# Part 1100 3D Design

# Section 1101 Introduction

The final quality review for any project occurs in the field. Mistakes and unresolved issues must be worked out under the time and cost constraints imposed by the construction contract. Hurried efforts to resolve issues frequently result in delays, added cost, and less than optimal solutions. Discovery and resolution of these issues during design helps to keep a project on time and within budget. By modeling a project in 3D, the designer "builds" a virtual project before it is constructed physically. The 3D design process and the resultant 3D engineered model reveal many of the design issues prior to construction when they can be managed more effectively.

A 3D engineered model, created by the designer, is a virtual representation of a real-world project. In its simplest form it consists of the geometry of the roadway: the points, lines and shapes that define the alignments and surfaces. The ultimate model includes not only the geometry of the roadway but also the associated features (drainage, structures, signing, signals, illumination, etc.) and related metadata.

In order to realize the greatest value from the model it must be designed to a higher level of detail than is required for 2D drawings and plans. The model should incorporate all of the grading details such as widening for guardrail or mailboxes and transitions between different cut and fill slope designs. Abutting surfaces need to match – not just the top surface but subgrade as well. These details allow for the use of automated machine guidance. Drainage facilities and foundations should be placed to identify conflicts between the various assets.

Because the 3D model captures the physical relationships between the various construction elements, the model conveys the intent of the project more effectively than 2D drawings and plans. The 3D model offers many advantages over 2D drawings:

- Visualizations and simulations help stakeholders more easily understand the scope and impacts of a project.
- Design analysis can be done graphically.
- Design gaps and clashes are more easily detected.
- Quantities can be measured directly from the model.
- Constructability issues can be identified and resolved early.
- Design of construction sequencing and staging is simplified.
- Grading is done directly from the design when using AMG.

3D model creation may require a considerable amount of time and resources. While this could increase design costs, it rarely increases the overall cost of a project. The engineering issues that have typically surfaced during construction are, in the 3D design workflow, resolved prior to the start of work.

# Section 1102 3D Engineered Models for Construction

The use of automated machine guidance (AMG) by ODOT's contractors has been steadily increasing since it first appeared in the late 1980s. A prerequisite for the use of AMG is a 3D model of the work. Historically, these models have been created by the contractors, or third-party consultants, based on the contract plans and cross sections or grades provided by ODOT. Recognizing the value of AMG to ODOT, in 2013, the agency started to require that its 3D design models be made available to contractors for use in bid preparation and, separately, for construction. ODOT's intent is to encourage and support the use of AMG. There is currently no plan, however, to prohibit the use of traditional survey and construction practices. The required contents of the data handoff packages have been selected to provide support for contractors using all types of survey and construction methods.

## 1102.1 Digital Design Handoff Packages

Digital design data is compiled into two separate digital design packages:

- The Bid Reference Handoff package (also known as the eBIDS Handoff Package):

  The contents of this data package are standardized in order to provide a "level playing field" for all bidders. Note that this handoff package is an estimating aid only; it is meant to convey design intent, not necessarily construction details. Do not leave information out of the contract plans expecting bidders to find the information in the handoff package. The data included in the Bid Reference Handoff package is not intended for use in project construction.
  The Bid Reference Handoff data is submitted to the ODOT Resident Engineer-Consultant Projects (RE-CP) or ODOT Transportation Project Manager (TPM) no later than 1 week prior to the Project Advertisement milestone. The ODOT RE-CP or TMP uploads this data to eBIDS as a reference document at the time of Project Advertisement to assist contractors in the bidding process.

- The Construction Survey Handoff package:

  The provided data communicates the design information needed for the administration of the construction contract. This handoff package is tailored to the needs of both the Resident Engineer and the contractor. The designer must coordinate with the Resident Engineer to establish its content. The Construction Survey Handoff package supersedes the data in the Bid Reference Handoff package.
  The Construction Survey Handoff data is due to the Resident Engineer 30 days after Bid Opening, which generally coincides with Notice to Proceed for the contractor.

The delay between the Bid Reference Handoff package and the Construction Survey Handoff package serves two purposes. It allows the designer time to refine and complete all details of the 3D model and it provides time for the designer to assemble the Construction Survey Handoff package requested by the Resident Engineer.

# 1102.2 Projects Requiring 3D Digital Design Packages

The Bid Reference Handoff package and Construction Survey Handoff package are required on all state and federal aid STIP roadway projects designed to 3R or 4R standards, but should also be included in any other project that includes designed grading. The handoff packages are only required for projects that are accepted by the ODOT Project Controls Office (PCO).

Preparation of the digital design data package may not be appropriate for some projects due to various constraints such as schedule, scope, and/or budget. The responsible Region Roadway Manager (RRM) may approve an exception to the requirement for the Bid Reference Handoff package upon written request prior to the Advance Plans milestone.

