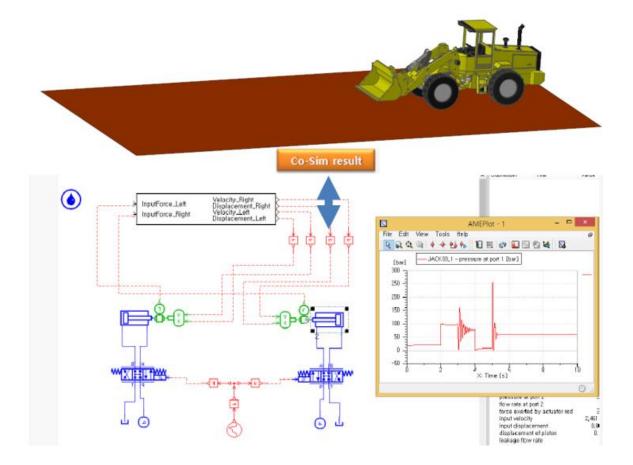


Wheel Loader

(General CoSim with AMESim by FMI)





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Edition Note

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

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Getting Started

This tutorial describes how co-simulation between RecurDyn and AMESim can be performed using the Functional Mockup Interface (FMI) method. RecurDyn handles kinematic analysis, and AMESim handles hydraulic system analysis, and these two analyses are co-simulated.

The model to be covered in this tutorial is a wheel loader vehicle model, which models the hydraulic actuator using AMESim and performs co-simulation with RecurDyn for steering control of the wheel loader.

Objective

This tutorial covers the following topics:

- How to create General Plant Input and Output in RecurDyn
- How to set up the environment of RecurDyn General CoSim FMI
- How to model AMESim Interface Block
- How to set up the environment of AMESim FMI
- How to perform co-simulation of the General CoSim FMI between RecurDyn and AMESim
- How to review the results with post-processing in RecurDyn

Prerequisites

- This tutorial is intended for users who have completed the basic tutorials provided with RecurDyn. If you have not completed these tutorials, then you should complete them before proceeding with this tutorial.
- The software for AMESim and Compiler must be installed to proceed with this tutorial. This tutorial is based on AMESim 2017 and Microsoft Visual Studio 2012 is used as a compiler. Specifically, for AMESim 2017, only up to Microsoft Visual Studio 2012 is supported, and the higher versions are not supported.

Procedures

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

(* The time required may vary depending on the specifications of the computer and the proficiency of the user.)

Task	Duration (minutes)
Modeling of General Input and Output in RecurDyn	10
Setting General CoSim FMI in Master Mode of RecurDyn	30
Setting General CoSim FMI in Slave Mode of RecurDyn	30
Result Analysis	10
Total	80

Estimated Time to Complete

80 minutes



Modeling of General Plant Input and Output in RecurDyn

Task Objective

Learn how to create Plant Input and Output in **RecurDyn**.



10 minutes

Opening the Model

To copy the example model

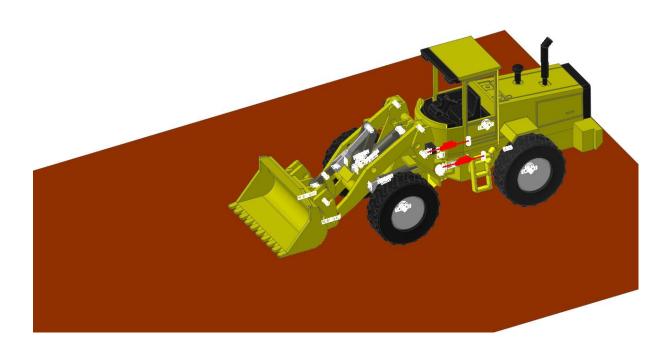
 Copy the FMI (AMESim) tutorial example folder provided by RecurDyn to an analyzable location.
 Folder path: <Install Dir>\Help\Tutorial\Control\AMESim\WheelLoader

To run RecurDyn and open the initial model:



- 1. On the Desktop, double-click the **RecurDyn** icon to run **RecurDyn**. The **Start RecurDyn** dialog window will appear.
- 2. When the **Start RecurDyn** dialog window appears, close it.
- 3. In the **File** menu, click **Open**.
- 4. In the example folder copied above, select **WheelLoader_Start.rdyn**.
- 5. Click **Open**. The model appears as shown in the following figure.
- 6. In the File menu, click Save As and save the file as WheelLoader_FMI.rdyn.

Tip: You need to specify the folder name so that there is no space in the path to save the model, so there is no problem in Co-Simulation process.



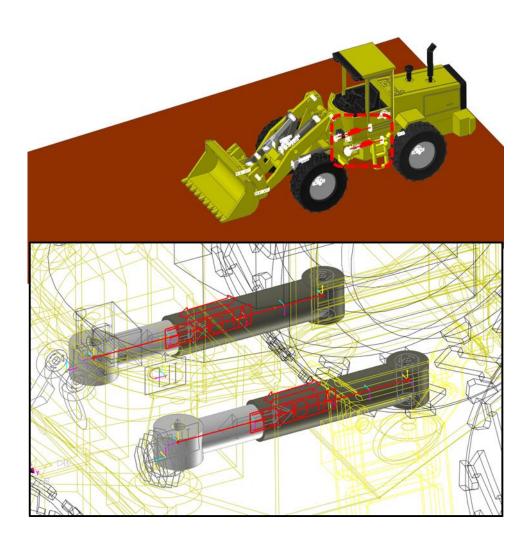
To analyze the model configuration:

ø

1. In **Render Toolbar**, select **Each Render**.

2. In the Database window, select **Axial1** and **Axial2**.

Zoom in the two highlighted Axial Force elements. These two Axial Force elements are the actuators for steering the wheel loader.



Creating General Plant Input

Create a General Plant Input to input the actuator hydraulic pressure generated in AMESim to the axial force.

To creating General Plant Input:



- On the Communicator tab, in the Control group, click GPlant_In (General Plant Input).
- In the General Plant Input List window, click Add to create GPlantInput1. Click Add again to create GPlantInput2.
- 3. Click **OK** to close the **General Plant Input List** window.
- 4. In the Database window, among the **Force** elements, right-click **Axial1** and click **Properties**.

