Let’s hit the road Jack! A BIM Workflow for Roads and Highways

Michelle Rasmussen – ASCENT

CI1646 This class will take you through an example workflow for a road and highway design project using the Autodesk Infrastructure Design Suite Ultimate 2014 software. We will start with Autodesk InfraWorks for the conceptual and preliminary design phases. Autodesk InfraWorks 360 will be used to perform vertical optimization of the road design. Then it will be moved into AutoCAD Civil 3D for the detailed design and construction documentation phases. Next, we will take the design into Autodesk Navisworks to perform clash detections and validate the design components coming from Autodesk Revit Structure and AutoCAD Civil 3D. Finally, the design will go back into Autodesk InfraWorks and into Autodesk 3ds Max Design to perform visual communication about the design to key stakeholders. Various types of analysis will be performed along the way to validate the design and insure design parameters are being met.

Learning Objectives
At the end of this class, you will be able to:

- Sketch layouts and create engineered roads of the proposed design in Autodesk InfraWorks.
- Create detailed design drawings inside AutoCAD Civil 3D.
- Analyze the design in Autodesk InfraWorks and Autodesk Navisworks Manage.
- Communicate the design visually with Autodesk InfraWorks and Autodesk 3ds Max Design.

About the Speaker
A specialist in the civil engineering industry, Michelle is a Senior Instructional Designer with ASCENT and is the first Autodesk® Certified Instructor (ACI) and Evaluator (ACE) worldwide for Civil 3D. Michelle started in the Air Force working in the Civil Engineering unit as a surveyor, designer, and construction manager. Her primary responsibility was to ensure proper grading of missile sites and tracking of base infrastructure.

Michelle has also served multiple years as an advisor to Autodesk on the Autodesk Authorized Training Center (ATC) Advisory Board and ATC Leadership Council where she served as Chair and Vice Chair. In her role, she advised Autodesk and other training centers how to make both the product and the product training more effective for end users.

mrasmussen@rand.com
Introduction
The Autodesk® Infrastructure Design Suite is a combination of powerful Building Information Modeling (BIM) software. It streamlines the workflow of infrastructure projects with a 3D model while reducing conflicts and changes during construction, reducing rework, producing better project outcomes, and improving productivity. This class takes you through an optimized workflow for road and highway design projects using the Autodesk Infrastructure Design Suite software. Students use the Autodesk® InfraWorks™, AutoCAD® Civil 3D®, Autodesk® Navisworks®, Autodesk® 360, AutoCAD® WS, and Autodesk® 3ds Max® Design software to complete a road design project from project planning through visual communication and construction scheduling.

Project Planning
Objective: Sketch layouts of the proposed design in Autodesk® InfraWorks™

Why Use A BIM Workflow for Roads and Highways?
Today’s infrastructure planners are expected to evaluate multiple design alternatives, recommend solutions, and help capture stakeholder buy-in before design begins. They do this with the help of Geographic Information System (GIS) professionals. Information is available from more sources than ever before, and GIS professionals need to be able to effectively aggregate and present the data in a way that is easily understood. Luckily, The Autodesk Infrastructure Design Suite provides tools to successfully access and gather the information needed.
Select the Appropriate Coordinate System for the Project

Of course, not all data that you receive from GIS professionals is in the same coordinate system. Some data may be in conical projection systems and other data may be in cylindrical projection systems. If we try to bring data together from various projection systems, we risk the data not lining up properly. That is why it is extremely important to communicate with whoever you get the data from and find out what projected coordinate system the data is in. Luckily, the Autodesk software has several projection systems available out of the box. It also has the ability to create additional systems manually. If you set the coordinate system of your project, then communicate to the software what system the source data is in, the software is able to automatically re-project data sources to line up with your project.

Configure Default Units for the Project

Setting the project coordinate system does not change the units you see in the model. Out of the box, the units for Autodesk® InfraWorks™ models is set to meters. Therefore, if you plan to work with feet, it is important that you change the model units. To change the units for the model, click (Application Menu), then (Options). In the left column, select Unit Configuration then change the unit as needed in the right column as shown below.

Figure 1 - Conical Projections

Figure 2 - Cylindrical Projections

Figure 3 - Application Option, Unit Configuration
How To: Create a New Model and Set the Coordinate System and Units

1. In the Application Menu, click [New].

2. Click [Browse] for the location and set it to C:/Autodesk Roads-Highways Workflow. Type NewTownCenter for the name. Select the Define Model Extent option. Type the following for the extents:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Y</td>
</tr>
<tr>
<td>Min.</td>
<td>346995</td>
</tr>
<tr>
<td>Max.</td>
<td>349968</td>
</tr>
</tbody>
</table>

3. Select Advanced Settings as shown below.

4. Select BritishNatGrid for the Coordinate Systems, as shown at the top of the next column.

5. Click [OK] to close the New Model dialog box.

6. Click [Application Menu] and click [Options] to set the units for the model.

7. In the Application Options, select Unit Configuration. Verify that the Default Units are set to Metric, as shown below.

8. Click [OK] to close the Application Options dialog box.
Effectively Aggregate Data of Various Types

Both Autodesk® InfraWorks™ and AutoCAD Civil 3D can integrate data from many different sources. Any model must start with surface or terrain data. Then you can add aerial images, road centerlines, parcel data, and many other important information sources. Two types of data sources can be added to the Autodesk® InfraWorks™ model. One is a file data source and the other is a database data source. The list below include all the data types that can be included.

File Data Sources
- 3D Model
- AutoCAD DWG
- Autodesk IMX
- CityGML
- LandXML
- Point Cloud
- Raster
- Revit RVT
- SDF
- SHP
- SQLite

Database Data Sources
- Oracle
- MySQL
- SQLServer Spatial
- WFS
- Generic (includes OSGEO, OGR, Autodesk, etc.)

Data Source Configuration

Once the data has been imported, it needs to be configured. In the Data Sources Explorer, select a data source and then click (Configure data source) to configure the data source. In the Data Source Configuration dialog box, give the data source a name, source, description, and type, as shown below.
Use Styles to Emphasize Differences Between Features Within the Same Data Source

Style Rules
Style rules automatically change the way an individual feature looks based on an expression. The expression can use a location to stylize features in a specific area of the model or a value from the source data’s properties. Each class of features is stylized separately.