# 1102.3 Required Content for Handoff Packages

## 1102.3.1 General

The contents of a digital design package will vary with the complexity of the project. Shoulder widening projects usually require some horizontal and cross section control and would merit a minimal package. An interchange or urban modernization project requires an extensive package that includes many alignments and surfaces defining the project. Regardless of project complexity, some guidelines must be followed to reduce the possibility of errors (and claims) during construction:

- Include only the information incorporated in the final design. Multiple versions or design iterations will create confusion during construction.
- Follow a consistent naming convention. Using ODOT's ProjectWise file naming standards will help to achieve that consistency.
- Organize the package logically and consistently. Construction office staff are usually under tight time constraints; they need to find the desired files quickly.

# 1102.3.2 Index

The index is mandatory for all handoff packages. Include the project data (name, highway, key number, etc.), directory structure, file names and file descriptions. Index the multiple models within design files as though they are files. An index template file is available at https://www.oregon.gov/odot/ETA/Docs_3DDesign/AppM-eBIDS_Index.xls. See Figure 1100-1 for a sample computer file index for the eBIDS handoff.

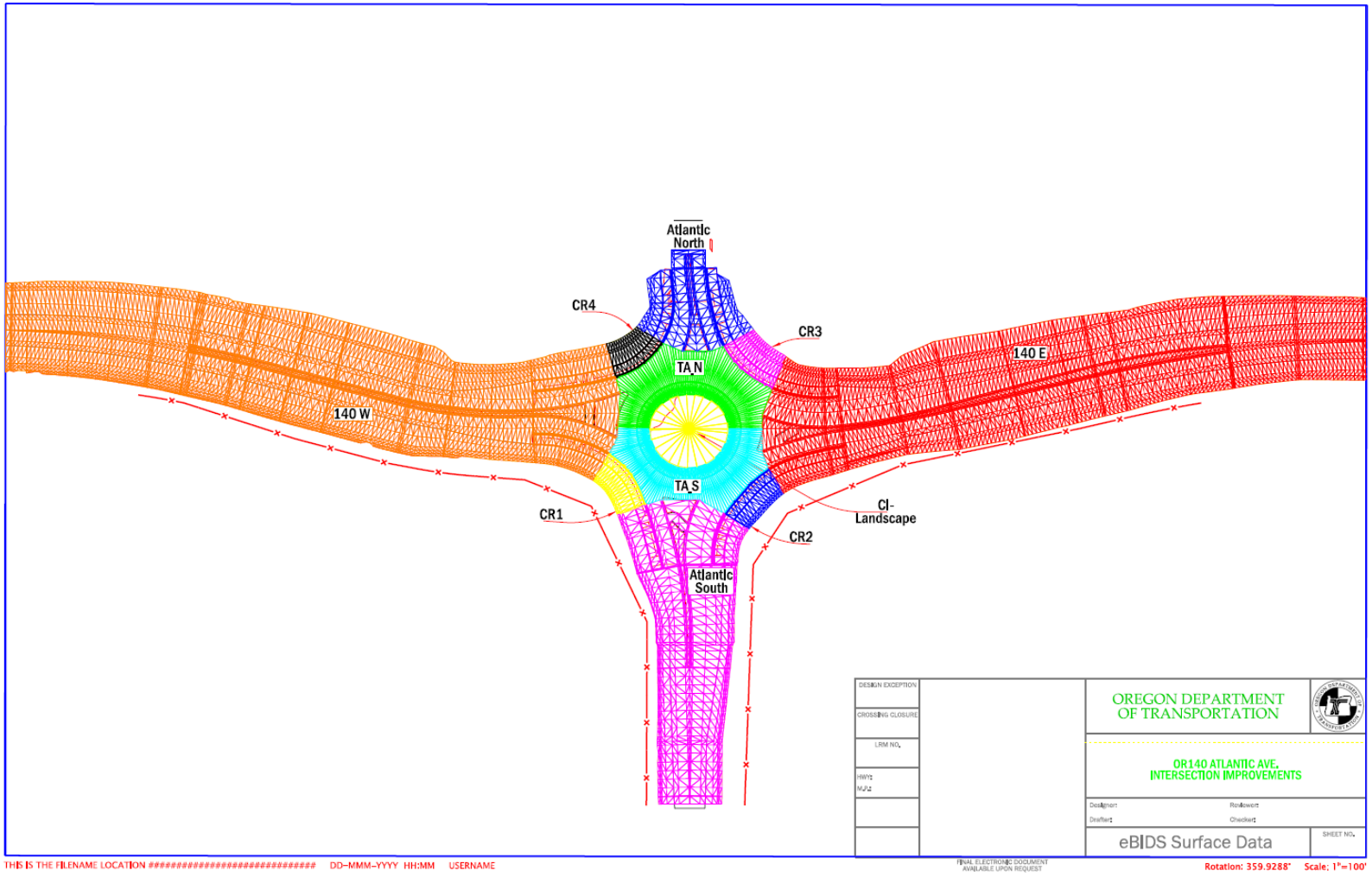
Figure 1100-1: Sample Computer File Index for eBIDS Handoff

