Simulation Optimization Decision Support System for Ship Panel Line Operations

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Case Study Track
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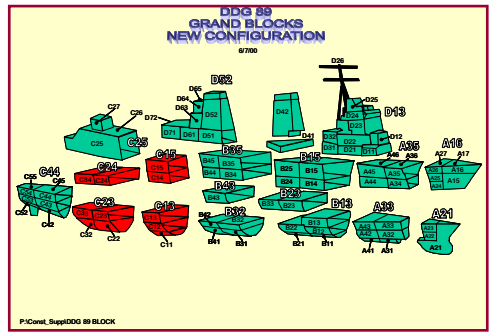
Broad objective: Maximize shipyard throughput, subject to customer due date

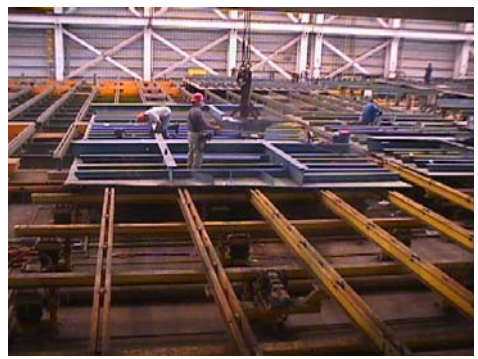
Problem*: U.S. shipyards take twice as long to build comparable ships; 1/3 as productive as the Japanese, 1/2 as productive as the Europeans

- Build ships faster and cheaper
- Increase throughput of the yard and sector; increase profit
- Reduce lead time
- Improve the use of key resources
- Employ best practices
- Effectively deal with variability

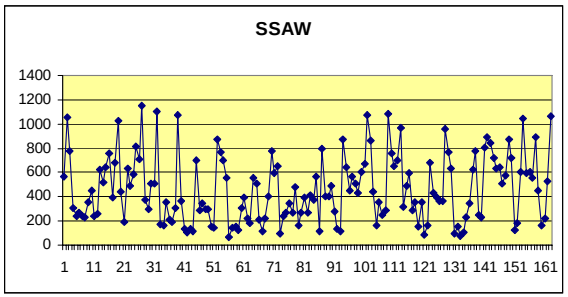
*Liker, J. K., and Lamb, T. A *Guide to Lean Shipbuilding*, Draft Version 0.5, June 26,2000, Maritech ASE project #10 TIA 2000214, p. 9

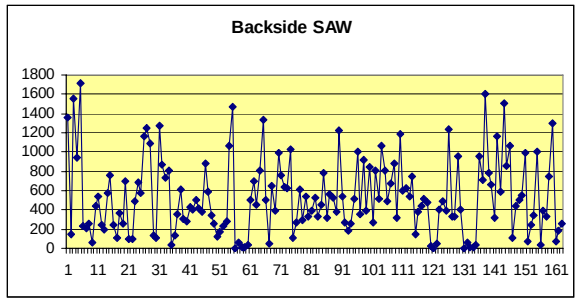
Focus on the shipyard bottleneck: Panel Shop

