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Systems *Engineering: Design and Development*

ENGR 387

Agenda

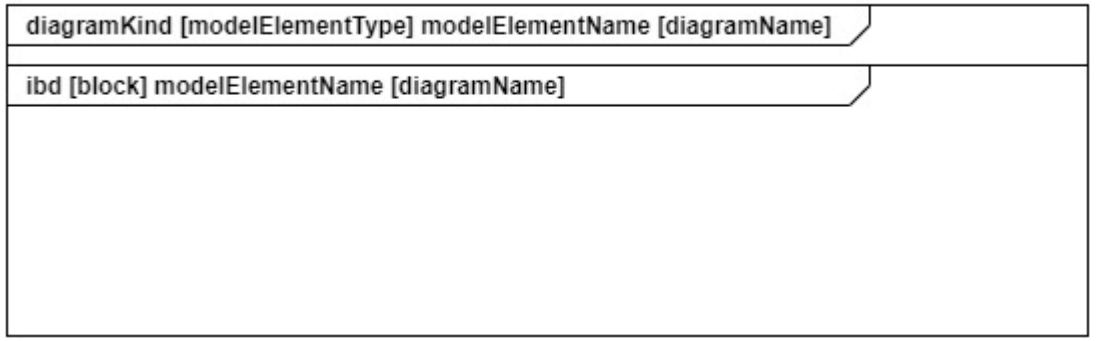
- Purpose of IBDs
- Diagram Header
- BDD Flashback
- Part Properties
- Default Multiplicities
- Reference Properties
- Connectors
- Ports (Standard or Flow)
- Item Flows
- Nested Part and Reference Properties
- BDD and IBD Comparison Examples
- References

Purpose of IBDs

- Display instances of types that exist in a particular configuration of the Block that you defined in a BDD.
- IBDs provide an internal view of a block's structure by displaying:
  - Elements of Usage owned by the block named in the header of the diagram
    - Mainly the Part Properties, Reference Properties, and sometimes Ports
  - How those elements of usage are connected to each other
    - Displayed by using Connectors
  - The services that are provided and required across the connections
    - Displayed by using Standard Ports
  - The types of matter, energy, or data that flow across those connections
    - Displayed by using Flow Ports and/or Item Flows
- NOTE:
  - IBDs CANNOT display elements of definition (blocks or other)

Diagram Header

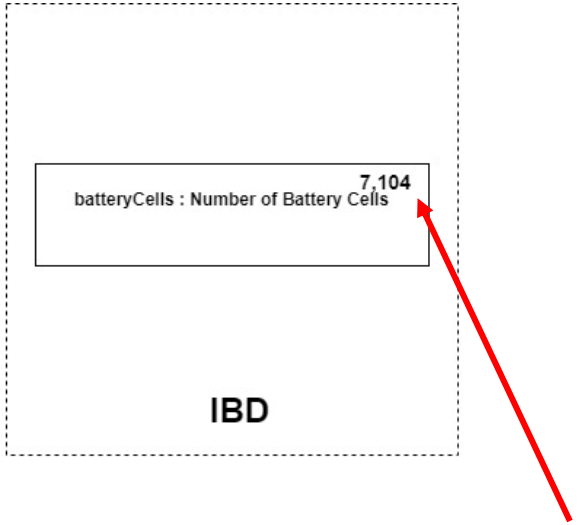
- diagramKind = ibd
- modelElementType = block



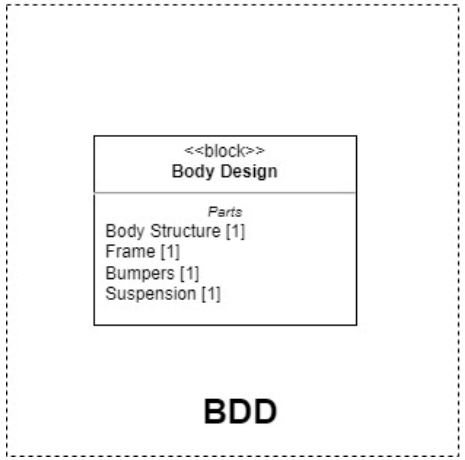
BDD Flashback

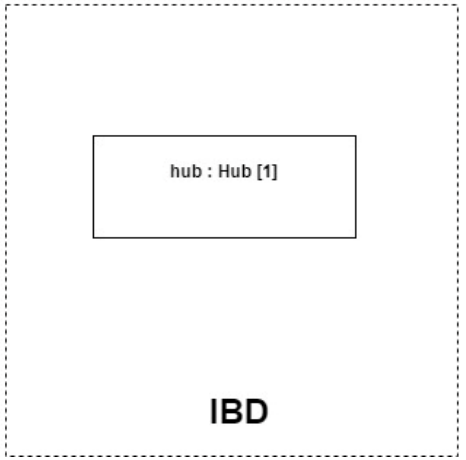
- Remember from BDDs that a Block can own 5 kinds of structural features:
  - Features come in two varieties **Structural** and **Behavioral**
  - 5 Kinds of structural features (aka **properties**)
    - Part properties
    - Reference properties
    - Value properties
    - Constraint properties
    - Ports
- IBDs generally show three of those 5 kinds of features:
  - Part Properties
  - Reference Properties
  - Ports
- Note: the other two kinds (Value and Constraint Properties) are shown on Parametric Diagrams!

Part Properties



- Graphical Notation:
  - Rectangle with a solid line border
- Namestring:
  - <part name> : <type> [<multiplicity>]
  - Default multiplicity when not shown = 1
- Note: It is an option to display multiplicity either at the end of the namestring or in the upper right-hand corner of the rectangle
- Remember:
  - Part property means a thing (block) that is internal to the block that owns the part property





Default Multiplicities

- Connector IBDs
  - SysML defines default multiplicities of 1 on each end of a connector. These multiplicities may be assumed if not shown on a diagram. To avoid confusion, any multiplicity other than the default should always be shown on a diagram.

