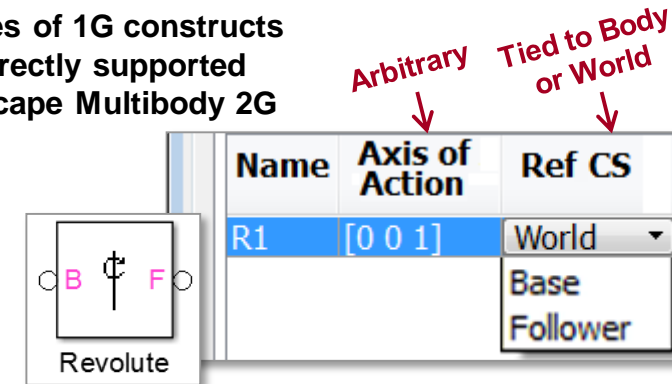


Converting Simscape Multibody 1G to 2G

- Full automatic translation is more-or-less impossible
 - Modeling conventions in 1G and 2G are very different
 - Maintaining parameterization is complex (variables, masks, etc.)
 - Exception: models exported using Simscape Multibody Link can be exported directly to 2G
- A large portion of the translation can be done automatically
 - Automatic construction and parameterization of bodies, joints, and constraints

Examples of 1G constructs not directly supported in Simscape Multibody 2G



Defined relative to multiple coordinate systems (local and global)

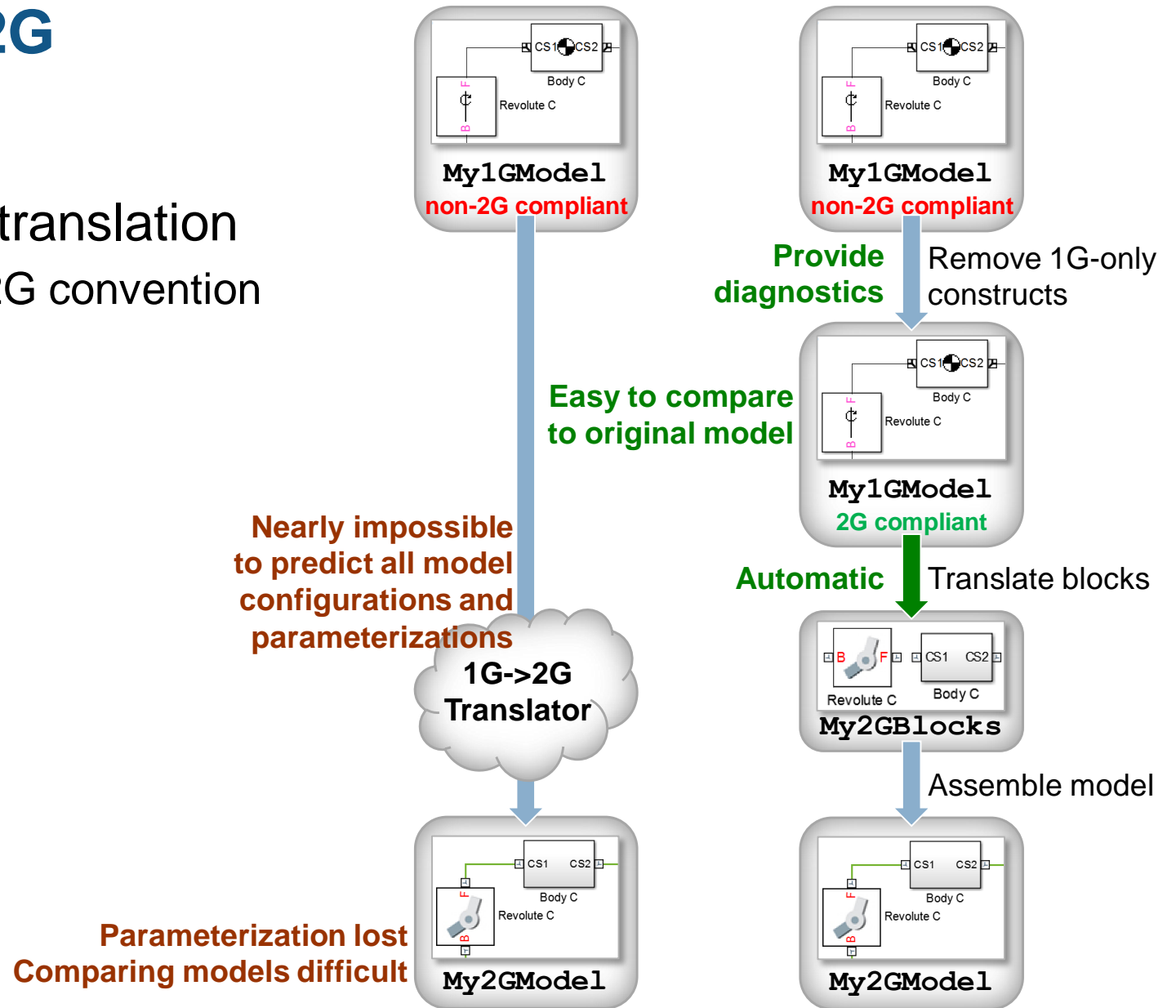
| Position | | Orientation | | Visualization | |
|----------|--------------------------------|-------------|---------------------------|-----------------------|--|
| Name | Origin Position Vector [x y z] | Units | Translated from Origin of | Components in Axes of | |
| CG | [C_a 0 0] | m | World | CS1 | |
| CS1 | [0.0 0 0] | m | Adjoining | Adjoining | |

| Position | | Orientation | | Visualization | |
|----------|--------------------|-------------|------------|---------------|--|
| Name | Orientation Vector | Units | Relative C | | |
| CG | [0 0 45] | deg | World | | |
| CS1 | orient_xyz | deg | Adjoining | | |

Automatic, if 2G compliant

Converting from 1G to 2G

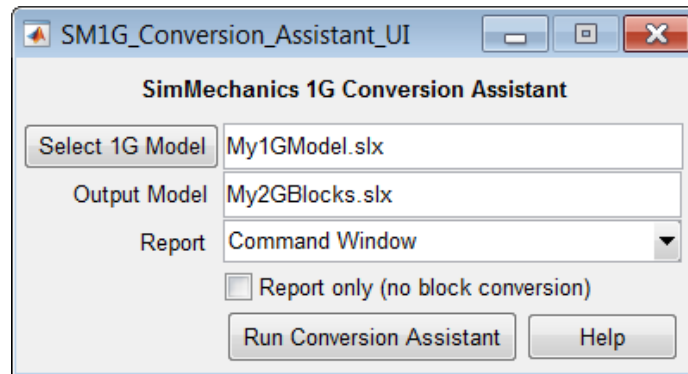
- Goal is to provide assisted translation
 - User revises model to meet 2G convention
 - Cannot be automated
 - Convert blocks
 - Automated
 - User assembles the model
 - Hard to automate
 - Better to debug piece by piece



