2020 Annual INCOSE international workshop
Torrance, CA, USA
January 25 - 28, 2020

Production and Logistics Modeling Challenge Team

Timothy Sprock[a], Leon McGinnis[b], Conrad Bock[a] , George Thiers[c]
[a] National Institute of Standards and Technology, [b] Georgia Tech, [c] MBSE Tools, Inc.

www.incose.org/IW2020

Audience Exercise: Stand Up!

- Now, sit down if you are involved in designing/developing:
  - Aerospace systems
  - Ground-based vehicle systems
  - Naval systems
  - Communication systems
  - Medical device systems
  - Anything that is not a production or logistics system
- Who’s left?

Thought Experiment

- New program: Falcon 2035
  - Program cost of $\$5 \times 10^9$
  - Revenue is $\$350 \times 10^6$ per unit
  - => 1428 units to breakeven
  - You have great confidence in your engineering estimates of performance

Thought Experiment

- New p
  - Prog
  - Rev
  - => 1
  - You ineering esti

Now suppose

- Estimate of facility cost was $2 x 10^9, is actually $2.4 x 10^9
- Estimated ramp of 12, 32, 60, 60 … per year is actually 6, 12, 32, 50, 50 ….per year
- Original time to breakeven estimated as 25 years
- New time to breakeven is 30 years

Now suppose

- Estimate , is actually $
- Estimate per year is actually ear
- Original t d as 25 years
- New time

“How could that happen?” You say

- It has and is happening
- In part because production and logistics system design is decades behind aerospace design
- Mission of this challenge team is to change that *(not limited to aerospace!)*

Why don't we just take what we already know about MBSE and apply it to production/logistics?

Because they are different domains!

Produced systems

- Semantic standards
- Well-defined requirements
- Continuous dynamics
- Minimal internal variability
- Tight integration
- Response very predictable
- Safety factors
- Integrated analyses

Producing systems

- No semantic standards
- Ambiguous requirements
- Discrete dynamics
- Large internal variability
- Decoupling
- Response hard to predict
- Risk factors
- *Ad hoc* analyses

Because they are different domains

Produced systems

- Semantic standards
- Well-defined requirements
- Continuous
- Minimal i
- Tight integra
- Response very predictabl
- Safety factors
- Integrated analyses

What we can impact (now)

Producing systems

- No semantic standards
- Ambiguous requirements
- Discrete dynamics
- Large internal variability
- Decoupling
- Response hard to predict
- Risk factors
- *Ad hoc* analyses

So how do we fulfill our mission?

- Understand key success factors for MBE/MBSE in product domain
- Adapt/adopt strategies to duplicate those success factors for production/logistics
- Demonstrate actual successes

Success Factors in Produced Systems?

- Almost 50 years of effort to “standardize” the specification of the product—culminating in the ability to exchange designs between CAD systems ***(Reference models)***
- Similar efforts to integrate engineering analyses with CAD models specifying the product ***(Analysis integration)***
- Emergence of SysML, a platform for unifying different disciplines and subsystem models ***(Enabling platform)***
- Recognition of the potential payoff ***(Value proposition)***
- Resulting commitment of resources to accomplish transformation ***(Demonstrations)***

Challenge Team Purpose

Increase the availability of reference models, awareness of these models and methods, and successful use of ***MBSE to support design of production and logistics systems***.

- Design methodology (like RFLP)
- Specify product, process, resource + behavior, control, interactions
- Feasibility and cost

What has been our focus?

- Foundation—reference model, semantics
- Application modeling—best practices
- Analysis integration/automation

In the production and logistics systems domain!

Available today:

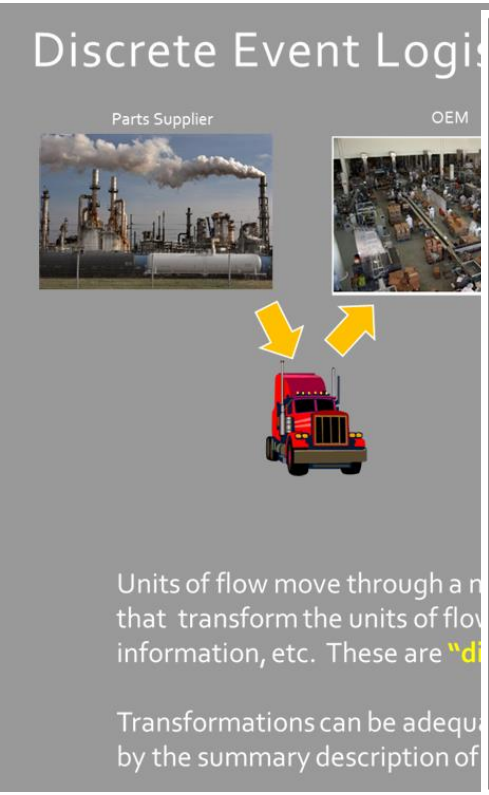
- “Foundations” document: fundamental concepts and abstractions ***(Reference model*** -> developers)
- Case: Aerospace composite production: product, process, resource (but not MH), behavior; examples of conforming analyses; 90 pp report plus MagicDraw SysML
- Case: Central Fill Pharmacy, product, process, resource (including MH), behavior, control; 75 pp report plus MagicDraw SysML