EXAMPLE

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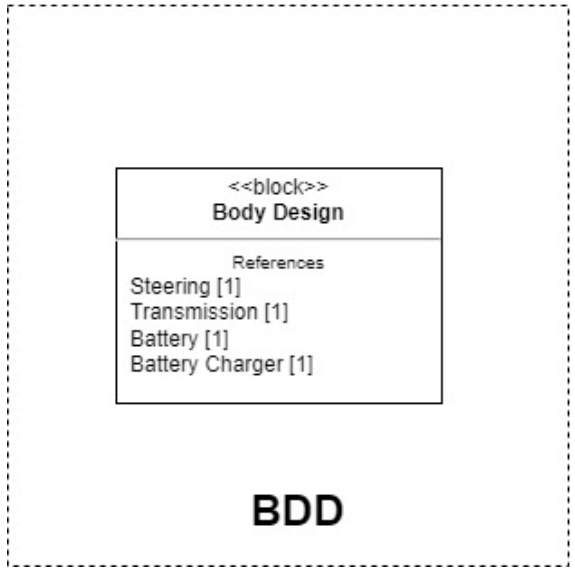
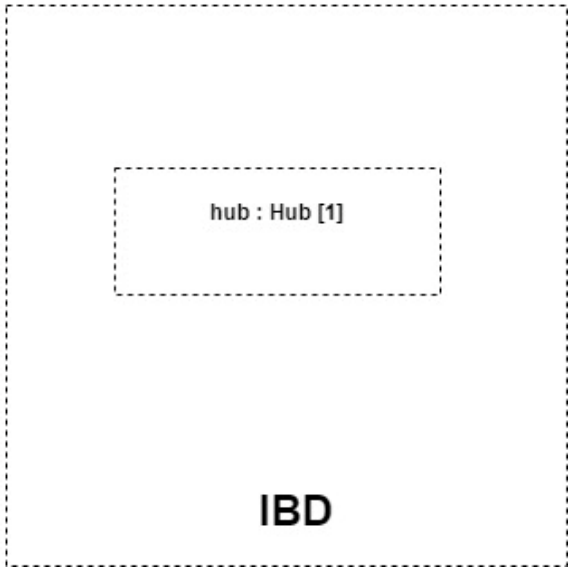
*Per OMG Standards

Reference Properties

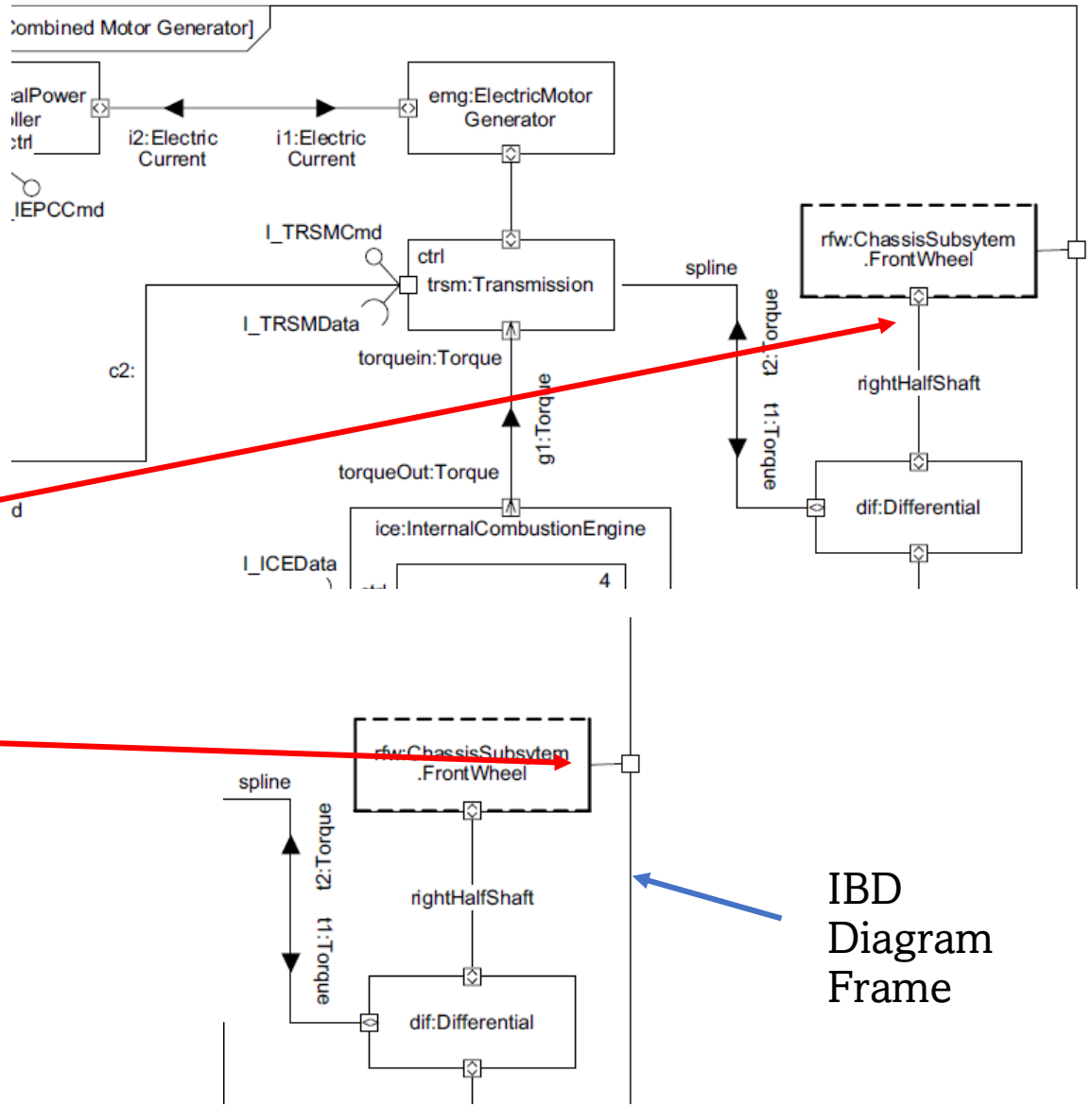
- Graphical Notation:
  - Rectangle with a dashed line border
- Namestring:
  - <reference name> : <type> [<multiplicity>]
  - Default multiplicity when not shown = 1
- Remember:
  - Reference property means a thing (block or actor) that is external to the block that owns the reference property





