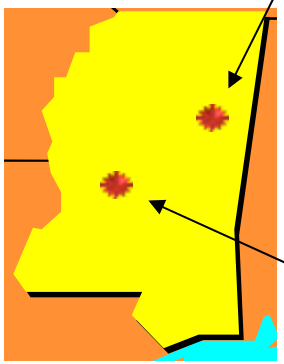
Model-Based Decision Making Through Simulation-Optimization Decision-Support Systems (DSS)

Allen Greenwood & Travis Hill, Mississippi State University

Outline of Presentation

- Context – MSU model & application development activities
- Basic Concepts -- Decision Support Systems (DSS)
- Examples of Model-based DSS (MB-DSS)
  - Panel Shop
  - Pipe Shop
  - Lean Manufacturing Flight Simulator

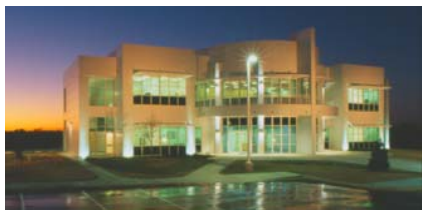
Mississippi State University



JAMES WORTH BAGLEY COLLEGE OF ENGINEERING
MISSISSIPPI STATE UNIVERSITY
INDUSTRIAL AND SYSTEMS ENGINEERING

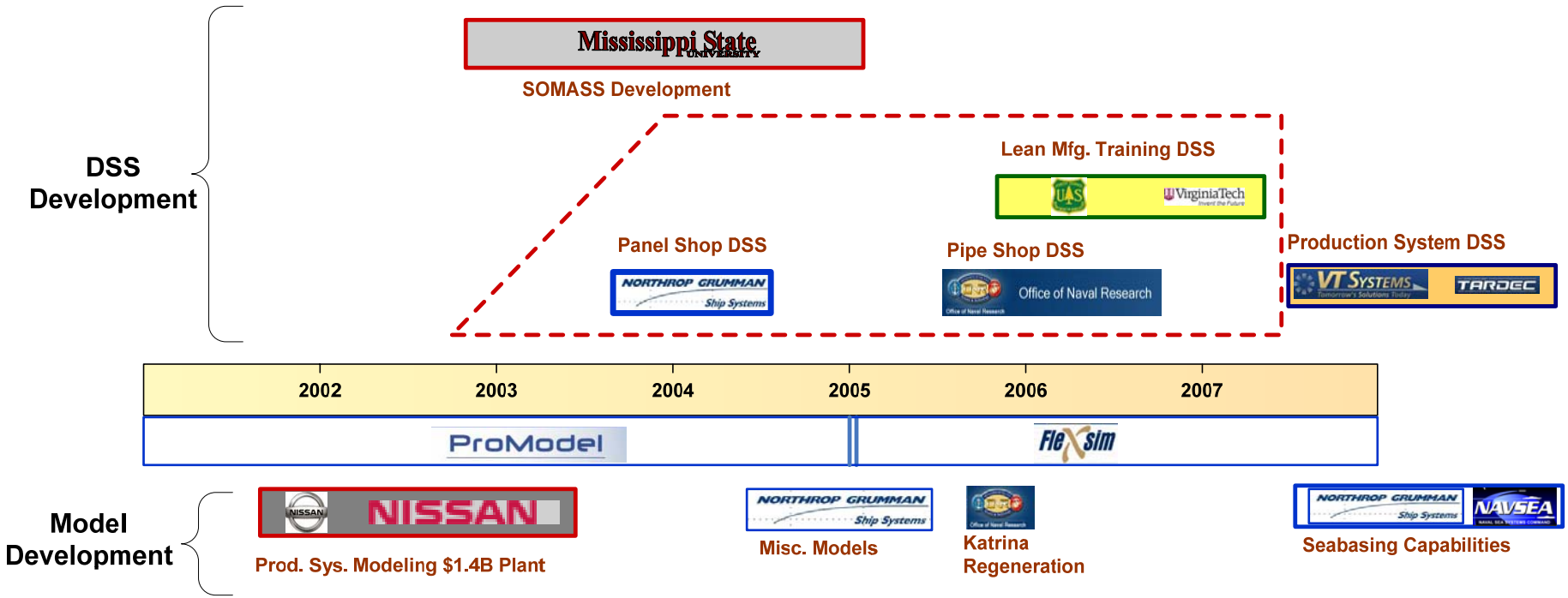
The Department of Industrial and Systems Engineering (ISE) provides education, research, and outreach in order to design, analyze, and manage systems of people, materials, information, equipment, and energy.

