

System Dynamics Based Cost Estimating NSRP Joint Panel Meeting Ponte Vedra, Florida

By

Mr. Patrick D. Cahill

Knowledge Based Systems, Inc.

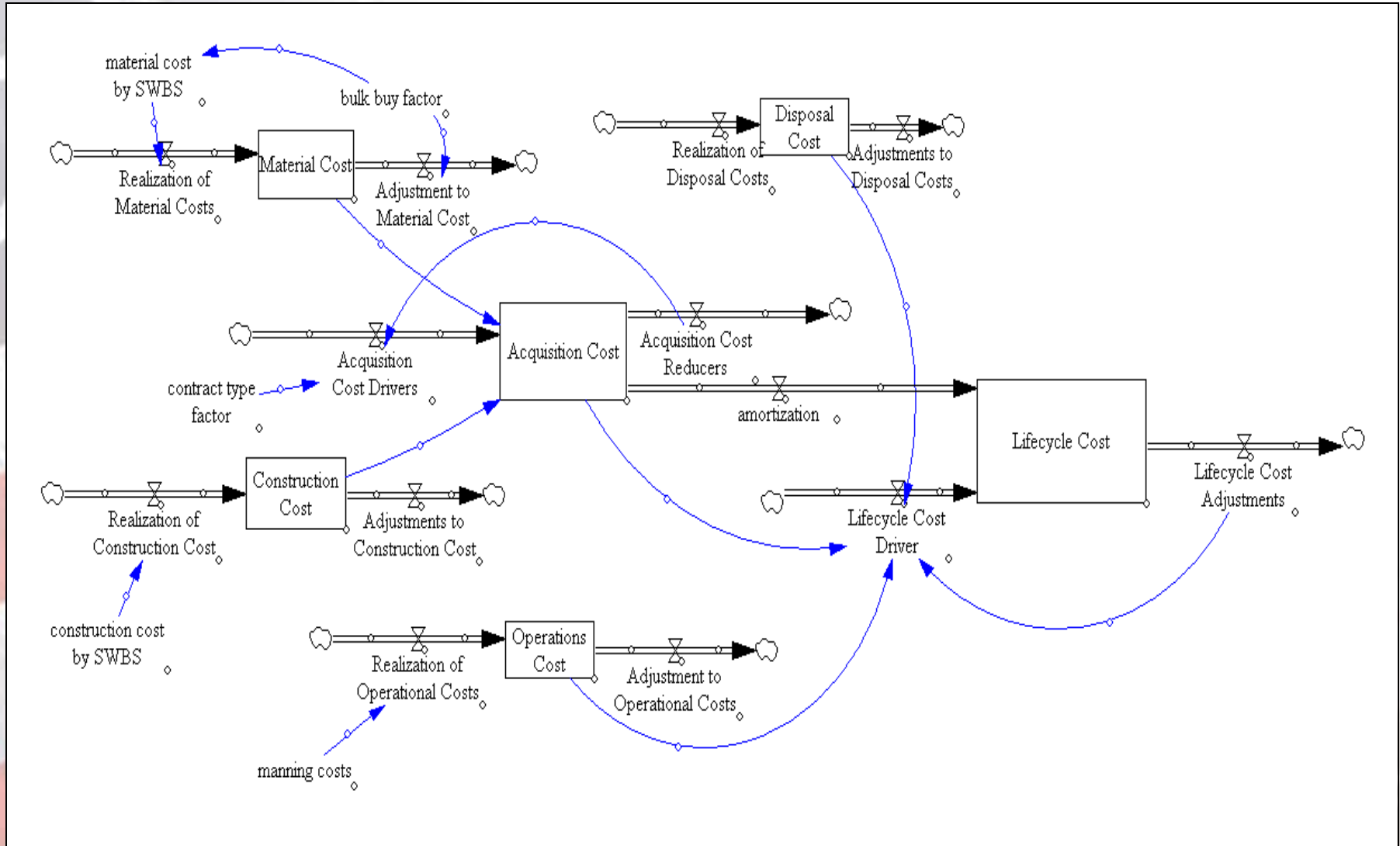
April 21, 2010

Presentation Agenda

- System Dynamics overview
- Ship's Lifecycle Affordability Model (SLAM) project overview
- Transitioning early stage design data to cost estimating
- System Dynamics applications in cost estimating
- Other applications of System Dynamics

- Three fundamental modes of a dynamic system (cost of acquisition and operations):
 - Exponential growth (cost growth)
 - Goal seeking (constraints to control costs)
 - Dynamic behavior (cost oscillations)
- Elements of a System Dynamics model
 - Stocks and flows (costs and cost realization rates)
 - Causal loops (effect of cost driving variables over time)
 - Influencing variables (cost drivers)