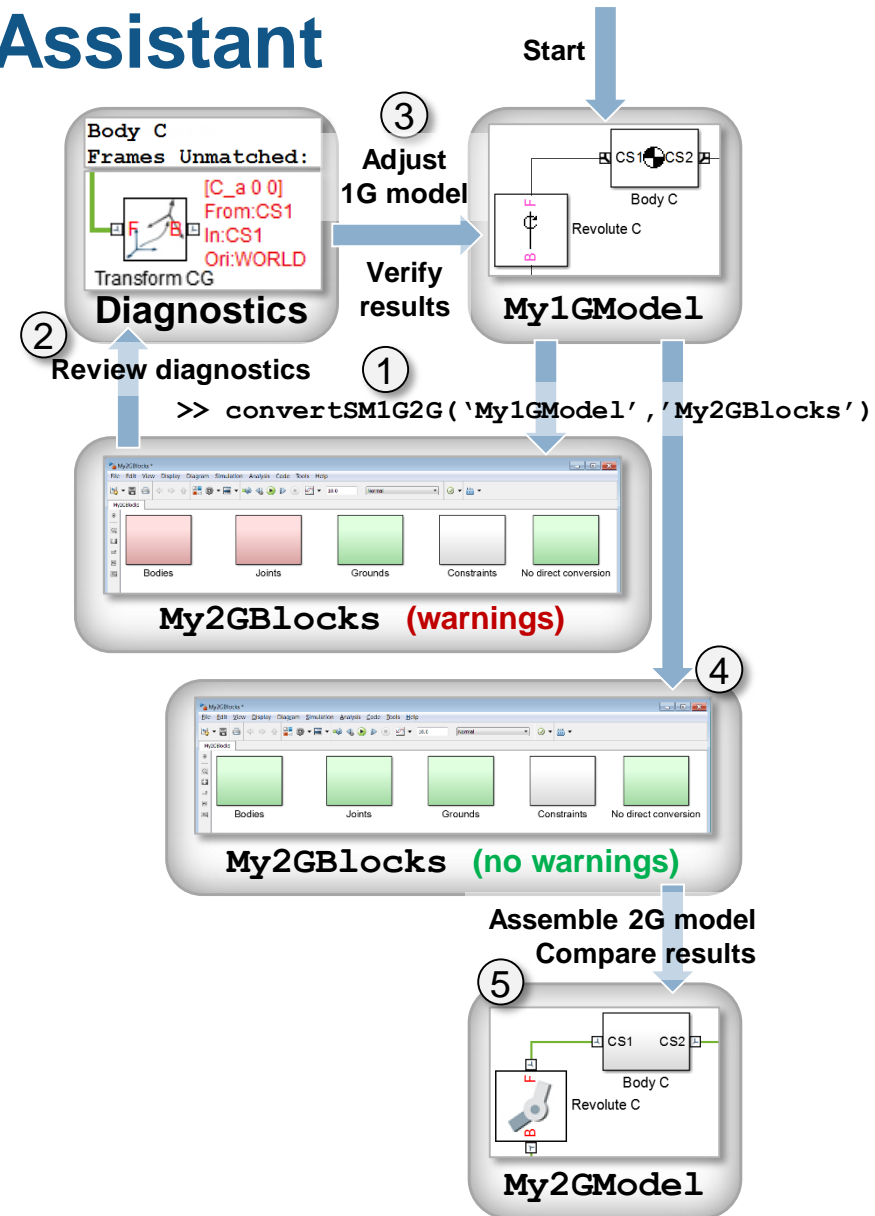
Simscape Multibody Conversion Assistant

Conversion Process

1. Convert blocks to 2G
2. Review diagnostics
3. Eliminate 1G-only modeling elements from 1G model
4. Convert blocks to 2G
5. Assemble 2G model



