average pulse count. For example: If the average pulse count is 14076, then all six pulse counts from the six calibration attempts must be within 14066 and 14086.

    If any of the six calibration attempts is outside the acceptable limits, then the unacceptable runs should be highlighted and deleted by pressing the F8 key. Following the deletion of the unacceptable runs, new calibration attempts (as detailed in steps 5 through 8) should be made for each run that was deleted. The intention is to only delete the poor runs and replace with new runs, and NOT re-run a complete set of 6 runs.

11. The new DCF value computed during DMI calibration has to be saved. Use the arrow keys to highlight the average shown at the top of the list and press the F2 key to accept the new DCF value. Press 'Enter' key to store.

    If for any reason the DCF values are unacceptable, press the F9 key. A verification line will appear at the top of the screen. The operator must then press the 'Y' key for deletion. This will wipe out all DCF's and reset the beginning of the distance calibration procedure.

    The results of the DMI calibration need to be recorded under the "DMI CALIBRATION" section on the MDT Profiler Calibration Record Sheet (Appendix B) and kept in the profiler log book. Record the DCF values for the prior calibration, the new average, and the six acceptable calibration

attempts. Also record the rear tire pressures values from before the DMI calibration was started and after the six acceptable calibration attempts were completed.

12. Press F10 to exit the Distance Calibration. The system will prompt 'Do You Want to Exit?' Press the 'Y' key to return to the MDR Main Menu.

4.0 FIELD OPERATIONS

The following sections describe the procedures to be followed each day prior to and during data collection with respect to pre-run checks of the profiling equipment and actual profiling activities.

4.1 PRE-RUN CHECKS

MDT has prescribed maintenance plans pertaining to the profiler's mechanical components. Any required maintenance checks should be performed on the profiler prior to any movement of the profiler.

Additionally, the profiling equipment on the profiler requires three pre-run checks that verify proper operation of the profile sensors. The next three sections describe the Laser Sensor Check, Accelerometer Calibration Check, and Bounce Test that should be performed prior to any profile data collection.

4.1.1 LASER SENSOR CHECK

A calibration check of the laser sensors is performed each day prior to data collection. In this procedure, the laser sensors are checked to see if they can accurately measure within the specified height tolerance by using calibration blocks. This procedure only checks the accuracy of the laser sensor over a ½" (12.7 mm) measuring range. This check is referred to as the Pre-Run Calibration Check of laser sensors and is different than the Full Calibration Check described in Chapter 3, which is performed every thirty (30) days during construction season. A full calibration check of the laser sensors must be performed whenever problems are suspected on the laser sensors or when a sensor is repaired or replaced.

The location where the pre-run calibration check is performed should protect profiler from wind and other vibrations. The pavement surface should be as level as possible and lighting conditions should be consistent from sensor to sensor (i.e., face profiler away from the sun). An external power source should be used whenever possible.

Gently clean each lens following the guidelines described in Chapter 2. When cleaning the lenses, extreme care should be taken to prevent scratching of the lenses.

Power to the electronic equipment should be turned on for about 15 minutes prior to performing any calibration or calibration checks so that the electronic equipment is allowed to warm up and stabilize.

The laser sensor check has the following steps:

1. The operator should be outside of the profiler when the calibration check is performed. Adjust the computer monitor so that it can be seen from outside the vehicle, and the keyboard should be placed on the seat of the profiler. Do not enter the profiler, bounce or bump the profiler, or lean on the profiler during the calibration check.

2. In the MDR Main Menu, select 'Calibration' to display the Calibration Menu. Highlight 'Sensors…' and press 'Enter' key to display the Calibration Sensors Menu.

3. Highlight 'Cal Temp' selection and press 'Enter' key. Enter an accurate air temperature value $\pm 3^{\circ}F$ and press 'Enter' key.

4. In the Calibration Sensors Menu, make sure that all parameters match the settings described in Section 2.3.

5. In the Calibration Sensors Menu, highlight 'Go' and press 'Enter' key. The monitor will display the sensor calibration screen similar to Figure 4-1.

```
======================= Sensor Calibration =======================
Sensor          #1      #2
Count          1600    1675
Height        0.262   0.275
Avg Height    0.263   0.274

Gate/Zero
Low
High
Dif
Total

Sensor
Count
Height
Avg Height

Gate/Zero
Low
High
Dif
Total
                          973 Samples
                     Press BkSp To Stop
```
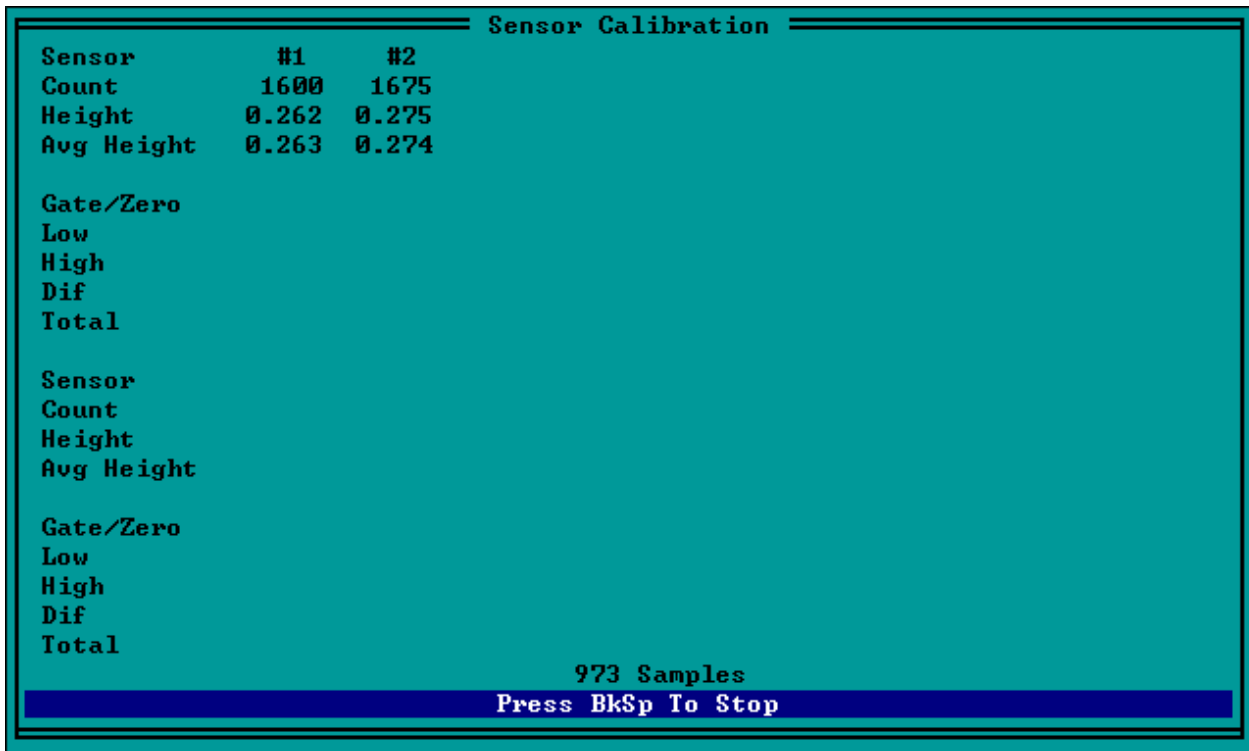
Figure 4-1. MDR Software Sensor Calibration Screen for Pre-Run Laser Sensor Check.

6. Verify that no blocks, objects, or debris are directly under the laser sensors. Press the Enter key to start reading the laser values. After a minimum of 1000 samples, press backspace to stop. From the Sensor Calibration Screen, record the left laser (sensor 1) Avg Height value for the ground height measurement.

7. Place the ½" calibration block on the ground under the left laser sensor, and position the block so that the laser will reflect approximately at the center of the block. Press the Enter key to start reading the laser values. After a minimum of 1000 samples, press backspace to stop. From the Sensor Calibration Screen, record the left laser (sensor 1) Avg Height value for the block height measurement.

8. Subtract the block height measurement value noted in step 7 from the ground height measurement value noted in step 6. Compare the difference to the actual block thickness (Section 3.1). The difference between the height measurement values compared to the block thickness should be less than or equal to 0.002 ft for the laser sensor to be considered working properly. If the value is greater than 0.002 ft, the trouble shooting procedure below is a suggested guide to verify and resolve any issues with the laser sensor.

9. Repeat steps 6 through 8 for the right laser (sensor 2).

10. Press 'Escape' key to return to the MDR Main Menu.

The following items are suggested to verify that there is an actual problem with a laser sensor. If these procedures do not successfully rule out a problem with the laser sensor(s), ICC should be contacted to assist and resolve sensor problems.

- Verify that all recorded values and computations are accurate.

- Repeat the laser sensor calibration check for the block(s) and laser that produced an unacceptable difference greater than 0.002 ft. It is possible that the block was not positioned under the laser sensor properly, or that the block was not sitting squarely on the floor. It is not necessary to repeat the calibration check for any blocks that satisfy the acceptable criteria.

- If the laser sensor calibration check was performed with the engine running, attempt to perform the calibration check (in its entirety) with the engine switched off and the profiling system plugged into house power (if possible).

- Move the profiler to another location and redo the laser sensor calibration check in its entirety.

4.1.2 ACCELEROMETER CHECK

A calibration check of the accelerometers is performed each day prior to data collection and anytime the system has been previously shut down. The accelerometers in the profiler should be calibrated as described in Chapter 3. The accelerometers should be calibrated if the accelerometer check indicates accelerometer calibration factor(s) are outside the allowable range or if the bounce test indicates a potential problem with the accelerometer(s). The accelerometers should be calibrated when repairs are performed on the accelerometer(s) or on computer cards associated with the accelerometer(s).

The accelerometer calibration check should be performed while the profiler is parked on a level surface. Location where calibration check is being performed should be free of any vibrations, and shielded from any environmental conditions such as gusty winds. The accelerometer calibration check can be performed when the engine of the profiler is running, but ideally the engine should be turned off while the check is being performed. The calibration check should be performed with the operator and driver sitting in the profiler seats. Do not enter the truck, bounce or bump the profiler, or lean on the profiler during the calibration check. The power to the system should be turned on for about 15 minutes for the system to warm up prior to the accelerometer calibration check. The following procedure should be followed to perform the accelerometer calibration check:

1. Boot up computer following procedures described previously in Section 2.2. The MDR Main Menu should now be displayed on the monitor.
2. In the MDR Main Menu, select 'Calibration' to display the Calibration Menu. In the Calibration Menu, highlight 'Accelerometer...' and press 'Enter' key, and the Accelerometer Calibration Menu shown in Figure 4-2 will be displayed on the monitor. Please note that accelerometer line on top of menu should read "2 of 2".
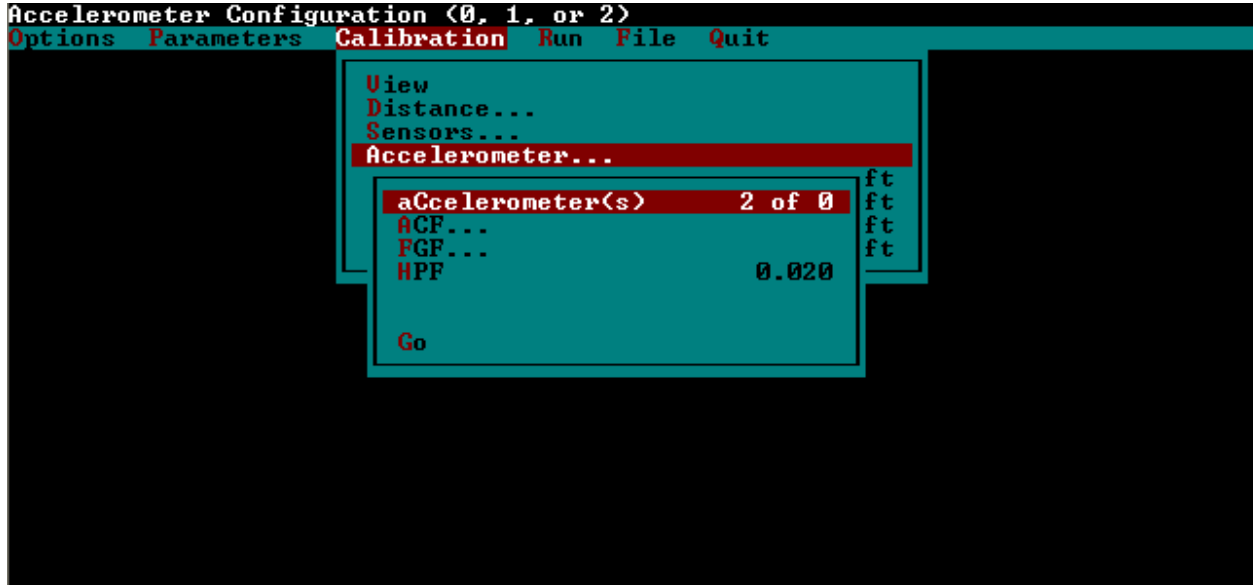
Figure 4-2. MDR Software Accelerometer Calibration Menu for Accelerometer Check.

