Raytheon

Customer Success Is Our Mission

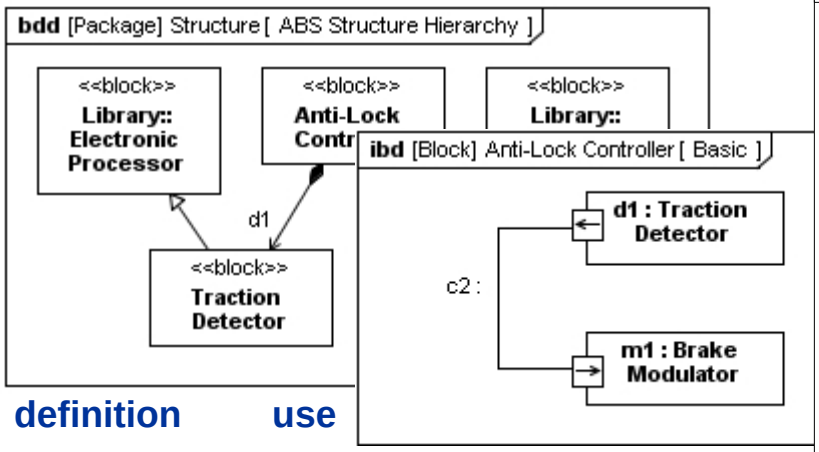
Deployment of SysML in Tools and Architectures: an Industry Perspective