Style Overrides
Styles are usually assigned to an entire layer or a style rule is used to specify how features display. However, different styles can be assigned to individual features to make them stand out. In addition, a different style can be assigned to one part of a feature if needed. For example, a building can have a specific style according to the type of building it is defined as in the database. All four sides of the building look the same. If you need to change the way one side looks, you can drag and drop a style from the Style Palette to the required side. Doing so overrides any rules or previously set style overrides.
How To: Import and Configure Data for Proper Display

**Import/Configure Data Sources.**

1. If the Data Sources palette is not displayed, click (Data Sources) in the Home tab>Import panel.

2. In the Data Sources palette, expand (Add file data source) and select **LandXML**.

3. Select **Danville SiteLiDAR.xml** in C:\Autodesk Roads-Highways Workflow\Existing Conditions and click **Open**.

4. In the Data Sources palette, double-click on **Danville Site LiDAR.xml** to open the Data Source Configuration dialog box.

5. In the Data Source Configuration dialog box, set the Coordinate System to **BritishNatGrid**, as shown below.

6. Leave all of the other settings as the default and click **Close & Refresh** to close the dialog box.

7. In the Data Sources palette, expand (Add file data source) and select **Raster**.

8. Browse to C:\Autodesk Roads-Highways Workflow\Existing Conditions\Images, press <Ctrl>+<A> to select all of the images, and click **Open**.

9. In the Data Sources palette, double-click on the **Images** layer to open the Data Source Configuration dialog box.

10. In the Data Source Configuration dialog box, in the Geo Location tab, set the Coordinate System to **BritishNatGrid**.

11. Leave all of the other settings as the default and click **Close & Refresh** to close the dialog box.

Next you will add the .SDF files, which include buildings. The **Buildings** layer contains the number of stories for each building listed. When you configure the building’s data source, you will set the height of the buildings according to the number of stories. To do so, you will multiply the stories by 3.1 giving an average of more than three meters per story to each building.

12. In the Data Sources palette, expand (Add file data source) and select **SDF**.

13. Browse to C:\Autodesk Roads-Highways Workflow\Existing Conditions\, select **Danville_Buildings**, hold down <Shift>, and select **Underground Utilities**. All three .SDF files should be selected. Click **Open**.

14. In the Data Sources palette, double-click on the **Danville_Buildings** layer to open the Data Source Configuration dialog box.

15. In the Data Source Configuration dialog box, select **Buildings** for the Type. In the Common tab, select the **Expression Editor** next to **Roof Height**, as shown on the next page.
16. In the Roof Height Expression Builder dialog box, expand Property and select Stories, as shown below.

17. For the Operator, select * (Multiply) and type 3.1 for the value, which sets each story to be 3.1 meters in height. Click OK to close the Roof Height Expression Builder dialog box.

18. In the Geo Location tab, set the Coordinate System to BritishNatGrid.

19. In the Source tab, select Drape for the Draping Options, as shown below.

20. Leave all of the other settings as the default and click Close & Refresh to close the dialog box.

21. In the Data Sources palette, double-click on the Danville_Water layer to open the Data Source Configuration dialog box.

22. In the Data Source Configuration dialog box, select Water Areas for the Type.

23. In the Geo Location tab, set the Coordinate System to BritishNatGrid.

24. In the Source tab, select Drape for the Draping Options and select the Convert closed polylines to polygons option.

25. Leave all of the other settings as the default and click Close & Refresh to close the dialog box.

26. In the Data Sources palette, double-click on the Underground Utilities layer to open the Data Source Configuration dialog box.

27. In the Data Source Configuration dialog box, select Pipelines for the Type.

28. In the Geo Location tab, set the Coordinate System to BritishNatGrid.

29. Leave all of the other settings as the default and click Close & Refresh to close the dialog box.

30. In the Data Sources palette, expand (Add file data source) and select SQLite.

31. Browse to C:\Autodesk Roads-Highways Workflow\Existing Conditions and select Existing Road Centerlines. Click Open.

32. In the Data Sources palette, double-click on the Existing Road Centerlines layer to open the Data Source Configuration dialog box.
33. In the Data Source Configuration dialog box, select **Roads** for the **Type**.

34. In the *Geo Location* tab, set the *Coordinate System* to **BritishNatGrid**.

35. In the *Source* tab, select **Drape** for the *Draping Options*, as shown below.

36. Leave all of the other settings as the default and click **Close & Refresh** to close the dialog box.

### Stylize data sources.

Now that the data is in the model, you need to change the style of the buildings to make them look more realistic. You will do this with the style rules and style overrides.

1. In the *Home* tab>*Stylize Model* panel, click **(Style Rules)** to open the Style Rules palette.

2. Select the *Buildings* tab to make it current.

3. In the Style Rules palette, click **(Add a new empty rule of the current rule type)**. In the Add Style Rule dialog box that opens, type **Single-Family** for the name, as shown below. Click **OK**.

4. In the Style Rule palette, select the new rule. Click **(Edit properties of the currently selected rule)**. The Rule Editor dialog box opens.

5. Under *Expression*, click **(Edit)** to open the Create Filter Expression dialog box.

6. Click **(Property)** and select **ROOF_HEIGHT**.

7. Click **(Operator)** and click **=** (Equals).

8. Click **(Get Values)**. Select **ROOF_HEIGHT** for the values to list. Click **(Get Values)** again to display the list.

9. Double-click on the 3.1 value to force it to populate the expression, as shown below. Click **OK**.

10. Under *Styles* in the Rule Editor, click **(Add an existing style)**. Select **Concrete & Glass** for the *Facade*, and select **Anviragus** for the style, as shown on the next page. Click **OK**.
11. Click OK again to close the Rule Editor dialog box.

12. Repeat Steps 3 to 11 to create four more rules with the parameters listed below. Note that the Appartments uses the OR conditions operator and that the Offices operator is greater than or equal to.