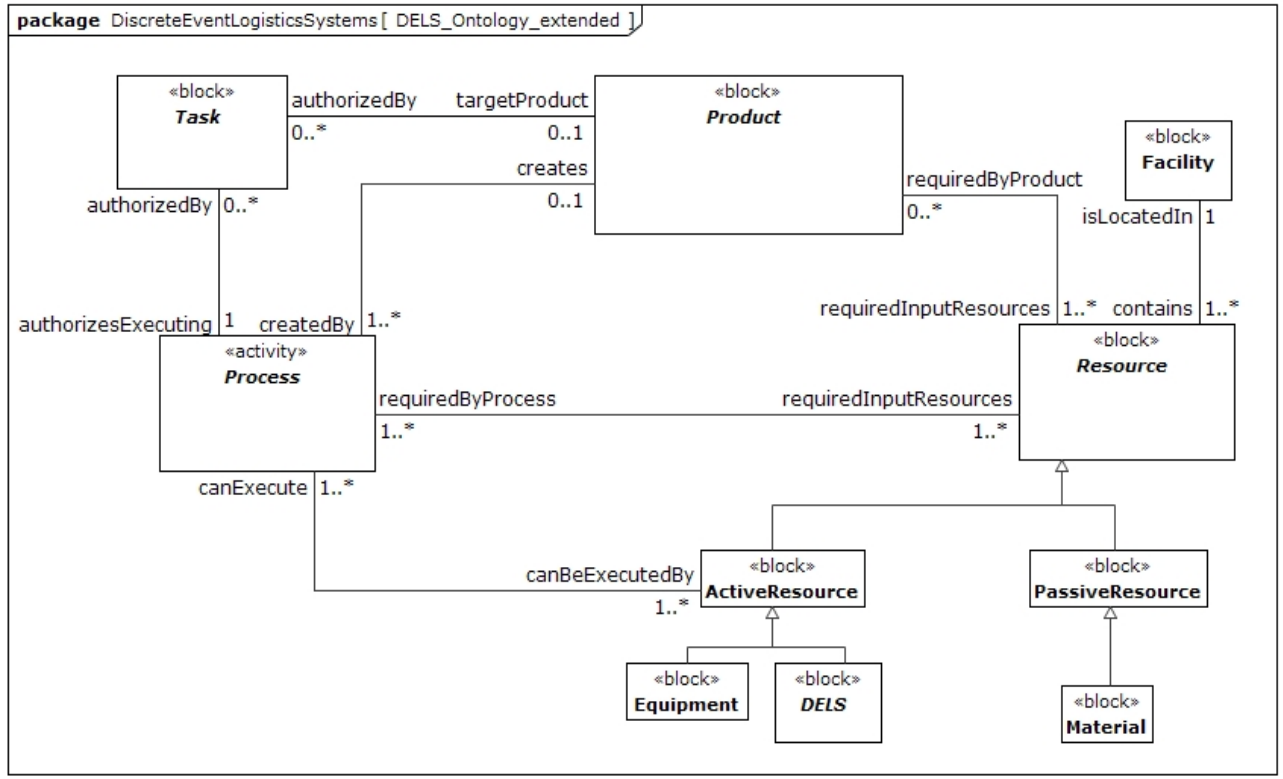
Preview the Tuesday working session

- DELS Reference Model

Preview the Tuesday working session

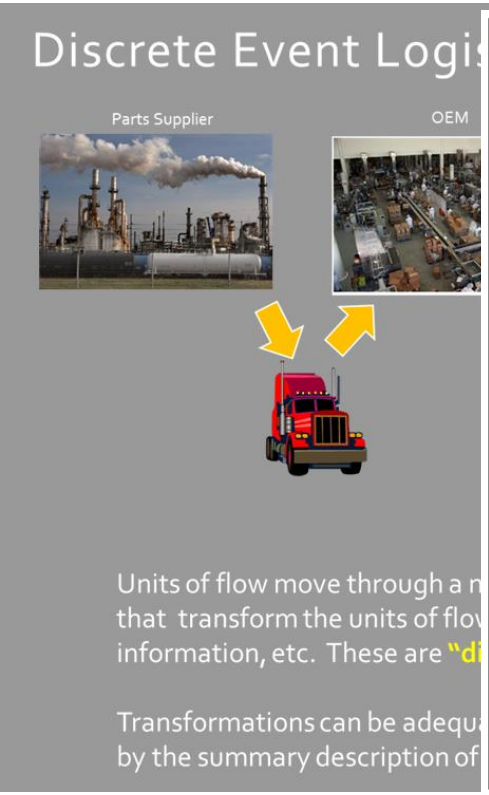
- DELS Reference Model

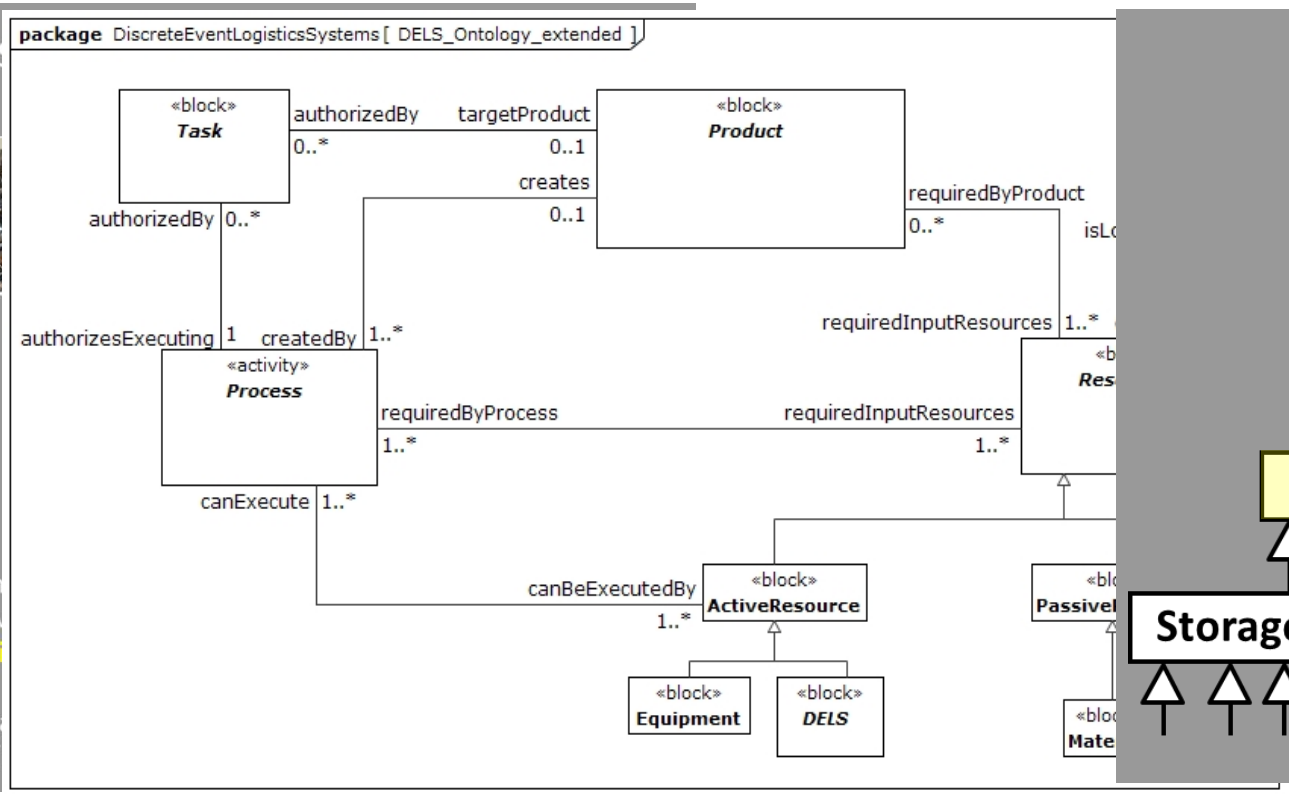


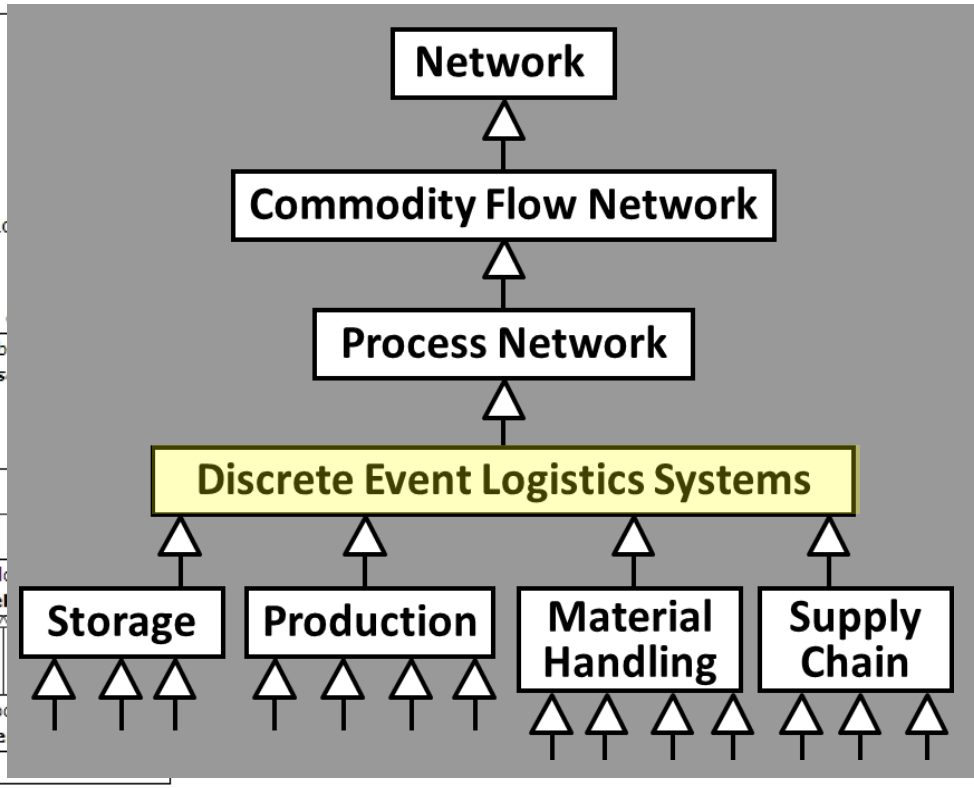


Preview the Tuesday working session

- DELS Reference Model

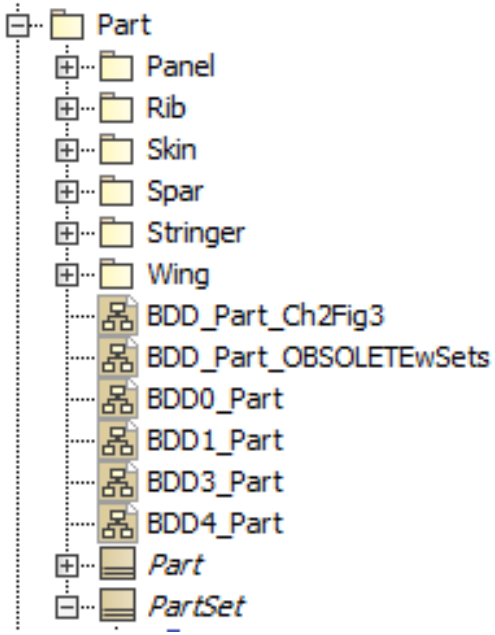


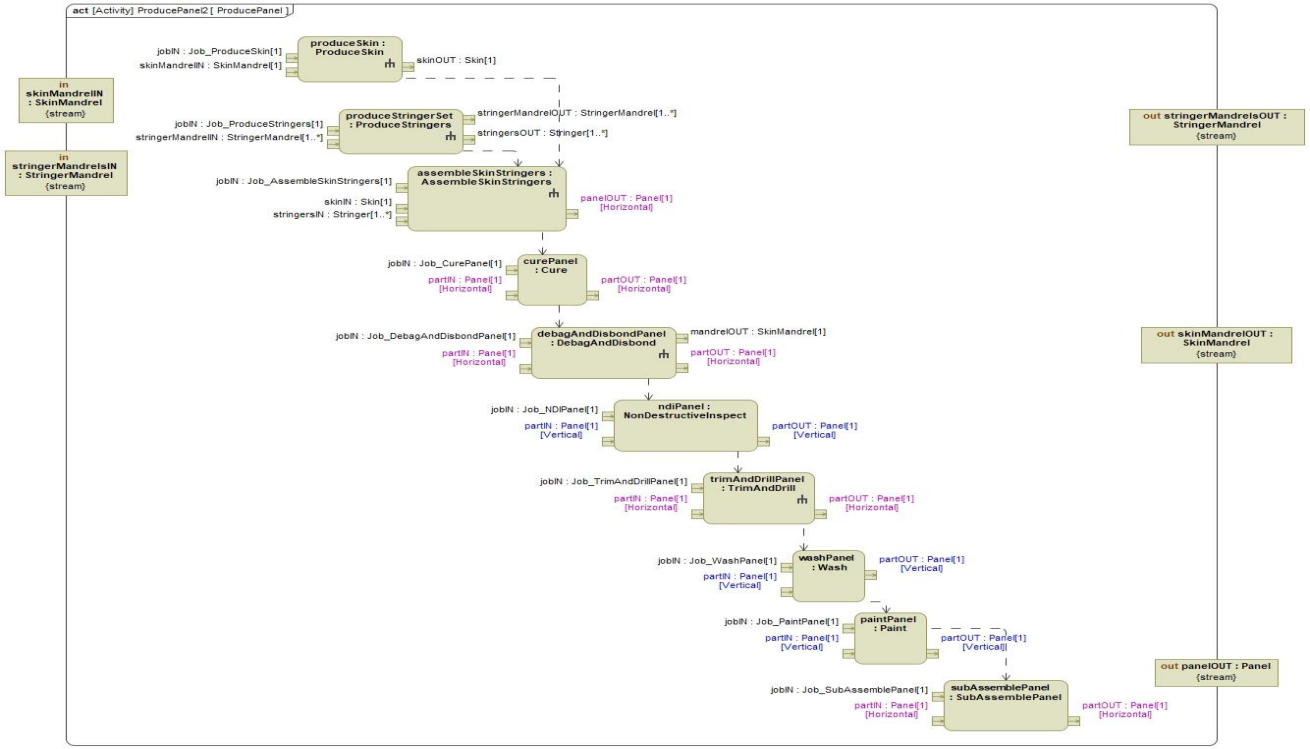


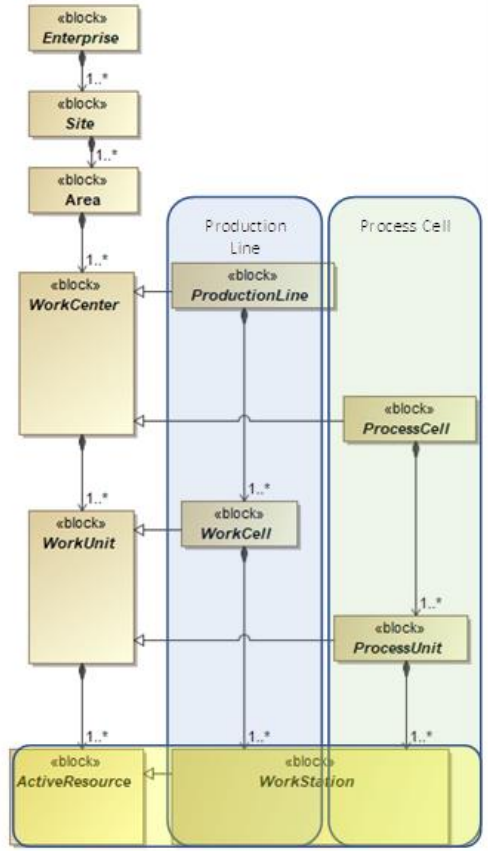


Preview the Tuesday working session

- Composite part manufacturing

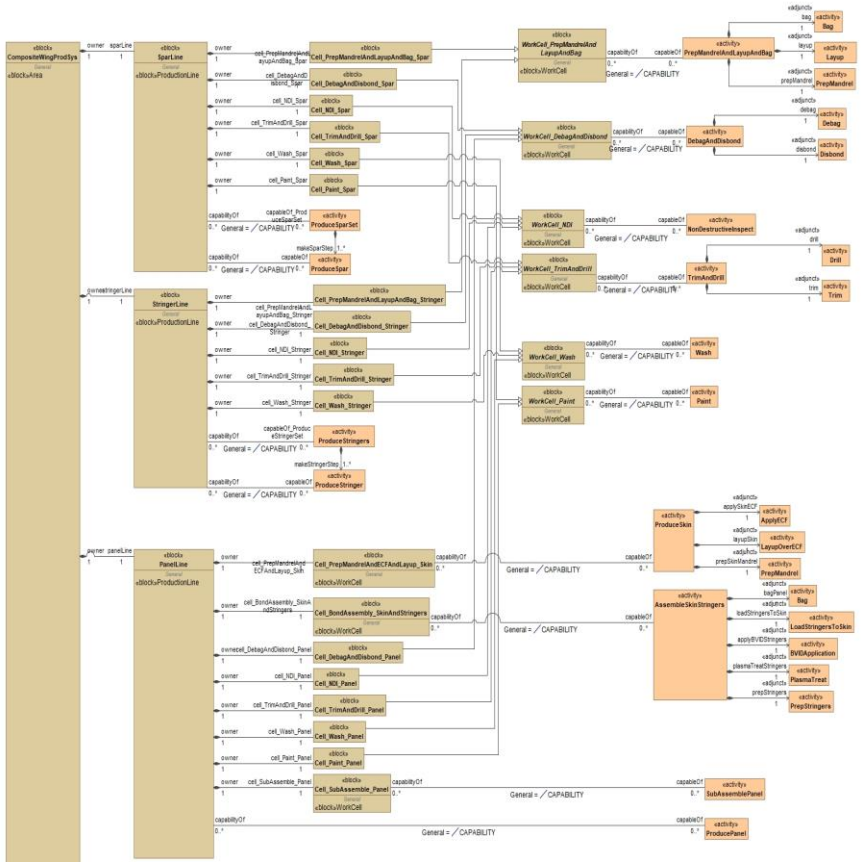






Preview the Tuesday working session