Rick Steiner
Raytheon IDS, San Diego
fsteiner@raytheon.com

4 Pillars of SysML – ABS Example

Raytheon
Integrated Defense Systems

1. Structure

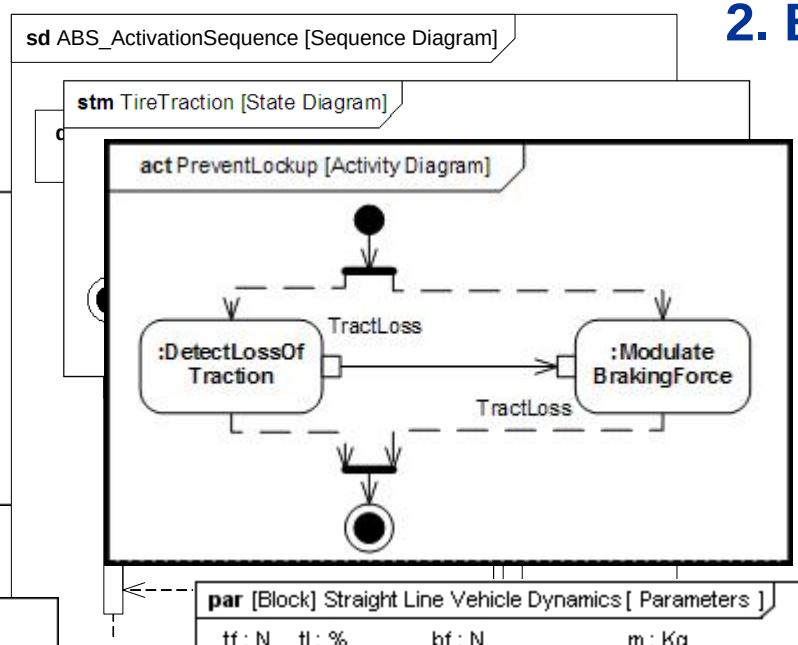


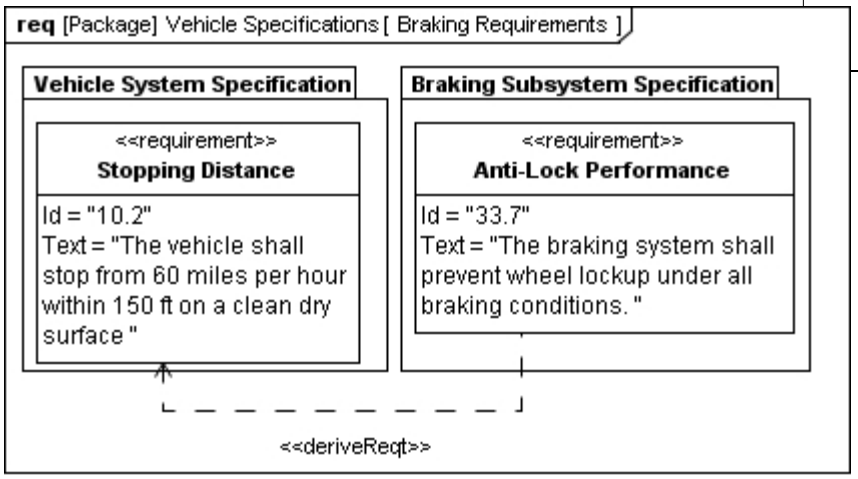
2. Behavior

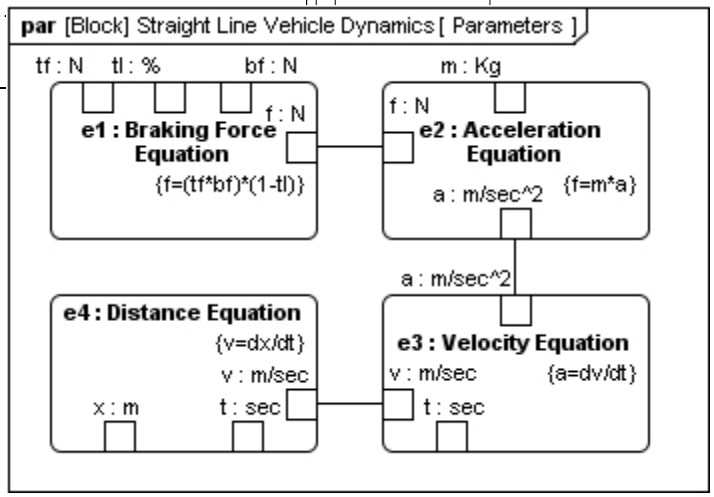
interaction

state machine

activity/ function



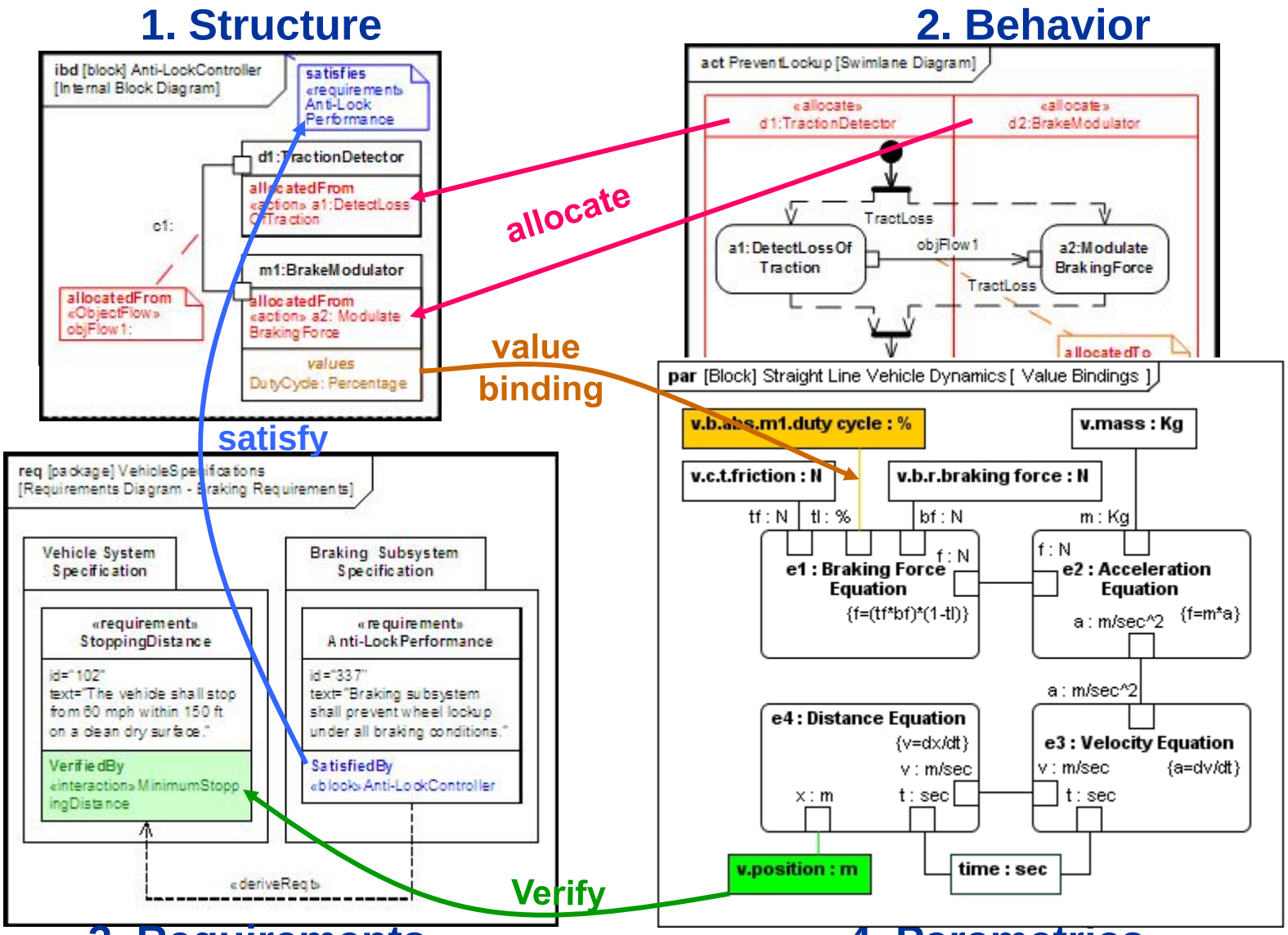




3. Requirements

4. Parametrics

Cross Connecting Model Elements



Key Considerations for SysML Tool Selection

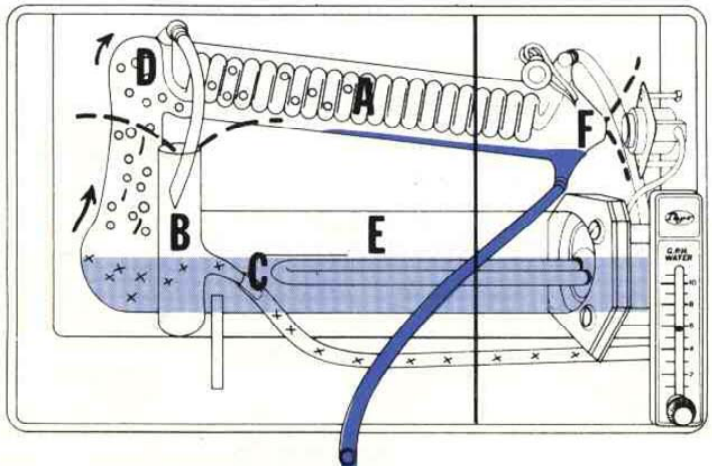
Raytheon
Integrated Defense Systems

- The specific MBSE method employed may leverage specific SysML features, but may not require other features. It is appropriate to ask the following questions to emphasize the features of SysML that a successful tool deployment will need to support.
  - Which behavior representations are most important? Activity diagrams? State machines? Sequence diagrams?
  - Will there be a need for item flow representation?
  - What kind of need will there be for detailed performance analysis and parametric modeling? Expression of mathematical equations relating parameters of system elements may be a very important part of the system development process/method employed.
  - Will there be a need for algorithm specification & development? It may be important to express information processing algorithms explicitly in mathematical form, using constraint blocks and eventually relating them to specific blocks representing software code.
  - Which architecting principles need to be supported by the tool?
  - How will allocation be used? The manner in which allocation is used to guide the development process may dictate a set of constraints & rules associated with allocation relationships. By enforcing or enabling these rules, a toolset can improve the efficiency of the modeling process.

OMG SysML Tutorial (omgsysml.org)
Water Distiller Example

Raytheon
Integrated Defense Systems

- Functional Analysis based, not OOA
  - Relies heavily on activity diagrams and functional allocation
- Solution to problem focused on activity modeling, flow allocation, item flows & parametrics
  - Heat balance of distiller relies on properties of water flowing through system
- Traditional UML tools just don't do these things



Tool Comparison For Distiller Example

Raytheon
Integrated Defense Systems

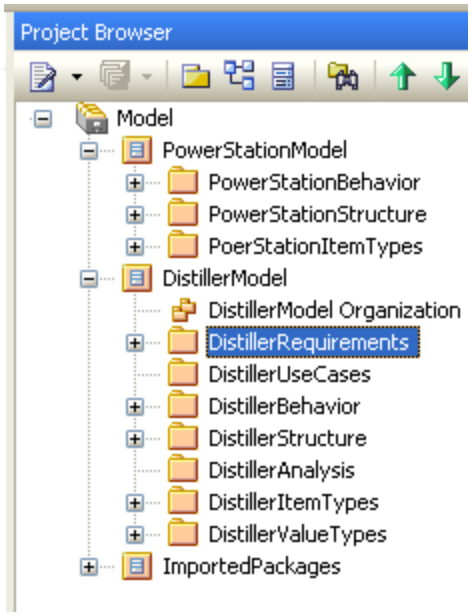
- No tool "fully" implements SysML
- Clearly, each tool has strengths & weaknesses
  - Make sure tool is compatible with your method
- Other tools exist, but not evaluated
- RS(X) is tool I'm least familiar with

	Enterprise Architect ver 7.1	Magic Draw ver 15.1	Rhapsody ver 7.2	RS(X) ver 7.0.5 E+ SysML ver 2.0.5.1
Activity Modeling	full	full	limited	full
Structural Modeling	full	full	full	full
Item Flows	limited	full	full	limited
Ports/Interfaces	full	limited	full	full
Functional Allocation	yes	yes	yes	yes
Flow Allocation	none	yes	yes	yes
Parametrics	full	full	full	full
Code Gen/Animation	none	none	yes	yes
Requirements	full	full	full	full
Distiller Model Source	Steiner	Steiner	Lussier	Steiner
UML4SysML 2.1	most	all	most	most