Name: Multi-Family
Expression: ROOF_HEIGHT=6.096
Style: Façade/Brick/Dercetas

Name: SmallBusiness
Expression: ROOF_HEIGHT=9.144
Style: Façade/Brick/Blackbird

Name: Appartments
Expression: ROOF_HEIGHT=12.192
OR ROOF_HEIGHT=15.24
Style: Façade/Brick/Aegeon

Name: Offices
Expression: ROOF_HEIGHT>=30.48
Style: Façade/Metal & Glass/Scaffold

13. At the bottom of the Style Rules palette, click (Refresh) to update the view with the new styles.


15. In the ViewCube, click (Home), and then zoom in using the scroll wheel to the area shown below.

16. In the model, hold down the left mouse button to orbit the view until it displays as shown below.

17. In the Home tab>Stylize Model panel, click (Style Palette).

18. In the Style Palette, select the Facade tab to set it to be current. Double-click on Marble & Stone to display the available styles.

19. Click and drag the Boomslang style from the style palette and drop it onto the Governor’s Mansion, as shown below.

20. Close the Style Palette and close the file.
Managing Proposals

Proposals provide a way to explore multiple design alternatives within the same model. By default, every model has a Master proposal. The Master proposal is the base model. It is recommended that you only populate the Master proposal with existing data. Once a base model has been created and existing data imported, the next step is to create a proposal for each conceptual design you want to explore. After multiple proposals have been created, they can be compared to each other and analyzed to find the best alternative. Elements from complimentary proposals can also be merged to create the best design alternative when necessary.

Sketch the Conceptual Design Using the Create Roads Tool

Using sketch tools, you can add roads, rail lines, buildings, bodies of water, landscaped regions, coverage areas, and city furniture to your model. Sketches can be displayed as 3D models or 2D drawings, as shown below.

To sketch a road, you first have to turn on the Draw Strip by clicking 🇬🇧 (Create/Edit Features) on the Tool Strip. Then hover over 🇬🇧 (Create/Design Roads) on the Draw Strip and select 🇬🇧 (Create Roads) from the flyout tools. The first time using this tool, you should be prompted to select a road style. After selecting a style, click in the model where you want the road to begin, click again for each point of intersection (PI), then double-click to end the sketch where you want the road to end.

Adjust Sketched Roads

After a road is sketched into the model, it is likely that it will need to be edited. There are a number of ways to adjust sketched roads all of which require that you select the road first. To select a road you must click 🇬🇧 (Edit Existing Features) on the Draw Strip. Once selected, a right-click allows you to do any of the following:
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<table>
<thead>
<tr>
<th>Icon</th>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Add Vertex" /></td>
<td>Add Vertex</td>
<td>Adds a point of intersection at the point at which you right-clicked.</td>
</tr>
<tr>
<td><img src="image" alt="Remove Vertex" /></td>
<td>Remove Vertex</td>
<td>Removes the point of intersection on which that you right-clicked.</td>
</tr>
<tr>
<td><img src="image" alt="Split Feature" /></td>
<td>Split Feature</td>
<td>Breaks the road at the point at which you right-clicked.</td>
</tr>
<tr>
<td><img src="image" alt="Properties" /></td>
<td>Properties</td>
<td>Opens the Properties palette in which you can change the style, number of lanes, elevation offset, etc.</td>
</tr>
</tbody>
</table>

Gizmos (Grips) can also be used to make quick edits to features in the model. Different gizmos appear depending on the camera angle of the current view. To see plan view gizmos, the camera view must be less than 45 degrees. To see vertical gizmos, the camera view must be greater than 45 degrees. The table below shows each gizmo and a description of what it does.

<table>
<thead>
<tr>
<th>Gizmos</th>
<th>Transformation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Elevation" /></td>
<td>Elevation</td>
<td>Used with linear features, such as roads, railways, and coverages. In a 3D View, it stretches features vertically by changing the elevation of a linear feature vertex.</td>
</tr>
<tr>
<td><img src="image" alt="Height" /></td>
<td>Height</td>
<td>Only used with buildings, city furniture, and trees. Changes the height of a building while leaving the footprint as is. Changes the scale of trees and city furniture proportionally.</td>
</tr>
<tr>
<td><img src="image" alt="Rotate" /></td>
<td>Rotate</td>
<td>Rotates a feature around the Z-axis.</td>
</tr>
<tr>
<td><img src="image" alt="Control Point" /></td>
<td>Control Point</td>
<td>Displays at each corner, point of intersection, or base of features. Stretches linear features (roads, rails, coverages, and building outlines) by moving the selected vertex of the feature. Moves the location of point features (trees or city furniture). Additional control points can be added by holding down &lt;Alt&gt; and selecting the new control point location.</td>
</tr>
<tr>
<td><img src="image" alt="Move" /></td>
<td>Move</td>
<td>Move the selected feature or vertex.</td>
</tr>
</tbody>
</table>
How To: Create a Proposal and Sketch Conceptual Roads

Create a Proposal

1. Open **CR-3A-Sketches.sqlite** from **C:\Autodesk Roads-Highways Workflow\CreateRoads**.

2. In the **Home** tab>Location Bookmarks panel, click (Bookmarks) and select **Governors Mansion**.

3. In the **Home** tab>Design panel, click (Proposals) to open the Proposals palette. Note that buildings, pipelines, and water features have already been added to the master proposal (base model) as shown below. These were added when the existing conditions base map was created.

4. In the Proposals palette, click (Add new proposal). In the Add New Proposal dialog box, type **EastAccess**. Click **OK**.

Sketch a conceptual road design.

1. In the Tool Strip, click (Create/Edit Features). The Draw Strip displays at the top of the model.

2. In the Draw Strip, hover over (Create/Design Roads). In the flyout, click (Create Roads [Roads]).

3. If the Style palette does not display, in the Draw Strip, click (Create Roads) slowly, twice. In the flyout, click (Select Style).

4. In the Style palette, in the **Roads** tab, expand the Street list and select **Sidewalks with Lamps** as shown below.
5. In the model, sketch a road from the north side of the roundabout, crossing the river, as shown below. Double-click to end the road sketch.