- Composite part manufacturing



#	Name	Node	Type
1	ApplyECF	partOUT : Resource::Passive::Part::Part mandrelIN : Resource::Passive::Fixture::LayupMandrel::LayupMandrel	*Part* *LayupMandrel*
2	AssembleSkinStringers	skinIN : Resource::Passive::Part::Skin::Skin stringerSetIN : Resource::Passive::Part::Stringer::Stringer panelOUT : Resource::Passive::Part::Panel::Panel loadStringersToSkin:LoadStringersToSkin applyBVIDStringers:BVIDApplication plasmaTreatStringers:PlasmaTreat prepStringers:PrepStringers bagPanel:Bag	*Skin* *Stringer* *Panel*
3	Bag	partIN : Resource::Passive::Part::Part partOUT : Resource::Passive::Part::Part	*Part*
4	BVIDApplication	partIN : Resource::Passive::Part::Part partOUT : Resource::Passive::Part::Part	*Part*
5	Cure		
6	CureBatch	batchIn recipeIn	
7	Debag	partIN : Resource::Passive::Part::Part partOUT : Resource::Passive::Part::Part	*Part*
8	DebagAndDisbond	debag:Debag disbond:Disbond partIN : Resource::Passive::Part::Part partOUT : Resource::Passive::Part::Part mandrelOUT : Resource::Passive::Fixture::LayupMandrel::LayupMandrel	*Part* *LayupMandrel*
9	Disbond	partIN : Resource::Passive::Part::Part partOUT : Resource::Passive::Part::Part mandrelOUT : Resource::Passive::Fixture::LayupMandrel::LayupMandrel	*Part* *LayupMandrel*
10	Drill	partIN : Resource::Passive::Part::Part partOUT : Resource::Passive::Part::Part	*Part*
11	Layup	partOUT : Resource::Passive::Part::Part mandrelIN : Resource::Passive::Fixture::LayupMandrel::LayupMandrel	*Part* *LayupMandrel*
12	LayupOverECF	partOUT : Resource::Passive::Part::Part partIN : Resource::Passive::Part::Part	*Part*
13	LoadRecipe	recipe	
14	LoadStringersToSkin	skinIN : Resource::Passive::Part::Skin::Skin stringerSetIN : Resource::Passive::Part::Stringer::StringerSet panelOUT : Resource::Passive::Part::Panel::Panel	*Skin* *StringerSet* *Panel*