3. In the Accelerometer Calibration Menu, highlight 'Go' and press 'Enter' key. The monitor will display an Accelerometer Calibration Screen similar to that shown in Figure 4-3.
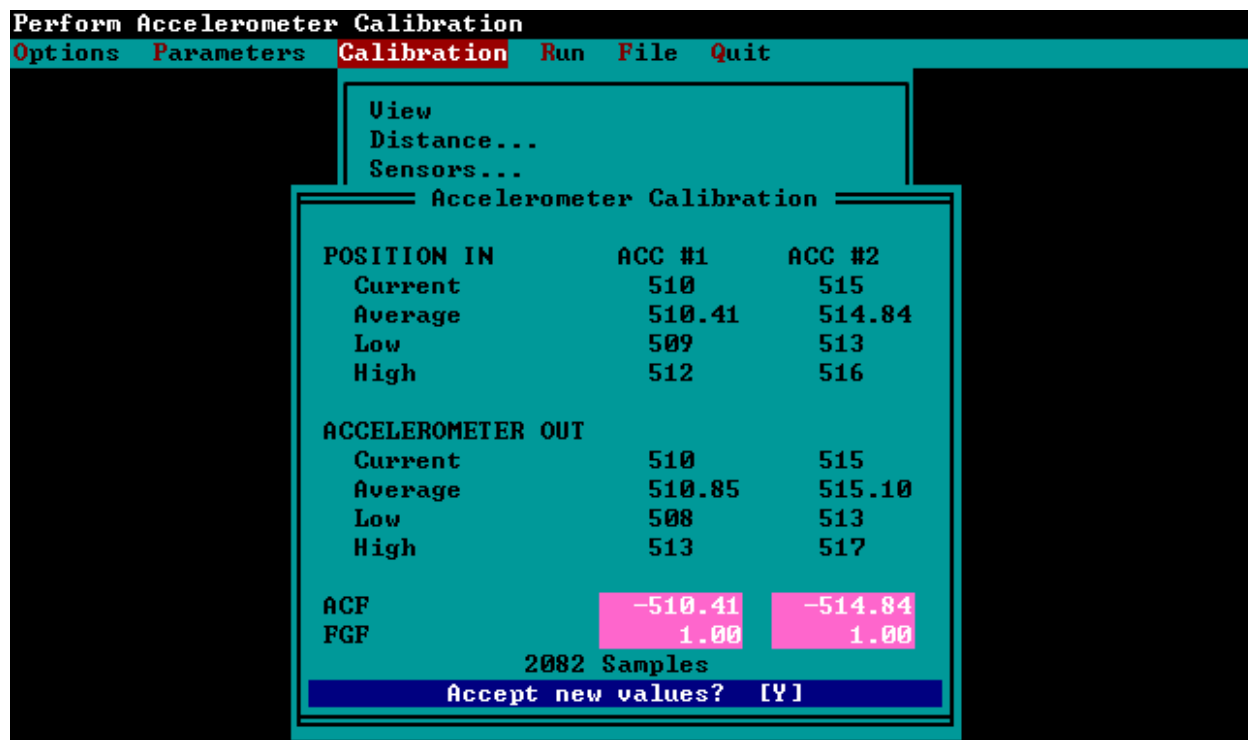
Figure 4-3. MDR Software Accelerometer Calibration Screen for Accelerometer Check.

4. Press 'Enter' key and the accelerometer calibration procedure will begin to sample accelerometer measurements. After approximately 2000 samples have been taken, press 'Backspace' key to end calibration.

5. System will prompt the operator if the new ACF values should be accepted. The accelerometers are considered to be working properly if the ACF values are within the range 512 ± 10. If test appears to be valid, press 'N' key because the daily accelerometer check is being performed only to test the accelerometers for proper operation.

    If the test was not valid, press 'N' key and repeat steps 3 and 4 to test the accelerometers again. If the repeat accelerometer calibration checks continue to produce results outside the acceptable range, perform a full calibration of the accelerometers as described in Section 3.2.

6. Press 'Escape' key to return to the MDR Main Menu.

4.1.3 PRE-RUN BOUNCE TEST

The bounce test is performed to verify that height sensors and accelerometers in the profiler are functioning properly. The pre-run bounce test should be performed every day prior to data collection. This bounce test consists of two parts, a static test and a dynamic test. Both the static and dynamic tests are combined into one test. This bounce test is different than the bounce test described in Chapter 3. The bounce test is performed following the Laser Sensor Calibration Check and Accelerometer Calibration Check described in Sections 4.1.1 and 4.1.2.

Power to the electronic equipment should be turned on for about 15 minutes prior to performing any calibration or calibration checks so that the electronic equipment is allowed to warm up and stabilize.

The bounce test should be performed while the profiler is parked on a level surface. Location where the bounce test is being performed should be free of any vibrations, and shielded from any environmental conditions such as gusty winds. The bounce test can be performed when the engine of the profiler is running but ideally the engine should be turned off while the bounce test is being performed. The operator should stand outside of the vehicle when the bounce test is performed, and the computer monitor should be adjusted so that it can be seen from outside the profiler with the keyboard placed on the seat.

The following procedure should be used to perform the bounce test:

1. Place brown wooden clipboards on the ground directly under the right and left laser sensors, so that the lasers spots are near the center of the clipboards. Metal, plastic, or colored clipboards are not recommended, as the intent is to have the laser sensor take height measurements off a flat neutral colored surface.

2. In the MDR Main Menu, select 'Options' to display the Options Menu. In the Options Menu, verify that the "Reference Post Display Mode" is set to "Mile" as shown in Figure 4-4.

Figure 4-4. MDR Software Options Menu for Pre-Run Bounce Test.

3. In the MDR Main Menu, select 'Run' to display the Run Menu. In the Run Menu, the entries for "County," "Route," "Direction," and "Lane" do not impact the bounce test and do not need to be changed from the last data collection project. However, the "Asc/Dsc Ref Point" should be set to "+," the "daTa Directory" should be changed to "D:\BOUNCE," and the "1 File Name" should be set as the date (e.g., "14JUL05") as shown in Figure 4-5.

Figure 4-5. MDR Software Run Menu for Pre-Run Bounce Test.

4. In the Run Menu, select 'Options…' to display the Run Options Menu. Highlight the "DMI Simulator" option and press 'Enter' key to toggle the distance simulator to "On" as shown in Figure 4-6. The remainder of the Run Options settings are described in Section 2.3. Press 'Escape' key to return to the Run Menu.

Figure 4-6. Run Options Menu Toggling Distance Simulator On for Pre-Run Bounce Test.

5. In the Run Menu, highlight 'Go' and press 'Enter' key to begin the bounce test. The monitor will display the Run Screen similar to that shown in Figure 4-7.

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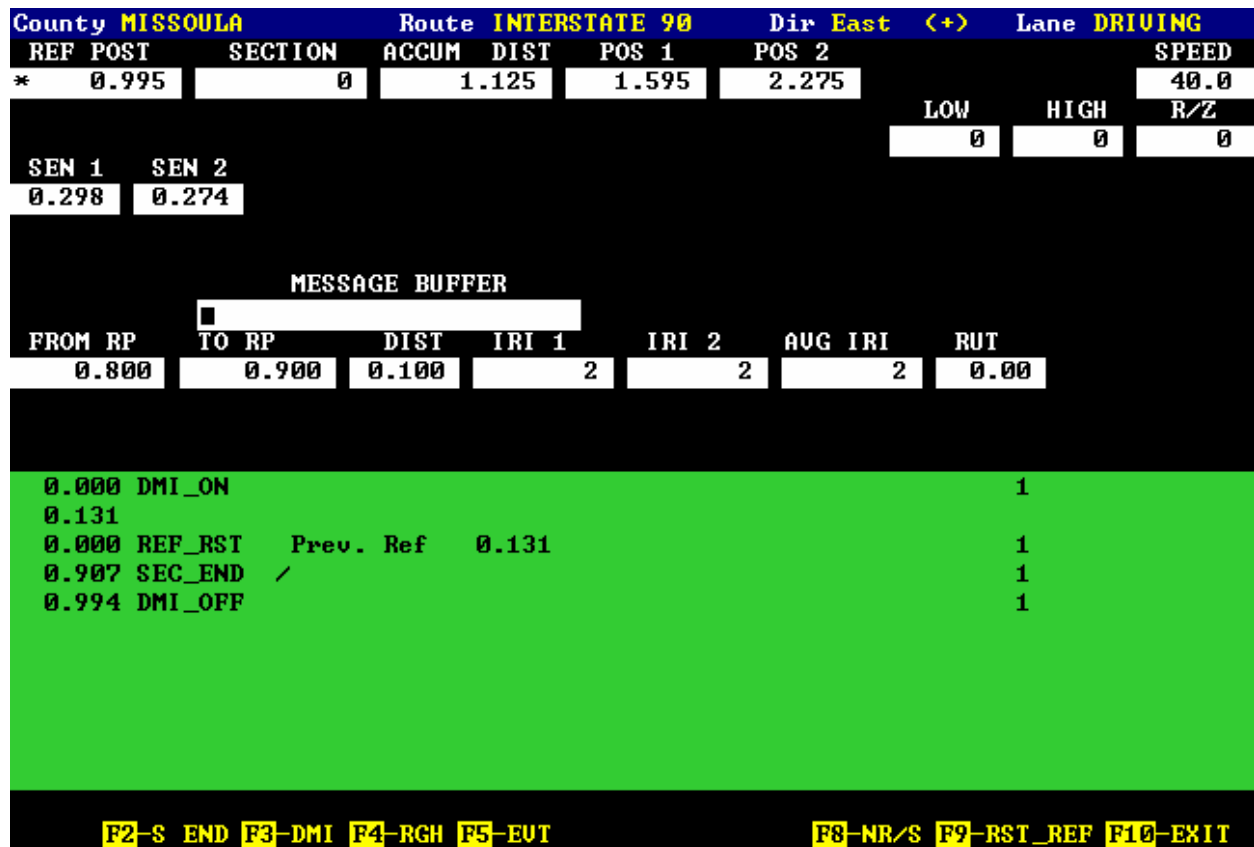
Figure 4-7. MDR Software Run Screen for Pre-Run Bounce Test.