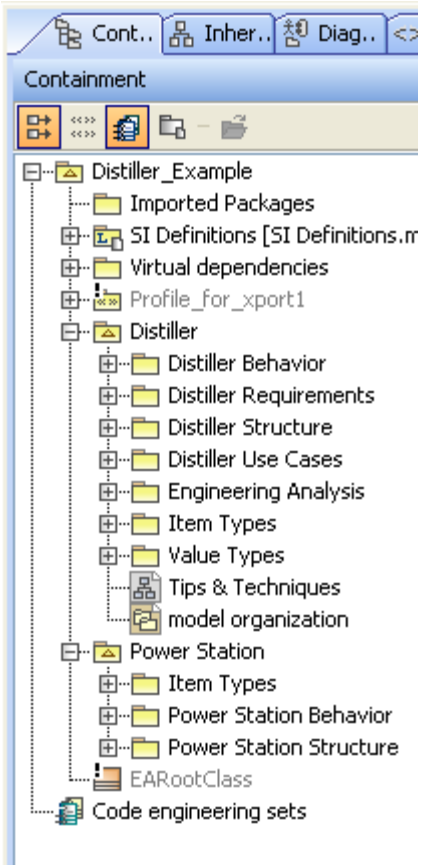
Distiller Model Organization

Raytheon
Integrated Defense Systems

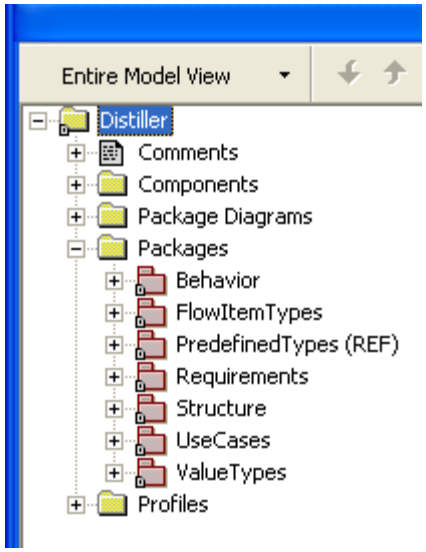
Enterprise Architect Browser



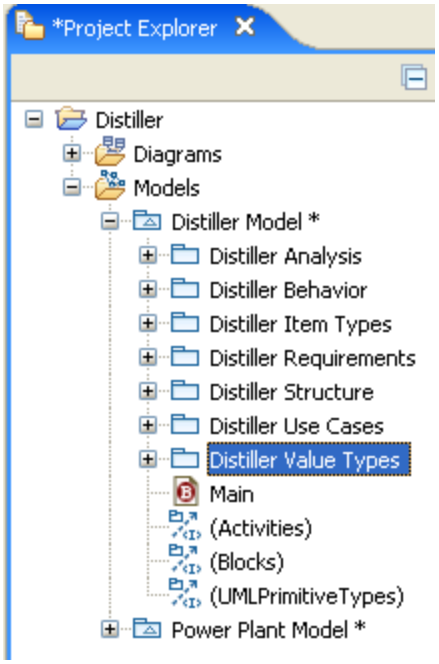
MagicDraw Browser



Rhapsody Browser

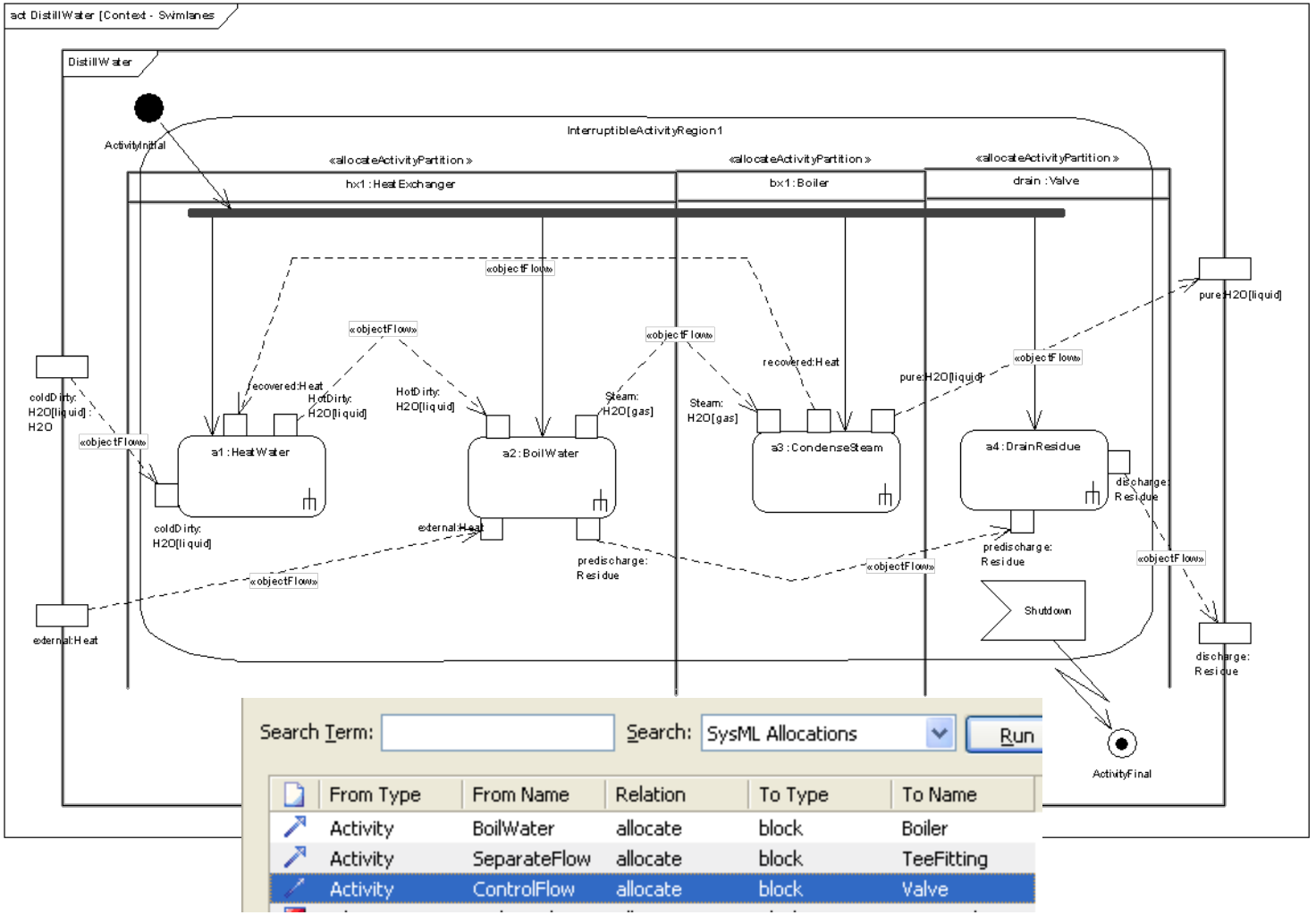


RS(X) Browser



EA Functional Allocation

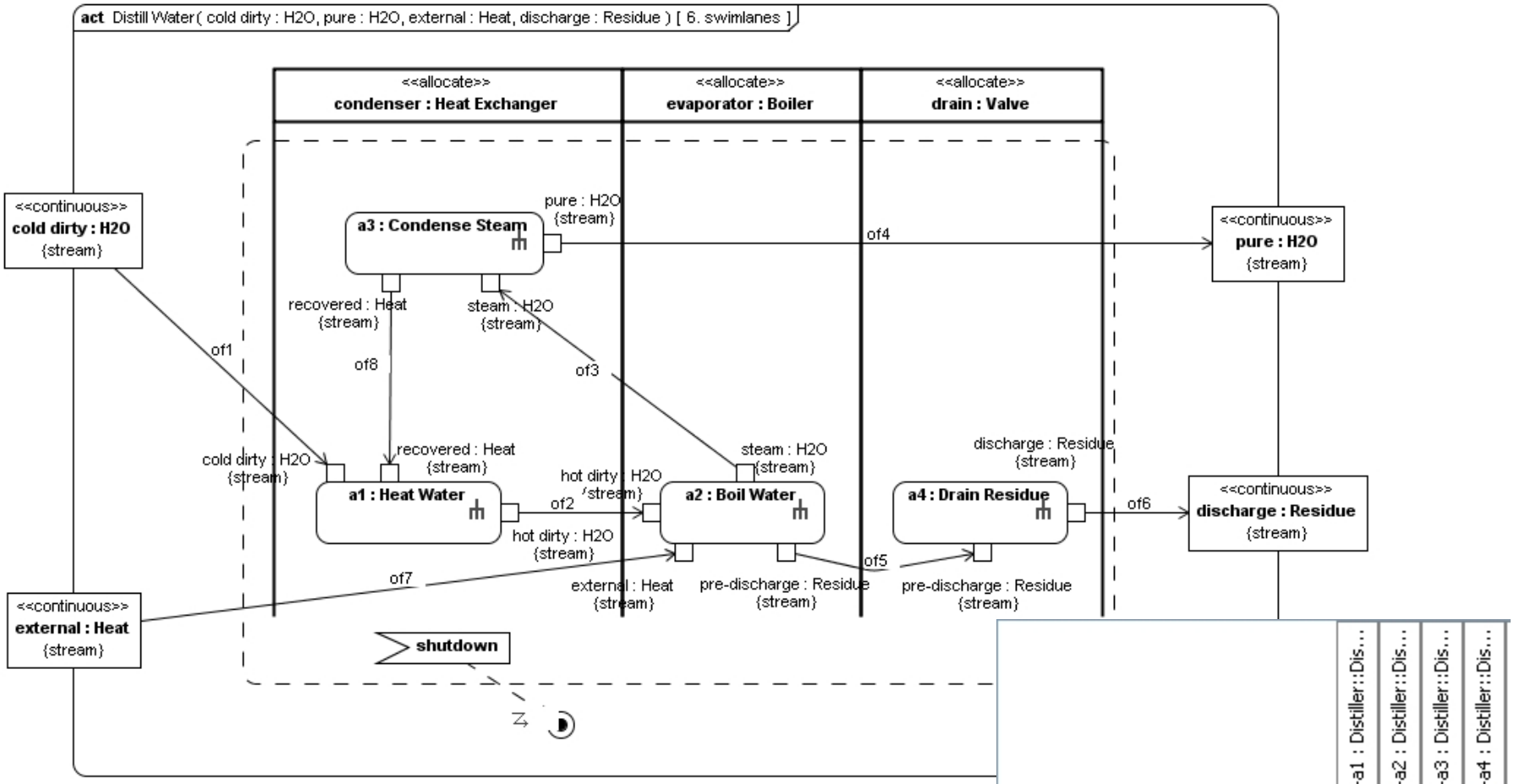
Raytheon
Integrated Defense Systems

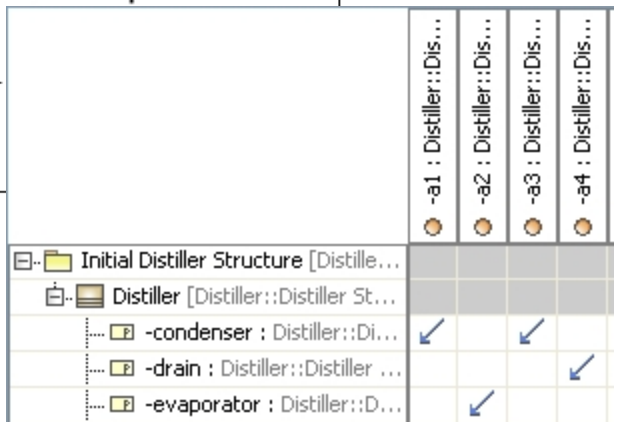


- Allocate activity partitions work well, allocation tables are fast & easy
- Flow allocation not possible (object flow to item flow)