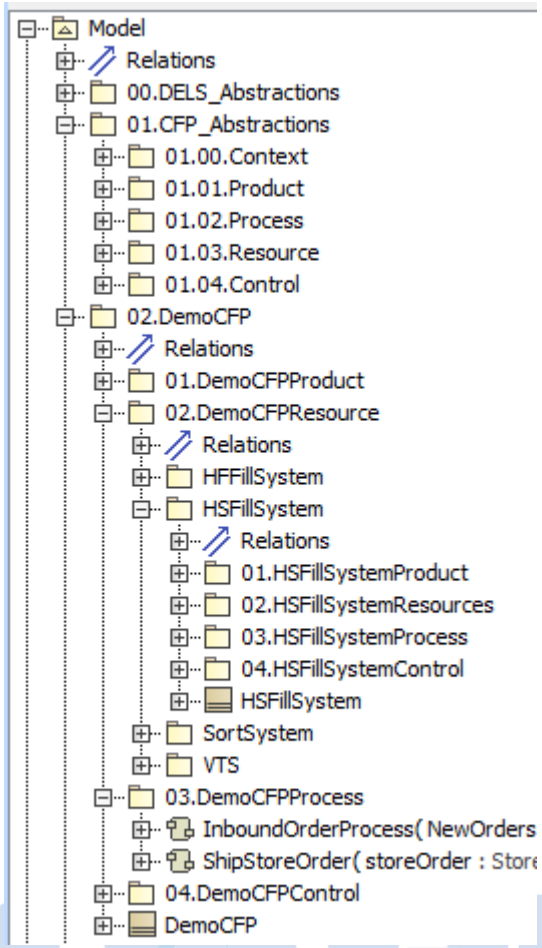
	Part Type	WP	SS	LS	S
Req'd TH		0.067	0.100	0.067	0.
Iteration 1	Mandrels	1	6	4	
	TH	0.043	0.114	0.074	0.
Iteration 2	Mandrels	2	6	4	
	TH	0.059	0.100	0.064	0.
Iteration 3	Mandrels	3	6	5	
	TH	0.070	0.090	0.071	0.
Iteration 4	Mandrels	3	7	5	
	TH	0.063	0.097	0.066	0.
Iteration 5	Mandrels	4	8	6	
	TH	0.068	0.098	0.070	0.
Iteration 6	Mandrels	4	9	6	
	TH	0.063	0.103	0.066	0.
Iteration 7	Mandrels	5	9	7	
	TH	0.069	0.095	0.070	0.
Iteration 8	Mandrels	5	10	7	
	TH	0.064	0.099	0.067	0.

