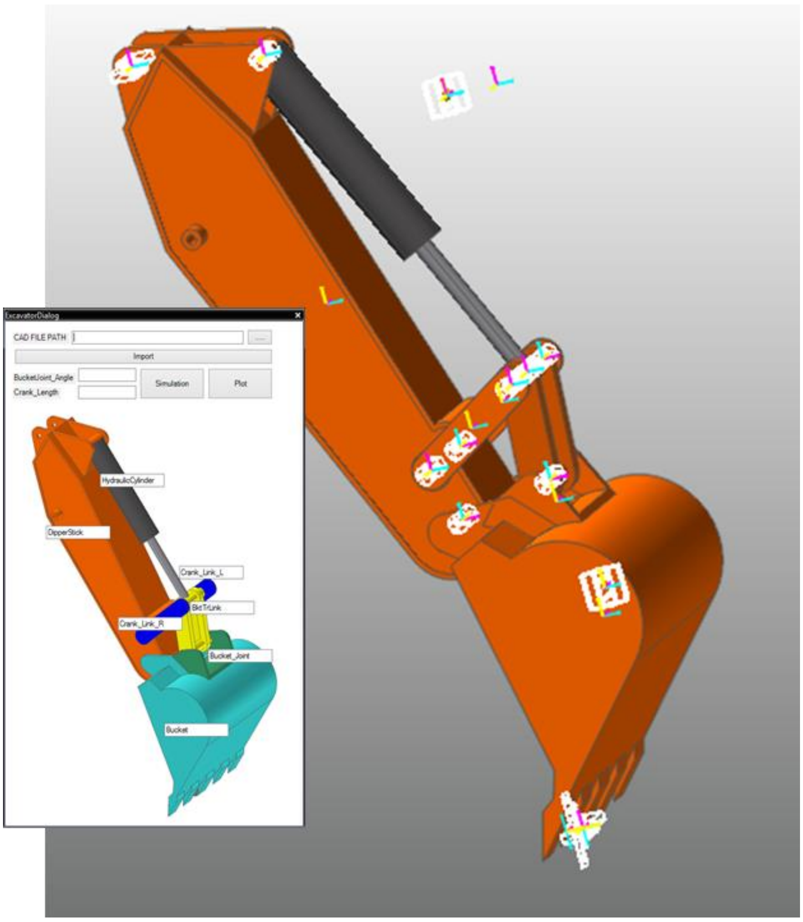
Dipper Stick with Bucket Tutorial (ProcessNet VSTA)



FunctionBay

Edition Note

This document describes the release information of **RecurDyn V9R4**.

Table of Contents

Chapter

1

Overview

Task Objectives

ProcessNet is a programming tool based on the .NET framework. It uses classes and variables in the same way as Microsoft Visual Studio does. Therefore, you can use a vast range of programming techniques with **ProcessNet**. In this tutorial, you will learn how to use b to create Windows Forms (WinForms), which are user interfaces based on the .NET framework. You can use WinForms to automate the modelling, analysis, and plotting processes in RecurDyn.

- Creating a user interface using WinForms
- Automating model creation using a CAD file
- Using **ProcessNet** functions in classes other than **ThisApplication**
- Automating modelling, analysis, and plotting processes using dialog windows

Prior Learning Requirements

The model used in this tutorial is based on the Dipper Stick with Bucket, a DOE & Batch simulation tutorial included in the RecurDyn tutorials. Therefore, before starting this tutorial, you must have already completed the Dipper Stick with Bucket tutorial.

Prerequisites

You must be well acquainted with **ProcessNet** and the **Dipper Stick with Bucket tutorial** or have performed comparable tasks. Also, you must have basic knowledge on physics.

Tasks

This tutorial consists of the following tasks. The following table outlines the time required to complete each task.

Task	Duration (minutes)
Starting ProcessNet	5
Creating a Dialog Window	15
Automatic Model Generation through Code	30
Analyzing a Model	10
Creating a Plot Automatically	10
Total	**70**

Estimated Time to Complete this Tutorial

70 minutes

Chapter

2

Starting ProcessNet

Task Objectives

To learn how to start **ProcessNet** in **RecurDyn**.

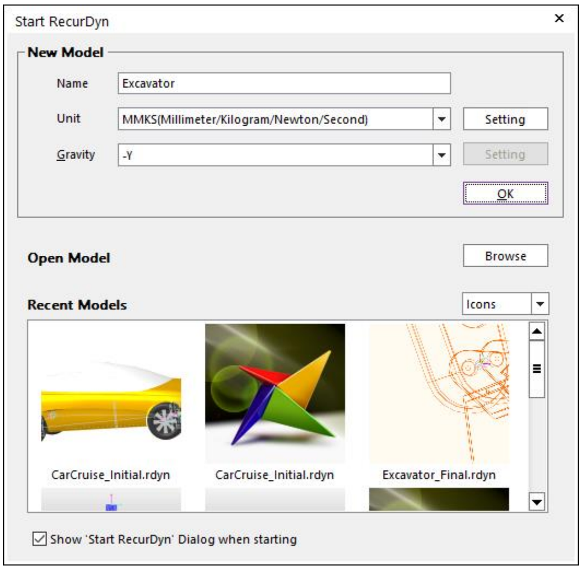
Estimated Time to Complete this Task

5 minutes

Starting RecurDyn

To start RecurDyn:

1. Run **RecurDyn**.
2. The **Start RecurDyn** dialog window appears.
3. In the **Name** field of the **New Model** pane, type **Excavator**.
4. Set the **Unit** to **MMKS**.
5. Click **OK** to create the new model.



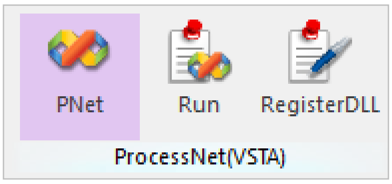
To save the model:

- In the **File** menu, click **Save As** and save the model as **Excavator.rdyn** in the folder you want.

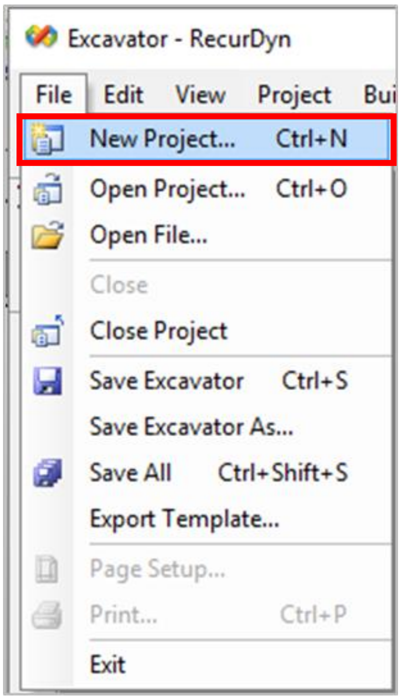
Starting ProcessNet

To start and initialize ProcessNet:

1. To open the **ProcessNet** integrated development environment (IDE), on the **Customize** tab, in the **ProcessNet(VSTA)** group, click **PNet**.

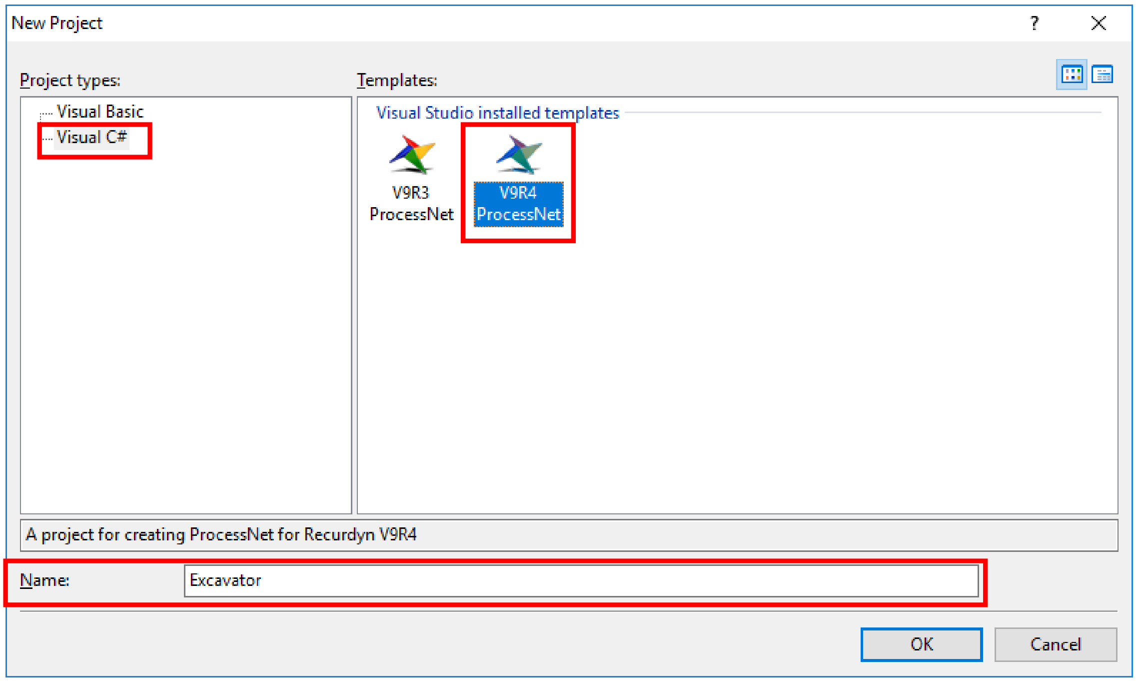


2. When the **ProcessNet IDE** starts, open the **File** menu, and then click **New Project**.
3. When the **New Project** dialog window appears, select the **Template** that corresponds to your version of **RecurDyn**.