High Level System Dynamics Cost Model



Prior System Dynamics Efforts for Modeling

Shipbuilding Related Activities

- **Cooper (1980)**, Naval Ship Production: A Claim Settled and a Framework Built
- **Alfeld et al (1998)**, The Virtual Shipyard: A Simulation Model of the Ship Building Process
- **Monga, Pavender (2001)**, "A System Dynamics Model of the Development of New Technologies for Ship Systems," Master's Thesis, September, 2001.
- **OSCAM** - Operating and Support Cost Analysis Model (Powersim Constructor)

- Early Design – ASSET
- Platform Analysis – LEAPS
- Cost Estimating – SEA 05C internal
 - PODAC
 - ACEIT
- Lifecycle Cost Estimating - OSCAM

Early Stage Design Data – Weights

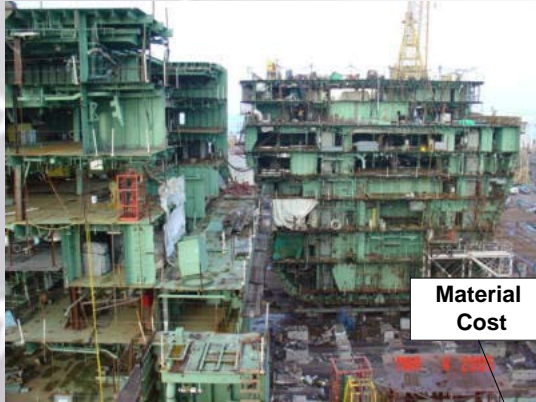
- Design data obtained from ASSET - Advanced Ship and Submarine Evaluation Tool
- System (SWBS) based organization of data
- Primary cost related data is weight

PRINTED REPORT NO. 3 - PROPULSION PLANT WEIGHT

SWBS	COMPONENT	WT-MTON	VCG-M	LCG-M
=====	=====	=====	=====	=====
200	PROPULSION PLANT	840.5	4.94	84.05
230	PROPULSION UNITS	101.7	5.62	71.60
234	GAS TURBINES	101.7	5.62	71.60
240	TRANSMISSION+PROPULSOR SYSTEMS		473.0	3.11 102.10
241	REDUCTION GEARS	142.9	3.83	71.54
* 243	SHAFTING	206.4	3.09	120.87
244	SHAFT BEARINGS	54.7	2.82	91.76
245	PROPULSORS	69.0	1.94	117.47
250	SUPPORT SYSTEMS	162.0	10.40	43.32
251	COMBUSTION AIR SYSTEM	36.6	12.44	69.93
252	PROPULSION CONTROL SYSTEM	28.6	8.30	71.60
* 256	CIRC + COOL SEA WATER SYSTEM	37.4	3.34	125.37
* 259	UPTAKES (INNER CASING)	59.4	14.61	-38.45
260	PROPUL SUP SYS- FUEL, LUBE OIL	49.0	3.95	69.50
261	FUEL SERVICE SYSTEM	12.6	3.79	64.42
262	MAIN PROPULSION LUBE OIL SYSTEM	26.0	3.66	71.60
264	LUBE OIL HANDLING	10.4	4.88	70.38
290	SPECIAL PURPOSE SYSTEMS	54.8	4.16	84.83
298	OPERATING FLUIDS	46.4	2.44	86.14
299	REPAIR PARTS + TOOLS	8.3	13.77	77.52

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

Relating Shipbuilding Processes To System Dynamics Variables



Material Cost

Stock Unit Price
Material Utilization %
Quality Assurance
Material Handling
Material Management Cost
Warehousing

Subassembly cost

Fitting
Tacking
Cleaning
Wipe/wash/sweep
QA
Fixturing
Grinding
Machine weld
Manual weld
bolting
Fastening
Testing

Testing Cost

Pipe Hydro
Welding
Electrical Operation
C4I Testing
Sea Trials
Aux Machinery operation
Weapon systems
Machinery Control & Main Engine
Kitting, staging
Handling and Kitting
In process handling

Construction Cost

Edge Prep
Secondary Operations
Finishing
Clean
Prime
Blast
Pre-fabrication Process
QA
Forming
Cutting
Part from Stock
Machine
Clean, grind, prep

Part Fabrication Cost

Transport
Painting
Paint/finish
Insulation
Installation
Fitting
Work Station Setup
Cover/protect
Protection
Dimensional accuracy
Quality
Welding
Material Handling And Staging

