MODEL CENTRIC ROADWAY DESIGN AND DELIVERY

Connecticut Department of Transportation Guidelines for Electronic Engineering Data Delivery
2016
<table>
<thead>
<tr>
<th>Time</th>
<th>Session Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 to 9:00</td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>- Milestones</td>
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<td></td>
<td>- Initiatives</td>
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<td>- Phased Approach</td>
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<tr>
<td>9:00 to 9:45</td>
<td>Review of CTDOT CAD Standards, with Q &amp; A</td>
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<tr>
<td>9:45 to 10:00</td>
<td>Break</td>
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<tr>
<td>10:00 to 10:45</td>
<td>Phase 1 &amp; 2 Submittal Requirements</td>
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<tr>
<td>10:45 to 11:30</td>
<td>Q &amp; A</td>
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<tr>
<td>11:30 to 12:00</td>
<td>Phase 3 – 3D Model Centric Design (OpenRoads Technology)</td>
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</tbody>
</table>
The purpose of this open house is to:

- Provide a review of the current CAD Standards and procedures
- Share strategy for submittal of Electronic Engineering Data (EED)
- Collaboration - Get feedback, comments and concerns

Manual
Standards to promote consistent, uniform, and useable deliverables

Check Lists (QA/QC)
Projects delivered in a consistent manner following best practices & industry standards

CTDOT Policies & Directives
In house designers and consultant engineers must conform
What are common Electronic Engineering Data (EED) Submittal Types?

- Proposed Design CAD Files
- Proposed Surface Data
- Existing Survey CAD Files
- Existing Surface Data
- Alignment Data

ProjectWise
EED is directly related to the FHWA Accelerating Innovation, Every Day Counts Initiatives

EDC-2 3D Engineered Models for Construction

“Using 3D engineered models allows for faster, more accurate and more efficient planning and construction of transportation projects. EDC-2 encouraged a transition from traditional two-dimensional design to 3D modeling as a strategy for shortening project delivery and improving quality and safety on the construction site.”

EDC-3 3D Engineered Models: Schedule, Cost and Post-Construction

“Using 3D engineered models enables the highway community to effectively connect a project’s design and construction phases. EDC-3 promotes the expansion of 3D applications to manage roadway inventory and assets, improve schedule and cost management, and create accurate as-built records.”
Users have received CT DOT CAD Standards training.

### 2013 – 2016
130 Users have received CT DOT CAD Standards training.

### INTRODUCTION

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2007</td>
<td>CAD Policy MicroStation &amp; InRoads</td>
</tr>
<tr>
<td>2008</td>
<td>Improvements made to the CAD Standards</td>
</tr>
<tr>
<td>2009</td>
<td>CTDOT InRoads Guide Released</td>
</tr>
<tr>
<td>2010</td>
<td>Simsbury Intersection Realignment First Pilot using GPS for Inspection</td>
</tr>
<tr>
<td>2011</td>
<td>Ellington Roundabout</td>
</tr>
<tr>
<td>2012</td>
<td>Salem Roundabout</td>
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<tr>
<td>2013</td>
<td>CTDOT MicroStation Guide for Traffic released</td>
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<td></td>
<td>Moses Wheeler Bridge</td>
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<tr>
<td></td>
<td>Began Development of EED Manual</td>
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<td>EED Workshop with contractors</td>
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<td></td>
<td>CTDOT MicroStation Guide for Highway Released</td>
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<td></td>
<td>AEC attends FHWA 3D Workshop in PA</td>
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<tr>
<td></td>
<td>GPS Inspection Training</td>
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<tr>
<td></td>
<td>Presented EED Initiative to contractors/CCIA</td>
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### 2015
- Contract 5 FastTrack
  - New Haven Long Wharf Stations on High Speed Rail West River Bridge I-95
  - Seymour Roundabout
  - New Haven 1-84
  - Implemented Formal CAD Training Program including online training
  - AEC Began OpenRoads Testing and Configurations
  - Software piloting revealed a need for upgraded computers for 3D design
  - Began development of Inspectors workflow for preparation EED
  - AEC attends IHEEP Conference
  - Farmington Route 4

### 2016
- 160 new computers installed for 3D design
- Pilot Phase 1 – 2D Model Centric Design
- Wallingford Route 15
  - 2D Model & Alignment Data delivered for bidding
  - GPS Inspection Training
  - Presented EED Initiative to contractors/CCIA
  - Auditors approved use of GPS equipment as method of measurement for payment
  - Contract in place for purchasing GPS equipment
  - FHWA 3D Engineered Models Workshop and Peer Exchange Hosted by CTDOT
  - Bristol Route 69
    - 2D Model & Alignment Data delivered for bidding
  - Began OpenRoads Piloting
  - Launch New Digital Solutions Website
  - Open House for Designers and Consultants
  - Finalize implementation teams from each district (SME’s)
  - OpenRoads Training

### 2017
- Pilot Phase 2 – Transition to 3D Design
- Pilot Phase 3 – 3D Model Centric Design
- Implement Phase 2 Policy
- Implement Phase 3 Policy

- Connecticut Department of Transportation
Why do we need phases?

