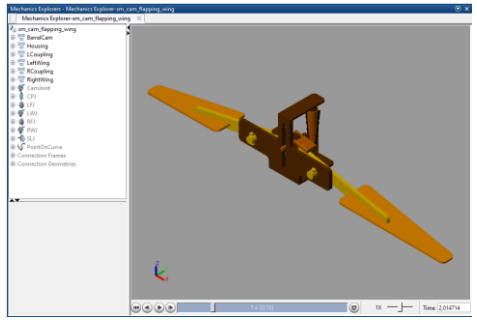
Simscape Multibody Animation in HiL Tests

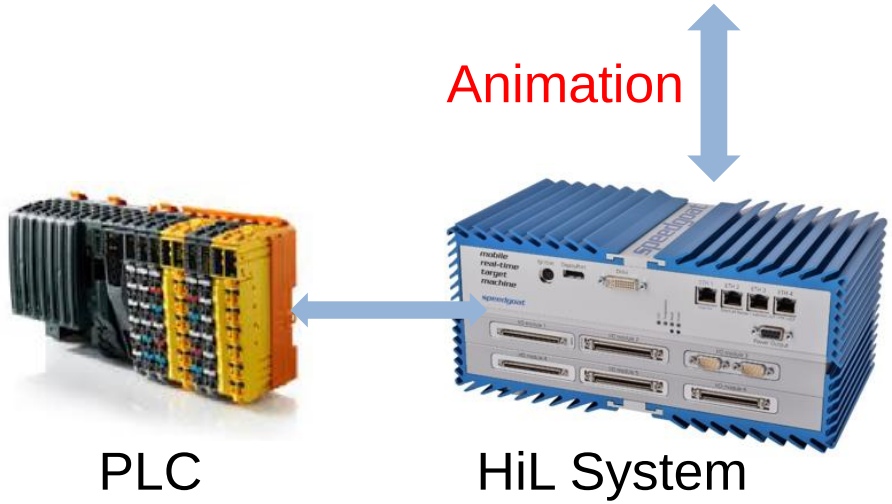
See Mechanics Explorer Animations during HIL testing

Koray Erer
Gernot Schraberger
Pablo Romero Cumbras
Jens Lerche
Jan Janse van Rensburg

Motivation

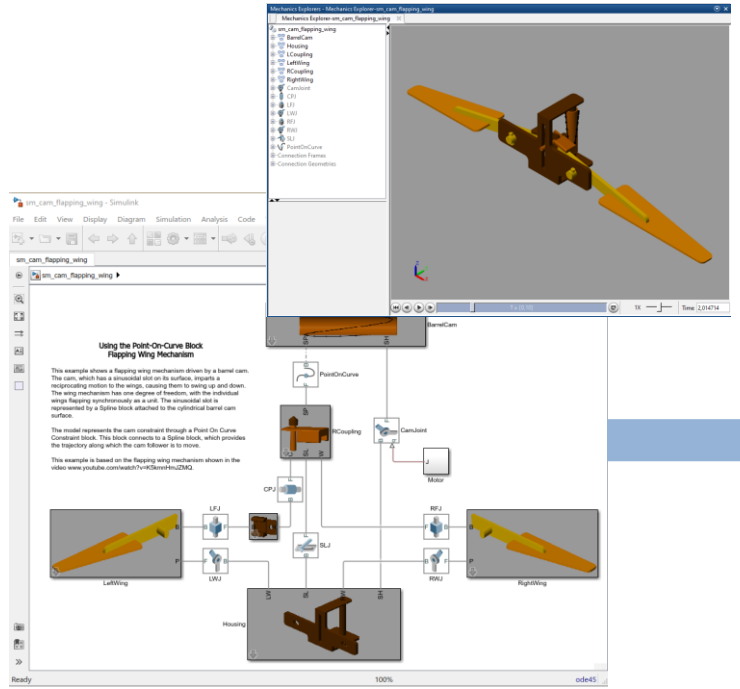
- Virtual Commissioning is a big topic in IA&M industry
  - Test controls on PLCs against virtual plant
    - PLC software often exists
    - Main pain is verifying algorithm behavior and not algorithm modeling or code generation
  - Visualization and animation of plant behavior is often expected for 3D mechanical systems
    - Get fast feedback of closed-loop behavior
- Problem
  - Simscape Multibody does not support animation of simulations from generated code (HiL)





Idea

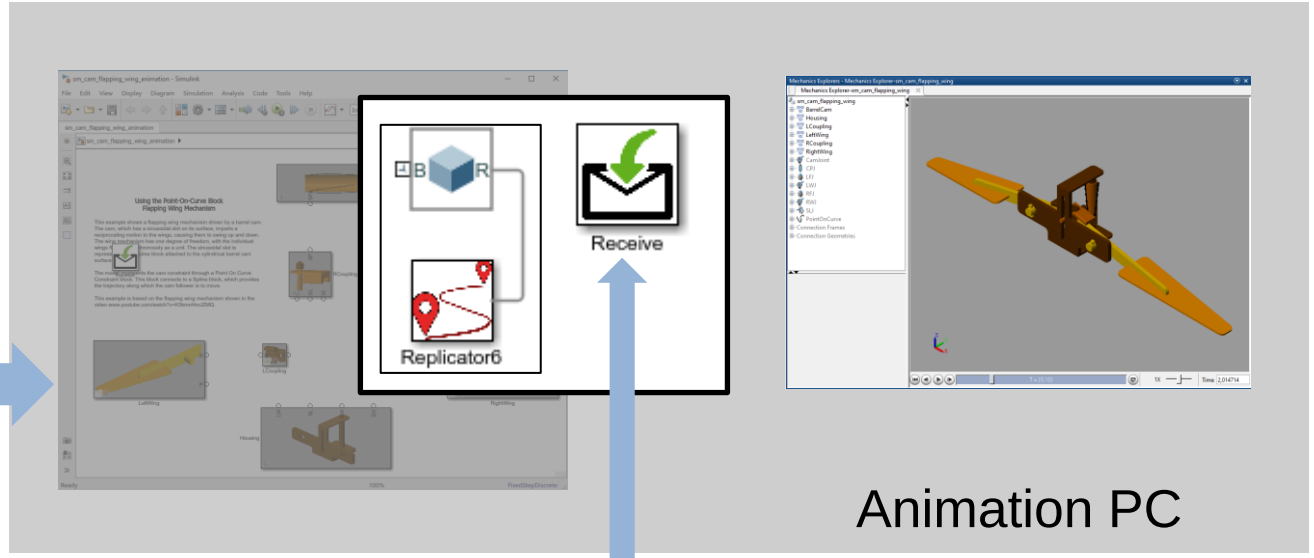
- Automatically derive
  - Real-time Model
  - Animation Model



Simulation Model (SS MB)