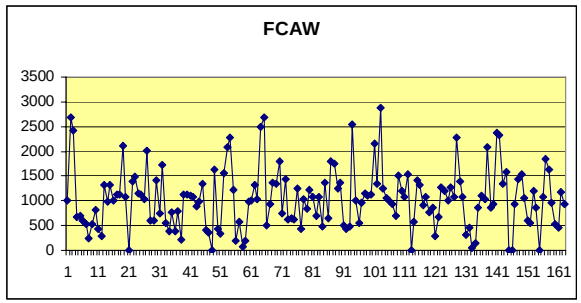


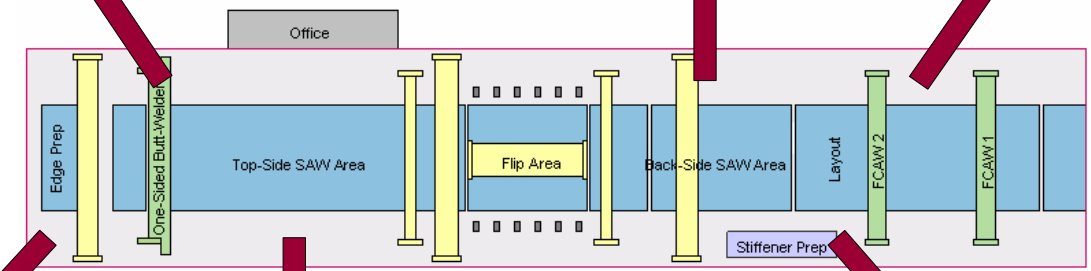


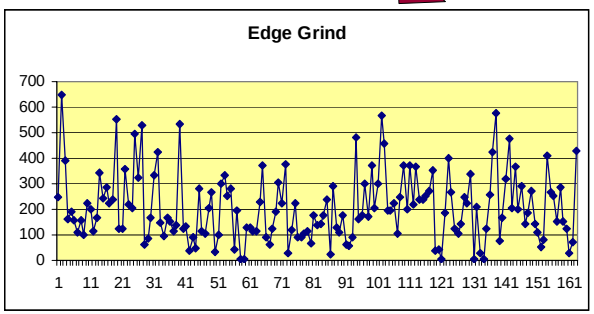
Every panel is unique → extreme variability in work content