Connectors

- Graphical Notation:
  - Solid lines between properties
  - May or may not have ports at the end of the lines
- Namestring:
  - <connector name> : <type>
  - name and type are both optional
- Additional info
  - Assembly Connector
    - internal to block / peer to peer
  - Delegation Connector
    - external interface of a block / whole-part relationship



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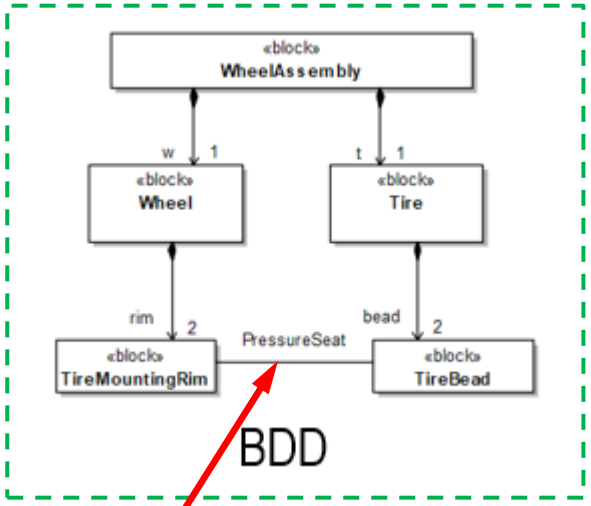
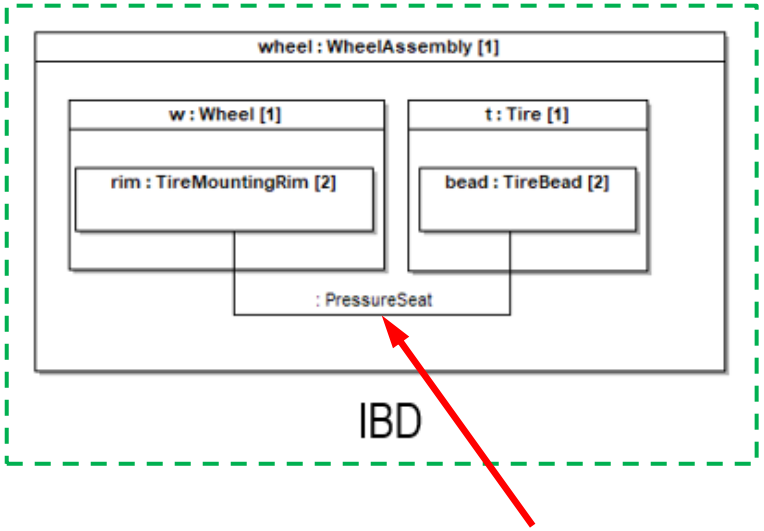
Connectors : Example

- If you choose to ‘type’ a connector then it must be ‘typed by’ a matching association (likely created and shown on a BDD).
  - The association must relate the same two blocks that ‘type’ the two properties at the ends of the connector
  - Remember that an IBD identifies things that do exist vs. a BDD that identifies things that could exist!



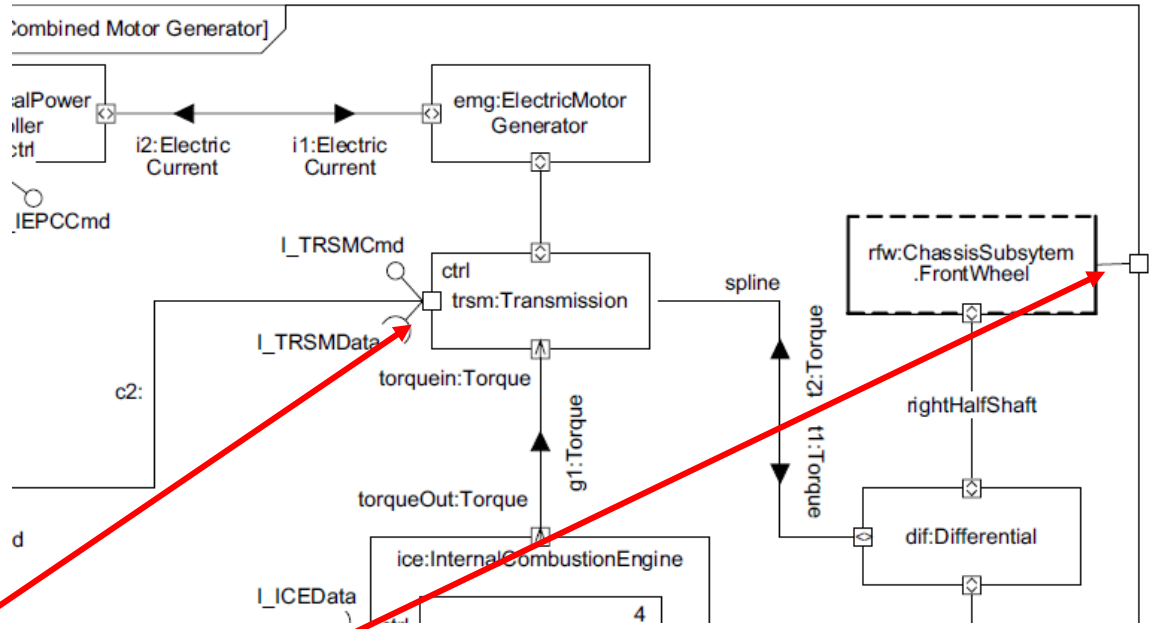
Reference Association named *PressureSeat*