6. Verify that the "SPEED" indicates a reasonable simulated speed. Press Page Up key to increase the speed to 70 mph (113 km/h). If the indicated speed is zero, exit the run screen and verify that the distance simulator is turned on as described in step 4 above.

7. Press the F3 key to begin simulating distance for the bounce test. The "REF POST" should indicate an ascending distance count.

8. When the "REF POST" indicates a minimum of 0.1 miles (0.16 km), press the F9 key to initiate the reference reset.

9. The profiler should remain settled for the static portion of the bounce test for a minimum of 0.5 miles (0.80 km) indicated on the "REF POST."

10. After the "REF POST" indicates a minimum of 0.5 miles (0.80 km), the operator should begin to apply a vertical up and down motion to the center of the sensor bar on the front of the profiler. The pitching motion on the sensor bar should impart a displacement of approximately 1 inch (25.4 mm) total, and all efforts should be attempted to avoid any side to side or rolling motions. This dynamic portion of the bounce test should continue, without interruption, for a minimum of 30 seconds.

11. At the conclusion of the dynamic portion, press the F2 key to mark the section end of the simulated profile.

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12. Press the F3 key to stop the simulated profile.

13. Press the F10 key to exit from the Run Screen. Press 'Enter' key to save the profile data file to the hard disk drive.

14. In the Run Menu, select 'Options…' to display the Run Options Menu. Highlight the "DMI Simulator" option and press 'Enter' key to toggle the distance simulator to "Off" as shown in Figure 4-8. Press 'Escape' key twice to return to the Main Menu.

Figure 4-8. Run Options Menu Toggling Distance Simulator Off for Pre-Run Bounce Test.

15. From the Main Menu, select 'Quit' to exit the MDR software. At the "Do You Want to Exit System" prompt, press the 'Y' key.

16. At the DOS prompt, change to the directory D:\BOUNCE.

17. From the DOS prompt, type MTIRI <FILENAME> 1 and press the enter key to analyze the bounce test data. <FILENAME> is the file name set in step 4 (e.g., "14JUL05"). "1" indicates the run file number; if more than one bounce test is performed, the number of the desired bounce test should be changed to the appropriate bounce test run number.

18. When the MTIRI analysis program prompts for the IRI Report Type, enter 'E' for English.

19. When the MTIRI analysis program prompts for the IRI Report Interval, enter '1' for 100 feet and the IRI report will be created.

20. When the MTIRI analysis program prompts how to output the IRI report, enter 'P' to print the file. The report can also be displayed on the monitor by entering 'D.'

21. Review the IRI report for Reasonableness.

    The first 0.5 mi (0.80 km) of intervals on the report should contain IRI values reflecting the profiler in a static condition. The resulting static IRI values should be less than or equal to 5 in/mi (0.08 m/km) for the profiler to be considered functioning properly under static conditions. As long as no more than two static intervals have IRI values greater than 5 in/mi (0.08 m/km) in either the left or right channels the profiler is considered to have satisfied the static bounce test criteria. If more than two static intervals have IRI values greater than 5 in/mi (0.08 m/km), the bounce test should be repeated to make sure that the profiler remained completely motionless (was not bumped, moved, or otherwise disturbed) during the static portion of the bounce test. The profiler can also be moved to a new location and the bounce test repeated if the static IRI values are not improved.

    The intervals following the static portion represent the profiler in a dynamic condition and typically have IRI values much larger than the static condition IRI values. The dynamic IRI values would typically be in the range of 20 to 45 in/mi (0.32 to 0.71 m/km) for the amount of motion imparted following this bounce test procedure. If more than three intervals of dynamic IRI values are less than 20 in/mi (0.32 m/km), the bounce test should be repeated with emphasis to make sure that a displacement of 1 inch (25.4 mm) is applied at the sensor bar during the dynamic portion of the bounce test. If a majority of intervals of dynamic IRI values are significantly more than 50 in/mi (0.79 m/km), the bounce test should be repeated with emphasis to make sure that a displacement of 1 inch (25.4 mm) is applied at the sensor bar during the dynamic portion of the bounce test. The profiler can also be moved to a new location and the bounce test repeated if the dynamic IRI intervals are not improved.

    If the bounce test indicates potential problems with the profiling system, ICC should be contacted for assistance in resolving any problems.

4.2 DATA COLLECTION

This section describes the procedures for performing profile data collection. Analysis of the profile data is described in Chapter 5.

4.2.1 PROFILER SETUP

Prior to collecting profile data at a site, the driver and operator need to prepare the profiler for data collection. Powering and boot-up procedures for the profiler computer and sensors are described in Chapter 2. The settings and parameters for the profile data collection MDR software are also described in Chapter 2.

The MDT Profiler Field Activity Report (Appendix B) is to be completed for each project profiled. This form will be kept in the profiler's log book and is a record of the profiling activities for the project.

Upon arrival at the project to be profiled, the driver and operator should coordinate with the Engineering Project Manager (EPM) to identify the beginning and ending points of the project, and the locations of any bridges or other significant events. The information gathered by performing a pre-survey of the project will be used to fill the required parts of the Profiler Field Activity Report and complete the setup of the MDR software for profiling.

4.2.2 FILE NAMING CONVENTION

The file naming convention to be used in specifying the name of the data file in the MDR software is described in this section. Failure to adhere to the file naming convention could create additional work in generating reports and archiving files. The file name should consist of six characters, where the characters one to four represent the Control Number (e.g., 1022, 1513, etc.), character five represents the direction of travel (i.e., N, S, E, W), and character six represents the lane of travel (i.e., D=Driving, P=Passing, or T=Turning). The following are examples of valid data file names:

1022ND: Control Number 1022, northbound direction, driving lane.
1513ST: Control Number 1513, southbound direction, turning lane.
3611EP: Control Number 3611, eastbound direction, passing lane.

Additionally, the profile data files will be saved to a directory specified by the user. The file directory will be the project control number. The following are examples of file directories using project control numbers:

D:\1022
D:\1513
D:\3611

4.2.3 OPERATING SPEED

A constant vehicle speed of 50 mph (80 km/h) should be maintained during a profile measurement run. If the maximum constant speed attainable is less than 50 mph (80 km/h) due to either traffic congestion or safety constraints then a lower speed depending on prevailing conditions should be selected. If the speed limit at the site is less than 50 mph (80 km/h), the site should be profiled at the posted speed limit. If traffic traveling at high speeds is encountered at a site, it is permissible to increase the profiling speed up to 65 mph (105 km/h). If the site is relatively flat, cruise control should be used to maintain a uniform speed. It is important to avoid changes in speed during a profile run that may jolt the vehicle or cause it to pitch on its suspension. Change in throttle pressure or use of brakes to correct vehicle speed should be applied slowly and smoothly.

4.2.4 EVENT INITIATION

During data collection, the MDR program uses an 'event mark' to record a Reference Reset in the event file. Event marks are generated by the photocell or manually by pressing the 'F9' key. Cones with the reflective marker should be placed on the shoulder at the beginning and end of the project to activate the photocell. The leave edge of the reflective marker should be aligned with the leave edge of the project's limits. Section 2.1.6 contains additional information about the operation of the photocell. The preferred method to initiate profile data collection is through the use of the photocell detecting the reflective marker at the beginning of the project.

If it is not feasible to use the photocell to initiate and stop the profile data collection, data collection can be initiated and stopped manually. When manually initiating and stopping profile data collection, cones should be placed at the beginning and end of the project to be used as reference points by the operator. To initiate profile data collection manually, press the 'F9' key to perform the Reference Reset as close as practical to the beginning of the project. To stop the profile data collection manually, press the 'F2' or 'F9' key as close as practical to the end of the project.

4.2.5 EXCLUDED AREAS

Bridges and other specific locations identified by the EPM need to be "marked" in the profile data so that the areas may be excluded from the roughness computations as defined in the Montana Ride Specification. The operator will denote the beginning and ending of the excluded location by pressing the 'F4' key as the profiler traverses the location during the profile runs. Specifically, the operator will press the 'F4' key approximately 10 feet (3 m) before the beginning of the excluded area and will press the 'F4' key again approximately 10 feet (3 m) before passing the end of the excluded area.

4.2.6 LOADING & SAVING FILES

Saving files to the hard disk, Zip disk, or floppy disk, or loading files from the hard disk, Zip disk, or floppy disk should not be done while the vehicle is in motion. At the completion of a profile run, the driver should pull over to a safe location and come to a complete stop and then save data file to hard disk.

4.2.7 TURNAROUNDS

Follow applicable laws in Montana regarding use of median turnarounds.

4.2.8 FLASHING SIGNALS & SAFETY EQUIPMENT

The profiler is equipped with a flashing signal bar. The flashing signal bar should be turned on during testing and used according to MDT policies. All relevant MDT safety policies should be followed without exception.

4.2.9 INCLEMENT WEATHER & OTHER INTERFERENCE

Inclement weather conditions (e.g., rain, snow, heavy cross winds) can interfere with the acquisition of acceptable ride data. Profile measurements should only be performed on dry pavements. In some cases, it may be possible to perform measurements on a damp pavement with no visible accumulation of surface water. Under such circumstances, the data should be monitored closely for run to run variations and potential data spikes.

When reviewing data, operator should keep in mind that spikes could occur due to pavement conditions (e.g., potholes, transverse cracks, bumps) and electronic interferences. Changing reflectivity on a drying pavement due to differences in brightness of pavement (e.g., light and dark areas) may yield results inconsistent with data collected on uniformly colored dry pavements. Run to run variations in data collected under such conditions should be carefully evaluated. If problems are suspected, profile measurements should be suspended until pavement is completely dry.

Electromagnetic radiation from radar or radio transmitters may also affect data recorded by the profiler. If this occurs, the operator should attempt to identify. Source can be contacted to ascertain suitable testing time (i.e., time when source is off).

4.2.10 PROFILING TEST SECTION

Once the setup information has been entered into the MDR software and the profiling equipment has warmed up sufficiently, the profiler is ready to begin profiling. The following procedures should be followed

to get an acceptable set of profile data. In these procedures keys on either the keyboard or the handheld event pad can be used.

1. From the Main Menu, highlight 'Run' and press 'Enter' key to display the Run Menu as shown in Figure 4-9.

2. From the Run Menu, highlight 'Go' and press 'Enter' key to display the Run Screen as shown in Figure 4-10.

3. The driver should attain a constant test speed of 50 mph (80 km/h) at least 575 ft (175 m) before the beginning of the test section and align the profiler with the wheel paths of the lane. A speed different from 50 mph (80 km/h) may be used depending on site conditions.

4. Press the F3 key to start the DMI about 500 ft (150 m) before the start of the test section. The profiler should have attained its constant testing speed prior to pressing the F3 key.