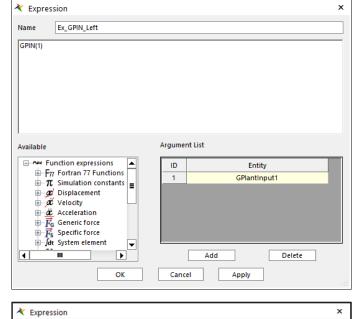
No	Use		ame	 Туре	Init	ial Value	
1			ntinput1	 DOUBLE		0.0	
2		GPlar	ntinput2	DOUBLE		0.0	
						elete	2

5. Click the **EL** button in the **Expression** pane to open the **Expression List**. Then click the **Create** button.

Properties of Axia	l1 [Current Unit : N/kg/mm/s/deg]
General Connect	or Axial
Туре	Standard Axial Force 👻
Expression —	
Name	EL
Expression	
Force Display	Action - Apply Only to Action Body
Scope	OK Cancel Apply

- 6. As the Expression Name, enter "Ex_GPIN_Left".
- 7. For a function, enter **GPIN(1)**.
- 8. In Argument List, click Add.
- 9. From the database, drag & drop **PlantInput1** to the ID 1 of the **Argument List** as shown in the figure on the right.
- 10. Click the **OK** button to complete the **Expression** setup for **Axial1**.

11. Open the **Properties** dialog window for **Axial2** as well and complete the **Expression** setup for **Axial2** as shown in the figure on the right in the same manner as steps 5 to 10 above.



GPIN(1)		
vailable	Argument	List
⊢ Punction expressions ⊕ Fη Fortran 77 Functions	▲ ID	Entity
 π π Simulation constants a 	1	GPlantInput2
Displacement		
Velocity	=	
\overline{F}_{G} Generic force		
\overline{F}_{s} Specific force		
∫dt System element		
If Arithmetic IF		
Interpolation	-	

Creating General Plant Output

To transmit the detected values of actuator length and change speed for steering control of wheel loader to **AMESim**, create the **General Plant Output**.

To create Plant Output:

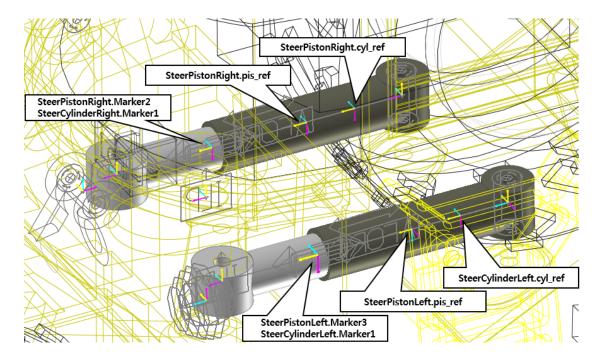


- 1. On the **Communicator** tab, in the **Control** group, click **GPlant_out** (General Plant Output).
- 2. In the General Plant Output List window, click Add.
- 3. If **GPlantOutput1** is created, click **E** under **Expression/String**.
- 4. In the **Expression List** window, click the **Create** button.

- 5. Change the Name of Expression to Ex_GPlantOutput1.
- 6. In the **Expression** window, enter the function **DZ(1,2,2)*0.001**.
- 7. In **Augment List**, click **Add** to make two **IDs**.
- 8. In the **Augment List**, enter the following two markers:
 - ID 1: SteerPistonLeft.DZ_ref
 - ID 2: SteerCylinderLeft.DZ_ref
- 9. Click **OK** to apply the changes.
- 10. In the **GPlant Output List** window, click **Add** to create **GPlantOutput2**.

eneral	Plant Output Lis	t		
Seneral	Plant Outputs			
No	Use	Name	Туре	Expression / String
1		GPlantOutput1	DOUBLE	Expression / Stilling
]	Add	Insert		Delete
			OK	Cancel Appl
pressi	on List			
pressio				
No	Name	Expression	Value	Comment
1	Ex_zero	0	E 0	
-	Ex_bucket Ex_boom	100*step(time,0,0,2,1)	E O	
	Ex_drv	200*step(time, 3, 0, 5, 1)*0 -time*PV_drv_velocity_m.		
	Ex_GPIN_Left	GPIN(1)	E N/A	
6	Ex_GPIN_Rigth	GPIN(1)	E N/A	4
				:
Cre	ate	Insert]	Delete
		L		Cancel Apply
			- OK	Current Appr
Expre	ssion			
me	EX_GPlantOutp	ut1		
Z(1,2,2)'	•0.001			
ailable		Argument	List	
- Parce F F 	unction expression TF Fortran 77 Funct Simulation cons Displacement Velocity Acceleration Generic force Specific force at System element	tions stants		Entity PistonLeft.DZ_ref ylinderLeft.DZ_ref
Ľ			Add	Delete
		OK Cancel		pply

- 11. In the **Expression List** window, click the **Create** button.
- 12. Change the Name of Expression to Ex_GPlantOutput2.
- 13. In the **Expression** window, enter the function **VZ(1,2,2)*0.001**.
- 14. In the Augment List, enter the following two markers:
 - ID 1: SteerPistonLeft.VZ_ref
 - ID 2: SteerCylinderLeft.VZ_ref
- 15. In the same manner as steps 1 to 14, create **GPlantOutput3** and **GPlantOutput4** by entering the following functions and markers in the **Augment List**.
 - GPlantOutput 3
 - Expression Name: Ex_GPlantOutput3
 - Function: DZ(1,2,2)*0.001
 - Augment List ID1: SteerPistonRight.DZ_ref
 - Augment List ID2: SteerCylinderRight.DZ_ref
 - GPlantOutput 4
 - Expression Name: Ex_GPlantOutput4
 - Function: VZ(1,2,2)*0.001
 - Augment List ID1: SteerPistonRight.VZ_ref
 - Augment List ID2: SteerCylinderRight.VZ_ref



Performing Simulation

Run the simulation to check the initial model status.

