CONNECTICUT DEPARTMENT OF TRANSPORTATION

GUIDELINES for

ELECTRONIC ENGINEERING DATA (EED)

Version 1.1

JANUARY 2018

Table of Contents

Introduction

1.1 Purpose

This guide has been prepared to give direction to project design personnel associated with the Connecticut Department of Transportation (CTDOT) in accordance with The Directive for Electronic Engineering Data Delivery (Electronic Engineering Data Delivery, Phase 1 (ECD-2017-4)). The intent of this document is to provide standards and guidelines to promote consistent, uniform, and useable deliverables for CTDOT construction projects. It is not the intent of this guide to add unnecessary additional responsibilities to the designer, but rather to have the projects delivered in a consistent manner following best practices and industry standards used in the today's CAD environment.

1.2 Definition of EED

Electronic Engineering Data (EED) refers to the Computer Aided Design (CAD) files and the Digital Civil Engineering data files (from applications like OpenRoads and InRoads) that were used to create the pdf contact plans. These files include:

- Geospatially correct 2D project location polygon
- 2D and 3D geospatially located CAD files
  - MicroStation (DGN) Design Models
- InRoads Data
  - Coordinate geometry - Horizontal and Vertical alignments (ALG) files
  - Roadway Surfaces - InRoads digital terrain models (DTM) files
- OpenRoads Infrastructure Consensus Models (ICM) & i-Models
  - Coordinate geometry
  - Digital Terrain Models
  - Storm Drainage, Structure and Pipe Data – Subsurface Utility Engineering (SUE)

In the future, EED may contain additional information such as asset data (signs, signals, guiderail, etc.)

1.3 Implementation Phases

The requirements for EED will be implemented in three phases. A phased structure was developed to facilitate the transition of the Department into the 2D/3D modeling arena. This guide has been divided to detail the files submittal types for all phases. 2-6 and Table 2 outline Data Requirements based on the Project type for each phase of implementation.

1.3.1 Phase 1

Phase 1 will focus on the practice of submitting proposed MicroStation 2D CAD, InRoads geometry files and a 2D project location polygon. These files are to be free of any extraneous data and match the contract plans. All projects designed using InRoads SS2 will follow the data requirement in Section 4 Phase 1 Requirerments.

1.3.2 Phase 2

Phase 2 will add the submission of curb to curb 3D roadway top surfaces using the Department's current modeling software, InRoads SS2. These projects are designed in-house on the internal network or by consultants on an external network. All projects designed using InRoads SS2 will follow the data requirements in Section 5 Phase 2 Requirements. Design submissions in this phase will require (at minimum) the 2D models to be complete from curb to curb for the entire project, along with the Phase 1 requirements.

1.3.3 Phase 3

Phase 3 will change the data delivery files type using OpenRoads technology (InRoads SS4 and beyond). In the upcoming years all new roadway projects designed at CTDOT will require the use of OpenRoads Technology. All projects designed using this technology will follow the data requirement in Section 6 Phase 3 Requirements. For these future projects 3D models will include finished (or "top") design surface and any subgrade excavation surfaces within the grading limits for the entire project. Phase 3 will also include Phase 1 requirements.

1.4 Why and When Should a 2D/3D Model be Developed?

Nationally the civil industry is quickly recognizing business improvements and lower costs by changing field operations to incorporate the use of EED. One of these practices is the utilization of 2D/3D modeling for the development of model based digital design data.

The concept of model centric design, and the generation of digital design data for use in construction, involves the following key steps:

1. Collection and development of geospatially located survey data for an accurate existing conditions model to be used for design, and also to be delivered for use in bidding on the project.
2. Utilization of the survey model in design, with design software capable of 3D model output.
3. Proposed output from design of critical digital deliverables for use in bidding, construction and inspection purposes on the project.
4. Utilization of digital deliverables in constructing the project in an automated fashion.

5. Field collection of as-constructed and inspection measurements and observations using modern positioning technology, relative to the engineered model data.
6. Archiving and preservation of digital model data for future use, including asset management.

FHWA has promoted the adoption of this technology through their Every Day Counts 2 and 3 initiatives. According to FHWA, "Three-dimensional (3D) modeling in transportation construction is a mature technology that serves as the building block for the modern-day digital jobsite. The technology allows for faster, more accurate and more efficient planning and construction."

For more information on please visit the U.S. Department of Transportation, Federal Highway Administration, EDC2 Website titled 3D Engineered Models website at:

https://www.fhwa.dot.gov/construction/3d/about.cfm

Digital 3D models of a highway project can convey a greater level of design intent than a 2D model; therefore, design projects should be developed in 3D when it is practical to do so. Basically, if the designer is using surfaces (existing and proposed) to develop contract plans, then a 3D model shall be delivered. The following are guidelines to help determine projects in which 3D models may be beneficial.

- Cross sections will be included in the final plan set.
- Reconstruction is proposed within the project limits. If the reconstruction is only a component of the overall project (e.g., mill and overlay scope of work with a section of reconstruction) only the reconstruction area should be designed in 3D unless an accurate surface was obtained of the entire project.
- Major roadway rehabilitation (structural enhancements that both extend the service life of an existing pavement and/or improve its load-carrying capability).
- Complex storm water and drainage in order to check for clearances under roadway subbase and clash detection (i.e. utility conflicts).
- Intersections
- Subsurface utility information that is field located.