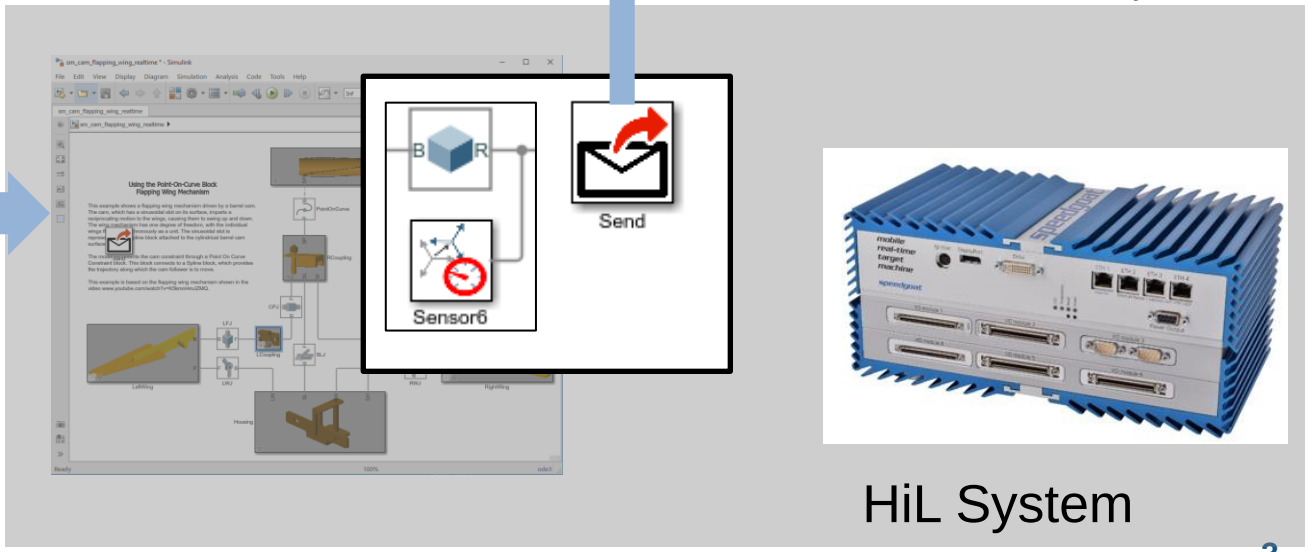
Derive Animation model

Derive Real-time model Code Generation

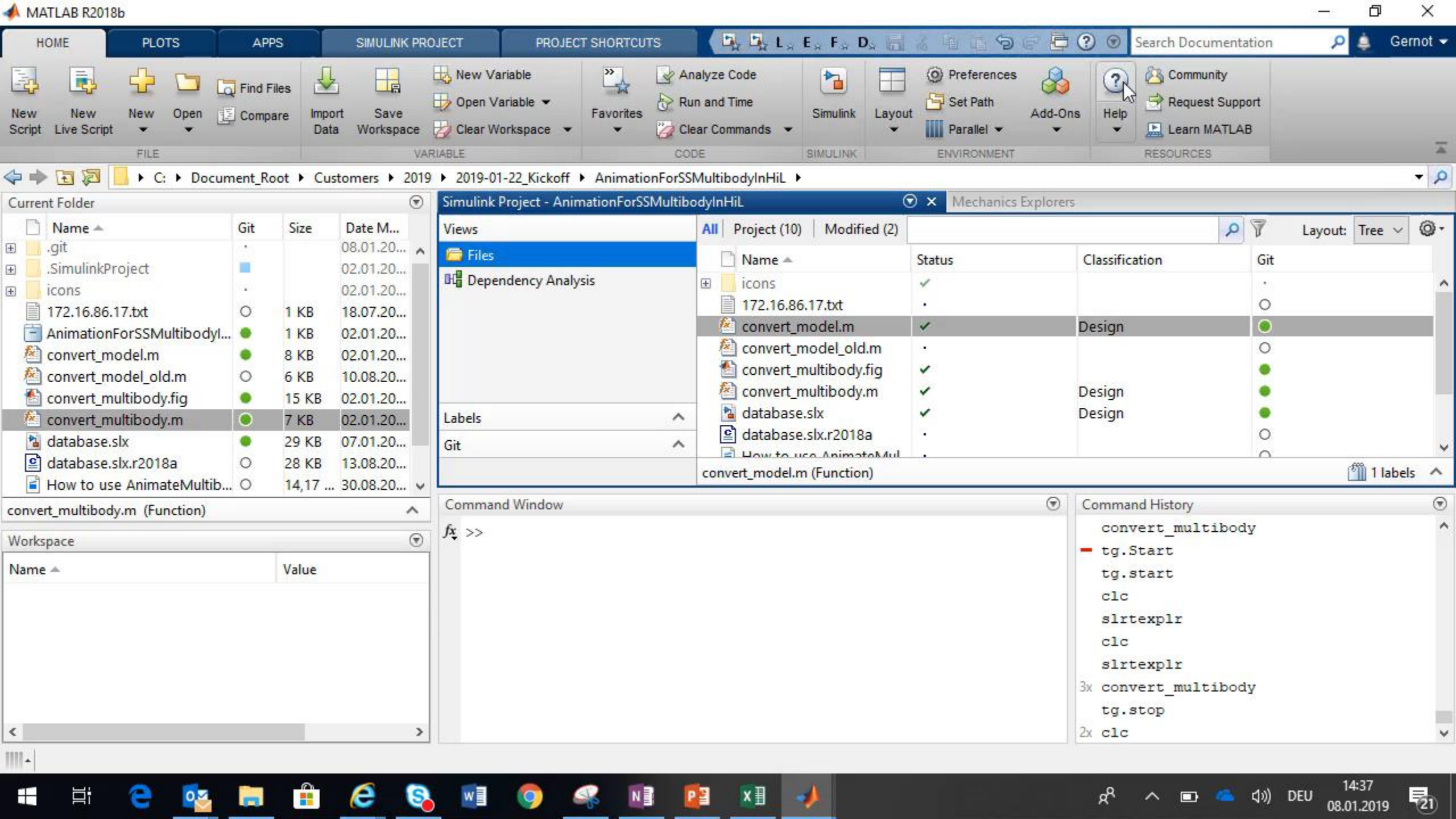


Animation PC

UDP
Position and Orientation from every Solid



HiL System


MATLAB R2018b
HOME
PLOTS
APPS
SIMULINK PROJECT
PROJECT SHORTCUTS
Search Documentation
Gernot
New Script
New Live Script
New
Open
Find Files
Compare
Import Data
Save Workspace
New Variable
Open Variable
Clear Workspace
Favorites
Analyze Code
Run and Time
Clear Commands
Simulink
Layout
Preferences
Set Path
Parallel
Add-Ons
Help
Community
Request Support
Learn MATLAB
FILE
VARIABLE
CODE
SIMULINK
ENVIRONMENT
RESOURCES
C: ▸ Document_Root ▸ Customers ▸ 2019 ▸ 2019-01-22_Kickoff ▸ AnimationForSSMultibodyInHiL ▸
Current Folder
Name
Git
Size
Date M...
.git
.SimulinkProject
icons
172.16.86.17.txt 1 KB 18.07.20...
AnimationForSSMultibodyI... 1 KB 02.01.20...
convert_model.m 8 KB 02.01.20...
convert_model_old.m 6 KB 10.08.20...
convert_multibody.fig 15 KB 02.01.20...
convert_multibody.m 7 KB 02.01.20...
database.slx 29 KB 07.01.20...
database.slx.r2018a 28 KB 13.08.20...
How to use AnimateMultib... 14,17 ... 30.08.20...
convert_multibody.m (Function)
Workspace
Name
Value
Simulink Project - AnimationForSSMultibodyInHiL
Mechanics Explorers
Views
Files
Dependency Analysis
Labels
Git
All
Project (10)
Modified (2)
Layout: Tree
Name
Status
Classification
Git
icons
172.16.86.17.txt
convert_model.m Design
convert_model_old.m
convert_multibody.fig
convert_multibody.m Design
database.slx Design
database.slx.r2018a
convert_model.m (Function)
1 labels
Command Window
>>
Command History
convert_multibody
tg.Start
tg.start
clc
slrtexplr
clc
slrtexplr
3x convert_multibody
tg.stop
2x clc
DEU
14:37
08.01.2019

Conversion Process – behind the scenes

Both models (Real-time & Animation)

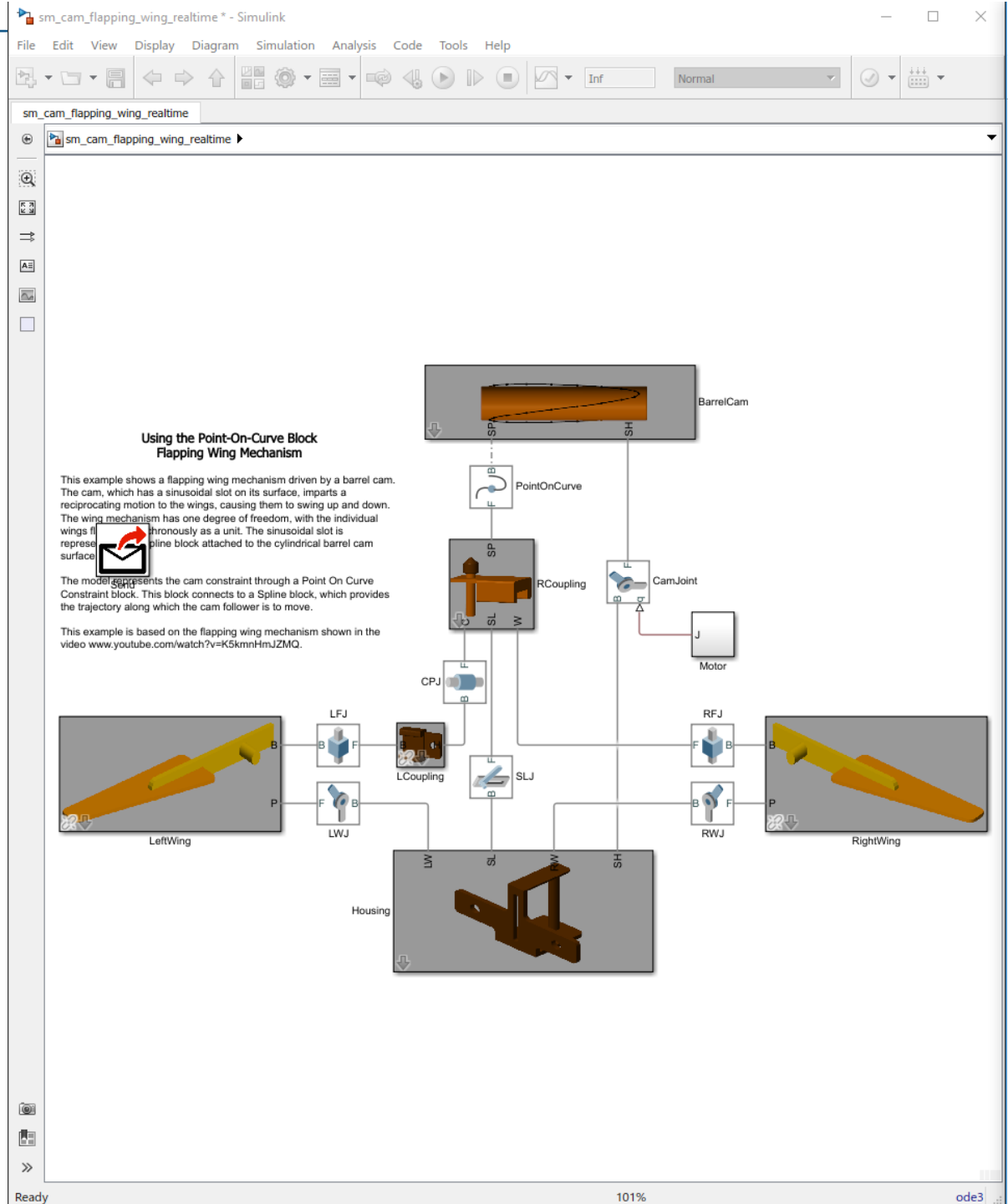
- Move all parameters into model workspace stored with model
- Break Links for all subsystems
- Modify Config Parameters (stop-time= inf, fixed step solver)