Why can’t we implement 3D requirements right away?

“Focused Solutions”

Will enable the CAD support group to build users confidence:

1. pushing the need to work geospatially & continue to instill the standard CAD Practices
2. fixing common 3D mistakes
3. focusing on full 3D using OpenRoads technology
CONSTRUCTION INITIATIVES

Contractor:
- Use data for bidding
- Use data for construction layout
- Use 3D model for automated for machine guidance

Inspectors:
- Field verification of layout
- Measurement for payments

Future:
- 4D Scheduling & Cost
- As-builds
- Assets

Connecticut Department of Transportation
EED DELIVERABLES

Phase 1
- Type 1, Type 2, & Type 3
  - MicroStation DGN CAD
  - InRoads ALG Geometry

*Indicates specific data is not a requirement unless used during the design

Phase 2
- Is Earth Work Required?
  - NO
    - Type 1 & Type 2
      - MicroStation DGN CAD
      - InRoads ALG Geometry
  - YES
    - Type 3
      - MicroStation DGN CAD
      - InRoads ALG Geometry
      - InRoads Curb to Curb DTM Surfaces
      - InRoads Substructure DTM Surfaces
      - InRoads Existing DTM Surfaces

Phase 3
- Is Earth Work Required?
  - NO
    - Type 1
      - MicroStation DGN CAD
      - OpenRoads Geometry
  - YES
    - Type 2
      - MicroStation DGN CAD
      - OpenRoads Geometry
      - Complete Proposed OpenRoads Surfaces
      - OpenRoads Sub Surfaces
      - Existing OpenRoads Terrians
    - Type 3
      - MicroStation DGN CAD
      - OpenRoads Geometry
      - Complete Proposed OpenRoads Surfaces
      - OpenRoads Sub Surfaces
      - Existing OpenRoads Terrians

Example Project Types
Included but not limited to the following:

Type 1
- No Earth Work
  - Milling and Overlay
  - Traffic Signs
  - Guiderail Improvements

Type 2
- Site Earth Work
  - Facility Construction (Site Work)
  - Hazardous Waste Removal
  - Wetland Replacement/Restoration
  - Retaining Walls/Slope Stabilization

Type 3
- Roadway Earth Work
  - Intersection Improvement
  - New Interchange
  - Realignment
  - Widening
REVIEW OF CTDOT CAD POLICIES
All plans shall be prepared in MicroStation CADD format in accordance with the Department’s “CADD Manual.”

POLICY STATEMENT

CONSULTANT DESIGN MANUEL

MEMORANDUM

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304.05 POST-FINAL DESIGN SUBMISSION

Inevitably, revisions to the Final Design Submission will be necessary as a result of the Department’s review and processing of final contract documents. When the Department is satisfied with the condition of the contract documents, the Consulting Engineer shall make a Post-Final Design Submission consisting of the following materials:

1. 3 copies of all documents that required revision as a result of the Department’s review and processing of final contract documents (except one copy each of original mylars).

2. Electronic CADD files for the entire project in conformance with the Department’s “CADD Manual.” The Consulting Engineer shall coordinate media type with the Project Engineer to ensure compatibility with Department hardware prior to making this submission.

The Department reserves the right to request design information at any time during the design process. This information would contain High Value Data (HVD) such as: InRoads DTMs, Alignments, Drainage Databases, and 3D Models in conformance with the DDE. CTDOT is investigating future submission requirements for HVD 3D and 4D models for GPS Machine Control, GPS inspection techniques, and future modeling applications.
Example Solicitation for Consultant Services

CAD POLICIES

CSO Solicitation No. 2271
Design Services for Project No. 0015-0373 – Barnum Station
Prequalification Categories - Facilities Design (All Modal Buildings/Vertical Structures) AND Rail Design AND Bridge and Structure Design

FIRMS WHO ARE ELIGIBLE TO SUBMIT WILL RECEIVE THIS LETTER IN THE MAIL.

IT IS BEING POSTED HERE FOR INFORMATION ONLY.