Magic Draw Functional Allocation

Raytheon
Integrated Defense Systems

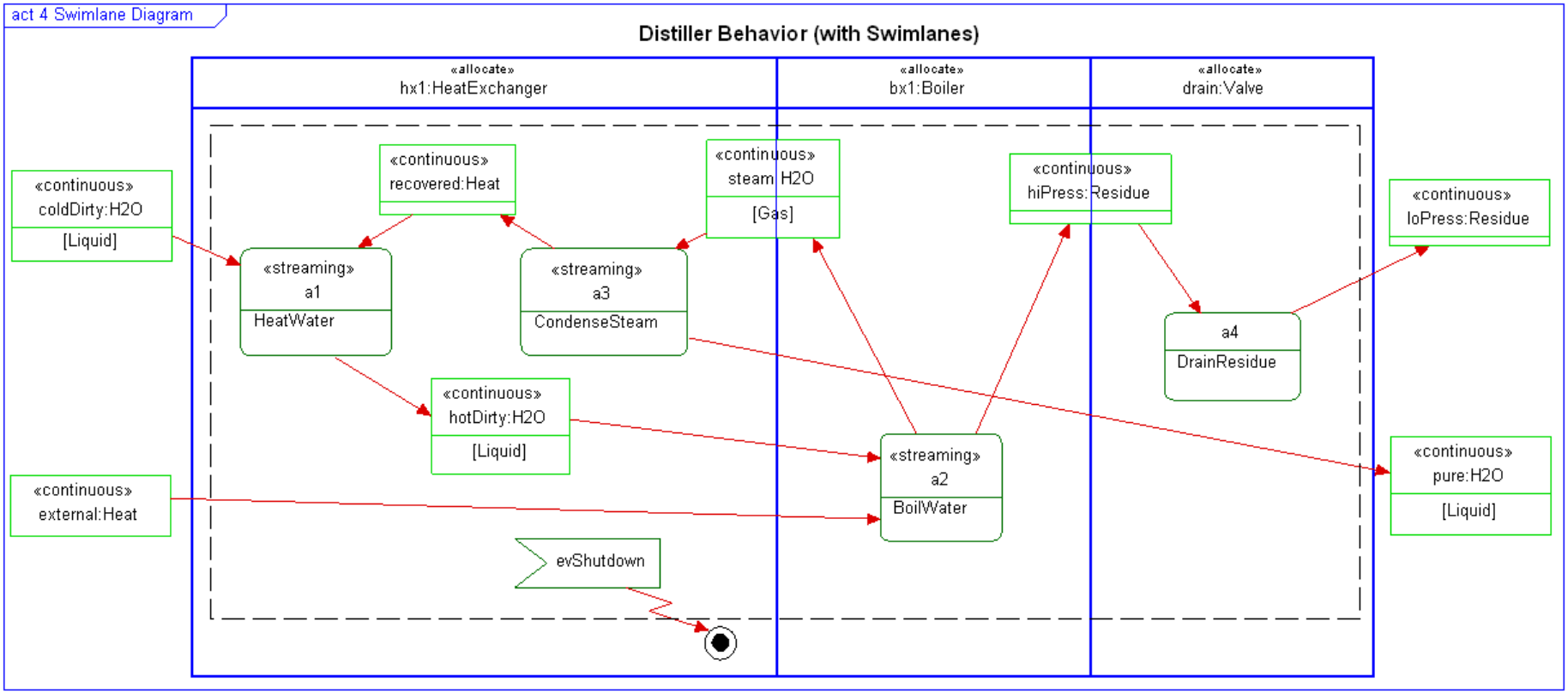




- Allocate activity partitions work
- Flow allocation works
- Flexible tabular view

Rhapsody Functional Allocation

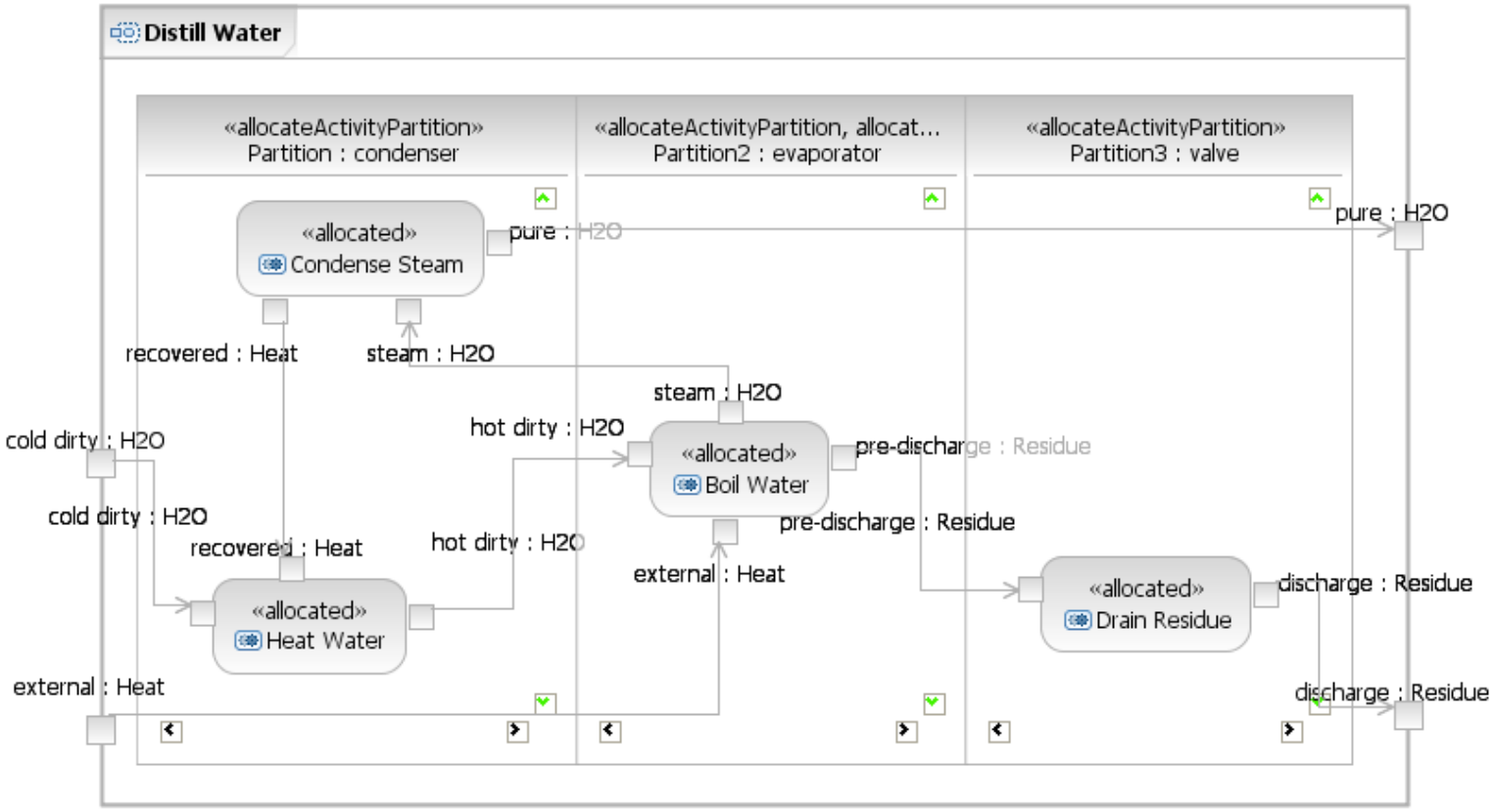
Raytheon
Integrated Defense Systems



- Action nodes do not invoke activities (no activity hierarchy)
- No activity parameter nodes (on diagram frame, or otherwise)
- Action pin notation is awkward, pins not reused when action referenced
- Can't distinguish control flow from object flow
- Tabular view & reports of allocation are available