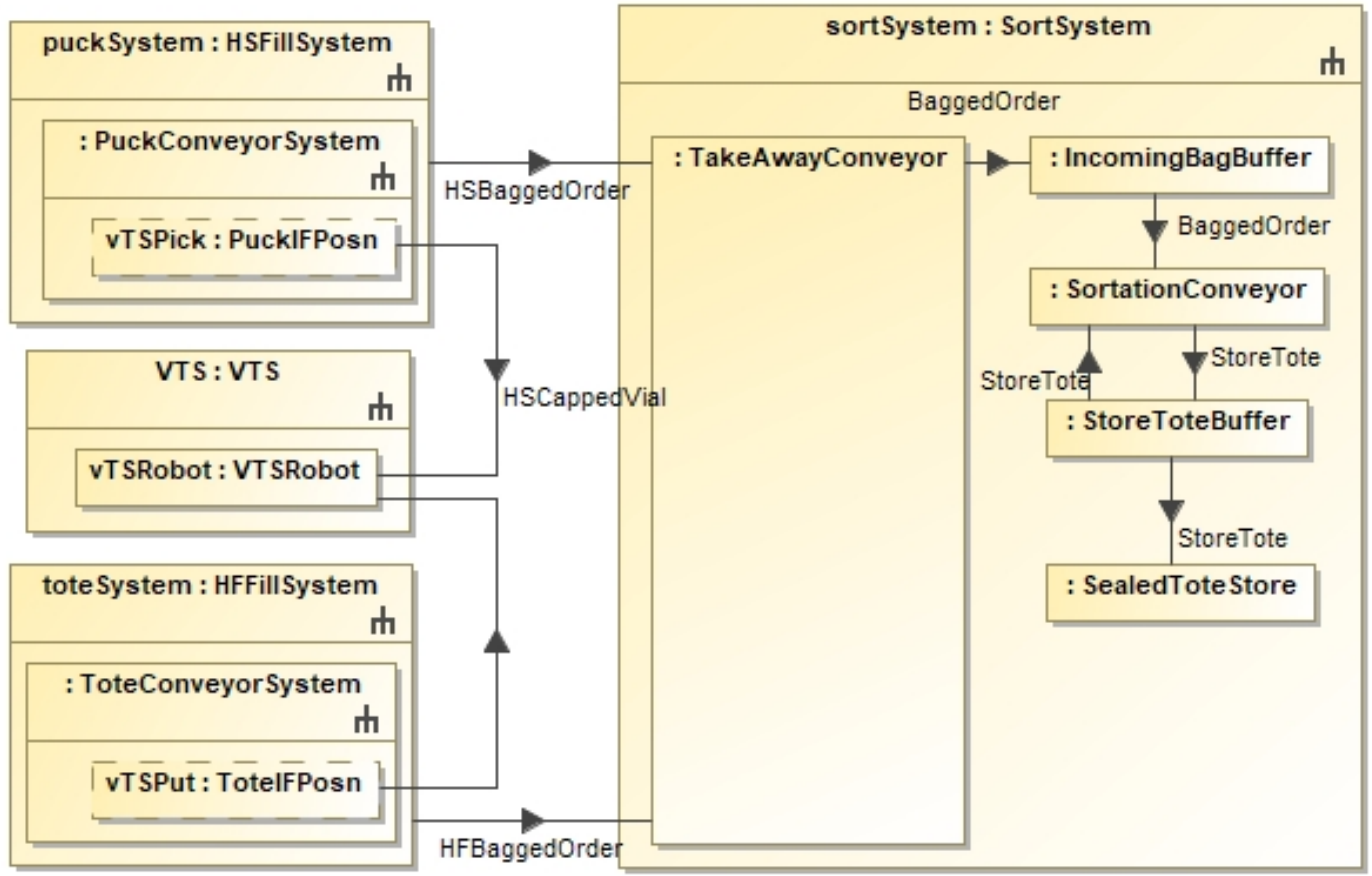
Preview the Tuesday working session

- Central-fill pharmacy case and model

Preview the Tuesday working session

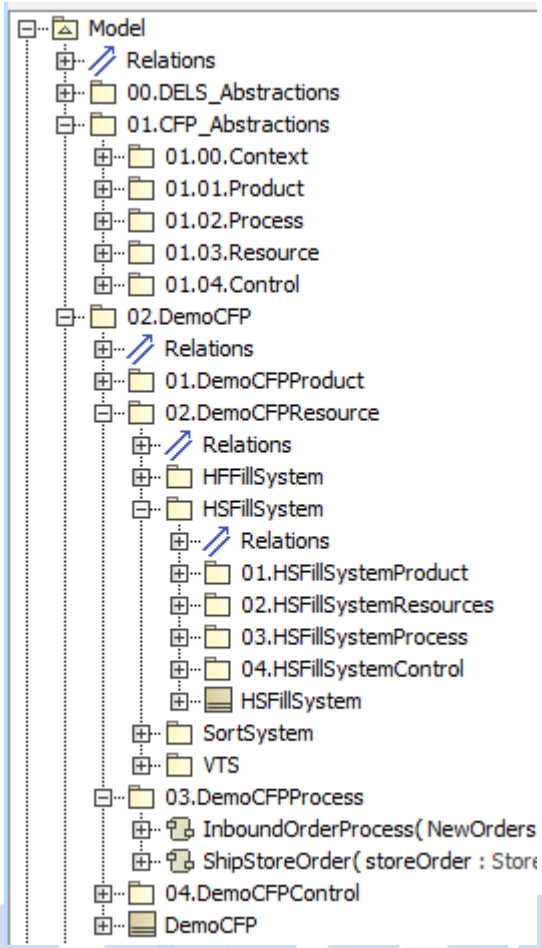
- Central-fill pharmacy case and model

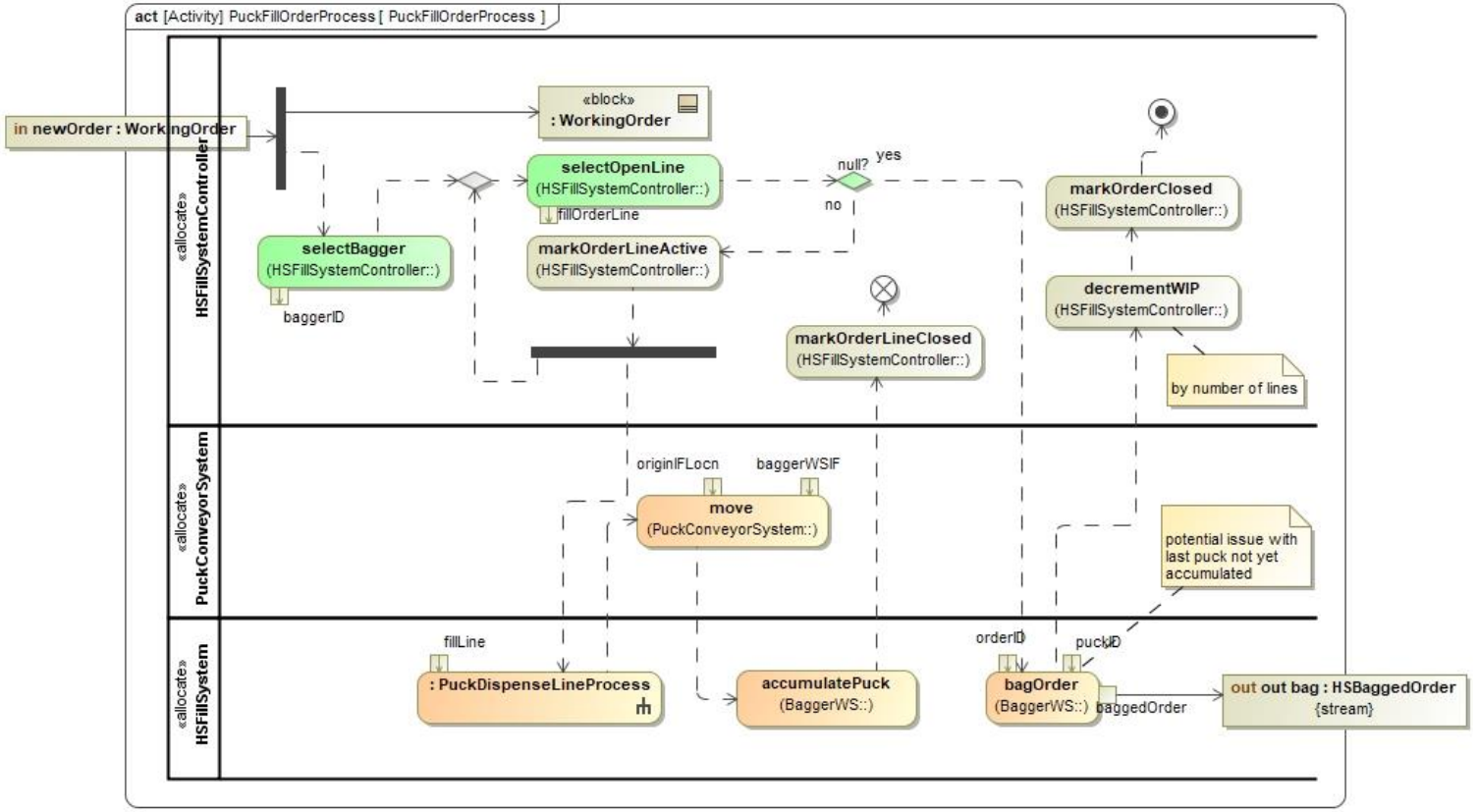




Preview the Tuesday working session

- Central-fill pharmacy case and model



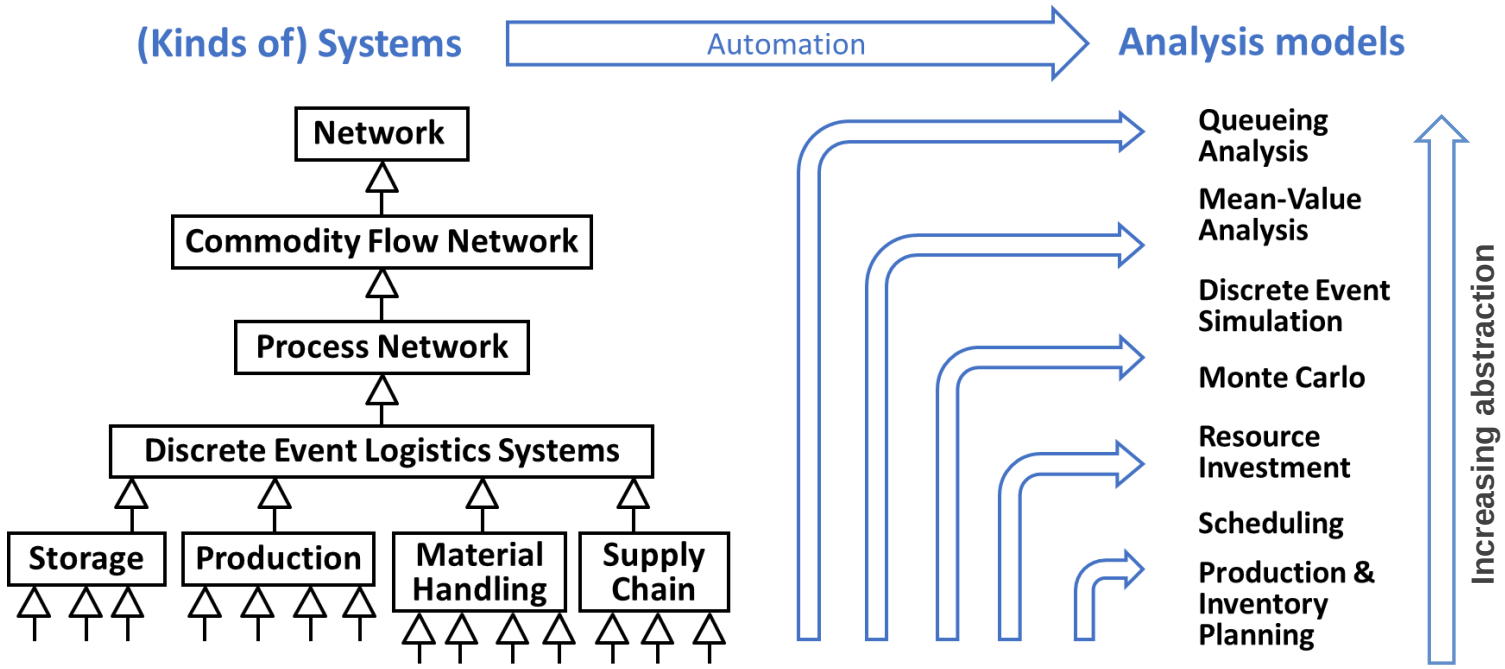


In process:

- “Playbook”: guidelines for creating production system models, using SysML, conforming to “foundations” document
- Analysis integration: automating access to network-centric OR models for answering key questions about performance
- Additional case studies: semiconductor manufacturing, distribution systems

Preview the Tuesday working session

- Analysis integration (George Thiers, MBSE Tools, Inc)



Preview the Tuesday working session

- Additional topics for discussion
  - MBSE impact on managing engineering data to manufacturing (Eugenio Rios, Collins Aero)
  - MBSE and new supply chain paradigms—case of additive manufacturing (Bill Bihlman, Purdue)
  - ***Your*** topic

Go forward plan:

- Define a neutral scenario
- Establish collaboration platform
- Build out alternative production/supply chain scenarios with associated system models and integrated analyses

Acknowledgements

- NIST