CAVS EXTENSION



The Center for Advanced Vehicular Systems (CAVS) provides new capabilities for Mississippi industry in order to reduce development and production costs while improving quality.

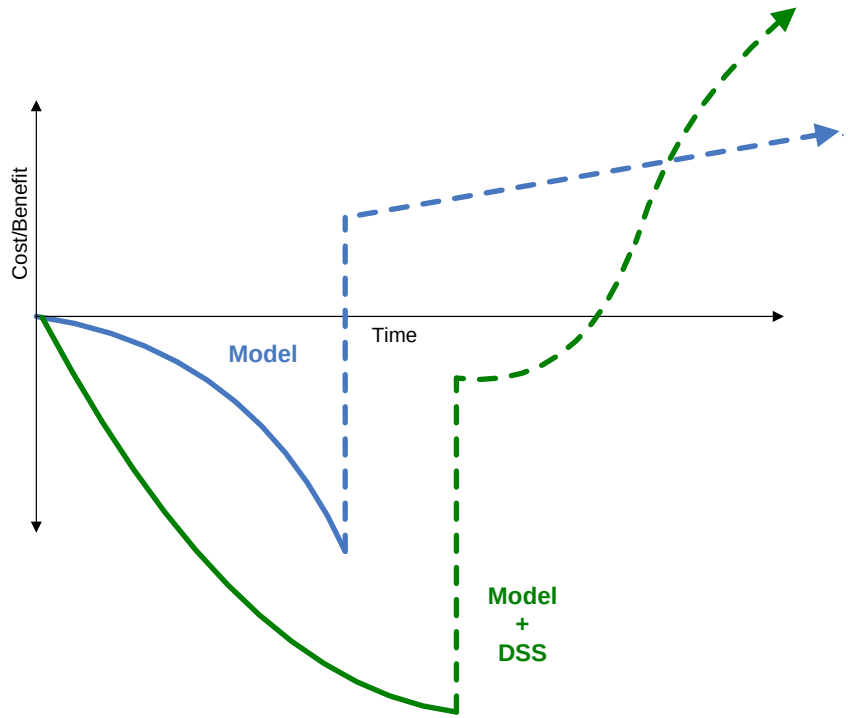
Key Projects to Provide Context



Why Model-based DSS?
Enhance Organizational Performance

- put sophisticated engineering tools into the hands of the decision makers to improve decision making