Figure 4-9. MDR Software Run Menu for Profiling.
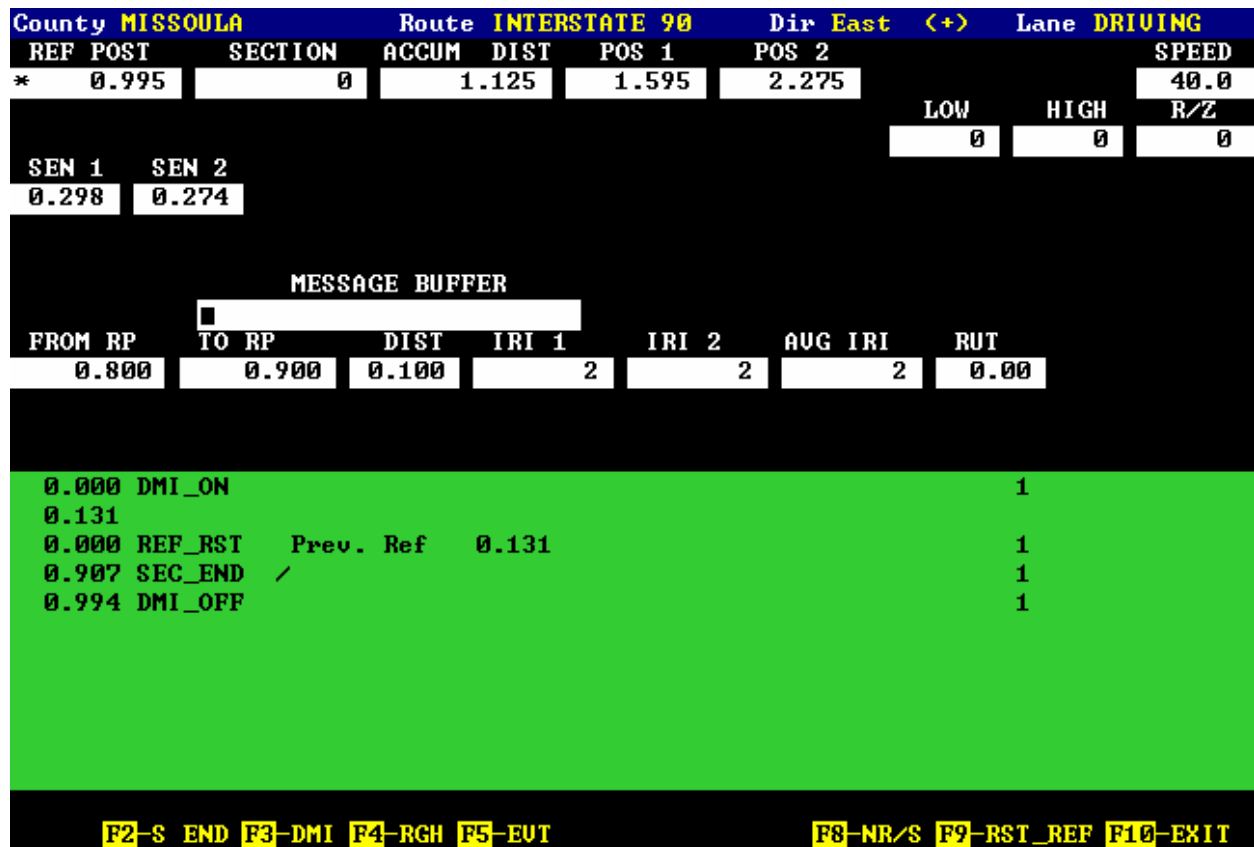
Figure 4-10. MDR Software Run Screen for Profiling.

5. When passing the target cone at the start of the project the system should show a "Reference Reset" and will now be collecting data. Continue driving to the end of the project.

6. When passing the target cone at the end of the project, the system should show a "Section" mark.

7. Press the F2 or F9 key to place a "Section End" mark in the data file and then press the F3 key to stop the data collection.

8. Press the F10 key to exit the Run Screen and save the profile data.

9. After saving the data file, the system returns to the MDR Run Menu. This represents a completed data collection run. To continue making profile runs, go back to step 2.

In order to assure quality profile data, a minimum of two runs (and a maximum of five runs) will be completed for each lane of the project. Each lane has a unique file name and the operator should verify that the file name is properly established prior to beginning the profile run.

Chapter 5 discusses the process for analyzing the profile data. After completing the profile runs for all lanes, the profile data will be analyzed for IRI and bump locations. Acceptability of the profile runs will be determined based on the IRI analysis.

4.2.11 RAW DATA BACKUP

Profile data collected at a site by the profiler should be backed up to a removable storage media (e.g., Zip disk). The location of the data files will depend on directory structure that is employed by the districts. The profiler should not leave a test site unless all data have been backed up. No collected profile data should be deleted from the hard disk until the district has copied the profile data to the MDT Ride Specification Share Drive.

4.3 RECORD KEEPING

There are several types of records that need to be completed and kept with the profiler or at the district office and include the following:

1. Profiler Field Activity Report,
2. Profiler Maintenance / Repair Activity Report,
3. Profiler Calibration Record Sheet, and
4. Profiler Problem Report.

A description of each of these forms / reports is presented in the following sections.

4.3.1 PROFILER FIELD ACTIVITY REPORT

The Profiler Field Activity Report (Appendix B) records all profiling activities at the test site. This report should be filled out for each testing day. The Profiler Field Activity Reports are kept in the profiler log book.

4.3.2 PROFILER MAINTENANCE / REPAIR ACTIVITY REPORT

This form (Appendix B) should be completed when scheduled or unscheduled maintenance or repairs are performed on the profiler computer equipment or sensors.

4.3.3 PROFILER CALIBRATION RECORD SHEET

Each time the full calibration check is performed on the profiler this form (Appendix B) should be filled out. The form is used to record information related to the laser sensor calibration check, accelerometer calibration, DMI calibration, and bounce test. The Profiler Calibration Record Sheets are kept in the profiler log book.

4.3.4 PROFILER PROBLEM REPORT

A Profiler Problem Report (Appendix B) provides the standard format for submitting problems associated with the profiler. It is a means of tracking a problem, who is responsible for resolving it, whether or not it has been resolved, and how and when it was resolved. The Profiler Problem Report is a means for communicating about issues with the profiler between the districts and MDT headquarters.

A Profiler Problem Report must be submitted whenever there are equipment problems in the profiler, problems with data collection or data processing software, problems with data collection guidelines, or other problems related to profiling activities or profile data.

If a problem was encountered, and it was resolved, and the profiler personnel feel that this information would be useful to the other Districts, an informational problem report should be submitted. When submitting an informational problem report, indicate that the problem report is being submitted for informational purposes in the description part of the form.

5.0 DATA PROCESSING & REPORTING

This chapter describes the MDT Ride Specification analysis that is performed on the inertial profiler data. The profile data is evaluated for two components: roughness expressed by IRI and bumps. The analysis is performed by the profiler operator immediately after making the profile runs at the project. The IRI and bump results are reviewed for quality, additional profile runs are completed if necessary, and then the results are delivered to the EPM.

The profile data is evaluated for roughness and bumps using the ICC supplied RP090L (reporting software) and PROSCAN (profilograph analysis software). The processing is simplified through the use of the batch files, MTIRI and MTBUMP, which automate the parameters and operation of the analysis software. Copies of these batch files are contained in Appendix A.

A minimum of two profile data runs are made in each lane of the project. The profile data files analyzed have the following format: <FILENAME>.P0#, where <FILENAME> is determined from the convention described in Section 4.2.2 and "#" is the run number. The directory where the profile data files are stored on the profiler (e.g., D:\1022) is also described in Section 4.2.2 and will be denoted by <DIRECTORY> for the following sections.

5.1 IRI PROCESSING

The IRI is computed in two phases. The first phase is for the quality control review by the profiler operator to assess the acceptability of the profiler data. The second phase is to report the results of the roughness to the EPM.

5.1.1 QUALITY CONTROL REPORT

IRI processing is automated by the MTIRI batch file. The following procedure is for determining the IRI at the easily reviewable 1 mi intervals:

1. At the DOS prompt, change to the directory containing the profile data file <DIRECTORY>.

2. At the prompt, type "MTIRI <FILENAME> #" for the lane and run to be analyzed, and press 'Enter' key to begin the analysis.

3. At the prompt, type 'I' to select the IRI Report. The other options are to process the Event Report, fix the Ascending distance values, and process the Speed Report but are not normally used in this procedure.

4. At the prompt, type 'E' to process the IRI report in English units. If the metric IRI report is desired, type 'M' instead.

5. At the prompt, type '3' to process the IRI report at 1 mi intervals. If the metric IRI report is being processed, the selection is also '3' to process the report at 1600 m intervals.

6. After the IRI report has been processed and printed, at the prompt type 'Q' to exit.

7. Repeat steps 2 through 6 to process the remaining profile data files for the other lanes and runs.

5.1.2 ROUGHNESS REPORT

IRI processing is automated by the MTIRI batch file. The following procedure is for determining the IRI at the MDT Ride Specification interval of 0.2 mi (0.32 km):

1. At the DOS prompt, change to the directory containing the profile data file <DIRECTORY>.

2. At the prompt, type "MTIRI <FILENAME> #" for the first error free run in each lane to be analyzed and press 'Enter' key to begin the analysis.

3. At the prompt, type 'I' to select the IRI Report. The other options are to process the Event Report, fix the Ascending distance values, and process the Speed Report but are not normally used in this procedure.

4. At the prompt, type 'E' to process the IRI report in English units. If the metric IRI report is desired, type 'M' instead.

5. At the prompt, type '2' to process the IRI report at 0.2 mi intervals. If the metric IRI report is being processed, the selection is also '2' to process the report at 300 m intervals.

6. After the IRI report has been processed and printed, at the prompt type 'Q' to exit.

7. Repeat steps 2 through 6 to process the remaining profile data files for the other lanes.

5.2 BUMP PROCESSING

Bump processing is automated by the MTBUMP batch file. The following procedure should be followed to perform the bump analysis on the profile data files.

1. At the DOS prompt, change to the directory containing the profile data file <DIRECTORY>.

2. At the prompt, type "MTBUMP <FILENAME> #" for the lane and run to be analyzed, and press 'Enter' key to begin the analysis.

3. At the prompt, type 'D' to select the Defect Report. The other options are to Graph the PROSCAN profile, process the Event File, and fix the Ascending distance values but are not normally used in this procedure.

4. At the prompt, type 'E' to produce the bump report in English units. If the metric bump report is desired, type 'M' instead.

5. After the bump report has been processed and printed, at the prompt type 'Q' to exit.

6. Repeat steps 2 through 5 to process the remaining profile data files for the other lanes.

5.3 QUALITY CONTROL REVIEW

The operator performs a quality control review on the profile data before delivering the results to the EPM.

5.3.1 ACCEPTANCE OF RUNS

Once the operator is confident that a minimum of two error free runs have been obtained, the Quality Control Review and Bump Reports are used to evaluate their acceptability. Profiler runs should satisfy the following criteria:

1. The average IRI values at each 1 mi (1.61 km) interval for each of the two runs are within ± 5.7% of the mean IRI of both runs.

2. If spikes (e.g., unusually high IRI) are present in the data, the operator should determine if spikes are pavement related or the result of equipment or operator error. The operator should examine the profile bump reports for discrepancies and features that cannot be explained by observed pavement features. The operator should also be familiar with the trouble shooting guide included in Appendix C.

5.3.2 NON-ACCEPTANCE OF RUNS

The operator is responsible for carefully reviewing profile data to determine if a high degree of run-to-run variability is indicative of 'bad' data or indicative of a pavement with a high degree of transverse variability. If profile runs do not meet the criteria in Section 5.3.2, the operator should perform the following steps to determine if variability is the result of equipment errors, operator errors, environmental effects, or pavement factors.

1. Recall if any of the following items could have affected collected data: passing trucks, high winds, rapid acceleration or deceleration of profiler.