Modify a conceptual road design.

In this task you will modify the new road sketch to ensure that it falls in an existing right-of-way. You will also split the sketch to create a bridge over the river.

1. In the model, use the road sketch gizmos to modify the layout of the sketched road so that it goes just past the existing center line, as shown below. This will cause it to line up with intersection without extending past the existing curb and gutter.

2. With the road sketch still selected, right-click near the southern-most dirt road north of the river, as shown below. Click (Split Feature) in the flyout.

Note that the curve near the northern split has changed. With a sketched
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road, you cannot change the curve radius.

3. In the Home tab>Explore panel, click Properties.

4. Select the middle section of the road. In the Properties palette, select the Manual Style value and click (Browse), as shown below.

5. In the Style palette, expand the Street/Interstate list and select Bridge General, as shown below. Click OK.

6. In the Properties palette, click to force the new style to take effect.

7. In the Home tab>Location Bookmarks panel, click (Bookmarks) and select Bridge Elevation.

8. Select the blue elevation grip in the center of the bridge to change the elevation, as shown below.
Preliminary Design

Objective: Create engineered roads of the proposed design in Autodesk® InfraWorks™

Differences Between Design and Sketch Roads
Design roads and sketch roads each have their benefits. Sketch roads are used to quickly see how a road will look in the model without having to worry about design constraints like tangent lengths, curve radii, or design speed. They also allow you to split the road into multiple sections and use different styles for each section. The drawback to using sketch roads is that they are splines and go into AutoCAD Civil 3D as such.

Design roads provide a way to add design constraints to a road. The design constraints that can be used include setting the tangent lengths, curve type and radius, and design speed. If you have the Infrastructure Design Suite Ultimate, you can also optimize the design road to balance cut and fill quantities. The most beneficial aspect of using design roads is the fact that they transfer into AutoCAD Civil 3D without losing the design constraints. When moved to AutoCAD Civil 3D, they become AutoCAD Civil 3D alignment and profile objects. Thus reducing any rework between preliminary design and detailed design phases of the project.

Design Speeds
The required design speed is determined by the type of road being designed and where it is located. For example, residential roads often have a design speed of 25 to 30 miles per hour unless the road passes in front of a school. In that case, the design speed is slower for the safety of the children at the school. On the other hand, freeways are meant to provide a faster mode of transportation and higher traffic volumes. Therefore, their design speeds might vary between 50 miles per hour and 85 miles per hour, depending on the location and the number of curves required to stay within the right-of-way. In the Autodesk® InfraWorks™ software, the default design speed is determined by the type of road selected. The types of engineered roads and their default design speeds are as follows:

<table>
<thead>
<tr>
<th>Icon</th>
<th>Road Type</th>
<th>Default Design Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Freeway Icon]</td>
<td>Freeway</td>
<td>70 mph or 110 km/h maximum</td>
</tr>
<tr>
<td>![Arterial Icon]</td>
<td>Arterial</td>
<td>50 mph or 80 km/h maximum</td>
</tr>
<tr>
<td>![Collector Icon]</td>
<td>Collector</td>
<td>40 mph or 60 km/h maximum</td>
</tr>
<tr>
<td>![Local Icon]</td>
<td>Local</td>
<td>30 mph or 45 km/h maximum</td>
</tr>
</tbody>
</table>
**Setting Curve and Tangent Constraints**

The design speed property of a road determines the default criteria used for parameters, such as the tangent length, spiral length, and minimum and maximum curve radius. As you create the design road, you have the option to adjust the type of curve being used and its radius within set parameters determined by the design speed, as shown below.

![Figure 9 - Design Road Curves](image)

**Modify Design Roads**

Design roads can be edited using a variety of methods. As with sketched roads, design roads have gizmos that can be used to modify the design. You can also use design road properties and a profile view to modify the road, as shown below.

![Figure 10 - Design Road Gizmos](image)

**Vertical Optimization**

Vertical optimization is used to automatically compare costs and environmental impacts on multiple vertical designs. Once the rough horizontal and vertical design geometry has been drawn in the model, vertical optimization can be calculated to produce multiple vertical design options based on parameters that you enter in the calculator. The optimization parameters that can be entered include design speed, minimum and maximum grades, and PVIs that must remain at a fixed station and elevation. In addition, you can attempt to keep construction costs down by adding borrow and waste pits along the corridor to reduce mass haul charges. The Autodesk® InfraWorks™ 360 optimization services are used for the calculations.
How To: Create Design Roads and Optimize the Design

Create design roads.

1. In the Home tab>Location Bookmarks panel, click \( \text{Bookmarks} \) and select \textbf{PrelimDesign}. In the Tool Strip, click \( \text{Create/Edit Features} \) to display the Draw Strip.

2. In the Draw Strip, hover over \( \text{Design or Create Roads} \), and click \( \text{Design Roads [Collector]} \).

3. In the Draw Strip, click \( \text{Design Roads} \) slowly, twice. This will display all of the road styles that have been used so far in this session. Click \( \text{Select Style} \), as shown below.

4. In the Select Style dialog box, select \textbf{Boulevard with Summer Hardwood}, as shown below. Click \text{OK}.

5. In the model, click the starting point for the road just north of the new office buildings, as shown below. This will eventually be a four-way intersection with through lanes and right turn lanes.

6. In the model, move the cursor due west of the new intersection. Type \textbf{120} to set the length and click in the model, as shown below.

7. In the model, move the cursor toward the second PI without clicking. A default Spiral Curve Spiral is placed in the model. Right-click and select \textbf{Curve}.

8. In the model, place the cursor so that the new road follows the existing dirt
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road. Type **372** to set the length and click in the model, as shown below.

9. In the model, place the cursor so that the road centerline touches the power line shadow, as shown below. Type **378** to set the length and click in the model.

10. In the model, place the cursor so that the road centerline touches the intersection of the two dirt roads, as shown below. Type **274** to set the length and click in the model.

11. In the model, place the cursor so that the road centerline aligns with the centerline of the south road, which is a three way intersection, as shown below. Type **420** to set the length and click in the model.