Assembly Cost

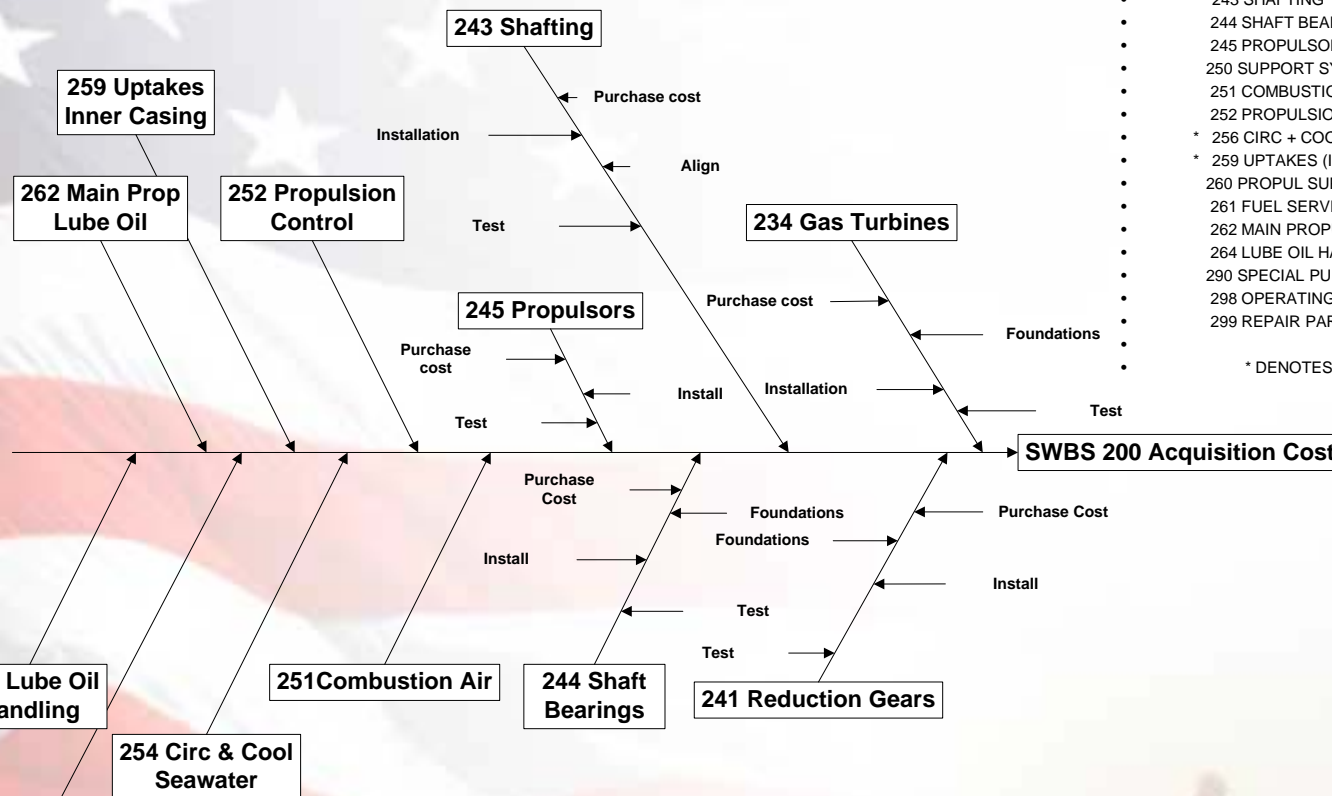


Relating ASSET Data to Costs through Influence Diagrams

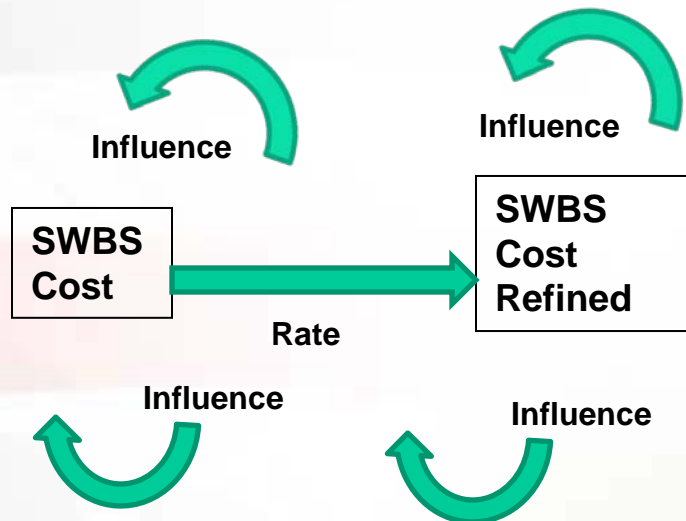