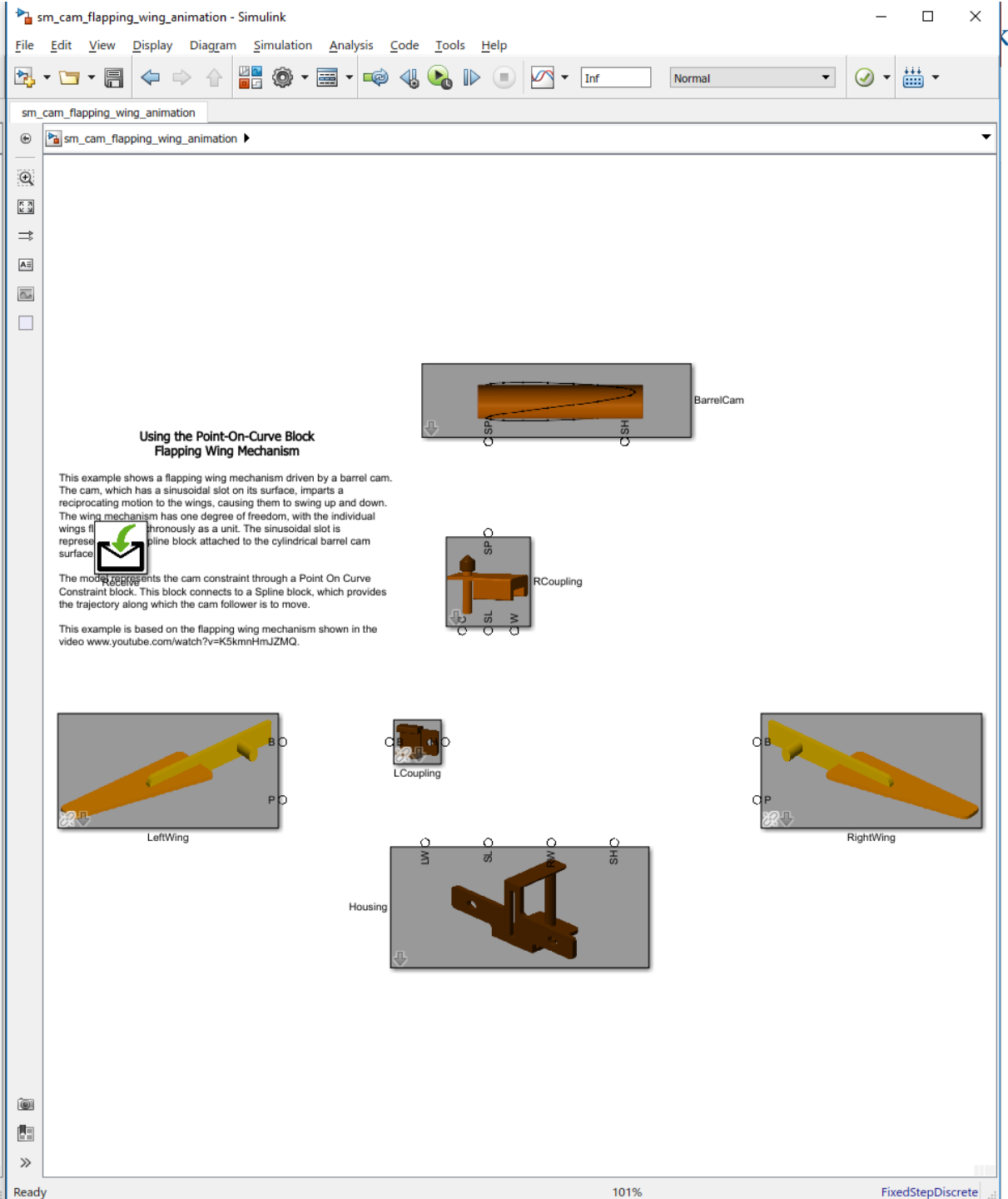
Real-time Model

- Modify Config Parameter (slrt-Target, do not open SS MM explorer)

Animation Model

- Delete all blocks and connections except solid body blocks


sm_cam_flapping_wing_realtime * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
sm_cam_flapping_wing_realtime
Using the Point-On-Curve Block
Flapping Wing Mechanism
This example shows a flapping wing mechanism driven by a barrel cam. The cam, which has a sinusoidal slot on its surface, imparts a reciprocating motion to the wings, causing them to swing up and down. The wing mechanism has one degree of freedom, with the individual wings fl hronously as a unit. The sinusoidal slot is represe pline block attached to the cylindrical barrel cam surface
Send
The model represents the cam constraint through a Point On Curve Constraint block. This block connects to a Spline block, which provides the trajectory along which the cam follower is to move.
This example is based on the flapping wing mechanism shown in the video www.youtube.com/watch?v=K5kmnHmJZMQ.
BarrelCam
PointOnCurve
RCoupling
CamJoint
Motor
CPJ
LFJ
RFJ
LCoupling
SLJ
LWJ
RWJ
LeftWing
RightWing
Housing
Ready
101%
ode3


sm_cam_flapping_wing_animation - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
sm_cam_flapping_wing_animation
Using the Point-On-Curve Block
Flapping Wing Mechanism
This example shows a flapping wing mechanism driven by a barrel cam. The cam, which has a sinusoidal slot on its surface, imparts a reciprocating motion to the wings, causing them to swing up and down. The wing mechanism has one degree of freedom, with the individual wings fl hronously as a unit. The sinusoidal slot is represe pline block attached to the cylindrical barrel cam surface
Receive
The model represents the cam constraint through a Point On Curve Constraint block. This block connects to a Spline block, which provides the trajectory along which the cam follower is to move.
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BarrelCam
RCoupling
LCoupling
LeftWing
RightWing
Housing
Ready
101%
FixedStepDiscrete

Conversion Process – behind the scenes

Both models (Real-time & Animation)

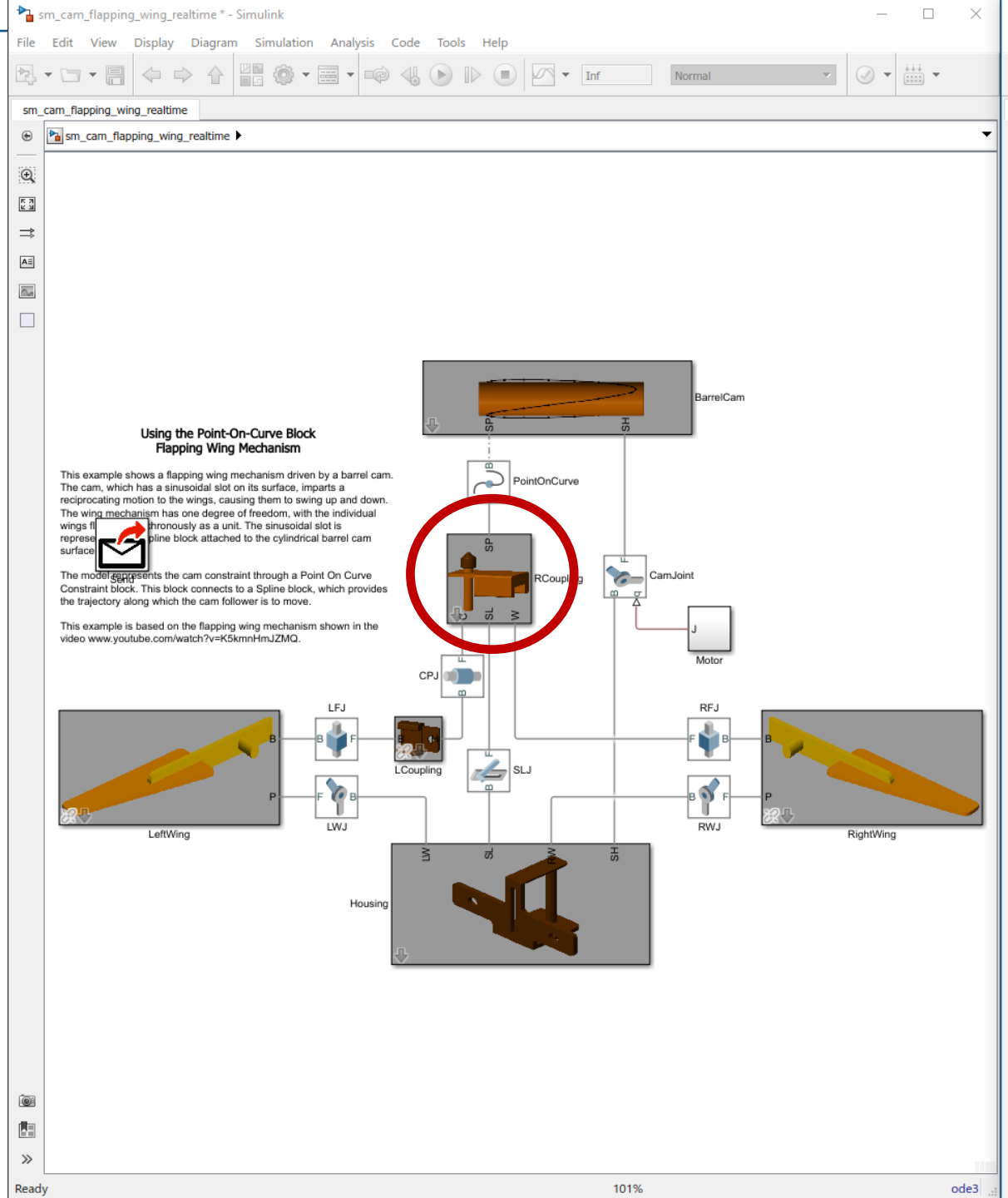
- Move all parameters into model workspace stored with model
- Break Links for all subsystems
- Modify Config Parameters (stop-time= inf, fixed step solver)