- increase the useful life of models; get a greater return on model investment



"Traditional" Decision Making

Information

Real System

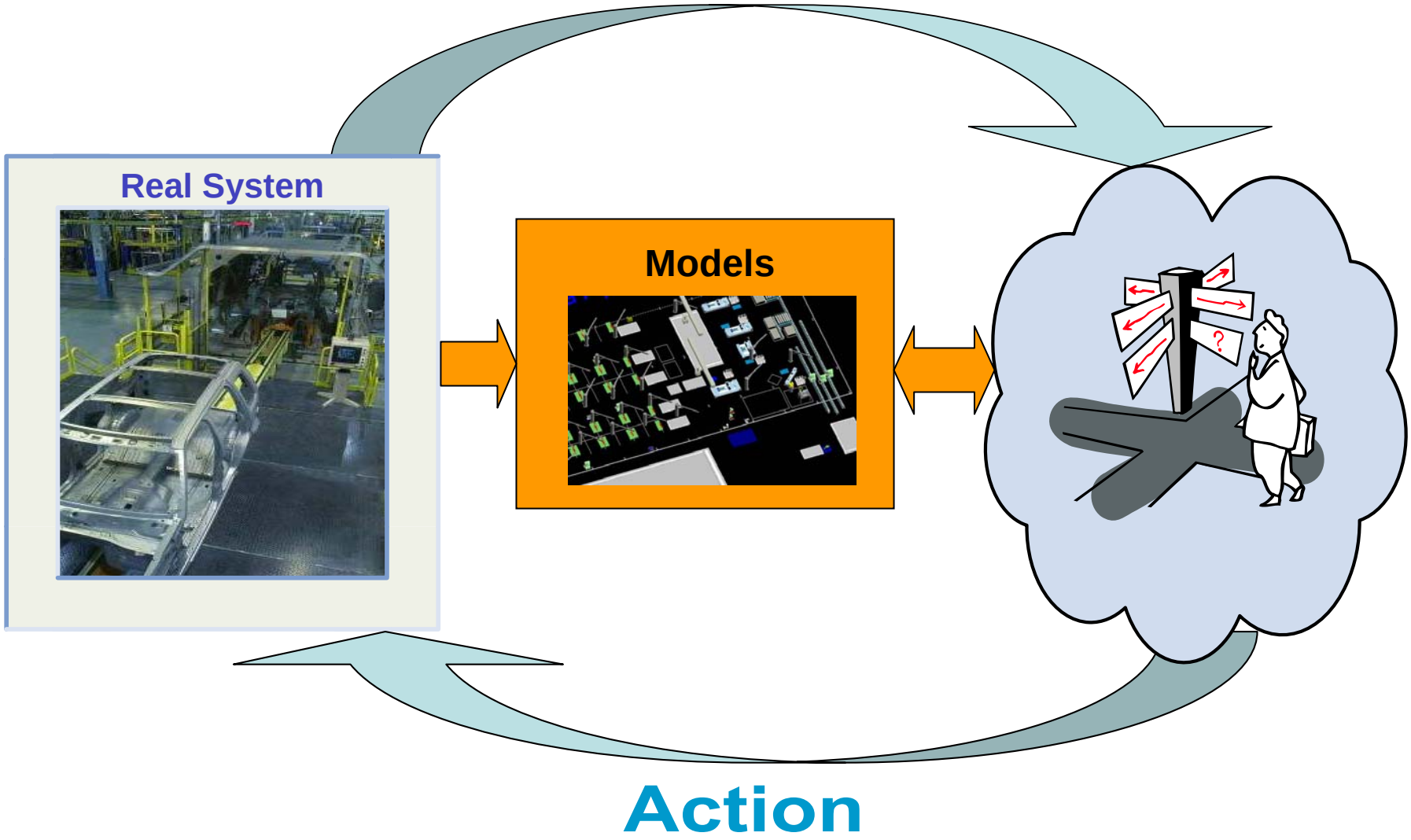
understand, analyze, design, manage, and make *decisions* about …

… complex operational processes (interdependencies + stochastic + dynamic)