12. Right-click and select **End Draw**.
Run a vertical optimization.


2. In the Quick Access Toolbar, click and select Sign In to Autodesk InfraWorks 360.

3. In the Autodesk Account Sign In dialog box, type your user name and password, as shown below. If you do not have an account, select Need an Autodesk ID? to create a new account.

4. Click Sign In.

5. In the Optimize tab>Corridors panel, click (Vertical Optimization).

6. In the model, select the Road - (4452) design road.

7. In the model, select the Road - (4452) design road.

8. In the Corridor Vertical Optimization palette, expand the Advanced Settings area.

9. In the Optimize tab>Corridors panel, click (Vertical Optimization).

10. In the Construction & Earthworks Costs Settings dialog box, edit the values in the Unit Price column according to the local market prices, as shown in next column.
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10. Set the Maximum Grade to 9 and the Minimum Tangent Length to 37.5. Then select PVIs 1, 4, and 6 to anchor, as shown below.

11. In the Corridor Vertical Optimization palette, click to optimize.

12. You are prompted that The data package has been sent out for vertical optimization. Click OK.

13. In the Optimize tab>Corridors panel, click (Job Monitor) to review the jobs that have been submitted. (Depending on the number of jobs submitted, the optimization calculations might take a while. Therefore, a .PDF file of the results is included with the Class Files. This enables you to complete Step 14 by opening Optimization.pdf in the DesignRoads folder in the Class Files folder. Steps 15 and 16 might need to be completed later after the optimization has finished in the background.)

14. Click (Download Optimization Report) in the Report column to display the results of the optimization in the form of a .PDF report, as shown below.

15. Click (Create a Proposal) in the Results column to create a proposal in the model and import the results to display the results of the optimization as a 3D design road.

16. A dialog box should open, prompting you that To display the result, a new proposal will be created. Do you want to continue? Click Yes.

Since Vertical Optimization calculates the rough cost of the project based on cut and fill balancing, note that the parts of the road before and after the bridge have an enormous amount of cut. A better way to handle this situation is to create three separate roads for vertical optimization and visualization purposes until Autodesk incorporates the ability to accommodate multiple styles within one road into the design roads functionality. Therefore, a separate proposal has been created for the visualization and analysis tasks in the following practice. If you plan to take the design roads into the AutoCAD® Civil 3D® software for detailed design, one long corridor model is recommended.
Detailed Design

Objective: Create detailed design drawings inside AutoCAD Civil 3D

Move the Design to AutoCAD Civil 3D Software
Once you have created and selected the preliminary design to move forward with, it is time to create the more detailed design. This involves taking the design from the Autodesk® InfraWorks™ software into the AutoCAD® Civil 3D® software. In the AutoCAD Civil 3D software, you gather more detailed existing conditions by importing the survey data. You then make any required adjustments to the alignments and profiles that came from the Autodesk® InfraWorks™ software.

Before you can import the roads into AutoCAD Civil 3D, you must launch the Autodesk® InfraWorks™ software and export the design roads to an .IMX file. When exporting the model, you can select a bounding box or polyline to export a portion of the model or you can export the entire model. It is recommended that you use a bounding box or polyline, as shown to the left, to reduce the file size and save time during the import process in the AutoCAD Civil 3D software. Reason being, if you take the entire model, you include all the existing data sources used to create the base model. It is better to connect that data to the AutoCAD Civil 3D model using the AutoCAD Map 3D commands found in the Planning and Analysis toolspace. The Data Connect command in the Planning and Analysis toolspace allows you to connect to the data rather than import it so that the drawing size is reduced and the stability of the drawing improved.

To take advantage of an .IMX file in the AutoCAD Civil 3D software, in the Insert tab>Import panel, click (Import IMX). Browse for the file in the dialog box that opens and click . Any roads that were created using the Design Roads tool inside Autodesk® InfraWorks™ turns into an alignment and a finish ground profile inside AutoCAD Civil 3D.

Create the Corridor and Detailed Design Drawings
Due to the short length of this class, we will not go into the details on how to do this in this class. Just make sure that you understand how to add additional baselines (alignments) regions (assemblies), and targets (transitions and daylights) to your corridor so that you have a complete model. Then you can round trip the model back into Autodesk® InfraWorks™ so that you can show stakeholders what the design will look like in a model that is much easier for the general public to understand.
How To: Take the Design into AutoCAD Civil 3D

Export an IMX file.

In this task you will import an .IMX file from the Autodesk® InfraWorks™ software to take advantage of the preliminary design road alignments and profiles.

1. Launch the Autodesk® InfraWorks™ software.

2. Open PreliminaryDesign.sqlite from C:\Autodesk Roads-Highways Workflow\DetailedDesign.

3. In the Quick Access Toolbar, expand Proposals and select Preliminary Design.

4. Expand (Application Menu) and select Export>IMX file, as shown below.

5. In the Export to IMX dialog box, select Polygon for the extents to use, as shown below.

6. In the drawing, draw a polyline around the preliminary design road, as shown below. Double-click to complete the polyline.

7. In the Export to IMX dialog box, set the Target Coordinate System to BritishNatGrid and define the Target File name and location, as shown below. Click Export.

Import an IMX file.

1. Open the AutoCAD Civil 3D software.

3. In the Prospector tab, expand Surfaces, Alignments, and Sites>Survey Site>Alignments. Note that only the Existing Ground surface is listed, as shown below.

4. In the Insert tab>Import panel, click ![Import IMX](image).

5. In the IMX File Selection dialog box, select **DesignRoads.imx** in **C:\Autodesk Roads-Highways Workflow\DetailedDesign** and click ![Open](image).

6. In the Prospector tab, expand Surfaces, Alignments, and Sites>Survey Site>Alignments. Note that multiple surfaces, alignments, and a profile have been imported, as shown below.

7. Save the drawing.
Objective: Analyze the design in Autodesk® InfraWorks™ and Autodesk Navisworks Manage

*Analyze the Design in Autodesk Navisworks Manage software*

The Autodesk Navisworks Manage software makes design review much easier. It provides interactive visualization and real-time walkthrough of 3D models, from simple to complex. This makes it easy to navigate and explore the design to improve quality and compress the review process.