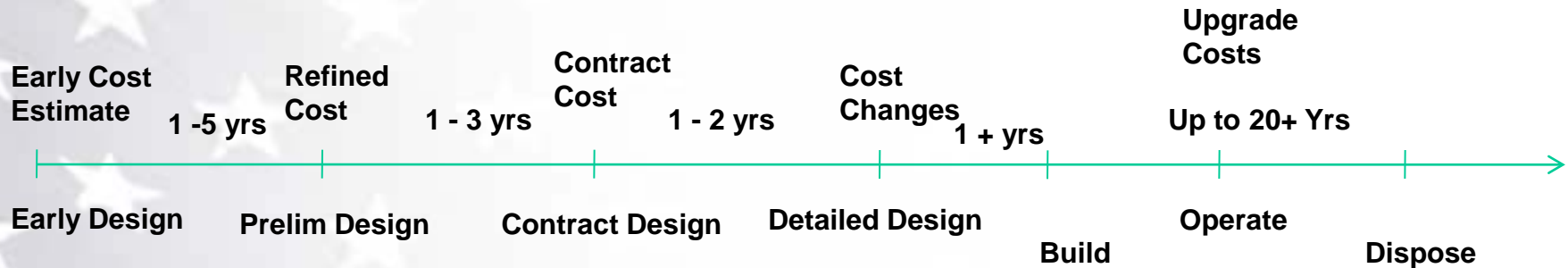
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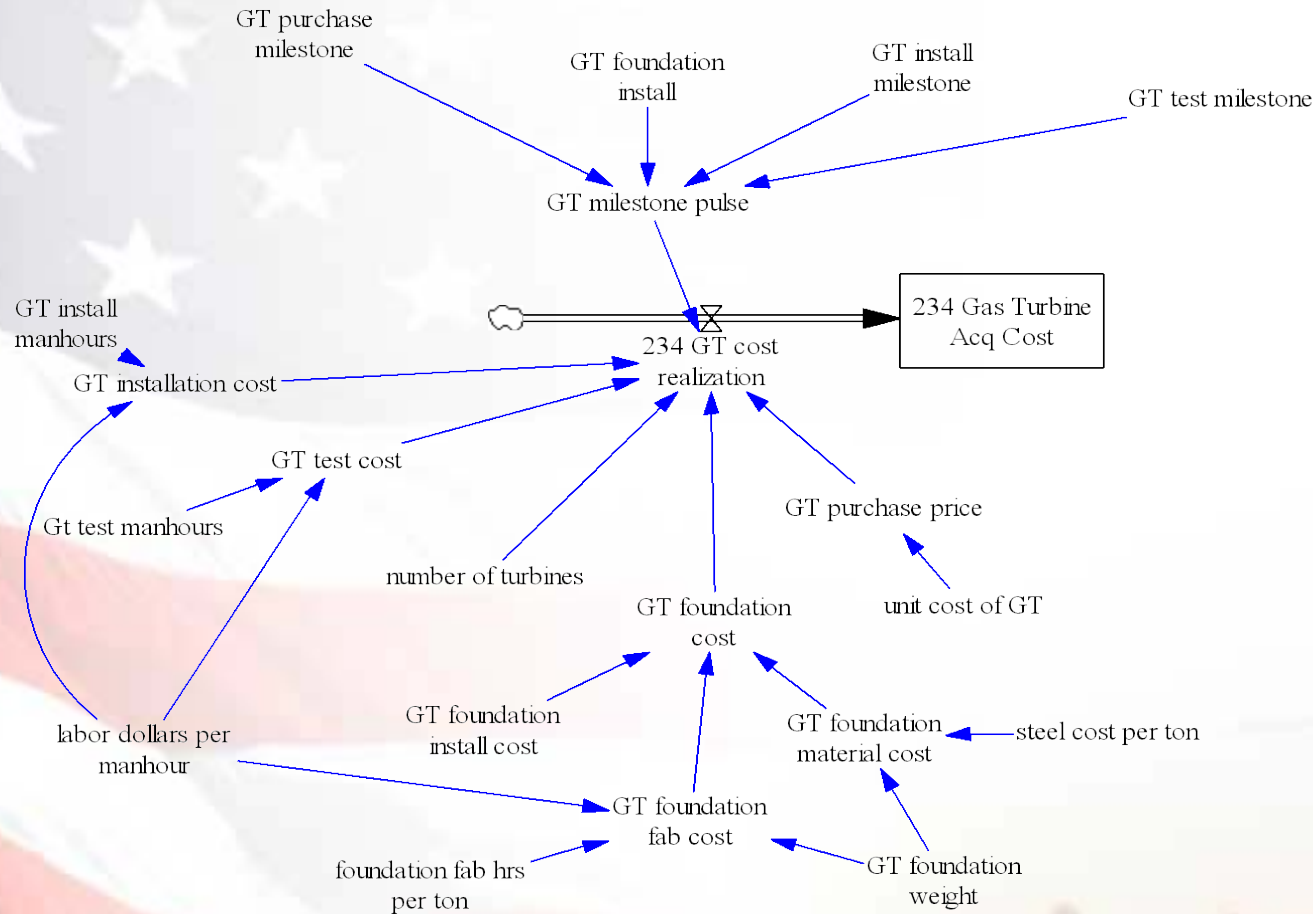


