# Photolog Field Data Collection Standard Operating Procedures



**Photolog Unit**

**Roadway Information Systems**

**Bureau of Policy and Planning**

**Connecticut Department of Transportation**

Introduction

# Forward

The Photolog Unit is located in the Roadway Information Systems Section of the Bureau of Policy and Planning.  It has the responsibility of maintaining a program to collect, process, analyze, report on an annual inventory of pavement condition, geometric and imagery data on roughly 12,500 miles of State highways and local roads for the Department.

To insure that only the best quality data are being produced, the following Standard Operating Procedures have been implemented for all field collection and office operations.

# Background

In order to better understand the complexities and responsibilities of the Photolog Unit today, it is important to first understand where the unit we came from and how changes in Federal requirements over time have caused the need for the Department to adapt its technical capacity and capabilities.

In the late 1960’s, the Federal Highway Administration (FHWA) first began to look at the concept of having States perform an automated collection of imagery along the State Highway System. Various discussions were held around the nation with Connecticut being an active participant in the northeast.

The Department’s Research Section, understood the potential benefits that Right of Way imagery could provide and in 1970 an imagery collection effort was initiated with acquisition of a passenger Van (Van 1), equipped with a film camera. The new van was then used to successfully collect two full statewide sets of imagery along the State highway over the next 4 to 5 years. Several new passenger vans were deployed along with newer filming technologies in the late 70’s and 80’s as national efforts were underway to research implementation of the first State managed Pavement Management Systems (PMS) to help better manage National infrastructure investments.

In 1994 Research acquired two of the latest Automated Road Analyzer (ARAN) 4900 Series Vans (Van 5 & Van 6) from FUGRO Roadware to aid in the collection of pavement condition data and imagery in support of the Department’s new PMS. The ARAN Series 4900 Vans were the first of their kind designed to collect basic pavement and imagery data in an automated fashion from the field for incorporation into the State’s PMS and for report out to FHWA. They were based on simple tabular data which was designed for the basic FHWA reporting needs of the PMS systems at the time.

Over the next thirty years FUGRO’s ARAN technology continued to evolve to become one of the most critically important and prominent tools in use today by State DOT’s enabling the collection of highly technical, detailed and complex pavement condition and infrastructure data.

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# Automatic Road Analyzer (ARAN) Vans

In the fall of 2015, to meet the new data requirements under the Map21 legislation and to stay current with the latest in roadway profiling technologies, the Department's Photolog and Pavement Management Units upgraded the systems on its existing ARAN data collection vehicle (Van 8), acquired a new build ARAN (Van 9) and upgraded to FUGRO's latest VISION data processing platform.

The new 3D technology on the new ARAN Vans and new centralized database Vision environment represent a significant departure from the previous data collection and data processing methods and procedures have been used. Unlike the previous IIE data processing system which dealt with tabular data files off the ARAN Vans for further data processing and reporting, the new VISION desktop processing software is reliant on an MS-SQL database and network level file storage based environment which needed to be shared between Photolog and Pavement Management Sections.

## ARAN 9000 Series Vans

The ARAN Series 9000 Vans have been retooled to meet today's rigorous data collection requirements of the road infrastructure data collection community. The ARAN's robust platform has been expanded to deliver:

- 50% reduction in computing hardware over the previous platform with the same functionality
- Database driven systems
- Robust, fault tolerant systems
- Plug and play system integration
- Microsoft.net platform
- Real-time sub-cm data synchronization
- Advanced mission management software
- Increased portability of subsystem components
- Global solution with interfaces in several languages
- User friendly operating system to minimize training costs and operator error
- Industry-defining warranty
- Dynamic architecture supporting future upgrades

**Table 1.0 details the two new ARAN 9000 Series Vans and latest equipment installed on each.**

| System equipment | ARAN Vehicle ID | |
|---|---|---|
| | VAN 8 | VAN 9 |
| Chassis | ARAN 9000, 2010 Dodge Sprinter | ARAN 9000, 2015 Mercedes Benz Sprinter |
| Geographic Coordinates | Real-Time Differential GPS +POS LV Inertial Positioning System | Real-Time Differential GPS +POS LV Inertial Positioning System |
| Distance | Wheel-mounted Distance Measurement Instrument | Wheel-mounted Distance Measurement Instrument |
| Longitudinal Profile | Two RoLine 4" Footprint Line Lasers | Two RoLine 4" Footprint Line Lasers |
| Roughness | Accelerometers Mounted in Front Bumper Enclosure | Accelerometers Mounted in Front Bumper Enclosure |
| Transverse Profile | 3-D Pavemetrics Laser Crack Measurement System | 3-D Pavemetrics Laser Crack Measurement System |
| Pavement Surface Image | 3-D Pavemetrics Laser Crack Measurement System (LCMS) | 3-D Pavemetrics Laser Crack Measurement System (LCMS |
| Front View Image | SONY HD Camera w/90 Degree Field of View Lens | SONY HD Camera w/90 Degree Field of View Lens |

# ARAN Van Subsystems

## Pave3D System (Rutting, Cracking and Transverse Profiles)

One of the most recent advances in road condition data collection is the adoption of 3D scanning laser technology. These systems, including that of the laser crack measurement system (LCMS) developed by INO and Pavemetrics Systems Inc., have the potential to measure pavement rutting (transverse profile), macrotexture (mean profile depth) and surface cracking. The Pave3D system is a combination of Fugro's fully integrated data collection system, Vision software analysis suite, WiseCrax analysis software and LCMS subsystem. The laser crack measurement system (LCMS) uses high speed cameras, custom optics and laser line projectors to acquire both 2D images (black and white intensity images) and high resolution 3D profiles (surface elevations) of the road. As a result this state-of-art system can reproduce a detailed image of a pavements surface which is ideal for the identification and rating of pavement distresses. This technology of high speed cameras, optics and laser line projectors produces which is known as a ".FIS" files containing all the measurements and light intensity readings collected using the Pave3D system. The benefits of this when it comes to processing the data into meaningful pavement distresses is that automated pavement distress algorithms have a much easier job of depicting the extent and severity of pavement cracks and distresses. Therefore much more accurate and repeatable rating of pavement cracks will result from automated distress rating.

The automated features of the Pave3D system include:

- Fully automated detection, classification and rating of transverse, longitudinal and alligator (fatigue) cracking;
- Fully automated detection of pavement raveling, potholing and patch deterioration;
- Fully automatic lane marking detection;
- Fully automatic lane drop off detection;
- Fully automated detection of transverse profile and pavement rut depths; and
- Fully automated detection of pavement texture according the five AASHTO bands.

It is important that the mounting for the equipment be completed such that it has a clear view of the surface with the least amount of vibration and signal noise possible. Fugro has designed a suitable mounting bracket to connect to the frame of the vehicle in a way as to reduce movement and potential vibration. The mount has also been designed to collect the profiles on a slight angle so as to best capture both longitudinal and transverse features with minimal interference. This solid and robust mount has proved to be the right solution through experience.

The system is not susceptible to changes in sunlight, shadows and general lighting conditions due to the way it works with a laser line. The LCMS system operates at up to 11.2 KHz (normal operating speed is 5.6KHz), to deliver a longitudinal resolution of 2.5mm per pixel (175 pixels per foot). The system has 2 measurement heads each capable of 2300 pixel transverse resolution (normal operating condition 2000 pixels). When set to 13 feet the maximum number of pixel per foot is 353 in transverse plane (normal operation 310 pixels per foot and 285 pixels per foot at 14 foot span). This system can be mounted to deliver up to 14 feet pavement images (normal operating viewing angle is 13.1 feet). The images generated from the FIS files (the native 3 format) can deliver 8 bit (256 levels), to 12 bit (1024 levels) images and is controlled within the Vision software. Vertical resolution is currently 0.5mm and developments are underway to achieve 0.3mm through a range of measurement of 250mm (~10 inches).

**Pavement Surface Elevation Video Images**

Pave3D outputs range and intensity data, which are used to derive a 3D image of the pavement surface (see Figure 2). These capabilities enable improved performance of post processing techniques, resulting in superior accuracy for the identification and the severity rating of pavement cracks. These images are designed for both automated and manual crack identification methods.

A few of the advantages of using the Pave3D system over conventional pavement video (comparison is made in the table below) includes but not restricted to:

- Operation in all types of lighting conditions both during the day and at night. Sun and shadows as well as various types of pavement types ranging from dark asphalt to light colored concrete can be measured at survey speeds to 70 mph and on roads reaching 14 feet in width and still achieve the 0.19 inches longitudinal resolution.
- Low power requirements due to the efficiency of the systems operation resulting in ARANs no longer requiring on-board generators that were once required to power the illumination of pavements for imaging.

- Continuous collection of pavement images along the length of the roadway with no interruptions that have historically been associated with pavement imaging technologies. This feature such allows the user to select their desired reproduction interval length of generated pavement images, to which can be made to align with predetermined right-of-way image intervals.
- Transverse resolution of the Pave3D system is twice that of conventional pavement imaging technologies. This is a great advancement in high-speed crack recognition technology, whereby it is now possible to successfully depict pavement cracks that are half the width of what could previously be rated.
- The addition of known pavement depth measurements 0.2 inches to the range view which utilized variation in pavement color only to locate and classify pavement cracks and distresses.

**Transverse Pavement Profile**

The Pave3D is highly capable of reproducing the transverse profile collected using the 4,000 transverse data points (1mm transverse resolution) produced by the system for the identification and rating of pavement rutting performance in each of the lane's wheel paths (effectively eliminating the effects of driver wander). Further the high operating frequency of 5,600 profiles per second facilitates the generation of transverse profiles at 5mm longitudinal intervals. This provides users with the greatest flexibility in capturing highly detailed transverse profile data, which can later be summarized to user-definable intervals for reporting purposes.

Using post-processing techniques in the Vision application, a transverse profile made up of a user-definable number of rut points, at user definable transverse locations can be generated. This process can be such utilized to easily generate pavement rutting in accordance to a simulated, standard 3-point or 5-point rutting system. This ensures that consistency and repeatability between collection systems will result.

With the complete transverse profile, we are able to examine the cross-section to determine cross-slope as well as the presence of edge drop-off and curbs. The full profile can then be used with Vision's Rut Depth Processor to examine the profile with a range of user-definable settings, allowing users to define where and how pavement rutting is to be defined, and at what interval it should be averaged for reporting. This system has been tested against manual pavement rut depth methods (ASTM E1703-10: Standard Test Method for Measuring Rut-Depth of Pavement Surfaces using a Straight-edge), and found to be accurate to within the required ± 1 mm.

In addition, the equipment can simulate a dynamic straight edge to view the maximum depth across the profile or simulate a sting/wire rut measurement method. Some of the in-built rutting and transverse profile features included in Vision package include:

- User definable pavement rut depth calculations based off fixed and moving straight-edge or wire algorithms.
- User definable pavement water depth calculations based off fixed and moving straight-edge or wire algorithms.
- User definable pavement lane width and edge drop-off for an improved representation of a given pavements transverse profile and such more representative pavement rut depths.
- Numerous methods in graphical analysis of transverse profiles with locations and magnitudes of maximum pavement ruts for a given profile.
- Ability to report the extent of pavement rut depths (user definable thresholds) or water depths at a network level (depth averages reported over long chainages; i.e. 0.1 or 0.2 miles) according to their severity state. Such the reporting of a segment maximum, minimum and standard deviation rut depths across the left, right and combined wheel path can be easily generated for an entire network.
- Flexibility to report pavement rutting depths/averages with a range of user defined options (such as reporting at defined intervals or ruts exceeding a certain severity state).