Real-time Model

- Modify Config Parameter (slrt-Target, do not open SS MM explorer)
- Add position/orientation sensors to all solid body blocks

Animation Model

- Delete all blocks and connections except solid body blocks
- Add position/orientation actuators solid bodies


sm_cam_flapping_wing_realtime * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
sm_cam_flapping_wing_realtime
Using the Point-On-Curve Block
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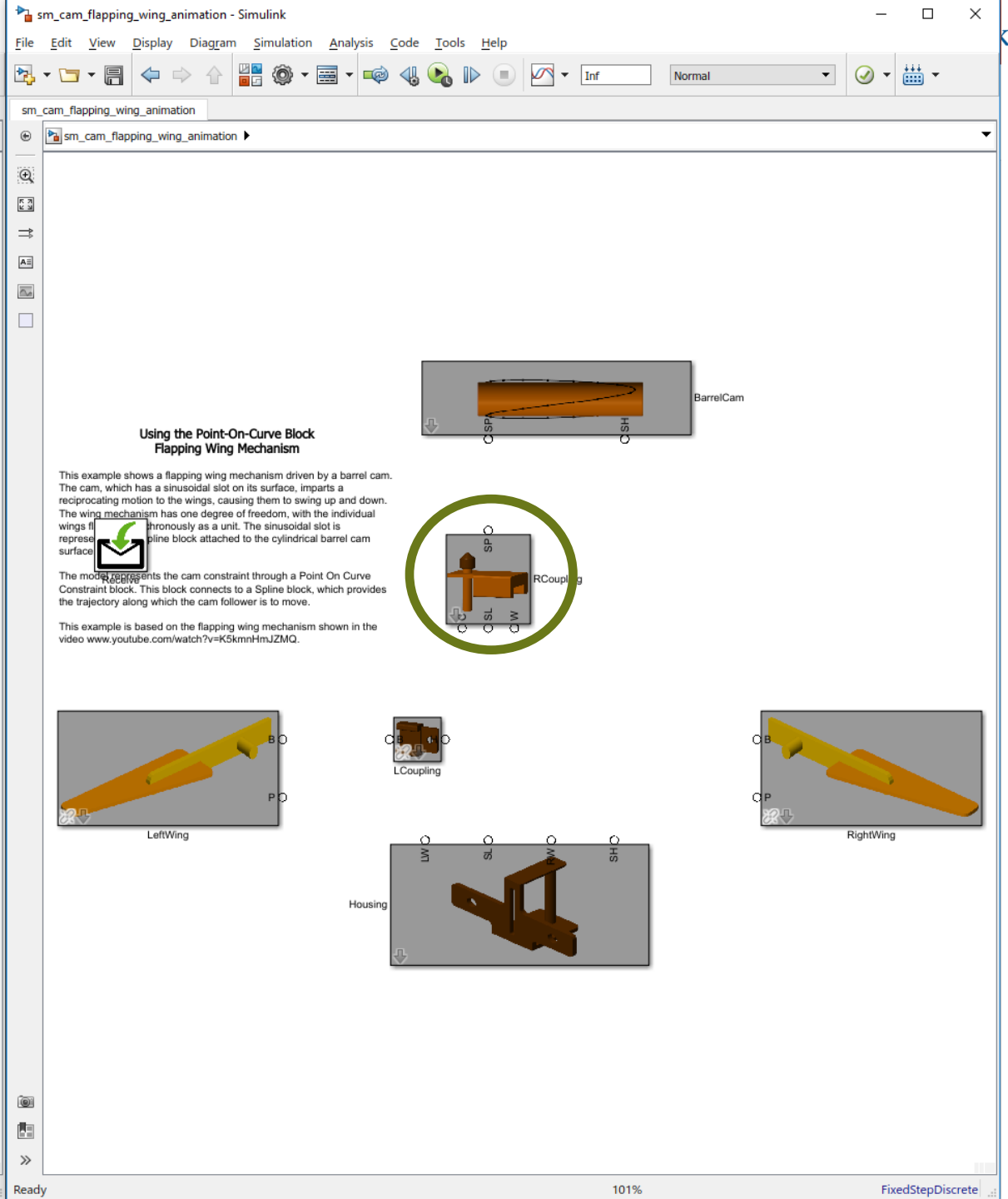
BarrelCam
PointOnCurve
RCoupling
CamJoint
Motor
CPJ
LFJ
RFJ
LCoupling
SLJ
LWJ
RWJ
LeftWing
RightWing
Housing
Send
Ready
101%
ode3