For use with MATLAB R2013a and higher

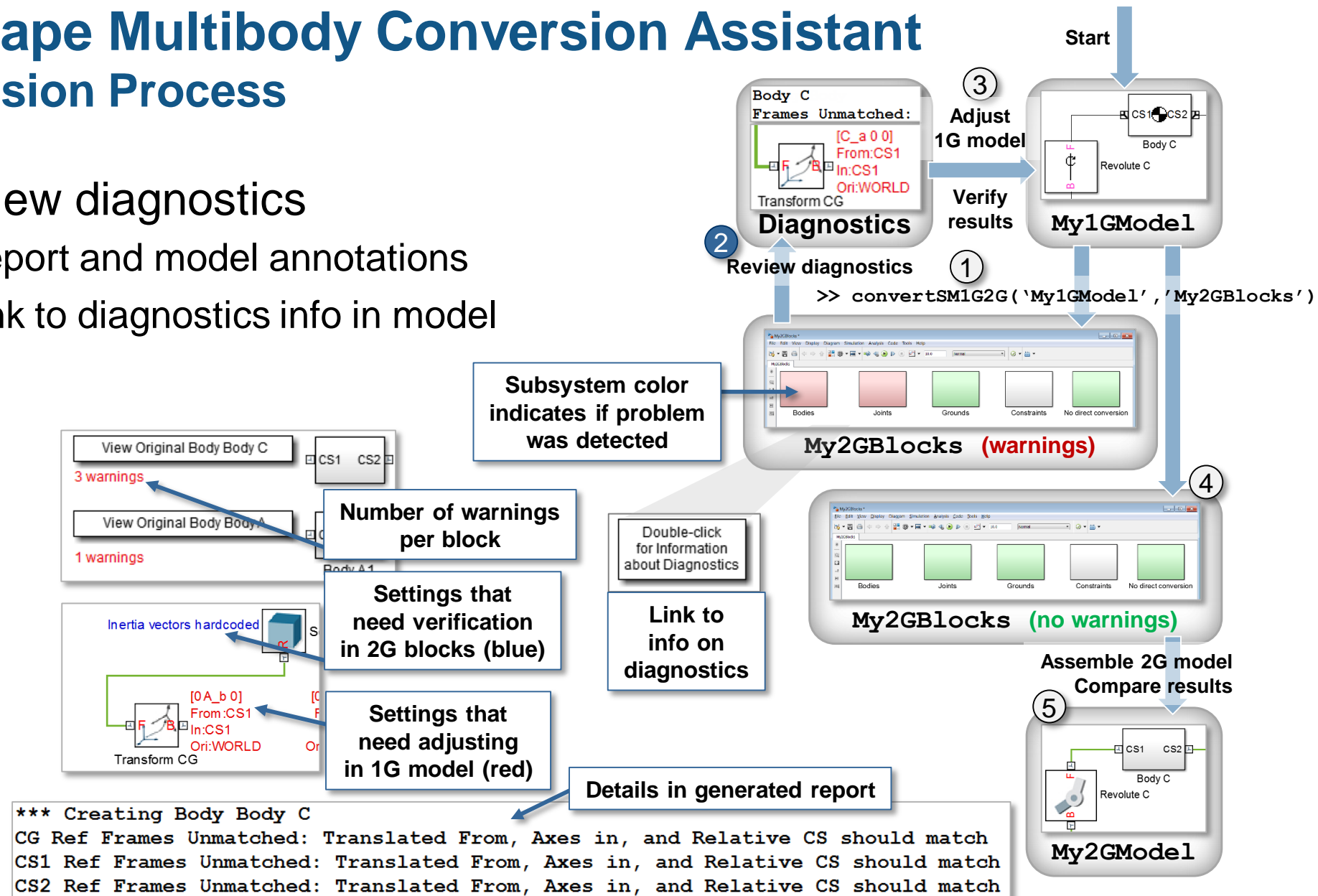


Simscape Multibody Conversion Assistant

Conversion Process

2. Review diagnostics

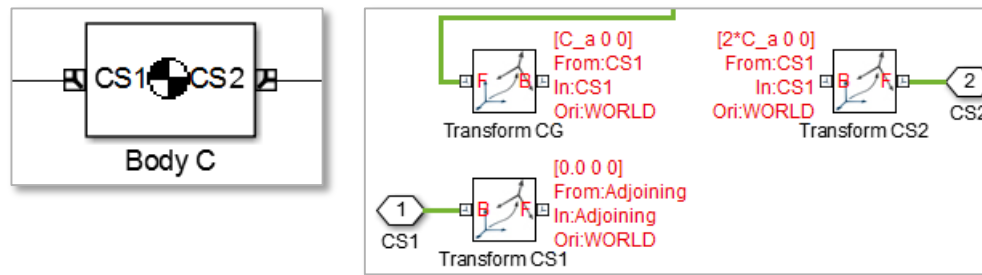
- Report and model annotations
- Link to diagnostics info in model



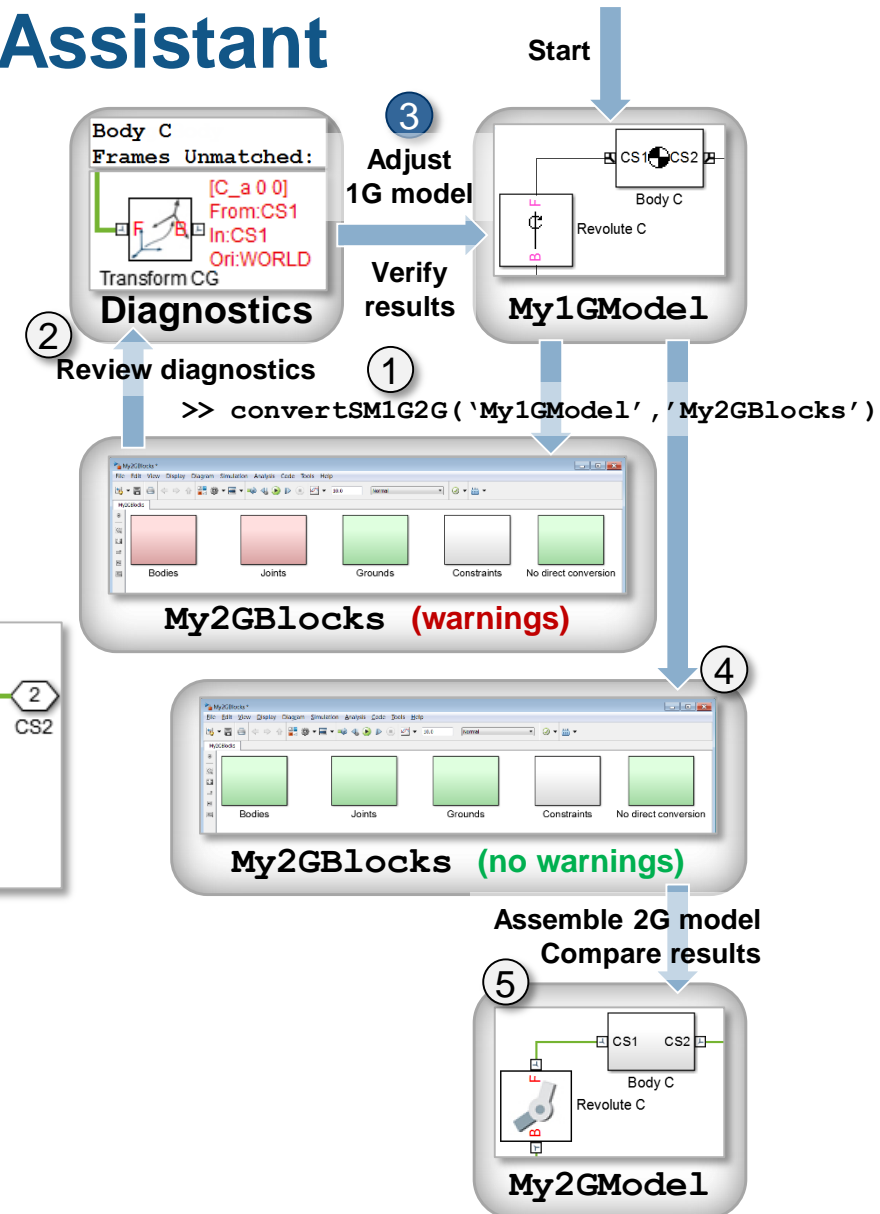
Simscape Multibody Conversion Assistant

Conversion Process

3. Eliminate 1G-only modeling conventions from 1G model
 - Edit original 1G model and verify results are still the same



| Position | Orientation | | Position | Orientation |
|----------|-------------|---|----------|-------------|
| Name | Relative CS | | Name | Relative CS |
| CG | World | → | CG | CS1 |
| CS1 | World | | CS1 | Adjoining |
| CS2 | World | | CS2 | CS1 |