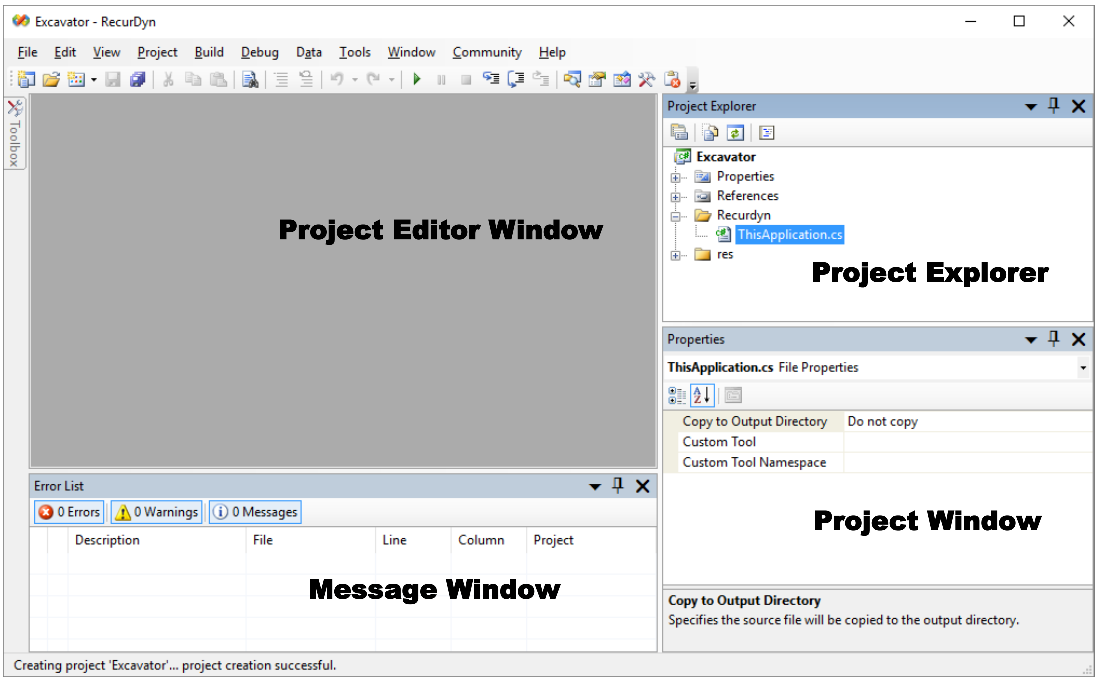


Note: You must use the **ProcessNet project** that is compatible with your version of RecurDyn. If the version is incorrect, then **ProcessNet** may not execute properly. The New Project dialog window shows all the templates that are compatible with the installed version of RecurDyn.

4. In the **Project Type** pane, select **Visual C# Project Types**, and then type **Excavator** in the **Name** field. Then, click **OK**.



5. An **Excavator Project** is created, as shown below.



6. Click **File**, click **Save Excavator**, and then save the **ProcessNet** project in the folder you want.
7. Now, you are ready to develop a **ProcessNet** application.

Chapter
3

Creating a Dialog Window

In this chapter, you will learn how to create a dialog window and configure its layout. This includes designing the layout of the dialog window and adding the code to call the dialog window in **ProcessNet**.

Task Objectives

To learn how to create a dialog window and a function to call the dialog window in **ProcessNet**.

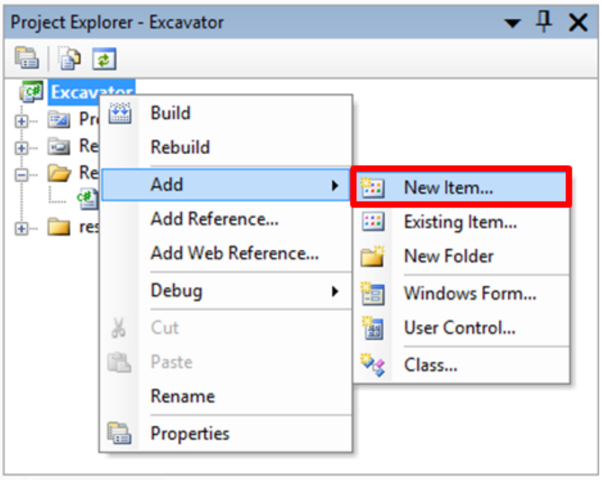
Estimated Time to Complete this Task

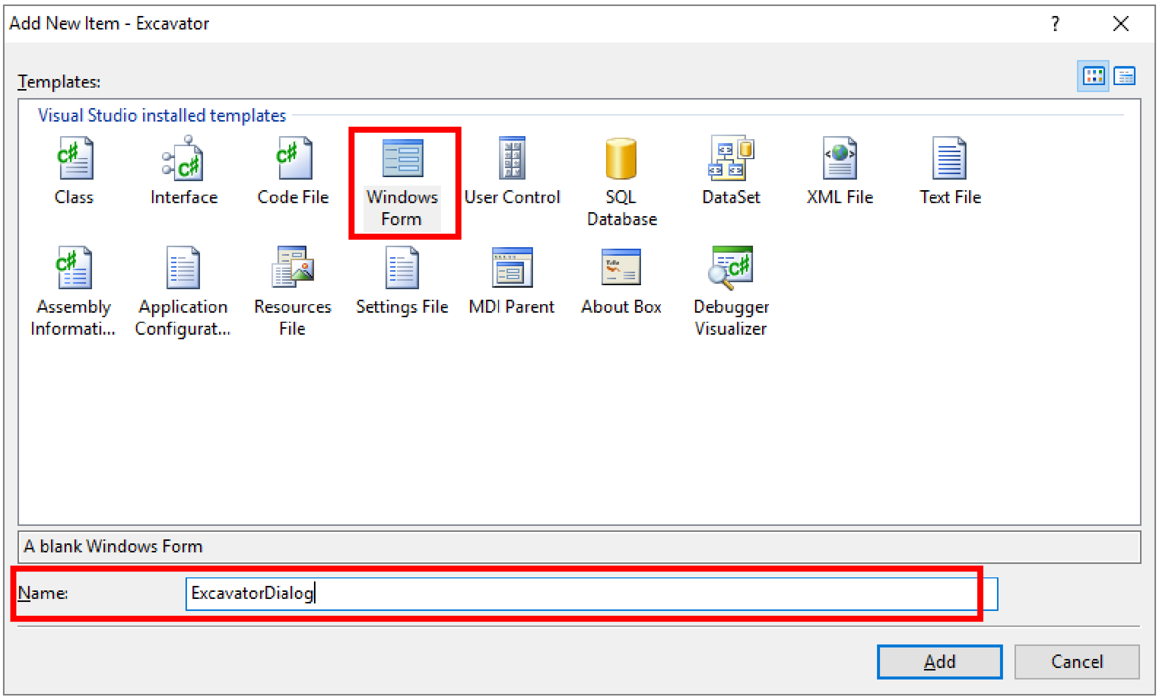
15 minutes

Creating a Dialog Window

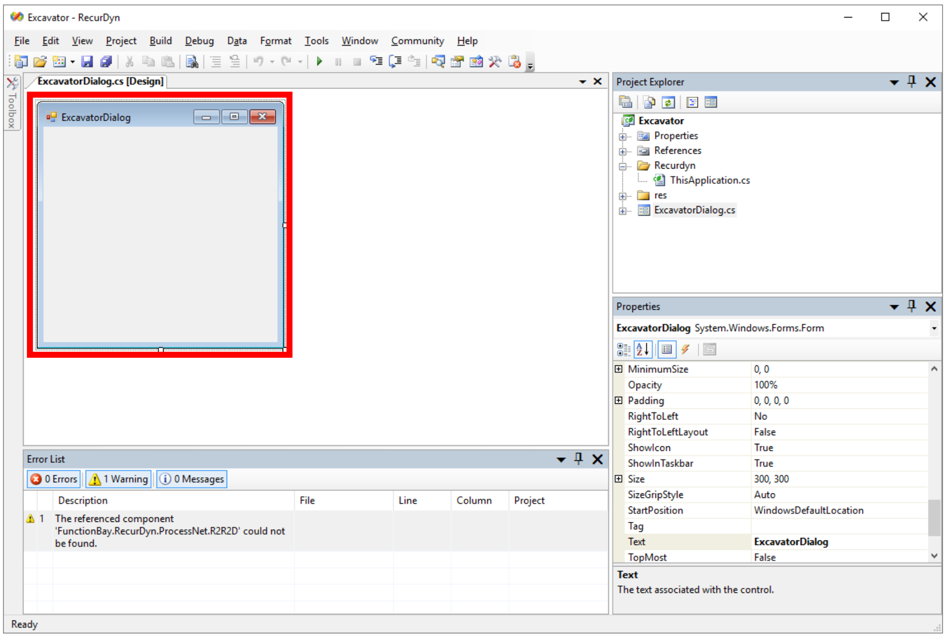
To create a dialog window:

1. In the **ProcessNet IDE**, right-click the **Project Explorer** pane.
2. Click **Add - New Item**.
3. When the **Add New Item** dialog window appears, click the **Windows Form** icon, and then type **ExcavatorDialog** in the name field.
4. Click **Add**.

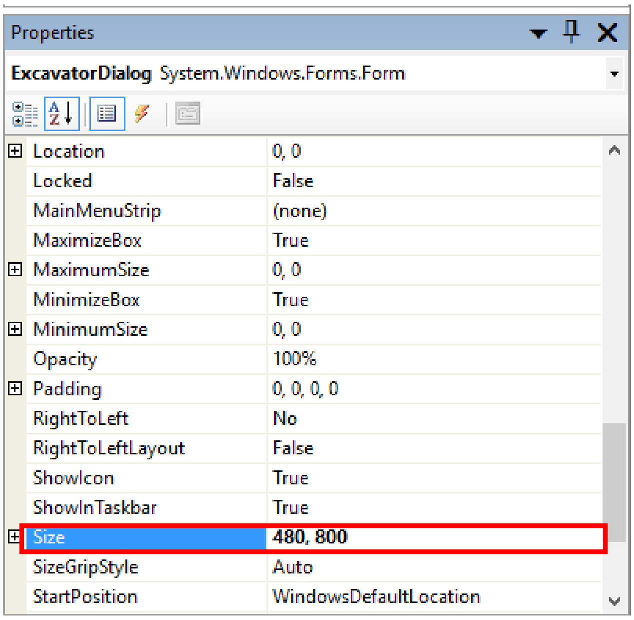


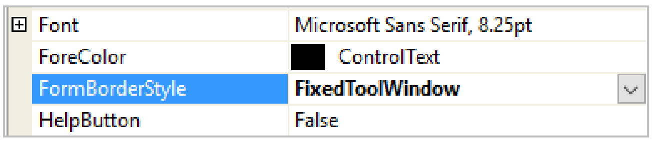


5. **ExcavatorDialog.cs[Design]**, a design window for **Windows Form**, appears in the **IDE Project Editor** pane.