sm_cam_flapping_wing_animation - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
sm_cam_flapping_wing_animation
Using the Point-On-Curve Block
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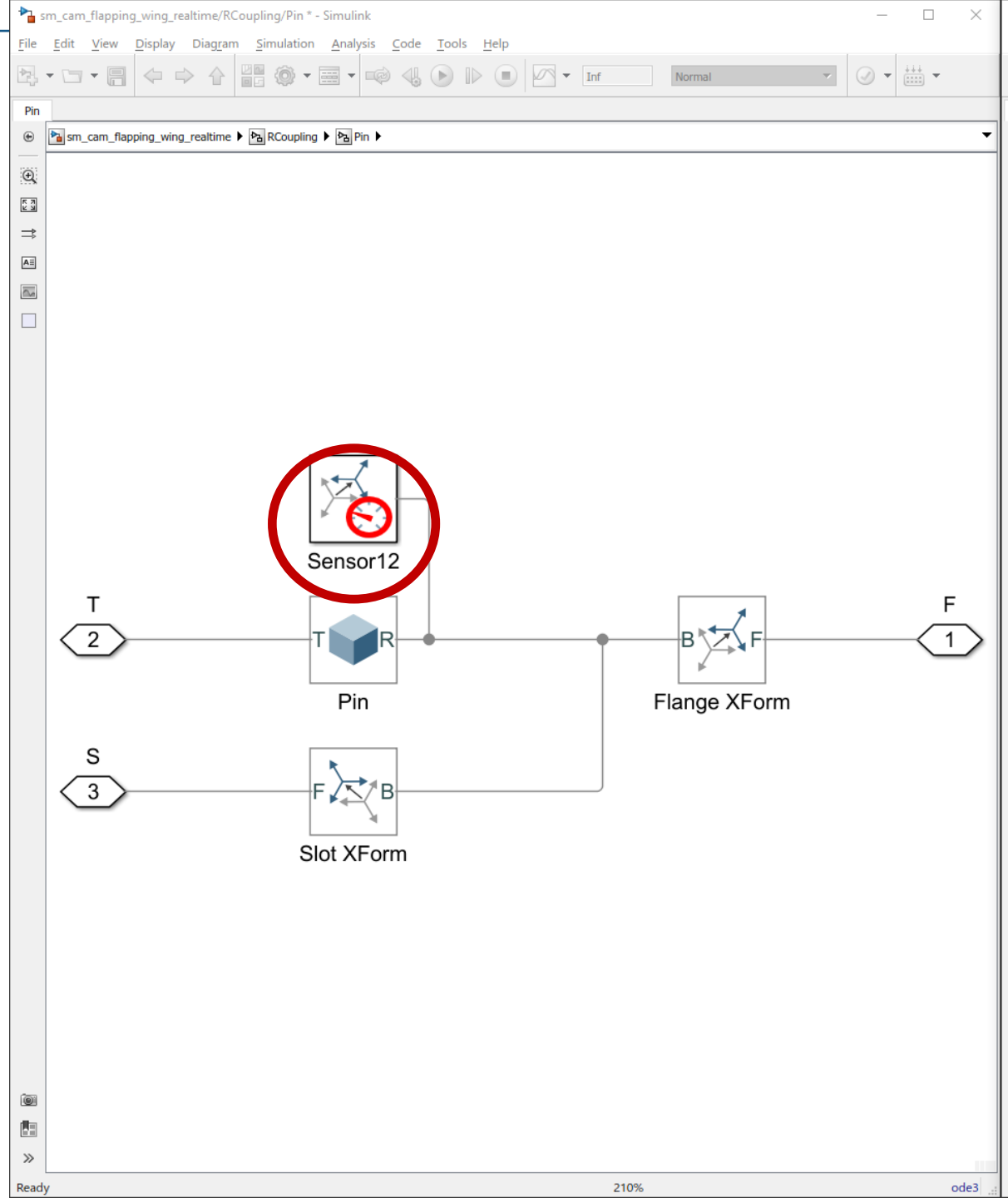
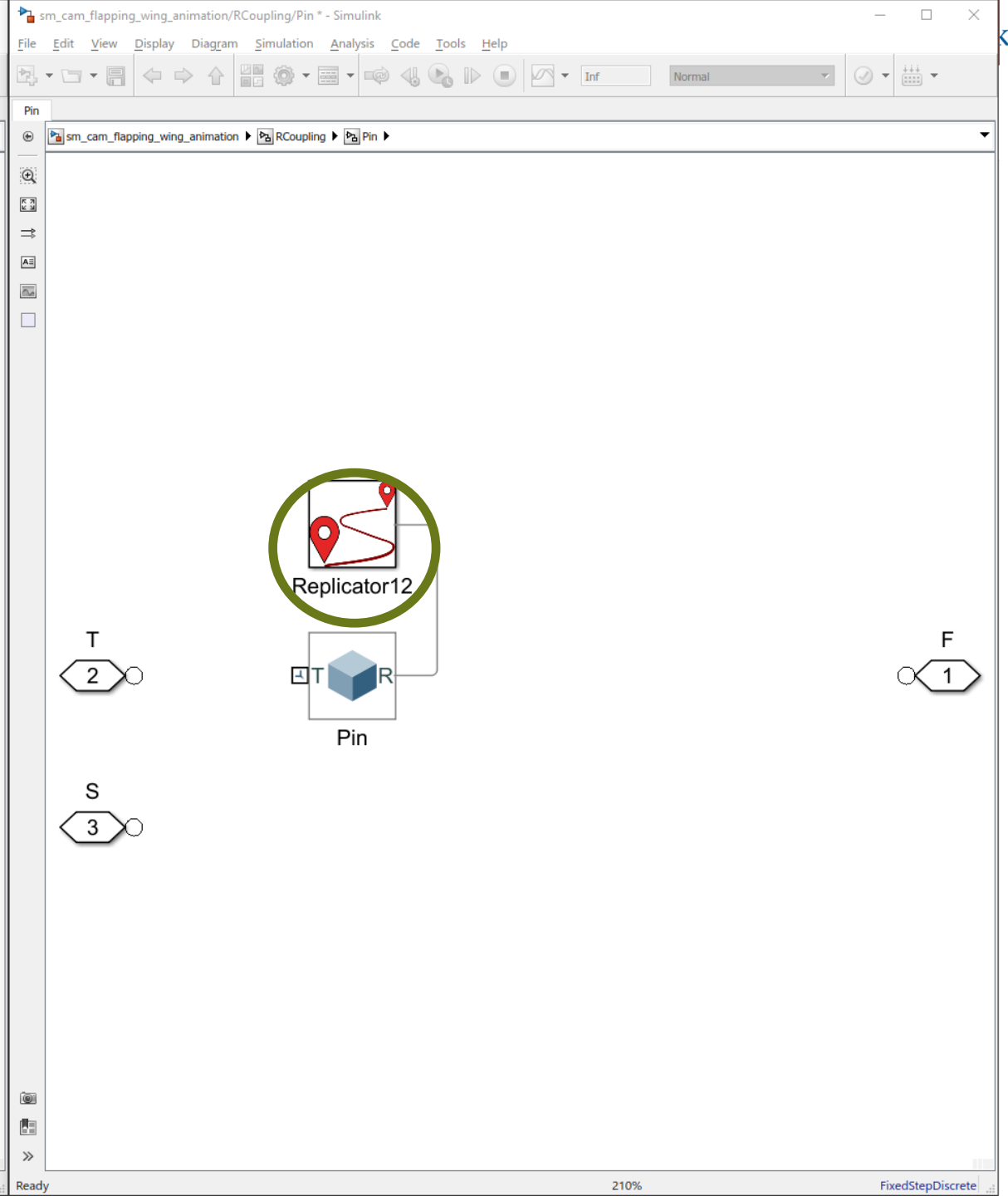
BarrelCam
RCoupling
LCoupling
LeftWing
RightWing
Housing
Receive
Ready
101%
FixedStepDiscrete


sm_cam_flapping_wing_realtime/RCoupling/Pin * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
Inf
Normal
Pin
sm_cam_flapping_wing_realtime ▸ RCoupling ▸ Pin ▸
Sensor12
T
2
T R
Pin
B F
Flange XForm
F
1
S
3
F B
Slot XForm
Ready
210%
ode3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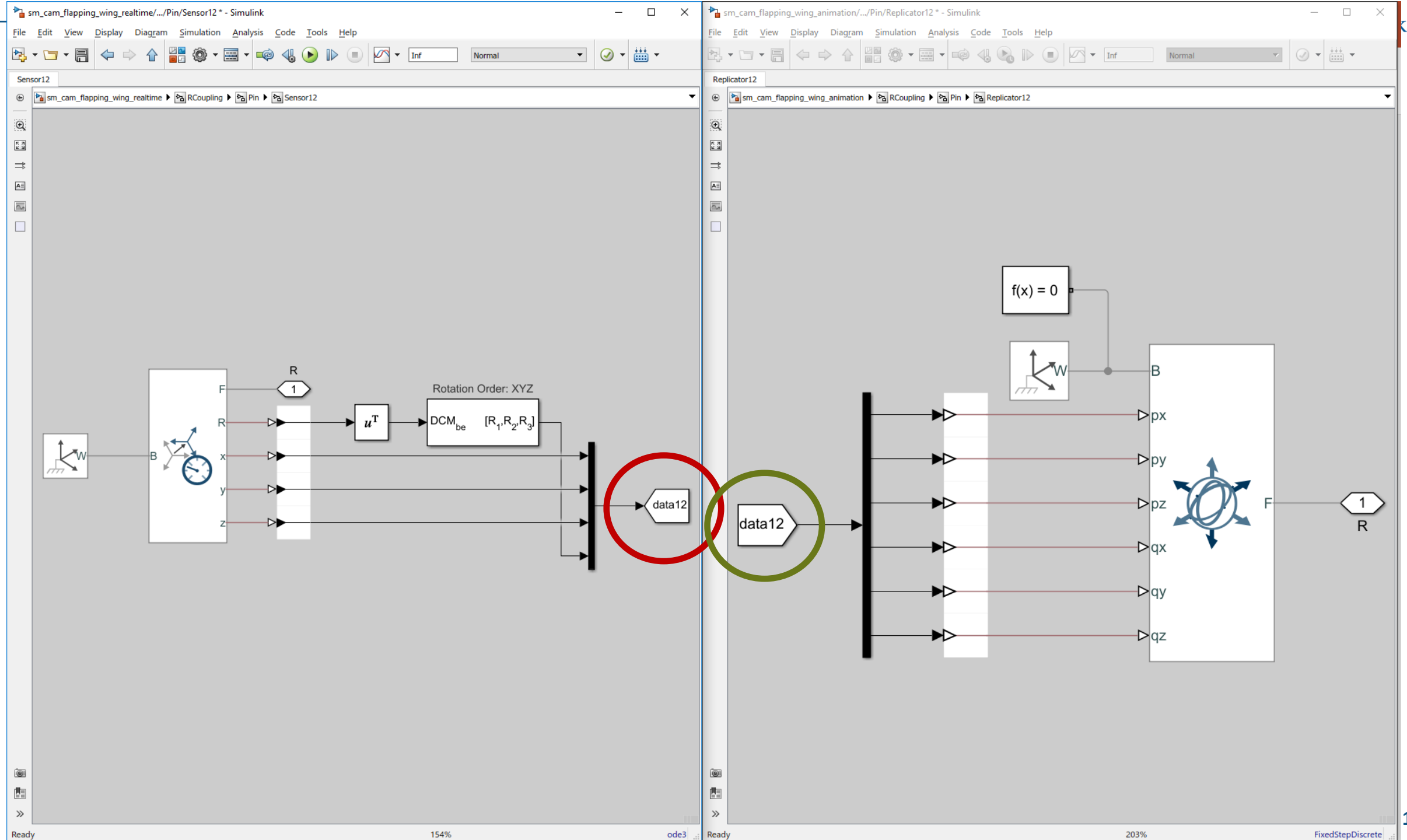
File Edit View Display Diagram Simulation Analysis Code Tools Help
Inf
Normal
Pin
sm_cam_flapping_wing_animation ▸ RCoupling ▸ Pin ▸
Replicator12
T
2
T R
Pin
F
1
S
3
Ready
210%
FixedStepDiscrete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File Edit View Display Diagram Simulation Analysis Code Tools Help
Sensor12
sm_cam_flapping_wing_realtime ▸ RCoupling ▸ Pin ▸ Sensor12
W
B
F
R
x
y
z
R
1
u^T
Rotation Order: XYZ
DCM_be [R1,R2,R3]
data12
Ready
154%
ode3
sm_cam_flapping_wing_animation/.../Pin/Replicator12 * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
Replicator12
sm_cam_flapping_wing_animation ▸ RCoupling ▸ Pin ▸ Replicator12
f(x) = 0
W
B
px
py
pz
qx
qy
qz
F
1
R
data12
Ready
203%
FixedStepDiscrete