Temporal Relationship of Costs

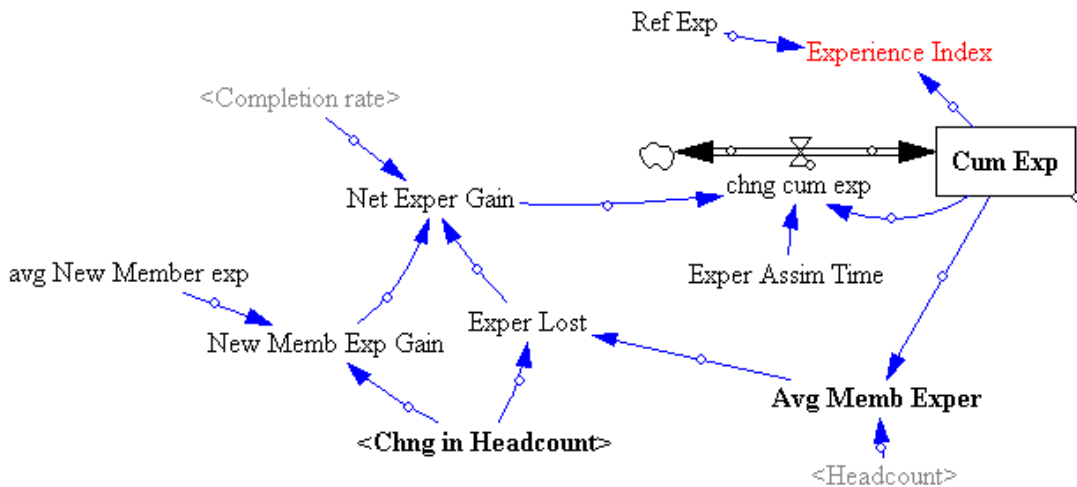




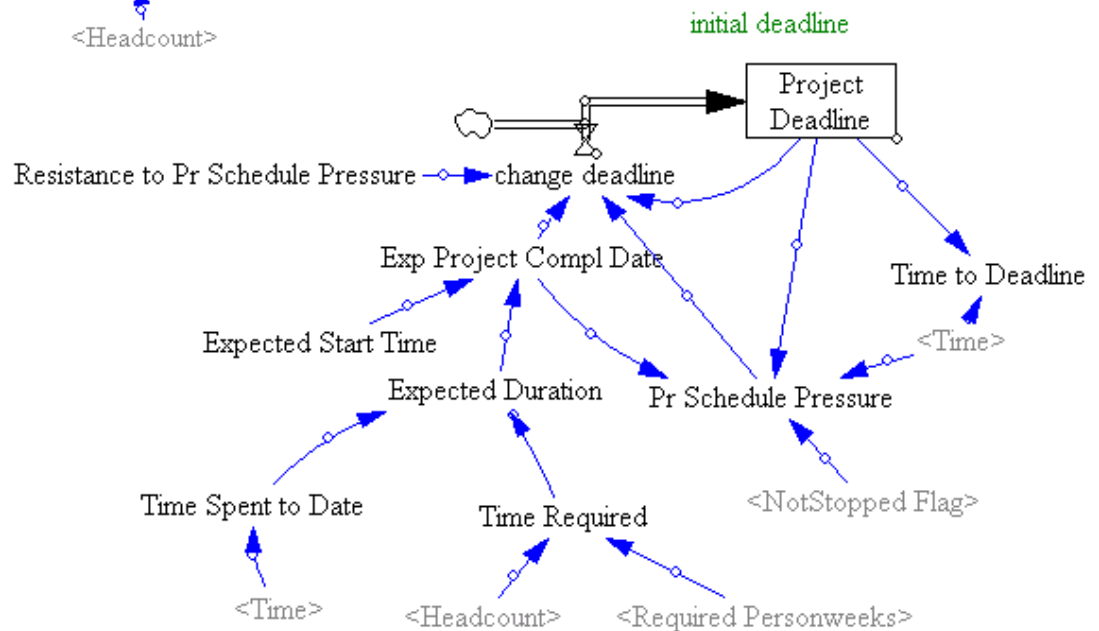
Combining ASSET Data and Influence Diagrams in a System Dynamics Model