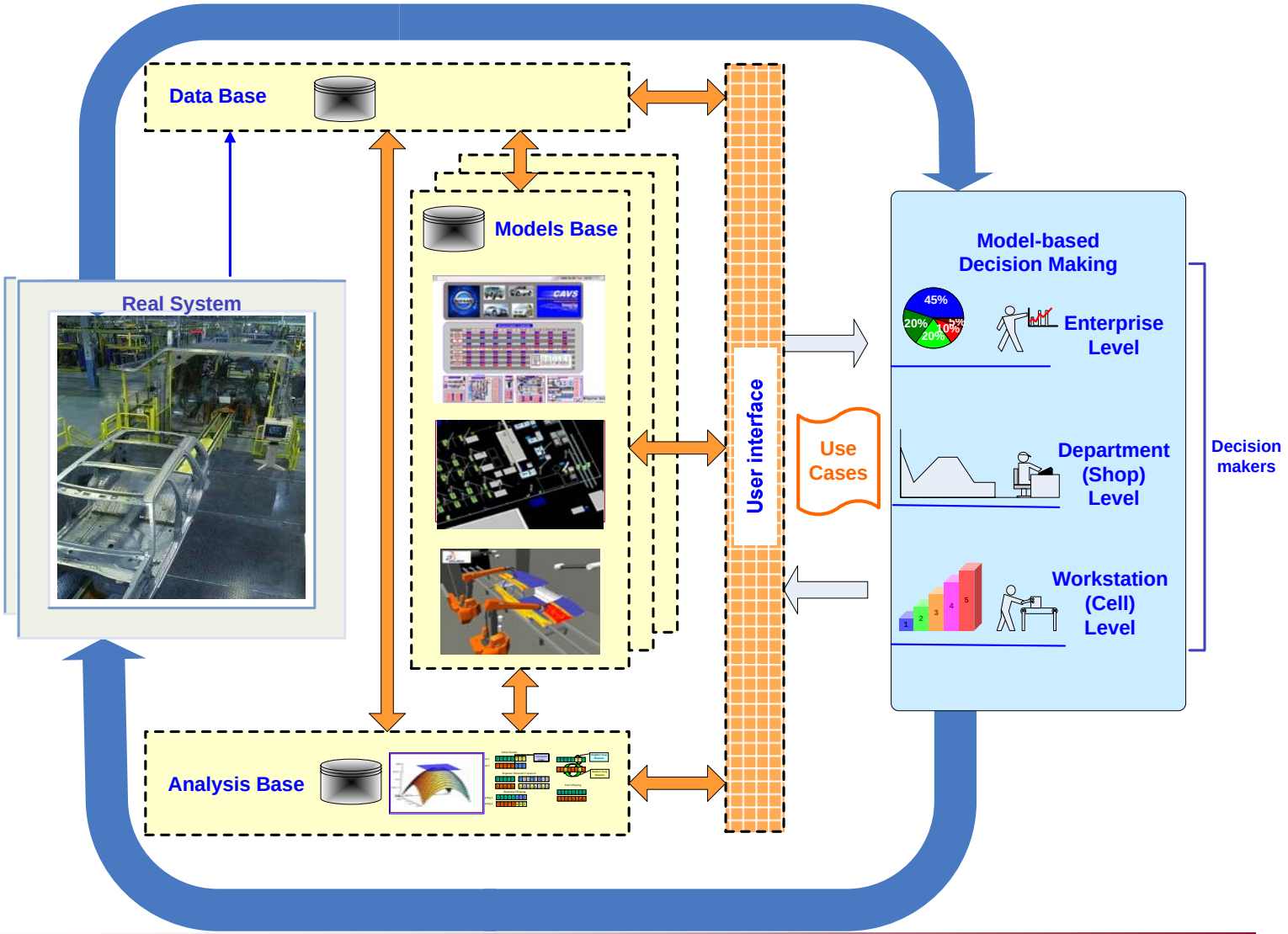
Decision Maker

Action

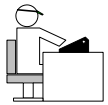
“Model-based” Decision Making



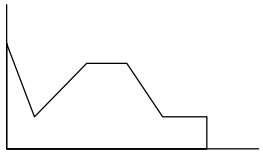
Model-Based Decision Making



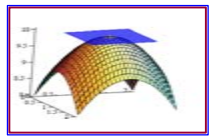
What changes need to be made?



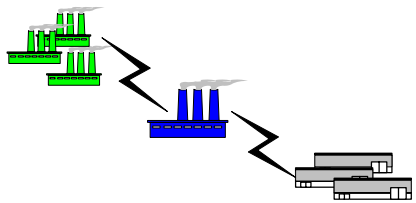
from modeler/analyst centric to decision-maker centric

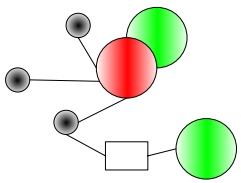


from point solutions to optimization

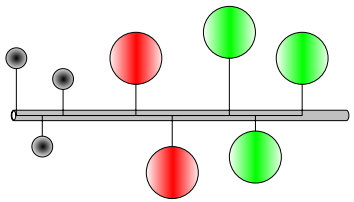


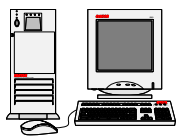
from work-cell → enterprise → supply-chain applications