Conversion Process – behind the scenes

Both models (Real-time & Animation)

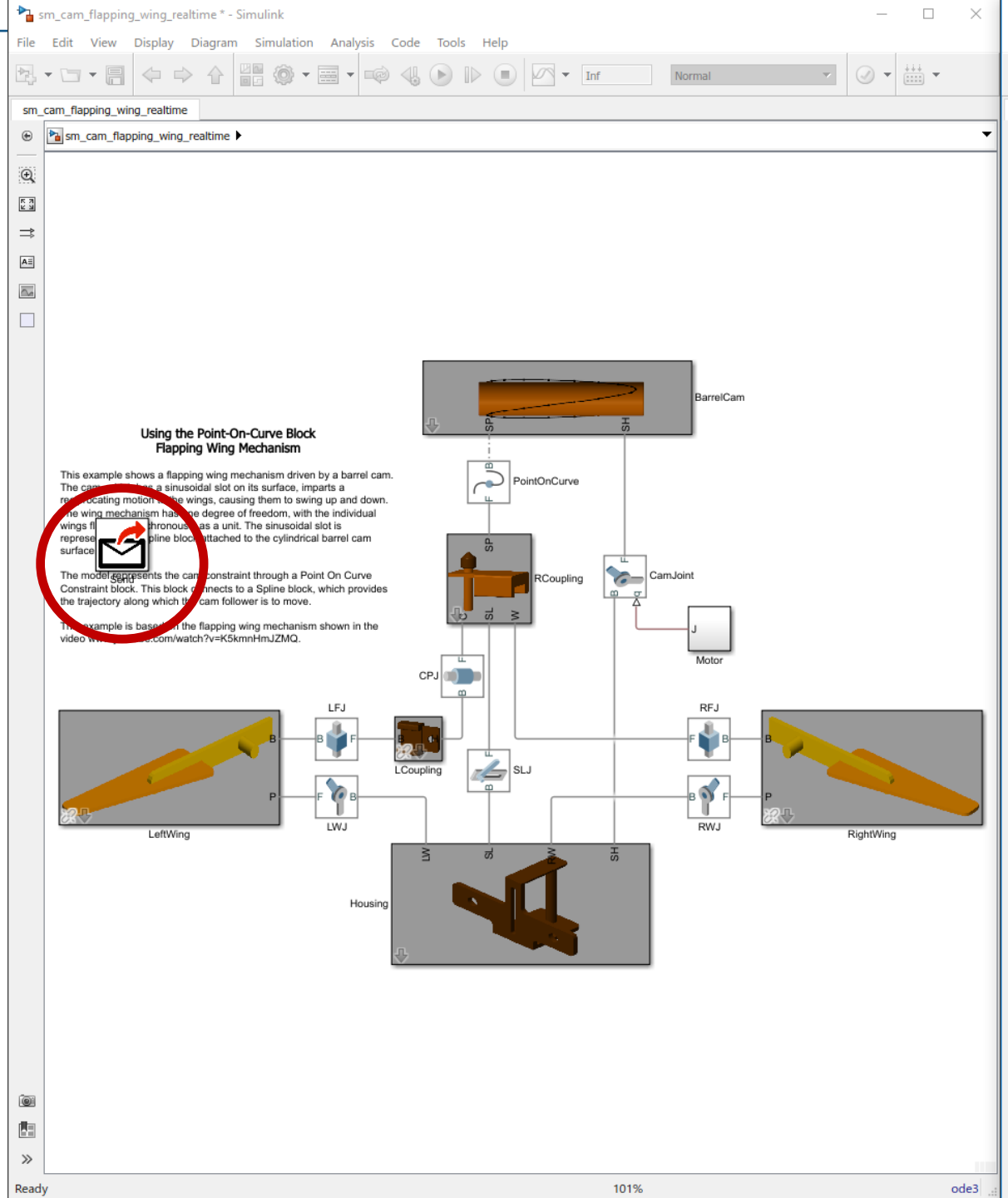
- Move all parameters into model workspace stored with model
- Break Links for all subsystems
- Modify Config Parameters (stop-time= inf, fixed step solver)