Following the characterization of pavement ruts according to these specified rutting algorithm settings, summaries of processed pavement ruts can be generated. Tabulated and graphical forms of pavement rutting can be viewed by users using the Vision application for quality control purposes. Generation of pavement rutting reports in accordance with predefined severity states can be accomplished using the Report Generator function. Rut depths can be reported according to their averaged, maximum, minimum criteria as well as a range of statistical functions which provide unique, user definable commands for the analysis of pavement rutting on a network or survey level.

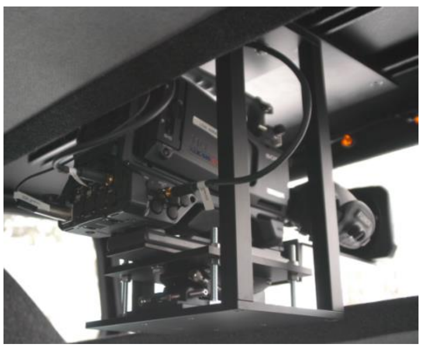


## LRS Positioning

The collected road data must be referenced accurately for it to be useful. Fugro has developed proprietary tools to collect data to the strictest tolerances while simultaneously matching it to existing Linear Referencing Systems (LRS) and Geographic Information Systems (GIS). The Vision software allows for processing of ARAN data to match any LRS or GIS system.

Each road section is uniquely identified using Locators such as route, direction, lane, or other identifiers. Usually each road section also has a GIS reference such as start/end GPS coordinate or a road centerline. The data collected in the field is matched using both GIS references and LRS references to existing definitions. This makes year-to-year comparisons accurate and consistent, eliminating the variability due to varying start/end points or collection path variances.

## Right of Way Imagery Collection



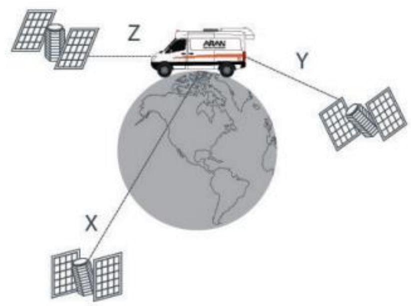
The ARAN Vans are each equipped with SONY HD cameras which offer greater depth of field as well as:

- High image quality
- True color, progressive scan images from 3CCD sensor
- 1920 x 1080 resolution
- 1/1000 of a second shutter speed for crisp image capture at highway speeds
- 60 Hz run rate and auto-adjustments for better image brightness and contrast in varying light conditions

Our experience has shown that pixel count is not as important as optics when it comes to image quality and the ability to see details within an image. The number of sensors used is even more important. We use the highest broadcast quality optics and professional HD 3CCD cameras, providing extremely high quality images over a range of lighting conditions. The 3CCD cameras measure the true color of every pixel in the image, as compared to most single sensor cameras that record only one of three colors for each pixel and interpolate the color based on surrounding pixels.

High-definition color digital images can be collected as often as every 12 feet. These images are captured and stored in JPEG format containing metadata with a banner or header displaying direction, coordinates, date, etc.

## GPS Positioning




GPS is used to provide the location coordinates of roadway features and to create maps using CAD or a Geographic Information System (GIS). The ARAN GPS is integrated with other subsystems so that if the receiver cannot lock onto enough satellites to determine its position or satellite lock is lost, the ARAN Distance Measuring Instrument (DMI) and the ARAN Inertial Reference System (Smart Geometrics or POS LV™) will fill in the gaps. The accuracy of the system in Real-time differential mode where differential corrections are received from satellite or FM transmitters is 1 meter.  FUGRO uses a twelve channel mobile receiver and Real-time Differential GPS OmniStar satellite differential correction service used to eliminate the need for fixed base stations.

## Roughness (IRI)  / Longitudinal Processing

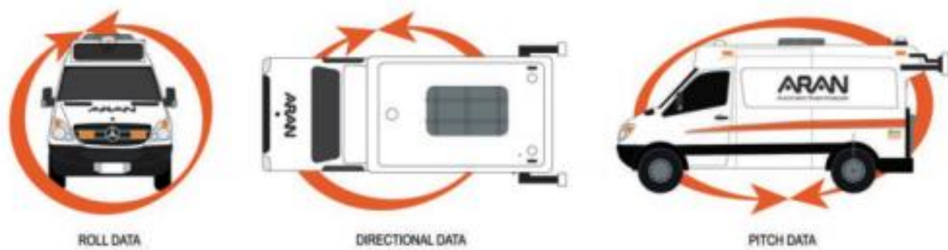
Surface roughness, in particular reported in relation to an International Roughness Indicator (IRI) value, is a key performance indicator being used widely around the world including the Federal Highway Administration's (FHWA) Highway Performance Monitoring System HPMS). Reporting such information to FHWA is a key requirement for U.S. States.

FUGRO Roadware's Laser SDP/2 (South Dakota Profiler RoLine - 4" (100mm) footprint line laser) is a Class I profiling device under ASTM E950 and has been proven over a large range of agency requirements including TTI and AASHTO R56-10 certifications.

Each of these sensors continuously measures the longitudinal profile, and calculates in real-time, pavement roughness indicators such as IRI, MRI, HRI, and Ride Number (RN) for 100% of the driven lane in accordance with ASTM Standard E1926.

FUGRO has reliable, speed-sensitive filters which improve the accuracy of the longitudinal profile calculated during in low-speed, stop and go environments or areas where there is not a long enough lead-in environments. They reduce the impact of the unwanted frequencies in the accelerometer signal which affect the profile (and International Roughness Index) calculation. This allows our customers to get as much roughness data across their network as possible.

## <u>**Position and Orientation System for Land Vehicles (POS LV)**</u>




The Position and Orientation System for Land Vehicles (POS LV) is a state-of-the-art aided inertial navigation system that provides precise roll, pitch, heading, velocity and position information to other onboard measurement subsystems. The POS LV successfully mitigates the real-world effects of GPS outage, signal interference and multipath, providing accurate positioning under situations where a stand-alone GPS antenna cannot deliver reliable data.

POS LV combines data from sensitive gyros and accelerometers, packaged in an Inertial Measurement Unit (IMU), with the Geographic Positioning System (GPS) and a Distance Measurement Instrument (DMI). This position information is used to motion-compensate the ARAN sensors, making it possible to accurately derive the position and attitude of points on the road surface. GPS and the inertial sensor are complementary technologies. GPS corrects any drift evident in the inertial sensor over time, while the inertial sensor ensures that positioning will be continuously available, even in periods of GPS outage (e.g. due to tree canopy or urban canyon). The POS LV solution helps determine longitudinal and transverse profiles of multi-lane roads as well as other geometric data such as curve radius, grade, and elevation measurements with survey-level accuracy. The Inertial Measurement Unit is mounted in the Front Instrument Enclosure (bumper) for precise “roll” information without the error introduced by the twist of the vehicle frame. This data is used to determine the transverse profile of the road surface. ARAN software utilizes the high-accuracy position and orientation solution provided by POS LV to construct or update existing maps when it is used with a Geographic Information System (GIS) database.

## Distance Measuring Instrument (DMI)

The Distance Measuring Instrument (DMI) measures ARAN chainage or linear distance travelled. It is the most basic and yet one of the most important measurements made by every ARAN vehicle. The DMI allows a vehicle to move at variable speeds in traffic and collect data safely without data corruption due to speed changes. All data must be accurately referenced to its location on the road and the DMI is an integral tool in carrying out that task.

ARAN sub-systems use distance as their base for measurement and are not speed dependent as are many competitive timebased measurement systems. This feature allows the vehicle to move at variable speeds in traffic and collect data safely without data corruption due to speed changes. They are also not prone to slippage as with contact-based systems. The DMI uses an optical shaft encoder driven from the rear wheel to produce a stream of 10,000 pulses per wheel revolution. These pulses are sent to the Central Data Acquisition Computer (CDAC) for use by all other ARAN sub-systems. The DMI also measures velocity changes which are used with the inertial reference subsystem and GPS subsystem to precisely determine the vehicle's position in geographic space. This provides the geographic coordinates for CAD and GIS mapping applications. The DMI offers the following features:

- Provides essential chainage measurements
- Divides each wheel revolution into 10,000 pulses
- Measures linear distance within ± 0.005%
- Links all data to linear location references
- Interfaces with Central Data Acquisition Computer
- Easy calibration to compensate for tire wear
- Provides distance trigger pulses to all ARAN subsystems
- Integrates with GPS and Inertial Reference System for geographic positioning
- Operator selectable Metric or Imperial units
- Simple, reliable operation
- Rugged environmentally-protected construction
- Adaptable to any vehicle

# Importance of Driving in the Wheel path

Safe, effect and proper operation of the ARAN Vehicles is critical to the collection of quality and accurate data.  The importance of keep the vehicle in the wheel path is essential and to best adhere to this the following roles and responsibilities have been outlined for field operations:

**Driver's role while collecting data:**

- The driver is the pilot of the ARAN.
- The driver is responsible for driving the ARAN between the pavement lines so that both of the painted lines appear in the pavement video.
- The "wheel path" is usually to the left of the middle painted line viewed in the pavement, if you have difficulty locating "the groove", position the ARAN in the middle of the lane you are collecting. If you are unsure, then ask the operator if you are in the middle of the lane.
- It is imperative that the driver concentrate on driving smoothly in a straight line with a constant speed and remain in the middle of the lane being collected  with no swerving or deviations. Cruise control can be utilized on straight roads, but should not be engaged when navigating curves.
- The driver should have both hands on the steering wheel at the 9 and 3 position. The driver should not be eating, using a cell phone, or have any other distractions that may affect proper collection techniques.
- Safe driving practices and professionalism should be the driver's main goal.

**Operator's role while collecting data:**

- The operator is the navigation and communication officer.  They are the lead for the day's collection operations.
- The operator should communicate every aspect of the data collection process and keep the driver informed of exactly where he/she wants the driver to maneuver the ARAN.
- It is the operator's responsibility to ensure that the ARAN is positioned in the middle of the lane being collected and that both painted lines are in the pavement video. If the driver moves from the "wheel path" while collecting, then the operator should not hesitate to inform he/she that they must get back on track.
- Accurate and flawless data collection is the operator's main priority.

# ARAN & Field Operations Safety

The following section shall define the safety guidelines implemented for Photolog field operations personnel. They are in addition to the policies as set forth by the Connecticut Department of Transportation.

**Driver Licensing**

Personnel authorized to drive the Department's Photolog ARAN Vans must have and maintain a valid Connecticut driver's license and have their license on their person while driving the ARAN Van. Drivers must be able to drive the vehicle safely and effectively without restriction.

**Driver Fines**

Fines for parking or moving violations, towing storage or impoundment are the personal responsibility of the assigned operator. The Department will not condone nor excuse ignorance of any motor vehicle violations that result in court summons being directed to itself as owner of the vehicle.

Towing requirements caused by normal operation will be covered by the Department.

**Accidents Involving ARAN Vans**

In the event of an accident employees are expected to follow the requirement as outlined in the "Connecticut Department of Transportation Incident Reporting Procedures" A copy of these procedures along with copies all relative documents are to be kept in the ARAN Vans at all times.

**Driver Responsibilities**

Each driver is responsible for the actual possession, care and use of the ARAN Van in their possession. Therefore, a driver's responsibilities include, but are not limited to, the following:

- Operation of the vehicle in a manner consistent with reasonable practices that avoid abuse, theft, neglect or disrespect of the equipment.
- Obey all traffic laws.
- The use of seat belts is mandatory for the driver and passengers.
- Adhering to manufacturer's recommendations regarding service, maintenance and inspection.
- Vehicles should not be operated with any defect that would prevent safe operation.
- Attention to and practice of safe driving techniques and adherence to current safety requirements.
- Reporting the occurrence of moving violations

## Safety Apparel

The following safety apparel shall be worn as prescribed by all Employees and guests riding in the ARAN Vans in accordance with Department Policies and Procedures.