Simscape Multibody Conversion Assistant

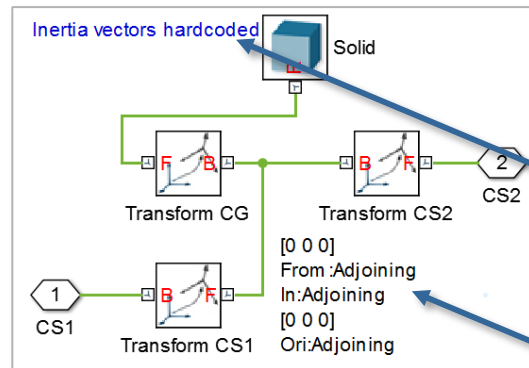
Conversion Process

4. Convert blocks to 2G

- Verify warnings are gone

| Bodies | Joints |
|--|--------|
| 5 Bodies, 0 may need adjustments. | |
| 7 Joints, 0 may need adjustments. | |
| 3 Grounds, 0 may need adjustments. | |
| 0 Constraints, 0 may need adjustments. | |
| 0 elements with no direct 2G conversion. | |

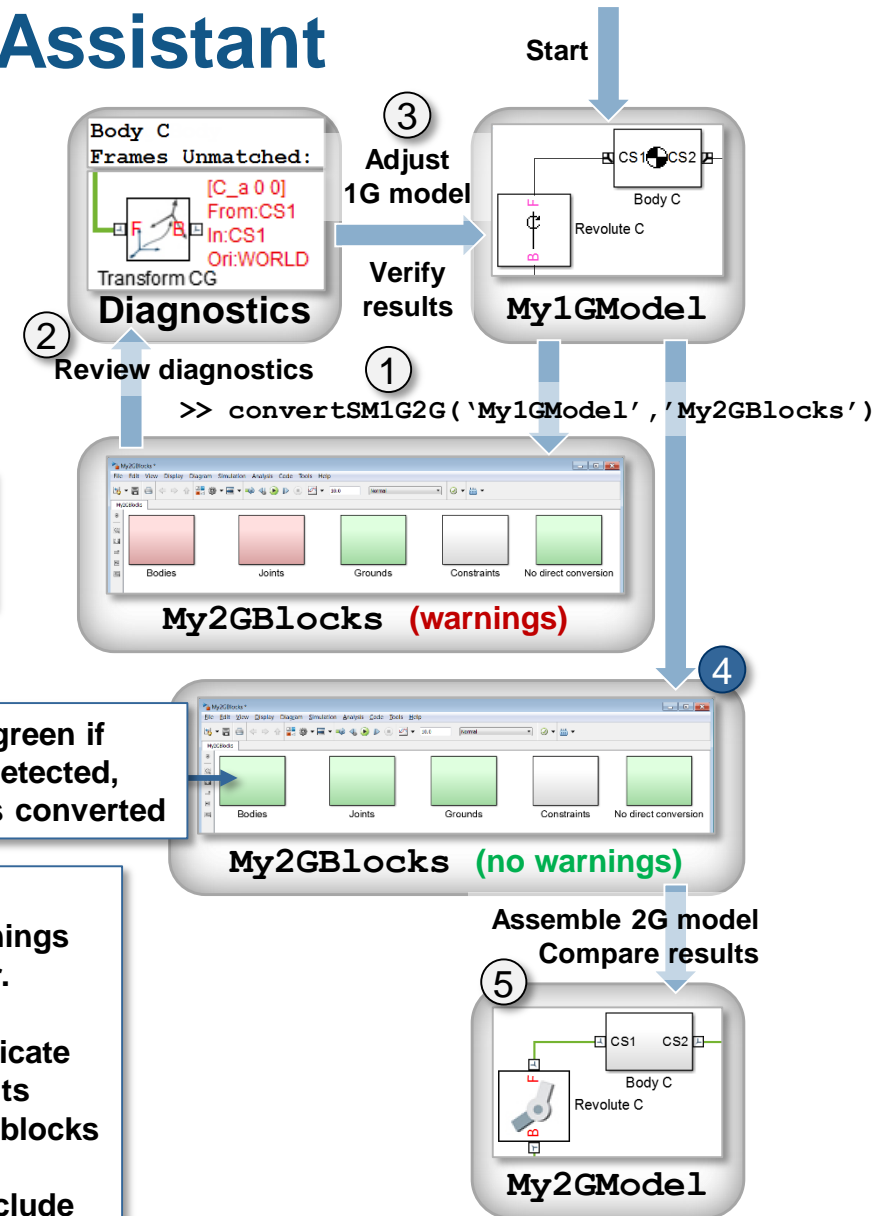
Report indicates
number of blocks
with issues



Red annotations
associated with warnings
no longer appear.

Blue annotations indicate
manual adjustments
may be required in 2G blocks

Black annotations include
additional information.