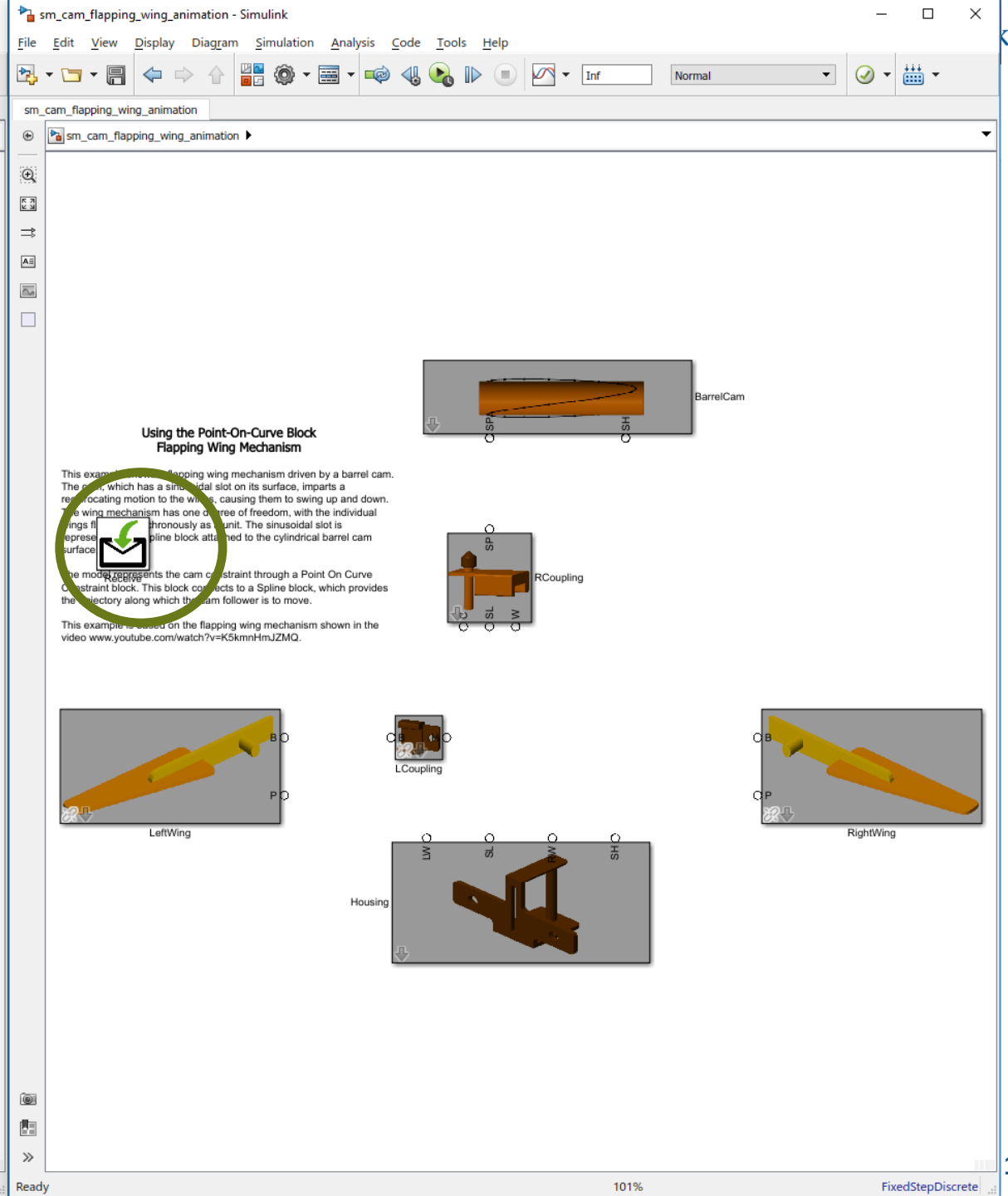
Real-time Model

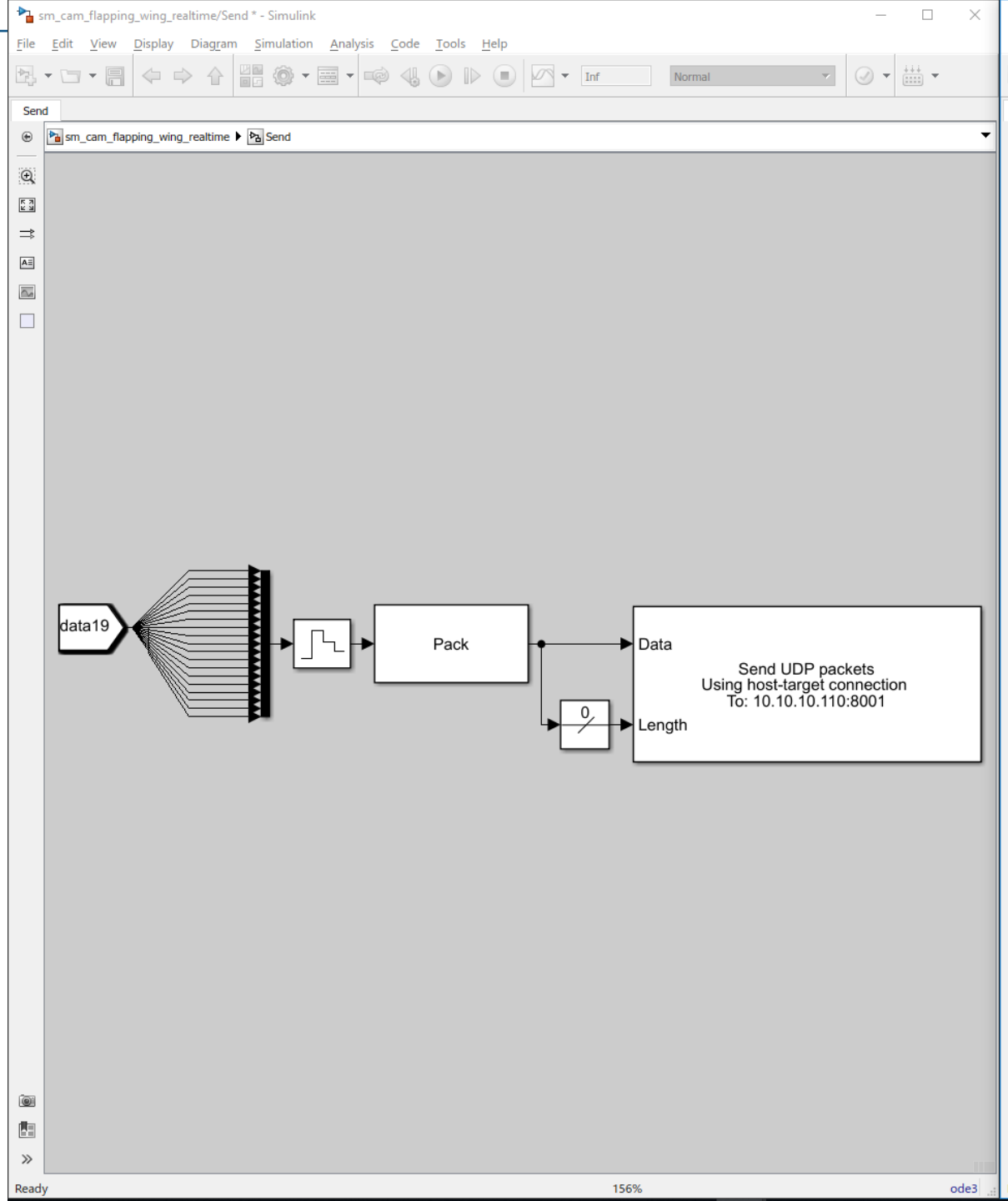
- Modify Config Parameter (slrt-Target, do not open SS MM explorer)
- Add position/orientation sensors to all solid body blocks
- Add UDP sender + mux + Add GoTo / From (from sensors)

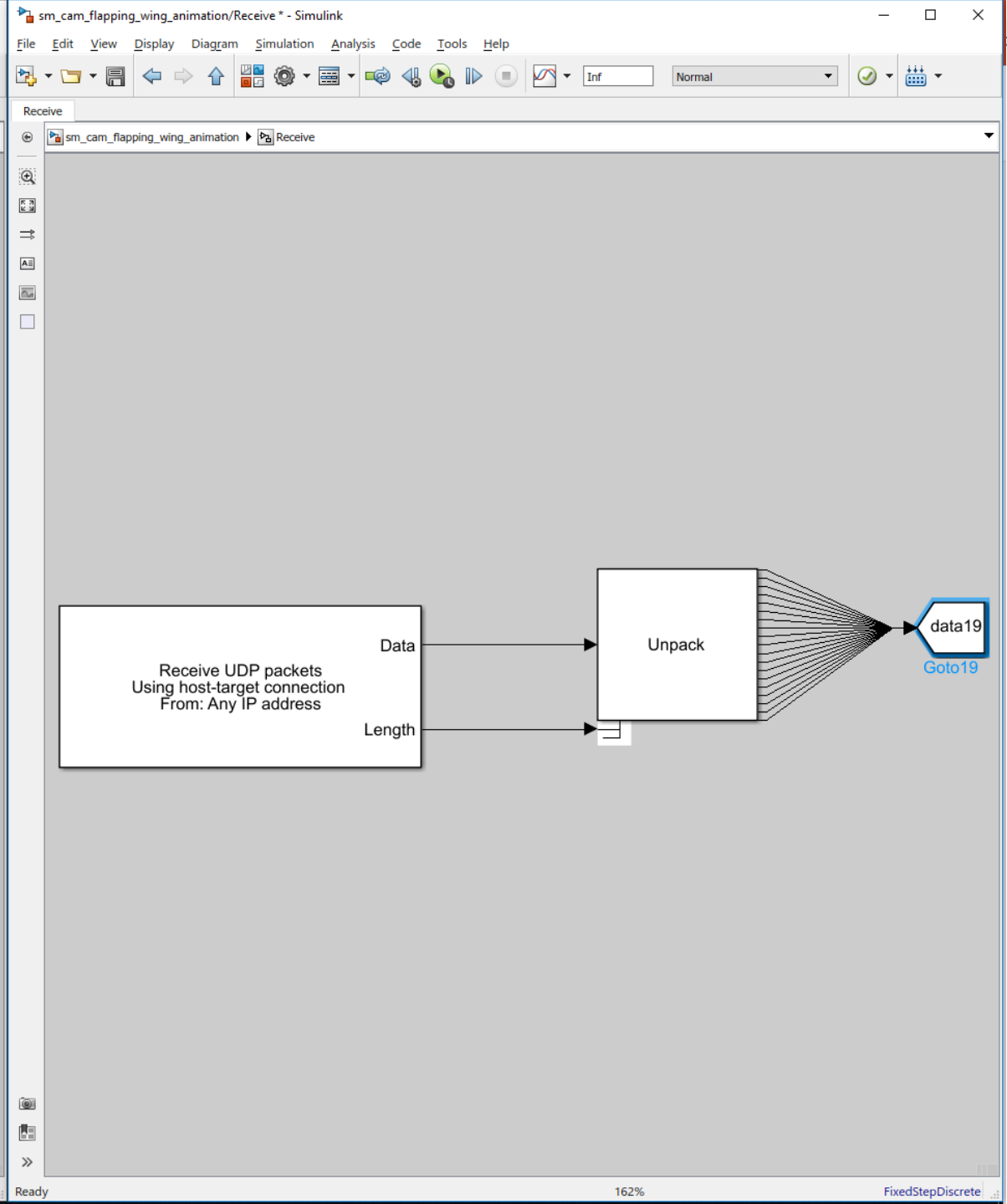
Animation Model

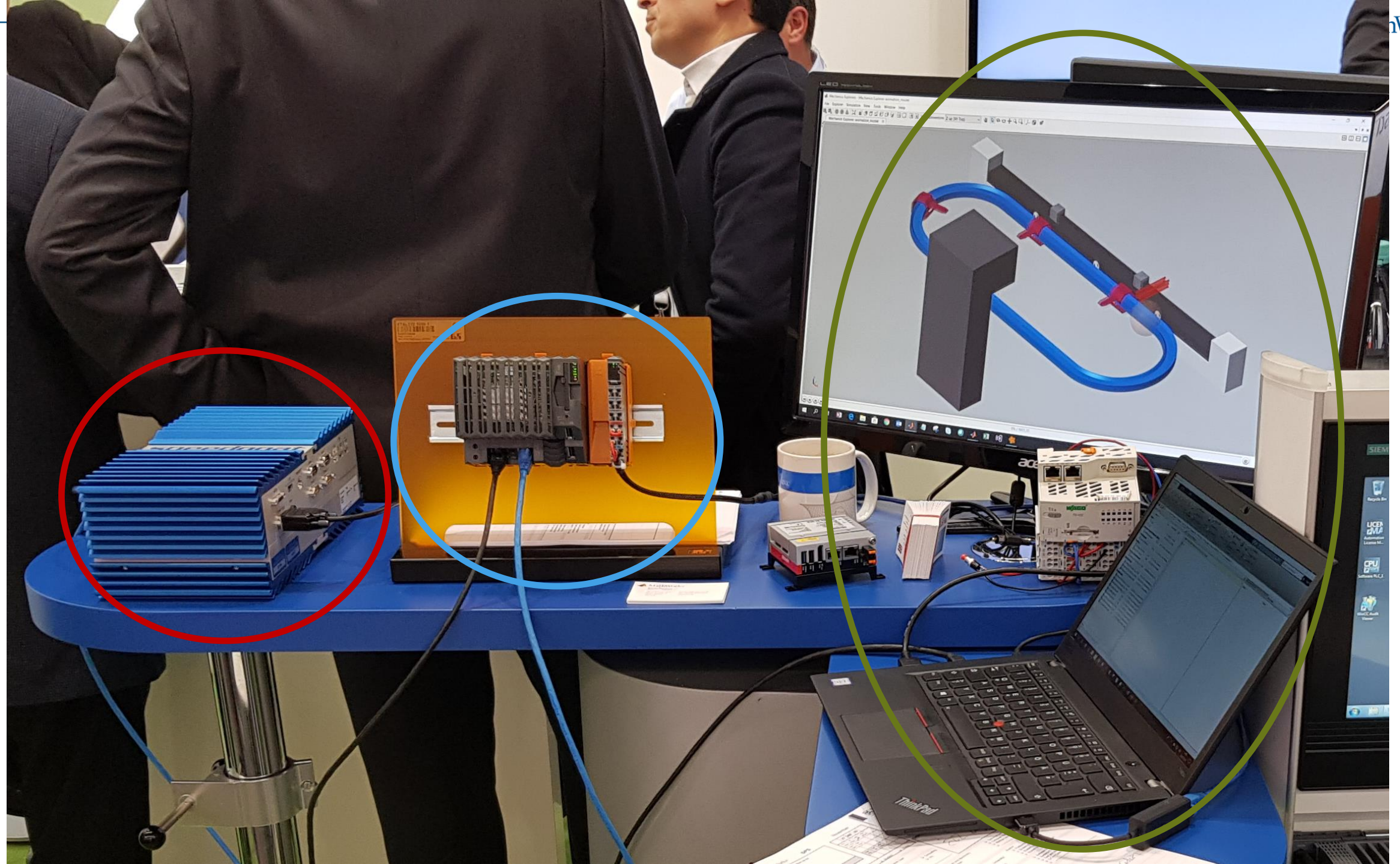
- Delete all blocks and connections except solid body blocks
- Add position/orientation actuators solid bodies
- Add UDP receiver + demux + Add From / GoTo (to actuators)