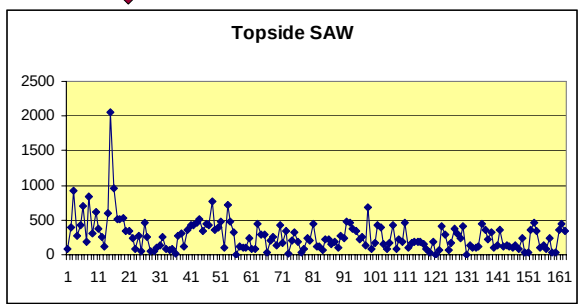


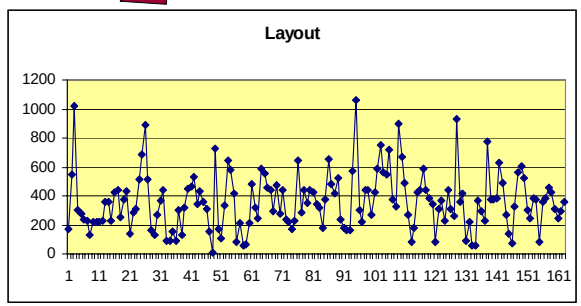










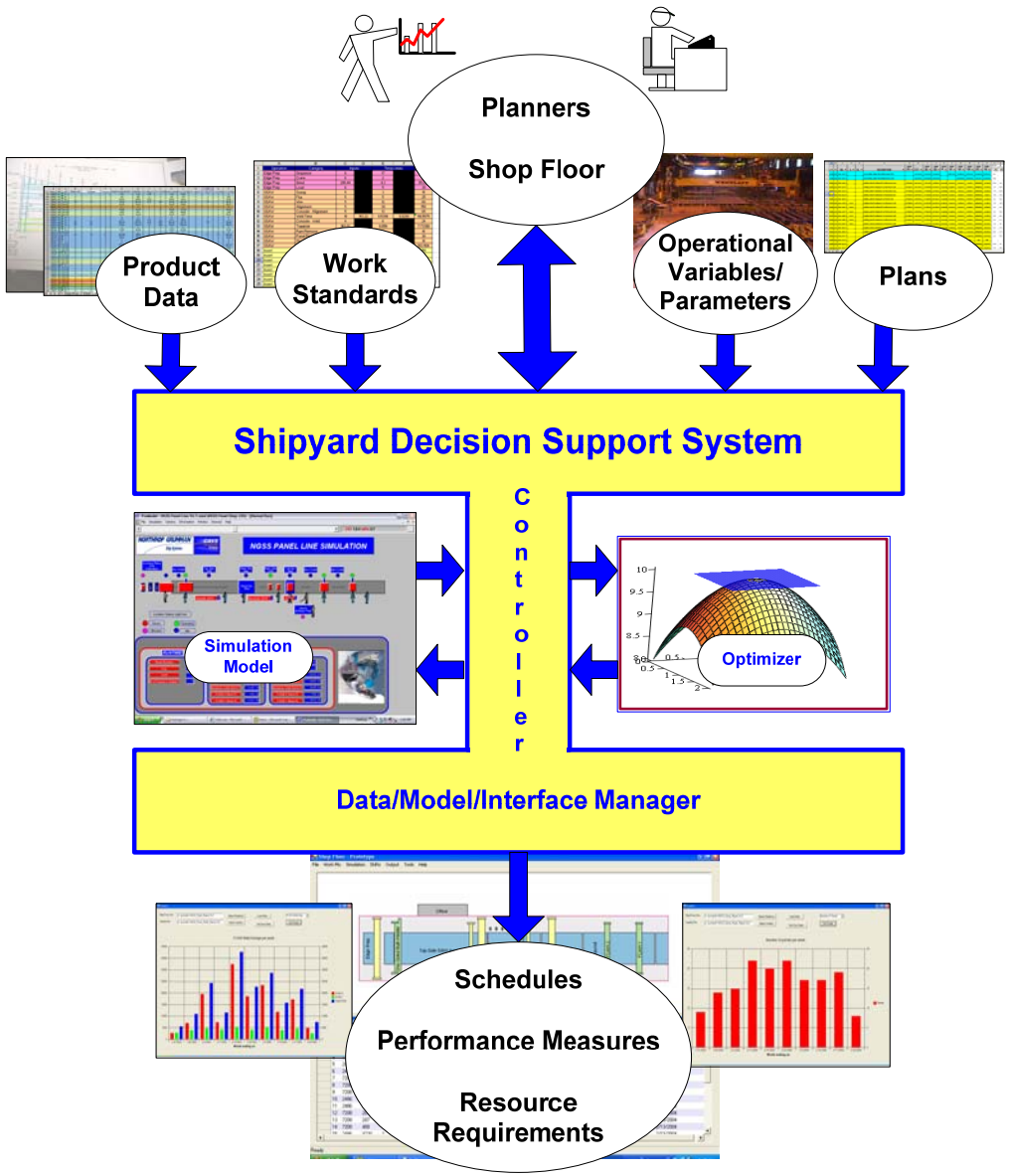


Project overview

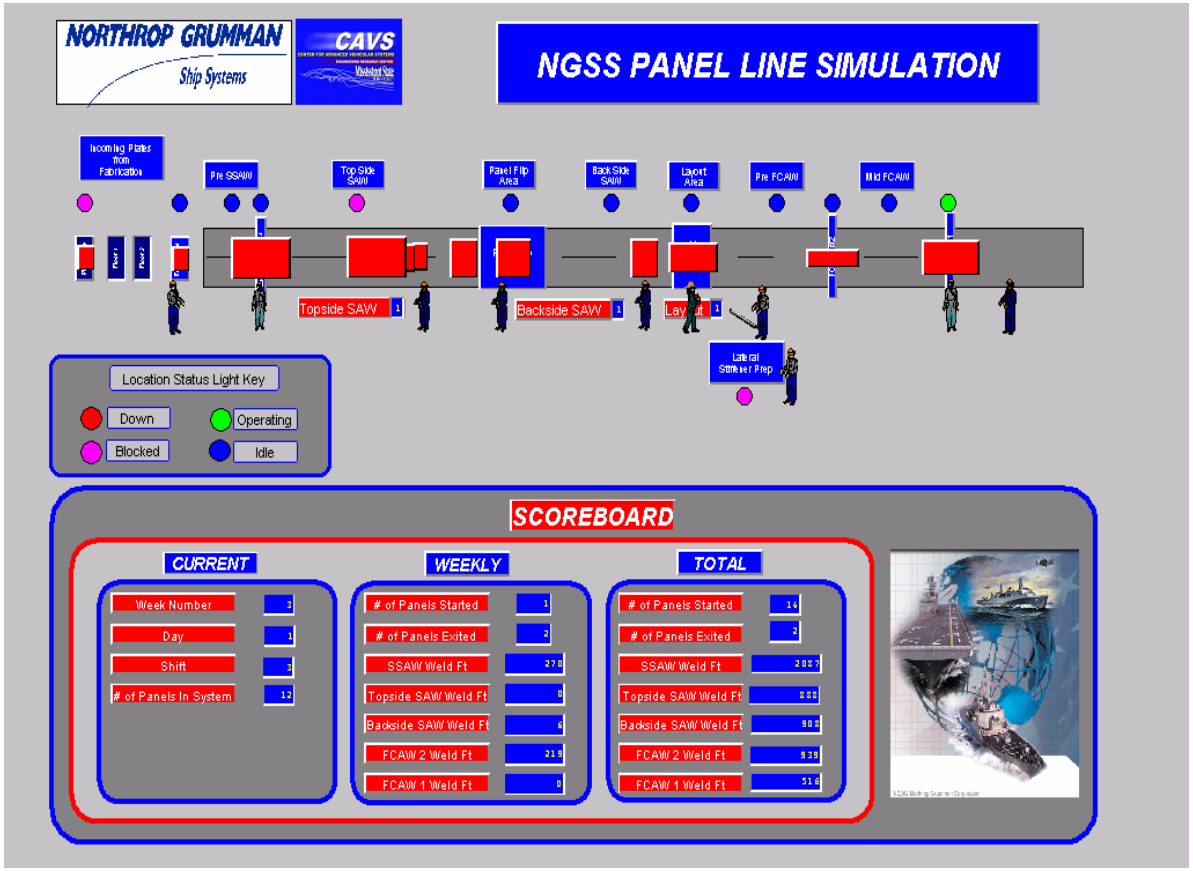
- Objective: provide a means to understand and assess the impact on shop performance of changes in:
  - resources,
  - operations practices,
  - panel characteristics,
  - sequence, etc.