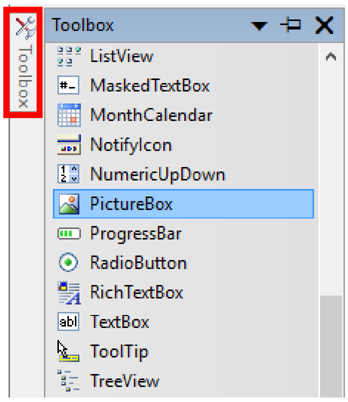
6. Click the **ExcavatorDialog** dialog window in the top left corner of the screen.
7. The information about **ExcavatorDialog** appears in the **Properties pane in the bottom right corner of the screen.** In the Properties pane, set the **Size** to 480, 800.
8. Also, set the **FormBorderStyle** to **FixedToolWindow**.





9. Move the cursor to the **ToolBox** 

in the top left corner of the screen. You will see the menu with which you can add a dialog window, button, and other control functions.



Note: If you cannot see the **ToolBox**, open the View menu, and then click **ToolBox** or press Ctrl + Alt + X.

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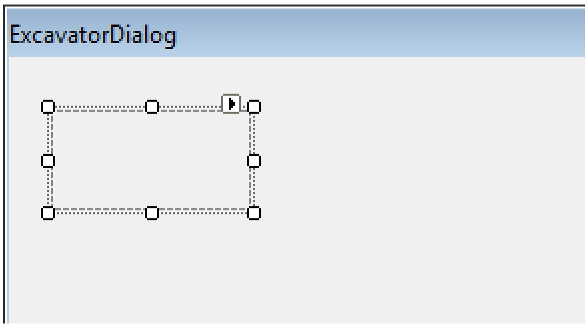
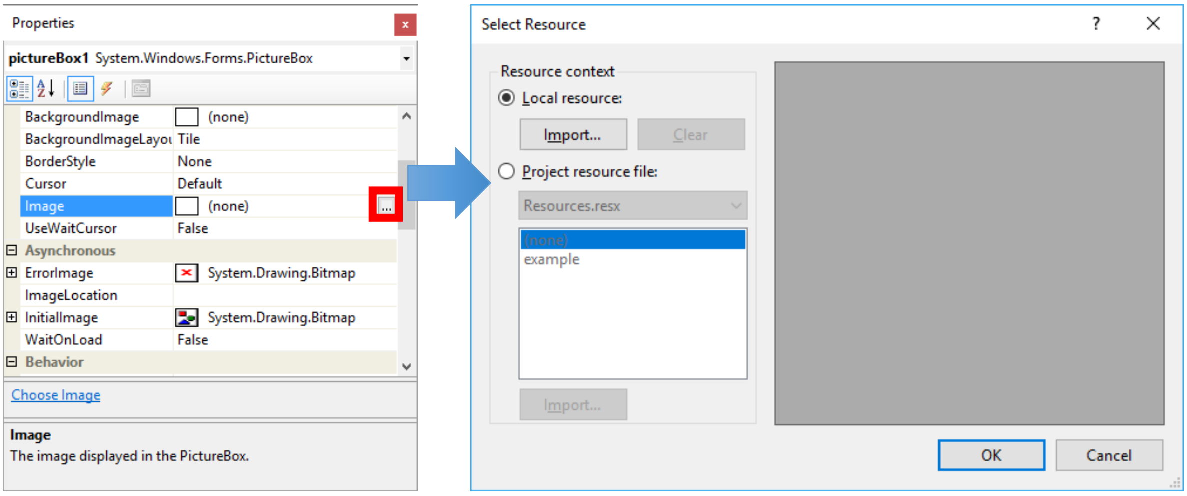
10. In the **Common Controls** list, select **PictureBox**, and then drag and drop the **Label** in the top left corner of the dialog window that you want to design.

11. Select the **PictureBox** you created.



12. As shown in the figure below, in the **Properties** pane in the bottom right corner of the screen, click the **...** button to the right of the **Image** row.

    The **Select Resource** dialog window appears.



13. In the **Select Resource** dialog window, select **Local resource**, and then click the **Import** button.

14. When the **Open** dialog window appears, select the picture file to use. (For this tutorial, use the Excavator_1.png file located in the "<InstallDir>/Help/Tutorial/ProcessNet/VSTA/Excavator/Excavator" directory.)

15. After confirming that the picture is correct, click the **OK** button.

16. In the **Properties** pane, set the **SizeMode** to **AutoSize** and type 0,0 in the **Location** field.

⊞ Location	0, 0
Locked	False
⊞ Margin	3, 3, 3, 3
⊞ MaximumSize	0, 0
⊞ MinimumSize	0, 0
Modifiers	Private
⊞ Padding	0, 0, 0, 0
⊞ Size	460, 761
SizeMode	AutoSize

17. Select the **ToolBox**.
18. In the **Common Controls** list, select **Label**, and then drag and drop the **Label** in the top left corner of the dialog window that you want to design.
19. Select the **Label** you created. Then, in the **Properties** pane, type **CAD File Path** in the **Text** field and type 12,17 in the **Location field**.

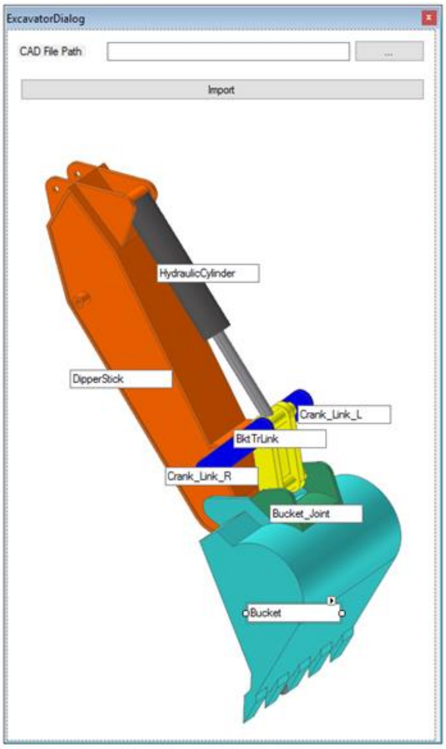
⊞ Location	12, 17
Locked	False
⊞ Margin	3, 0, 3, 0
⊞ MaximumSize	0, 0
⊞ MinimumSize	0, 0
Modifiers	Private
⊞ Padding	0, 0, 0, 0
RightToLeft	No
⊞ Size	83, 12
TabIndex	1
Tag	
Text	CAD File Path

20. Select the **ToolBox** again. Then, click and drag the **TextBox** from the **Common Controls** list and drop it to the right of the **Label**.
21. In the **Properties** pane for **Textbox1** in the top right corner of the window, type 108, 14 in the **Location** field, **tbPath** in the **Name** field, and 260,20 in the **Size** field.
22. For **Button1, Button2, TextBox1, TextBox2, TextBox3, TextBox4, TextBox5, and TextBox6**, change the **Text** and **Name** values as described in the procedure above by referring to the following table.

Dialog Element	Text	Name	Location	Size
Button1	...	btSearchPath	373, 12	75, 23
Button2	Import	btImport	15, 53	433, 23
TextBox1	HydraulicCylinder	tbHydraulicCylinder	161, 251	110, 21
TextBox2	DipperStick	tbDipperStick	68, 364	110, 21
TextBox3	Crank_Link_L	tbCrank_Link_L	312, 402	100, 21
TextBox4	Crank_Link_R	tbCrank_Link_R	170, 468	100, 21

TextBox5	BktTrLink	tbBktTrLink	243, 428	100, 21
TextBox6	Bucket_Joint	tbBucket_Joint	282, 508	100, 21
TextBox7	Bucket	tbBucket	258, 614	100, 21

23. After setting all of the values described above, the dialog window should resemble the figure below.
24. Open the **File** menu and click **Save ExcavatorDialog.cs** to save the file.

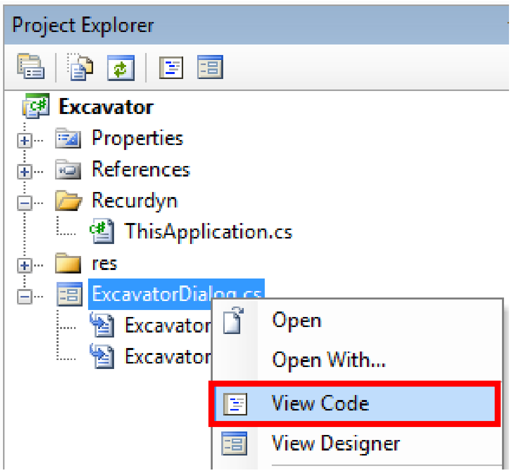


Note: The size or location of the dialog window may differ depending on the PC environment.

Configuring the Initial Settings of the Dialog Window

The previous procedure configured the appearance of the dialog window. Now, you must add variables to the dialog window to define what values users can enter and the event generated when users click a button. Also, you will also learn how to use the **ProcessNet** function in the dialog window.

To configure the initial settings of the dialog window:

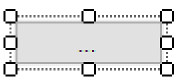


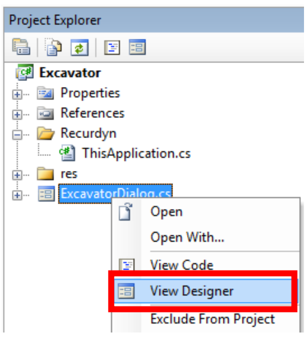
1. In the **Project Explorer**, right-click **ExcavatorDialog.cs**. In the context menu, click **View Code** to display the source code for **ExcavatorDialog.cs** in the **Edit IDE Project** window.
2. In the **Edit IDE Project** window, enter the variables to be used in the dialog window.
   - **FunctionBay.RecurDyn.ProcessNet** provides the reference information to use in **ProcessNet** functions.
   - **IApplication** is the interface used to recognize RecurDyn.
   - The **strFilePath** and **StrExcavatorPartName** are the string to display and the path of the CAD file or subsystem file to use when Excavator does not exist, respectively.

```
using System.Windows.Forms;
using FunctionBay.RecurDyn.ProcessNet;

namespace Excavator
{
        public partial class ExcavatorDialog : Form
        {
                IApplication application;
                string strFilePath;
                string[,] strExcavatorPartName = new string[7, 2];
                public ExcavatorDialog(IApplication app)
                {
                        InitializeComponent();
                        application = app;
                }
```

3. In the **Project Explorer**, right-click **ExcavatorDialog.cs**, and then click **View Designer** to display the dialog window you created in the previous procedure.
4. In the dialog window, double-click the **...** button to create the function to call when the user double-clicks a button.