Section 2. Project Types & Phases

This section defines the types of projects that EED will be delivered, along with the contract plans, at FDP.

Project Type 1 – No Earth Work 2D Projects
Bridge Deck/Superstructure Replacement
Bridge Restoration/Rehabilitation
Bridge Substructure/Superstructure Repairs
Concrete Barrier Rail
Drainage - Minor
Facility Rehabilitation
Fixed Objects Modification
Grade Crossing - Minor Improvement
Guiderail Improvements
Illumination
Intelligent Trans Systems
Landscaping
Maintenance
Noise Barriers
Resurfacing By Contract
Roadside Safety Improvements
Traffic - Paint & Epoxy Pavement Markings
Traffic - Signal Installation
Traffic - Signal System Improvement
Traffic - Signing
Transit
Utility Projects

Project Type 2 – Site Earth Work 3D Site Projects
Bicycle/Pedestrian Facility (Multiuse Trails)
Bridge Replacement W/Realignment Of Approaches
Drainage - Major
Facility Construction (Site Work)
Hazardous Waste Removal
Retaining Walls/Slope Stabilization
Wetland Replacement/Restoration

Project Type 3 – Roadway Earth Work 3D Roadway Projects
Grade Crossing - Major Improvement
Intersection Improvement - Minor
Intersection Realignment
New Interchange
Operational Lane
Realignment
Widening - Major (4r Projects)
Widening (3r Projects) - Minor

Table 1. Delivery Requirements of EED for Different Project Types

		Project Type 1 No Earth Work			Project Type 2 Site Earth Work			Project Type 3 Roadway Earth Work		
		Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
CAD Files	Proposed MicroStation File	R	R	R	R	R	R	R	R	R
	Existing Ground MicroStation File	D	D	D	D	D	D	R	R	R
InRoads Files	Geometry ALG File	D	D		D	D	D	R	R	
	Top Surface Curb to Curb DTM File					D			R	
	Substructure Surface DTM File					D			D	
	Existing Surface DTM File					D			R	
OpenRoads Files	Geometry Data			D			D			R
	Top Surface Data Terrain						R			R
	Subsurface Data Terrain						R			R
	OpenRoads Terrain						R			R
	Existing Surface Data Terrain						D			R
	Storm Drainage Data SUE						D			R

R = Required
D = Discretionary (Required if used during design)

Table 2. EED Requirements for each Phase of Implementation

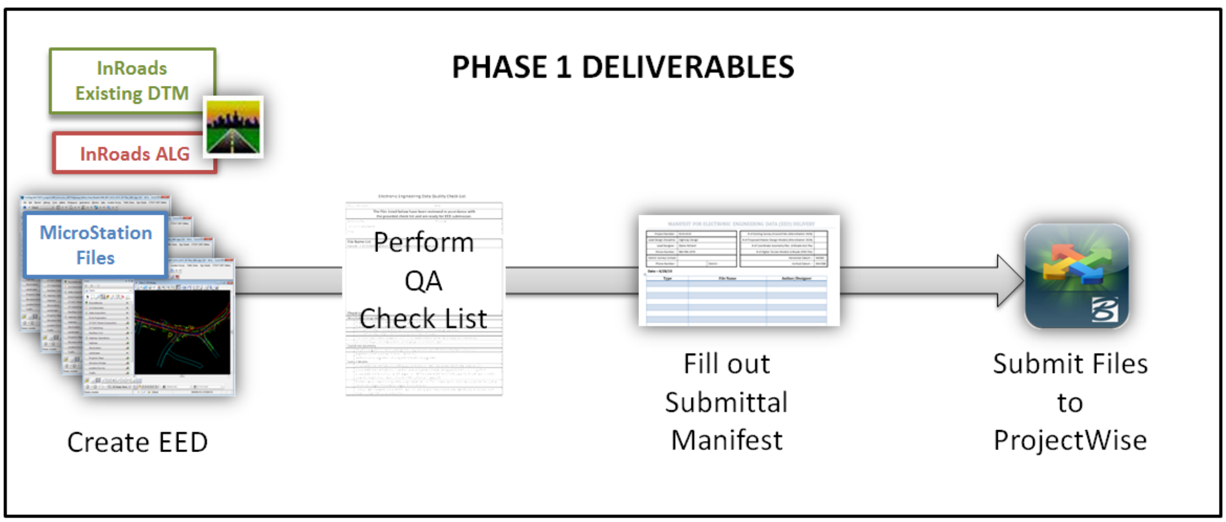
Section 3. Contract Plans and EED Conflicts

In all cases the EED will be issued as "For Information Only" purposes and the contract plans shall govern. An EED Notice to Contractor (0.055_NTC_EED_ELECTRONIC_ENGINEERING_DATA.DOC) will be issued with each contract informing the potential users of this information as such.

Section 4. Phase 1 Requirermentsnotify

Note: Also see Appendix IEED Phase 1 Quick Start

Phase 1 will require the delivery of MicroStation 2D CAD models, InRoads alignments and existing ground surfaces. CTDOT uses Bentley software products for all their computer aided design needs, with MicroStation (.dgn format) being the foundation to all computer modeling. Therefore it is critical that MicroStation EED files be submitted to the CTDOT and conforms to the criteria outlined in this section.