Connector of type *PressureSeat*
Note: the Connector has no name!

Port (Standard or Flow)

- Purpose:
  - Standard Port: used to identify the services that are provided and required across connections
  - Flow Port: used to identify matter, energy, or data that could flow
- The language does not require you to show Ports!
  - Only use them based on what you are trying to convey
- Notations:
  - Same as on BDDs
  - If used, they must be compatible and will appear at the end of Connectors
  - Can be located on the border of a Part or Reference Property or on the IBD diagram frame

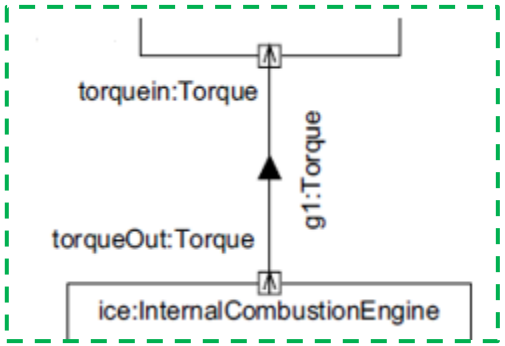


Item Flows

- Graphical Notation:
  - Solid triangular arrow, with a label, over a connector that joins two flow ports

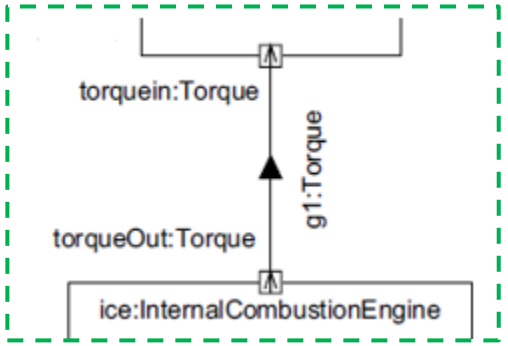
- Namestring:
  - <item flow name> : <type>

- Represents a type of item (matter, energy, or data) that flows between two connected properties.



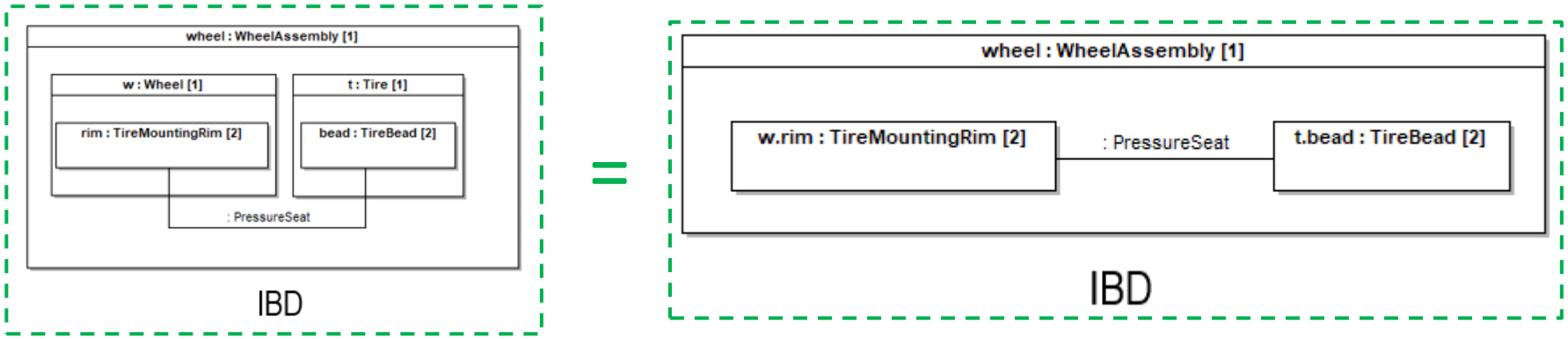
Item Flows Cont.

- <type>
  - Item Flows are typed by a block, value type, or signal that exists in your model
  - The type can be more than one item, it can be a comma separated list of acceptable items that flow between properties
  - The type must be compatible with the flow ports at the ends of the connector
    - Atomic Flow Port: The type of item flow is generally equal to types of ports
    - Non-atomic Flow Port: type of item flow equals a flow property with matching type and direction that is included within the flow specification for the non-atomic flow ports
- Why?
  - Why put an item flow on a connector?
    - Without ports on the diagram, it is very useful to show an Item Flow
    - With ports it may still be useful because those ports may be typed by a flow specification that has many allowable things, but you want to convey specific information in that diagram