2. Review spikes to determine if spikes are result of field related effects (e.g., potholes, transverse cracks, bumps) or due to electronic failure or interference.

3. If variability between runs or spikes are believed to be operator related or equipment error, identify and correct cause(s) of anomalies and make a maximum of three additional runs until a minimum of two runs free of equipment or operator errors are obtained. Where data anomalies are believed to be caused by pavement features rather than errors, additional runs should be obtained on that lane and evaluated using the processing and reporting software. If data from the additional runs are consistent with those runs collected previously in terms of variability and presence of pavement-related anomalies, no further runs are required. If data from the additional runs differ from the previous runs, the profiler operator should re-evaluate cause of variability or apparent spike conditions.

5.4 DATA RESULTS DELIVERY

Once the profiler operator has performed the quality control review, the final step is to deliver and review the results with the EPM.

A Roughness Report will be generated using the procedure described in Section 5.1.2 for the first profile run deemed to be error free for each lane profiled. This report will contain the IRI values for the left and right wheel paths at 0.2 mi (0.32 km) intervals. These IRI values will be applied to the most recent pay incentives/disincentives as described in MDT Ride Specification.

A Bump Report will be generated using the procedure described in Section 5.2 for the first profile run deemed to be error free for each lane profiled. The Bump Report will indicate the locations of potential defects. These will be reviewed with the EPM. Location should be physically examined to determine if, at the EPM's discretion, the location should be considered a defect.

5.5 FINAL DATA BACKUP

After delivering and reviewing the results with the EPM, the electronic profile data files need to be backed up on the MDT Ride Specification Share Drive. All data at the project should be copied into the "Ride Data" directory for the appropriate district (e.g., D:\Butte\1002). The data should be organized in subdirectories for the year and project control number.

REFERENCES

1. LTPP Manual for Profile Measurements and Processing, Version 4.1, May 2004.

2. International Cybernetics Corporation MDR 4080 / 4097 Mobile Data Recorder Manual.

3. 2004 AASHTO Provisional Standard, MP11-03, "Inertial Profiler", June 2004.

4. 2004 AASHTO Provisional Standard, PP37-04, "Determination of International Roughness Index (IRI) to Quantify Roughness of Pavements", June 2004.

5. 2004 AASHTO Provisional Standard, PP49-03, "Certification of Inertial Profiling Systems", June 2004.

6. 2004 AASHTO Provisional Standard, PP50-03, "Operating Inertial Profilers and Evaluating Pavement Profiles", June 2004.

7. 2004 AASHTO Provisional Standard, PP51-03, "Pavement Ride Quality When Measured Using Inertial Profiling Systems", June 2004.

APPENDIX A. COMPUTER FILES

AUTOEXEC.BAT file

```
@ECHO OFF
C:\DOS\SMARTDRV.EXE /X
PROMPT $p$g
PATH C:\DOS;C:\MDRSW;C:\IOMEGA;C:\
SET TEMP=C:\TEMP
@SET SCSI_DRIVER = C:\IOMEGA
@SET SCSI_UTILITY = C:\IOMEGA
DOSKEY
DATE
TIME
```

CONFIG.SYS file

```
DEVICE=C:\DOS\SETVER.EXE
DEVICE=C:\DOS\HIMEM.SYS
DEVICE=C:\DOS\EMM386.EXE
DOS=HIGH,UMB
FILES=30
LASTDRIVE=Z
rem DEVICE = C:\IOMEGA\ASPIPPM1.SYS FILE=NIBBLE.ILM SPEED=10 Quiet
rem DEVICE = C:\IOMEGA\ASPIPPM2.SYS FILE=NIBBLE2.ILM SPEED=10 Quiet
DEVICE = C:\IOMEGA\ASPIIDE.SYS Scan Info Quiet
DEVICE = C:\IOMEGA\ASPIATAP.SYS Scan Info Quiet
DEVICE = C:\IOMEGA\SCSICFG.EXE /V
DEVICE = C:\IOMEGA\SCSIDRVR.SYS
```

```
md0901lw.exe
```

```
@ECHO OFF
REM             MTIRI.BAT        Batch file 4-4-2001 REOSR V 1.0
REM
REM      This batch file was written for the Montana DOT district offices
REM      to evaluate newly constructed pavements using ICC road profilers
REM      with two lasers and accelerometers. The road profile data is
REM      converted into IRI numbers using evaluation parameters established
REM      by the DOT. The procedure provides for both English and Metric data.
REM      See the Help section at the end of the batch file.
REM      Contact Bob Olenoski at ICC 727-547-0696 for any questions.
REM
  ECHO.
  ECHO Montana DOT IRI Report Batch File
  ECHO.
  IF "%1" == "/?" GOTO HELP
  IF "%1" == "" GOTO HELP
  IF "%2" == "" GOTO HELP

REM MAIN LOOP START TO CHECK TO SEE WHAT SHOULD BE DONE
:CHECKEND
  ECHO.
  Choice /c:IEASQ /n Goto: I=IRI Report, E=Event Report, A=SET ASC, S=Speed Report, Q=Quit ?:
  ECHO.
  IF ERRORLEVEL 5 GOTO QUIT
  IF ERRORLEVEL 4 GOTO SPD
  IF ERRORLEVEL 3 GOTO SETASC
  IF ERRORLEVEL 2 GOTO EVT
  IF ERRORLEVEL 1 GOTO STARTIRI
  GOTO CHECKEND

REM PROCESS PROFILE DATA INTO IRI REPORTS HERE
:STARTIRI
  ECHO.
  Choice /c:EMHS /n Select IRI Report Type; E=English, M=metric, H=Help, S=Skip to Event ?:
  ECHO.
  IF ERRORLEVEL 4 GOTO EVT
  IF ERRORLEVEL 3 GOTO HELP
  IF ERRORLEVEL 2 GOTO METIRI
  IF ERRORLEVEL 1 GOTO ENGIRI
  GOTO STARTIRI

REM HERE FOR METRIC IRI REPORT
:METIRI
  ECHO.
  ECHO Metric Report Selected
  ECHO.
  IF NOT EXIST %1.P0%2 GOTO FILEHELP
  IF EXIST %1.30%2 DEL %1.30%2

:IRITYPEM
  ECHO.
  Choice /c:123Q /n Select IRI Report Interval; 1=30 Meters, 2=300 Meters, 3=1600 Meters, Q=Quit
?:
  ECHO.
  IF ERRORLEVEL 4 GOTO QUIT
  IF ERRORLEVEL 3 GOTO METIRI3
  IF ERRORLEVEL 2 GOTO METIRI2
  IF ERRORLEVEL 1 GOTO METIRI1
  GOTO IRITYPEM

:METIRI3
  ECHO.
  ECHO  Creating Metric IRI Report for %1.p0%2 with 1600 meter Interval
  ECHO.
  rp090l /reset /meter /filt /wav 91 /aver 0 /sectc /int 1600 /intres /iris 63360 /spdl 5 /upd
  rp090l /calprohdr user4,user5,user6,user7 /upd
```

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```
  rp090l /meter /iri /spdf /if %1.p0%2 /of %1.30%2 /addsectend /f4move 15 /f9move 45 /ff
  GOTO IRICHECK

:METIRI2
  ECHO.
  ECHO  Creating Metric IRI Report for %1.p0%2 with 300 meter Interval
  ECHO.
  rp090l /reset /meter /filt /wav 91 /aver 0 /sectc /int 300 /intres /iris 63360 /spdl 5 /upd
  rp090l /calprohdr user4,user5,user6,user7 /upd
  rp090l /meter /iri /spdf /if %1.p0%2 /of %1.30%2 /addsectend /f4move 15 /f9move 45 /ff
  GOTO IRICHECK

:METIRI1
  ECHO.
  ECHO  Creating Metric IRI Report for %1.p0%2 with 30 meter Interval
  ECHO.
  rp090l /reset /meter /filt /wav 91 /aver 0 /sectc /int 30 /intres /iris 63360 /spdl 5 /upd
  rp090l /calprohdr user4,user5,user6,user7 /upd
  rp090l /meter /iri /spdf /if %1.p0%2 /of %1.30%2 /addsectend /f4move 15 /f9move 45 /ff
  GOTO IRICHECK

REM HERE FOR ENGLISH IRI REPORT
:ENGIRI
  ECHO.
  ECHO English Report Selected
  ECHO.
  IF NOT EXIST %1.P0%2 GOTO FILEHELP
  IF EXIST %1.30%2 DEL %1.30%2

:IRITYPEE
  ECHO.
  Choice /c:123Q /n Select IRI Report Interval; 1=100 Feet, 2=1056 Feet, 3=1 Mile, Q=Quit ?:
  ECHO.
  IF ERRORLEVEL 4 GOTO QUIT
  IF ERRORLEVEL 3 GOTO ENGIRI3
  IF ERRORLEVEL 2 GOTO ENGIRI2
  IF ERRORLEVEL 1 GOTO ENGIRI1
  GOTO IRITYPEE

:ENGIRI3
  ECHO.
  ECHO  Creating English IRI Report for %1.p0%2 with 1 Mile Interval
  ECHO.
  rp090l /reset /foot /filt /wav 300 /aver 0 /sectc /int 5280 /intres /iris 63360 /spdl 5 /upd
  rp090l /calprohdr user4,user5,user6,user7 /upd
  rp090l /iri /foot /spdf /if %1.p0%2 /of %1.30%2 /addsectend /f4move 50 /f9move 150 /ff
  GOTO IRICHECK

:ENGIRI2
  ECHO.
  ECHO  Creating English IRI Report for %1.p0%2 with 1056 Foot Interval
  ECHO.
  rp090l /reset /foot /filt /wav 300 /aver 0 /sectc /int 1056 /intres /iris 63360 /spdl 5 /upd
  rp090l /calprohdr user4,user5,user6,user7 /upd
  rp090l /iri /foot /spdf /if %1.p0%2 /of %1.30%2 /addsectend /f4move 50 /f9move 150 /ff
  GOTO IRICHECK

:ENGIRI1
  ECHO.
  ECHO  Creating English IRI Report for %1.p0%2 with 100 Foot Interval
  ECHO.
  rp090l /reset /foot /filt /wav 300 /aver 0 /sectc /int 100 /intres /iris 63360 /spdl 5 /upd
  rp090l /calprohdr user4,user5,user6,user7 /upd
  rp090l /iri /foot /spdf /if %1.p0%2 /of %1.30%2 /addsectend /f4move 50 /f9move 150 /ff

:IRICHECK
  IF EXIST %1.30%2 GOTO IRIPRT
  ECHO.
  ECHO PROGRAM ERROR; IRI Report not Created
  ECHO.
  GOTO EVT
```

```
:IRIPRT
  ECHO.
  Choice /c:PDEQ /n Output IRI Report? P=Print, D=Display, E=Event File, Q=Quit ?:
  ECHO.
  IF ERRORLEVEL 4 GOTO QUIT
  IF ERRORLEVEL 3 GOTO EVT
  IF ERRORLEVEL 2 GOTO EDITIRI
  IF ERRORLEVEL 1 GOTO PRTIRI
  GOTO IRIPRT

:EDITIRI
  EDIT %1.30%2
  GOTO IRIPRT

:PRTIRI
  ECHO.
  ECHO  Printing IRI Report %1.30%2
  ECHO.
  COPY %1.30%2 PRN
  GOTO IRIPRT