- **Safety Shoes -** are required to be worn at all times while working on or around the fleet vehicles, including the ARANs in accordance with Department Policy.
- **Safety Vests -** are required to be worn any time you are outside the fleet vehicles and the vehicle is in operation, except in parking lots or at lunch in accordance with Department Policy.
- **Safety Eyewear -** is to be worn when working with the vehicles LCMS System Lasers, moving mechanical parts or underneath the fleet vehicles.
- **Soft High Visibility Baseball Hats -** are required anytime you may be in the field and out of the ARAN Van where you are endangered by vehicular traffic accordance with Department Policy.

## Jewelry and Long Hair

Jewelry is not to be worn while performing mechanical tasks that have moving parts or while performing any electrical task. Long hair is to be tied back (covered with hat or net) at all times while working on mechanical tasks with moving parts or electrical tasks.

## Vehicle Height, Weight and Width

The respective fleet vehicle's height, weight and width must be posted inside on the dashboard (visible to the driver) at all times. The Dimensions of the vehicle is valuable to avoid incidents, especially when driving the ARAN. If the posting is illegible, please advise your supervisor and have it replaced.

## Amber Lights

The amber flashing lights on the ARAN are designed to let other vehicles know that we may be operating differently than other traffic on the road e.g. driving slower, performing different turns etc.  Therefore, the amber lights should be on at all times during data collection, transiting at a lower speed, or doing something different than other drivers on the road would be expecting.

Amber lights do not need to be used if transiting or when operating if travelling the same speed as the other vehicles on the road.

## Carbon Monoxide Detector

The carbon monoxide detector must always be attached low in the vehicle close to the generator in the main cabin in order to detect hazardous levels of carbon monoxide gas before reaching the driver, operator or passenger. It is mandatory for all ARAN's to have a carbon monoxide detector and it must be in use at all times while operating the ARAN.

**Emergency Brake**

At no time should the emergency brake be blocked or tampered with. Nothing is to be stored on, around or near the emergency brake at any time.

**Incident and Accident Reporting**

All incidents and/or accidents must be reported IMMEDIATELY to your Field Supervisors, Manager, Health and Safety Department, and Director of Operations by phone and email. The incident form must be completed within 24 hours and submitted to your Field Supervisors, Manager, Health and Safety Department, and Director of Operations by email.

***(Disciplinary actions for at-fault vehicle accidents are at the discretion of the Department.)***

**Your Ability to Work**

Workplace injuries/or injuries interfering with your ability to work must be reported to your supervisor immediately so that we can take any necessary actions to assist you with your specific circumstances.  Always seek appropriate medical attention: in case of emergency, please call your local emergency number 911.

**Exiting the ARAN during Collection Conditions**

The vehicle should be placed in park anytime the driver, operator, or passenger of the vehicle is required to work out of their seat inside the vehicle, or is required to exit the vehicle, including exiting for ground guidance.

While operating the ARAN, the operator may frequently have to exit the vehicle to clean the ROW glass. In order to ensure this is done safely the operator must request the driver to pull over in a safe location. Then the operator will exit the vehicle to clean the glass at the front of the ARAN. When the operator exits the vehicle, it is mandatory for the driver to put the vehicle in park in order to ensure that the vehicle will not move in any direction.

**Ground Guiding**

Drivers will not reverse the vehicle before first checking for sufficient clearance and any hazards. Hazards can include, but are not limited to pedestrians, other vehicles, trees, and buildings.

If a reverse camera is installed, the driver must check the mirrors and the camera viewer prior to beginning to move the vehicle. If rear visibility is blocked or the risk of injury or damage is elevated (e.g. children playing, people or objects nearby), drivers will use ground guides (banksmen or signalers).

The ARAN Van should be placed in park until the driver has established eye contact with the guide behind the vehicle. Ground guides must be in view of the driver at all times. If ground guides are not available, the driver will dismount, go to the rear of the vehicle, and check clearance before backing.

If requested and safe to do so, the operator or other passenger must exit the vehicle to assist as a ground guide. The job of the ground guide is to guide drivers and make sure reversing areas are free of pedestrians and hazards. If you are using ground guide, make sure:

- they are clearly visible to drivers at all times;
- a clear and recognized system is adopted;
- they stand in a safe position throughout the reversing operation.

Please review the images below for the correct signals to be used for ground guiding.

Turn Right or Left

Slow Down

Moving Forward

Stop

**Parking and Cones**

When parking ARANs, try to choose a location that is away from high traffic areas but in a visible location with good lighting in order to protect the Van. Parking with the (parking lot) line at the center of the vehicle should provide the driver and operator sufficient room for daily tasks. For ARANs, it is preferred to use four cones as shown in the pictures below; two cones at the front on opposite sides of the ARAN and the same in the rear.

When parking ARAN Vans on the side of the road you should utilize the traffic cones behind the vehicle to warn oncoming traffic. Remember, while putting out traffic cones:

- Start deploying cones at the rear of the vehicle
- Always face traffic when placing or removing cones
- Space cones equally at least 20 feet apart
- Photo of Preferred ARAN Parking

**Cleaning the Row Camera**

A squeegee is available in the ARANs to assist with cleaning the Row glass. If work at height must be completed a work plan must be presented to the Field Supervisor, Field Operations Manager and the HSE department for prior approval.

**Re-fueling of Vehicle**

ARAN Vans must be turned off while refueling. As applicable, generators must also be shut off. Please ground yourself by touching a metal object on the vehicle before refueling. After exiting the vehicle do not renter the vehicle until refueling is complete. Gloves are not mandatory for refueling but can be used at the discretion of the Field Operations team member and will be provided if requested. ***(A list of DOT Fuel Stations has been provided at the end of this document)***

**Use of Cell Phones**

Use of personal cell phones and hands free devices are ***prohibited*** to be used while driving any company vehicle (fleet, rental, etc). Personal phone calls are not to be made during working hours unless it is an emergency; otherwise phone calls are to be made on breaks or during lunch. A Photolog Unit cell phone is available for business needs and use throughout the day but should not be used by the Van Driver during operation of the van.

**Smoking Policy**

Smoking in or around the ARAN Vans is prohibited. Employees are allowed to smoke on breaks and lunch only unless it is not interfering with the required daily operation i.e. rain day, maintenance day, scheduled stop or required stop.

**Securing Vehicle Contents**

When leaving the vehicle you must ensure that the contents are secured, anything that can be put away such as the GPS device should be removed from sight or taken with you. Anything that must stay in the vehicle should be covered or put away if possible in order to deter theft and or damage to the equipment.

**Seatbelts**

Seatbelts are **mandatory**; they must be worn at all times when the vehicle is in operation. While the vehicle is in motion all passengers must be secured with a seat belt, therefore at no time can an individual be standing or moving around in the vehicle unless the vehicle is parked.

**Chemicals on board the ARAN**

All chemicals on board the ARAN must be kept in their original bottle or container. This is required in order to make sure that anyone using the product is aware of what it is and what the potential risks are. If you are unaware of the risks please check the MSDS.

**Spill Kits/ First Aid Kits** The Spill Kits and First Aid Kits are to remain stocked at all times, the kits come with a checklist if anything is missing or used you must ensure the required parties are made aware so that the correct items can be purchased and sent out to the truck.

**Disposal of Oil**

The disposal of oil products such as generator oil must be done through the DOT Maintenance Facility in accordance with Department policies and procedures.

**Railway Crossing**

Please ensure that you are following the rules of the road when dealing with railway crossing, ensure that the safety of the personnel and the vehicle is the first priority. Please make sure that if you are not going to stop for the railroad crossing that you slow down to ensure that the ARAN crosses the tracks safely. NEVER stop your vehicle atop of a set of railway tracks.

**Cruise Control**

Using cruise control should not replace driving the vehicle. It is a convenience, not a replacement driver. As the driver you are still responsible for the vehicle and its passenger's safety. Please ensure that you use cruise control carefully. Cruise control is designed for long transits and open road conditions e.g. highway driving at normal conditions. It is not designed for use during:

- inclement weather
- in city or congested traffic
- in hilly or mountainous areas
- or at any time when you need to have full control of the vehicle

If you are using cruise control a speed monitoring device, please ensure that you take into account hills or places where the vehicle may increase speed because if you set the cruise at 65 mph and the posted speed limit is 65 mph then you may be at risk of speeding. Therefore, it may be of value to set the cruise control lower than the posted speed to ensure that road conditions are accounted for.

**Speed**

The maximum speed allowed while driving the ARAN at any point is 65mph per Department Policy. Drivers must adhere to the posted speed limits unless you are required to go slower due to conditions e. g. collecting, weather, etc.

**Laser Safety Training and Laser Use**

Laser safety training is mandatory in the first month of employment and on an annual basis thereafter. If any deviation must be made from the training schedule prior approval must be received from the Field Operations Manager or the HSE Department.

When using lasers, the safety precautions discussed in the laser safety training program must be used at all times with no exceptions.

# Basic Weather and Light Conditions Requirements

## Weather Effects

When collecting pavement video, never collect on days where the pavement is obscured or non- representative of actual conditions due to road debris, severe dampness, snow etc. The ARAN should not be moved during weather that may present a hazard to the crew or vehicle, such as extreme high winds, slippery or blizzard-like conditions, etc.

## Video Collection Procedures

To ensure the best quality ROW and FIS imagery is collected in the field, the following video collection parameters and procedures shall be adhered to at all times.

The operator shall:

- Ensure that suitable weather conditions allow for optimal data and imagery collection. This means that the weather is expected to be clear and dry for the entire day of collection. That the road surfaces are clear of snow, ice, leaves and moisture.
- Ensure that there are adequate ambient light conditions for ROW images to maintain all video detail. This means the collection shall not begin until lighting is bright enough to ensure that all street signs are clearly legible in all ROW images.
- Continually review ROW and pavement images to ensure all images meet collection requirements. This includes any technical issues. Several times a day an end of day report should be run. Both the QC_Pcs_Files.csv and the QC_Video.csv must be opened in Microsoft Excel, each time the end of day reports are run, to make sure PCS is being collected and no images from the ROW camera(s) have dropped any images.

## Maintaining Visibility

Prior to start of section ensure that the camera lens cover and enclosure windshields are clear. Also make sure that visibility is unobstructed. If debris appears on the camera lens or windshield during collection, stop the ARAN and clean immediately, as is safe to do so, or restart the section as appropriate. Any obstructions can be readily seen by carefully monitoring the camera view during collection. It is up to the operator to determine when sufficient time exists between rating and monitoring the collection screen to check the video of all cameras.

# Office Preparation

Each year following final acceptance and reporting of the production year's data, the Photolog staff must prepare for the upcoming collection season. Preparations include:

- Cleanup and backup of the previous production year's data
- Free up current storage spaces on both the MS-SQL server and Photolog_48TB Network Area Storage (NAS) drive
- Setup and organize new file directories on both MS-SQL server and Photolog_48TB (NAS) drive for the upcoming collection season

As the total set of each production year's data is roughly 24 terabytes in size, to make best use of current system resources, the Photolog and Pavement Management Sections have determined that only the current and previous year's data will be maintained within the active Vision System. This will be done on a rolling basis with older year's data currently being moved off the live Vision System to external hard drives or possibly on cloud storage in the future.