To run the simulation:



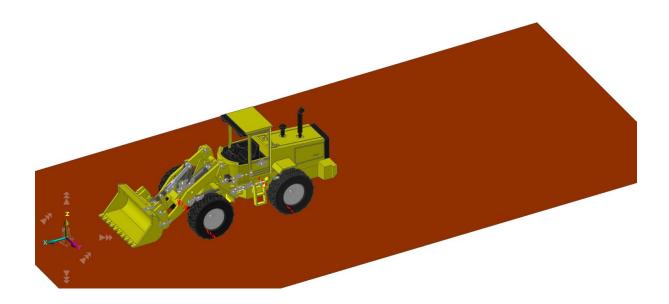
►

- 1. On the Analysis Tab, in the Simulation Type group, select Dyn/Kin. The Dynamic/Kinematic Analysis dialog window appears.
- 2. After entering parameters as follows, click the **Simulation** button.
 - End Time: 7
 - Step: 700

To view the result:

1. Under the **Analysis Tab**, in the **Animation Control** group, press the **Play** button to check if the wheel loader moves as shown in the figure below.

If the analysis is completed normally and there is no problem with the model, the wheel loader will go straight from the initial state to before the last 7 seconds. This is because the hydraulic pressure was not applied to the actuator for wheel loader steering.



Chapter 3

Setting General CoSim FMI in Master Mode of RecurDyn

Task Objectives

Learn how to perform **Co-simulation** by setting **General CoSim FMI** to **Master Mode** for **RecurDyn** and **Slave Mode** for **AMESim**. At this time, an **Interface Block** is required in the **AMESim** to exchange the detected values of the **RecurDyn** model mechanism and the hydraulic pressure generated in **AMESim**. Learn how to create the **AMESim Interface Block** model and configure FMI settings.



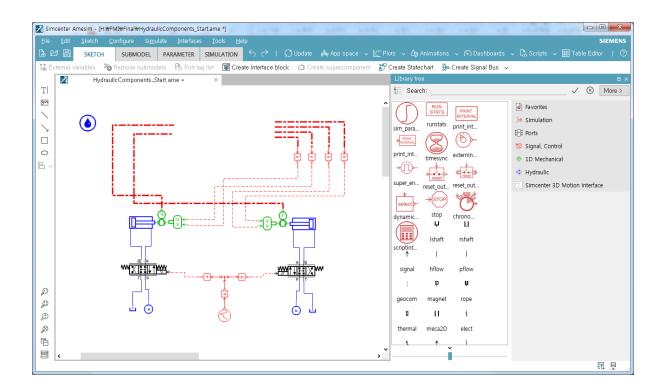
30 minutes

Importing the AMESim Model

AMESim model with an actuator is also available in the tutorial example folder copied in the previous chapter. Perform the **Interface Block** modeling by utilizing the provided model.

To run AMESim and import the initial model:

- 1. Double-click the **AMESim** icon on the Windows Desktop, etc. to run **AMESim**.
- 2. In the File menu, click Open.
- 3. In the example folder copied above, select HydraulicComponents_Start.ame.
- 4. Click **Open**. The AMESim model with an actuator is displayed as shown in the figure below.
- Select File > Save as to change the name of the model file to HydraulicComponents_fmu_export.ame.

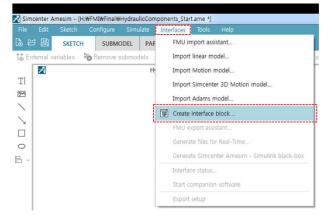


Modeling of AMESim Interface Block

To create AMESim Interface Block:

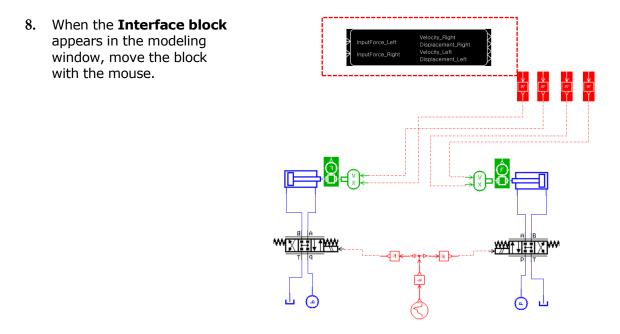
1. Click Menu > Interfaces > Create Interface Block to create an Interface block.

> (Menu positions may vary depending on the **AMESim** version.)



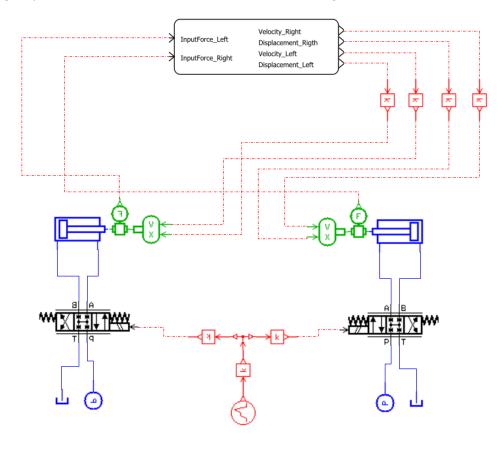
- 2. In the Interface Icon Creation dialog window, set the Number of inputs to two.
- 3. Change Type of interface to Functional Mock-up Interface (FMI).
- 4. Set the **Number of outputs** to four.
- 5. Enter the names of the **Inputs** in the correct order as follows.
 - >1: InputForce_Left
 - >2: InputForce_Right
- 6. Enter the names of the **Outputs** in the correct order as follows.
 - 4>: Velocity_Right
 - 3>: Displacement_Right
 - 2>: Velocity_Left
 - 1>: Displacement_Left
- 7. Click the **OK** button to complete creation.

Number of inputs: Type of interface:	Number	of outputs:
2 🗘 Functional Mock-up Interface (FMI)	~ 4	
		^
	Velocity_Right	4 >
> 1 InputForce_Left	Displacement_Right	3 >
> 2 InputForce_Right	Velocity_Left	2 >
	Displacement_Left	1> 🗸
Clear all text	Auto-set names Lo	ad setup



To connect the AMESim Interface Block:

 Connect the **Interface block** and the actuator elements as shown in the figure below. If the connection is different from the figure, you may get incorrect results. Therefore, it must be correctly connected to the port of the actuator component and the **Input & Output** port of the **Interface block** as shown in the figure below.



Setting AMESim FMI

To set the environment of AMESim Compiler:

1. Click **Menu > Tool > Preferences** to run it.

Interfaces		Tool	s Help	
RAMETER	S		Preferences Ctrl+Shift+P	
🗟 Port ta	🚔 Port tag I		Advanced	>
draulicCompor			Model update assistant Ctrl+K	
			Library update assistant	
			Table Editor	

- 2. In the **Preferences** dialog window, click the **Compilation** tab.
- 3. Under the Model Compilation, check the Debug by default option.
- 4. Under the Active compiler, select Microsoft Visual C++ (64-bit).