- Components:
  - Discrete-event simulation model of panel shop
  - Optimizer to determine best sequence for producing panels
  - DSS so the simulation model and optimizer could be used by planners and shop floor supervisors

Overview of Simulation-Optimization Decision Support System



ProModel simulation model captures shop behavior

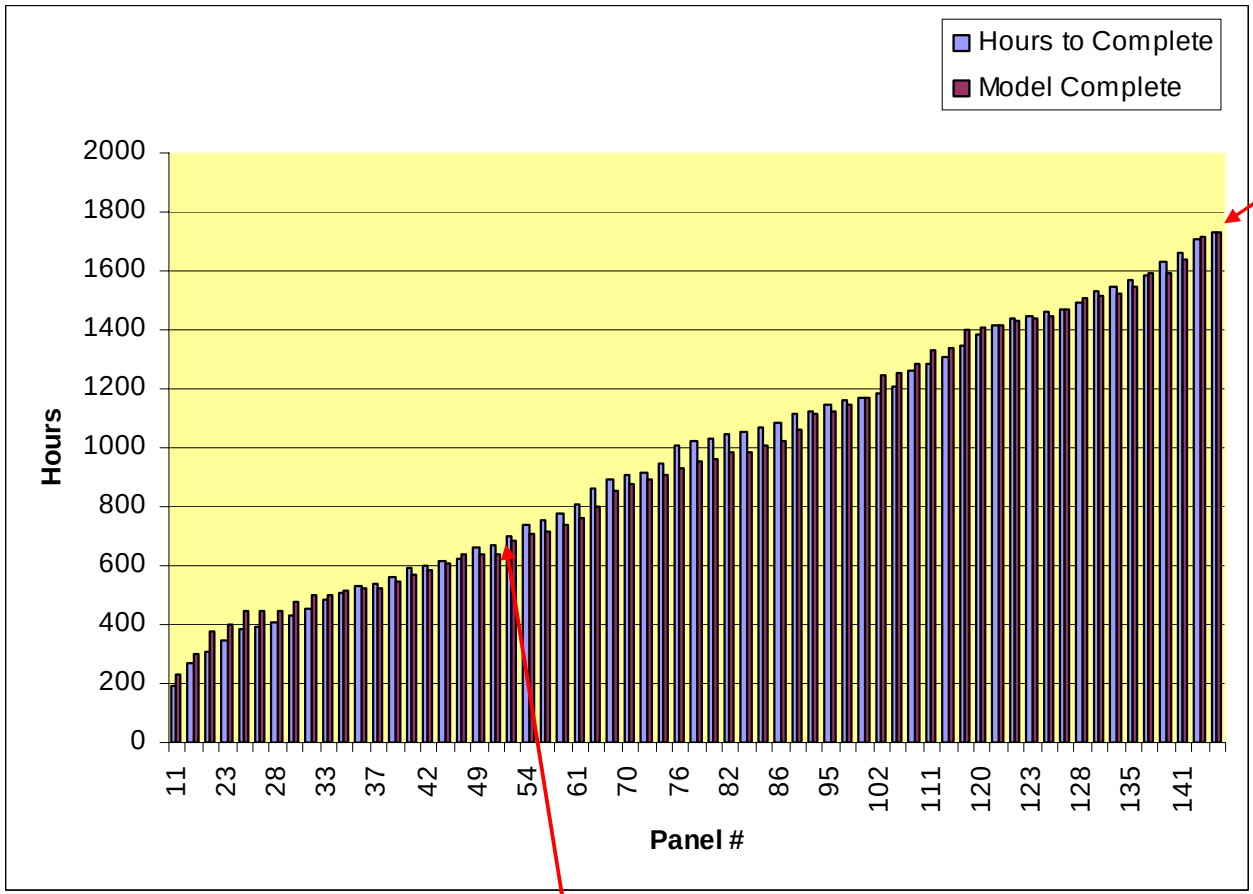


Model considers:

- Panel size and conveyor capacity
- Work content
- Resource availability
- Work assignments
- Operational rules
- Downtime
- Task variability
- Shift schedule
- Relevant measures of performance

Model runtime: approximately 5 seconds to process 154 panels (~13 weeks in real time)

Model accurately captures shop behavior



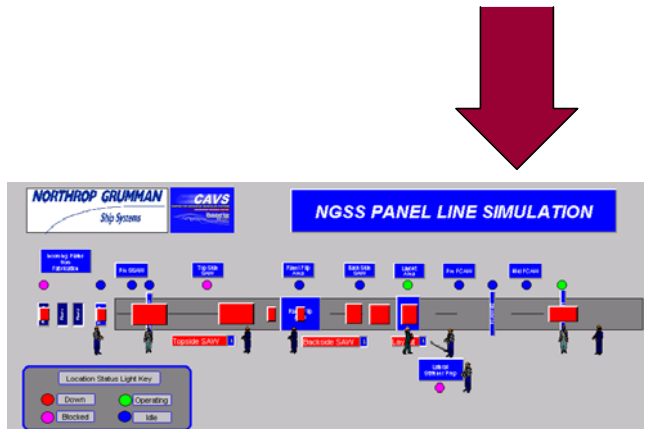
Panel 150: Model 1729 – Actual 1734

Hours to complete is based on observation; the number of panels that had exited at a specified time; e.g., at time 697, 52 panels had been competed.

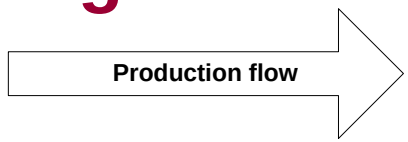
Model Complete is the time a panel left the system in the model; e.g. Panel 52 was completed at time 681.

Workstation processing times based on work standards and panel characteristics

	Standards		Panel DDG 356		
	min/seam	min/ft	seams	feet	Time
Sweep	3		5		15
Flux	5		5		25
Wire	12		5		60
Align	30		5		150
Console	13		5		65
Weld		0.83		143.2	119
Traverse return					
Console	6		4		24
Traverse		0.054		143.2	8
Remove ram	2		5		10
Remove plate	6		5		30
Slag chips	2		5		10
Defect repair		0.72		143.2	103
					619



Simulation model incorporates dynamic resource assignments



Panel Weld Time (min.)