| COMPUTER FILE INDEX - eBIDS Handoff | | | |
|---|---|---|---|
| **PROJECT** | Old Hwy 99N: Oakland Bridge and Melrose Rd: Conn Ford Bridge | **KEY #** | 21591 |
| **HIGHWAY** | Oakland Shady Highway & Melrose Road | **MILEPOINTS** | 0.55-0.84 (Oakland); 0.70-0.92 (Melrose) |
| **COUNTY** | Douglas County | **DESIGNER** | Jakki R. Carter, P.E. |
| **CONTRACT # (Optional)** | C15318 | **DATE** | September 18, 2021 |
| **COORDINATE SYSTEM** | OCRS Cottage Grove - Canonville Zone | **VERTICAL DATUM** | NAVD88, GPS DERIVED (GEOID 12A) |

| FOLDER NAME | FILENAME | DESCRIPTION |
|---|---|---|
| | **Alignment Data in XML format** | |
| **Melrose XML** | *L-ALG.xml* | Melrose Road mainline centerline alignment with existing right of way stationing. |
| **Oakland XML** | *AP2-ALG.xml* | AP2 centerline alignment. |
| | *AP3-ALG.xml* | AP3 centerline alignment. |
| | *G-ALG.xml* | Green Valley Road re-alignment construction centerline alignment. |
| | *MA-ALG.xml* | Maintenance Access centerline alignment. |
| | *O-ALG.xml* | Oakland Bridge re-alignment construction centerline alignment. |
| | **Surface Data in XML format** | |
| **Melrose XML** | *L-FG.xml* | Melrose Road finish grade surface. |
| | *Melrose_Extg.xml* | Melrose Road existing ground surface. |
| **Oakland XML** | *AP2-FG.xml* | AP2 finish grade surface. |
| | *AP3-FG.xml* | AP3 finish grade surface. |
| | *Bent1-FG.xml* | Bent 1 abutment fill finish grade surface. |
| | *Bent4-FG.xml* | Bent 4 excavation finish grade surface. |
| | *G-FG.xml* | Green Valley Road finish grade surface. |
| | *MA-FG.xml* | Maintenance access finish grade surface. |
| | *Maintenance_Pad-FG.xml* | Maintenance pad finish grade surface. |
| | *Oakland_East_Merged.xml* | Oakland Bridge merged surface 1/2; East end (includes G-FG, O-FG east of proposed bridge, Bent1-FG) |
| | *Oakland_West_Merged.xml* | Oakland Bridge merged surface 2/2; West end (includes O-FG west of Bent 1.) |
| | *Oakland_EG.xml* | Oakland Bridge existing ground surface. |
| | *O-FG.xml* | Oakland Bridge finish grade surface. |
| | **Cross Sections in pdf format** | |
| **Cross-Sections** | *G-Line.pdf* | Contains cross sections of G-FG surface along G-ALG at 10' intervals. |
| | *L-Line.pdf* | Contains cross sections of L-FG surface along L-ALG at 25' intervals. |
| | *O-Line.pdf* | Contains cross sections of O-FG surface along O-ALG at 25' intervals and at points of interest (i.e. guardrail flares, taper points, etc.) |
| | **Computer File Index - Excel** | |
| | *R_K21591_eBidCFI.xls* | Excel version of computer file index. |

On large projects a graphical index helps to locate the various alignments within the project limits.

Figure 1100-2: Sample Graphical Index for eBIDS Handoff



## 1102.3.3 Project Identification

Include the project name and the names of any alignments included in reports or on sheets. Do not include the "V-number" shown on the plans; this number is to be used only on the contract plans.

## 1102.3.4 Original Ground Survey

Survey provides the original ground surface data, which is the basis for design and quantity calculations with both the Bid Reference Handoff package and the Construction Survey Handoff package. The surface shall be in LandXML format and shall include all features and triangle definitions. The designer includes the LandXML file(s) in the design package.

# 1102.4 Bid Reference Handoff Package

All files in the Bid Reference Handoff package must be in non-proprietary format: standard Microsoft Office file types (.docx, .xlsx), pdf, text, LandXML or html. Do not include CAD graphics files in the Bid Reference Handoff package. Provide any necessary graphic information – e.g., cross sections – in the pdf file format. Include a completed copy of the handoff checklist (ODOT Form No. 734-5019) with the data package.