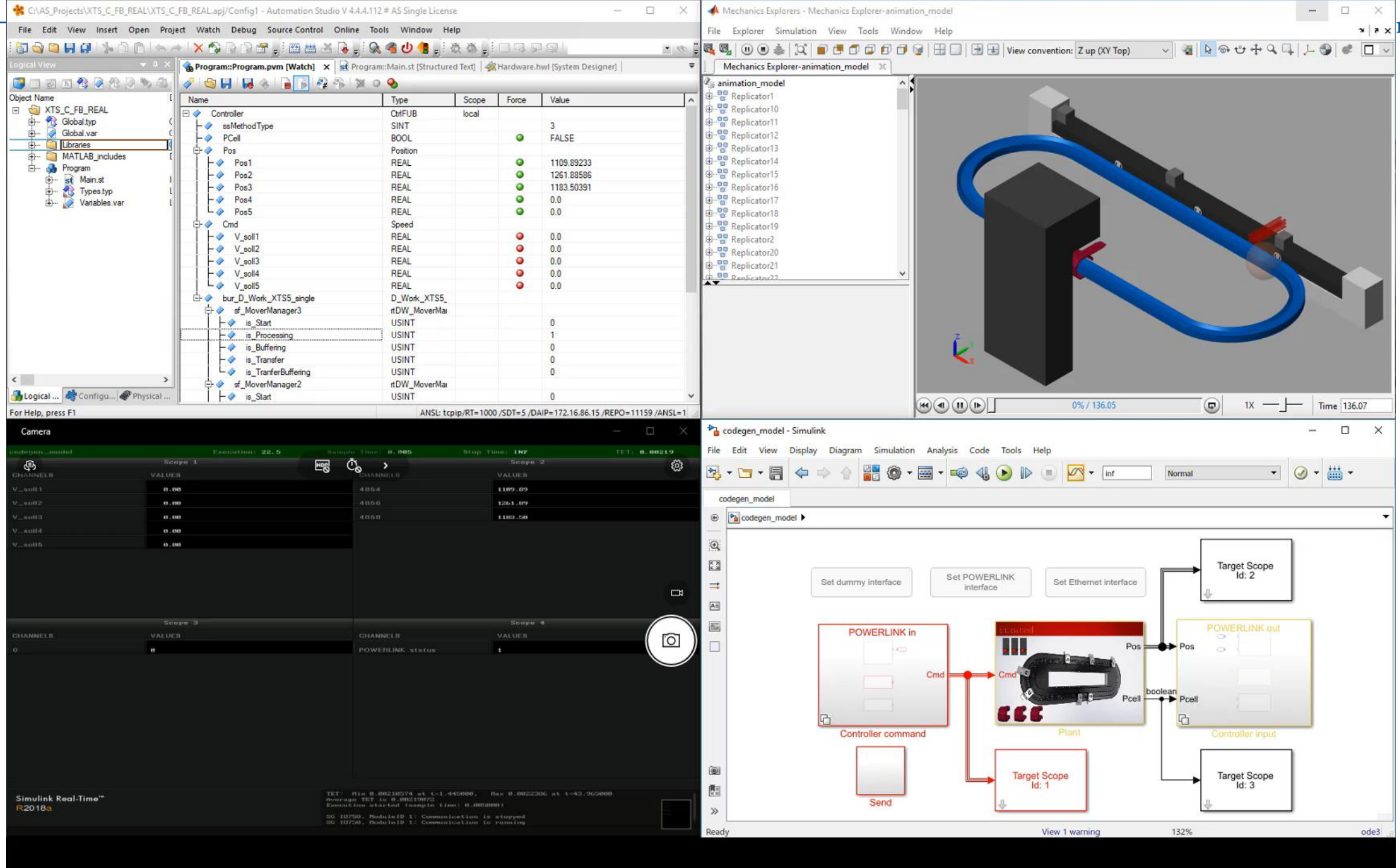

sm_cam_flapping_wing_realtime * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
sm_cam_flapping_wing_realtime
Using the Point-On-Curve Block
Flapping Wing Mechanism
BarrelCam
PointOnCurve
RCoupling
CamJoint
Motor
CPJ
LFJ
RFJ
LCoupling
SLJ
LWJ
RWJ
LeftWing
RightWing
Housing
Ready
101%
ode3


sm_cam_flapping_wing_animation - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
sm_cam_flapping_wing_animation
Using the Point-On-Curve Block
Flapping Wing Mechanism
BarrelCam
RCoupling
LCoupling
LeftWing
RightWing
Housing
Ready
101%
FixedStepDiscrete


sm_cam_flapping_wing_realtime/Send * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
Inf
Normal
Send
sm_cam_flapping_wing_realtime
Send
data19
Pack
Data
Length
0
Send UDP packets
Using host-target connection
To: 10.10.10.110:8001
Ready
156%
ode3


sm_cam_flapping_wing_animation/Receive * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
Inf
Normal
Receive
sm_cam_flapping_wing_animation
Receive
Receive UDP packets
Using host-target connection
From: Any IP address
Data
Length
Unpack
data19
Goto19
Ready
162%
FixedStepDiscrete




C:\AS_Projects\XTS_C_FB_REAL\XTS_C_FB_REAL.apj/Config1 - Automation Studio V 4.4.4.112 # AS Single License
File Edit View Insert Open Project Watch Debug Source Control Online Tools Window Help
Logical View
Object Name
XTS_C_FB_REAL
Global.typ
Global.var
Libraries
MATLAB_includes
Program
Main.st
Types.typ
Variables.var
Program::Program.pvm [Watch]
Program::Main.st [Structured Text]
Hardware.hwl [System Designer]
Name Type Scope Force Value
Controller CtrlFUB local
ssMethodType SINT 3
PCell BOOL FALSE
Pos Position
Pos1 REAL 1109.89233
Pos2 REAL 1261.88586
Pos3 REAL 1183.50391
Pos4 REAL 0.0
Pos5 REAL 0.0
Cmd Speed
V_soll1 REAL 0.0
V_soll2 REAL 0.0
V_soll3 REAL 0.0
V_soll4 REAL 0.0
V_soll5 REAL 0.0
bur_D_Work_XTS5_single D_Work_XTS5_
sf_MoverManager3 rtDW_MoverMa
is_Start USINT 0
is_Processing USINT 1
is_Buffering USINT 0
is_Transfer USINT 0
is_TranferBuffering USINT 0
sf_MoverManager2 rtDW_MoverMa
is_Start USINT 0
Logical ... Configu... Physical ...
For Help, press F1
ANSL: tcpip/RT=1000 /SDT=5 /DAIP=172.16.86.15 /REPO=11159 /ANSL=1
Mechanics Explorers - Mechanics Explorer-animation_model
File Explorer Simulation View Tools Window Help
View convention: Z up (XY Top)
Mechanics Explorer-animation_model
animation_model
Replicator1
Replicator10
Replicator11
Replicator12
Replicator13
Replicator14
Replicator15
Replicator16
Replicator17
Replicator18
Replicator19
Replicator2
Replicator20
Replicator21
0% / 136.05
1X
Time 136.07
Camera
Scope 1
Scope 2
Scope 3
Scope 4
CHANNELS
VALUES
V_soll1
V_soll2
V_soll3
V_soll4
V_soll5
POWERLINK status
Simulink Real-Time™
R2018a
codegen_model - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
inf
Normal
codegen_model
Set dummy interface
Set POWERLINK interface
Set Ethernet interface
Target Scope Id: 2
POWERLINK in
Cmd
Controller command
Pos
Cmd
Pcell
Plant
boolean
POWERLINK out
Pos
Pcell
Controller input
Send
Target Scope Id: 1
Target Scope Id: 3
Ready
View 1 warning
132%
ode3

The way forward

- More Testing & Integration
  - Referenced models
  - Data dictionary
  - External mode
- Add support for more components
  - Variable mass solid bodies
  - Visualization of spline curve
- Possibility to use a real hardware and Animation in parallel ?