5. Insert the following code to create the function automatically.
   - This code imports the folder path from the Folder Dialog window.

- Click the … button to execute the btSearchPatch_Click() function and create the Folder Dialog window.

```
private void btSearchPath_Click(object sender, EventArgs e)
{
        FolderBrowserDialog dialog = new FolderBrowserDialog();
        dialog.ShowDialog();
        this.tbPath.Text = dialog.SelectedPath;
}
```

6. In the **Project Explorer**, right-click **ExcavatorDialog.cs**, and then click **View Designer**. In the dialog window, double-click the **Import** button to create the **btImport_Click() function.**
7. Under the **btImport_Click ()** function, create a new function called **UpdateDB()** and enter the following code.
   - The UpdateDB() function stores the variable entered in the textbox of the dialog window.
   - The This.tbPath.text procedure retrieves the value entered in the textbox named tbPath..
   - The strExcavatorPartName is a two-dimensional array that saves the name and path of a CAD file or subsystem file.

```
private void UpdateDB()
{
        strFilePath = this.tbPath.Text;
        strExcavatorPartName[0, 0] = this.tbDipperStick.Text.ToString();
        strExcavatorPartName[0, 1] = strFilePath + @"\" + this.tbDipperStick.Text.ToString() + ".x_t";
        strExcavatorPartName[1, 0] = this.tbCrank_Link_L.Text.ToString();
        strExcavatorPartName[1, 1] = strFilePath + @"\" + this.tbCrank_Link_L.Text.ToString() + ".x_t";
        strExcavatorPartName[2, 0] = this.tbCrank_Link_R.Text.ToString();
        strExcavatorPartName[2, 1] = strFilePath + @"\" + this.tbCrank_Link_R.Text.ToString() + ".x_t";
        strExcavatorPartName[3, 0] = this.tbBucket.Text.ToString();
        strExcavatorPartName[3, 1] = strFilePath + @"\" + this.tbBucket.Text.ToString() + ".x_t";
        strExcavatorPartName[4, 0] = this.tbBucket_Joint.Text.ToString();
        strExcavatorPartName[4, 1] = strFilePath + @"\" + this.tbBucket_Joint.Text.ToString() + ".x_t";
        strExcavatorPartName[5, 0] = this.tbBktTrLink.Text.ToString();
        strExcavatorPartName[5, 1] = strFilePath + @"\" + this.tbBktTrLink.Text.ToString() + ".rdsb";
        strExcavatorPartName[6, 0] = this.tbHydraulicCylinder.Text.ToString();
        strExcavatorPartName[6, 1] = strFilePath + @"\" + this.tbHydraulicCylinder.Text.ToString() + ".rdsb";
}
```

8. Insert the following code to create the function automatically.
   - The code executes the **UpdateDB()** function when a user clicks the **Import** button in the dialog window.

```
private void btImport_Click(object sender, EventArgs e)
{
        UpdateDB();
}
```

9. In the **File** menu, click **Save ExcavatorDialog.cs** to save the file.

Displaying a Dialog Window when the User Runs the Application

This section teaches you how to display a dialog window when a user runs the ProcessNet application in RecurDyn and how to make a dialog window dependent on RecurDyn.

To display a dialog window when a user runs the application:

1. In the **Project Explorer**, double-click **ThisApplication.cs**.
2. In the **ThisApplication.cs** file, delete the **HelloProcessNet()** and **CreateBodyExample()** functions marked with strikethroughs, as shown below. (These functions are generated automatically as an example.)

```
public void HelloProcessNet()
{
        //application is assigned at Initialize() such as
        //application = RecurDynApplication as IApplication;
        application.PrintMessage("Hello ProcessNet");
        application.PrintMessage(application.ProcessNetVersion);
}

public void CreateBodyExample()
{
        refFrame1 = modelDocument.CreateReferenceFrame();
        refFrame1.SetOrigin(100, 0, 0);

        refFrame2 = modelDocument.CreateReferenceFrame();
        refFrame2.SetOrigin(0, 200, 0);

        IBody body1 = model.CreateBodyBox("body1", refFrame1, 150, 100, 100);
        application.PrintMessage(body1.Name);
        IBody body2 = model.CreateBodySphere("body2", refFrame2, 50);
        application.PrintMessage(body2.Name);
}
```

3. Write the **Run()** function shown below.
   - This function creates a new instance of ExcavatorDialog.
   - It delivers the values of Application and MainWindow to the ExcavatorDialog class.

Note: The Application and MainWindow values must be delivered to this class to use ProcessNet methods in WinForms.

   -

```
public void Run()
{
        ExcavatorDialog DialogRun = new ExcavatorDialog(application);
        DialogRun.ShowDialog(MainWindow);
}
```

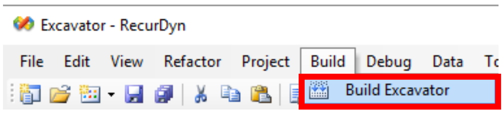
4. In the **File** menu, click **Save ThisApplication.cs** to save the file.

Testing a Dialog Window

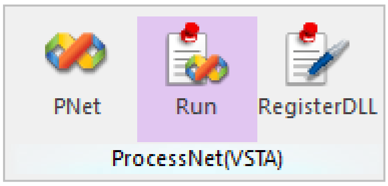
In this section, you will test whether the application created above works properly.

To run the application:

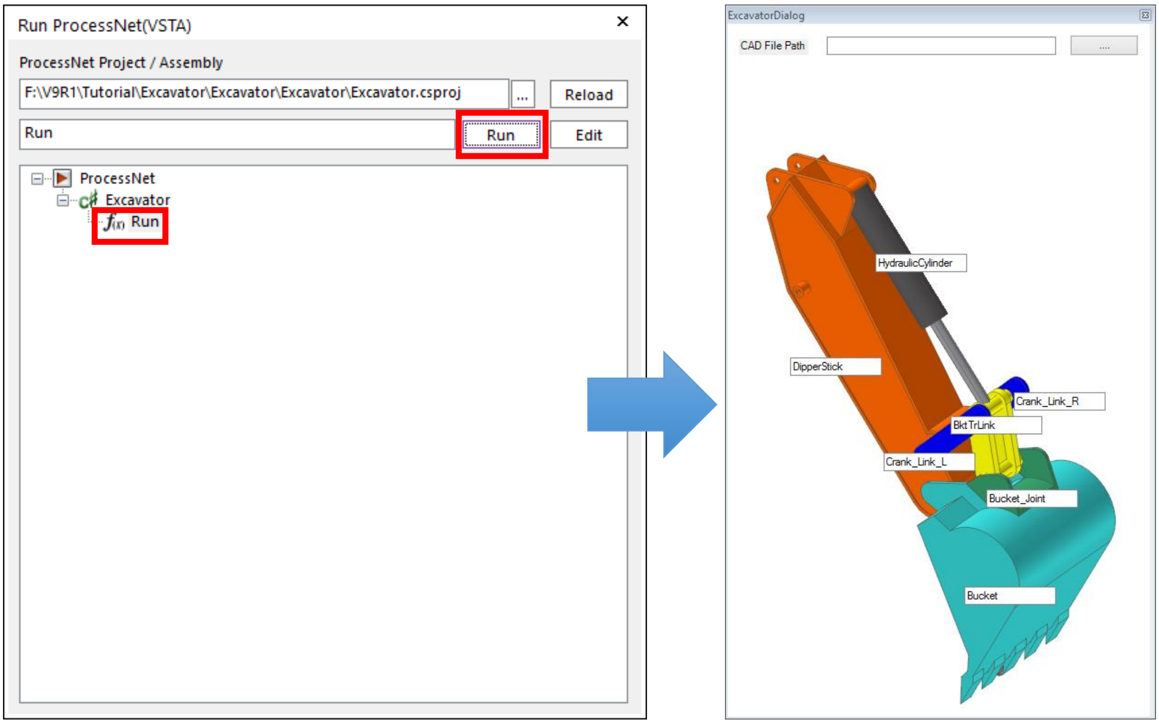
1. Check if any errors or warnings appear in the **Error List** pane at the bottom of the **IDE** window. If there are any errors or warnings, correct the problems. In the **Build** menu, click **Build Excavator**.



2. In **RecurDyn**, on the **Customize** tab, in the **ProcessNet(VSTA)** group, click **Run**.



3. In the tree in the lower half of the **Run ProcessNet** dialog window, click **Run** under **Excavator**.
4. In the **Run ProcessNet** dialog window, click the **Run** button.



5. The created dialog window appears.
6. Once you confirm that the application runs properly, close the dialog window.
7. Close the **Run ProcessNet** dialog window.

Chapter
4

Automatic Model Generation through Code

Task Objectives

In this chapter, you will create a new class and write a ProcessNet function under that class. Then, you will learn how to call this function in the dialog window created in the previous chapter.