Figure 1100-3: eBIDS Handoff Checklist

Oregon Department of Transportation

**QUALITY CONTROL OF ROADWAY DIGITAL DESIGN**
eBIDS Handoff Checklist*

| PROJECT NAME | DESIGNER | MILE POINTS (FROM / TO) | COUNTY |
|---|---|---|---|
| | | | |

| HIGHWAY | REGION | KEY NUMBER | DATE OF PROJECT ADVERTISEMENT |
|---|---|---|---|
| | | | |

| Item | Description** | Required? | Provided? |
|---|---|---|---|
| **Notice of eBIDS Roadway Digital Design Data Letter** | Include Notice of eBIDS Roadway Digital Design Data Letter using template provided | Yes | ☐ |
| **Computer File Index*** ** | List of computer file names with a brief description for all provided files | Yes | ☐ |
| **Alignment Data** | Primary alignments in LandXML Format | Yes | ☐ |
| | Secondary Alignments in LandXML Format | Not currently required | ☐ |
| | Design Finish Surface in LandXML Format | Yes | ☐ |
| | | Not currently | |

# 1102.4.1 Notification Letter

Submit a notification letter (ODOT Form No. 734-5037), separate from the data package, with the Bid Reference Handoff package. The letter notifies contractors that 3D design information is available and updated information will be provided for construction. Print the filled form; do not just save. The document remains fillable if only saved. Attach copies of the handoff package checklist and file index to the letter.

Figure 1100-4: Sample Notice of eBIDS Roadway Digital Design Data

Oregon
Tina Kotek, Governor

**Department of Transportation**
Statewide Project Delivery Branch
Project Development Section
Project Controls Office
4040 Fairview Industrial Drive SE, MS 1
Salem, Oregon 97302

Date:

To: **PLAN HOLDERS**

**Notice of eBIDS Roadway Digital Design Data**

Subject: Key Number
Project Name
Highway Name
County
Type of Project (grading, paving, etc.)
Bids to be opened and read

ODOT design staff and/or Consultant partners have prepared an “eBIDS Handoff Package” that contains roadway digital design data. The digital data includes alignment data and three-dimensional surfaces provided in LandXML format, as described in the attached eBIDS Handoff Checklist and Computer File Index.

The “eBIDS Handoff Package” roadway digital design data provided on the eBIDS reference documents site is for bidding purposes only. As with all documents on the eBIDS reference documents site, use of this data for any other purpose is at the Bidder's own risk.

In addition to the “eBIDS Handoff Package”, a “Construction Survey Handoff Package” may be provided to the awarded Contractor at the pre-survey meeting. Additional information regarding the content of the Construction Survey Handoff Package is provided in Appendix M of ODOT's Highway Design Manual. The roadway digital design data provided to the awarded Contractor may be used to aid in the use of automated machine control equipment, such as GPS grade control, for earthwork construction. Three dimensional representations of physical project component “solids” (pipes, footings, structures, poles, etc.) will not be provided.

# 1102.4.2 Geometry

Include alignment data for all alignments shown on the general construction plan sheets. Alignment names are to match the names shown on the plans. Where applicable, include the corresponding vertical alignments. Provide the alignments in both the LandXML format and a text report. See Figure 1100-5 and Figure 1100-6 for examples of alignment reports in text format.