The post-production value of 3D models is significantly increased by the wide-ranging access that the Autodesk Navisworks Manage software offers for investigating and examining a design. The Autodesk Navisworks Manage software includes file readers that support a variety of CAD file formats and laser scan file formats. When you open a CAD file in the Autodesk Navisworks Manage software, the appropriate file reader is used automatically. If necessary, you can adjust the default file reader settings to improve the conversion quality. Once opened, the file can be saved in an Autodesk Navisworks Manage format.

*Perform Clash Detection*

The Autodesk Navisworks Manage Clash Detective identifies, inspects, and reports interference clashes in a 3D project model. Clash Detective can automate the manual task of checking for clash errors. You can use it for a quick check of design work that an engineer has just completed or for an ongoing audit check of the project by the project coordinator. You have the ability to one of three Clash types in the Type pull-down menu, as shown below:

![Clash Types Diagram]

*Figure 12 - Clash Types*

**Hard**: Where two objects actually intersect.

**Clearance**: Where two objects come within a specified distance of each other.

**Duplicates**: Where two objects are identical, both in type and position.
How To: Perform a Clash Detection in Autodesk Navisworks Manage

Combine Autodesk Revit Structure and AutoCAD Civil 3D files.

You might need to change the File of type to Autodesk DWG/DXF files.

1. In the Quick Access Toolbar, click (Open) and open C:\Autodesk Roads-Highways Workflow\Navisworks\NAV-B1-Civil.dwg.

If the file displays the AEC objects correctly, skip to Step 6. If the AEC objects are displayed as boxes, use the following steps to import NAV-B1-Civil.dwg into the Autodesk Navisworks Manage software:

2. In the AutoCAD Civil 3D software, open NAV-B1-Civil.dwg.

3. In the Command Line, type NWOut.

4. In the Export to Autodesk Navisworks Exporters dialog box, type NAV-B1-Civil and click the Save button.

5. In the Autodesk Navisworks Manage software, open NAV-B1-Civil.nwc (change the file type to Navisworks Cache (*.nwc).

You might need to change the File of type to Autodesk Revit Structure files.

6. In the Home tab>Project panel, click (Append) and select Bridge.rvt from C:\Autodesk Roads-Highways Workflow\Navisworks. Click Open.

Check and set the file units.

1. Continue working from the file from the previous task or open NAV-B2-

Civil.nwf from C:\Autodesk Roads-Highways Workflow\Navisworks.

Once a Measure tool has been selected, it remains in this mode until another Navigation Mode is selected. If measuring an object that is larger than the current Autodesk Navisworks Manage view, select the first point, navigate to another part of the model, and select the next point.

2. In the Review tab>Measure panel, expand Measure and click (Point to Point).

3. Select a point at the left edge of the bridge and a second point at the right edge of the bridge to measure its width, as shown below.

The bridge should be approximately 19 meters wide. However, the distance between the two points is only 0.02 meters. This is because the default unit settings are not set correctly for this model.

4. In the Measure panel, click (Clear) to remove the measure lines from the view.

5. Expand (Application Menu) and click Options. In the Options Editor dialog box,
expand Interface and select Display Units.
6. In the Options Editor dialog box, in *Linear Units* field, verify that Meters is selected. For the *Decimal Places*, verify that 2 is selected, as shown below, and click OK.

7. In the Selection Tree, right-click on NAV-B1-Civil.dwg and select Units and Transform.
8. The file is currently set to Millimeters, change it to Meter, as below, and click OK.

The bridge from the Autodesk Revit Structure file also needs to be corrected. Since the Autodesk Revit Structure software usually has the model close to the origin rather than at its real world coordinates, the origin also needs to be corrected to line up it up properly.
9. In the Selection Tree, right-click on Bridge_Final.rvt and select Units and Transform.
10. The file is currently set to Millimeters, change it to Feet. For in the *Origin*, type 348148,313450,0. Select the *Reflected transform* option as below, and click OK.

11. In the Selection Tree, select Bridge_Final.rvt. In the Navigation Bar, select *Zoom Selected* as shown below.

The bridge from the Autodesk Revit Structure file also needs to be corrected.
Conduct the Clash Test.

1. In the *Home* tab>Tools panel, click "Clash Detective".

2. In the Clash Detective dialog box, select **Add Test** at the top right.

3. For the **Name**, type **PipesVsBridge**.

4. In the **Selection B** pane, select **Bridge_Final.rvt**. In the **Selection A** pane, expand **NAV-B1-Civil (.dwg or .nwc)**. Hold down <Ctrl> and select **C-SSWR-PIPE**, **C-SSWR-PROF**, and **C-SSWR-STRC**, as shown to the right.

   Click **Run Test**.

   **One clash is reported that needs to be resolved.**
Move the Design back to Autodesk® InfraWorks™ Software

To round trip files back to Autodesk® InfraWorks™ software, .IMX files are used. You can export the following elements from the AutoCAD Civil 3D software for use in the Autodesk® InfraWorks™ software:

- **Surfaces:** Existing ground and finish ground surfaces become terrain surfaces.
- **Alignments and Profiles:** (Not associated with a corridor.) Become road centerlines on import into the Autodesk® InfraWorks™ software.
- **Corridors:** Become road centerlines and coverage areas. (Only one centerline alignment is exported, others associated with the corridor are ignored. If more than one corridor model exists, only one corridor centerline alignment can be used for stylizing roads if Autodesk® InfraWorks™ styles are going to be used. Therefore, it is important to create one corridor model with multiple regions before exporting to .IMX.)
- **Pipe Networks:** Become pipes and pipe connectors.

Once you have imported design elements, it is important to configure them for display. You have two road options when configuring corridors for display. You can use a native Autodesk® InfraWorks™ road style or you can use the AutoCAD Civil 3D regions or top surface, as shown below. Using the corridor regions instead of the top surface provides a higher level of detail to making sure you notice curbs, medians, and other raised or lowered areas.