Developing “soft” variable Influences



Experience Factors

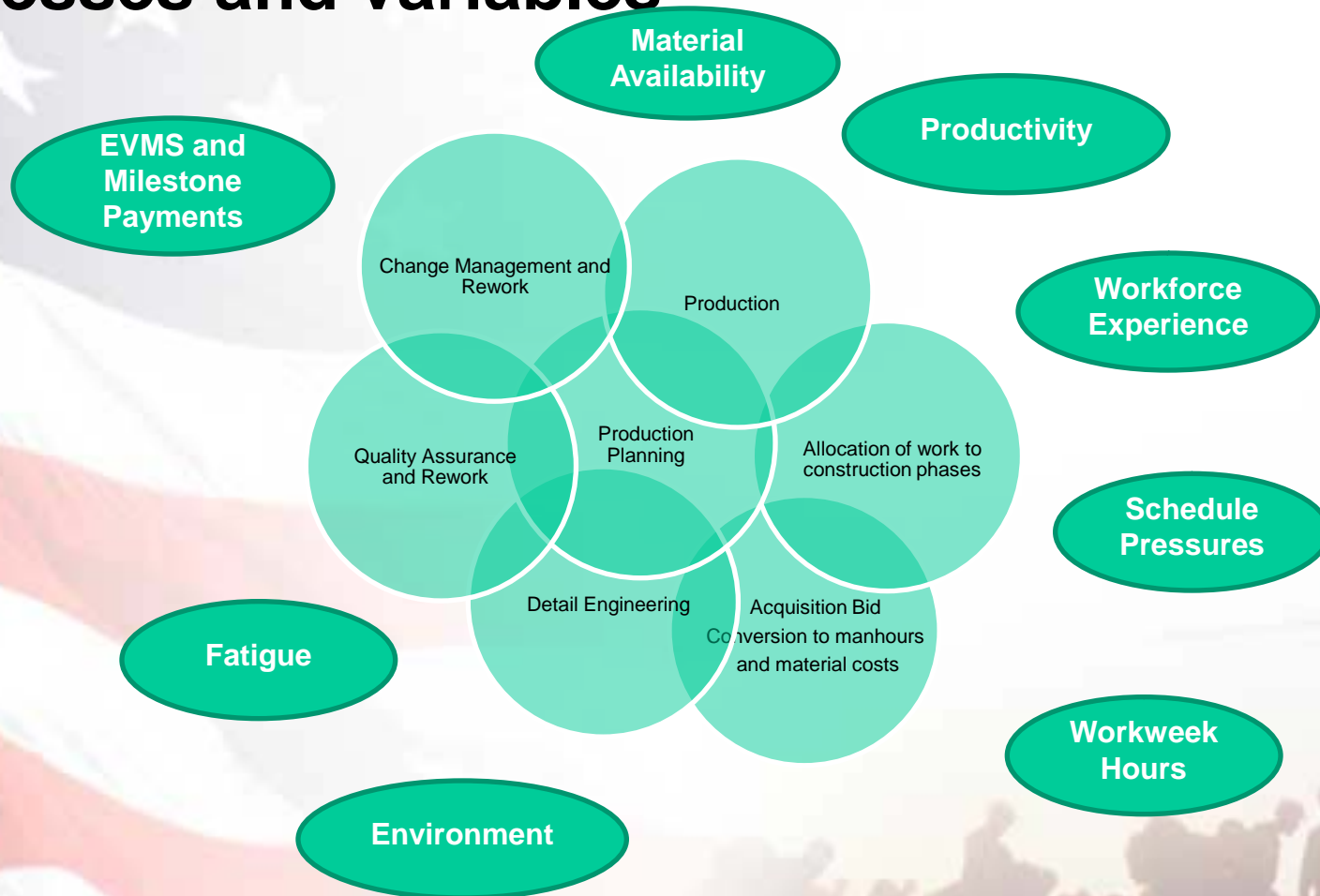


Schedule Effects

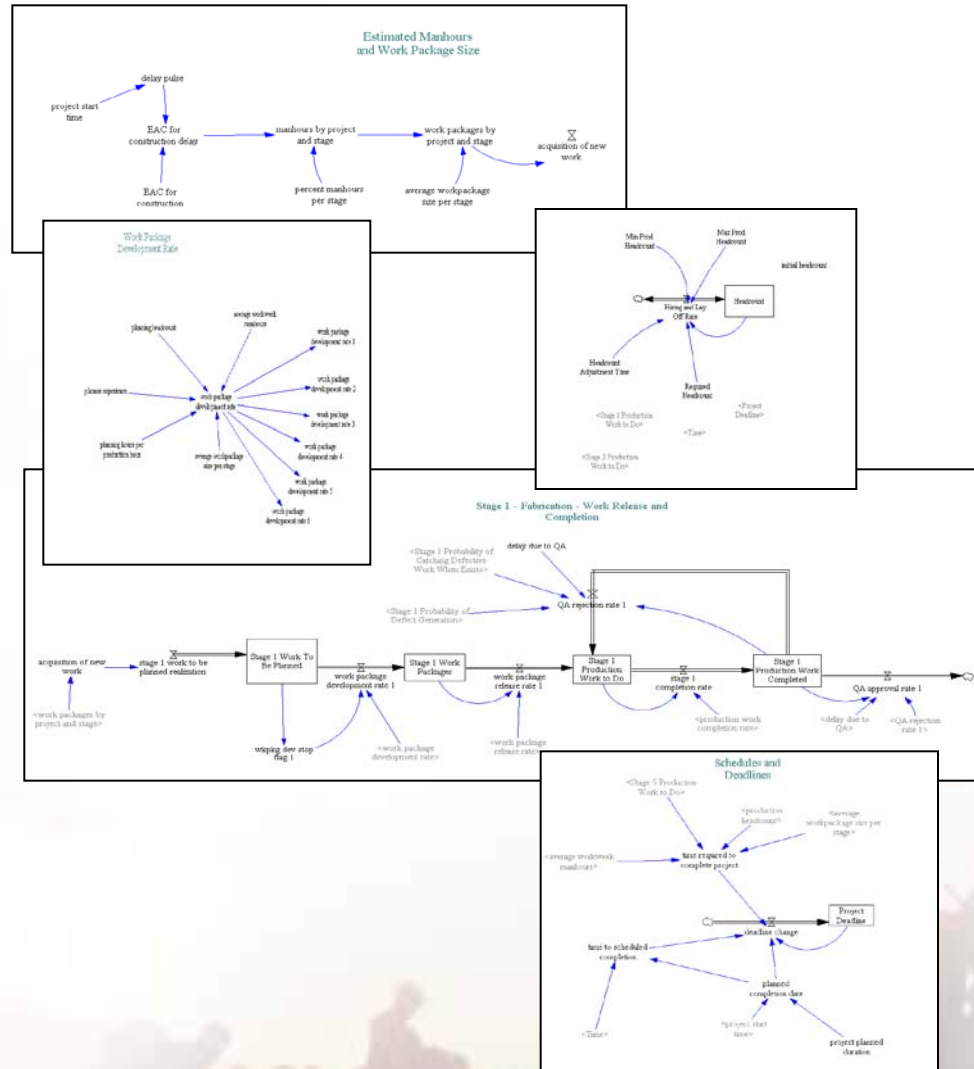
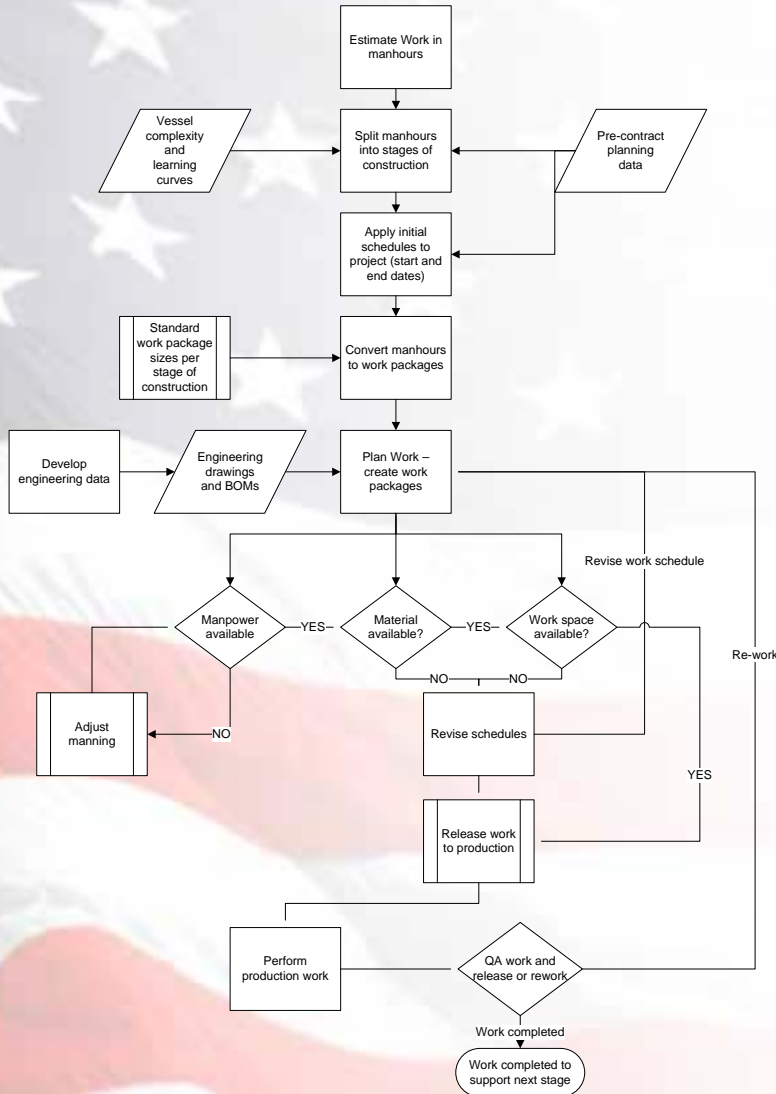
- Concept as developed will provide a time phased view of ship acquisition and construction costs
- Vision is to provide a “cash flow” view of a ship program, rather than static, “point in time” estimates
- Incorporating soft factors (such as experience and schedule effects) allows for realistic “what-if” analyses
- Concept could be combined with other stochastic estimating tools to generate initial values for variables