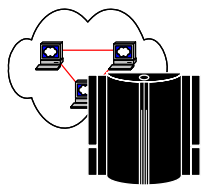


from closed, local analyses to open, distributed analyses





from PC/server based to web/GRID based



Applying the MB-DSS Approach at NGSS

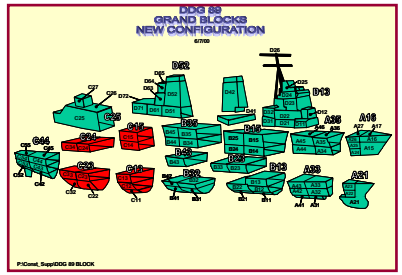
NORTHROP GRUMMAN

DEFINING THE FUTURE

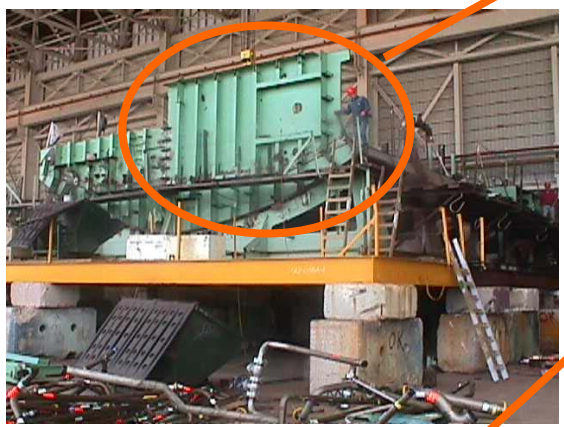
Sim-Opt DSSs for NGSS

NORTHROP GRUMMAN

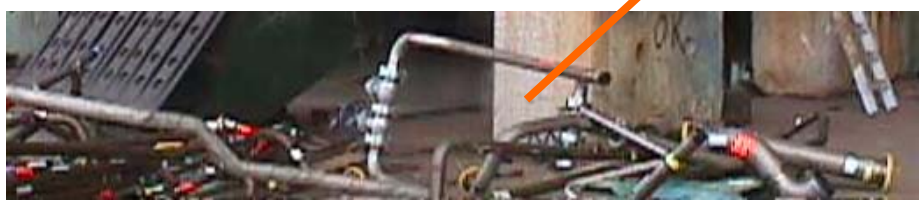