The Connecticut Department of Transportation (Department) is seeking to engage one (1) prequalified consultant engineering firm, in the categories listed above, to provide engineering services associated with the design of a new railroad station, several railroad bridges and associated railroad infrastructure improvements in the City of Bridgeport (City). This project, often referred to as the “Barnum Station,” received a TIGER VII grant from the Federal Transit Administration in the fall of 2015. Both AMTRAK and Metro North Railroad are expected to service this station.

The selected firm will be required to provide preliminary design, design development, final design and design services during construction. It is anticipated the scope of the work will be performed in phases. The first phase of the effort will involve the design and construction of new retaining walls and the railroad bridges to support the track bed which will be widened to accommodate center island platforms for passenger loading. A subsequent second phase of the effort will involve design of cross track pedestrian access as well as vertical circulation from grade to platforms. Separate construction contracts will be pursued for the two phases. A public involvement program will be required, along with coordination with Department and City staff, to ensure design initiatives in the vicinity of the station are compatible with the necessary construction conditions and final configuration of the developed site.

The selected firm must provide all electronic design data (i.e., Ground files, Design files, Digital Terrain Models [surfaces], Alignments, Contract Plans, and/or all other Electronic Engineering Data) in Bentley Systems, Inc. MicroStation V8i (SELECT series 3) and InRoads Suite V8i (SELECT series 2) formats. Submissions will also be required to comply with the Department’s Digital Design Environment and the Digital Project Development Manual (http://www.ct.gov/dot/cwp/view.asp?a=3194&q=483668).

If your firm would like to be considered for this assignment, your submittal should consist of a letter-of-interest limited to one (1) page, a Department Form CSO 255 (Revised January 2016) and a maximum of five (5) resumes which are limited to two (2) pages each. One of the resumes must be that of the proposed Project Manager in charge of the work, as well as the assurance that he/she will be available for work when required. (The CSO 255 form can be found online at www.ct.gov/dot/business/consultant/selection.) Four (4) copies of the submittal are required and they must be either postmarked or hand-delivered by 3:00 p.m. on July 14, 2016. Firms, who are shortlisted based on their CSO 255 submittal, will be notified by the Consultant Selection Office of the time and date for their final selection interview. A final selection is anticipated by September 20, 2016.
REVIEW OF CTDOT CAD STANDARDS

- Benefits
- Useful Resources
- Customized CTDOT MicroStation Workspace
- MicroStation File Types
- Tips for Improvement
Following standard CAD practices will

• Ensure consistency throughout the Department (both in-house & consultant engineers)
• Improved productivity
  – Enhancing coordination between design disciplines
  – Ensuring all parts tie together (roadway, structures, & traffic signals)
• Reduce errors
  – Lessing the need for construction change orders
  – improving permitting and ROW coordination
• Improve estimates
RESOURCES

CTDOT Webpages

Digital Project Solutions

SELECTSeries
RESOURCES

CTDOT MicroStation Guides & Classes

Prerequisite
Bentley Training Class
MicroStation V8i Essentials

File Storage Locations
The CTDOT level structure
Customized discipline tasks & tools
Placing design features
Annotation & Dimensioning
Creating geospatial cut sheet
What belongs in a Design vs a Sheet Model
Creating detail sheets
RESOURCES

CTDOT InRoads Guides & Classes

Prerequisite
Bentley Training Classes
MicroStation V8i Essentials
Road Fundamentals

Connecticut Department of Transportation

CTDOT InRoads V8i Guide

250 Pages - Issued 2009

Project Start up
Creating Alignments
Using the CTDOT Template Library
Superelevation
Roadway Modeler
Plan & Profile Generator
Creating Cross sections
Using Storm & Sanitary

CTDOT InRoads SS2 V8i Survey Guide

99 Pages - Issued 2010

Project Start up
Importing Survey Data
Editing the fieldbook
Surface editing
Creating Alignments
Creating Cross sections

Continued
A Task comprises a MS command with the correct symbology for a pay item/feature.

Tasks are used to:

- Ease coherence with CTDOT Standards
- Simplify drafting, annotation, & dimensioning
- Promotes the ease of putting features on the correct levels
- Promotes the ease of using standard text sizes and fonts
RESOURCES

CTDOT Customized Tasks & Tools

Roadway Task – CUT
Invokes the Place SmartLine command
Sets the CUT Level Active
Activates the Template Symbology for a Cut Slope Limit

ONE TASK
Proper CAD Model Types and Usage

Design Model w/ Survey Referenced

Sheet Models
Contain Border Cell & Call-Outs
The Design & Survey is referenced into the sheet

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Proper CAD Model Types and Usage

Sheet Models

Transitory Shape for publishing PDFs & plotting
Does not display in print, MicroStation recognizes the shape so users do not have to place a fence.