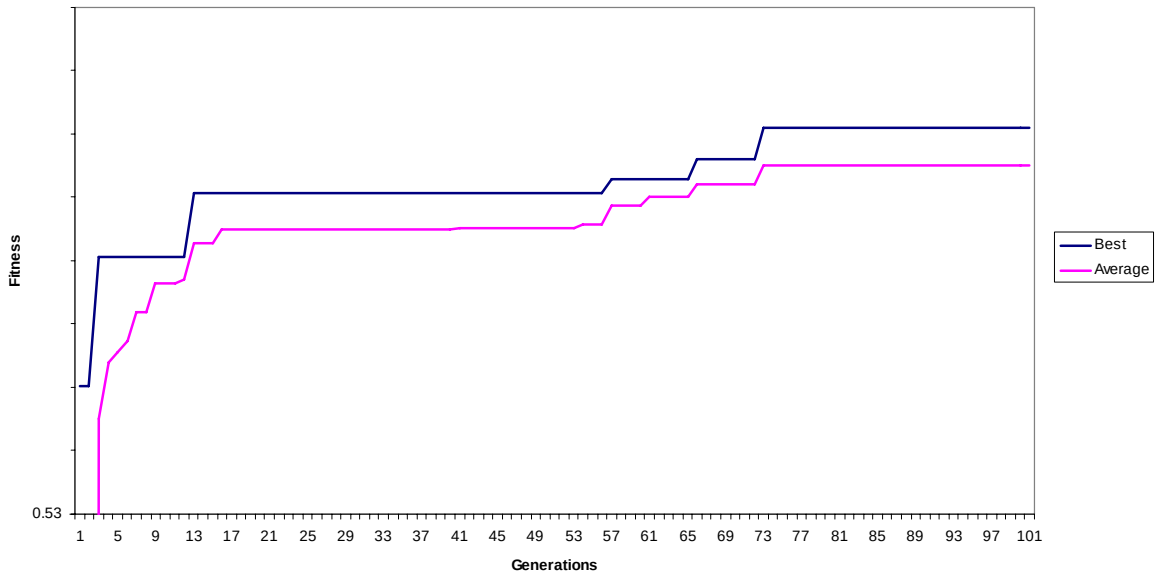
Panel sequence

Hull	Unit	SA	SSAW	Topside SAW	Backside SAW	Layout	FCAW 2	FCAW 1
6250	315	01-03	288	719	230	244	290	311
6250	323	01-01	276	152	314	235	341	291
6250	323	01-02	309	700	260	139	228	**37**
6250	323	01-03	291	295	63	220	**145**	414
6250	332	01-01	487	428	370	**170**	343	526
6250	324	01-01	284	426	**577**	223	379	47
6250	324	01-03	282	208	320	136	228	141
6250	343	01-01	652	117	119	158	73	1198
6250	353	01-01	527	721	753	360	859	154

Assign 4 welders (based on work in process ahead)

Optimal sequence based on genetic algorithm

- Modified evolutionary strategy
- Fitness function
  - based on total weld feet, make span, days late for each job
  - value is evaluated for each combination using the simulation model..
- DSS manages optimization process, including evaluation of each solution by the discrete-event simulation model
- Sample run for a set of 50 panels



Example analyses

Percent change in makespan (time to complete panel set)

		Machine Utilization				
		100	**90**	**80**	**70**	**60**
Personnel Utilization	**100**	6.0%	5.8%	5.7%	5.2%	4.4%
	95	3.9%	3.9%	3.8%	3.2%	2.7%
	85	0.0%	-0.6%	-0.6%	-1.6%	-1.1%
	70	-7.7%	-7.4%	-8.3%	-8.5%	-9.0%

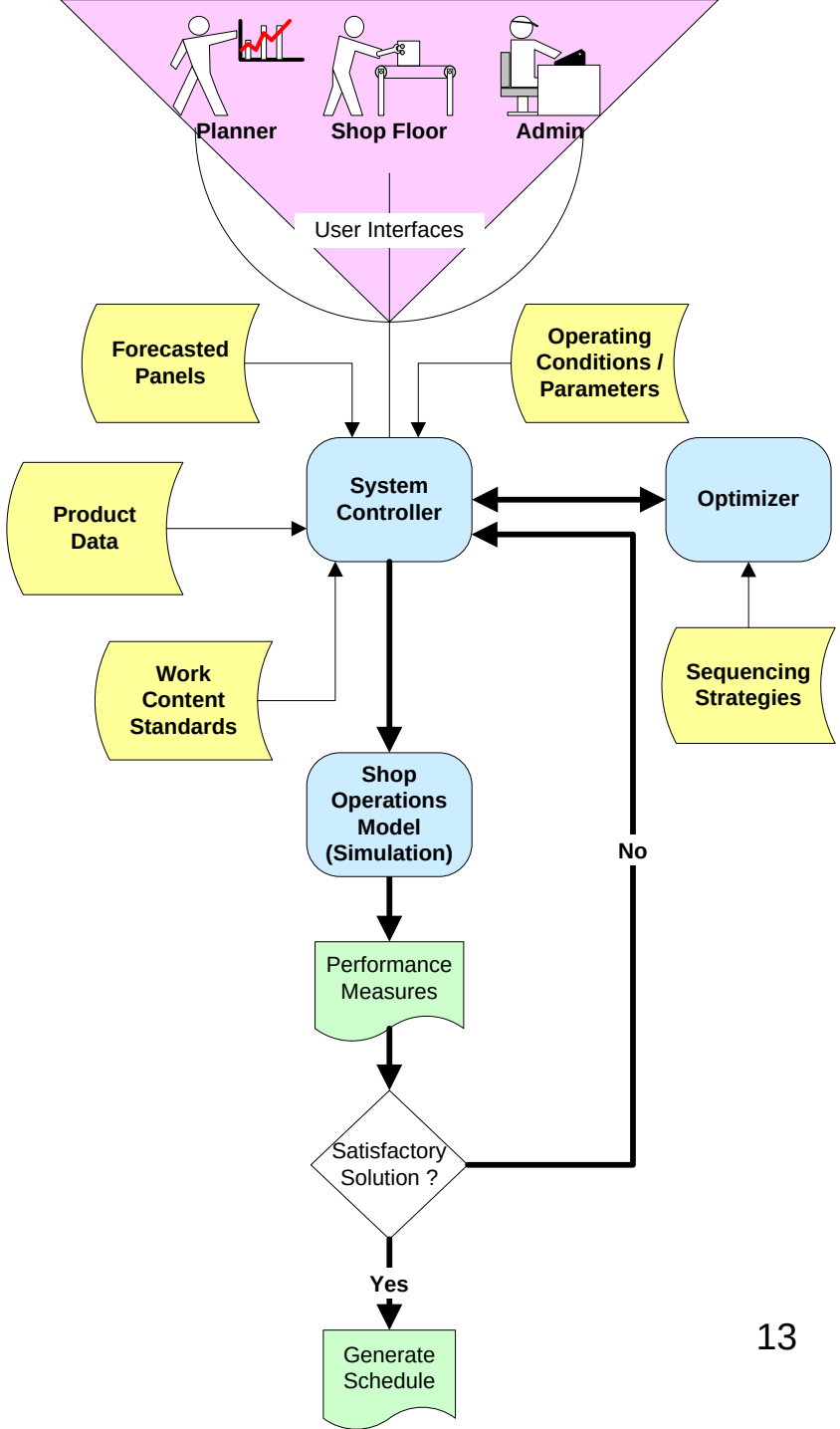
Base Case: Personnel Utilization = 85%, Machine Utilization = 100%