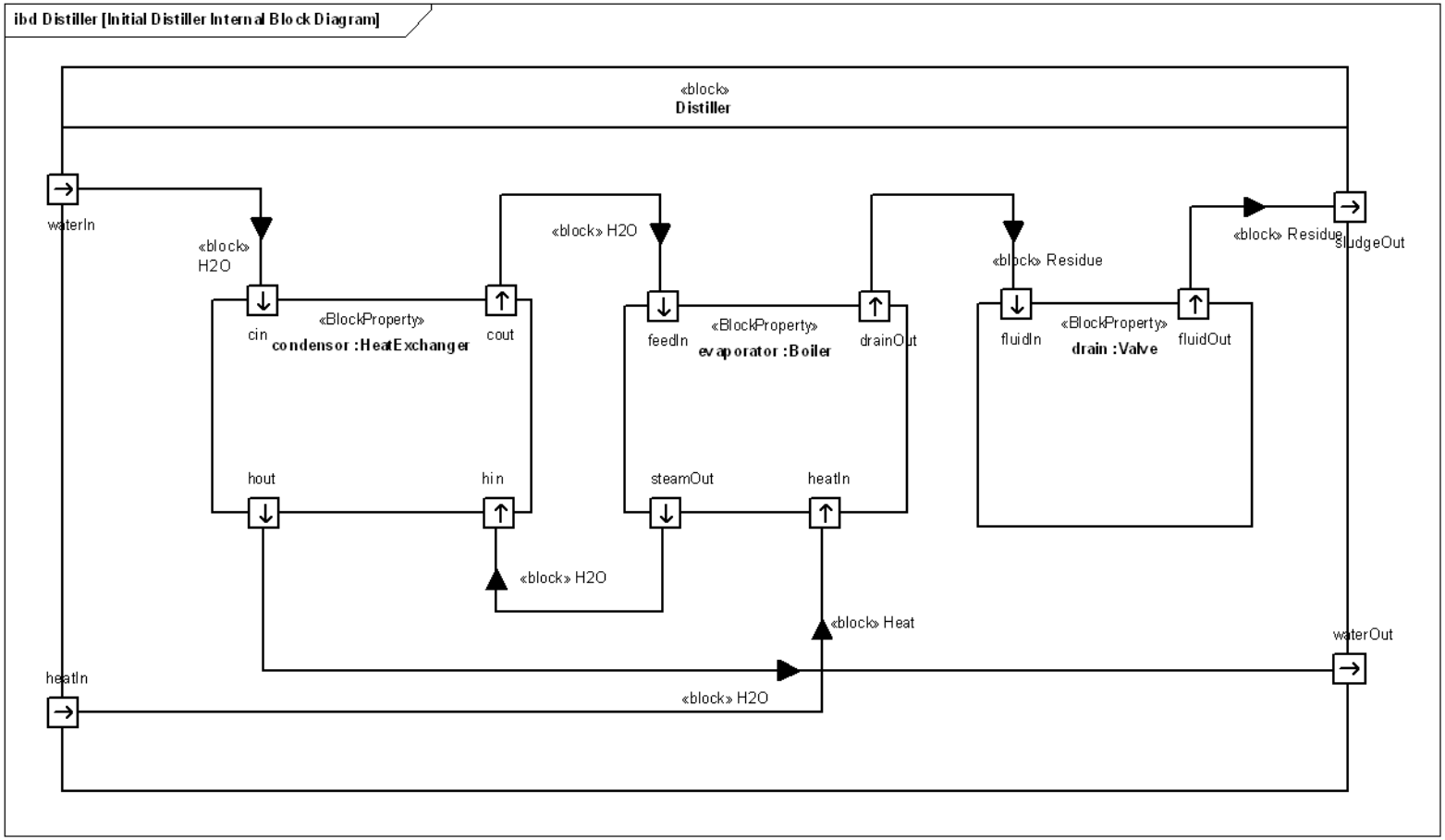
RS(X)/E+ Functional Allocation

Raytheon
Integrated Defense Systems



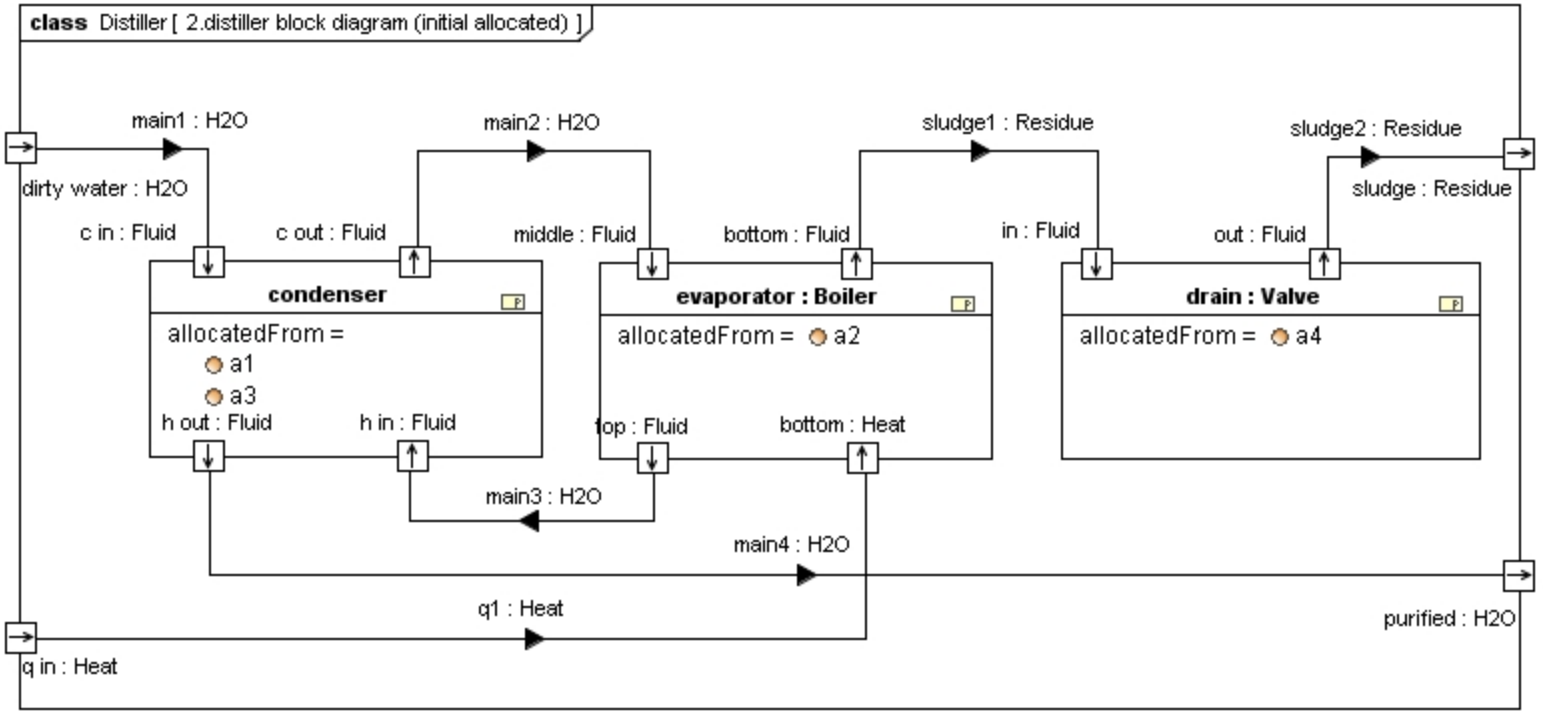
- Non-standard diagram frame/label
- No unique action names (must be same name as activity), but allocation is unique
- Allocation partitions work (automatically create allocation relationships) to blocks or parts.

EA ibd/ItemFlow



- Allocation works, but compartments not supported
- Can't access value properties of item properties (e.g. temp of water into Heat Exchanger) -> can't do parametric analysis of distiller example.

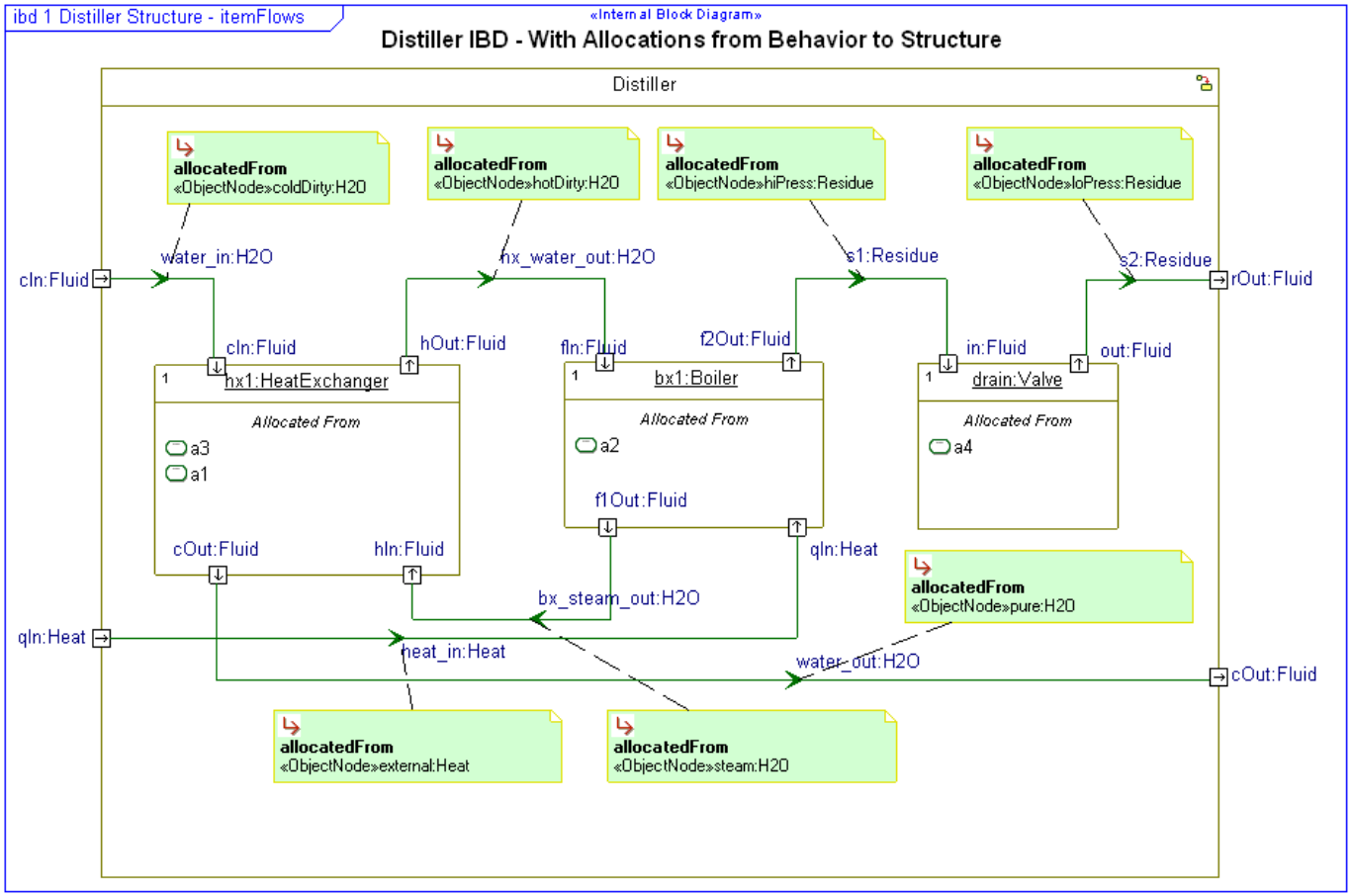
MD ibd/ItemFlow



- Diagram frame uses incorrect nomenclature
- Allocation compartment incorrect format
- DOES allow full access to item properties