**Analyze the Model Visually**

The project location and time of day and/or year can be set to help you understand how shadows affect the design. For example, buildings or vegetation might cast longer shadows over a bridge or parking lot in the winter causing excess ice to form. As a result, this might cause an increase in traffic accidents. Running a shadow analysis is done by toggling on Shadows in the Visual Effects tab>Appearance panel.
How To: Analyze the Model in Autodesk® InfraWorks™

Perform a sun/shadow study.


2. In the Proposals palette, set the proposal to WestAccess because this is the only route that accommodates river traffic under the bridge.

3. In the Visual Effects tab>Appearance panel, select Shadows and Ambient Occlusion.

4. In the Visual Effects tab>Sun & Sky Settings panel, set the date to 12/31/2013. Slide the Time back and forth and note how the shadows change throughout the day. Note that the bridge remains in the building shadows throughout the morning commute, as shown below. This might cause a problem with ice on the steep road segment coming off the bridge.

Perform a line of sight study and create images from a specific location.

The view from the Governor’s Mansion historic site is a major concern. In this task, you will perform a line of sight study and create an image from the specified location.

1. In the Home tab>Location Bookmarks panel, click (Bookmarks) and select GovernorsView so that you are looking out the window of the Governor’s Mansion in the direction shown below.

2. In the Analyze tab>Line of Sight panel, click (Select Visible). Note the items that are selected.

3. In the Present tab>Imagery panel, click (Snapshot).

4. In the Camera Snapshot dialog box, set the file name and location.

5. Set the resolution that you want to use, as shown below.

6. Click .

7. Open the image file that was created to ensure that it is correct.
Visual Communication

Objective: Communicate the design visually with Autodesk® InfraWorks™ and Autodesk 3ds Max Design

Ensure Buy In of All Stakeholders
Using visualization tools to better communicate the project results early in design can end up saving millions upon project completion. The Legacy Parkway in Utah is an 11.5 mile four-lane freeway that cost tax payers $685 million due to multiple construction delays from a lawsuit that halted construction over environmental concerns. We learned from this project how extremely important it is to get buy in for the project from all stakeholders throughout the design process.

Render Images
Stake holders, like those who are directly affected by the new road design, often want to know what the new transportation corridor is going to look like from a certain point of view. For example, neighboring residence might want to see what it is going to look like from their back yard. You can create images from any view in the model. Zoom in on the required area in the model and orbit around the corridor until the camera is looking in the required direction. Use the navigation controls in the View tab>Navigate panel to set the camera elevation and angle. Then in the Present tab>Imagery panel, click (Snapshot) or (Render) depending on the type of image you need to create. Taking a snapshot create an image that resembles what you see in the view. Rendering the view creates a more realistic image, as shown below.

Figure 17 - Snapshot
Figure 18 - Rendering

Storyboards
Storyboards enable you to capture and compile views of the model to create a slideshow. The slides can follow a specific camera path to simulate driving down a new road or accessing neighboring businesses and/or residences. You can specify the transition between each shot and the camera speed. You can also add notes or captions to the slides to indicate specific points of interest in key frames. Multiple captions can be added to a single slide. To access the storyboards, click (Storyboards) in the Present tab>Storytelling panel. The Storyboards
panel should display at the bottom of the model window, as shown below. When playing the storyboard, the model window displays the current storyboard snapshot.

![Image of a model window with a storyboard panel highlighted](image)

*Figure 19 - Storyboards*

**Export a Storyboard to Video**
Sharing storyboard files with other users is helpful if they have the Autodesk® InfraWorks™ software and can play the storyboard. However, having a license for every user is not always cost effective or necessary. If you need to share a storyboard with a user who does not have the Autodesk® InfraWorks™ software, you can create a video of the storyboard by exporting it to video.
Let’s hit the road Jack! A BIM Workflow for Roads and Highways

How To: Communicate the Design with a Storyboard

Create a rendered image.

1. Open VIZ-B1-Civil.sqlite from C:\Autodesk Roads-Highways Workflow\Visualization.

2. In the Present tab>Imagery panel, click (Render)

3. In the Render Model dialog box, set the Exposure Settings and the Sun/Sky Settings (as shown below), and click (Start Render).

4. In the Render Model dialog box, click (Stop Render) once the image displays correctly (usually after 30 or more seconds).

5. Click (Save) to export the image.

Create a storyboard.

1. In the Present tab>Storytelling panel, click (Storyboards).

2. In the Storyboard panel toolbar, expand (Add Camera Path) and select Create from Design Road, as shown in the next column.

3. Select the design road ending at the new town center, as shown below.

4. In the animations and path area, select the last key frame. In the Storyboard panel, in the Setting area, click (Go to thumbnail view), as shown below.

5. In the Storyboard panel toolbar, expand (Add Animation) and select Add Crane Animation, as shown below.
6. In the Home tab>Location Bookmarks panel, click (Bookmarks) and select AddLookAround. In the Storyboard panel toolbar, expand (Add Animation) and select Add Look Around Animation, as shown below.

7. In the Storyboard panel, click (Play Current Storyboard).

---

3. Select Storyboard.json and AddToScenario.json in C:\Autodesk Roads-Highways Workflow\Visualization and click Open.

4. In the Storyboard palette, select a storyboard and click (Play the current Storyboard). Select the next storyboard and click (Play the current Storyboard) to view it as well.

5. In the Storyboard palette, select your favorite storyboard and click (Export current Storyboard to Video).

   - In the Export Storyboard dialog box, select Windows Media Video for the encoder.
   - Set the File name and location.
   - Set the video resolution to 25.00 frames per second, as shown below.
   - Click Record.

---

Create a video from a storyboard.

In this task, you will import two storyboards that were created earlier in the design process in other files. The designer that created them has already exported them for you. After importing them, view each one and select the storyboard that you want to export to a video.

1. In the Present tab>Storytelling panel, click (Storyboards).

2. In the Storyboard palette, click (Import existing Storyboards).
**Take the Design into Autodesk 3ds Max Design**

While the Autodesk® 3ds Max® Design software has a robust 2D and 3D modeling system, many users find it most efficient to link or import some or all of their design data from other applications. This is especially the case if the bulk of the design work is completed in other Autodesk software, such as AutoCAD Civil 3D. It is recommended that you import 3D ground surfaces from Civil/Survey products, such as AutoCAD Civil 3D using the vsp3d data format. The import process involves using Civil View in Autodesk 3ds Max Design.