## Current Year System and Data Backup

Once the field collection, data processing and reporting have been finalized by both the Pavement Management and Photolog Sections for the previous year, it is time to back up the previous year's data and prepare for the upcoming collection season. To do this, there are several items that must be addressed as follows:

1. Insure that external storage (@ 24tb) is available for the year before previous year data.
2. Procure external storage if needed.
3. Perform finalized database backups for previous year's projects data on the SQL server:
    a. State Routes
    b. Local HPMS Routes
    c. Specials
    d. Ramps
    e. Control
    f. PM

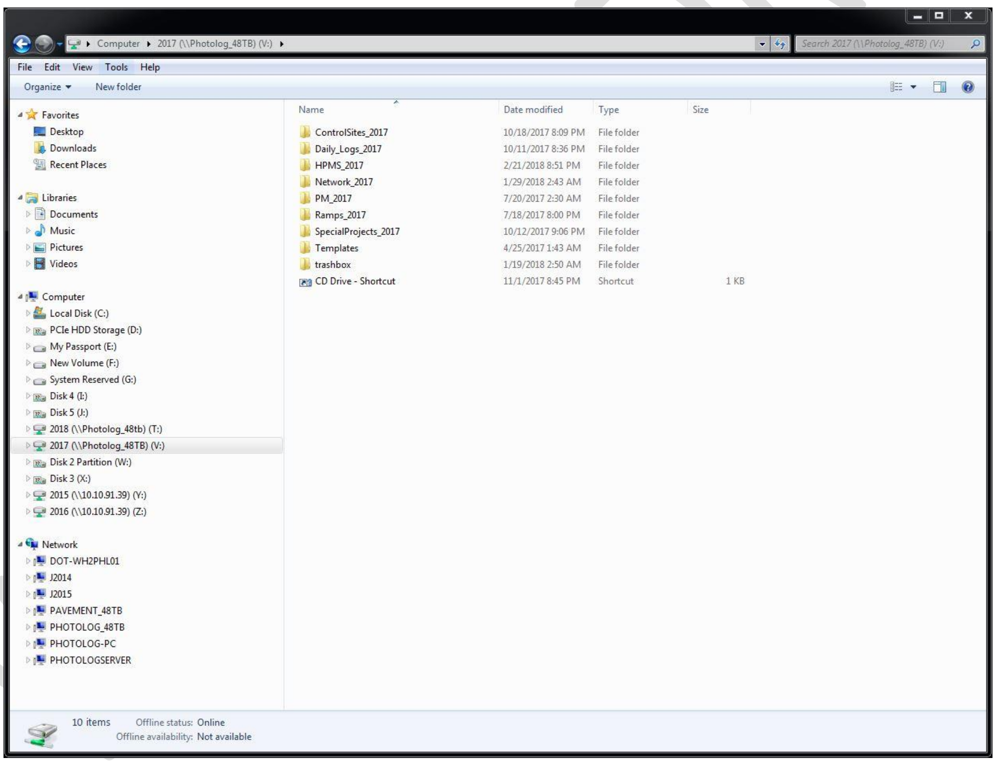
4. For each project, copy data and backups for the year to external storage including:
    a. Each project database backup
    b. Office copies of ROW, FIS, data files and pavement jpeg files
    c. ARAN Van database backup

d. ARAN Raw ROW, FIS and data files

5. Once external storage copy is complete, remove older files and free up the storage space from Production Vision MS-SQL Database and Network Area Storage (NAS).

6. Create a new year folder on NAS drive. Map this folder to a drive letter. Under this folder, create subfolders for:

    a. State Routes
    b. Local HPMS Routes
    c. Specials
    d. Ramps
    e. Control
    f. Preventative Maintenance (PM)



7. Setup up new collection year projects in Data Control Software (DCS) ***(Refer to Vision User Manual P306)*** for:
    a. State Routes
    b. Local HPMS Routes
    c. Specials
    d. Ramps
    e. Control
    f. Preventative Maintenance (PM)

8. Use Data Control Software, evaluate and accept the configuration template and format of the routing files for each project: ***(Refer to Vision User Manual Chapter 27, Routing Importer)***
    a. State Routes
    b. Local HPMS Routes
    c. Specials
    d. Ramps
    e. Control
    f. Preventative Maintenance (PM)

    Make sure that the field mappings are the same for ARAN ACS and Vision Software.

9. Set up current year PM database locally for preventative maintenance (PM). The local database is used to process and get prompt PM results. The results are utilized to verify and evaluate Consultant's PM work. Photolog staff should coordinate with Pavement Management engineers to set up their LCMS related processing templates on the local system.

# Routing File Preparation

The required routing file is a tabular data structure of a road network and is used in two parts of the process:

- It allows the ARAN to store collected data against a specific set of Locators (a group of attributes that can uniquely identify a section of road), such that a particular piece of data can be identified later on.
- To match the data later on in Vision (process called Segmenting) and make a decision on what truth is to be used; the pre-defined routing or the actual collected information.

Routing files are made for the following annually collection efforts ***(all routing files must contain the same column headers and formatting)***:

- State Network Collection
- Local HPMS Collection
- Special Requests – for contract smoothness specification verification
- Ramp Collection
- Control Sites
- Preventative Maintenance

The routing files in use today were initially created using the existing list of checkpoints and chainages were derived from Department's Highway Log serving as its framework. In order to work properly with the ARAN Collection Software (ACS) and Vision, it was necessary to add certain fields/columns to the table. The required fields are listed below:

- **Route** – Can be either populated with a number (for routes, HPMS sections, ramps) or a description of the section, including van number, run number, direction, etc. (used with control sites) – Can include leading 0s.
- **UniqueID** – Can only contain numbers and letters. Must be unique for each route and allows for longer routes, those over 30kms, to be broken up into multiple segments without making each piece appear as an entirely different route.
- **Direction** – We have changed this header to "Flow" and is used to indicate whether the route direction is primary/log (represented by "5") or secondary/reverse ("6")
- **Lane** – The lane number being driven; this is usually the right hand most travel lane except for some of the specials and potentially control sites
- **RoadClass** – represents the function class of the route/road collected

- **Length** – Distance length between checkpoints. We currently have two columns for length, one named “LengthKM” and the other “LengthMile.” Only one field is required, but we have opted to use both
- **Begin Chainage** – Changed to “BeginKM” and BeginMile”
- **End chainage** – Changed to “EndKM” and EndMile”

Our routing files all also contain the following optional fields which provide more detail when out in the field and which improve the accuracy and functionality of the Vision segmenting process:

- **BeginDescription** – Description of beginning checkpoint for each section
- **EndDescription** – Description of ending checkpoint for each section
- **BeginLatitude, BeginLongitude, EndLatitude, EndLongitude** – Lats and Longs for each checkpoint in decimal degrees format
- **Direction** – Cardinal direction of the route/road being collected; represented as N, S, E, or W
- **Town** – The name of the town each checkpoint begins in; particularly useful for local HPMS collection
- **TownNumber** – The town number; includes leading 0s.

Prior to the start of each collection season, the routing files are manually updated based on route change notices sent us from the Department Roadway Inventory Section. Changes may include the addition or removal of routes/HPMS/ramps, a change in the chainage/mile points of a particular checkpoint, the total length of the route/section, or a renaming of the route name (typically for HPMS if this occurs). Additionally, throughout a collection season, changes or corrections may be made to the routing file. When this occurs the routing file is first updated by office staff and it is then loaded into Vision before being uploaded to each of the two ARAN Vans.

# ARAN Van Preparations

Mike Longo working on draft……..

# ARAN Van Preventative Maintenance Maintenance

To ensure that the ARAN Vans are operating in peak condition for each collection season the Department schedules FUGRO Roadware Technical staff to perform onsite annual Preventative Maintenance (PM) on the ARAN Vans, typically in early April, prior to the beginning of the collection season. During the PM, field staff works alongside the FUGRO Roadware field technicians performing calibration of the ARAN systems and sensors. Once completed field collection tests are done on our calibration sites and data is compared to ground truth, between the vans and against historical information to confirm that quality and accurate data is being collected.

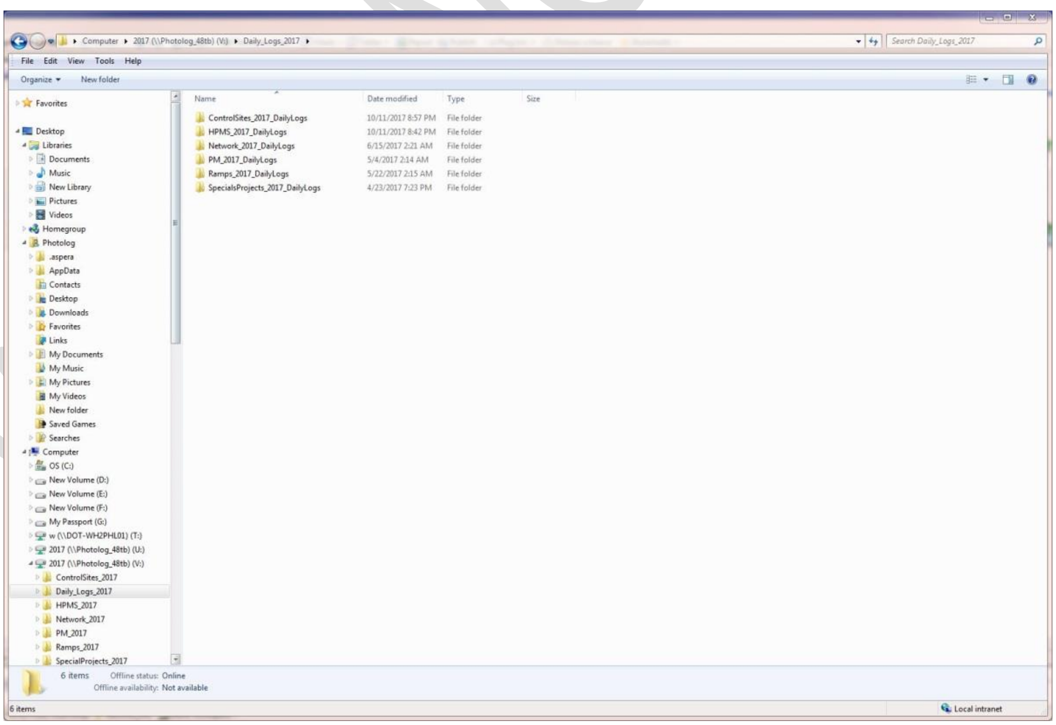
# Office Procedures

The Photolog Unit has two Vision Work Stations to process ARAN yearly collected state network, local HPMS routes, Specials, Ramps, Control Sites and Preventative Maintenance data. These data are stored in the databases on the PC WH2-PHL01 which is served as the SQL server. The Vision workstations are connected to the SQL server via a virtual Local Area Network (VLAN).

Vision is an integrated suite of modules which provides access to all data that is collected by ARAN. Vision is used to process and report the results, meanwhile to view and QA/QC the detailed source of each data item at all times.

Data collected on the ARAN is first imported into a processing database using the Data Control Software, and then accessed using Roadware Vision.