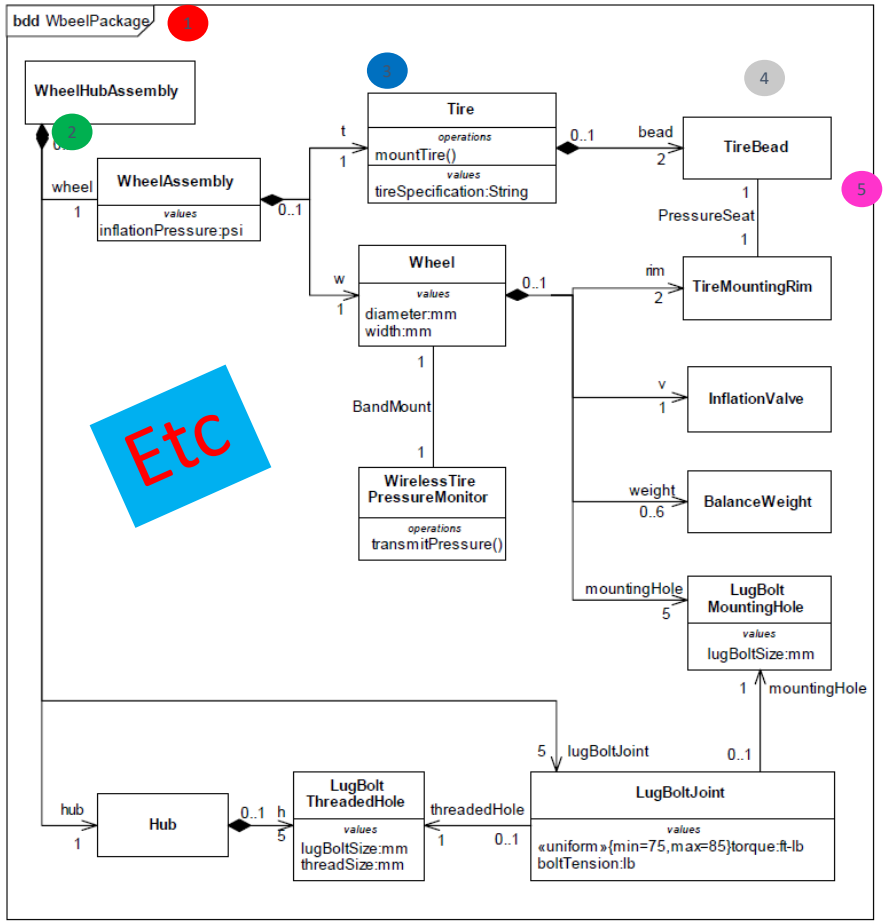


Nested Parts and Reference Properties

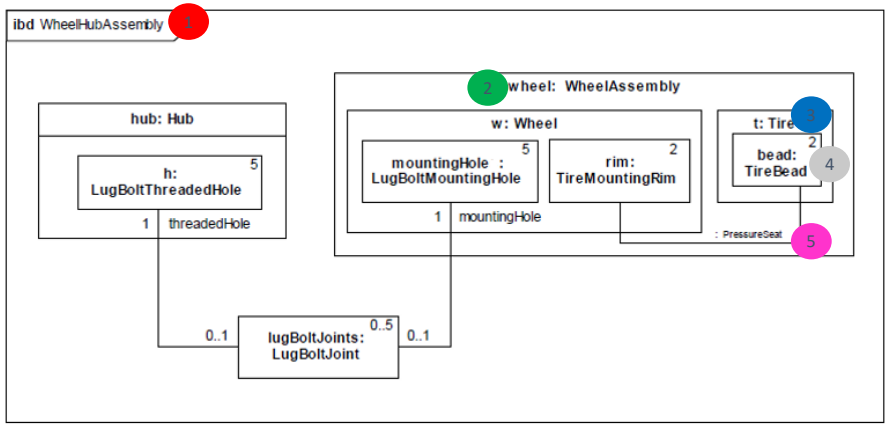
- You can show multiple levels of decomposition on an IBD.
  - Connectors may be drawn that cross the boundaries of nested properties to connect to properties within them.
    - This violates object-oriented rules of encapsulation, but is allowed by SysML
- Dot Notation
  - Dot notation portrays system hierarchy NOT model hierarchy.
  - The rectangle represents the last ‘thing’ in the string before the colon.
  - Drawbacks: The string “w.rim : TireMountingRim [2]” does not convey:
    - The name of the block that ‘types’ the part property “w”
    - The multiplicity of the part property “w”



BDD & IBD Comparison (Example #1) OMG SysML v1.2 Spec



OMG Spec Figure 8.8



OMG Spec Figure 8.9

Note:
In Figure 8.9 an Internal Block Diagram (IBD) shows how the blocks defined in the Wheel package are used. This ibd is a partial view that focuses on particular parts of interest and omits others from the diagram, such as the “v” InflationValve and “weight” BalanceWeight, which are also parts of a Wheel.