Figure 1100-5: Sample Horizontal Alignment Report

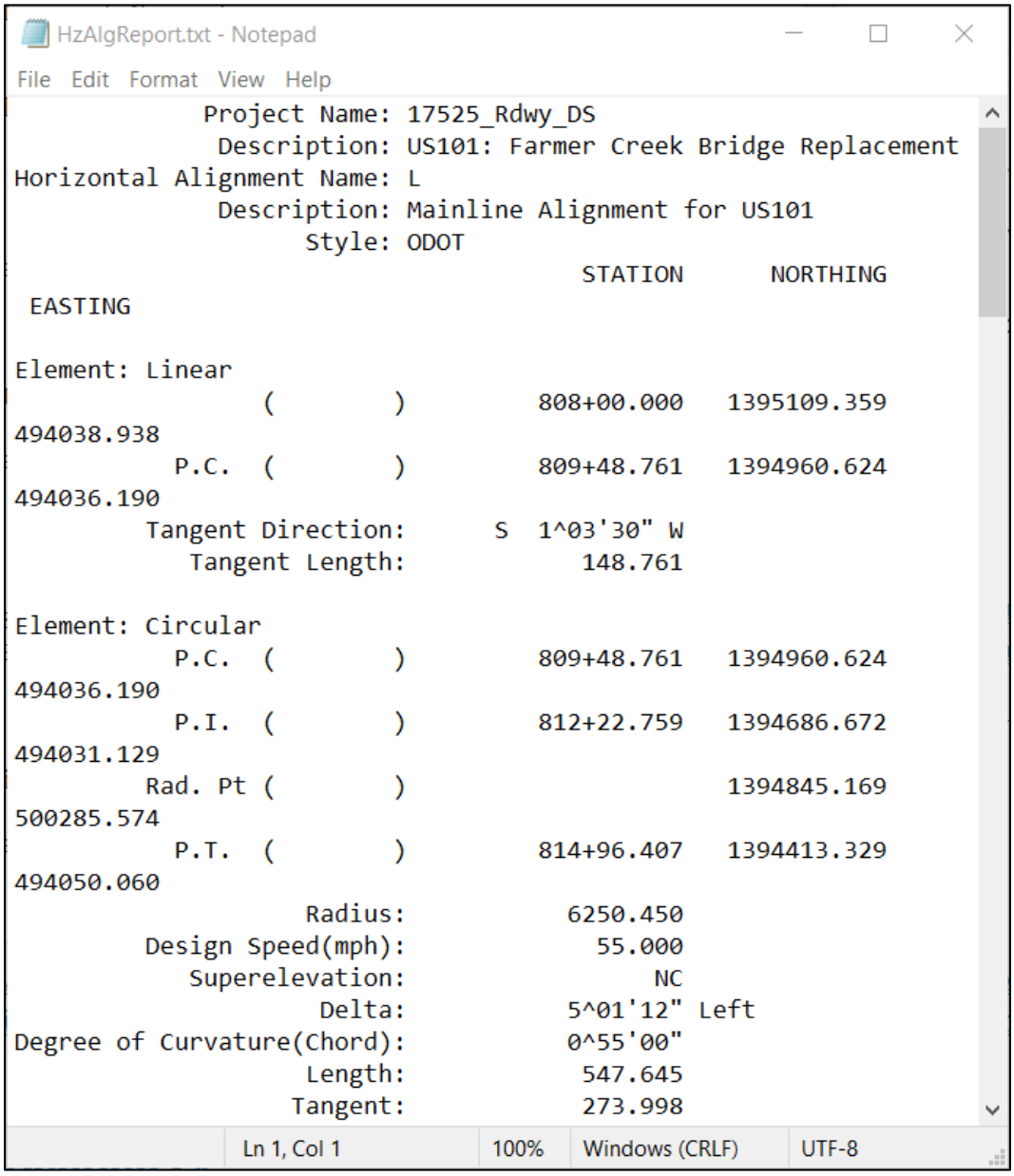
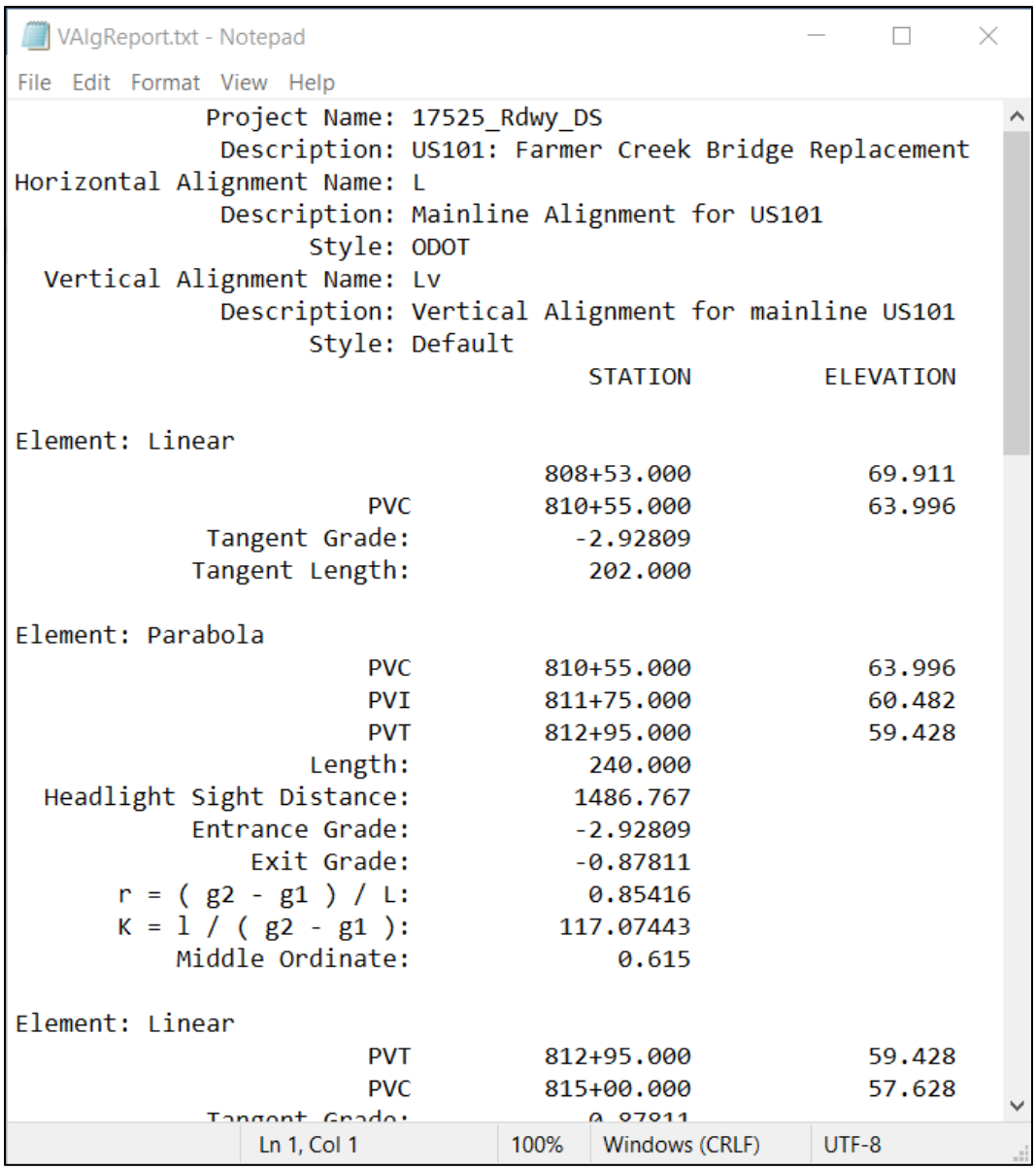