REM  PROCESS EVENT FILE HERE
:EVT
  IF NOT EXIST %1.E0%2 GOTO FILEHLPE
  ECHO.
  Choice /c:EMSQ /n Output Event Report? E=English, M=Metric, S=Skip, Q=Quit ?:
  ECHO.
  IF ERRORLEVEL 4 GOTO QUIT
  IF ERRORLEVEL 3 GOTO CHECKEND
  IF ERRORLEVEL 2 GOTO METEVT
  IF ERRORLEVEL 1 GOTO ENGEVT
  GOTO EVT

:METEVT
  ECHO.
  ECHO Metric Report Selected
  ECHO.
  IF EXIST %1.F0%2 DEL %1.F0%2
  ECHO.
  Choice /c:FNESQ /n Report Type? F=F4 F9 Moved, N=Not Moved, E=Edit Style, S=Skip, Q=Quit ?:
  ECHO.
  IF ERRORLEVEL 5 GOTO QUIT
  IF ERRORLEVEL 4 GOTO CHECKEND
  IF ERRORLEVEL 3 GOTO METEVTED
  IF ERRORLEVEL 2 GOTO METEVTNM
  IF ERRORLEVEL 1 GOTO METEVTMV
  GOTO EVT

:METEVTED
  rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
  RP090L /METER /IF %1.E0%2 /OF %1.F0%2 /FF /EDIT
  GOTO PRTEVT

:METEVTNM
  rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
  RP090L /METER /IF %1.E0%2 /OF %1.F0%2 /FF
  GOTO PRTEVT

:METEVTMV
  rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
  RP090L /METER /IF %1.E0%2 /OF %1.F0%2 /addsectend /f4move 15 /f9move 45 /FF
  GOTO PRTEVT

:ENGEVT
  ECHO.
  ECHO English Report Selected
  ECHO.
  IF EXIST %1.F0%2 DEL %1.F0%2
  ECHO.
  Choice /c:FNESQ /n Report Type? F=F4 F9 Moved, N=Not Moved, E=Edit Style, S=Skip, Q=Quit ?:
  ECHO.
```

```
    IF ERRORLEVEL 5 GOTO QUIT
    IF ERRORLEVEL 4 GOTO CHECKEND
    IF ERRORLEVEL 3 GOTO ENGEVTED
    IF ERRORLEVEL 2 GOTO ENGEVTNM
    IF ERRORLEVEL 1 GOTO ENGEVTMV
    GOTO EVT


:ENGEVTED
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /FOOT  /IF %1.E0%2 /OF %1.F0%2 /FF /EDIT
   GOTO PRTEVT


:ENGEVTNM
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /FOOT  /IF %1.E0%2 /OF %1.F0%2 /FF
   GOTO PRTEVT


:ENGEVTMV
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /FOOT  /IF %1.E0%2 /OF %1.F0%2 /addsectend /f4move 50 /f9move 150 /FF
   GOTO PRTEVT


:PRTEVT
   IF NOT EXIST %1.F0%2 GOTO FILEHLPF
:EVTOUT
   ECHO.
   Choice /c:DPS /n Display-Print Event Report? D=Display, P=Print, S=Skip ?:
   ECHO.
   IF ERRORLEVEL 3 GOTO CHECKEND
   IF ERRORLEVEL 2 GOTO EVTPRT
   IF ERRORLEVEL 1 GOTO EDITEVT
   GOTO EVTOUT


:EDITEVT
   EDIT %1.F0%2
   GOTO EVTOUT


:EVTPRT
   COPY %1.F0%2 PRN
   GOTO EVTOUT

REM PROCESS SPEED FILE HERE
:SPD
   IF NOT EXIST %1.V0%2 GOTO FILEHLPV
   ECHO.
   Choice /c:EMSQ /n Output Speed Report? E=English, M=Metric, S=Skip, Q=Quit ?:
   ECHO.
   IF ERRORLEVEL 4 GOTO QUIT
   IF ERRORLEVEL 3 GOTO CHECKEND
   IF ERRORLEVEL 2 GOTO METSPD
   IF ERRORLEVEL 1 GOTO ENGSPD
   GOTO SPD

:METSPD
   ECHO.
   ECHO Metric Report Selected
   ECHO.
   IF EXIST %1.S0%2 DEL %1.S0%2
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /METER /IF %1.V0%2 /OF %1.S0%2 /FF
   GOTO PRTSPD

:ENGSPD
   ECHO.
   ECHO English Report Selected
   ECHO.
   IF EXIST %1.S0%2 DEL %1.S0%2
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /FOOT  /IF %1.V0%2 /OF %1.S0%2 /FF
:PRTSPD
   IF NOT EXIST %1.S0%2 GOTO FILEHLPS
```

```
:SPDOUT
  ECHO.
  Choice /c:DPS /n Display-Print Speed Report? D=Display, P=Print, S=Skip ?:
  ECHO.
  IF ERRORLEVEL 3 GOTO CHECKEND
  IF ERRORLEVEL 2 GOTO SPDPRT
  IF ERRORLEVEL 1 GOTO EDITSPD
  GOTO EVTOUT

:EDITSPD
  EDIT %1.S0%2
  GOTO SPDOUT

:SPDPRT
  COPY %1.S0%2 PRN
  GOTO SPDOUT

REM FIX ASC IN FILES HERE
:SETASC
  IF NOT EXIST %1.E0%2 GOTO FILEHLPE
  DB_EDIT %1.E0%2 C:\MDRSW\FIXASC.SCR
  IF NOT EXIST %1.P0%2 GOTO FILEHLPP
  DB_EDIT %1.P0%2 C:\MDRSW\FIXASC.SCR
  IF NOT EXIST %1.V0%2 GOTO FILEHLPV
  DB_EDIT %1.V0%2 C:\MDRSW\FIXASC.SCR
  IF NOT EXIST %1.R0%2 GOTO FILEHLPR
  DB_EDIT %1.R0%2 C:\MDRSW\FIXASC.SCR
  ECHO.
  ECHO  ASC SET In %1.E0%2 and ASSOCIATED  .P0%2, .V0%2, AND .R0%2 Files
  ECHO.
  GOTO CHECKEND

REM NORMAL ENDING HERE
:QUIT
  ECHO.
  ECHO  Batch File Ended Normally
  ECHO.
  GOTO END

REM HELP SECTION
:FILEHELP
ECHO.
ECHO INPUT PROFILE DATA FILE %1.P0%2 NOT FOUND
ECHO.
GOTO HELP1

:FILEHLPE
ECHO.
ECHO INPUT EVENT FILE %1.E0%2 NOT FOUND
ECHO.
GOTO HELP1

:FILEHLPV
ECHO.
ECHO INPUT SPEED FILE %1.V0%2 NOT FOUND
ECHO.
GOTO HELP1

:FILEHLPR
ECHO.
ECHO INPUT REFERENCE FILE %1.R0%2 NOT FOUND
ECHO.
GOTO HELP1

:FILEHLPS
ECHO.
ECHO PRODRAM ERROR: SPEED FILE %1.S0%2 NOT CREATED, CHECK RP_ERROR.$$$
ECHO.
GOTO HELP1

:FILEHLPF
```

```
ECHO.
ECHO PROGRAM ERROR: EVENT FILE %1.E0%2 NOT CREATED, CHECK RP_ERROR.$$$
ECHO.
GOTO HELP1

:HELP
  ECHO.
  ECHO.
  ECHO This Batch file will perform the following using selections:
  ECHO.
  ECHO     1) Run RP090L to produce IRI REPORT.
  ECHO     2) Run RP090L to produce Event File Report.
  ECHO     3) Run RP090L to produce Speed File Report.
  ECHO     4) Run EDIT to display IRI and Event reports.
  ECHO     5) Print IRI and Event Reports.
  ECHO     6) Fix Data Files to set Asc instead of Dsc.
  ECHO.
  ECHO     Selections can be made for metric or english
  ECHO     and 100 feet, 1056 feet, 1 mile,
  ECHO     30 meter, 300 meter, or 1600 meter intervals.
  ECHO.
  ECHO     Fromto Parameters are not used with this batch file.
  ECHO     Use the FROMTO batch file when start and end stations are required.
  ECHO.
  ECHO.
  ECHO.
  ECHO.
  pause
:HELP1
  ECHO Usage: %0 filename n
  ECHO.
  ECHO filename  - filename to be processed in this directory
  ECHO n         - last digit of file extension
  ECHO               typically 1 when single file is created
  ECHO.
:END
```

```
@ECHO OFF
REM            MTBUMP.BAT        Batch file 4-4-2001 REOSR V 1.0
REM
REM      This batch file was written for the Montana DOT district offices
REM      to evaluate newly constructed pavements using ICC road profilers
REM      with two lasers and accelerometers. The road profile data is
REM      converted into data simulating the output of a California Profilograph
REM      which is evaluated for bumps using evaluation parameters established
REM      by the DOT. The procedure provides for both English and Metric data.
REM      See the Help section at the end of the batch file.
REM      Contact Bob Olenoski at ICC 727-547-0696 for any questions.
REM
  ECHO.
  ECHO Montana DOT Bump Report Batch File
  ECHO.
  IF "%1" == "/?" GOTO HELP
  IF "%1" == "" GOTO HELP
  IF "%2" == "" GOTO HELP

REM MAIN LOOP START TO CHECK TO SEE WHAT SHOULD BE DONE
:CHECKEND
  ECHO.
  Choice /c:DGEFHQ /n Goto: D=Defect Report, G=Graph, E=Event File, F=Fix Asc, H=Help, Q=Quit ?:
  ECHO.
  IF ERRORLEVEL 4 GOTO QUIT
  IF ERRORLEVEL 4 GOTO HELP
  IF ERRORLEVEL 4 GOTO SETASC
  IF ERRORLEVEL 3 GOTO EVT
  IF ERRORLEVEL 2 GOTO GRAPH
  IF ERRORLEVEL 1 GOTO DEFECTS
  GOTO CHECKEND

REM PROCESS PROFILE DATA INTO BUMP REPORTS HERE
:DEFECTS
  ECHO.
  Choice /c:EMHS /n Select DEFECTS Report Type; E=English, M=metric, H=Help, S=Skip to Event ?:
  ECHO.
  IF ERRORLEVEL 4 GOTO EVT
  IF ERRORLEVEL 3 GOTO HELP
  IF ERRORLEVEL 2 GOTO METDEF
  IF ERRORLEVEL 1 GOTO ENGDEF
  GOTO DEFECTS

REM HERE FOR METRIC REPORT
:METDEF
  ECHO.
  ECHO Metric Report Selected
  ECHO.
  IF NOT EXIST %1.P0%2 GOTO FILEHELP
  IF EXIST %1.IA%2 DEL %1.I?%2
  IF EXIST %1.JA%2 DEL %1.J?%2
  IF NOT EXIST PROSCAN.MET COPY C:\MDRSW\PROSCAN.MET .
  IF NOT EXIST PROSCAN.MET GOTO HELPPM
  COPY PROSCAN.MET PROSCAN.CFG
  IF NOT EXIST RPTDESC.ICC COPY C:\MDRSW\RPTDESC.ICC .
  IF NOT EXIST PROSCAN.CFG GOTO HELPPM
  IF NOT EXIST RPTDESC.ICC GOTO HELPRI


:METDEF2
  ECHO.
  ECHO  Creating Metric PROSCAN FILES for %1.p0%2
  ECHO  Left wheel path (I) in Track 1, Right Wheel Path (J) in Track 2
  ECHO.
  rp090l /reset /meter /nofilt /aver 0 /sectc /nointc /calpro /spdl 5 /upd
  rp090l/calprohdr
filename,route,lane,operator,vehicle,user2,user3,user4,user5,user6,user7,date,time /upd
```