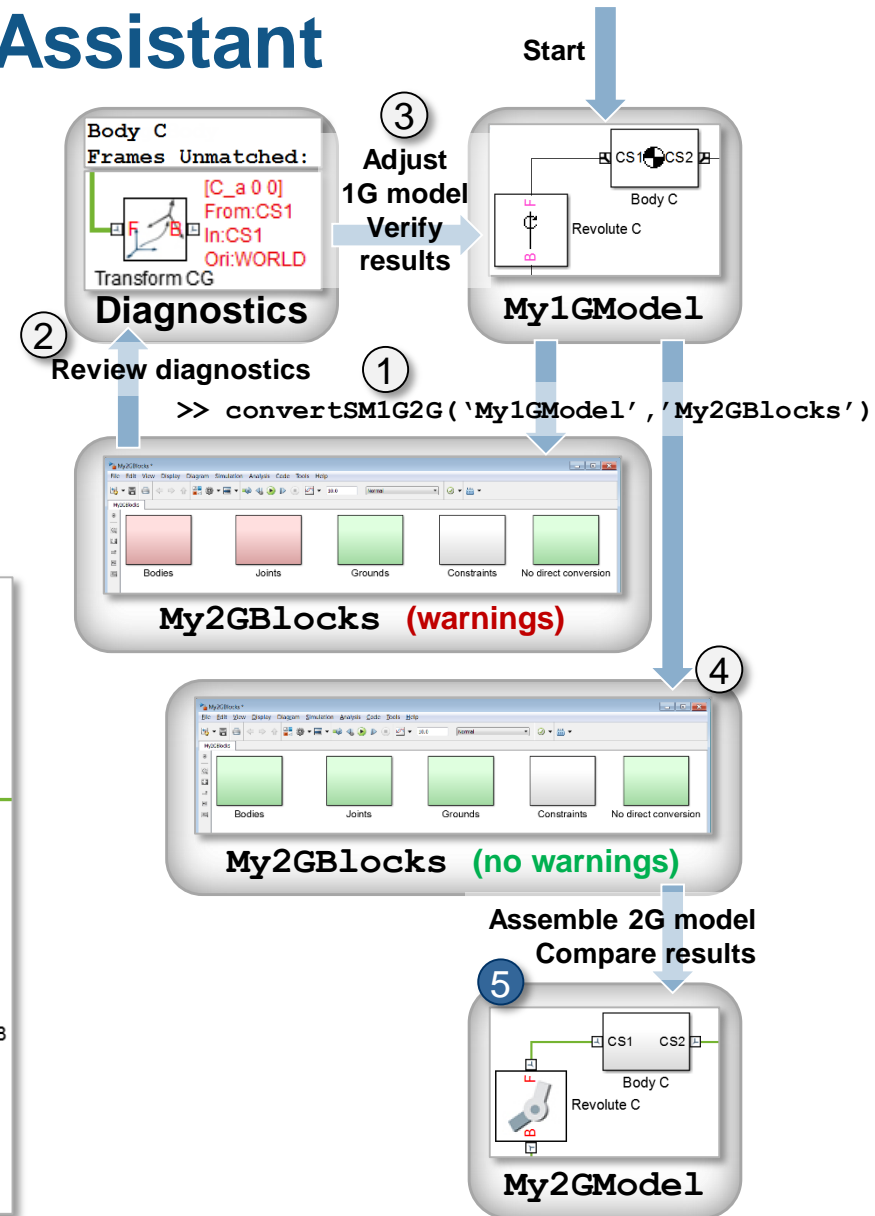
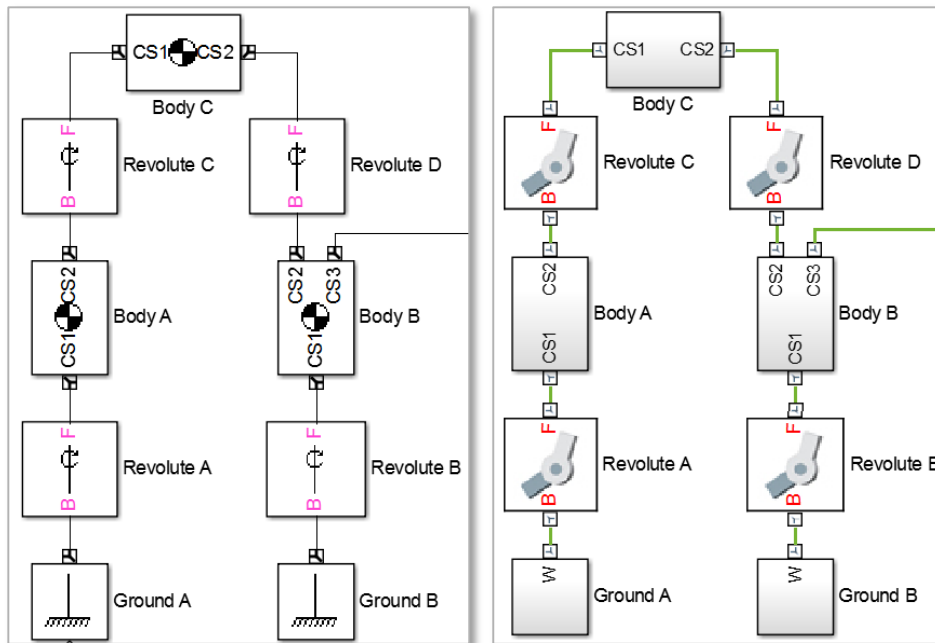


Simscape Multibody Conversion Assistant

Conversion Process

5. Assemble 2G model

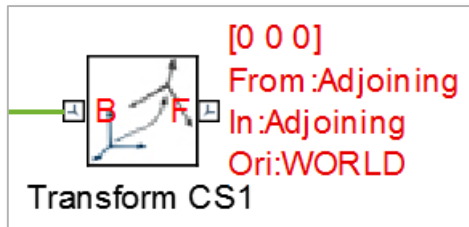
- Blocks have same port order and size
- Test and verify results



Simscape Multibody Conversion Assistant

Interpreting Warnings

- Reference Frames Unmatched



CS1 Ref Frames Unmatched: Translated From, Axes in, and Relative CS should match

Choose reference frames so that they all match. Adjust position and orientation vectors to ensure frames are still located properly (if necessary).

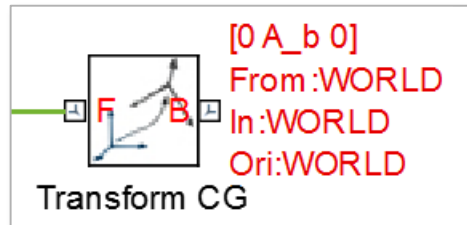
| Position | Orientation | Visualization | Position | Orientation | Vis |
|----------|---------------------------|-----------------------|----------|-------------|-----|
| Name | Translated from Origin of | Components in Axes of | Name | Relative CS | |
| CG | World | World | CG | World | |
| CS1 | Adjoining | Adjoining | CS1 | World | |
| CS2 | CS1 | CS1 | CS2 | CG | |

1G Body Block Parameters

Simscape Multibody Conversion Assistant

Interpreting Warnings

- Reference Frame is World



CS1 Ref Frame World: Reference frames should only be local or Adjoining

Only choose local and Adjoining, not World.
Adjust position and orientation vectors to ensure frames are still located properly (if necessary).