Figure 1100-6: Sample Vertical Alignment Report



VAlgReport.txt - Notepad

File Edit Format View Help

```
             Project Name: 17525_Rdwy_DS
              Description: US101: Farmer Creek Bridge Replacement
Horizontal Alignment Name: L
              Description: Mainline Alignment for US101
                    Style: ODOT
  Vertical Alignment Name: Lv
              Description: Vertical Alignment for mainline US101
                    Style: Default
                                       STATION         ELEVATION

Element: Linear
                                   808+53.000            69.911
                        PVC        810+55.000            63.996
             Tangent Grade:          -2.92809
            Tangent Length:           202.000

Element: Parabola
                        PVC        810+55.000            63.996
                        PVI        811+75.000            60.482
                        PVT        812+95.000            59.428
                    Length:           240.000
  Headlight Sight Distance:          1486.767
            Entrance Grade:          -2.92809
                Exit Grade:          -0.87811
      r = ( g2 - g1 ) / L:           0.85416
      K = l / ( g2 - g1 ):         117.07443
          Middle Ordinate:             0.615

Element: Linear
                        PVT        812+95.000            59.428
                        PVC        815+00.000            57.628
             Tangent Grade:          -0.87811
```

Ln 1, Col 1 | 100% | Windows (CRLF) | UTF-8

# 1102.4.3 Surfaces

Provide LandXML files for all top surfaces. Include both the features (breaklines, random points, and boundaries) and the triangle definitions. Separate files (one for features and one for triangle definitions) are recommended for large surfaces. No file should have more than one surface. Non-triangulated features and surfaces, other than the top, are helpful but not required.

# 1102.4.4 Cross Sections

Include pdf sheets of cross sections for all modeled alignments. Space the cross sections no more than 25’ apart. Include cross sections at the following key points along alignments:

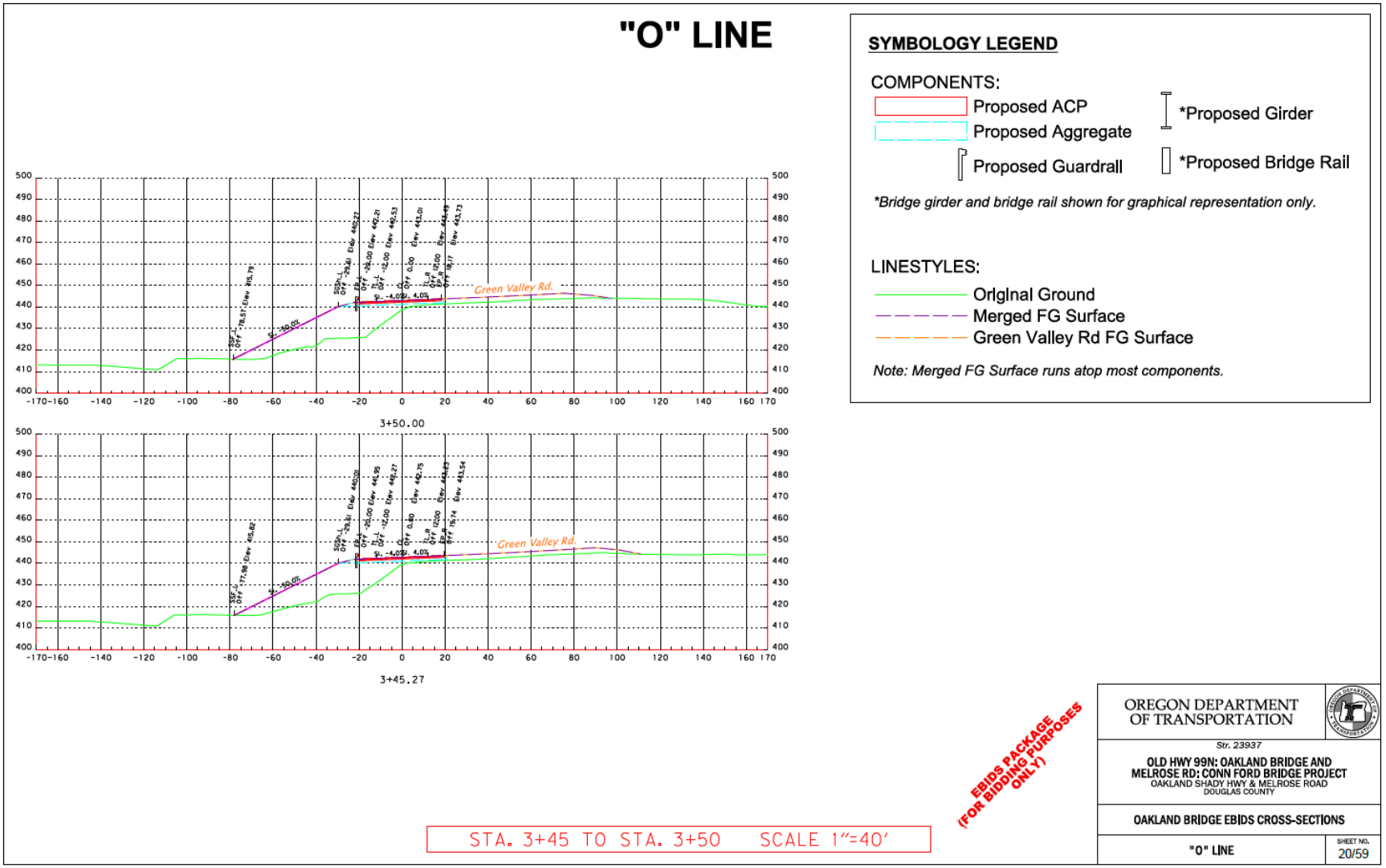
- Typical section changes
- Alignment cardinal points
- Drainage facilities
- Taper start and stop locations
- Guardrail and barrier limits
- Centerline of approaches
- Curb or pavement return points
- Luminaire and signal pole locations

There may be other features unique to a project that will require special sections.

Include all surfaces and components that fall within the range of the cross section set. Annotate the features in the cross sections with name, offset and elevation. Identify all surfaces and components by either labeling directly or with a legend at least once on each sheet. Be sure to print to pdf in a vector (not rasterized) format with lightweight lines.

On each sheet, include the disclaimer that the cross sections are informational only and are not to be used for construction.

Figure 1100-7: Sample eBIDS Cross-Section



# 1102.5 Construction Survey Handoff Package

The Construction Survey Handoff package includes the data to be used for construction. The contents are tailored to meet the needs of the Resident Engineer to administer the contract and the needs of the contractor to construct the project. Typically, the model is not complete at the time of bidding – there may be several, usually small, details requiring attention before it can be used for construction. After a project is advertised, the designer has six to seven weeks to finalize the model and assemble this handoff package. The contents of the package are dictated by the needs of the project participants: the Resident Engineer and the contractor. The designer must collaborate with the Resident Engineer to define what information is needed and in what format it should be provided.

These are some general expectations and some of the common file types:

- **Geometry** - Include all alignment data for the project, the horizontal and vertical alignments used to control the model as well as alignments identified in the plans. These might be in CAD files, LandXML files, text reports, or other formats.
- **Surfaces** - All surfaces that define construction materials or pay quantities. LandXML and 3D CAD files of the model will probably be the most useful.
- **Cross Sections** - Updated surfaces and components will necessitate new cross sections. Different or additional cross sections may be required at this handoff. CAD and pdf are common file formats.
- **Reports** - Grade and staking reports will probably be required. These are usually spreadsheets, text files, or PDF files.
- **Additional Information:**
    - Drainage facility information can frequently be delivered as 3D alignments and COGO points, surface features or in 3D CAD files.
    - Sign and other traffic-related locations.
    - Earthwork around structures.
    - Files describing many of the boundaries – R/W, no-work areas, clearing limits, etc. – may be required.

  Coordination with other disciplines may be required and source information should be obtained from the discipline performing the work.

The Resident Engineer is the agency's contact with the contractor. Route all communication with the contractor through the Resident Engineer's office.