Preferences		8 ×
General	Model Compilation	
	Compile for the legacy simulator	
Drawing	Automatic window close on successful compilation	
	Automatically add missing libraries in path list	
Compilation	Debug by default	
Simulation	Active compiler:	
	 Microsoft Visual C++ (32-bit) 	
Parallel processing	○ GNU GCC (32-bit)	
	Intel C++ (32-bit)	
Post processing	 Microsoft Visual C++ (64-bit) 	
Model management	Intel C++ (64-bit)	
model management	Encrypted Supercomponents	
Modelica	Use old encryption mechanism	Compiler Settings
	Information	
Help Restore def	aults	Cancel Apply

Exporting AMESim FMU

To export *.fmu file in AMESim:

4		🔀 Simcenter Amesir	m - [H:₩FMI₩Fi	inal₩FMU_Tes	st_by_DA₩Hydrau	ulicCompon	ents_fmu_export.
1.	Click the SIMULATION Tab	<u>F</u> ile <u>E</u> dit <u>S</u> ke	etch <u>C</u> onfigu	ure Si <u>m</u> ula	ate <u>I</u> nterfaces	<u>T</u> ools	<u>H</u> elp
	to change mode.	🕼 🗁 🖺 🛛 si	KETCH SU	JBMODEL	PARAMETER	SIMULATI	ON
		Run simulation	👼 Run Para	ameters	🚟 Global paran	neters i	🚮 Performance
		-		ŀ	HydraulicCompo	nents_fmu	_export,ame *

Tip: You can check the **Build** status of the model by checking the **Completed message** on the **Message Tab** and the **System build completed message** on the **Details Tab**.

System Compilation - [HydraulicComponents_fmu_export]	?	×	System Compilation - [HydraulicComponents_fmu_export] ? X
essages Details			O Messages Details
Creating a simulation program for your system. Number of states: Exploits: 8 Dedared mpiolits: 0 Generated inploits: 0			AlyTOR.Ib [*] "C:/Program Files/Simcenter/v1700/Amesim/libmoton/lib/win64/AMEMOTION.Ib [*] dexe 4.D -o HydraulicComponents_fmu_exportdbj @'HydraulicComponents_fmu_exportobj
Completed		Ш	d : Command line warning D9035 : option 'o' has been deprecated and will be removed in a future release d 'c: jprogram files juncenter /1/1702/amesim/libmec/slaumodels/wine4/#T002.obj' 'c: jprogram files juncenter /1702/amesim/libm/cd/ orgam files/juncenter /1702/amesim/libm/cd/ submodels/wine4/#T002.obj' 'c: jprogram files/juncenter /1702/amesim/librig/slaumodels/wine4/#T002.obj' 'c: jprogram files/ juncenter /1702/amesim/librig/slaumodels/wine4/#F00.obj' 'c: jprogram files/juncenter /1702/amesim/librig/slaumodels/ /wine4/#1202.obj' 'c: jprogram files/jincenter /1702/amesim/librig/slaumodels/wine4/#D00.obj' 'c: jprogram files/ juncenter /1702/amesim/librig/slaumodels/wine4/#F01.obj' 'c: jprogram files/jincenter /1702/amesim/librig/slaumodels/ /vin04/#1202.obj' 'c: jprogram files/jincenter /1702/amesim/librig/slaumodels/wine4/#F0100.obj' 'c: jprogram files/ /vin04/#1202.obj' 'c: jprogram files/jincenter /1702/amesim/librig/slaumodels/wine4/#AMEMOdels/ /vin04/#1202.obj' 'c: jprogram files/jincenter /1702/amesim/librig/slaumodels/ /vin04/#1202.obj' c: jprogram files/jincenter /1702/A
Help	C	ose	Help Cose

2. Click Menu > Interfaces > FMU export assistant....

Simu	ulate	Inte	rfaces Tools Help
DDEL	PAR		FMU import assistant
ters	謂 G		Import linear model
	Hydra		Import Motion model
			Import Simcenter 3D Motion model
			Import Adams model
		Ţ	Create interface block
			FMU export assistant
			Generate files for Real-Time
			Generate Simcenter Amesim - Simulink black-box
			Interface status
			System contains FMI interface
			Export setup

- 3. In the **Export settings** page, set **FMU type and version** to **Co-simulation 2.0**.
- 4. Set the **Output directory** to the folder where the **RecurDyn** file of this manual is located.
- 5. Click the **Next** button.

FMU Export Assistant		8 X
Welcome Configure a Funct	ional Mock-up Unit (FMU) to export	
Export settings	FMU type and version	
	Visibility level: exposed elements	
FMU generation	 High: expose all parameters and variables Low: expose nothing except input and output variables User-defined: expose only the watch parameters and variables 	
	 Generate log file ✓ Embed tables Provide directional derivative when applicable 	
	FMU for real-time	
	Output directory: H:₩FMI₩Final	
<u>H</u> elp	< <u>B</u> ack <u>N</u> ext >	Cancel

- 6. On the **Platform selection** tab, verify that the **compiler** is set to **Microsoft Visual** C++.
- 7. Click the **Generate** button to begin creating the ***.fmu** file and exporting the file.

FMU Export Assistant	8	×
Platform selection Configure binaries	to include in the FMU	
✓ Export settings	32-bit compilation Microsoft Visual C++ (32-bit)	
Platform selection	 GNU GCC (32-bit) Intel C++ (32-bit) 	
FMU generation	64-bit compilation Microsoft Visual C++ (64-bit) Intel C++ (64-bit) Additional compilation settings:	
Help	< <u>B</u> ack <u>G</u> enerate > Ca	ancel

8. Export the *.fmu file generated by **AMESim** to the location you set.

FMU Export Assistant		? X
Results FMU export results		
✓ Export settings	Messages Details	
✓ Platform selection	Starting FMU creation process Starting Python	
	Starting FMI interface	
FMU generation	Preparing C files	
	Compiling FMU code for target win32-vc	
	Compiling FMU code for target win64-vc,	
	Generating FMU	
	FMU generation succeeded,	
	End interface generation -> OK	
	FMU generation completed.	
<u>H</u> elp	< <u>B</u> ack	<u>C</u> lose