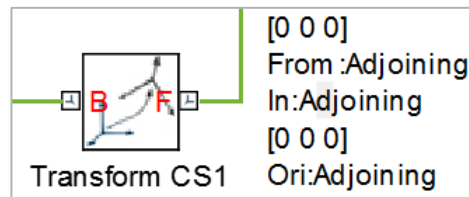
| Position | Orientation | Visualization | Position | Orientation | Vis |
|----------|---------------------------|-----------------------|----------|-------------|-----|
| Name | Translated from Origin of | Components in Axes of | Name | Relative CS | |
| CG | World | World | CG | World | |
| CS1 | Adjoining | Adjoining | CS1 | World | |
| CS2 | CS1 | CS1 | CS2 | CG | |

1G Body Block Parameters

Simscape Multibody Conversion Assistant

Interpreting Warnings

- Reference Frame is Adjoining



CS1 Ref Frame Adjoining: Check downstream frame positions and orientations

Adjoining frame is identified in model. Many frames will often be defined relative to this frame so check them carefully if this frame is changed.

Not included in warning count

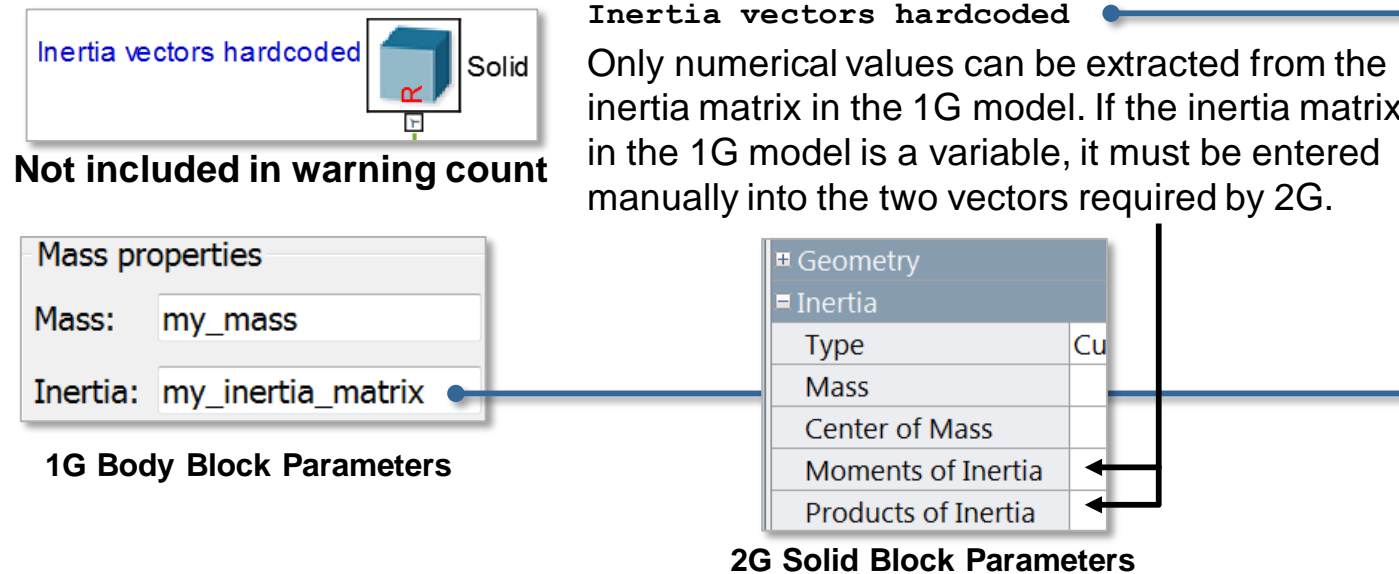
| Position | Orientation | Visualization | Position | Orientation | Vis |
|----------|---------------------------|-----------------------|----------|-------------|-----|
| Name | Translated from Origin of | Components in Axes of | Name | Relative CS | |
| CG | CS1 | CS1 | CG | CS1 | |
| CS1 | Adjoining | Adjoining | CS1 | Adjoining | |
| CS2 | CS1 | CS1 | CS2 | CS1 | |

1G Body Block Parameters

Simscape Multibody Conversion Assistant

Interpreting Warnings

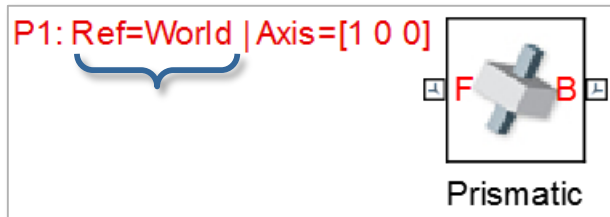
- Inertia vectors hardcoded



Simscape Multibody Conversion Assistant

Interpreting Warnings

- Joint axis reference is World



| Axes | | |
|----------|----------------|--------------|
| Advanced | | |
| Name | Axis of Action | Reference CS |
| P1 | [1 0 0] | World |

1G Joint Block Parameters

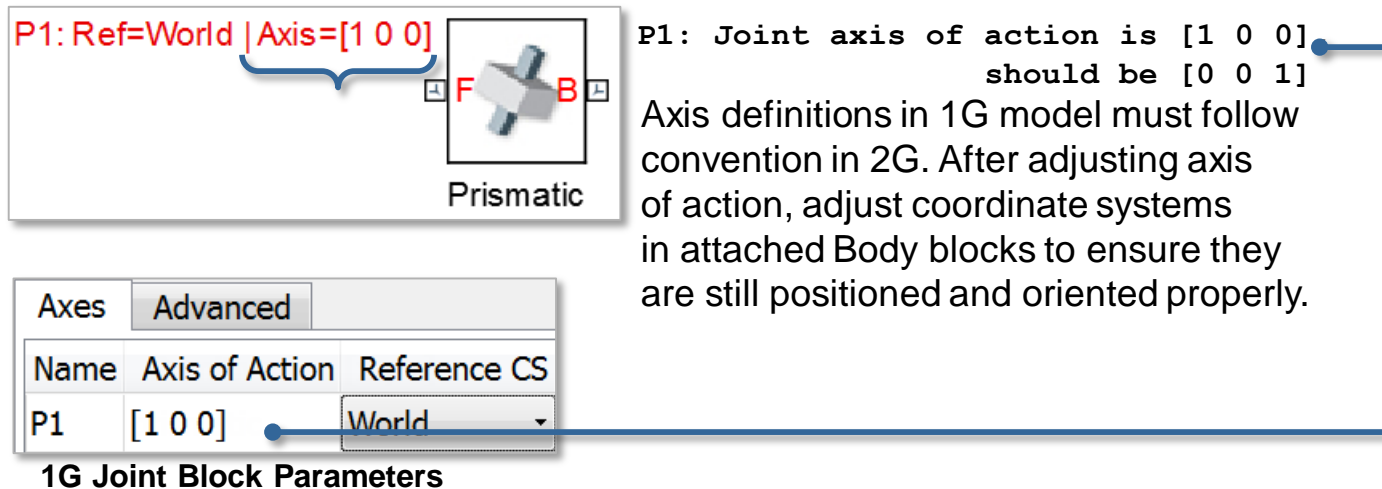
P1: Joint axis reference is World, should be Base

Axis definitions in 1G model must refer to local coordinate systems following the convention in 2G. After adjusting axis reference, adjust coordinate systems in attached Body blocks to ensure they are still positioned and oriented properly.