4.1 Existing Survey

4.1.1 3D Ground Model(s) (.dgn)link

- All elements shall be placed using CTDOT's customized MicroStation Task Manager or be generated by InRoads Survey Tools. This will ensure that all CAD graphics have the correct attributes (color, weight, line style, level).
- Must be compatible with CTDOT's current SELECTSeries DDE.
- Elements must be placed in real world modified state plane coordinates (see Section 3.0 of CTDOT's Location Survey Manual, June 1997) and be geospatially correct

- Only one design model per dgn file; no drawing or sheet models are to be used

All elements representing existing topography features shall be drawn according to the current CTDOT Survey standards; CTDOT's Location Survey Manual, June 1997. These MicroStation file(s) shall contain a single 3D design model including both 3D and 2D elements of the existing survey. 2D elements included but are not limited to ROW lines and control lines. 3D element includes tangible elements such as edges of pavement, shoulders, curbs, gutters, sidewalks and retaining walls.

4.1.2 Existing Survey Surface File (.dtm)

Existing Digital Terrain Models represent existing ground conditions at the time that surveying data was collected. This original ground DTM represents the undisturbed ground surface prior to construction. There may be several existing DTM's depending on the length of the project and the number of project site locations. The existing surface dtm will adhere to the specifications outlined in CTDOT's Location Survey Manual, June 1997.

See 5.4 Digital Terrain Models (DTM)

4.2 Proposed Master Design Models (.dgn)

CTDOT uses Bentley software products for all their computer aided design needs, with MicroStation (.dgn format) being the foundation to all computer modeling. Therefore it is critical that MicroStation EED files be submitted to the CTDOT and conforms to the following criteria:

- All elements shall be placed using CTDOT's customized MicroStation Task Manager or be generated by InRoads using the CTDOT preference files. This will ensure that all CAD graphics have the correct attributes (color, weight, line style, level) and follow CTDOT's CAD standards.
- Must be compatible with CTDOT's current SELECTSeries DDE.
- Elements must be placed in real world modified state plane coordinates and be geospatially correct
- If a 3D model is developed during design, it should be exported to a 2D model. Any 2D files generated from a 3D file must be in direct correlation to the 3D parent file.
- Only one design model per dgn file; no drawing or sheet models are to be used

4.2.1 Proposed Master Highway Models

This 2D Design Model DGN will include geometric line work such as centerlines, and proposed right of way lines. This file will also include right of way dimensions, roadway dimensions and centerline annotation. All features that are to be quantified shall be included in this file (i.e. guide rail, fences, etc.).

Level of Detail
Patterned Riprap Channels
Patterned Riprap Slopes
Patterned Pavement Removal
Patterned Milling
Erosion control Matting for Channels
Erosion control Matting for Slopes
Processed Aggregate
Pavement for Railing
Sodding
Turf Establishment
Project Polygon

Table 3. LOD Proposed Master Highway Model for Areas

Level of Detail
Sedimentation Control Fences
Cut limit
Fill limit
Fence
Front face of landscape wall
Single PCBC
Double PCPC
Temporary PCBC
Cut Pavement
Parking lot
Driveway
ROW – graphical representation of an InRoads alignment.
Centerline and Baseline – graphical representation of an InRoads alignment.

Guide Rail –The end anchor should be placed in the correct location. The smart line is to be offset from EOR so it can be graphically seen (Connecticut Standard Details for placement will supersede plan placement).

Table 4. LOD Proposed Master Highway Model for 2D Smartlines

4.2.2 Proposed Master Structure/Bridge Models

The lead structural designer shall submit to the CTDOT a single 2D design model, per site and project, in a single 2D DGN file for every project that contains a new footing (including new box culverts). Each 2D design model shall include all components associated to the particular site and project.
The single 2D DGN file and its corresponding model shall conform to the following formats and include the following components:

- All components must be referenced into a single model
- Elements shall be placed using CTDOT's customized MicroStation Task Manager.
- Components modeled in MicroStation shall be Feature Model Elements.
- All elements shall be geospatially correct.
- All elements shall be placed at 1:1 scale.

The master structural model shall include but not be limited to the following components:

Level of Detail
Structure excavation earth and rock
Pervious structure back fill
Granular fill

Table 5. - LOD Structure Elements Earth

4.2.3 Proposed Master Environmental Compliance Models

The master landscape model shall include a single DGN file with one 2D design model per file, per location, per project. All features that are to be quantified shall be included in this model.

4.2.4 Proposed Master Traffic Models

The master traffic model shall include one 2D design model per site. This model shall include all items that are to be quantified.

4.2.5 Proposed Master Miscellaneous Models

These models could be but not limited to staging plans and or other disciplines not listed above that have items to quantify.