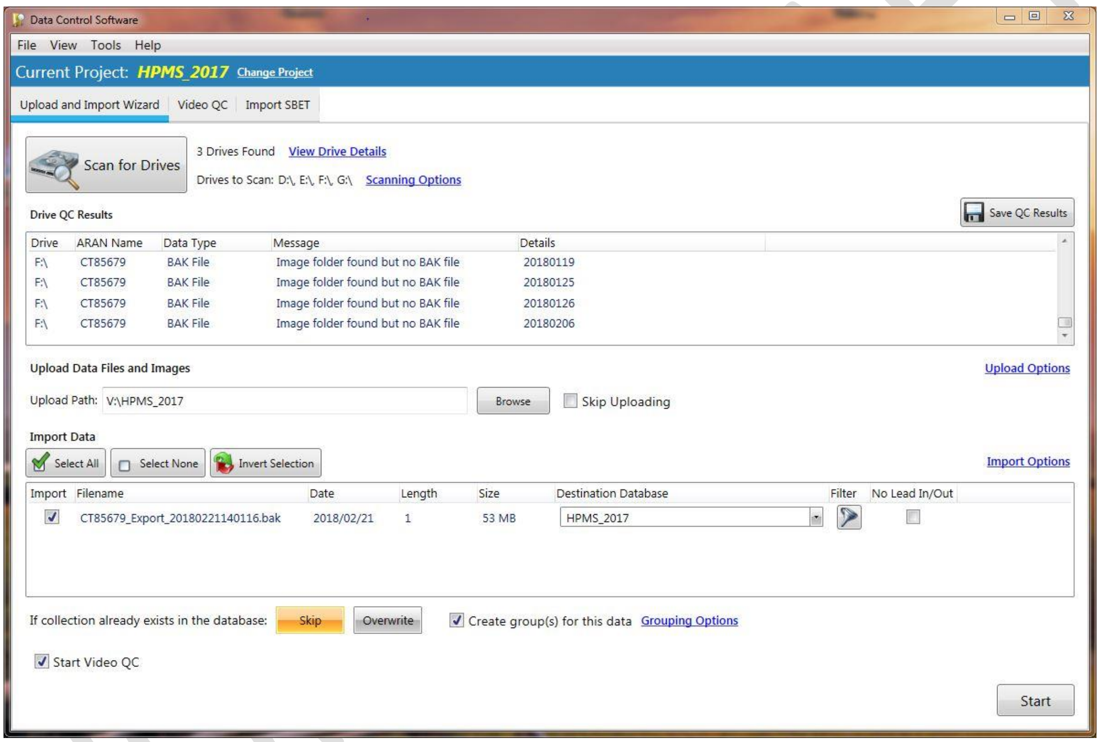
1. Both Vans should send the Daily Log Sheet after daily collection via E-mail. The Daily Log Sheet has each van's name and collection date as its file name. Set up separate folders for each Van under Project Daily logs folder on Photolog_48TB NAS drive. These files are referenced by both Photolog Unit and Pavement Management unit daily.



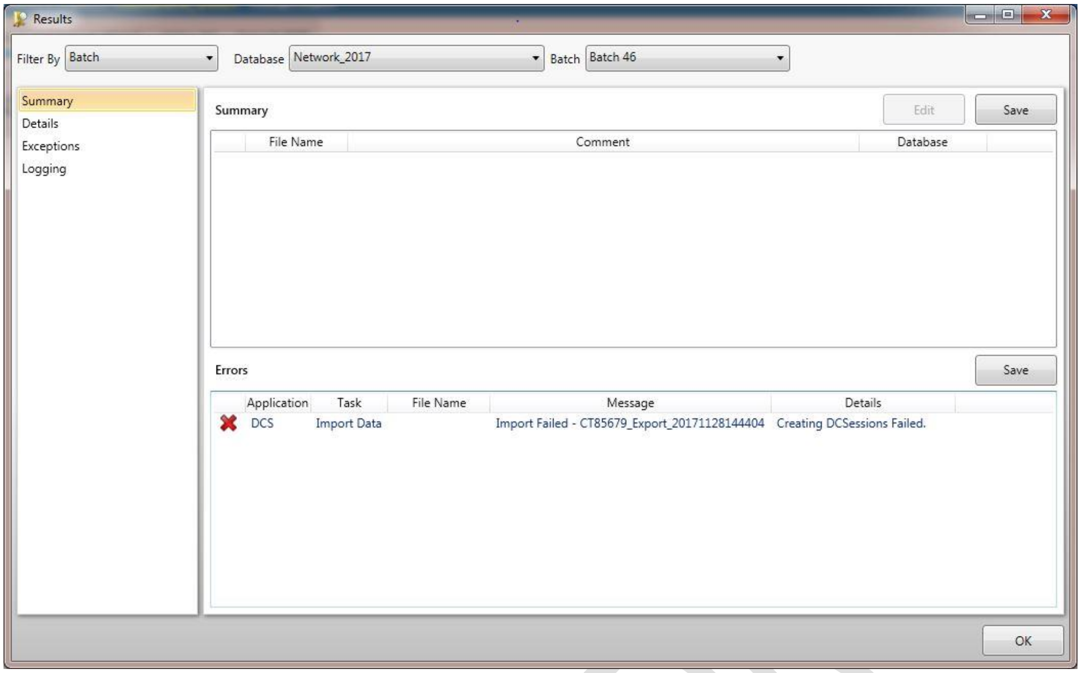
2. QA/QC daily collection by using the daily log sheet to make sure the collected routes and data elements are not missing, the collected items are within the acceptance range. Pay attention to the comments which reflect the real collection situation.

3. Every week Wednesday, upload V8 ARAN collected data into the specified database. Every Thursday, upload V9 ARAN collected data into the specified database (Refer to Vision User Manual P. 315).

    a. Use Auto Scan for ARAN Drives method to upload data without any system interruption.




    b. Assume the ARAN drives are re-formatted weekly before the new week's collection, upload all the database files using one set of the drives (3 top removable drives).
    c. Reference the daily log sheet. Filter out the 100% sure void sections for uploading.
    d. For the questionable sections, upload them into database for later decisions. The goal is to avoid missing any collected valuable data.
    e. The Status bars show the current step in the importation process.
    f. The upload process is completed when the Status Bar showing 100%. If not, the upload process will alert users with different errors including process, system, network, collection etc.

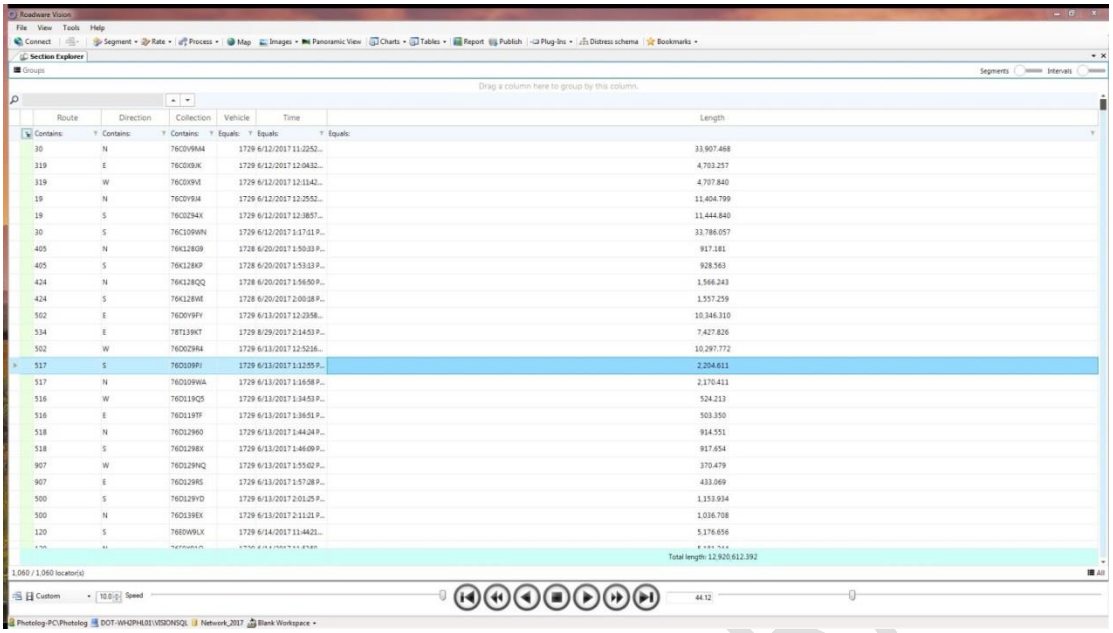



g. Perform Video QC on the data being imported. The QC will report any missing images or folders compared to what is expected in the database being merged. (Refer to Vision User Manual P322)
h. During the uploading QC process, if the ROW or FIS images are flagged missing, Photolog staff need to review the original ARAN drives to make sure the raw images are collected and saved on the drives. If necessary, use the backup (bottom) set. After making sure the data are not there, the correction actions need to be taken to re-export from the VAN or to recollect.

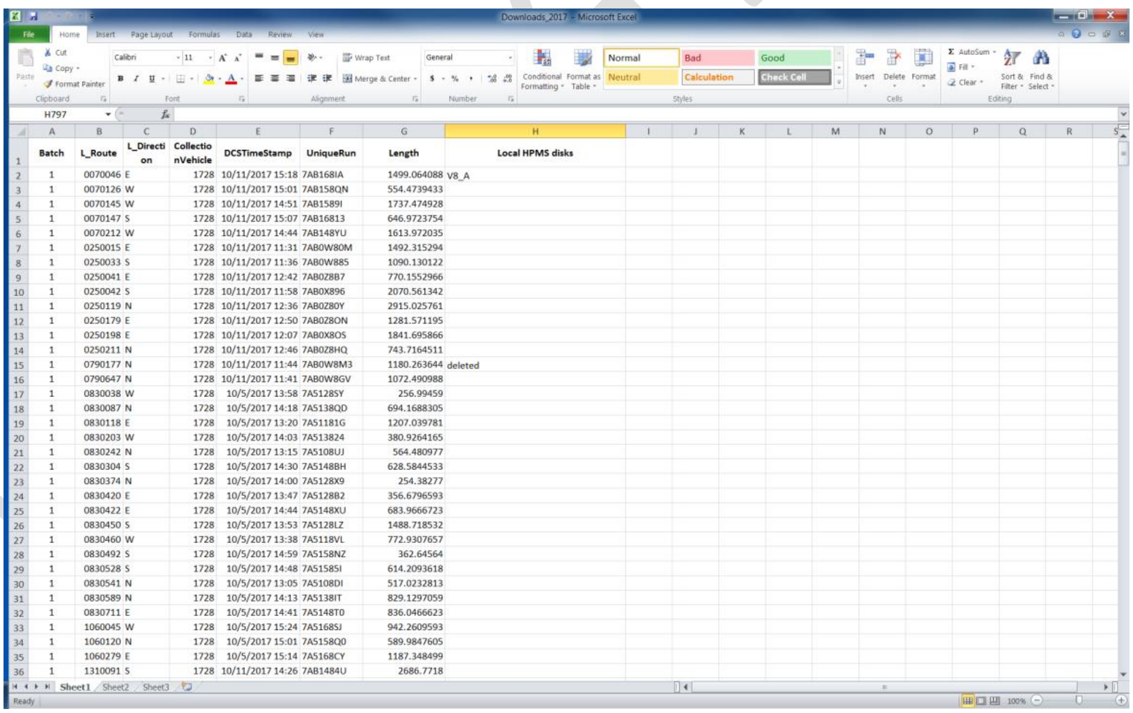
4. Segmenting data in Vision

Segmenting in Vision is a process where data collected by the ARAN is matched against the routing file that was imported before. This allows the data collected by the ARAN to be matched into the Department official length of a road. (Refer to Vision Training Guide 2.3.5 p61)

a. Select a project from Vision.
b. Navigate sections by locators, ARAN filename, Vans, collection time etc.