System Dynamics Based Impact Analysis and Capacity Planning

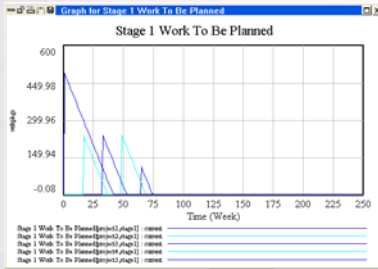
Complex interactions of multiple processes and variables



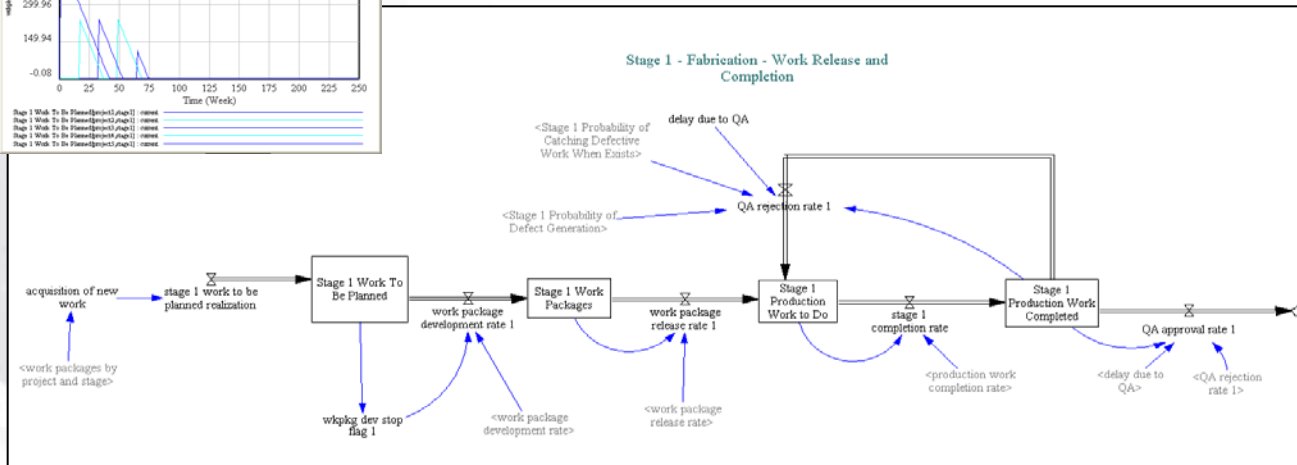
System Dynamics Model Flow



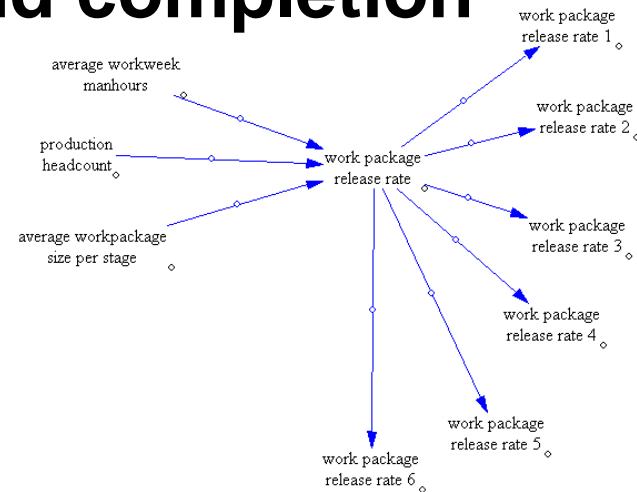
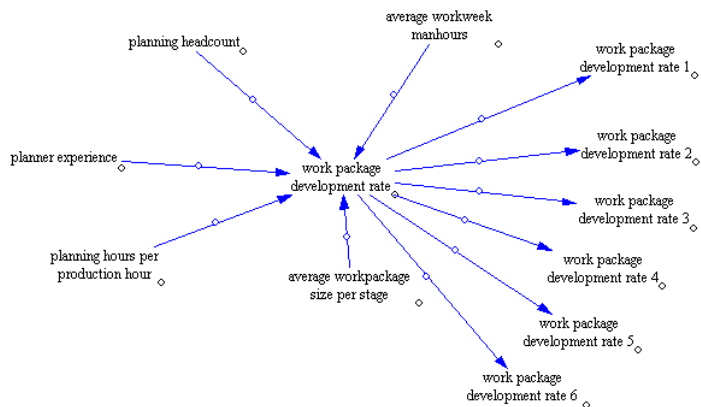
System Dynamics Model of Workflow



Basic Workflow repeated for each stage



Work creation and completion



Conclusions

- System Dynamics provides a method of modeling the constantly changing environment in shipbuilding
- Potential applications in cost estimating, impact analysis of considered process or facilities changes, and capacity planning
- Potential for use as a Program Management tool
 - Navy PEOs
 - Shipyard management

Thank you

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