9. You can see that the *.fmu file is created in the folder as shown on the right:

이름
2d_flat.rdf
HydraulicComponents_fmu_export.ame
HydraulicComponents_fmu_export.fmu
HydraulicComponents_Start.ame
🖹 WheelLoader_Start.rdyn
WheelLoader_V9R3.rdyn

Setting General CoSim FMI in RecurDyn

To set the environment of FMI Co-Sim in RecurDyn:

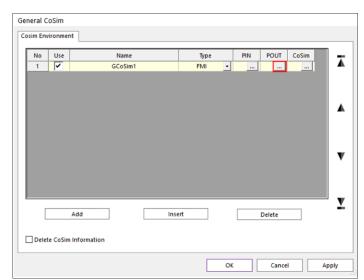


- 1. On the **Communicator** tab, in the **Control** group, click **GCoSim**.
- 2. In the **General CoSim window**, on the **CoSim Environment** page, click the **Add** button.
- 3. Set Name to GCoSim1.
- 4. Select **Type** to **FMI**.
- 5. Click the 🗔 button under **PIN**.
- In the General Plant Input List (GCoSim1) window, click Add twice to add GPlantInput1 and GPlantInput2.

	Home	SubEntity	Analysis	Profession	nal Fle	xible Po	st Analysis	TSG
2 Plant_In	Plant_C	Dut Simulink	External	AMESim	FMI	GPlant_In (Dent_Out	GCoSim
Genera	al CoSim							
Cosim	Environmer	nt						
N	o Use	Nar	ne	Туре	e Pit	N POUT	CoSim	_
	1	GCos		FMI				Ā
								•
	al Plant Inp	Add Dut List (GCoSim1		Insert		Delete		Y
	lo	Name		Tv	pe	Initial Value		- 11
	1	GPlantInput	1		JBLE	0.0		
	2	GPlantinput	2	V DOU	JBLE	0.0		• • •
		Add		Insert		Delete		
				Γ	OK	Cancel	App	bly

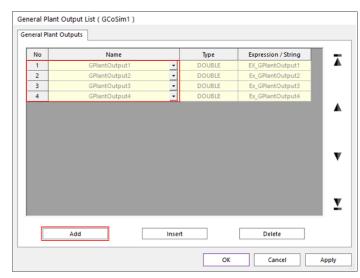
7. Click the **OK** button.

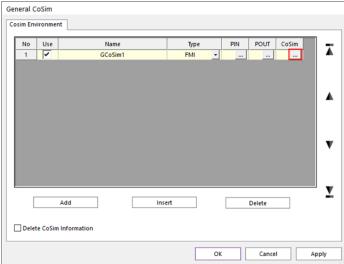
 In the General CoSim window, on the CoSim Environment page, click the button under POUT.



- In General Plant Output List (GCoSim1) window, click the Add button four times to add four GPlantOutputs.
- 10. Click the **OK** button.

11. In the **General CoSim** window, on the **CoSim Environment** page, click the button under CoSim.





- 12. In the **FMI (GCoSim1)** dialog window, on the **CoSim Environment** page, select the Import option.
- 13. Set Interface Version to 2.0.
- 14. In Model File, click the 🗔 button, and select **HydraulicComponents**

_fmu_export.fmu file created in the Open dialog window.

- 15. Click the **OK** button in the **FMI (GCoSim1)** dialog window to complete the settings.
- 16. In the **General CoSim** window, on the **CoSim Environment** page, click the **OK** button to complete the settings.

Interface Version	2.0
Model File	HydraulicComponents_fmu_ev
Plant File Name	WheelLoader_FMI
Interface Time Step	1.e-003
Following the Interface Time (of Master (Host)
Waiting Time (seconds)	100.
Create a FMU File	
WheelLoader_FMI	Export

RecurDyn Master Mode Co-simulation

Performing co-simulation in RecurDyn

Co-simulate the wheel loader model of **RecurDyn** and the actuator model of **AMESim** using **FMI**.

To run the simulation:

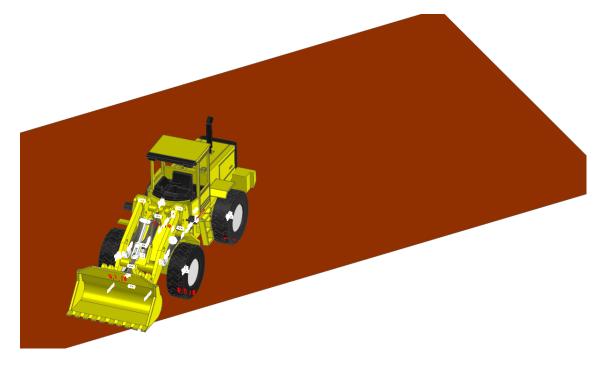
- 1. On the Analysis Tab, in the Simulation Type group, select Dyn/Kin. The Dynamic/Kinematic Analysis dialog window appears.
- 2. After entering parameters as follows, click the **Simulation** button.
 - End Time: 7
 - Step: 700

To view animation result:

1.

Dyn/Kin

- On the **Analysis Tab**, in the **Animation Control** group, click the **Play** button to check if the wheel loader moves as shown in the figure below.
 - ※ If co-simulation is successfully completed between RecurDyn and AMESim, the wheel loader will move to the left. This is because the hydraulic pressure is generated in the actuator in AMESim for wheel loader steering and this hydraulic pressure is applied to the actuator in RecurDyn.





Setting General CoSim FMI in Slave Mode of RecurDyn

Task Objectives

In this chapter, as opposed to the previous one, you will learn how to perform **FMI Co**simulation by setting **RecurDyn** to **Slave Mode** and **AMESim** to **Master Mode**.



30 minutes

Setting General CoSim FMI in RecurDyn

To set the environment of FMI Co-Sim in RecurDyn:



- On the Communicator tab, in the Control group, click GCoSim.
- In the General CoSim window, on the CoSim Environment page, click the _____ button under CoSim.
- 3. In the **FMI** dialog window, on the **CoSim Environment** page, select the **Export** option.
- 4. Set Interface Version to 2.0.
- In Create a FMU File, set the name of the file to WheelLoader_RDSlave.
- 6. Click the **Export** button to export the ***.fmu** file.