Simscape Multibody Conversion Assistant

Interpreting Warnings

- Joint axis of action different than 2G convention



The diagram shows a Prismatic joint block with a warning message. The warning message states: "P1: Joint axis of action is [1 0 0] should be [0 0 1]. Axis definitions in 1G model must follow convention in 2G. After adjusting axis of action, adjust coordinate systems in attached Body blocks to ensure they are still positioned and oriented properly." A blue line connects the warning message to the "Axis of Action" parameter in the "1G Joint Block Parameters" table.

P1: Ref=World | Axis=[1 0 0]

Prismatic

| Axes | | |
|----------|----------------|--------------|
| Advanced | | |
| Name | Axis of Action | Reference CS |
| P1 | [1 0 0] | World |

1G Joint Block Parameters

P1: Joint axis of action is [1 0 0]
should be [0 0 1]
Axis definitions in 1G model must follow
convention in 2G. After adjusting axis
of action, adjust coordinate systems
in attached Body blocks to ensure they
are still positioned and oriented properly.

Simscape Multibody Conversion Assistant

Interpreting Warnings

- Gear Constraint



Parameters

Base pitch circle radius: 1.5 m

Follower pitch circle radius: 0.5 m

The image shows the Parameters section of the Gear Constraint block. It contains two input fields: "Base pitch circle radius" with a value of 1.5 and a unit dropdown set to "m", and "Follower pitch circle radius" with a value of 0.5 and a unit dropdown set to "m".

1G Joint Block Parameters

Internal/External not verified

1G block does not specify if gear shafts spin in the same direction (internal) or in opposite directions (external). Must be entered manually in 2G block.

Properties

| | |
|----------------------|--------------------|
| Type | External |
| Specification Method | Pitch Circle Radii |

The image shows the Properties section of the Gear Constraint block. It contains two dropdown menus: "Type" set to "External" and "Specification Method" set to "Pitch Circle Radii". An arrow points to the "Type" dropdown.

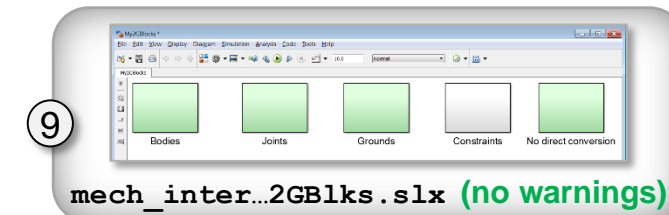
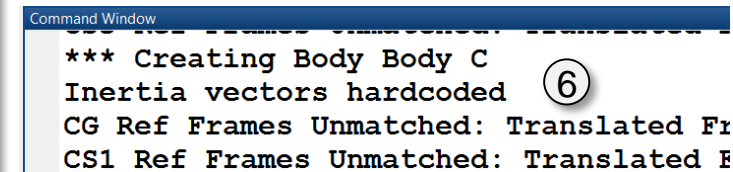
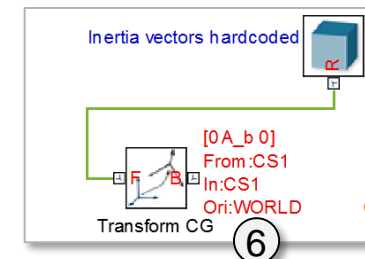
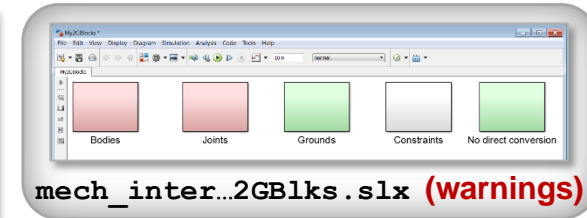
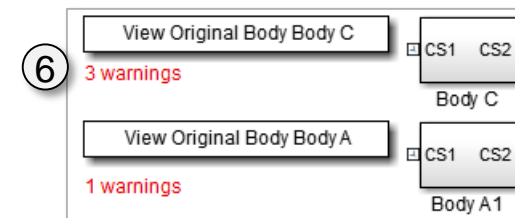
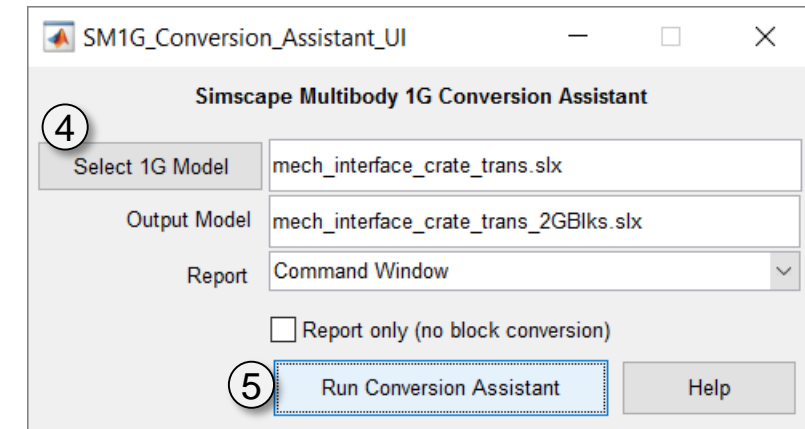
Gear axis orientation not verified

1G block does not require gear axes to be parallel. If gear axes are not parallel, then Bevel Gear Constraint must be used in 2G.