- Collins Aerospace
- McKesson High Value Solutions
- Boeing
- Physical Internet Center, GaTech.
- MBSETools, Inc.

Summary: DELS-related Products

- Model Libraries
  - https://github.com/usnistgov/DiscreteEventLogisticsSystems
- Documentation (DRAFT)
  - Overleaf: https://v2.overleaf.com/read/hhsmnkssjwcp
- Central Fill Pharmacy Case
  - https://doi.org/10.6028/NIST.GCR.19-022
- MBISE Playbook – How to apply DELS model libraries
  - INCOSE Production and Logistics Systems Modeling Challenge Team
  - Overleaf (DRAFT): https://v2.overleaf.com/read/rsjqhqzmxtxq
  - http://www.omgwiki.org/MBSE/doku.php?id=mbse:prodlog
- Reference Implementation of SAI (Matlab)
  - https://github.com/usnistgov/dels-analysis-integration
    - Email timothy.sprock@nist.gov for access (need github account)

Challenge team:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:prodlog

Tuesday @ 10:00 am in Bungalow

timothy.sprock@nist.gov
leon.mcginnis@gatech.edu
conrad.bock@nist.gov
george.thiers@mbsetools.com
Gregory.Pollari@collins.com
eugenio.rios@collins.com

Quick overview of DELS reference model
Intro to system models for composites manufacturing, central fill pharmacy
Focused discussion: focusing on key needs, identifying the players
Next steps

2020
Annual INCOSE
international workshop
Torrance, CA, USA
January 25 - 28, 2020