Rhapsody ibd/ItemFlow

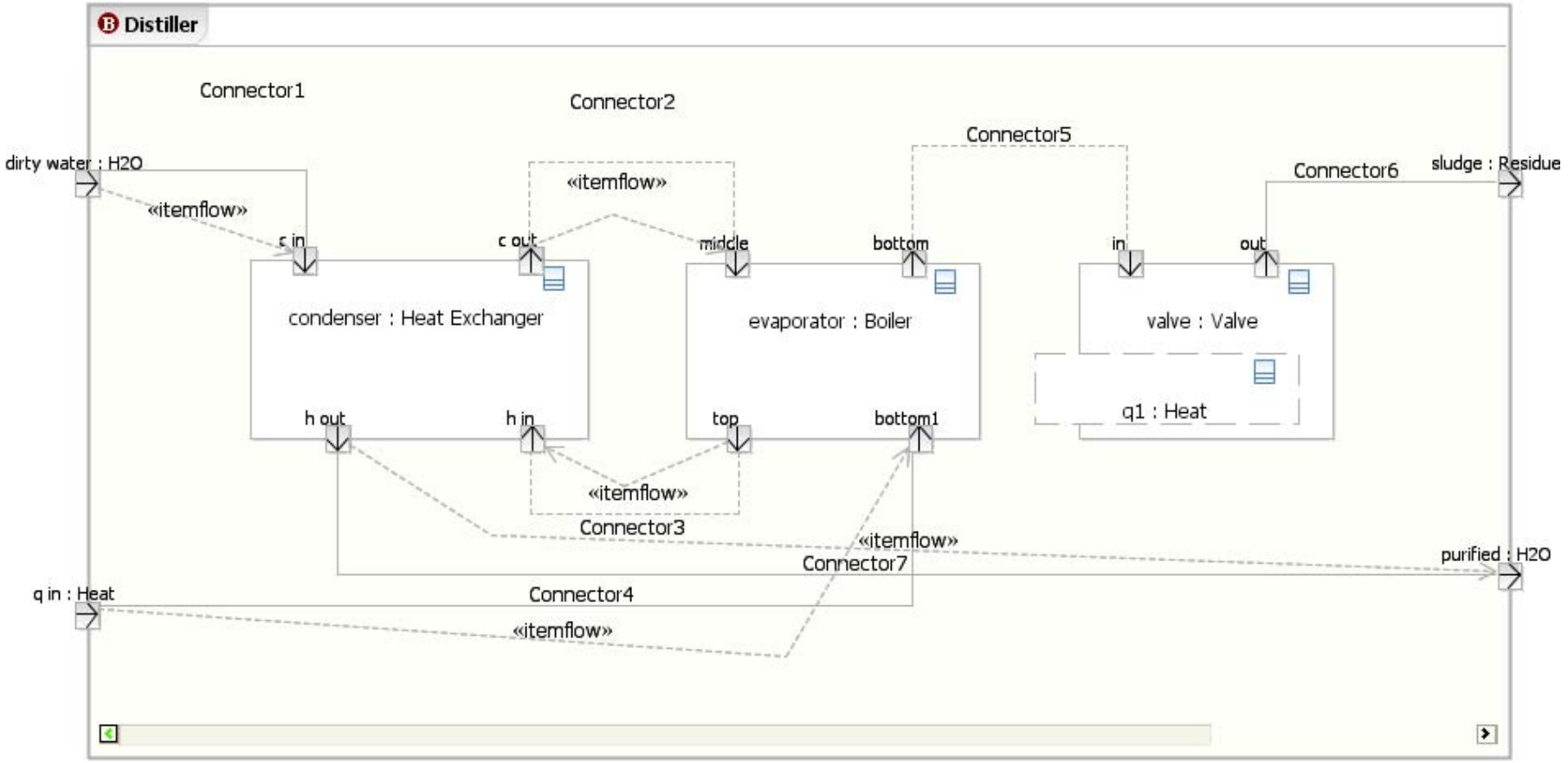
Raytheon
Integrated Defense Systems



- Item flows and item properties fully allocable
  - Item flows look weird, but work fine
  - ObjectFlows can't be allocated, but ObjectNodes can.
- Full allocation compartments & callouts

RS(X)/E+ ibd/ItemFlow

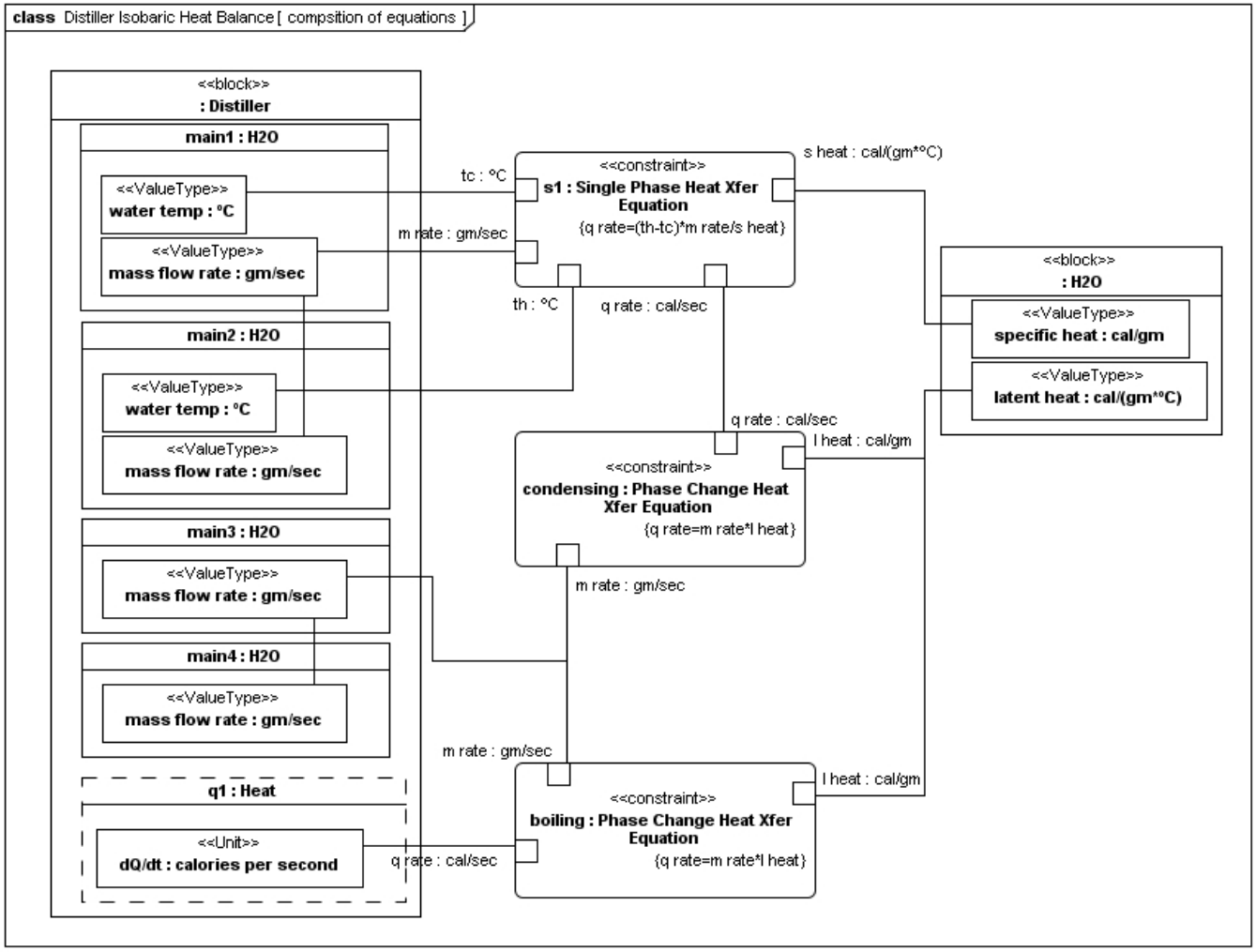
Raytheon
Integrated Defense Systems



- ItemFlows incorporated in RSD 7.0.5/E+ 2.0.5.1, but
  - no icon or name/ItemProperty on diagram, ItemFlow not associated with Connector
- Non-standard diagram frame/label
- Allows Allocation of ObjectFlow to ItemProperty, but not to ItemFlow
  - no allocation compartment/callouts on parts