	Ho	me	SubEntity	Analys	is Pro	fessional	Flexible	Post Ana	lysis TSG
-57	1	1	S S	1	. 1	1 4	🂫	1 1	
Plant_	in Pi	lant_O	ut Simul	ink Extern	al AME	Sim Fl	MI GP	lant_In GPlant	Out GCoSim
Ger	neral C	oSim							
Co	osim Env	ironmer	nt						
	No	Use		Name		Туре	PIN		Sim
	1	Y		GCoSim1		FMI	· .		
									v
									v
			Add		Inse	rt		Delete] –
	Delet	e CoSim	Information						
							ОК	Cancel	Apply

► FMI ► Final
새 졸더
이름
2d_flat.rdf
HydraulicComponents_Start.ame
WheelLoader_RDSlave.fmu
WheelLoader_Start.rdyn
,
,

FMI (GCoSim1)	
CoSim Environment	
OImport	Export
Interface Version	2.0 🔻
Model File	HydraulicComponents_fmu_export.
Plant File Name	WheelLoader_FMI
Interface Time Step	1.e-003
O Following the Interface Time of M	aster (Host)
Waiting Time (seconds)	100.
Create a FMU File	
WheelLoader_RDSlave	Export
0	K Cancel Apply

Setting AMESim FMI

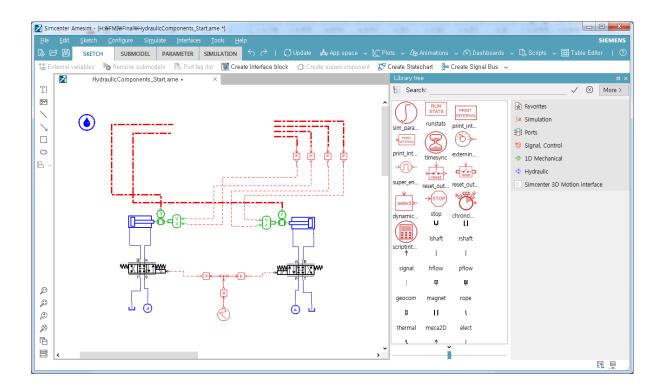
To run AMESim and import the initial model:



1. Double-click the **AMESim** icon on the Desktop of Windows, and then run **AMESim** again.

(X If AMESim is already running, close it and run it again.)

- 2. In the File menu, click Open.
- 3. In the example folder copied above, select HydraulicComponents_Start.ame.
- 4. Click **Open**. The AMESim model with the actuator is displayed as shown in the figure below.
- Select File > Save as to change the name of the model file to HydraulicComponents_fmu_import.ame.



Modeling of AMESim Interface Block

To import FMU Interface Block:

1.	Click Menu >	🔀 Sim	center A	Amesim - [H:	₩FMI₩Final₩	Hydraul	icCom	ponents_Sta	rt.ame *]		
	Interfaces > FMU	File		Sketch	Configure		late	Interfaces	Tools	Help	
	import assistant	[≩ ⊵	∮₿	SKETCH	SUBMO	DDEL	PAR	FMU i	mport ass	sistant	
		î@ E>	ternal v	ariables 🖁	🕲 Remove s	ubmod	els	Import	t linear m	odel	
			A				H	Import	t Motion I	model	
		Τl						Import	t Simcent	ter 3D Motion model	
		<u></u>						Impor	t Adams r	model	
								Create	interface	block	
		7						FMU e	export assi	istant	
								Genera	ate files fo	or Real-Time	
								Genera	ate Simce	enter Amesim - Simulink black-box	L
								Interfa	ce status.		
								Start o	ompanio	n software	
								Export	setup		
•							L				

- On the Functional Mock-up page, in the FMU setting, connect the WheelLoader_RDSlave.fmu file created by RecurDyn.
- 3. Set the **Submodel storage directory** to the folder where the files ***.rdyn** and ***.ame** are located.
- 4. Set the name of **Submodel** to **RECURDYN**.
- 5. Click the **Next** button.

FMU Import Assistant		8 x
Welcome Choose a Functional M	ock-up Unit (FMU) to import	
Functional Mock-up Unit	FMU:	neelLoader_RDSlave,fmu
langest on the set	Submodel storage directory:	H:/FMI/Final/Tutorial
Import settings	🗹 Submodel name:	RECURDYN
Submodel generation		
	_	
	Add submodel to catego	ry path list
<u>H</u> elp		Back <u>N</u> ext > Cancel

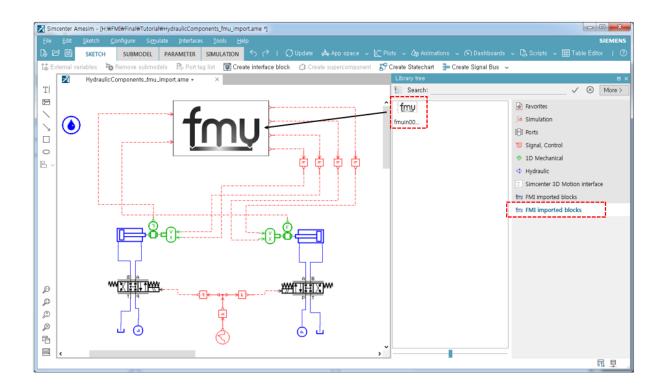
- 6. On the **Import settings** page, under **Compilation settings**, set the **Compiler** option to **Microsoft Visual C++(64-bit)**.
- 7. Set the **Preferred simulation type** to **co-simulation**.
- 8. Click the **Generate** button.

FMU Import Assistant	? ×
Import settings Set import options	
🗸 Functional Mock-up Unit	Compilation settings Microsoft Visual C++ (64-bit) v
Import settings	Preferred simulation type
Submodel generation	 co-simulation model exchange
	Additional compilation settings:
Help	< <u>B</u> ack Generate > Cancel

9. Check the **messages** to see whether **Submodel generation is** completed, and click the **Finish** button.

FMU Import Assistant	? <u>x</u>										
Results Native Simcenter Amesim submodel generation results											
🗸 Functional Mock-up Unit	Messages Warnings/Errors										
✓ Import settings	> Starting: "C:\Program Files\Simcenter \V1700\Amesim\win64\fmi_import_compiler,exe -outdir H:/FMI -name RECURDYN -ccopt -win64 - preferred cs H:/FMI/Final/										
Submodel generation	WheelLoader_RDSIave,fmu"										
	It is an FMU for Co-simulation, version 2,0, running on win64 Submodels Windows compilation batch file, 										
	This batch file is to automate the compile procedure for submodels										
<u>H</u> elp	< <u>B</u> ack Cancel <u>F</u> inish										

10. In Library tree, click FMI imported blocks to see the fmu block model. Create this fmu block in the AMESim model by dragging & dropping the block and connect it with other elements as shown in the figure below.