Simscape Multibody Conversion Assistant

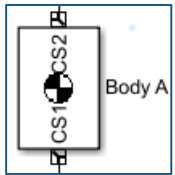
Tutorial Example - mech_interface_crate_trans.slx

1. Run startup script `>> startup_SM1GConvUI`
2. Within MATLAB, move to the Examples folder that matches your MATLAB release, and go to Models\01_mech_crate_transfer
`\SimscapeMultibody1GConvAssist\Examples_R17a\` Models\01_mech_crate_transfer
3. Open model `mech_interface_crate_trans.slx`
Run it and review results in animation and on Scope.
4. In the Conversion Assistant UI, click on “Select 1G Model” and select `mech_interface_crate_trans.slx`
5. Click on the “Run Conversion Assistant” button
6. Look at the diagnostics to see what needs to be fixed
7. Make changes in `mech_interface_crate_trans.slx` and redo conversion. See if errors disappear.
8. If you can't figure out how to make errors go away, look at `mech_interface_crate_trans_fixed.slx` for hints.
9. Eventually, your conversion should produce no warnings
10. Assemble your new 2G model using the blocks.
If you have problems, look at `mech_interface_crate_trans_2G.slx`
11. A 2G version with adjusted geometry (affects animation only) is available in `mech_interface_crate_trans_2G_finalModel.slx`



Simscape Multibody Conversion Assistant

Tutorial Example - mech_interface_crate_trans.slx



Block Parameters: Body A

| Position | | Orientation | | Visualization | |
|-------------------------------------|-----------|-------------|--------------------|---------------|-------------|
| Show Port | Port Side | Name | Orientation Vector | Units | Relative CS |
| <input type="checkbox"/> | Bottom | CG | [0 0 0] | deg | World |
| <input checked="" type="checkbox"/> | Bottom | CS1 | [0 0 0] | deg | World |
| <input checked="" type="checkbox"/> | Top | CS2 | [0 0 0] | deg | World |

Block Parameters: Body A

| Position | | Orientation | | Visualization | |
|-------------------------------------|-----------|-------------|--------------------|---------------|-------------|
| Show Port | Port Side | Name | Orientation Vector | Units | Relative CS |
| <input type="checkbox"/> | Bottom | CG | [0 0 0] | deg | CS1 |
| <input checked="" type="checkbox"/> | Bottom | CS1 | [0 0 0] | deg | Adjoining |
| <input checked="" type="checkbox"/> | Top | CS2 | [0 0 0] | deg | CS1 |

Similar for Body B, C, D, A1

*** Creating Body Body A

Inertia vectors hardcoded

CG Ref Frames Unmatched: Translated From, Axes in, and Relative CS should match

CS1 Ref Frames Unmatched: Translated From, Axes in, and Relative CS should match

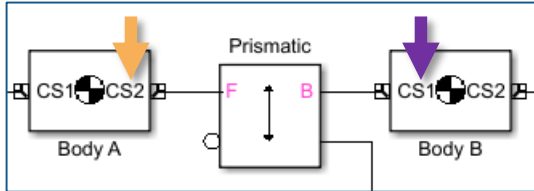
CS2 Ref Frames Unmatched: Translated From, Axes in, and Relative CS should match

The diagnostics indicate that the reference frames do not match.

Adjust the Relative CS to make it match the frame referenced in Translated From and Axes In fields on the Position Tab.

Simscape Multibody Conversion Assistant

Tutorial Example - mech_interface_crate_trans.slx



*** Creating Joint Prismatic

P1: Joint axis of action is $[1 \ 0 \ 0]$, should be $[0 \ 0 \ 1]$

Diagnostics indicates that the Axis of Action for the Prismatic Joint is incorrect. Adjust the Axis of Action so that it matches the axis convention in 2G Technology. This requires that the frames on the adjoining bodies also be adjusted so that their z-axes point along the desired axis.

Block Parameters: Body A

| Position | | Orientation | | Visualization | |
|-------------------------------------|-----------|-------------|--------------------|---------------|-------------|
| Show Port | Port Side | Name | Orientation Vector | Units | Relative CS |
| <input type="checkbox"/> | Left | CG | $[0 \ 0 \ 0]$ | deg | CS1 |
| <input checked="" type="checkbox"/> | Left | CS1 | $[0 \ 0 \ 45]$ | deg | World |
| <input checked="" type="checkbox"/> | Right | CS2 | $[0 \ 0 \ 0]$ | deg | CS1 |

Block Parameters: Prismatic

| Axes | | Advanced | |
|------|-----------|------------------------------|--------------|
| Name | Primitive | Axis of Action $[x \ y \ z]$ | Reference CS |
| P1 | prismatic | $[1 \ 0 \ 0]$ | Base |

Block Parameters: Body B

| Position | | Orientation | | Visualization | |
|-------------------------------------|-----------|-------------|--------------------|---------------|-------------|
| Show Port | Port Side | Name | Orientation Vector | Units | Relative CS |
| <input type="checkbox"/> | Left | CG | $[0 \ 0 \ 0]$ | deg | CS1 |
| <input checked="" type="checkbox"/> | Left | CS1 | $[0 \ 0 \ 0]$ | deg | Adjoining |
| <input checked="" type="checkbox"/> | Right | CS2 | $[0 \ 0 \ 0]$ | deg | CS1 |

Block Parameters: Body A

| Position | | Orientation | | Visualization | |
|-------------------------------------|-----------|-------------|--------------------|---------------|-------------|
| Show Port | Port Side | Name | Orientation Vector | Units | Relative CS |
| <input type="checkbox"/> | Left | CG | $[0 \ 0 \ 0]$ | deg | CS1 |
| <input checked="" type="checkbox"/> | Left | CS1 | $[0 \ 0 \ 45]$ | deg | Adjoining |
| <input checked="" type="checkbox"/> | Right | CS2 | $[0 \ 90 \ 0]$ | deg | CS1 |

Block Parameters: Prismatic

| Axes | | Advanced | |
|------|-----------|------------------------------|--------------|
| Name | Primitive | Axis of Action $[x \ y \ z]$ | Reference CS |
| P1 | prismatic | $[0 \ 0 \ 1]$ | Base |

Block Parameters: Body B

| Position | | Orientation | | Visualization | |
|-------------------------------------|-----------|-------------|--------------------|---------------|-------------|
| Show Port | Port Side | Name | Orientation Vector | Units | Relative CS |
| <input type="checkbox"/> | Left | CG | $[0 \ -90 \ 0]$ | deg | CS1 |
| <input checked="" type="checkbox"/> | Left | CS1 | $[0 \ 0 \ 0]$ | deg | Adjoining |
| <input checked="" type="checkbox"/> | Right | CS2 | $[0 \ -90 \ 0]$ | deg | CS1 |