MagicDraw Parametric Diagram

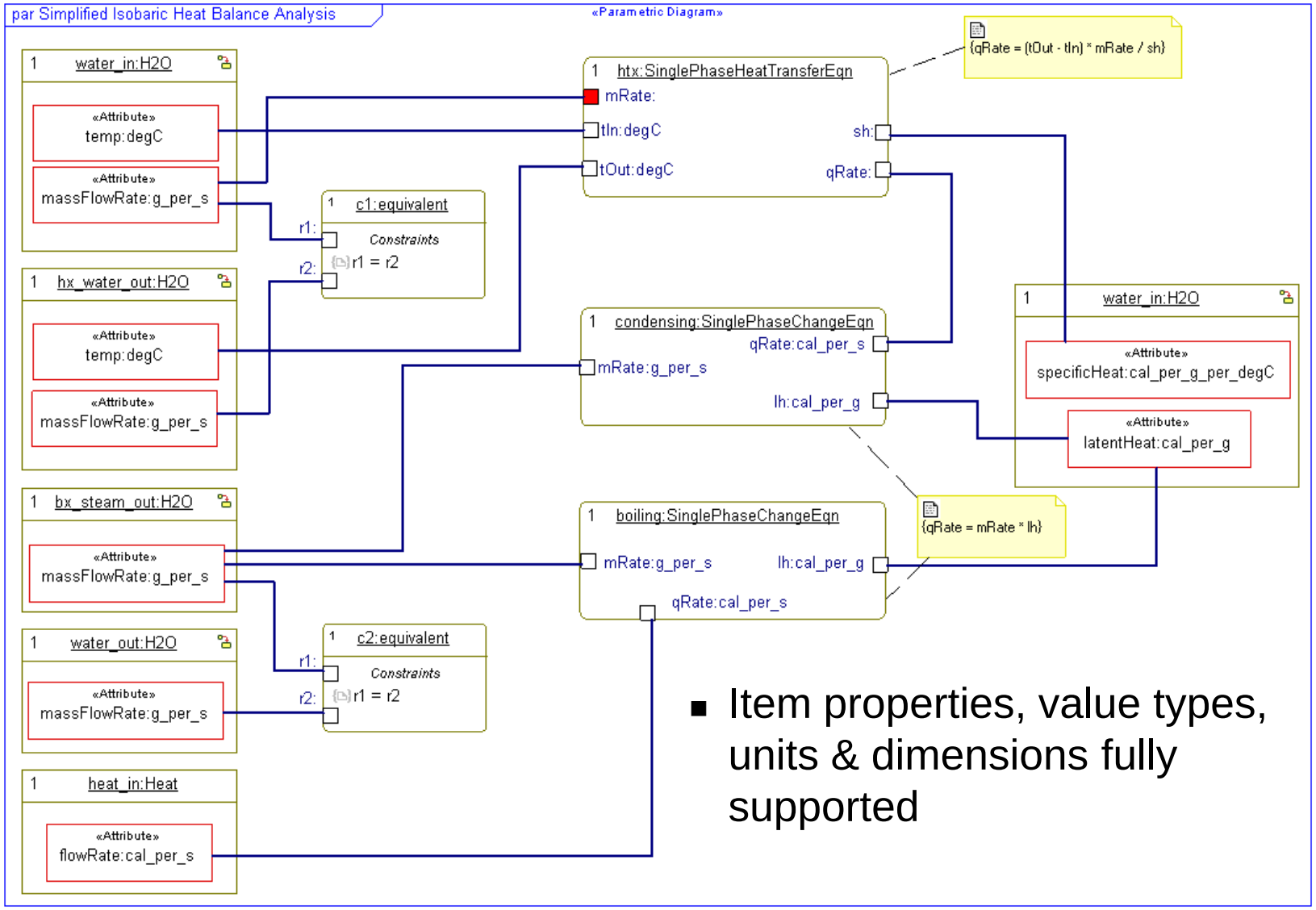
Raytheon
Integrated Defense Systems



- Item properties, value types, units and dimensions fully supported

Rhapsody Parametric Diagram

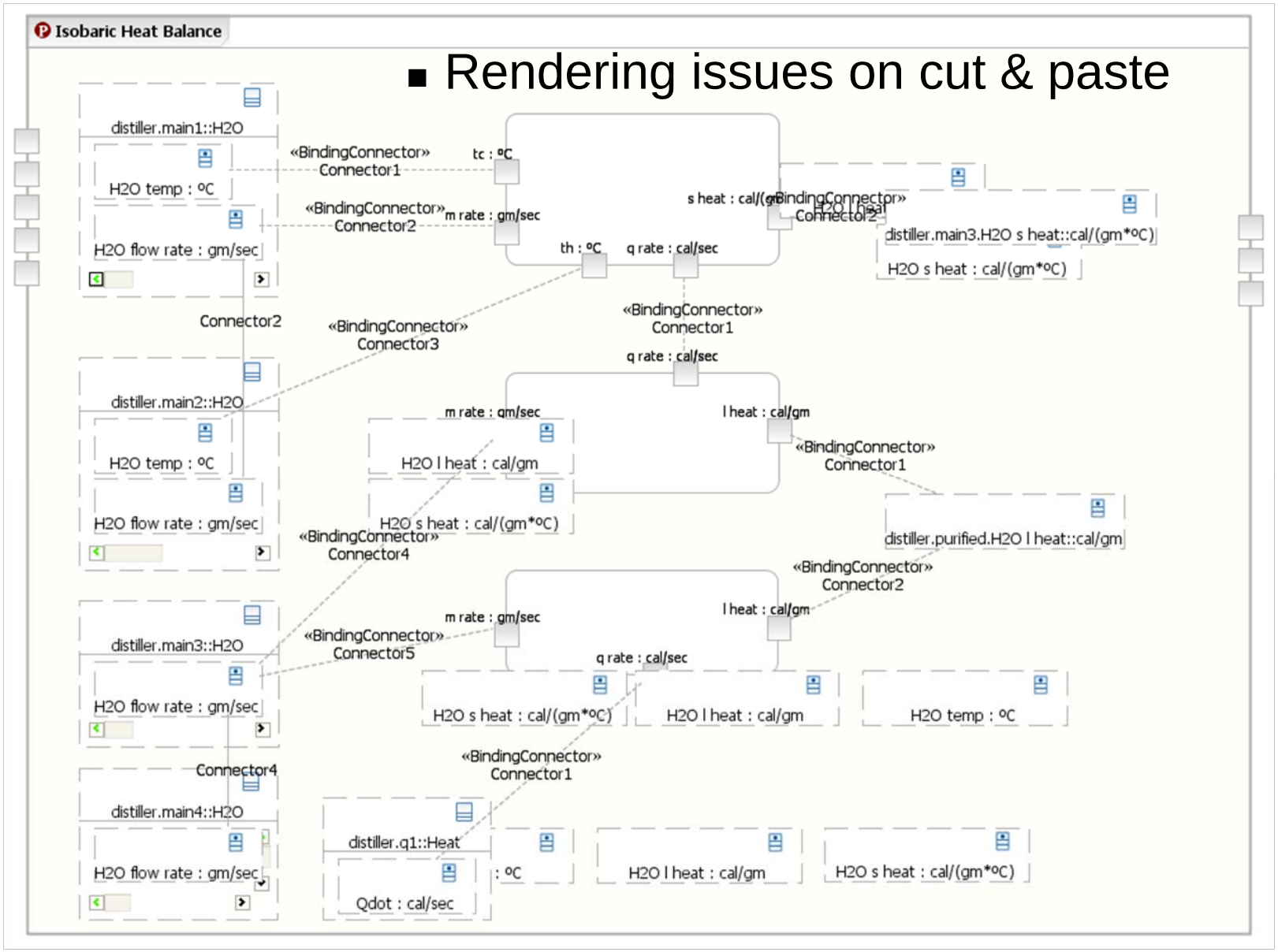
Raytheon
Integrated Defense Systems



- Item properties, value types, units & dimensions fully supported

EA & RS(X)/E+ Parametrics

Raytheon
Integrated Defense Systems



- Rendering issues on cut & paste

EA & RS(X)/E+ Parametrics

Raytheon
Integrated Defense Systems

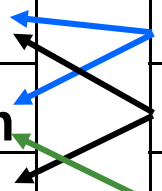
- Both support units, dimensions, value types, constraint blocks, and parametric diagrams
- Neither support value properties of item properties on item flows
  - Item Flows incorporated in RSD 7.0.5/E+ 2.0.5.1