```
   rp090l /meter /norghct /calpro L /if %1.p0%2 /addsectend /f9move -7.6 /track 1
REM LEFT TO TRACK 1 FILES
   IF NOT EXIST %1.IA%2 GOTO HELPIA
   rp090l /meter /norghct /calpro R /if %1.p0%2 /addsectend /f9move -7.6 /track 2
REM RIGHT TO TRACK 2 FILES
   IF NOT EXIST %1.JA%2 GOTO HELPIA
   COPY %1.H0%2+%1.IA%2+%1.JA%2 %1.M0%2
   COPY %1.M0%2 ^%1.M0%2
   GOTO DEFCHECK

REM HERE FOR ENGLISH REPORT
:ENGDEF
   ECHO.
   ECHO English Report Selected
   ECHO.
   IF NOT EXIST %1.P0%2 GOTO FILEHELP
   IF EXIST %1.IA%2 DEL %1.I?%2
   IF EXIST %1.JA%2 DEL %1.J?%2
   IF NOT EXIST PROSCAN.ENG COPY C:\MDRSW\PROSCAN.ENG .
   IF NOT EXIST PROSCAN.ENG GOTO HELPPM
   COPY PROSCAN.ENG PROSCAN.CFG
   IF NOT EXIST RPTDESC.ICC COPY C:\MDRSW\RPTDESC.ICC .
   IF NOT EXIST PROSCAN.CFG GOTO HELPPE
   IF NOT EXIST RPTDESC.ICC GOTO HELPRI


:ENGDEF2
   ECHO.
   ECHO  Creating English PROSCAN FILES for %1.p0%2
   ECHO  Left wheel path (I) in Track 1, Right Wheel Path (J) in Track 2
   ECHO.
   rp090l /reset /foot  /nofilt /aver 0 /sectc /nointc /calpro /spdl 5 /upd
   rp090l                                                              /calprohdr
filename,route,lane,operator,vehicle,user2,user3,user4,user5,user6,user7,date,time /upd
   rp090l /foot  /norghct /calpro L /if %1.p0%2 /addsectend /f9move -25 /track 1
REM LEFT TO TRACK 1 FILES
   IF NOT EXIST %1.IA%2 GOTO HELPIA
   rp090l /foot  /norghct /calpro R /if %1.p0%2 /addsectend /f9move -25 /track 2
REM RIGHT TO TRACK 2 FILES
   IF NOT EXIST %1.JA%2 GOTO HELPIA
   COPY %1.H0%2+%1.IA%2+%1.JA%2 %1.M0%2
   COPY %1.M0%2 ^%1.M0%2
   GOTO DEFCHECK

:DEFCHECK
   DIR %1.I?%2 /W
   DIR %1.J?%2 /W
   DIR ^%1.?0%2 /W
   IF EXIST %1.PSA DEL %1.PS*
   PROSCAN &%1$^%1.M0%2$RnXX$

:DEFPRT
   ECHO.
   Choice /c:RDEBQ /n Output FILE? R=Run PROSCAN to Graph, E=Event File, B=Begin, Q=Quit ?:
   ECHO.
   IF ERRORLEVEL 5 GOTO QUIT
   IF ERRORLEVEL 4 GOTO CHECKEND
   IF ERRORLEVEL 3 GOTO EVT
   IF ERRORLEVEL 2 GOTO EDITIA
   IF ERRORLEVEL 1 GOTO RUNPROS
   GOTO DEFPRT

:EDITIA
   EDIT ^%1.M0%2
   GOTO DEFPRT

:RUNPROS
:GRAPH
   IF NOT EXIST %1.PSA GOTO NOGRAPH
   PROSCAN
   GOTO DEFPRT
```

```
:NOGRAPH
   ECHO.
   ECHO  NO PROSCAN FILE TO GRAPH, CHOOSE DEFECT REPORT TO CREATE FILE
   ECHO.
   GOTO CHECKEND

REM  PROCESS EVENT FILE HERE
:EVT
   IF NOT EXIST %1.E0%2 GOTO FILEHLPE
   ECHO.
   Choice /c:EMSQ /n Output Event Report? E=English, M=Metric, S=Skip, Q=Quit ?:
   ECHO.
   IF ERRORLEVEL 4 GOTO QUIT
   IF ERRORLEVEL 3 GOTO CHECKEND
   IF ERRORLEVEL 2 GOTO METEVT
   IF ERRORLEVEL 1 GOTO ENGEVT
   GOTO EVT

:METEVT
   ECHO.
   ECHO Metric Report Selected
   ECHO.
   IF EXIST %1.F0%2 DEL %1.F0%2
   ECHO.
   Choice /c:FNESQ /n Report Type? F=F9 Moved, N=Not Moved, E=Edit Style, S=Skip, Q=Quit ?:
   ECHO.
   IF ERRORLEVEL 5 GOTO QUIT
   IF ERRORLEVEL 4 GOTO CHECKEND
   IF ERRORLEVEL 3 GOTO METEVTED
   IF ERRORLEVEL 2 GOTO METEVTNM
   IF ERRORLEVEL 1 GOTO METEVTMV
   GOTO EVT

:METEVTED
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /METER /IF %1.E0%2 /OF %1.F0%2 /FF /EDIT
   GOTO PRTEVT

:METEVTNM
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /METER /IF %1.E0%2 /OF %1.F0%2 /FF
   GOTO PRTEVT

:METEVTMV
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /METER /IF %1.E0%2 /OF %1.F0%2 /addsectend /f9move -7.6 /FF
   GOTO PRTEVT

:ENGEVT
   ECHO.
   ECHO English Report Selected
   ECHO.
   IF EXIST %1.F0%2 DEL %1.F0%2
   ECHO.
   Choice /c:FNESQ /n Report Type? F=F4 F9 Moved, N=Not Moved, E=Edit Style, S=Skip, Q=Quit ?:
   ECHO.
   IF ERRORLEVEL 5 GOTO QUIT
   IF ERRORLEVEL 4 GOTO CHECKEND
   IF ERRORLEVEL 3 GOTO ENGEVTED
   IF ERRORLEVEL 2 GOTO ENGEVTNM
   IF ERRORLEVEL 1 GOTO ENGEVTMV
   GOTO EVT

:ENGEVTED
   rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
   RP090L /FOOT  /IF %1.E0%2 /OF %1.F0%2 /FF /EDIT
   GOTO PRTEVT
```

```
:ENGEVTNM
  rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
  RP090L /FOOT  /IF %1.E0%2 /OF %1.F0%2 /FF
  GOTO PRTEVT

:ENGEVTMV
  rp090l /RESET /calprohdr user4,user5,user6,user7 /upd
  RP090L /FOOT  /IF %1.E0%2 /OF %1.F0%2 /addsectend /f9move -25 /FF
  GOTO PRTEVT

:PRTEVT
  IF NOT EXIST %1.F0%2 GOTO FILEHLPF
:EVTOUT
  ECHO.
  Choice /c:DPS /n Display-Print Event Report? D=Display, P=Print, S=Skip ?:
  ECHO.
  IF ERRORLEVEL 3 GOTO CHECKEND
  IF ERRORLEVEL 2 GOTO EVTPRT
  IF ERRORLEVEL 1 GOTO EDITEVT
  GOTO EVTOUT

:EDITEVT
  EDIT %1.F0%2
  GOTO EVTOUT

:EVTPRT
  COPY %1.F0%2 PRN
  GOTO EVTOUT

REM FIX ASC IN FILES HERE
:SETASC
  IF NOT EXIST %1.E0%2 GOTO FILEHLPE
  DB_EDIT %1.E0%2 C:\MDRSW\FIXASC.SCR
  IF NOT EXIST %1.P0%2 GOTO FILEHLPP
  DB_EDIT %1.P0%2 C:\MDRSW\FIXASC.SCR
  IF NOT EXIST %1.V0%2 GOTO FILEHLPV
  DB_EDIT %1.V0%2 C:\MDRSW\FIXASC.SCR
  IF NOT EXIST %1.R0%2 GOTO FILEHLPR
  DB_EDIT %1.R0%2 C:\MDRSW\FIXASC.SCR
  ECHO.
  ECHO  ASC SET In %1.E0%2 and ASSOCIATED  .P0%2, .V0%2, AND .R0%2 Files
  ECHO.
  GOTO CHECKEND

REM NORMAL ENDING HERE
:QUIT
  ECHO.
  ECHO  Batch File Ended Normally
  ECHO.
  GOTO END