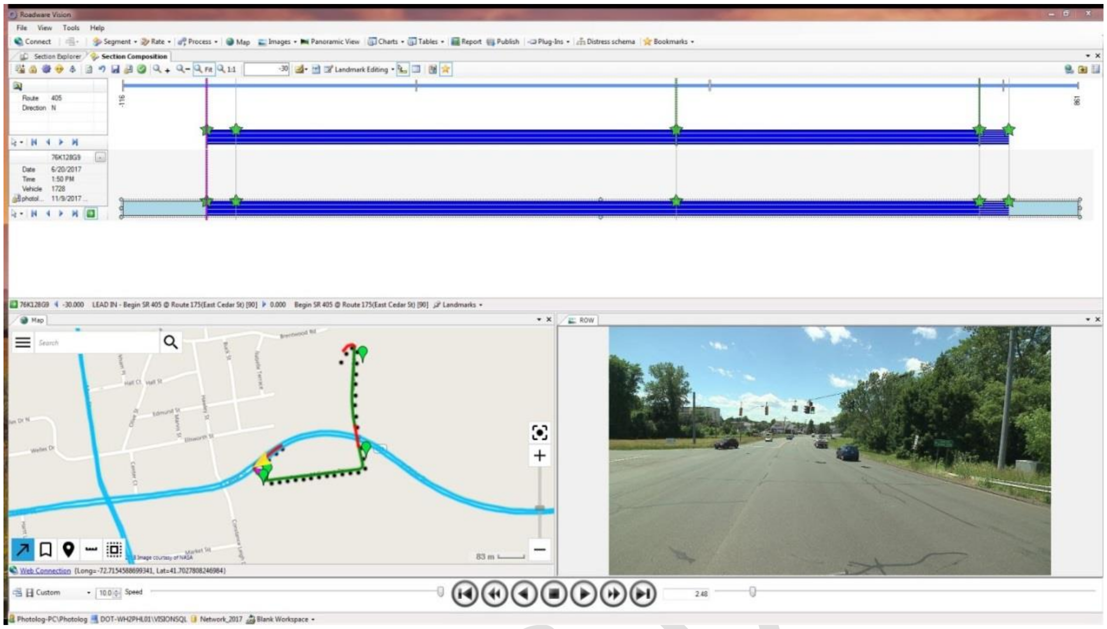
c. Select all the newly uploaded routes and saved to the upload file which is saved on Photolog_48TB NAS drive under each project to be shared by Photolog Unit and Pavement Unit.

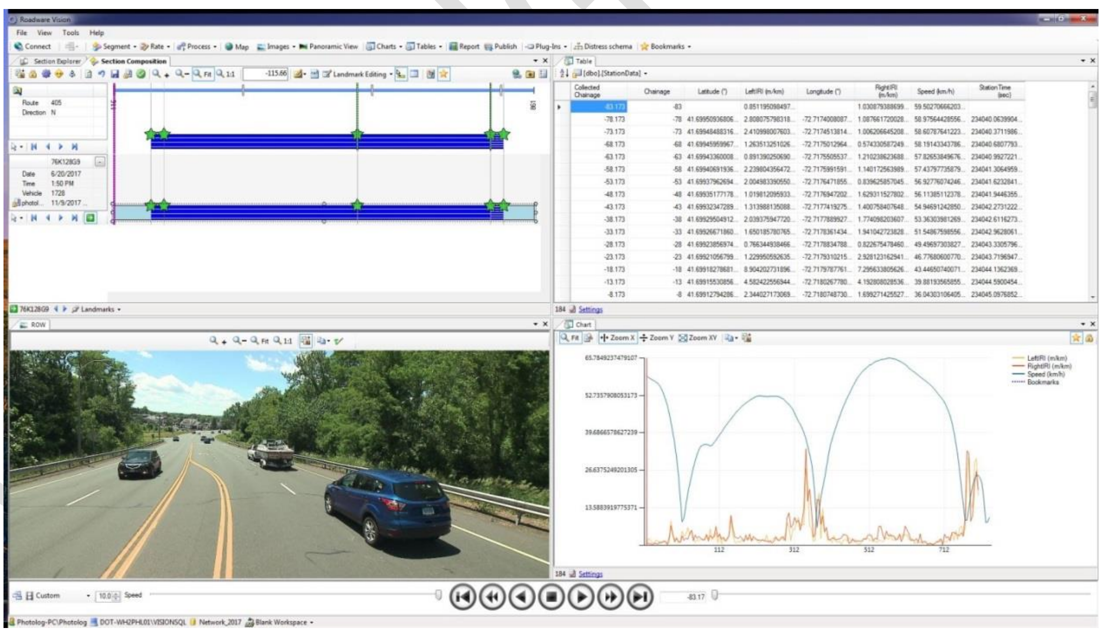


d. Perform auto matching in batches using Auto Segmentation Batch Processor.

e. Go back to each auto-matched route, manually QA/QC each route matching using the Section Composition.

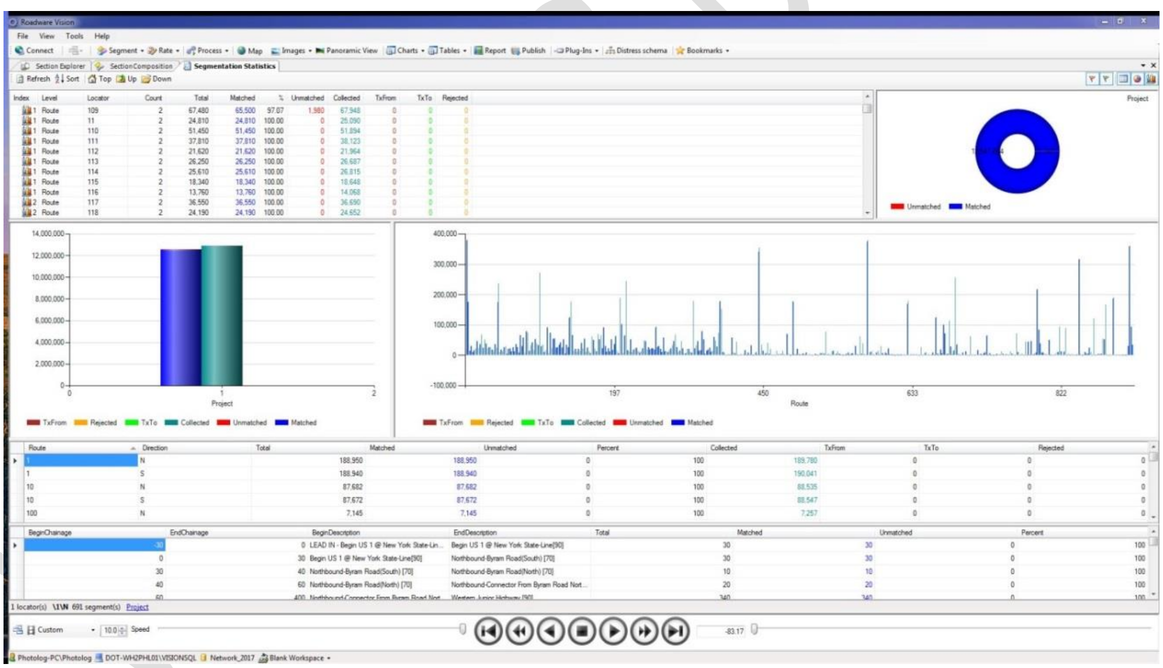
- QA/QC the completeness of the route, section. Use image stream, tables, charts to verify no missing data items, images (ROW, FIS).





- Check start and end boundaries for all road segments.
- Auto-matching is not always accurate and need to be deleted and manually re-matched.

- Verify GPS positions, landmark node etc. with the GIS map, webMap, Image Stream etc. and by the project protocol, by measurement and observation. If the chainage lengths, GPS positions, etc. differ, the landmark may need to be adjusted if it is deemed to be in the incorrect position,
- Sometimes the routing files are not accurate for some routes. The routing file for the specific route needs to be modified and re-imported into the Vision system to replace the existing routing file.
- Check for duplicate or absolutely not necessary sessions. Deletion of a particular session can be done in Vision but need extreme caution. After the delete of a session, the only way to get it back is to re-import the file in question from the ARAN drives.
- Save and check-in work.
- Use Segmentation Statistics to QC collection versus routed lengths as well as what has been segmented (matched) versus what is still remaining to segment (unmatched). (Refer to Vision User Manual, p301)




- Communicate with Pavement Management Engineers to inform them the successfully segmented routes for their further process.

5. Reporting Data

   Data can be reported after it has been segmented and processed. The reports generated are located in the SQL database.

6. QA/QC is implemented for global database and aggregated data using SQL databases, including:

   a. Data completeness
   b. No missing data or invalid NULL data
   c. Reasonable range of values
   d. Implement QA/QC of the monthly testing of control sites for both V8 and V9. Make sure the repeatability and reproductbility criteria are met.
   e. Comparison of different data items between different years.

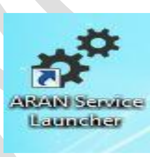
WORKING DRAFT

Routine Field Procedures

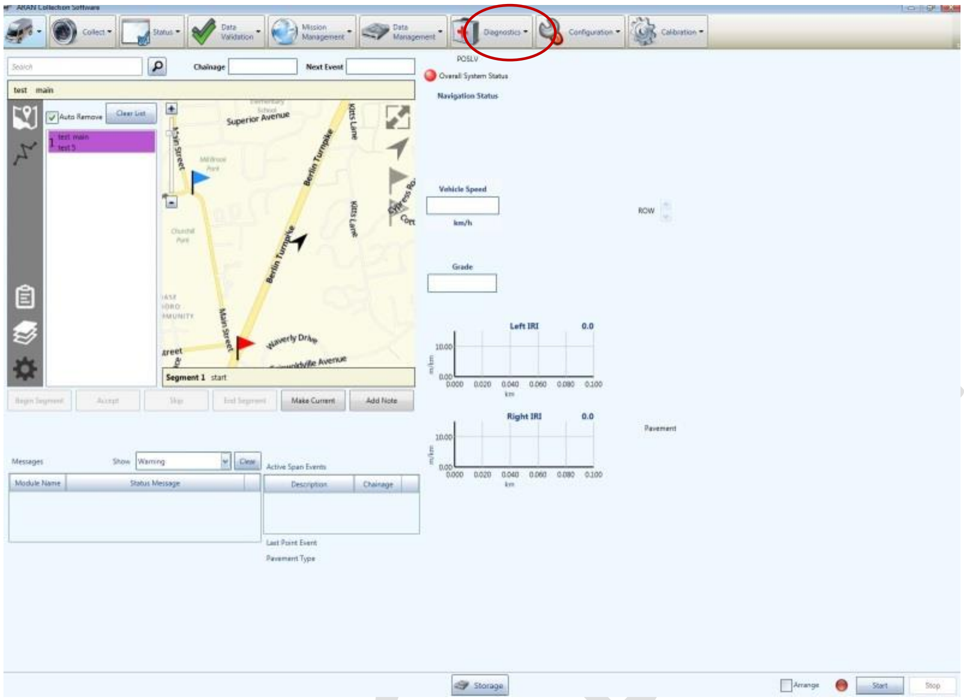
# Morning Setup

This section shall detail general instruction on the inspections and other procedures that must be following each morning as the vehicle is prepared for operation and collection of data.

1. Ensure ARAN Van is fueled up and ready for the day.
   ***(A list of available DOT fuel stations is included in the reference section of this document)***
2. The process of completing the daily Mechanical and Sub System Inspections checklists is the first step at the beginning of each day on the ARAN and must be completed every day the ARAN is to be driven whether for collection or not.
   a. Perform walk around the ARAN and make note of any damage. Pay close attention to DMI, Rut Bar and ROW enclosures rear pavement cameras or LCMS lasers. Also pay close attention to tire wear, suspension and steering problems. ***(A copy of the mechanical and Sub System Inspection checklist is included in the reference section of this document).***
   b. Start the vehicle and inspect wear on belts and listen for any unusual noises stemming from the engine compartment.
   c. Inspect and clean HD ROW capture window, grade sensors, IRI lasers and LCMS lasers.
   d. Check and adjust tire pressure as needed.
   e. Insert removable hard drives into ROW, Server and Pave computers if needed.
   f. Start Inverters and let computers boot up. Map & create network shares for hard drives if necessary.
   g. Start ARAN 9000 sub-systems, initiate ACS Launcher and bring up collection software.
   h. Double click Aran Service Launcher on desktop and click *start services* (ACS collection software automatically starts once all services are running).



i. Run ARAN 9000 system **Diagnostics** and check for any warnings or errors. ***Allow 15 min. idle time for GPS accuracy and computer communications***.