		Process Variability				
		none	**-5/+10**	**-10/+20**	**-25/+50**	**-25/+100**
Personnel Utilization	**100**	6.5%	6.0%	5.4%	3.0%	-4.8%
	85	-0.1%	0.0%	-1.2%	-3.4%	-11.7%
	70	-7.1%	-7.7%	-8.4%	-11.6%	-20.0%

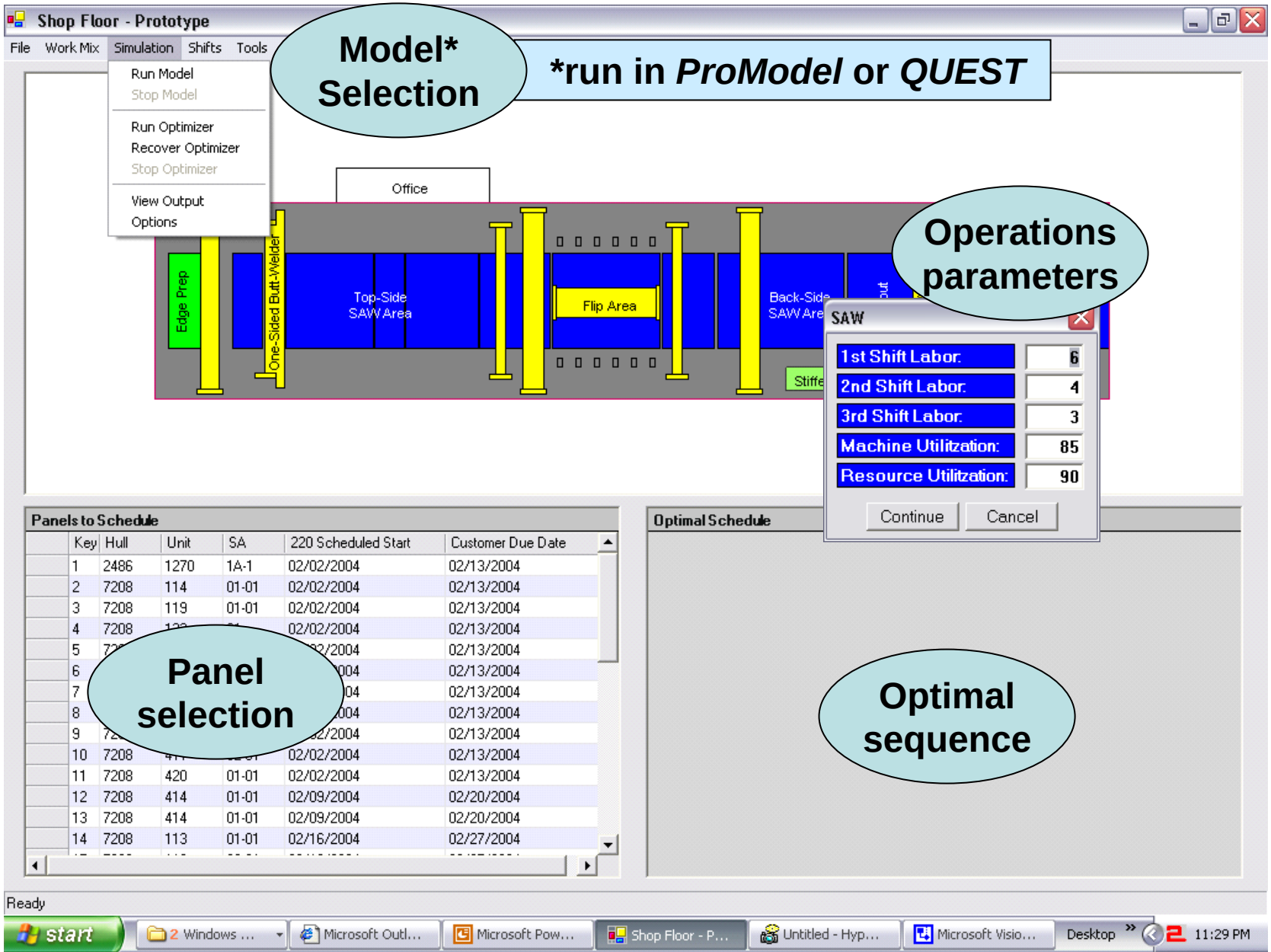
Base Case: Personnel Utilization = 85%, Process Variability = -5% / +10%