Geospatially Located Sheet File
Used for plan view sheets – contains only annotation

Detail Sheet Fill
Used for typical sections, miscellaneous details – non-geospatial

Design Models

All geospatial features – horiz. alignment, guiderail layout, sed. Control, signs, pavement markings etc...
ESSENTIAL IMPROVEMENTS

Resolve 3D inconsistencies

Elev. 0.00

Elev. 300+
ESSENTIAL IMPROVEMENTS (Continued)

Refrain from copying other units design features

Proposed design elements are being copied from other disciplines instead of referenced. This practice makes it easy to miss critical design updates.

NO COPYING IN OTHER UNITS DESIGN FEATURES, USE REFERENCING

- Edge of Road copied in from Highway Design to Signal plan early in design stage
- Actual Edge of Road location at Final Design
- Proposed Signal equipment is in the wrong location

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All appurtenances/features will be placed in the correct geospatial location in a design model not the cut sheet.

Design layouts are being placed directly in the sheet model, cut up and portions moved to fit within the sheet border. With these appurtenances no longer in the correct geospatial location other design units can not easily reference them to check for conflicts.
ESSENTIAL IMPROVEMENTS

Place the design in the correct geospatial location

When features are not in the correct geospatial location other design units can not easily reference them to check for conflicts.

ALL FEATURES WILL BE PLACED IN THE CORRECT GEOSPATIAL LOCATION IN A DESIGN MODEL

Actual geospatial location of existing topo
Check your Coordinates

After rotating the **REFERENCE FILE** the coordinates no longer match.

After rotating the **VIEW** the coordinates still match.

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Everything in **one** File
- plan – profiles – cross sections

OK for InRoads Working File
Not acceptable for Master Design Model Layout

**Disorganized final design files**

**Defined Model Types and Uses**
ESSENTIAL IMPROVEMENTS

Consistent InRoads geometry naming

Only the final option should be included

Only one profile should be present for each horizontal

The names are not intuitive

Names of alignment shall be intuitive and easy to understand
5 Easy Steps to a Clean CAD File

1. Do not copy in other units features
   **USE REFERENCING**

2. Place all features in the correct geospatial location
   **ROTATE THE VIEW NOT THE REFERENCE FILES**

3. Follow CTDOT procedures for defined model types
   **SHEET VS DESIGN**

4. Use CTDOT Customized Tasks and Tools
   **DO NOT CREATE YOUR OWN LEVELS**

5. Only the current design data should be present
   **DELETE OLD DATA**

Connecticut Department of Transportation
PHASE 1 - 2D MODEL CENTRIC DESIGN

- Notice To Contractor that EED is For Information Only – Contract documents supersede
<table>
<thead>
<tr>
<th>Check List</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MicroStation Design Models</strong></td>
</tr>
<tr>
<td>All graphical elements are at the correct geospatial location.</td>
</tr>
<tr>
<td>All graphical elements are placed on the correct CT DOT Level.</td>
</tr>
<tr>
<td>Files are free of all cross sections, profiles, construction lines for design purposes.</td>
</tr>
<tr>
<td>Files are free of annotation that should reside in the cut sheets.</td>
</tr>
<tr>
<td>Files have clean reference attachments, only needed reference files &amp; no redundant references.</td>
</tr>
<tr>
<td>All 3D files have lines and elements at the proper elevation (no spikes).</td>
</tr>
<tr>
<td><strong>Coordinate Geometry</strong></td>
</tr>
<tr>
<td>Only final alignments are included (preliminary and alternate information has been removed).</td>
</tr>
<tr>
<td>Alignments names and descriptions are intuitive.</td>
</tr>
<tr>
<td>Each horizontal alignment has only one child vertical alignment.</td>
</tr>
<tr>
<td><strong>Surface Models</strong></td>
</tr>
<tr>
<td>Visualized breakline features and they appear to be consistent and match the 2D MicroStation file.</td>
</tr>
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<td>Visualized breakline features, no vertical faces are present; breaklines appear to be horizontally offset.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>Contours were viewed to ensure the low points line up with the proposed drainage structures and structure flowlines match the proposed surface.</td>
</tr>
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</table>
PHASE 2 – TRANSITION TO 3D DESIGN

1. InRoads DTM
2. InRoads ALG
3. MicroStation Files
4. Create EED
5. Complete QA Check List
6. Receive QA Check List from Support Units
7. Fill out Submittal Manifest
8. Add EED & Manifest to Zip File
9. Submit Zip File to ProjectWise
Current Practice of Manual Cross Section Editing

Slope limit modified in cross section using the MicroStation Modify Element Tool

- No connection to the InRoads Surface.
- Requires manual modification to slope limit Plan Graphic
- Subject to error
- The InRoads surface no longer matches the Cross Section or Plan View
**Existing Ground**

undisturbed ground surface prior to construction.