4.3 Coordinate Geometry Files (.ALG)

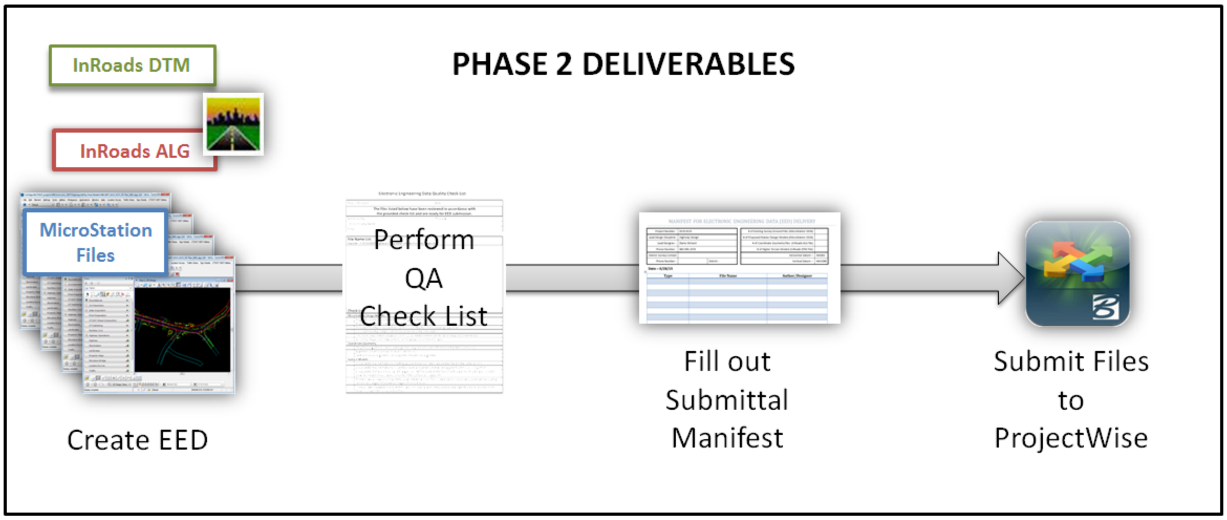
If used, an InRoads (.alg) file shall be submitted per discipline. Submit only final alignments. Do not include preliminary or alternates information). The .ALG files shall:

- All centerline and baseline horizontals with a maximum of one vertical geometry alignment per horizontal alignment (including structures).
- All geometry contained in these file shall have names representative of the designed alignments and features found in the plans (Centerline = Route_84_ Eastbound).
- All coordinate geometry information must be provided in the native InRoads (*.alg) format.
- Engineering discretion shall be used in determining which geometry elements shall be displayed in the master highway model.
- Alignments shall follow the specifications outlined in CTDOT's Location Survey Manual, June 1997.

Level of Detail
Horizontal alignments for all roadway centerlines/baselines
Type 2 Projects only - Vertical alignments for all roadway centerlines/baselines
Horizontal alignments for all proposed ROW
Special alignments used for drainage purposes, skewed driveways or stage construction
Alignments used for design features such as edge of roads, sidewalks & retaining walls
Structure centerlines of bearings
Structure centerlines of girders

Table 6. LOD ALG Files

Section 5. Phase 2 Requirements



5.1 Existing Survey Ground File(s) (.dgn)

See Section 4.1.1 3D Ground Model(s) (.dgn)

5.2 Proposed Master Design Files (.dgn)

See Section 4.2 Proposed Master Design Models (.dgn)

5.3 Coordinate Geometry Files (.ALG)

See Section 4.3 Coordinate Geometry Files (.ALG)

5.4 Digital Terrain Models (DTM)

A Digital Terrain Model (DTM) is a three-dimensional topographic model which mathematically and graphically represents the existing and proposed surfaces. It consists of a triangulated surface with features. A feature is a named set of points in a Digital Terrain Model (DTM). There are five feature types which define the structure of the feature and controls how it affects the triangulated model. Each of these feature types has a feature style or styles, which controls how they are displayed.

- Random - “spot” points which have no direct relationship with other points
- Breakline - groups of points with a direct linear relationship
- Exterior - Surface boundary extent; closed and only one per surface
- Interior - defines undefined areas; closed and no limit to number
- Contour - groups of points with a direct linear relationship and same elevation

Any DTM used to generate final contract plans must be submitted. For Phase 1 Type 2 projects this will include all surfaces curb to curb for the entire project. These projects would also be the type which in most situations will require the inclusion of Item 9.80 Construction Staking. Files must meet the following criteria to be submitted with the EDD for CTDOT projects:

- InRoads uses DTM data to produce contours, display the existing and proposed ground lines in profile and cross section grids, and in the calculation of cut and fill quantities. Supplied surface files must be in the native InRoads .dtm format.
- Project model deliverables shall include at a minimum, two proposed DTMs and an existing DTM. One proposed surface shall be a finished grade DTM, and the other shall be a top of subgrade DTM. It is important to note that the subgrade data is available with the top surface DTM but when the top surface gets exported using LAND XML for use with AMG technology the subgrade data gets automatically dropped. For this reason a separate subgrade surface needs to be delivered.

Level of Detail
3D design has no overlaps of breaklines or visual inconsistencies of features.
Surface features are continuous over their entire length, not broken into multiple pieces.
2D contract plans match the surface models.
No vertical faces are present (all vertical surfaces are to be offset a minimum of 1/12 in – 1/8 in to be accepted into the AMG software).
Accuracy clash detection, spot check x, y and z coordinates.

Table 7. Level of Detail DTM FILES

5.4.1 Existing

Existing Digital Terrain Models represent existing ground conditions at the time that surveying data was collected. This original ground DTM represents the undisturbed ground surface prior to construction. There may be several existing DTM's depending on the length of the project and the number of project site locations.