# Section 1103 Digital Design Elements

## 1103.1 Software

ODOT roadway designers use Bentley OpenRoads Designer to provide digital design packages for construction projects. Subject to their respective contracts, ODOT's consultant partners may use other software to execute their design, but the deliverables shall be in file formats compatible with ODOT's design software.

## 1103.2 Possible Digital File Formats

These are the various file types and formats that may be used in the digital handoff packages:

- **CAD (graphics)** – MicroStation design file (.dgn). Do not include CAD files in the Bid Reference Handoff package.
- **Horizontal control coordinates** – ASCII/text (.txt).
- **Elevations** – ASCII/text (.txt).
- **Horizontal and vertical alignments** – Text file (.txt); Geometry report (.xml or .html); LandXML (.xml) alignment; MicroStation design file (.dgn).
- **Superelevation** – superelevation diagram in MicroStation design file (.dgn); HTML (.html) report; text (.txt).
- **Existing ground surface** – LandXML surface (.xml); MicroStation design file (.dgn).
- **Proposed surfaces** – LandXML surface (.xml); MicroStation design file (.dgn).
- **Cross section data** – MicroStation design file (.dgn); Adobe PDF; cross section report (.xml, .html and .txt); spreadsheet (.xlsx).
- **Quantities**:
    - **Volume** – volume report (.xml or .html); MicroStation design file (.dgn); text (.txt); spreadsheet (.xlsx).
    - **Area** –surface area report (.txt); MicroStation design file (.dgn); text (.txt); spreadsheet (.xlsx).
    - **Linear** – MicroStation design file (.dgn); text (.txt); spreadsheet (.xlsx).

# Section 1104 3D Design Quality Control

Review of the 3D model is a part of the region quality control process. While the 3D model may be used for design analysis or as an aid to design review, the 3D model review should not be considered a design or a plan review. The purpose of the 3D model review is to ensure the integrity of the model and to verify that it agrees with other project documents. Review digital design data handoff packages prior to submission. Review at other design milestones may also be beneficial. Ideally, reviewers of the handoff packages have direct knowledge of construction methods and contract administration practices.

Provide the following information to the reviewer:

- Engineering files defining the 3D model:
    - Alignments.
    - Original ground surface.
    - Design surfaces.
    - Cross sections.
    - 3D models from other disciplines if available,
    - Pertinent information from other disciplines.
- Latest set of plan sheets (DAP, Preliminary, Advance, Final, Mylar).
- Quantity summary.

Reviews at design milestones have a different objective from reviews of the handoff packages. Milestone reviews focus on how well the model represents the designer's intent. The degree to which the model matches the designer's intent depends on the design stage and increases as the project progresses.

Handoff package reviews focus on the suitability of the digital data package for estimating or construction, respectively. Since an accurate representation of the design is essential to estimating and construction, the review focuses on the finer details of the model and composition of the digital design data package itself. There should be very few discrepancies or errors in the model when the Bid Reference Handoff package is due, which is at the time of contract advertisement.

Handoff package reviewers must check the following items:

- Alignments
    - Alignments match plans
    - Stationing matches plans

  - Alignment integrity is suitable
  - Alignment names match the names on plans
  - Only alignments used for final model included; no alternative or early versions
- Surfaces
  - Accurate triangulation
  - Suitable triangle density
  - Abutting finish grade surfaces match
  - Abutting subgrade surfaces match, if applicable
  - Design model surfaces and features tie into original ground
  - Features match plan
  - Component depths match typical section thicknesses
  - Constructability
  - Reasonable transitions between differing slope rates
  - Separate file for each surface
  - No gaps or overlaps
  - Constructible transitions at typical section changes and surface connections
  - Feature and component names consistent with naming convention
  - Components match typical sections
- Quantities measured from model match quantity summary
- Package Documentation
  - Notification letter (printed to pdf so fields are no longer fillable) with checklist and index attached
  - Handoff checklist
  - Computer file index
    - All project data is provided, including project geographic coordinate system
    - All files listed are included in package
    - All files included are listed in index
    - Files are sorted by data type
    - All files have descriptions

    - Corridor map index for complicated projects
- Cross Section Data
    - Project identified on all sheets
    - Alignment identified on all sheets
    - All components shown on each sheet and identified by legend or annotation
    - Key point labeled with name, offset and elevation
    - All surfaces falling within the cross section extent are shown
    - Cross sections spaced no more than 25 feet apart
    - Cross sections included at key stations (typical section changes, alignment cardinal points, drainage facilities, taper start and stop locations, guardrail or barrier ends, centerline of approaches, curb/pavement return points, and luminaire and signal pole locations)
    - Disclaimer on bid reference cross sections
- Drainage
    - Locations and inverts of drainage pipes and structures are shown
    - Earthwork adapted to accommodate drainage features – e.g., ditch deepened to match pipe invert