Basic DSS architecture

- Support planner-level and shop-floor-level decisions
  - Easy-to-use interfaces
  - Intuitive and relevant output
  - Model operations transparent to users
- Driven by NGSS data; responsive to changes in data
- Sequence:
  - based on shop-floor behavior, capabilities, and constraints
  - performance assessed using simulation model
  - generated by genetic algorithm
- Provides work assignments required to meet optimal sequence



DSS interface



DSS output

Output Viewer - [Reports: Resource Prescription]

File Graphs Reports Window

MainReport

NORTHROP GRUMMAN SHIP SYSTEMS

Resource Allocation

NGSS Panel Level Resource Prescription

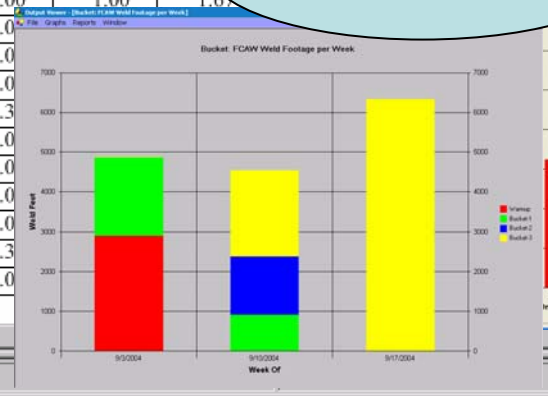
Hull	Unit	SA	Start Date	Exit Date	Edge Grinders Required	SSAW Required	Topside SAW Required	Backside SAW Required	Layout Required	FCAW 2 Required	FCAW 1 Required	Repair Required	Stiffener Required	FCAW Fitter
7208	225	01-01	08/30/04	09/04/04	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
7208	225	02-01	08/30/04	09/05/04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	0.00
5213	323	01-01	08/30/04	09/07/04	1.00	1.00	1.00	1.00	1.00	1.00	1			
5213	323	01-02	08/30/04	09/07/04	1.00	1.00	3.00	1.00	1.00	1.00	1			
5213	323	01-03	08/31/04	09/07/04	1.00	1.00	1.00	1.00	1.00	1.00	1			
7208	341	06	08/31/04	09/08/04	1.00	1.00	3.00	4.00	1.00	1.00	1			
							3.67	3.00	1.00	1.00	1			
							1.33	1.00	1.00					
							3.00	2.00	1.0					
							2.33	1.00	1					
							1.00	1.00	1.67					
							2.0							
							1.0							
							1.0							
							3.3							
							3.0							
							2.0							
							2.0							
							1.0							
							3.3							
							3.0							

Schedule

Optimal Schedule

I	Hull	Unit	SA	Simulated Start Date	Simulated Delivery Date
1	7208	323	01-01	1/5/2004	2/23/2004
2	7208	325	03-01	1/5/2004	2/9/2004
3	7208	326	01-01	1/5/2004	
4	7208	416	04	1/5/	
5	2486	4720	1A-1	1	
6	2486	4721	F-1A	1/	
7	7208	107	01-01	1/12/2004	
8	7208	115	02-01	1/12/2004	2/16/2004
9	7208	116	02-01	1/12/2004	2/16/2004
10	2486	1381	1-1	1/12/2004	2/13/2004
11	2486	1380	1-1	1/12/2004	2/13/2004
12	7208	207	01-01	1/12/2004	2/13/2004
13	7208	207	02-01	1/12/2004	2/13/2004
14	7208	408	02-01	1/12/2004	2/13/2004
15	2486	4220	1	1/12/2004	2/13/2004

Performance



Future directions: application across a sector