5.4.2 Design

Proposed Digital Terrain Models represent the project design as generated by InRoads using the horizontal alignments, vertical alignments, templates, roadway definitions and surfaced editing tools.

A top surface for each corridor will need to be created representing at minimum the proposed finished grade **curb to curb** as part of the design data deliverables. All proposed DTM surfaces shall be defined by a breakline density interval (frequency of cutting templates) of no more than five feet, and at every event location. In tightly constrained or critical drainage areas, or on the outside of sharp horizontal curves, the break line interval may need to be reduced to two feet or less.

5.4.3 Substratum

All files created to represent the approximate Substratum surfaces will also need to be supplied. Substratum surfaces are used to represent assumed existing subsurface layers, such as rock, sand, clay etc.

5.4.4 Subgrade (Structure)

If underground structures are involved multiple subgrade surfaces will need to be generated to include all bottoms of footings, granular fill, box culverts, piers, walls, abutments, sign supports and bottom of excavation.

5.4.5 Proposed Master Storm Drainage Models

The Storm Drainage Model DGN file will be either 3D using InRoads Storm and Sanitary or 2D using StormCAD. The master Storm Drainage Models shall include but not be limited to the following:

Level of Detail
Pipes – Double line representing the inside Diameter at invert elevations
Culvert ends – 2D cell placed at invert elevations
Endwalls, Riprap Splash Pads and Scour Holes – 2D shape at invert elevation
Catch Basins – 2D cell placed at top of grate elevation
Paved Apron– 2D shape at grate elevation
Manhole – 2D cell placed at top of frame elevation

Table 8. LOD Storm Drainage using Storm and Sanitary

Level of Detail
Pipes – Double line representing the inside Diameter at elevation 0
Culvert ends – 2D cell placed at elevation 0
Endwalls, Riprap Splash Pads and Scour Holes – 2D shape at elevation 0
Catch Basins & Structures – 2D cell placed at elevation 0
Paved Apron– 2D shape at elevation 0
Manhole – 2D cell placed at top of elevation 0

Table 9. LOD Storm Drainage using StormCAD

Section 6. Phase 3 Requirements

6.1 Overview Phase 3

Phase 3 will consist of delivering a full 3D model of the entire project, slope limit to slope limit. This will be accomplished using Bentley's OpenRoads Designer (ORD). This software allows the designer to create a 3D model much more easily than the current production software, InRoads Select Series 2.

The deliverables for Phase 3 will just be the MicroStation dgn file itself. All of the engineering data is written to the dgn including the coordinate geometry, surfaces, and CAD line work. The dgn is simply saved as an i-Model which can be consumed by the GPS field equipment directly with no conversions necessary.

Bentley is currently developing the production version. After the release of ORD and testing, CTDOT will be adopting ORD as the production software sometime later this year.

6.1.1 Existing Survey Ground File

Details coming soon

6.1.2 Proposed Master Design Files

Details coming soon

6.1.3 Coordinate Geometry Files

Details coming soon

6.1.4 Integrated Civil Models

Details coming soon

Section 7. Submission Procedures

7.1 Submission Dates

All required EED documents shall be delivered:

- At FDP
- At award of Contract (includes all addenda)
- After design initiated change orders, that the lead design deems necessary to supply to the contractor.

7.2 EED Delivery Manifest

The EED delivery manifest must be delivered to the CTDOT with every EED submittal. A blank copy can be found by clicking on the following link: EED File Manifest. This form will include general project information; the datum used for the ground survey; file names and specific information about each EED file being submitted. The contact information for the lead designer and lead surveyor must also be provided. For a sample manifest see EED File Manifest Example.

7.2.1 ProjectWise File Location

Each discipline will upload their EED files to the *01.0 - Projects - Active\XXXX-XXXX\240_Contract_Development* folder where XXXX-XXXX is the project number.

For uploading documents to ProjectWise see Section 6 of

7.2.2 EED Notice to Contractor (NTC)

The Notice to Contractor (0.055_NTC_EED_ELECTRONIC_ENGINEERING_DATA.DOC) must be filled out by the lead designer with the correct project number in the last line of the notice. This NTC informs the Office of Construction and the contractors that the EED will be available, along with the contract plans, at advertisement. The NTC also states that all EED files are for information only. This will be submitted along with the specifications at FDP.

For uploading documents to ProjectWise see Section 6 of Digital Project Development Manual

7.3 Notification

Send a link to AEC Applications at DOT.AECApplications@ct.gov that the files are ready with EED in the subject field.

7.4 Converted Data

AEC will convert MicroStation CAD files (dgn) into a dxf format, InRoads alignment files (alg) into xml, and InRoads surface files (dtm) into xml. These conversions are necessary to be utilized in the GPS field equipment and automated machine guidance/control equipment. It will be AECs responsibility to zip all files, both native and converted, and upload to the *100_Contract_Plans (PDF)* folder in ProjectWise. Contracts will be notified so that the EED zip file can be posted along with the contract plans, specifications, and estimates on the State's contracting portal at advertisement.

The converted data is being provided by CTDOT to insure that inspectors and contractors are utilizing the same set of data.