Estimated Time to Complete this Task

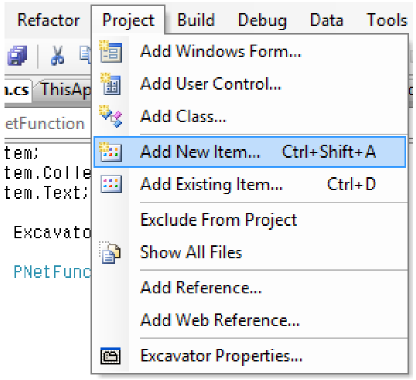
30 minutes

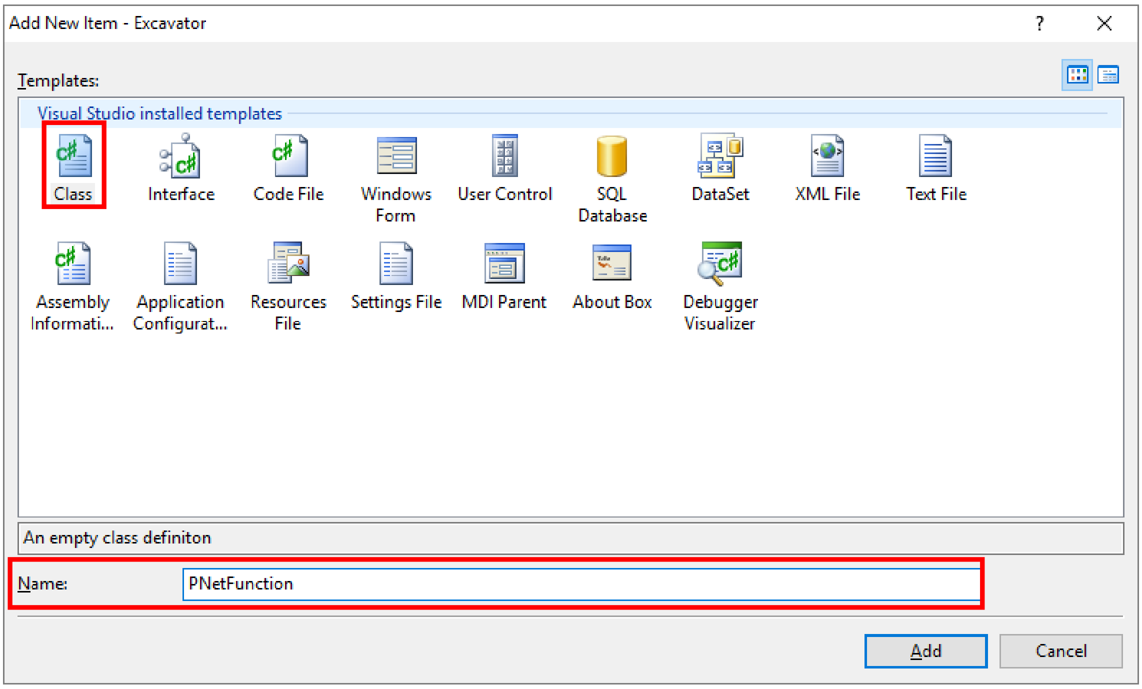
Creating a New Class

This section teaches you how to create a new class and enter a **ProcessNet** function under that class.

To create a new class:

1. In the **ProcessNet IDE**, click **Project - Add New Item**.
2. When the **Add New Item** dialog window appears, select **Class** in the **Templates** pane and type **PNetFunction** in the **Name** field. Then, click the Add button.





3. When the **PNetFunction.cs** appears in the **Edit IDE Project** pane, enter the following code. . (Enter the bold text.) This code resets the basic variables used to execute a **ProcessNet** function.
   - **IApplication**: Used to recognize RecurDyn
   - **IModelDocument**: A model document used in RecurDyn
   - **ISubsystem**: A subsystem used in the model document
   - **IReferenceFrame**: A reference frame of RecurDyn
   - **IPlotDocument**: A RecurDyn plot document

```
using FunctionBay.RecurDyn.ProcessNet;
namespace Excavator
{
        class PNetFunction
        {
                static public IApplication application;
                public IModelDocument modelDocument = null;
                public IPlotDocument plotDocument = null;
                public ISubSystem model = null;

                public IReferenceFra me refFrame1 = null;
                public IReferenceFrame refFrame2 = null;

                public PNetFunction(IApplication app)
                {
                        application = app;
                }
        }
}
```

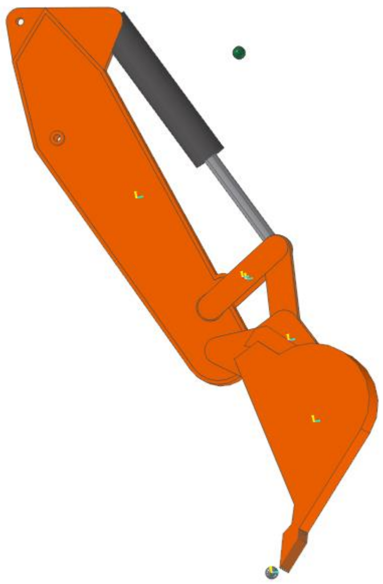
4. In the **File** menu, click **Save PNetFunction.cs** to save the file.

Creating a Model

In this section, you will learn how to create an **Excavator** model automatically.

To import a body:

1. Write a code that creates an **Excavator** model using a **CAD** file and **Subsystem** file.



2. Create the following **Import()** function.

```
public void Import(string[,] strExcavatorPartName)
{
}
```

3. Then, insert the following variable declaration in the **Import()** function.

```
modelDocument = application.ActiveModelDocument;
model = modelDocument.Model;

refFrame1 = modelDocument.CreateReferenceFrame();
refFrame1.SetOrigin(0, 0, 0);
refFrame2 = modelDocument.CreateReferenceFrame();
refFrame2.SetOrigin(0, 0, 0);
```

4. After the variable declaration, add the following loop to import the *.x_t and *.rdsb files. The *.x_t files are the CAD files for the respective parts of the model and the *.rdsb files are the subsystem files.
   - **FileImport()** imports the CAD and subsystem files.
   - Crank Link R creates a marker without importing the CAD files. So, a continue statement is used to go to the next loop.

```
for (int iCount = 0; iCount < 7; iCount++)
{
            if( iCount == 2)
            continue;
            model.FileImport(strExcavatorPartName[iCount,1]);
}
```

5. Enter the following code to use the **SubSystemCollection** property to compose a list of subsystems in the model and then declares the subsystems as Sub01, Sub02, and so on.

```
ISubSystemCollection SubCollection01 = model.SubSystemCollection;
ISubSystem Sub01 = SubCollection01[0];
ISubSystem Sub02 = SubCollection01[1];
```

6. Use the **GetEntity()** function to search the imported body.
   - The **GetEntity()** function searches the entities in RecurDyn.
   - Basically, **IGeneric** is returned for the function. The function can perform type conversion according to the type of entity you want.

```
IBody BodyDipperStick = model.GetEntity(strExcavatorPartName[0,0]) as IBody;
IBody BodyCrankLinkL = model.GetEntity(strExcavatorPartName[1, 0]) as IBody;
IBody BodyBucket = model.GetEntity(strExcavatorPartName[3, 0]) as IBody;
IBody BodyJoint = model.GetEntity(strExcavatorPartName[4, 0]) as IBody;

IBody BodyBktTrLink_CylRod_Cylinder = Sub01.GetEntity("BktTrLink_CylRod_Cylinder") as IBody;
IBody BodyBktTrLink_Bucket_BktTrLink_Cylinder = Sub01.GetEntity("Bucket_BktTrLink_Cylinder") as
IBody;
IBody BodyBktTrLink_Right_Link = Sub01.GetEntity("Right_Link") as IBody;
IBody BodyHydraulicCylinder_Cylinder =  Sub02.GetEntity("Cylinder") as IBody;
IBody BodyHydraulicCylinder_Rod = Sub02.GetEntity("Rod") as IBody;
IBody BodySub02Mother = Sub02.GetEntity("MotherBody") as IBody;
```

7. Enter the following code to generate a marker in the link body called Crank_Link_R and the Bucket_Joint body.
   - Crank_Link_R creates a marker instead of importing the CAD file so that you can control the model posture by entering the PP in its second variable.

```
IBody BodyCrankLinkR = model.CreateBodyLinkWithRadius(strExcavatorPartName[2, 0], new double[]
{ 5506.1017, -495.8525, 2231.9958 }, new double[] { 5606.1017, -495.8525, 2231.9958 },100,100, 35);
BodyCrankLinkR.Graphic.Color = 26367;

refFrame1.SetOrigin(6060.3717, -207.8525, 1993.4767);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 180, 90, 90);
IMarker Marker01 = BodyJoint.CreateMarker("Marker1", refFrame1);
```

8. Declare the ground of the assembly mode as bodyground.

```
IBody BodyGround = model.Ground;
```

9. Create a dummy body.

```
refFrame1.SetOrigin(5579.2685, -207.8525, 62.560441);
IBody BodyDummyBucketTip = model.CreateBodyEllipsoid("BucketTip", refFrame1, 50, 50, 50);
refFrame1.SetOrigin(6100, -207.8525, 4200);
IBody BodyDummyDrivingForceBody = Sub02.CreateBodyEllipsoid("DrivingForceBody", refFrame1, 50, 50,
50);
```

10. In the **File** menu, click **Save PNetFunction.cs** to save the file.

To create a SubEntity:

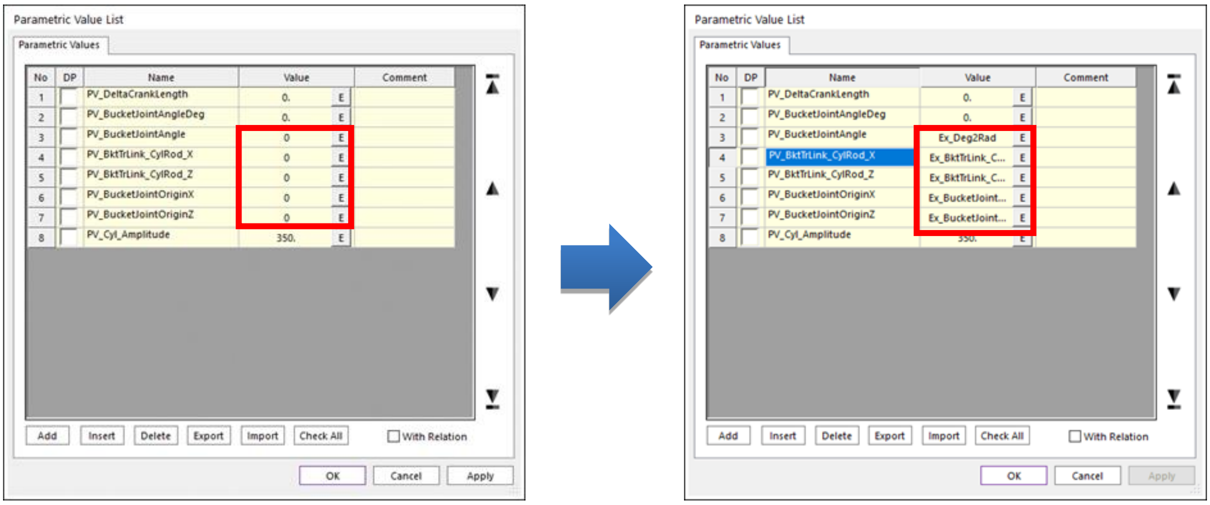
1. In this section, you will create the **SubEntity** to be used in the **Excavator** model.
2. Add the following code to create the PVs in the **Import()** function created in the previous procedure.
3. (All the codes from creating the SubEntity to creating the variable equations should be added consecutively with the same indentation inside the **Import()** function.)

```
IParametricValue PV_DeltaCrankLength = model.CreateParametricValue("PV_DeltaCrankLength", 0);
IParametricValue PV_BucketJointAngleDeg = model.CreateParametricValue("PV_BucketJointAngleDeg", 0);
IParametricValue PV_BucketJointAngle = model.CreateParametricValue("PV_BucketJointAngle", 0);
IParametricValue PV_BktTrLink_CylRod_X = model.CreateParametricValue("PV_BktTrLink_CylRod_X", 0);
IParametricValue PV_BktTrLink_CylRod_Z = model.CreateParametricValue("PV_BktTrLink_CylRod_Z", 0);
IParametricValue PV_BucketJointOriginX = model.CreateParametricValue("PV_BucketJointOriginX", 0);
IParametricValue PV_BucketJointOriginZ = model.CreateParametricValue("PV_BucketJointOriginZ", 0);
IParametricValue PV_Cyl_Amplitude = model.CreateParametricValue("PV_Cyl_Amplitude", 350);
```