**Design (Top of Pavement)**

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

**Subgrade (Structure)**

Bottom of excavation for footings, box culverts, piers, abutments, sign supports etc....
**PHASE 2 – TRANSITION TO 3D DESIGN**

Continued

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![A Bad Breakline](image1)

![Results in Spiking Triangles](image2)

![Creates Inconsistent Contours](image3)

Connecticut Department of Transportation
PHASE 3
3D MODEL CENTRIC DESIGN

CONSTRUCTION

3D MODEL

SHEET PRODUCTION

INSPECTION
CTDOT Current Practices use Non-Centric Models

INITIAL ROADWAY COORIDOR IS CREATED IN 3D
MODEL IS CUT INTO 2D PLANS, PROFILES AND CROSS SECTIONS.
EACH DESIGN CHANGE IS MANUALLY DONE 3 TIMES = PRONE TO ERRORS
• 3D surface models beyond the pavement limits - Sideslopes, Ditches, driveways, bridges etc...
  ✓ Existing
  ✓ Top
  ✓ Base Courses
  ✓ Subgrade
  ✓ Substratum

• 3D models for field use need to be created in a 3D environment, not reverse-engineered from 2D

• Models will be “true” data source for plan sheets

• Additional content
  ✓ Horizontal alignments
  ✓ Vertical profiles
  ✓ Longitudinal breaklines
  ✓ Superelevation transition information
  ✓ 3D Storm Drainage Models
PHASE 3 – 3D MODEL CENTRIC DESIGN

Benefits

- Valuable tool to represent data to others (designers, contractors, stakeholders and the public)
- Serves as base model to aid in constructability analysis
- Easy to identify where proposed road & structure may not match
- Easy identification of vertical clearance issues
- Easier modeling of drainage & identification of Subsurface conflicts
- Improve sight distance determination
- Design changes are easier to incorporate (parametric modeling)
OVERVIEW OF OPENROADS TECHNOLOGY

Why do we need OpenRoads Technology to implement 3D Model Centric Design?

New 3D surface type enabling the use of larger:
- Roadway Corridors
- Existing Terrains
- Site Models

Dynamic models
Sites automatically respond to modifications made to a corridor.

InRoads would crash when trying to handle large files

InRoads site model had no connection to the corridor model

Civil Cells
Allow the repurpose of common geometric configurations in design layouts to ensure design standards are held “Easy to add Driveways & Intersections – finish the model”

Parametric modeling capabilities
Incorporates rules, relationships, and constraints into the modeling workflow “Design Intent”

Not available with InRoads

Very difficult and time consuming to finish the model using InRoads
OVERVIEW OF OPENROADS

TECHNOLOGY

InRoads

OpenRoads

MANUAL UPDATE

Layout Horizontal and Vertical Alignments
Roadway Designer Typical Sections Superelevation
Create Surface Plan Graphics are automatically displayed
Display Cross Sections
Edit Horizontal Alignment
Delete Cross Sections and Plan Graphics
MicroStation is used to edit graphic slope limits in Cross Sections & Plan View
Final Design Files Do Not Match
Above edits not made in InRoads Surface

Surfaces
Alignments
Cross Sections
Plan Graphics

DYNAMIC UPDATES

Surface Modeling

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OPENROADS IMPLEMENTATION PLAN

Scope

• InRoads SS2 to OpenRoads SS4
• New Level Structure
• Parametric Constraints
• Annotation Scale
• ProjectWise Managed workspace (no network install)

• 200 ± Inhouse Designers and Surveyors
• 500± Consultants Engineers
OPENROADS IMPLEMENTATION PLAN

Schedule

Currently

• All of Highway Design has upgraded workstations
• Maintenance release OpenRoads testing completed

Summer 2016

• All In house users will receive the software install
• Begin OpenRoads in house pilots

Fall 2016

• In house Surveyors OpenRoads training
• In house Designers OpenRoads training

Full Implementation Date - T.B.D.
CLOSING

Summary of Phases

Phase 1 – Q4 2016
- 2D Model Centric Design

Phase 2 – Q2 2017
- 2D Model Centric Design
- Transition to 3D

Phase 3 – Q4 2017
- 2D Model Centric Design
- 3D Model Centric Design

Please email any comments to:
ronald.tellier@ct.gov or elaine.richard@ct.gov