SysML Diagrams– a Method for Model Integration

Raytheon
Integrated Defense Systems

- 3 separate hierarchies of Structure, Behavior, and Data
  - Usage (internal connection) is documented with separate diagrams
- These 3 hierarchies maintained at Operational and System level

	Hierarchy	Usage		Cross-Connect
Structure	**bdd**	**ibd**		**act** (swimlane), **seq** (lifeline, op)
Behavior	**bdd**	**act, stm**		**ibd** (itemFlow), **seq** (msgType)
Data	**bdd**	(none)		**act** (objFlow), **seq** (msg,op), **stm**

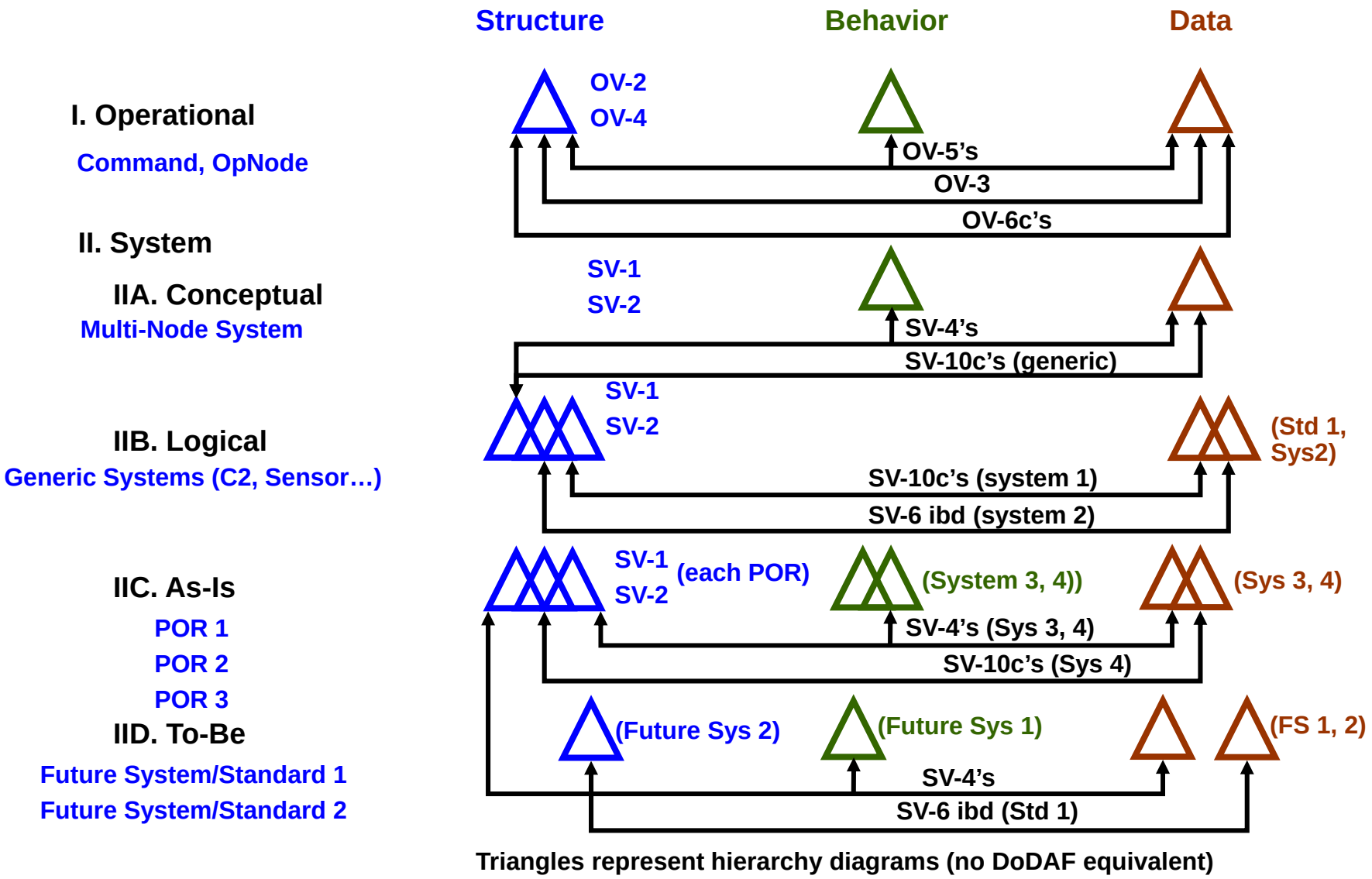


bdd = Block Definition Diagram (no DoDAF)
ibd = Internal Block Diagram (OV-2, SV-1, SV-2)

act = Activity Diagram (OV-5, SV-4)
seq = Sequence Diagram (OV-6c, SV-10c)
stm = State Machine Diagram (OV-6b, SV-10b)

DoDAF Views Horizontally Cross-Connecting a Complex SoS Model

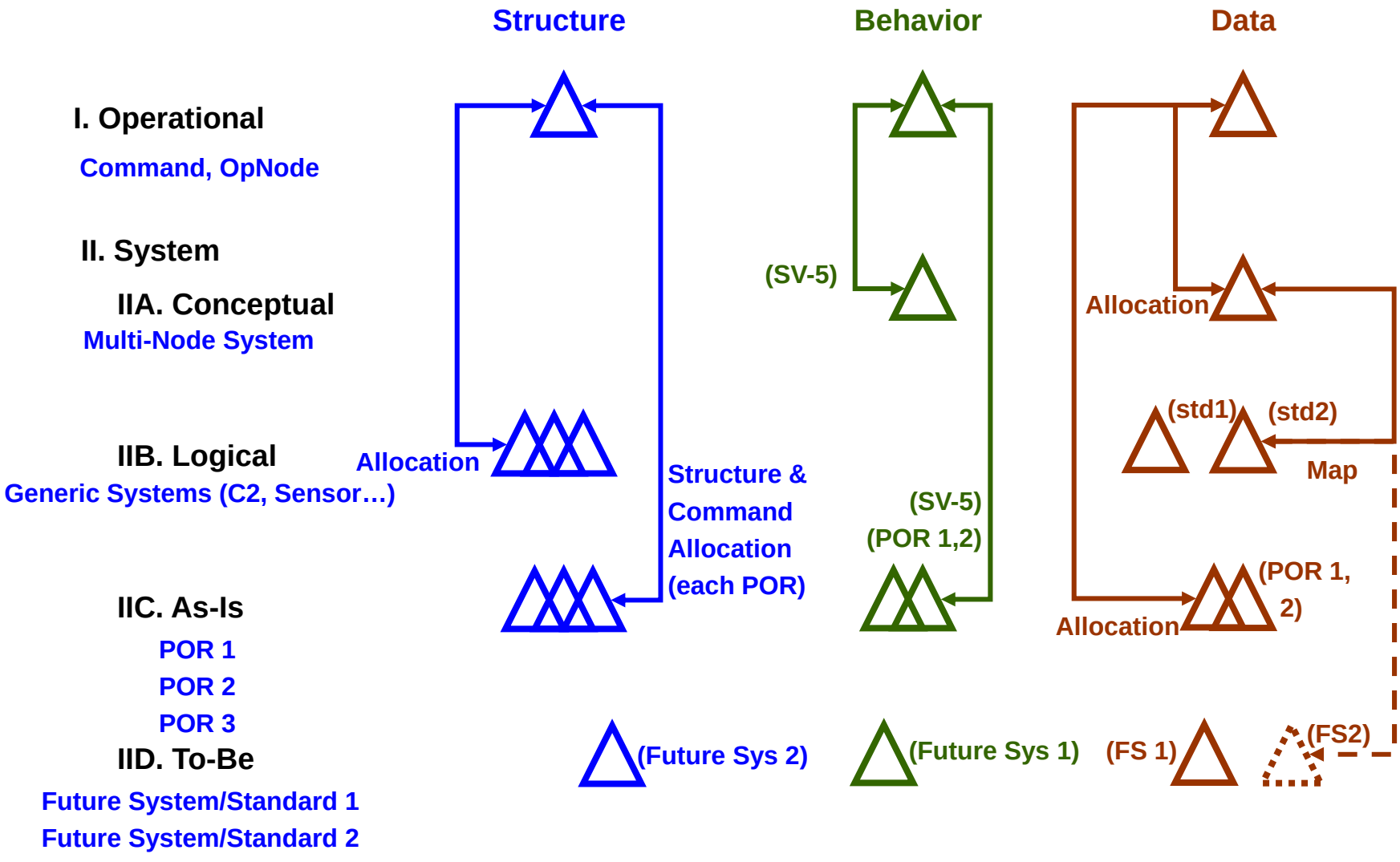
Raytheon
Integrated Defense Systems



Triangles represent hierarchy diagrams (no DoDAF equivalent)

Allocation Vertically Cross-Connecting a Complex SoS Model

Raytheon
Integrated Defense Systems



Triangles represent hierarchy diagrams (no DoDAF equivalent)