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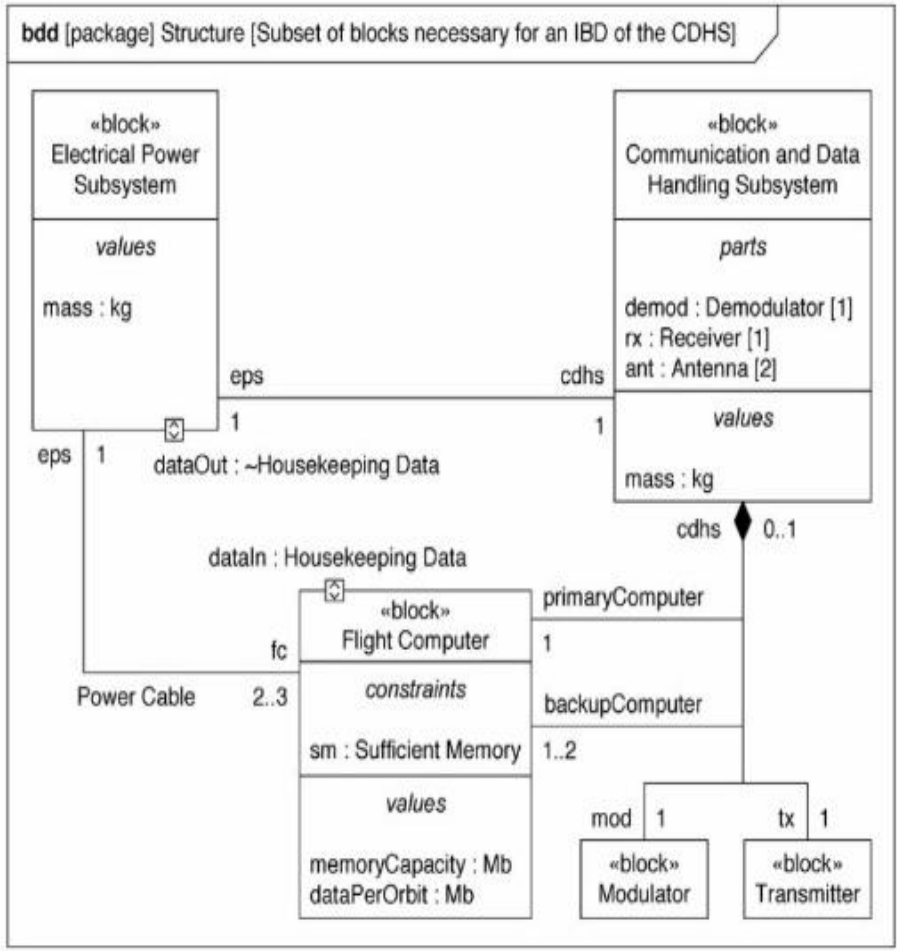
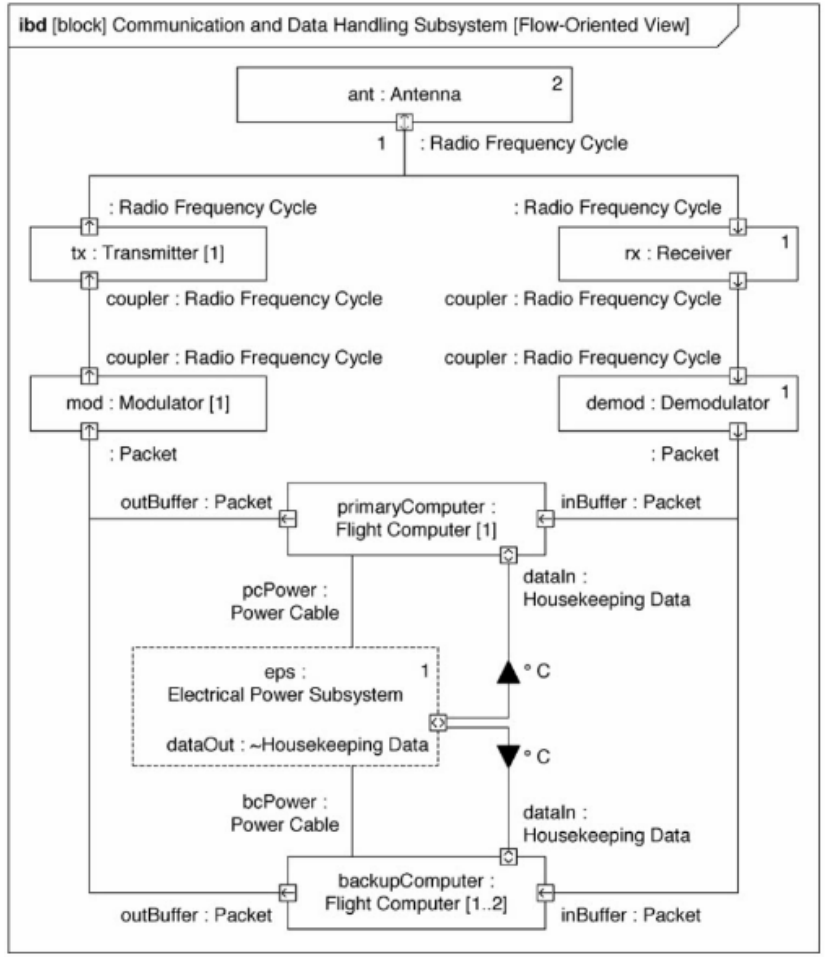
BDD & IBD Comparison (Example #1) SysML Distilled (Delligati)



SysML Distilled Figure 4.1



SysML Distilled Figure 4.2

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Questions

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References

- Additional information can be obtained by reviewing:
  - SysML Distilled (Delligatti)
    - Chapter 4: Internal Block Diagrams
  - A Practical Guide to SysML (Friedenthal)
    - Chapter 7: Modeling Structure with Blocks
      - The Block section covers both BDDs and IBDs
  - OMG SysML Spec v1.2
    - Section 8: Blocks
      - The Block section covers both BDDs and IBDs
    - Section 9: Ports and Flows

Summary

Review Questions

Question 1

- What model element can an IBD represent?
  - A. Reference Association
  - B. Part Property
  - C. Block
  - D. Value Type
  - E. Reference Property
  - F. Operation
  - G. Constraint Block
  - H. Connector
  - I. Value Property
  - J. Port