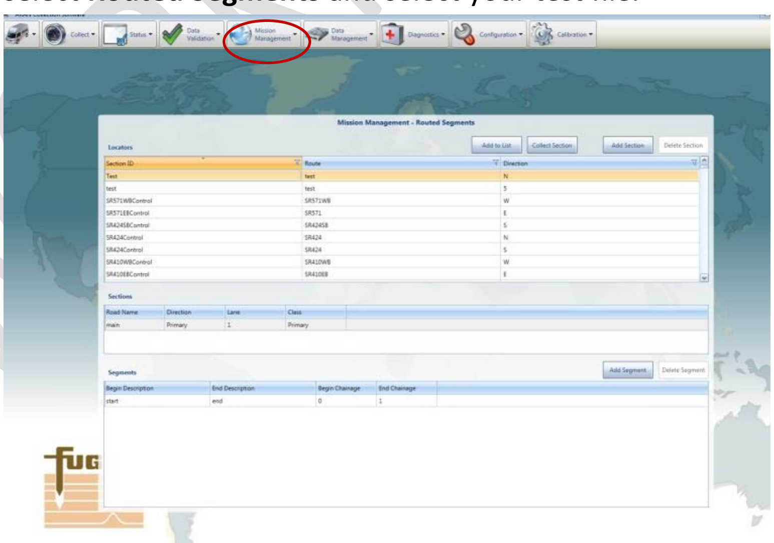



j. Run Dummy file and Review Data for any discrepancies. (See Procedure Below)

k. Transit to collection area and commence with planned daily collection.

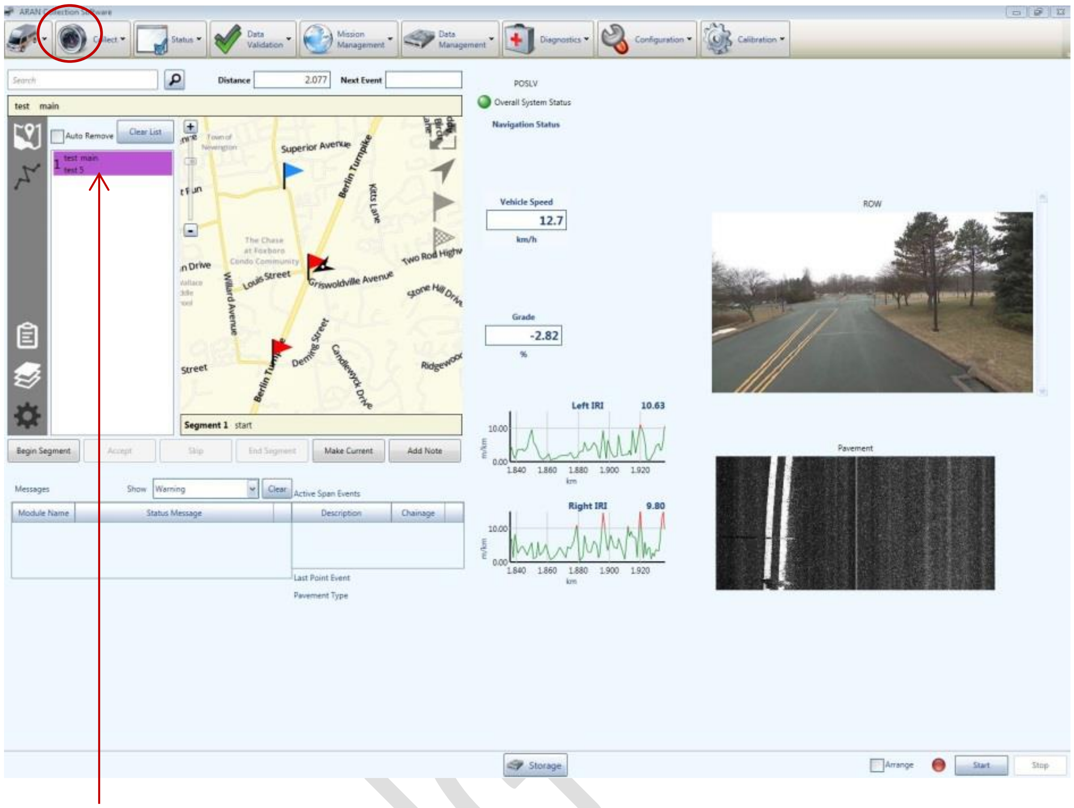
3. Run Dump File -

a. Load a test run for use as a dummy file. Click on **Mission Management** tab then select **Routed Segments** and select your test file.




b. Proceed to collect data.

c. Open the ***summary*** screen from the ***Collect*** tab in ACS software




c. Select a Section from the Routing table, and select Make Current (another option is to right click on the section of interest and select Make Current)

d. Click Start at least 100 m before the beginning of the Section for the system to initialize.

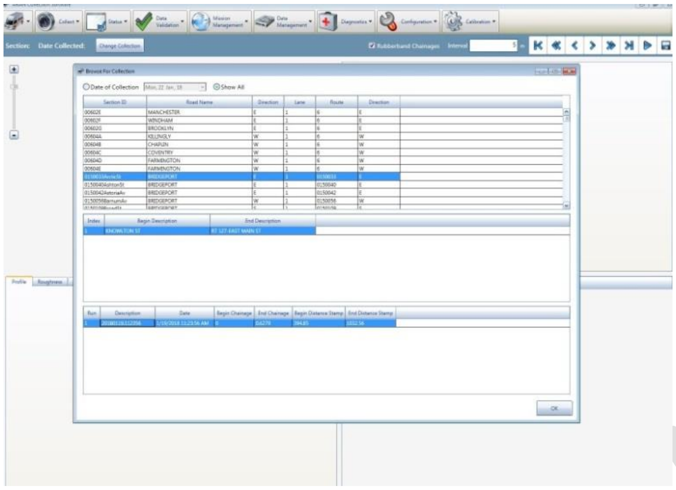
e. Click Begin Segment to mark the beginning of your segment.

f. Click End Segment to mark the end of the Section.

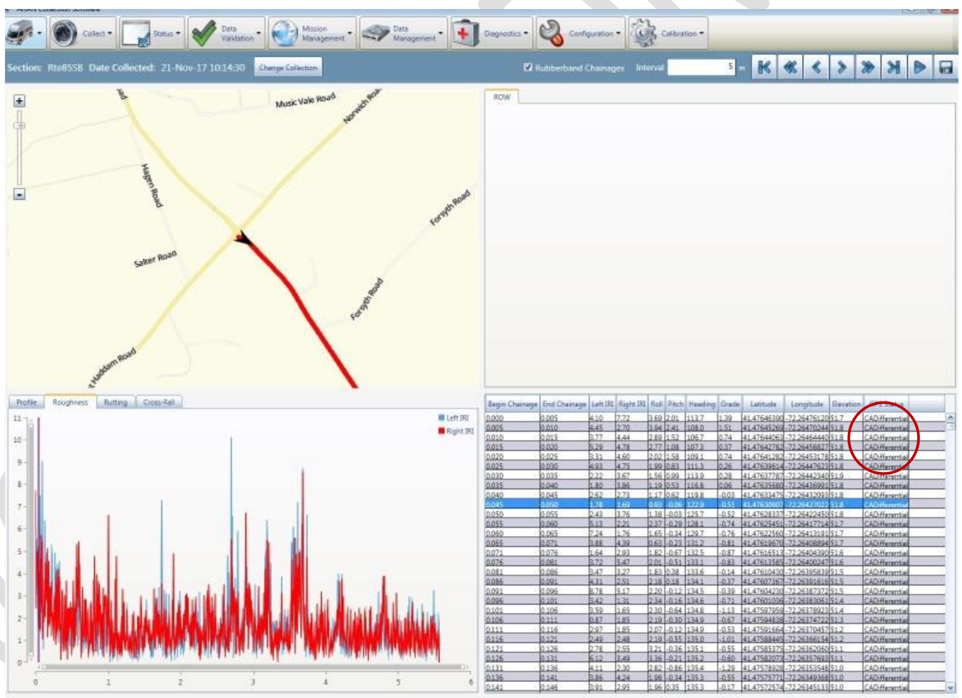
g. Click Stop to stop data collection.

h. Open Review data

i. Select collected file.



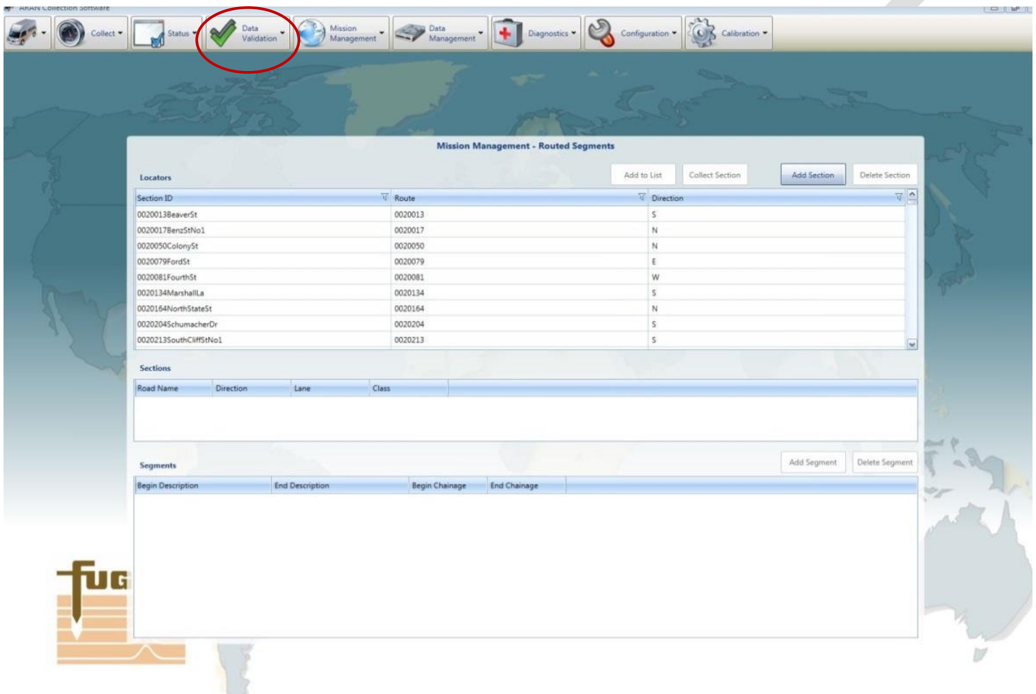
j. Make sure all columns have data and video is being recorded and the gps mode is in 'CADifferential' NOT 'SingleEnded'.



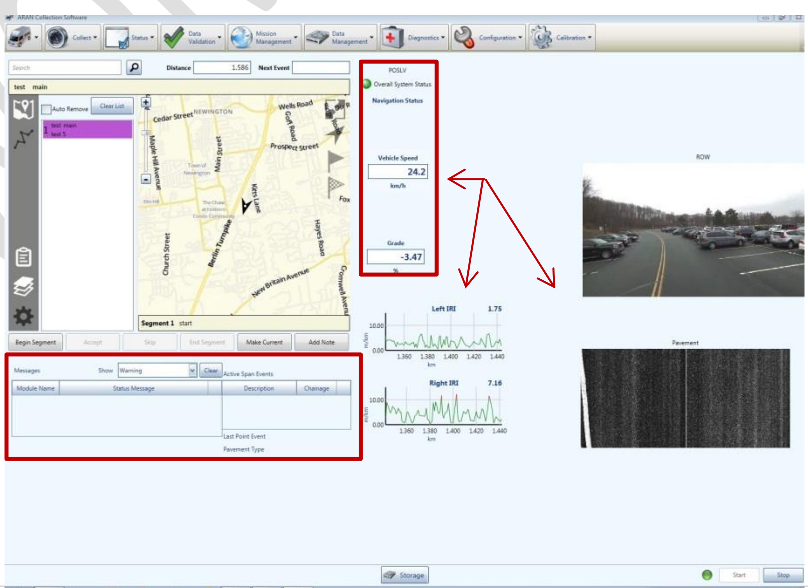

k. Transit to collection area. Check HD capture window for debris and clean if needed. Commence with planned daily collection.