REM HELP SECTION
:FILEHELP
ECHO.
ECHO INPUT PROFILE DATA FILE %1.P0%2 NOT FOUND
ECHO.
GOTO HELP1

:FILEHLPE
ECHO.
ECHO INPUT EVENT FILE %1.E0%2 NOT FOUND
ECHO.
GOTO HELP1

:FILEHLPV
ECHO.
ECHO INPUT SPEED FILE %1.V0%2 NOT FOUND
ECHO.
GOTO HELP1
```

```
:FILEHLPR
ECHO.
ECHO INPUT REFERENCE FILE %1.R0%2 NOT FOUND
ECHO.
GOTO HELP1


:FILEHLPF
ECHO.
ECHO PROGRAM ERROR: EVENT FILE %1.F0%2 NOT CREATED, CHECK RP_ERROR.$$$
ECHO.
GOTO HELP1


:HELPPM
ECHO.
ECHO PROSCAN.MET FILE NOT FOUND IN C:\MDRSW
ECHO.
GOTO HELP1


:HELPPE
ECHO.
ECHO PROSCAN.ENG FILE NOT FOUND IN C:\MDRSW
ECHO.
GOTO HELP1


:HELPRI
ECHO.
ECHO RPTDESC.ICC FILE NOT FOUND IN C:\MDRSW
ECHO.
GOTO HELP1


:HELPIA
  ECHO.
  ECHO PROGRAM ERROR; PROSCAN FILES .IA? OR .JA? not Created
  ECHO.
  GOTO EVT




:HELP
  ECHO.
  ECHO.
  ECHO This Batch file will perform the following using selections:
  ECHO.
  ECHO      1) Run RP090L to produce 2 Track Proscan Files for Defects and Graphs
  ECHO      2) Run RP090L to produce Event File Report.
  ECHO      3)
  ECHO      4) Run EDIT to display created files.
  ECHO      5) Print Defects Report and PI Graph
  ECHO      6) Fix Data Files to set Asc instead of Dsc.
  ECHO.
  ECHO      Selections can be made for metric or english
  ECHO
  ECHO.
  ECHO      Fromto Parameters are not used with this batch file.
  ECHO      Use the ???????? batch file when start and end stations are required.
  ECHO.
  ECHO.
  ECHO.
  ECHO.
  pause
:HELP1
  ECHO Usage: %0 filename n
  ECHO.
  ECHO filename  - filename to be processed in this directory
  ECHO n         - last digit of file extension
  ECHO             typically 1 when single file is created
  ECHO.
:END
```

APPENDIX B. PROFILER FORMS

MONTANA DEPARTMENT OF TRANSPORTATION

PROFILER FIELD ACTIVITY REPORT

MDT DISTRICT: _____ VEHICLE ID: _____ DRIVER / OPERATOR: _____

DATE: _____ TIME: _____ TEMPERATURE: _____

LOCATION: _____ COUNTY: _____ HIGHWAY: _____

JOB NUMBER: _____ CONTROL NUMBER: _____ KM / MILE MARKER: _____

File Name	Direction	Lane	Run 1 IRI Values			Run 2 IRI Values			Run 3* IRI Values			Run 4* IRI Values			Run 5* IRI Values		
			Left	Right	Average	Left	Right	Average	Left	Right	Average	Left	Right	Average	Left	Right	Average

Runs 3, 4, & 5 to be completed only if necessary.

Number of Bridges: _____ Location of Bridges: _____

Additional Events / Locations of Note: _____

Comments: _____

MONTANA DEPARTMENT OF TRANSPORTATION
PROFILER MAINTENANCE / REPAIR ACTIVITY REPORT

MDT DISTRICT: _____   DATE: _____

VEHICLE ID

MAKE: _____   VEHICLE ID: _____

MODEL: _____   ODOMETER: _____

REASON FOR MAINTENANCE WORK (CHECK ONE)

SCHEDULED: ☐   ROUTINE: ☐

NOT SCHEDULED: ☐

DESCRIPTION OF MAINTENANCE / REPAIR AND REASONS

MONTANA DEPARTMENT OF TRANSPORTATION

PROFILER CALIBRATION RECORD SHEET

OPERATOR: _____ DATE: _____

VEHICLE ID: _____ TIME: _____

LOCATION: _____

LASER SENSOR CALIBRATION CHECK

Lens to Ground Measurement   Left: _____   Right: _____

	Measurement Action	1 -- Left			2 -- Right		
		1/4" Block	1/2" Block	1" Block	1/4" Block	1/2" Block	1" Block
1	Actual Block Thickness						
2	Height: Floor						
3	Height: Block						
2-3	Height: Floor - Block						
1-(2-3)	Difference: Actual - Height						

Acceptable Difference Value = +/- 0.002 ft

ACCELEROMETER CALIBRATION

Calibration Factor (ACF)	1 -- Left	2 -- Right
Prior Value		
New Value		

Acceptable New ACF Value = 512 +/- 10

BOUNCE TEST

IRI (100 ft Interval)	1 -- Left	2 -- Right
Static Value		
Dynamic Value		

Acceptable Static IRI Value <= 5 in/mile

DMI CALIBRATION

Prior DCF	New DCF	Run 1 DCF	Run 2 DCF	Run 3 DCF	Run 4 DCF	Run 5 DCF	Run 6 DCF

Acceptable Run Pulse Count Values = +/- 10 of Average Pulse Count

Tire Pressures	Left Rear	Right Rear
Before Calibration		
After Calibration		

COMMENTS: _____

MONTANA DEPARTMENT OF TRANSPORTATION
PROFILER PROBLEM REPORT

ATTENTION:

TYPE OF PROBLEM:

GUIDELINES:

EQUIPMENT:

SOFTWARE:

NAME:

VERSION:

OTHER:

REPORTED BY:

DATE:

URGENT? (Y/N)

PAGE 1 OF

DESCRIPTION:

THIS SECTION FOR USE BY MDT DISTRICT OFFICE

RECEIVED BY:

REFERRED TO:

DATE REFERRED:

DATE RECEIVED:

APPROVED BY:

DATE APPROVED:

RESOLUTION:

NOTES:

APPENDIX C. TROUBLE SHOOTING GUIDE

C.0 PROFILE TROUBLE SHOOTING GUIDE

This appendix contains problems that commonly occur when collecting and reviewing profile data. Knowledge of these problems will help operators to collect better data for the MDT program. These commonly encountered problems can be grouped into the following three categories:

- Spikes in Profile Due to Equipment Problems,
- Miscalibrated DMI, or
- Early Start of Data Collection.

A brief description of each of these problem groups is provided next along with typical plots illustrating such conditions. To detect most of these problems, the profile data in question must be compared to those collected during the previous run.

C.1 SPIKES IN PROFILE DUE TO EQUIPMENT PROBLEMS

Spikes can be introduced in the profile data as a result of equipment problems. These spikes can be identified by comparing multiple profile runs at a section. This comparison should be performed separately for each path of profile data. Figure C-1 illustrates the presence of a spike in the profile data. This figure shows seven profile runs of the right wheel path. Several runs have spikes and several do not have spikes. In this case, the spikes were likely due to transverse cracks.
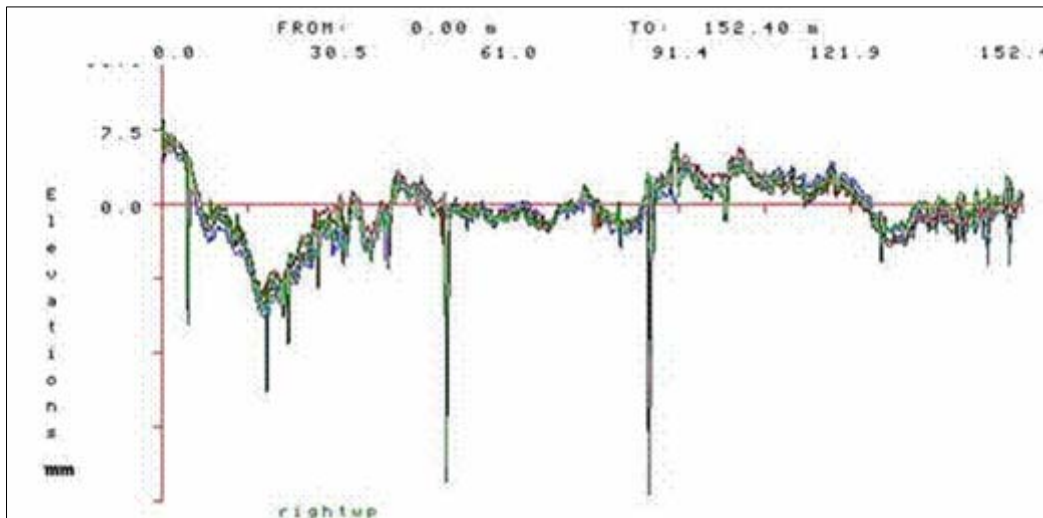

Figure C-1. Spikes in Profile Data.

C.2 MISCALIBRATED DISTANCE MEASURING INSTRUMENT (DMI)

A miscalibrated DMI cannot always be detected simply by comparing repeat profile runs obtained during a site visit. However, the profile runs should be plotted together to check for this phenomenon. If there is a question with the DMI, data may appear squeezed or stretched in the horizontal direction (Figure C-2). After running the calibration site, profile runs should be plotted together with previous profile runs and checked.

When this problem occurs, operator should check tire pressure of vehicle to ensure it is at the appropriate values. If the tire pressure is outside those limits, operator should adjust tire pressure and obtain a new set of measurements at the section.
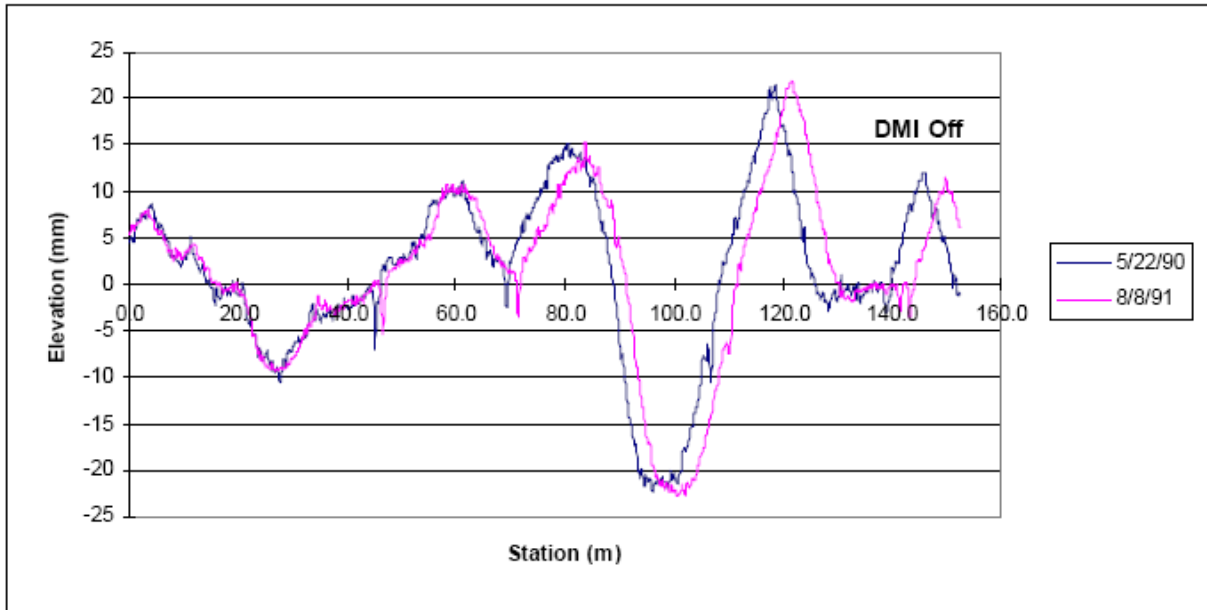

Figure C-2. Data Collected with Calibrated & Miscalibrated DMI.

C.3 EARLY START OF DATA COLLECTION

An early profile start can occur when the photocell triggers a reference reset prior to the start of the test section. It is possible for all repeat profile runs during a visit to have the same starting location, but all are early starts. This problem can occur if there is a mark on the pavement that triggers data collection to start at the same location, but this location is before the beginning of the test section. When the current profile data are compared with those collected during an earlier visit, the early start problem can be easily identified by a clear shift in the profile data sets (Figure C-3).
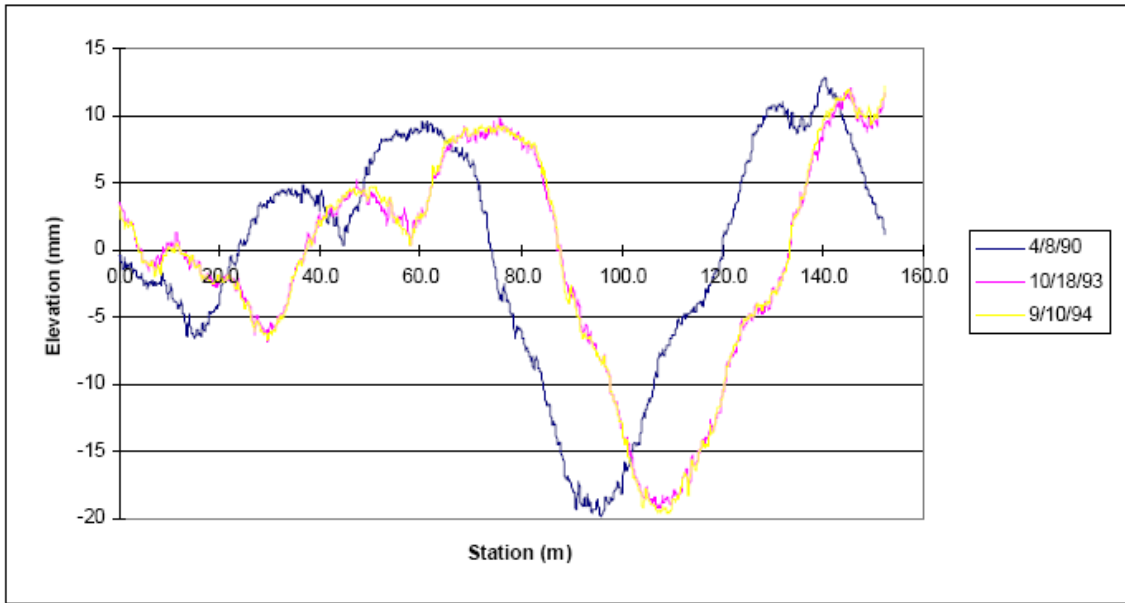
Figure C-3. Example of Early Profile Start.