4. Add a code that creates the following expressions under the code that creates the PVs.

```
IExpression Ex_Deg2Rad = model.CreateExpression("Ex_Deg2Rad", "PV_BucketJointAngleDeg*PI/180");
IExpression Ex_BktTrLink_CylRod_X = model.CreateExpression("Ex_BktTrLink_CylRod_X", "COS(0.291724-
ACOS(((704.58305+PV_DeltaCrankLength)*(704.58305+PV_DeltaCrankLength)-10996911)/(-
10963694)))*965.471+SIN(0.291724-
ACOS(((704.58305+PV_DeltaCrankLength)*(704.58305+PV_DeltaCrankLength)-10996911)/(-10963694)))*(-
2034.522)+5139.0782");
IExpression Ex_BktTrLink_CylRod_Z = model.CreateExpression("Ex_BktTrLink_CylRod_Z", "-SIN(0.291724-
ACOS(((704.58305+PV_DeltaCrankLength)*(704.58305+PV_DeltaCrankLength)-10996911)/(-
10963694)))*965.471+COS(0.291724-
ACOS(((704.58305+PV_DeltaCrankLength)*(704.58305+PV_DeltaCrankLength)-10996911)/(-10963694)))*(-
2034.522)+4638.4021");
IExpression Ex_BucketJointOriginX = model.CreateExpression("Ex_BucketJointOriginX", "(1-
COS(PV_BucketJointAngle))*6191.0835-SIN(PV_BucketJointAngle)*1340.8818");
IExpression Ex_BucketJointOriginZ = model.CreateExpression("Ex_BucketJointOriginZ",
"SIN(PV_BucketJointAngle)*6191.0835+(1-COS(PV_BucketJointAngle))*1340.8818");
IExpression Ex_BucketTipLoad = model.CreateExpression("Ex_BucketTipLoad", "0");
IExpression Ex_DrivingForce = Sub02.CreateExpression("Ex_DrivingForce", "0");
Ex_DrivingForce.Arguments = new string[] { "Cylinder.Marker1@HydraulicCylinder",
"Rod.Marker1@HydraulicCylinder" };
Ex_DrivingForce.Text = "FZ(1,2,2)";
```

5. Add a code that generates values for the PVs under the code that creates each expression.
   - After creating an expression, enter the values for the PVs. When the following code is executed, the values of the PVs change to the expressions shown below.




```
PV_BucketJointAngle.Text = "Ex_Deg2Rad";
PV_BktTrLink_CylRod_X.Text = "Ex_BktTrLink_CylRod_X";
PV_BktTrLink_CylRod_Z.Text = "Ex_BktTrLink_CylRod_Z";
PV_BucketJointOriginX.Text = "Ex_BucketJointOriginX";
PV_BucketJointOriginZ.Text = "Ex_BucketJointOriginZ";
```

6. Once the values for PVs are set, add the following code to create PPs.

```
IParametricPoint PP_CrankL_BktTrLink = model.CreateParametricPointWithText("PP_CrankL_BktTrLink",
"PV_BktTrLink_CylRod_X,80.147498,PV_BktTrLink_CylRod_Z", null);
IParametricPoint PP_Bucket_BktTrLink = model.CreateParametricPoint("PP_Bucket_BktTrLink", new double[] { 0,
0, 0 }, null);
IParametricPoint PP_BktTrLink_Rod = model.CreateParametricPointWithText("PP_BktTrLink_Rod",
"PV_BktTrLink_CylRod_X,-207.85255,PV_BktTrLink_CylRod_Z", null);
IParametricPoint PP_DipperStick_Cyl = model.CreateParametricPoint("PP_DipperStick_Cyl", new double[]
{ 5139.0782, -207.85255, 4638.4021 }, null);
IParametricPoint PP_BucketJointOrigin = model.CreateParametricPointWithText("PP_BucketJointOrigin", "
PV_BucketJointOriginX,0.,PV_BucketJointOriginZ", null);
IParametricPoint PP_CrankR_BktTrLink = model.CreateParametricPointWithText("PP_CrankR_BktTrLink",
"PV_BktTrLink_CylRod_X,-495.8525, PV_BktTrLink_CylRod_Z", null);
PP_Bucket_BktTrLink.RefMarker = Marker01;
```

7. Under the code that creates the PPs, add the following code to create the PPCs and PVCs.

```
IParametricPointConnector PPC_Bucket_BktTrLink = model.CreateParametricPointConnector("PPC_Bucket_BktTrLink");
PPC_Bucket_BktTrLink.Point.ParametricPoint = PP_Bucket_BktTrLink;
IParametricPointConnector PPC_BktTrLink_CylRod = model.CreateParametricPointConnector("PPC_BktTrLink_CylRod");
PPC_BktTrLink_CylRod.Point.ParametricPoint = PP_BktTrLink_Rod;
IParametricPointConnector PPC_Cyl_End = model.CreateParametricPointConnector("PPC_Cyl_End");
PPC_Cyl_End.Point.ParametricPoint = PP_DipperStick_Cyl;
IParametricPointConnector PPC_Rod_End = model.CreateParametricPointConnector("PPC_Rod_End");
PPC_Rod_End.Point.ParametricPoint = PP_BktTrLink_Rod;

IParametricValueConnector PVC_Cyl_Amplitude = model.CreateParametricValueConnector("PVC_Cyl_Amplitude");
PVC_Cyl_Amplitude.Value.ParametricValue = PV_Cyl_Amplitude;
```

8. Under the code that creates the PPCs and PVCs, add the following code to change the second point and normal direction of Crank_Link_R.

```
IGeometryLink GeoLink1 = BodyCrankLinkR.GetEntity("Link1") as IGeometryLink;
GeoLink1.SecondParametricPoint = PP_CrankR_BktTrLink;
GeoLink1.SetNormalDirection(0, 1, 0);
```

9. In the **File** menu, click **Save PNetFunction.cs** to save the file.

To create a joint:

1. In this section, you will create the **joints** to be used in the **Excavator** model.

In the **Import()** function created in the previous procedure, add the following code to create the **fixed joints**.

```
refFrame1.SetOrigin(4440.16, -387.85255, 4768.1811);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 0, 90, 0);
IJointFixed FixedJoint_Dipper_Ground = model.CreateJointFixed("Fixed_Dipper_Ground", BodyGround,
BodyDipperStick, refFrame1);

refFrame1.SetOrigin(6191.0835, -207.8525, 1340.8818);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZYX, 0, 0, 0);
IJointFixed FixedJoint_Bucket_BucketJoint = model.CreateJointFixed("Fixed_Bucket_BucketJoint", BodyBucket,
BodyJoint, refFrame1);
FixedJoint_Bucket_BucketJoint.BaseMarker.RefFrame.EulerAngle.Beta.ParametricValue = PV_BucketJointAngle;

refFrame1.SetOrigin(5679.2685, -207.8525, 62.560441);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 0, 90, 0);
IJointFixed FixedJoint_BucketTip_Bucket = model.CreateJointFixed("Fixed_BucketTip_Bucket",
BodyDummyBucketTip, BodyBucket, refFrame1);

refFrame1.SetOrigin(6100, -207.8525, 4200);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 0, 0, 0);
IJointFixed FixedJoint_DrivingForceBody = model.CreateJointFixed("Fixed_DrivingForceBody", BodyGround,
BodyDummyDrivingForceBody, refFrame1);
```