Question 2

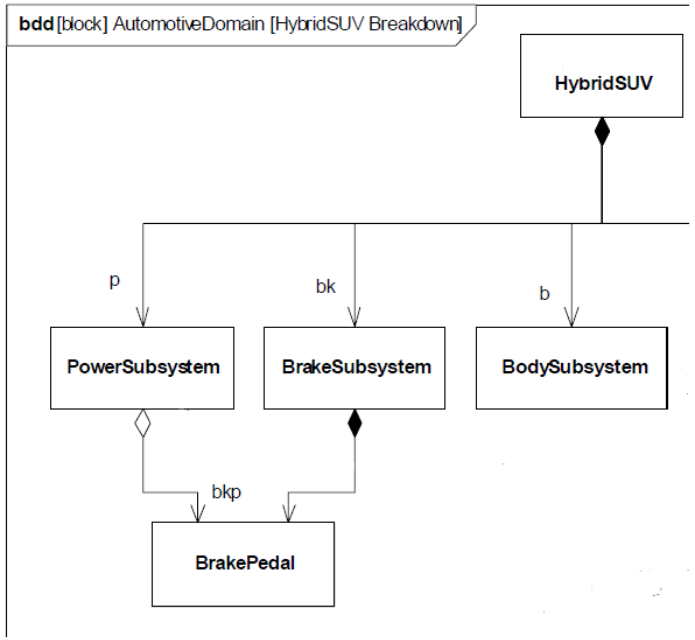
- On an IBD, ___ appear as solid boundary rectangles and ___ appear as dashed boundary rectangles.

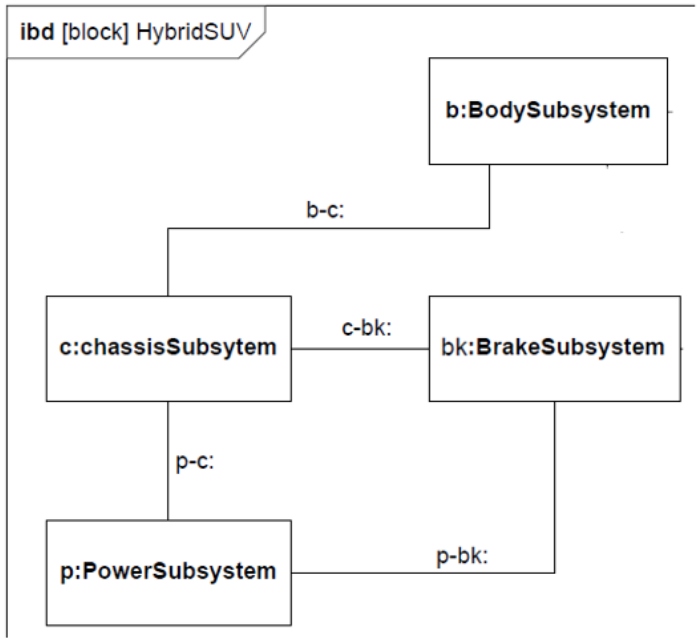
A. Reference Properties, Reference Associations
B. Part Properties, Reference Properties
C. Part Properties, Value Types
D. Reference Properties, Constraint Blocks

Question 3

- All solid lines on an IBD are:
  A. Associations
  B. Constraints
  C. Connectors
  D. Reference Associations
  E. Sometimes they are Connectors (when they are not typed) and sometimes they are associations (when they are typed)

Question 4





Using the two <u>partial</u> diagrams, what is *p-bk*?

A. None of the below options accurately describe p-bk
B. Two Part Properties of *HybridSUV*
C. A Connector
D. An Association
E. A Flow Property

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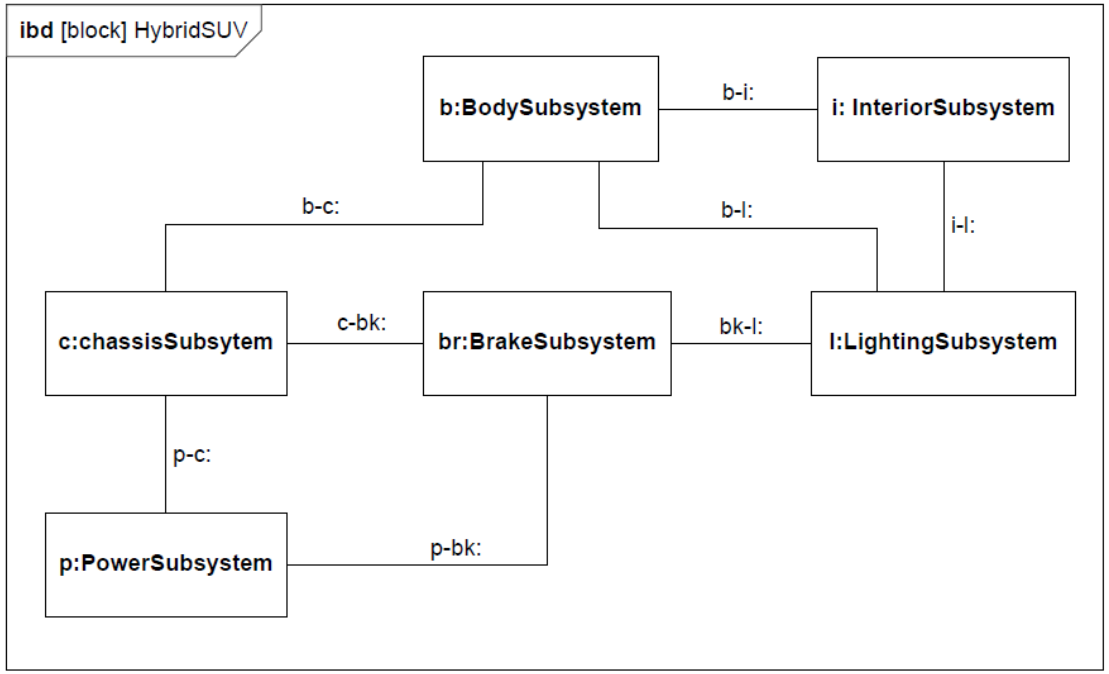
Question 5



Based on the diagram shown, what is *i*?