7.4.1 ProjectWise File Attribution Conventions

Phase		File Type	Discipline	Main Category	Sub Category	Label	Description	Example
		MicroStation Files						
PHASE 2	PHASE 1	Existing Survey Ground DGN	SV	CAD	MAP	EED_3D	Existing Survey Ground DGN	EED_3D_SV_D1_MAP_1234-5678.dgn
		Proposed Master Design DGN 2D (Phase 1)	Discipline	CAD	DESIGN	EED_2D	Proposed *Discipline* Master Design	EED_2D_HW_DESIGN_1234-5678.dgn
		Proposed Master Design DGN 3D (Phase 2)	Discipline	CAD	DESIGN	EED_3D	Proposed Discipline Master Design	EED_2D_HW_DESIGN_1234-5678.dgn
	PHASE 1	Addendums	Discipline	CAD	DESIGN	EED_A1	Addendum No.*X Discipline*	EED_A1_HW_DESIGN_1234-5678.dgn
		Change Orders	Discipline	CAD	DESIGN	EED_C1	Change Order No.X Discipline	EED_C1_HW_DESIGN_1234-5678.dgn
		InRoads Coordinate Geometry						
PHASE 2	PHASE 1	Proposed Geometry ALG	Discipline	CAD	RESOURCE	EED_ALG	InRoads *Discipline* Geometry File	EED_ALG_HW_RESOURCE_1234-5678.alg
		Addendums	Discipline	CAD	RESOURCE	EED_ALG_A1	Addendum No.*X Discipline*	EED_ALG_A1_HW_RESOURCE_1234-5678.dgn
		Change Orders	Discipline	CAD	RESOURCE	EED_ALG_C1	Change Order No.X Discipline	EED_ALG_C1_HW_ RESOURCE _1234-5678.dgn

Table 10. File Naming Conventions

Phase		File Type	Discipline	Main Category	Sub Category	Label	Description	Example
InRoads Digital Terrain Models								
PHASE 2	PHASE 1	Existing DTMs	SV	CAD	RESOURCE	EED_DTM	Existing Survey Ground Surface	EED_DTM_SV_D1_RESOURCE_1234-5678.dtm
		Proposed Finished Grade DTM	Discipline	CAD	RESOURCE	EED_DTM_FIN	Proposed *Discipline* Top Surface	EED_DTM_FIN_HW_RESOURCE_1234-5678.dtm
		Substratum DTMs	Discipline	CAD	RESOURCE	EED_DTM_STRAT	Proposed *Discipline* Substratum Surface	EED_DTM_STRAT_HW_RESOURCE_1234-5678.dtm
		Roadway Subgrade DTMs	Discipline	CAD	RESOURCE	EED_DTM_SUB	Proposed *Discipline* Subgrade Surface	EED_DTM_SUB_HW_RESOURCE_1234-5678.dtm
		OpenRoad Designer Files						
PHASE 3		Existing Survey Ground DGN/ICM	SV	CAD	MAP	EED_ORD	Existing Survey Ground DGN/ICM	EED_ORD_SV_D1_MAP_1234-5678.dgn
		Proposed Master Design DGN 3D	Discipline	CAD	DESIGN	EED_ORD	Proposed *Discipline* Master Design	EED_ORD_HW_DESIGN_1234-5678.dgn
		Supporting Documents						
ALL PHASES		EED Delivery Manifest	Discipline	REPORT	MANIFEST	EED	EED Delivery Manifest	EED_HW_MANIFEST_1234-5678.pdf
		EED Notice to Contractor (NTC)	Discipline	SPECS.	NTC	EED	EED Notice to Contractor (NTC)	EED_HW_NTC_1234-5678.doc

Table 11. File Naming Conventions Continued

7.5 Addendums and Design Initiated Change Orders

Changes to the EED that require edits to the CAD models, surfaces or alignments shall be submitted along with submission of the revised contract plans. The files will be attributed in accordance with 7.4.1 ProjectWise File Attribution Conventions.

A new zip file will be created containing the renamed updated files and uploaded to ProjectWise. AEC will then be notified that the amended files are complete. Send a link to AEC Applications at DOT.AECApplications@ct.gov that the files are ready with EED in the subject field.

Appendix I EED Phase 1 Quick Start

Note: EED is due with the FDP plans at FDP

1. Ensure that the MicroStation Design Models meet 4.2 Proposed Master Design Models (.dgn) for your discipline. 3D CAD models will be exported to 2D CAD models.
    a. All graphical elements are at the correct geospatial location and are on the correct level.
    b. Models are free of all cross sections, profiles, construction lines for design purposes.
    c. Models are free of annotation that should reside in the cut sheets.
    d. Models have clean reference attachments, only needed reference files & no redundant references.
    e. Models are a 2D design model, not a sheet or drawing model
    f. Files contain only one model
2. Ensure that the InRoads Coordinate Geometry file(s) meets Section 4.3 Coordinate Geometry Files (.ALG).
    a. Only final alignments included (do not include preliminary or alternates information).
    b. Alignments names and descriptions are intuitive.
    c. Each horizontal alignment has only one child vertical alignment.
3. At FDP:
    a. Check that the Appendix II EED Checklist criteria is met.
    b. Fill out EED File Manifest for all files (native data only). Also see EED File Manifest Example.
    c. Upload the MicroStation dgn and InRoads alg (if applicable) to the ProjectWise folder *01.0\Projects - Active\XXXX-XXXX\240_Contract_Development* where XXXX-XXXX is the project number. Use the naming convention in 7.4.1 ProjectWise File Attribution Conventions.
4. Send a link to AEC Applications at DOT.AECApplications@ct.gov that the files are ready with EED in the subject field.