2. Add the following code to create the **revolute joints**.

```
refFrame1.SetOrigin(5506.1017, 62.147449, 2231.9959);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 180, 90, 90);
IJointRevolute RevJoint_Dipper_Crank_L = model.CreateJointRevolute("Rev_Dipper_Crank_L", BodyCrankLinkL,
BodyDipperStick, refFrame1);

refFrame1.SetOrigin(5504.8615, -207.8525, 1879.9098);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 180, 90, 90);
IJointRevolute RevJoint_Dipper_Bucket = model.CreateJointRevolute("Rev_Dipper_Bucket", BodyDipperStick,
BodyBucket, refFrame1);

refFrame1.Origin.ParametricPoint = PP_CrankL_BktTrLink;
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 180, 90, 90);
IJointRevolute RevJoint_BktTrLink_Crank_L = model.CreateJointRevolute("Rev_BktTrLink_Crank_L",
BodyCrankLinkL, BodyBktTrLink_CylRod_Cylinder, refFrame1);
RevJoint_BktTrLink_Crank_L.ActionMarker.RefFrame.Origin.ParametricPoint = PP_CrankL_BktTrLink;
RevJoint_BktTrLink_Crank_L.BaseMarker.RefFrame.Origin.ParametricPoint = PP_CrankL_BktTrLink;

refFrame1.Origin.ParametricPoint = PP_Bucket_BktTrLink;
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 180, 90, 90);
IJointRevolute RevJoint_Bucket_BktTrLink = model.CreateJointRevolute("Rev_Bucket_BktTrLink", BodyJoint,
BodyBktTrLink_Bucket_BktTrLink_Cylinder, refFrame1);
RevJoint_Bucket_BktTrLink.ActionMarker.RefFrame.Origin.ParametricPoint = PP_Bucket_BktTrLink;
RevJoint_Bucket_BktTrLink.BaseMarker.RefFrame.Origin.ParametricPoint = PP_Bucket_BktTrLink;

refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 0, 90, 0);
IJointRevolute RevJoint_Dipper_Crank_R = model.CreateJointRevolute("Rev_Dipper_Crank_R", BodyCrankLinkR,
BodyBktTrLink_Right_Link, refFrame1);
RevJoint_Dipper_Crank_R.ActionMarker.RefFrame.Origin.ParametricPoint = PP_CrankR_BktTrLink;
RevJoint_Dipper_Crank_R.BaseMarker.RefFrame.Origin.ParametricPoint = PP_CrankR_BktTrLink;

refFrame1.SetOrigin(5506.1017, -477.85255, 2231.9959);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 0,90,0);
IJointRevolute RevJoint7 = model.CreateJointRevolute("RevJoint3", BodyDipperStick, BodyCrankLinkR,
refFrame1);

refFrame1.Origin.ParametricPoint = PP_DipperStick_Cyl;
IJointRevolute RevJoint8 = model.CreateJointRevolute("RevJoint4", BodyDipperStick,
BodyHydraulicCylinder_Cylinder, refFrame1);

refFrame1.Origin.ParametricPoint = PP_BktTrLink_Rod;
IJointRevolute RevJoint9 = model.CreateJointRevolute("RevJoint5", BodyHydraulicCylinder_Rod,
BodyBktTrLink_CylRod_Cylinder, refFrame1);
```

3. In the **File** menu, click **Save PNetFunction.cs** to save the file.

To create a force:

1. In this section, you will create the **Force** to be used in the **Excavator** model.
2. Under the code you entered in the previous procedure, **enter the following code to create the force.**

```
refFrame1.SetOrigin(5679.2685, -207.8525, 62.560441);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 90,90,-90);
refFrame2.SetOrigin(5579.2685, -207.8525, 62.560441);
refFrame2.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 90, 90, -90);

IForceAxial ForAxial1 = model.CreateForceAxial("BucketTipLoad", BodyDummyBucketTip, BodyBucket, refFrame2,
refFrame1);
ForAxial1.ForceDisplay = ForceDisplay.Action;
ForAxial1.Expression = Ex_BucketTipLoad;

refFrame1.SetOrigin(6400, -207.8525, 4200);
refFrame1.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 0, 90, 0);
IMarker Marker02 = Sub02.CreateMarker("Marker1", BodySub02Mother, refFrame1);

refFrame2.SetOrigin(6100, -207.8525, 4200);
refFrame2.SetEulerAngleDegree(EulerAngle.EulerAngle_ZXZ, 0, 90, 0);
IForceAxial ForceAxial02 = Sub02.CreateForceAxial("Ex_Rq_CylPow", BodyDummyDrivingForceBody,
BodySub02Mother, refFrame2, refFrame1);
ForceAxial02.ForceDisplay = ForceDisplay.Base;
```

3. In the **File** menu, click **Save PNetFunction.cs** to save the file.

To create a variable equation:

1. In this section, you will create the **variable equations and requests** to be used in the **Excavator** model.
2. Under the code you entered in the previous procedure, **enter the following code to create the variable equations and requests.**
   - The model.Redraw() function redraws the graphics in the Working pane.

```
IExpression Ex_MaxPosRot = model.CreateExpression("Ex_MaxPosRot", "0");
IVariableEquation VE_MaxPosRot = model.CreateVariableEquation("VE_MaxPosRot", Ex_MaxPosRot);
Ex_MaxPosRot.Arguments = new string[] { "Bucket.Marker3", "DipperStick.Marker3", "VE_MaxPosRot" };
Ex_MaxPosRot.Text = "IF(VARVAL(3)-AZ(1,2):AZ(1,2),VARVAL(3),VARVAL(3))";

IExpression Ex_MaxNegRot = model.CreateExpression("Ex_MaxNegRot", "0");
IVariableEquation VE_MaxNegRot = model.CreateVariableEquation("VE_MaxNegRot", Ex_MaxNegRot);
Ex_MaxNegRot.Arguments = new string[] { "Bucket.Marker3", "DipperStick.Marker3", "VE_MaxNegRot" };
Ex_MaxNegRot.Text = "IF(AZ(1,2)-VARVAL(3):AZ(1,2),VARVAL(3),VARVAL(3))";

Ex_BucketTipLoad.Arguments = new string[] { "Bucket.Marker3", "DipperStick.Marker3" };
Ex_BucketTipLoad.Text = "50000*IF(WZ(1,2,2):0,0,1)";
IExpression Ex_CylinderPower = model.CreateExpression("Ex_CylinderPower", "0");
Ex_CylinderPower.Arguments = new string[] { "Ground.Marker2",
"DrivingForceBody.Marker1@HydraulicCylinder", "Rod.Marker1@HydraulicCylinder",
"Cylinder.Marker1@HydraulicCylinder" };
Ex_CylinderPower.Text = "FX(1,2,2)*VZ(3,4,4)";
IRequestExpression ExRq_CylPow = Sub02.CreateRequestExpression("ExRq_CylPow", Ex_CylinderPower,
Ex_MaxPosRot, null, null, null, null);

model.Redraw();
```

3. In the **File** menu, click **Save PNetFunction.cs** to save the file.
4. In the **Build** menu, click **Build Excavator** to execute the build. Check if any errors or warnings appear in the **Error List** pane at the bottom of the **IDE** window. If there are any errors or warnings, correct the problems.

Linking a Function to the Dialog Window

In this section, you will learn how to call the Import() function when the user clicks the Import button in the dialog window.

To link a function to a dialog window:

1. In the **Project Explorer, right-click ExcavatorDialog.cs**.
2. In the context menu, click **View Code**.
3. Enter the following code. (Enter the bold text.)
   - Create an instance of PNetFunction to use the Import function.

```
public partial class ExcavatorDialog : Form
{
        IApplication application;
        string strFilePath;
        string[,] strExcavatorPartName = new string[7, 2];
        PNetFunction Function;

        public ExcavatorDialog(IApplication app)
        {
                InitializeComponent();
                application = app;
                Function = new PNetFunction(application);
        }
```

4. In the **btImport_Click()** function, enter the following code to use the **PNetFuction** instance to call the **Import()** function. (Enter the bold text.)

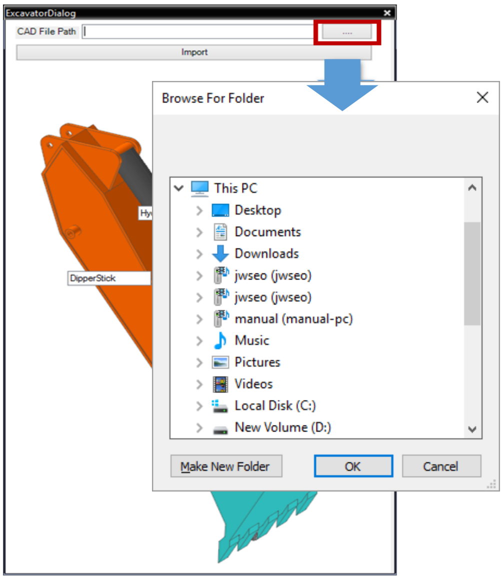
```
private void btImport_Click(object sender, EventArgs e)
{
        UpdateDB();
        Function.Import(strExcavatorPartName);
}
```

5. In the **File** menu, click **Save ExcavatorDialog.cs** to save the file.

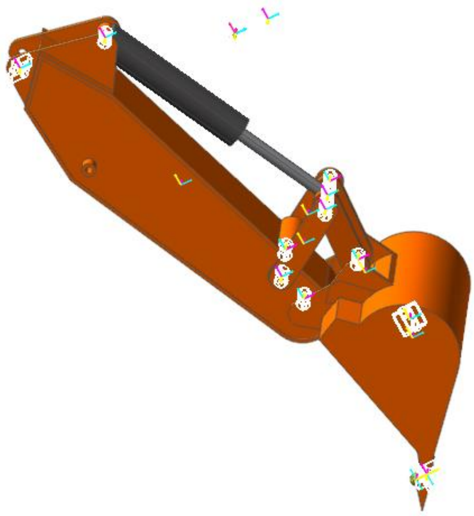
Testing a Dialog Window

In this section, you will test whether the application you created works properly.

To run the application:



1. In the **Build** menu, click **Build Excavator**. Check if any errors or warnings appear in the **Error List** pane at the bottom of the **IDE** window. If there are any errors or warnings, correct the problems.
2. In **RecurDyn, on the Customize** tab, in the **ProcessNet** group, click **Run**.
3. In the tree in the lower half of the **Run ProcessNet** dialog window, click **Run** under **Excavator**.
4. In the **Run ProcessNet** dialog window, click the **Run** button.
5. The dialog window shown on the right appears.
6. In the dialog window, click the **...** button.
7. When the **Browse For Folder** dialog window appears, specify the path where the file to import exists. (For this tutorial, the file is located in the "<InstallDir>/Help/Tutorial /ProcessNet/VSTA/Excavator/Excavator" directory.)
8. Once you confirm that the file path has been entered in the CAD File Path, click the **Import** button.
9. The Excavator model appears automatically, as shown below.
10. Click the × button in the top right corner of the dialog window to close the **ExcavatorDialog** window.
11. Close the **Run ProcessNet** dialog window.



Chapter

5

Analyzing a Model

Task Objectives

In this chapter, you will create a function that applies the values of an entity to the model when the user changes them in the dialog window and learn how to perform model analysis in the dialog window.