A. A block of type *InteriorSubsystem*
B. A reference property of type *InteriorSubsystem* owned by *BodySubsystem*
C. A constraint block owned by *HybridSUV*
D. A part property of type *InteriorSubsystem* owned by *BodySubsystem*
E. A part property owned by *HybridSUV*

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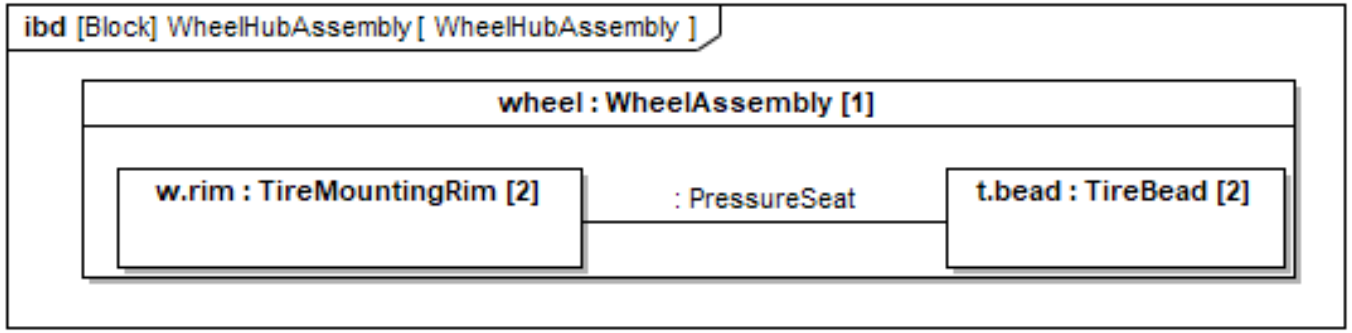
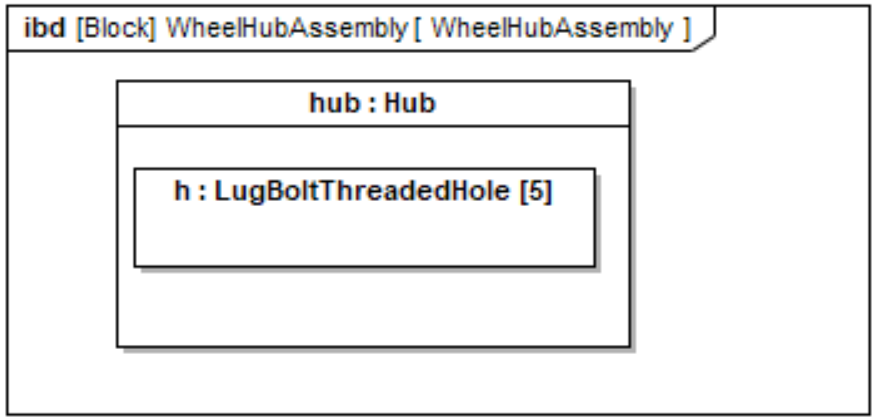
Question 6



What does the above diagram show?

A. An association between *w* and *t* reference properties
B. An association between *w* and *t* part properties
C. An association between *rim* and *bead* reference properties
D. An association between *rim* and *bead* part properties
E. A Connector between *w* and *t* reference properties
F. A Connector between *w* and *t* part properties
G. A Connector between *rim* and *bead* reference properties
H. A Connector between *rim* and *bead* part properties

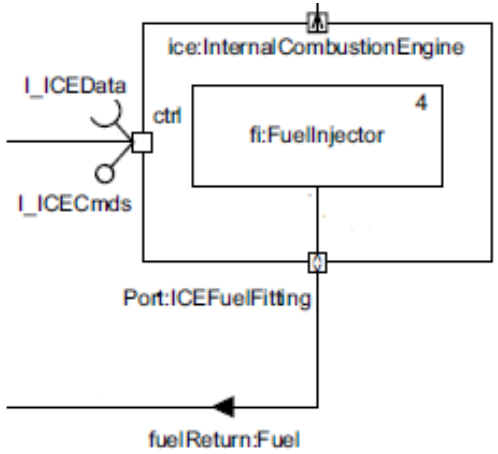
Question 7



What is the multiplicity of *hub*?

A. 0
B. 1
C. 0..1
D. 0..5
E. 5

Question 8



Reviewing the partial IBD above, identify all of the statements below that are False?

fi is a part of *ice*

There must be a Flow Specification called *ICEFuelFitting* that includes a flow property of type *Fuel*

Port is an atomic flow port

There must be a flow specification called *Fuel* that includes a flow property of type *ICEFuelFitting*

fi is a part of *InternalCombustionEngine*

Port cannot be located on the border of *ice*, it should be on the border of *fi*

Question 9

T/F An Item Flow is an element of definition?

Answer Key on Next Sheet

Don’t peek unless you are ready!!

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Sample Question Answer Key

Question	Answer	Justification
Question 1	C	See slides 4 & 5
Question 2	B	See slides 7 & 8
Question 3	C	See slide 9
Question 4	C	See slide 9
Question 5	E	See slide 7
Question 6	H	See slides 7, 9, & 14
Question 7	B	See slide 7
Question 8	A,C,D,F	many BDD and IBD concepts combined
Question 9	False	See slide 12