Appendix II EED Checklist

Check List	
MicroStation Design Models	
☐	All graphical elements are at the correct geospatial location.
☐	All graphical elements are placed on the correct CT DOT Level.
☐	Files are free of all cross sections, profiles, construction lines for design purposes.
☐	Files are free of annotation that should reside in the cut sheets.
☐	Files have clean reference attachments, only needed reference files & no redundant references.
☐	All 3D files have lines and elements at the proper elevation (no spikes).
☐	Files are a 2D or 3D design model, not a sheet or drawing model
☐	Files contain only one model
Coordinate Geometry	
☐	Only final alignments are included (preliminary and alternate information has been removed).
☐	Alignments names and descriptions are intuitive.
☐	Each horizontal alignment has only one child vertical alignment.
Surface Models	
☐	Visualized breakline features and they appear to be consistent and match the 2D MicroStation file.
☐	Visualized breakline features, no vertical faces are present; breaklines appear to be horizontally offset.
☐	Visualized both the contours and triangles in a 3D file. Looked at it from the top and front, side, and isometric view. No irregular dips, spikes or voids in the surface are apparent.
☐	Triangles were viewed on top of the proposed design file. The triangles do not cross obvious breaklines such as centerlines, edges of pavement, edges of shoulders, etc.
☐	Contours were viewed to ensure the low points line up with the proposed drainage structures and structure flowlines match the proposed surface.
☐	If automated machine control/ guidance will be used during construction, at intersections or other critical areas, contours should be viewed at a 0.1 foot interval to ensure the model is accurate enough for automated machine control/ guidance use.

Table 12. EED Checklist

Appendix III Electronic Data Definitions

3D Model – Models includes all engineering data which is geospatially positioned and graphically displayed on project related datums and are used to describe the existing conditions or proposed design of a capital project. This can include multiple DTM surfaces and related Graphics Information. The "Model" is what is generally what is referred to as the deliverable for projects which anticipate using AMG.

Automated Construction and Inspection – Automated Construction & Inspection include all technologies used for the construction and inspection of capital projects, and require the input of reliable EED to operate effectively. Examples of this may include Automated Machine Guidance, Automated Stakeout & Inspection, and Intelligent Compaction operations.

Automated Machine Guidance (AMG) – AMG uses computers and survey technology on construction equipment to automate the calculation and interpolation between a proposed digital terrain surface (or a control alignment with templates) and survey geospatial positioning. This interpolation provides visual horizontal and vertical guidance to the operator of the construction equipment. AMG is also referred to as Machine Control or Automated Machine Operations.

Automated Stakeout & Inspection – Use of computers and survey technology to automate the calculation and interpolation between a proposed digital terrain surface (or a control alignment with templates) and survey geospatial positioning. This interpolation provides horizontal and vertical guidance to the operator of the equipment, for the stakeout of proposed work or positional verification or measurement of completed work.

CAD Model (design) – Master Design CAD dgn file. The model usually consists of one dgn file (for large projects there may be more than one) that contains all of the proposed design work. There are separate models for each discipline that is doing design for the project (Highways, Traffic, Bridge, etc.) This model is referenced into the individual cut sheets and clipped to the correct size.

CAD Model (existing) - Master existing CAD dgn file. The model usually consists of one dgn file (for large projects there may be more than one) that contains all of the existing survey. This model will also contain other information such as the datum used and control tie box information.

CAD files – refers to any CAD files that are not defined as a CAD model (see above). Examples of these files would be the title sheet, miscellaneous details, detailed estimate sheet, plan sheets, etc. Plan sheets would have CAD models referenced into them but would not contain any design work in the file itself.

Digital Terrain Model (DTM) – A DTM is a digital map representation of a three dimensional topographic surface. (Also referred to as Digital Elevation Model DEM, or a Triangulated

Irregular Network TIN). DTMs are visualized electronically by draping a surface over triangulated points which are generally determined along breaklines where changes occur in the slope of the surface. The points are defined geospatially by coordinates and elevation values. In the civil engineering industry, DTMs can represent existing natural terrain of the earth's surface, or proposed terrain intended to represent a completed surface. DTMs can portray triangulated and/or non-triangulated features, shapes and solids.

Documents & Publications – Includes reports, manuals, contract proposals, specifications or other publications which record or document decisions, standards, policies, procedures or other legal requirements related to capital projects.

Electronic Engineering Data (EED) – Includes all types of design project related engineering data which is used for the defining, developing, designing, documenting, spatially locating, constructing, and historical recording on a CTDOT Project. This includes Documents and Publications, Geospatial Data, Digital Terrain Models, and Graphics Information.

Elements – Elements are points or lines which are described geospatially in two or three dimensions.

Features – Features consist of points and lines which may be connected to form geospatial objects, and can be used to form the ground surface displayed in a DTM. Features can be either 3D triangulated (including elevations) or 2D non-triangulated (without elevation). Features store attribute information about the symbology, level, and text.

Finished Grade DTM – FG DTM shall include the entire proposed project surface area which will be disturbed by construction operations out to all limits of work. The FG DTM shall be a true representation of the entire finished surface that the Designer intends to be built. The outer limits of a project's DTM shall include all disturbed/modified terrain surfaces that require excavation or fill of greater than 6" from the existing ground surface over a 1,000 sqft area.