Estimated Time to Complete this Task

10 minutes

Editing the Layout of the Dialog Window

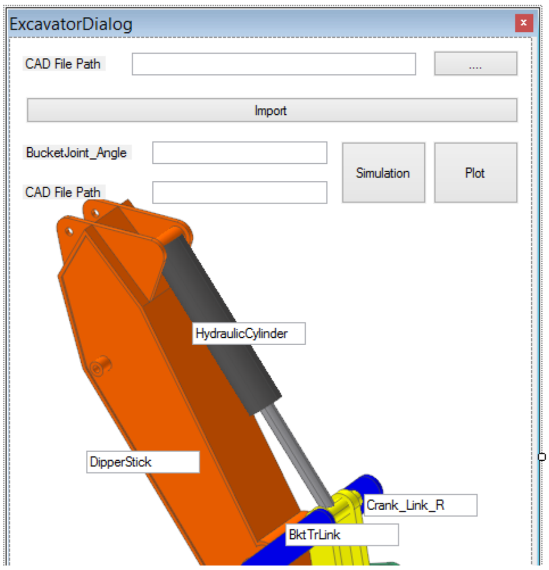
In this section, you will add a text box and a button to the dialog window so that users can perform model analysis and plotting from the dialog window.

To edit the layout of the dialog window:

1. In the **Project Explorer**, double-click **ExcavatorDialog.cs**. The **ExcavatorDialog.cs** dialog window appears in the **Edit IDE Project** pane.
2. Select the **ToolBox**, and then add the following controls to the **Common Controls** list. Then, change the values of these controls.

Dialog Element	Text	Name	Location	Size
Button1	Simulation	btSimulation	292, 90	75, 57
Button2	Plot	btPlot	373, 90	75, 57
TextBox1		tbBucketJointAngle	126, 92	154, 21
TextBox2		tbCrankLength	126, 127	154, 21
Label1	BucketJoint_Angle	lbBucketJointAngle	12, 95	82, 12
Label2	Crank_Length	lbCrankLength	12, 130	82, 12

3. In the File menu, click Save ExcavatorDialog.cs to save the file.



Model Analysis Function

In this section, you will create a function that applies the length of a cylinder and the angle of a bucket to the model when a user enters these values in the dialog window. The code will then perform the model analysis when the user clicks the relevant button.

Model analysis function

1. In the **Project Explorer**, double-click **PnetFunction.cs**.
2. Under the **Import()** function created in the previous chapter, create a **simulation** function.
   - Enter the following code to change the PV values of PV_DeltaCrankLength and PV_BucketJointAngleDeg using the Bucket Joint Angle and Crank Length values in the dialog window.

```
public void Simulation(double[] dPVValue)
{
            modelDocument = application.ActiveModelDocument;
            model = modelDocument.Model;

            IParametricValue PV_DeltaCrankLength = model.GetEntity("PV_DeltaCrankLength") as IParametricValue;
            IParametricValue PV_BucketJointAngleDeg = model.GetEntity("PV_BucketJointAngleDeg") as IParametricValue;
            PV_BucketJointAngleDeg.Value = dPVValue[0];
            PV_DeltaCrankLength.Value = dPVValue[1];
            model.Redraw();

            modelDocument.ModelProperty.DynamicAnalysisProperty.SimulationStep.Value = 400;
            modelDocument.ModelProperty.DynamicAnalysisProperty.SimulationTime.Value = 4;
            modelDocument.Analysis(AnalysisMode.Dynamic);
}
```

3. In the **Project Explorer**, right-click **ExcavatorDialog.cs**, and then click **View Designer**.
4. In the function created by double-clicking the **Simulation** button, enter the following **code**.

```
private void btSimulation_Click(object sender, EventArgs e)
{
            double dAngle = Convert.ToDouble(this.tbBucketJointAngle.Text);
            double dLength = Convert.ToDouble(this.tbCrankLength.Text);
            double[] dPVVAlue = new double[] { dAngle , dLength};
            Function.Simulation(dPVVAlue);
}
```

5. In the **File menu, click Save ExcavatorDialog.cs** to save the file.

Chapter

6

Creating a Plot Automatically

Task Objectives

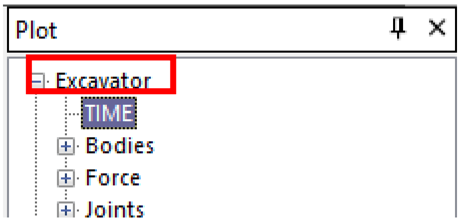
In this chapter, you will learn the commands used to draw a plot in ProcessNet.

Estimated Time to Complete this Task

10 minutes

Plot Function

To use the plot function:



1. In the Project Explorer, double-click PNetFunction.cs.
2. Under the Simulation() function created in the previous chapter, create the following **Plot** function.
   - For GetPlotData, "EXCAVATOR" is the root of the plot. This root may differ depending on the RecurDyn version.
   - Use the ActivateView function to specify the view.

```
public void Plot()
{
        modelDocument = application.ActiveModelDocument;
        plotDocument = modelDocument.CreatePlotDocument(PlotDocType.WithRPLT);

        double[] Time = plotDocument.GetPlotData("EXCAVATOR/TIME");
        double[] dRelative = plotDocument.GetPlotData
        ("EXCAVATOR/Joints/TraJoint1@HydraulicCylinder/Pos1_Relative");
        double[] dDrivingForce = plotDocument.GetPlotData
        ("EXCAVATOR/Joints/TraJoint1@HydraulicCylinder/Driving_Force");
        double[] dPos1_Relative = plotDocument.GetPlotData
        ("EXCAVATOR/Joints/Rev_Dipper_Bucket/Pos1_Relative");

        plotDocument.PlotShowWindowType(ShowWindowOption.ShowAll);
        plotDocument.LoadAnimation(PlotWindowPosition.LeftLower);

        plotDocument.ActivateView(0, 0);
        plotDocument.DrawPlot("Relative", Time, dRelative);
        plotDocument.DrawPlot("DrivingForce", Time, dDrivingForce);
        plotDocument.SimpleMathMultiply(0, 1, false, true);

        plotDocument.ActivateView(0, 1);
        plotDocument.DrawPlot("Post Relative", Time, dPos1_Relative);
}
```

3. In the **Project Explorer**, right-click **ExcavatorDialog.cs**, and then click View Designer.
4. Double-click the **Plot** button.
5. Under the created function, enter the following Plot function.

```
private void btPlot_Click(object sender, EventArgs e)
{
        Function.Plot();
}
```

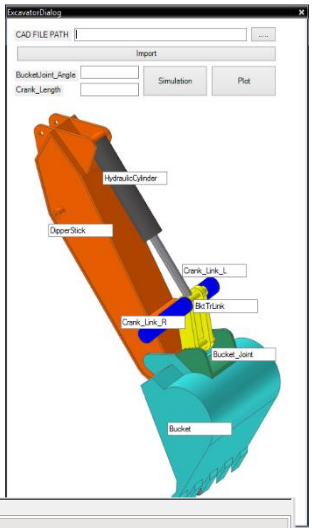
6. In the **File menu**, click **Save ExcavatorDialog.cs** to save the file.

Testing the Created Application

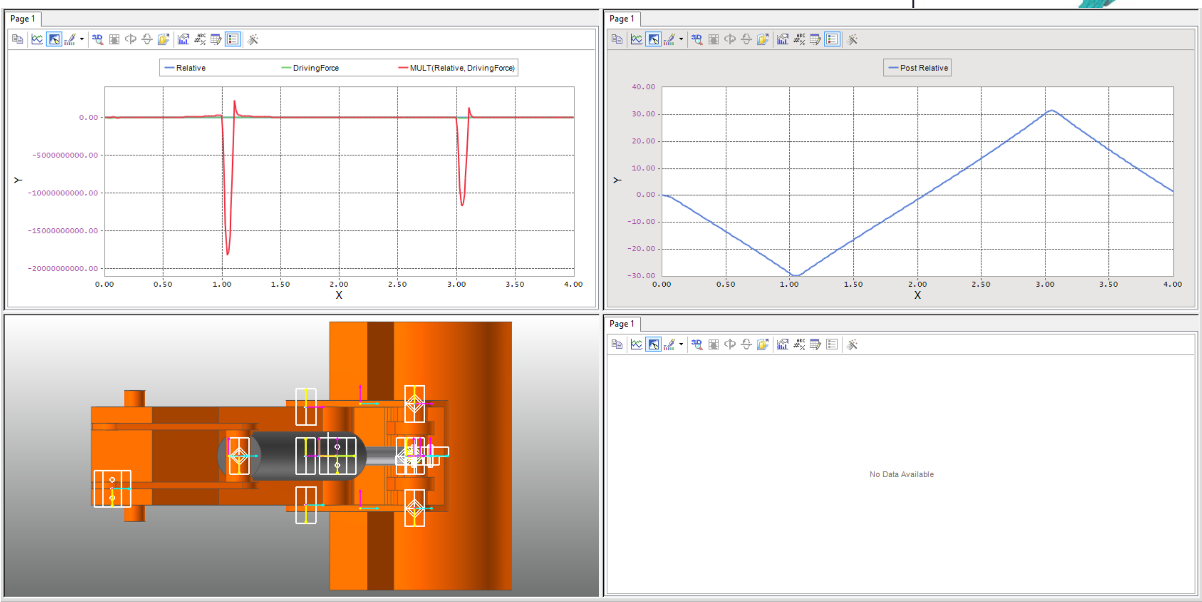
In this section, you will test whether the application you created works properly.

To run the application:

1. In the **Build** menu, click **Build Excavator**. Check if any errors or warnings appear in the **Error List** pane at the bottom of the **IDE** window. If there are any errors or warnings, correct the problems.
2. In **RecurDyn**, on the **Customize** tab, in the **ProcessNet(VSTA)** group, click **Run**.
3. In the tree in the lower half of the **Run ProcessNet** dialog window, click **Run** under **Excavator**.
4. In the **Run ProcessNet** dialog window, click the **Run** button.
5. The dialog window shown on the right appears.
6. In the dialog window, type 0 for both the **BucketJoint_Angle** and **Crank_Length.**
7. Click the Simulation button to confirm that the PV_DeltaCrankLength and PV_BucketJointAngleDeg values change according to the BucketJoint_Angle and Crank_Length values you entered and that the model analysis is performed according to the new values.



8. Once the analysis is complete, click the **Plot** button to draw a plot shown below.



9. Close the **ExcavatorDialog** window.
10. Close the **Run ProcessNet** dialog window.

Thanks for participating in this tutorial