# Daily Collection

1. Select routes for collection via ***Mission Management*** tab from ACS software and add to collection list. Proceed to ***Collect*** tab then select ***Summary*** option. Collection screen will be visible. Ensure that checkpoints for routing are in proper order (a glitch sometimes causes them to be scrambled).

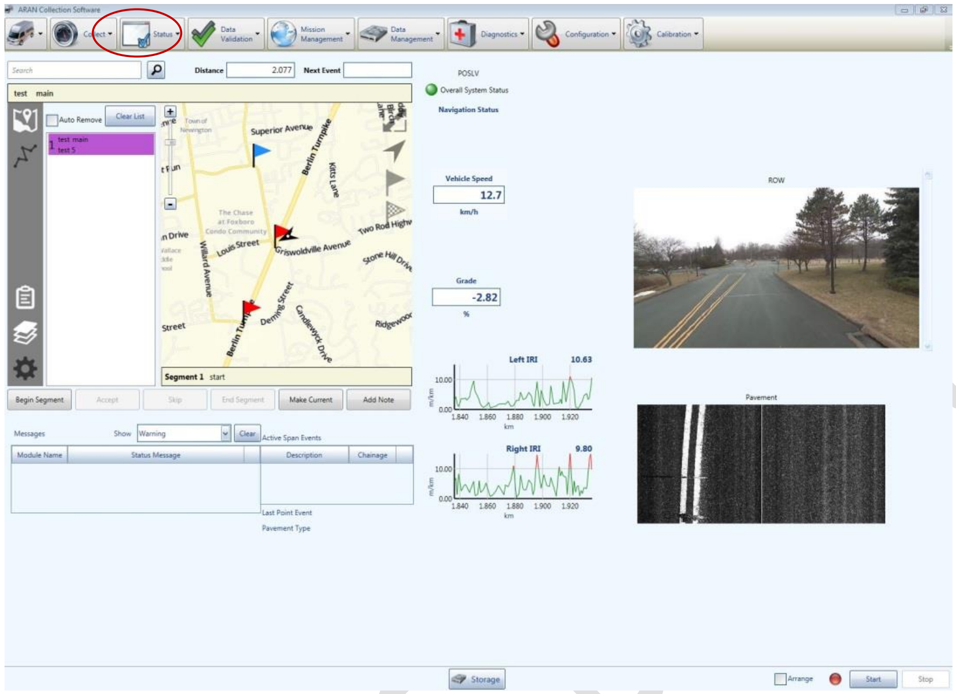



2. Start collection for the day.
    a. Operator monitors live data via ACS Summary screen for every collection. Check for ROW/Pave image, Left /Right IRI, POS, Grade, Speed and warnings/errors.

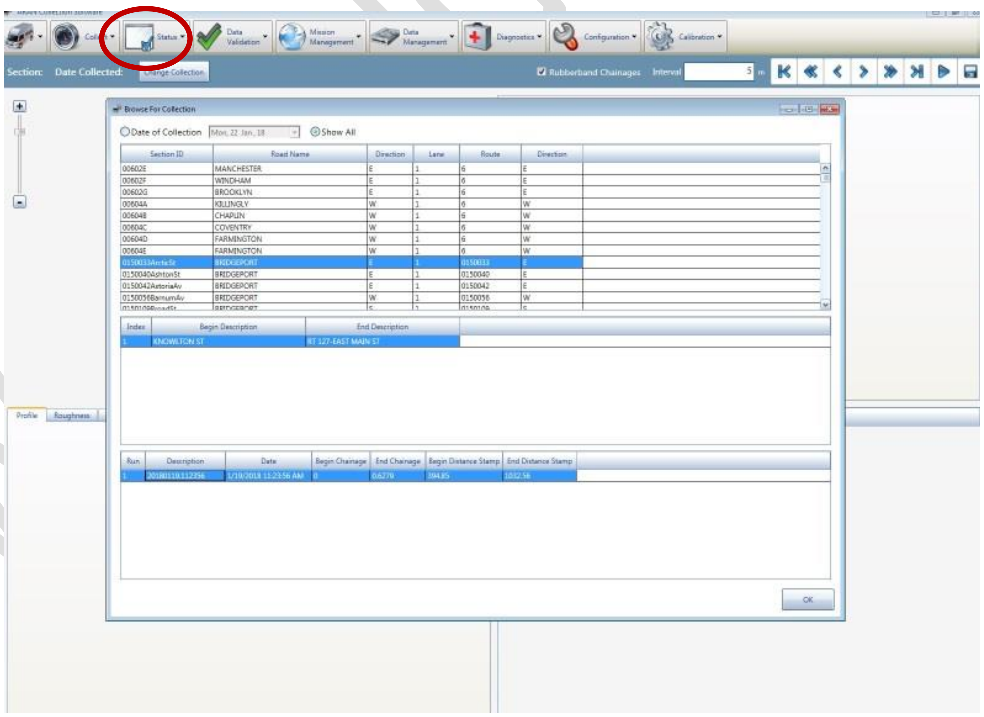


3. Data Validation

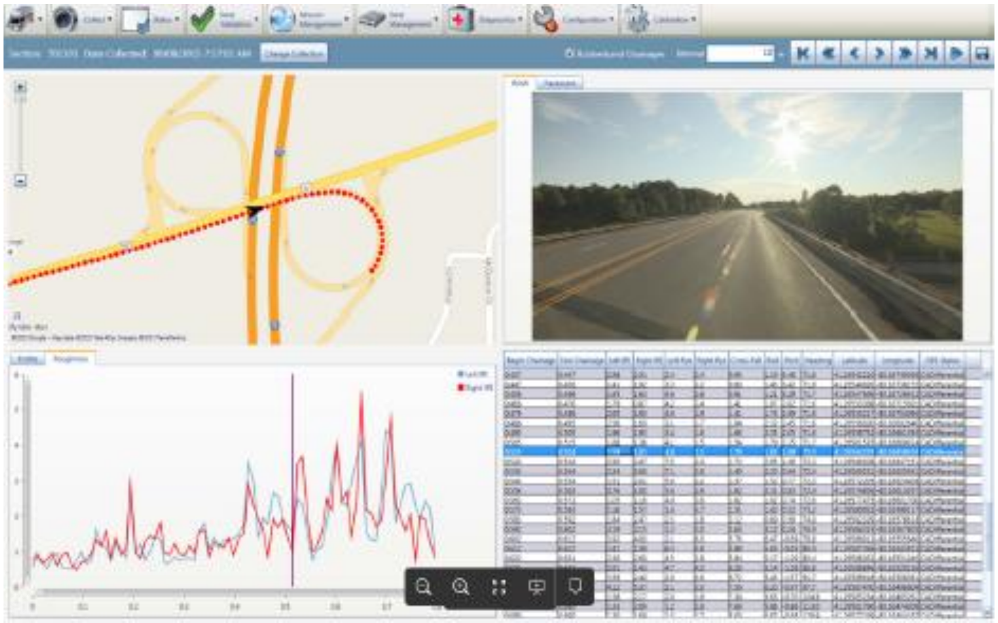
a. View all collected data by selecting the ***Data Validation*** tab on the ACS software.



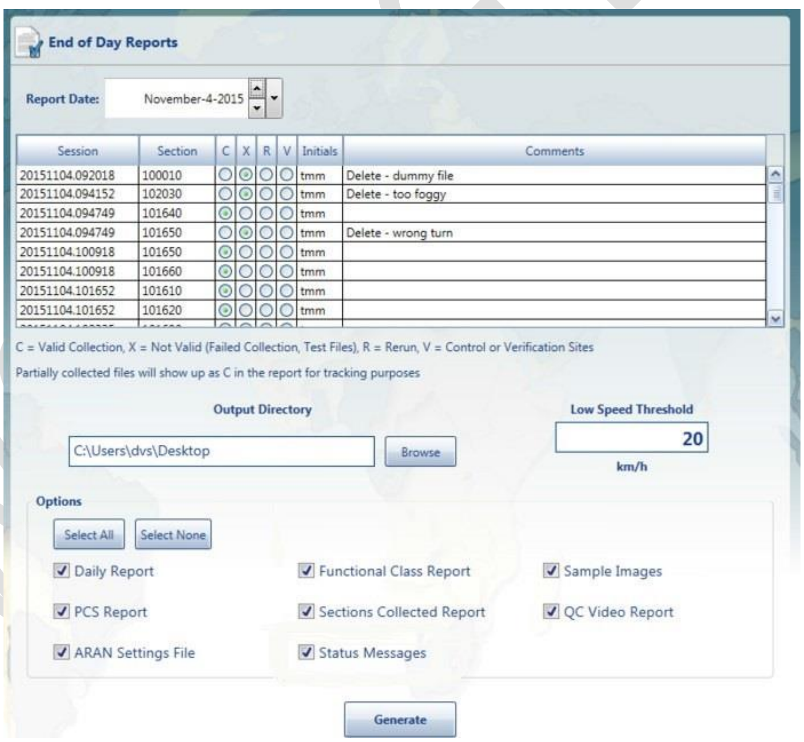

b. Open ***Review Data*** from ***Data Validation*** tab. Select file to view.



c. Review Data for any discrepancies



d. Create a daily report. Open ***End of Day Report*** from ***Data Validation*** tab.

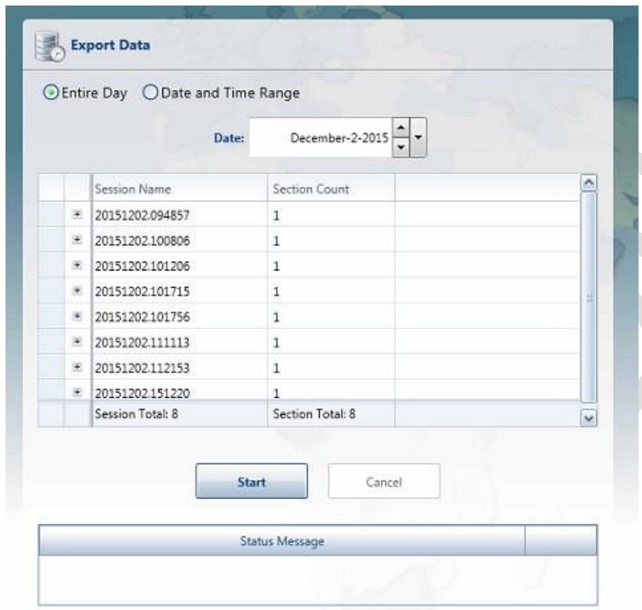



e. When data is not valid (e.g. dummy file, error, wet pavement) select ***X*** for appropriate run and provide comments. Other codes can also be used C (Valid

Collection) X (Not Valid), R (Rerun) and V (Verification Site). Comments can be added to valid runs also.

f. Daily update file is emailed back to the office.

4. Export data
    a. Collected data needs to get exported for the day.
    b. Open ***Data Management*** tab then select ***Export data.***
    c. Select the entire day option and click ***start.*** (A message box will appear when exporting is completed.)




    d. A message box will appear when exporting is completed.
    e. Click ***ok*** on the message box and Exit out of all software.
    f. Shut down all computers by selecting ***Shutdown All*** icon from the desktop.


Once all computers are powered off, the hard drives may be removed and brought into the office for data uploading and processing (Note: removal of hard drives for data uploading and processing occurs once a week.)

Resource Information

# Contact Information

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## Connecticut Department of Transportation Continued…

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# DOT Fueling Stations

*To be inserted here…..*

# Incident Report

*To be inserted here…..*