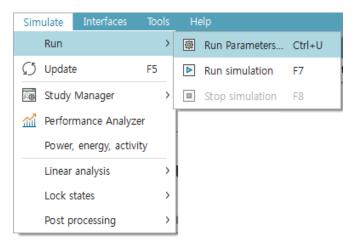


11.	Run the Simulation		_	mesim - [H:	_							_export.
	mode.	<u>F</u> ile	<u>E</u> dit	<u>S</u> ketch	<u>C</u> o	nfigure	Si <u>m</u> u	late	Interfaces	<u>T</u> ools	<u>H</u> elp	
		l} ⊭	B	SKETCH		SUBMO	DDEL PA		ARAMETER SIMUL		ON	
		🕨 Run	Run simulation 🛛 👜 Run Parameters			ters	🚟 Global parameters	neters	📶 Perfor	mance		
		· [$\boldsymbol{\lambda}$					Hydra	aulicCompo	nents_fmu	_export, a	me *

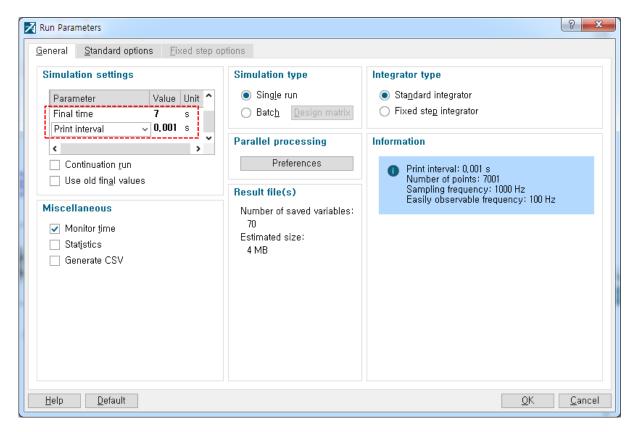
Tip: You can check the **Build** status of the model by checking the **Completed message** on the **Message Tab** and the **System build completed message** on the **Details Tab**.

System Compilation - [HydraulicComponents_fmu_export]	?	×		
\odot			System Compilation - [HydraulicComponents_fmu_export] ?	×
Messages Details			${\boldsymbol{ \oslash}}$	
Creating a simulation program for your system. Number of states: Exploits 8 Dedared implicits: 0 Generated implicits: 0			Messages Details 4[HYDR.IIb* "C:/Program Files/Simcenter/v1700/Amesim/libmotion/lib/win64/AMEMOTION.IIb" d.exe+LD = 0 HydraulicComponents_fmu_export_dil+dydaulicComponents_fmu_export_obj @'Hydra Components_fmu_export_malk_ink_args" "C:/Program Files/Simcenter/v1700/Amesim/lib/win64/AMESOL.IIb" "C:/Program Files/Simcenter/v1700/Amesim/lib/wi	
Completed			d : Command line warning D9033 : option 'o has been deprezated and will be removed in a future release d 'c:/program files/inscenter/ 1000/amesi/files/inscenter/ 1100/amesi/files/inscenter/ 1200/amesi/files/inscenter/ 1200/	c:/pr hydr/ n files odels enter "C:/P
			Creating library HydraulicComponents_fmu_export_lib and object HydraulicComponents_fmu_exportexp System build completed!	
Help	Close	2		~
			Help	llose

12. Click Menu > Simulate > Run > Run Parameters to open the Run Parameters window.



13. Set **Final time** to **7 s** and **Print interval** to **0.001 s**, which are the same values as those set for Interface Time Step in RecurDyn.



14. Click **OK** to complete the settings.

RecurDyn Slave Mode Co-simulation

Run co-simulation in AMESim.

To run the simulation:

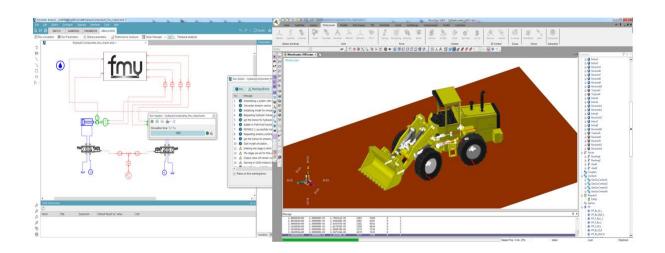
 Save and Close the WheelLoader_FMI.rdyn model of RecurDyn, and then exit RecurDyn.

(If RecurDyn is still running, cosimulation cannot be performed because AMESim cannot run RecurDyn automatically.)

2. Select Menu > Simulate > Run > Run simulation.

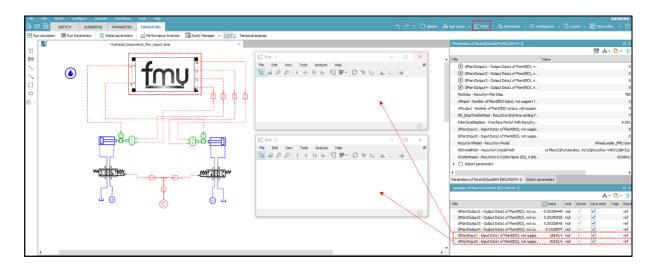
	Sim	ulate	Interfaces	Тос	ols	H	elp		
		Run			>	讏	Run Parameters	Ctrl+I	J
ł	Ø	Update	е	F5	_	▶	Run simulation	F7	
	2	Study	Manager		>		Stop simulation	F8	
	<u>.</u>	Perfor	mance Analyze	r					
		Power,	, energy, activit	y					
		Linear	analysis		>				
		Lock s	tates		>				
		Post p	rocessing		>				

3. When the simulation starts, **AMESim** runs **RecurDyn**, opens the model, and starts the co-simulation automatically.