Note: Civil View is available only in the Autodesk 3ds Max Design software.
How To: Visualize the Design in Autodesk 3ds Max Design Software.

### Create the .VSP3D File in AutoCAD Civil 3D

1. In the AutoCAD Civil 3D software, open the `SiteDesign.dwg` file in `C:\Autodesk Roads-Highways Workflow\3dsMax`.

2. In the Output tab>Export panel, click ![Export to Civil View for 3ds Max Design](image)

3. In the Export to Civil View for 3ds Max Design dialog box, make sure everything is selected in the left column, and shown below. Click ![Export](image)

4. When it is done processing, you should see the export details in the Export to Civil View for 3ds Max Design dialog box, as shown below. Click ![Close](image)

### Initialize Civil View.

The import process involves using Civil View in Autodesk 3ds Max Design. You only have to initialize Civil View once.

1. Open the Autodesk 3ds Max Design software.

2. In the Menu bar, select Civil View>Initialize Civil View to initialize Civil View.

3. In the Initialize Autodesk Civil View dialog box, set the System Unit to Feet because the civil project that you will be opening uses Feet as its unit of measurement. Verify that Don’t warn me about System Units again is selected.

4. In the Select a Country Resource Kit area, select US IMPERIAL and verify that Start Mode for Civil View is set to Manual. Click ![OK](image)

5. Restart the Autodesk 3ds Max Design software.
Hint: Starting Civil View

Once you have initialized Civil View, the next time you launch the Autodesk 3ds Max Design software, you need to start Civil View because Start Mode for Civil View is set as Manual. You can change this setting later and set it so that Civil View starts when you launch the Autodesk 3ds Max Design software. In the Civil View Preferences dialog box, in the General tab, select Automatically start Civil View? as shown below.

6. Open Civil Base XRef.max from your Class Files\scenes folder. If a dialog box opens prompting you that there is a Mismatch, click OK to accept the default values. If prompted, click OK to accept the file's Unit Scale. This is an empty max file in which the System Unit Scale has been set to 1 Unit=1.0 Feet.

7. If required, start Civil View by selecting Civil View>Start Civil View.

8. In the Menu bar, select Civil View>Geometry Import>Civil 3D (VSP 3D) File, as shown below.

9. In the Civil 3D Import panel, click Open. In the Select a VSP3D File dialog box, browse to your Class files\Import folder and open Civil surfaces.vsp3d file.

The objects listed include surfaces, site/grading featurelines, corridor (surfaces, baselines, featurelines etc.), and point groups, etc.

10. In the Civil 3D Import panel, a list of objects contained in the AutoCAD Civil 3D .DWG file are listed. In the left pane, select Surfaces [9] to display all of the surfaces in the right pane. Select Building Pad, hold down <Shift>, and select Parking Lot Surface to highlight the first seven surfaces. Select the checkbox for Building Pad to select all seven highlighted surfaces, as shown on the next page. You can select them individually as well.
11. You will select the corridor surfaces and the baseline. In the left pane, select **Corridors [1]** and in the right pane, select **PrimaryAccess, Region(1), Region(2), and Region(3)**, as shown below.

12. Click **OK**. In the Civil View Information, click **Yes** to accept the global shift values.

13. You did not select any feature interpretation. Click **Yes** to proceed without a feature interpretation style.

   *It takes a few minutes to load the file.*

14. The ground surfaces, building pad, corridor, and parking lot are displayed in all of the viewports. If not, click **(Zoom Extents All)**. Note that only the corridor displays the surface material and that the rest of the surfaces display a checkerboard material.

15. In the Menu bar, select **Civil View>Civil View>Civil View Explorer** to open the Civil & View Explorer. Dock it along the left side of the screen.

16. Verify that the **Civil Explorer** tab is open. Expand **Civil View Objects>Imported Objects**, if not already expanded. Select **Surfaces** and in the Object List rollout, note that all of the surfaces are listed, as shown below.

   A material is not required for the first three corridor regions.

17. In the Object List rollout, select **C3Dsurface-C-TOPO-Building Pad**. In the Surface Parameters rollout, select the **Statistics** tab and note that in the **Face Selection Sets**, in **By Material ID**, [31] **Ground Type 4** has been assigned, as shown on the left below.

   The complete list might not be visible in the Explorer. Hover the cursor in empty
space in the information area until it displays as a hand cursor. Grab and slide the Explorer panel up or down to display all of the information.

18. Right-click on [31] Ground Type 4 and select Modify Material ID Assignment, as shown below.

19. Click Yes in the Warning dialog box.

20. In the Modify material channel dialog box, select [22] Concrete Type 1 as below. Click OK.

21. In the Perspective viewport, use Zoom and Pan to zoom into the building pad. Note how the new material is applied.

22. If required, select Surfaces again and in the Object List rollout, select C3Dsurface-C-TOPO-Existing Ground. Select the Statistics tab, right-click on [31] Ground Type 4, and select Modify Material ID Assignment. In the Warning dialog box, click Yes.

23. In the Modify material channel dialog box, select [28] Ground Type 3 and click OK. In the Perspective viewport, note that the new ground type material is applied to the ground surface.

24. Similarly, for the other surfaces, apply the material types as follows. A material is not required for the first three corridor regions.
   - C3Dsurface-C-TOPO-Inside Curbing: [38] Concrete Type 3
   - C3Dsurface-C-TOPO-Inside Grading: [28] Ground Type 3
   - C3Dsurface-C-TOPO-Outside Curbing: [38] Concrete Type 3
   - C3Dsurface-C-TOPO-Outside Grading: [28] Ground Type 3
   - C3Dsurface-C-TOPO-Parking Lot Surface:[39] Asphalt Type 4

25. Close the Civil View Explorer.

26. Click (Zoom Extents All). In the Perspective view, the scene displays as shown below.

27. Save your work as MyCivil Base XRef.max