Geospatial Data – This information identifies the geographic position and characteristics of natural or proposed constructed elements, features and boundaries and how they are positioned related to the earth's surface.

Graphics Information – Graphical representations of project information portrayed either by raster or vector images. Files include graphical representations of points, lines or shapes, text annotation, and images. CAD files are generally in MicroStation DGN formats, and include all associated reference files. Graphics are generally published in PDF format.

GPS – Global positioning system, the Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver.

GPS Rover – GPS device that collects the data in the field. Typically consists of a receiver (antenna), a fixed rod and a data collector. The receiver can also be mounted to a vehicle.

LOD – Level of detail.

RTK – Real Time Kinematics, Real Time Kinematic (RTK) satellite navigation is a technique used in land survey and in hydrographic survey based on the use of carrier phase measurements of the GPS, GLONASS and/or Galileo signals where a single reference station provides the real-time corrections, providing up to centimeter-level accuracy.

RTN – Real Time Network is similar to RTK yet it uses a network of base stations located on maintenance garages, the internet, satellites and host server software. Though fairly new to the U.S., these types of networks have been very successful in Europe and Asia where networks span entire countries where utilization is spreading beyond surveying to mapping, utilities, emergency response, agriculture, forestry, public safety, transportation, machine control for construction, environmental, and scientific research.

RTS – Robotic Total Station. This equipment utilizes the same software as the GPS rovers but does not rely on satellites for locations. RTS equipment localizes to a project area by calibrating using control points set by traditional survey techniques.

Appendix IV Benefits

Construction operations which may produce the greatest productivity gains by the use of EED are for material excavation or placement. Construction items which optimize the efficiency and accuracy of AMG are earth excavation, fill and subbase courses. These items are all volume measured and their quantities can directly be calculated from the terrain models for the existing surface, the finished grade surface, and the top of subgrade surface.

Other construction installations which would benefit most from providing EED for stakeout and inspection verification are bridge substructures, public and private utilities, curbing, sidewalks, commercial driveways, signs, lighting & signal posts, and pile driving. Bridge superstructure and substructure layout could be modernized to provide contractors with 2D or 3D spatial descriptions (features) of all structural elements and critical control lines. This information could be used by AMG for the excavation of the footings, backfills up to finished grades, by pile drivers to position proposed pile locations, by carpenters to automate the layout and building of concrete forms, by steel workers to automate the positioning of steel supports and for installing of reinforcement, and by DOT Inspectors to verify the correct spatial locations.

Projects which do not contain 3D DTMs can also benefit from using supplied EED. Sign or guiderail replacements, or pavement striping contracts could benefit from locations derived by GIS approximated or GPS field measured 2D coordinates for positional locations. Using geospatially described locations (coordinates) or station-offsets provided by alignment files instead of record plan scaled stations and offsets will provide more clearly defined designer intent as to the location of the items.

General:

- Greater ease of design implementation at time of construction.
- Enhanced quality of constructed facilities.
- Greatly reduces the need for construction staking which in turn reduces survey costs
- Contractor and agency labor savings when measuring and documenting as-built quantities and pay-quantity management.

Design:

- Increased accuracy and data intelligence going into design.
- Enhanced visualization capabilities during the design process.
- Identify clashes and constructability issues prior to construction.
- Greater accuracy for quantity computations

Construction:

- Points or alignments of features can be used by Contractors to locate items in the field by using Total Stations or GPS/RTK survey equipment (available in CT).
- Breaklines, features and other alignments included with digital terrain models (DTMs) are used by Contractors for Automated Machine Guidance (AMG) operations. Use of GPS for AMG allows for the most efficient operation of earthwork machinery, less operator time is required for construction, idle time and rework.
- Uniform compaction
- Check constructability
- Track stage construction
- Improved Safety for the inspectors and contractor personnel
- Equipment resource savings
    - Machine idle time can be reduced when there is less waiting for excavation and embankment staking and clarifications.
    - Finish grading iterations are lessened or nullified because of GPS accuracy, therefore resulting in a reduction of machine hours.
- Earthwork construction tasks are shortened because:
    - Contractors can mobilize to the site and begin work without waiting for surveyors to position grade stakes for the initial lifts.
    - Checking grades and rechecking spot locations immediately versus calling and scheduling a survey crew.
    - Time saved in layout and grade checking can be devoted to machine movement and cycle time efficiency.
    - Reduction in rework - Jobsite grade and location errors are more easily spotted and corrected with GPS technology than with reliance upon 2 dimensional drawings and surveyor's grade stakes.
    - Construction field managers can make decisions more quickly and accurately because position and grade information is provided in real time.

Construction Inspection:

- Accurate quantity take off for pay-items (point locations, areas, volumes)
- Pay-items are easily tracked
- A single person can locate and document exact x,y,z positions providing real-time verification of an item being inspected or a point location being disputed.
- Reduction of conflict resolution time.
- Electronic as-built data can be produced and easily incorporated on the electronic contract plans either during construction ("live" as-builts) or post construction.

Appendix V Revisions

DATE	REVISION	PAGE NO.
01/09/2018	Updated email addresses, added revision table	