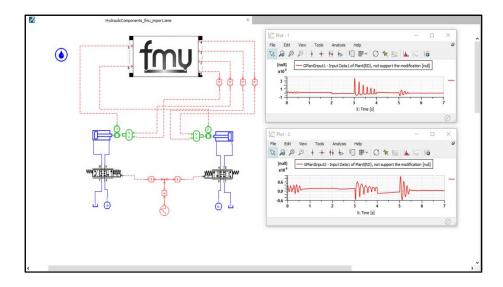


To view analysis results in AMESim:

- 1. After the analysis is complete, double-click the **Plots** button on the ribbon menu in AMESim to create a Plot window.
- 2. In AMESim, click **FMI Import blocks**.
- 3. In Variables of fmuin002out004 [RECURDYN-1], drag & drop GPlantInput1 and GPlantInput2 to the Plot window.



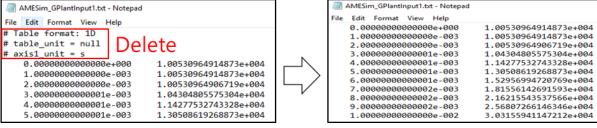
4. Then, in AMESim, you can see the results of **GPlantInput1** and **GPlantInpput2** displayed as a plot.



 In the Plot window, click File > Save data. In the Save window, save the result of PlantOutput1 as the

AMESim_GPlantInput1.txt file.

 Open the AMESim_GPlantInput1.txt file using a text editor program. Delete the unnecessary header part in the upper text and save the file.
 Plot - 1 File Edit View 0 Tools Analysis Help 🗓 🎟 - 🗘 🛠 🔄 🛓 🖾 🙆 New page Ctrl+N Ctrl+W Data1 of Plant(RD), not support the modification [null] Close page Load data. E Save data.. Add to system Export for submodel Export to picture ... Print preview ... Print... Ctrl+P Close -1 ż X: Time [s] Save data to file AMESim_GPlantInput1.txt - Notepad





Verifying and Analyzing Results

Task Objectives

Use the **General CoSim FMI** method to perform the **Co-simulation** between **RecurDyn** and **AMESim** and check the animation result and numeric data produced.



10 minutes

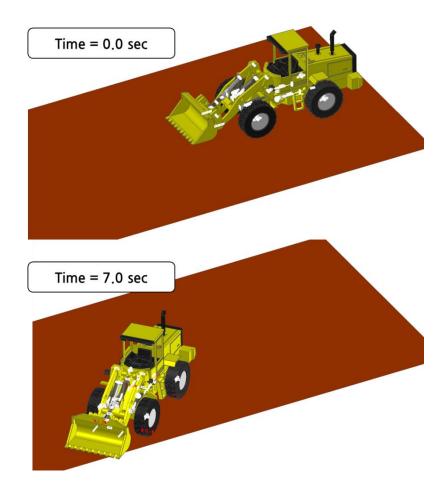
Verifying and Analyzing Results

Make sure that the GPlantInput value in RecurDyn matches the GPlantInput value in AMESim. In the wheel loader model, when steering with the hydraulic pressure generated by the actuator, check the dynamic results such as the reaction force of the joints in each part.

Importing the result of RecurDyn animation and checking the result

If you perform co-simulation in the master mode of RecurDyn, you can execute Animation Play directly from RecurDyn. If you perform co-simulation in the master mode of AMESim, import the animation result file (*.rad).

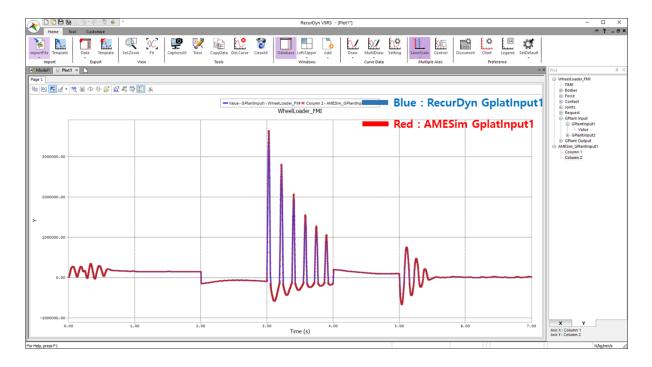
- 1. Go to the **Analysis** tab.
- 2. In the **Animation Control** group, click the **Play** button to check the result of animation. You can see that the wheel loader moves to the left.



To run RecurDyn Plot and plot the result:

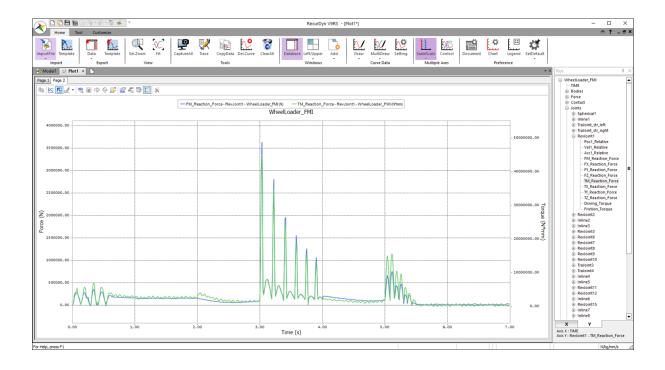


- 1. Run RecurDyn/Plot.
- 2. **Import** the ***.rplt** file, which is the result of dynamic analysis by **RecurDyn**.
- 3. Import the AMESim_GPlantInput1.txt file, which is the result of AMESim GPlantInput1 created in the previous chapter.
- 4. **Draw** the values of **GPlantInput1** in the Plot database window.
- 5. **Plot** the **Column2** of the result of AMESim. (At this time, the value on the **X** axis must be **Column1**.)



6. You can see that the two results match. From these results, you can see that all the numerical data have been exchanged properly between the two software.

- 7. Click the **Plot Page Add** button to add a new page.
- 8. Plot **FM_Reaction_Force** and **TM_Reaction_Force** of **RevJoint1** in the Plot database window. At this time, modify the value of **Axis X** into **Time**.
 - RevJoint1 is a joint that connects the left cylinder and the vehicle. You can check
 the reaction force and torque of the joint when hydraulic pressure is generated in
 the actuator. In this way, you can remodel various operating conditions of the
 wheel loader and check the reaction force and torque values.



Thanks for participating in this tutorial!