DEFINING THE FUTURE



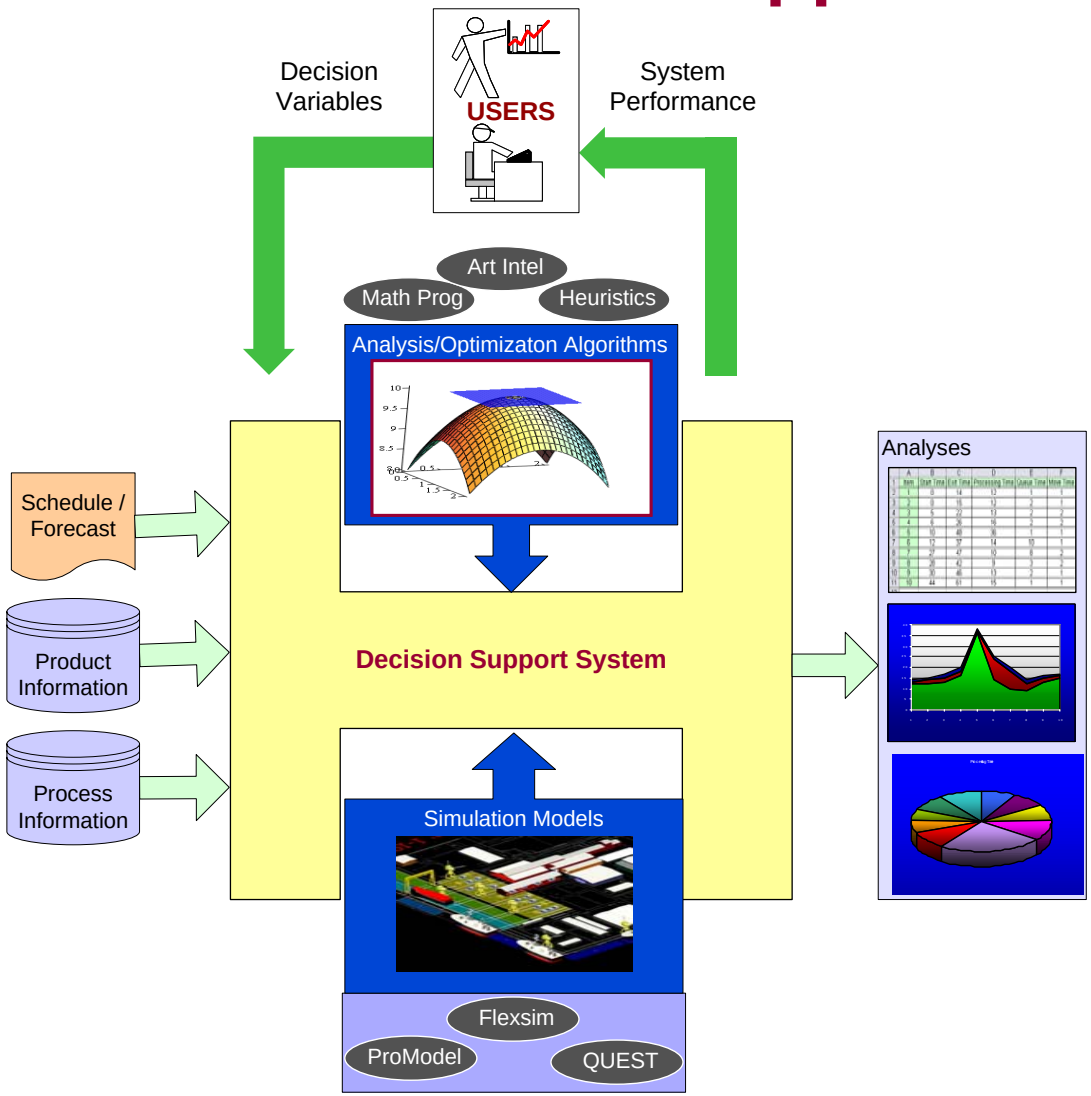
Panel



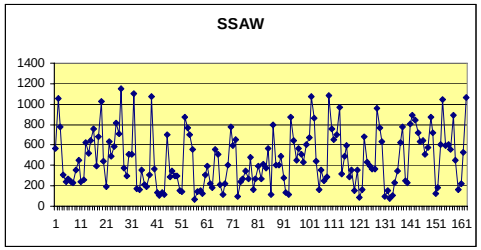
Pipe Details

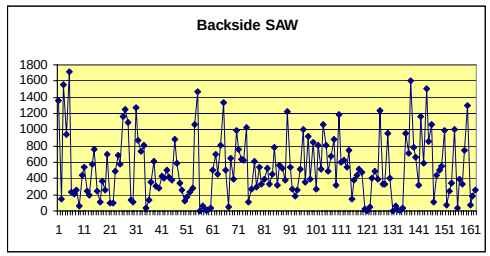


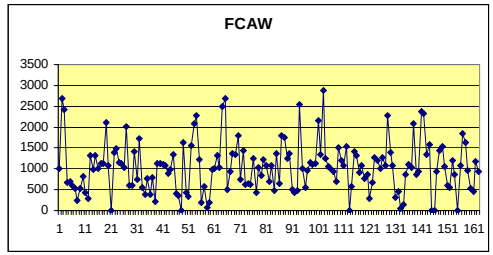
General MB-DSS Approach

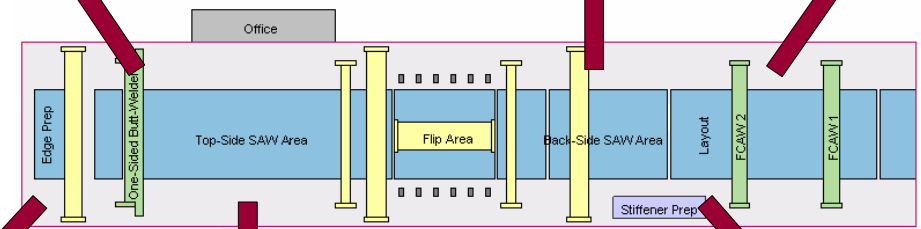


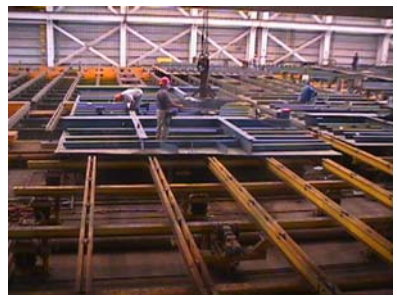
Panel Shop Problem:
Every Panel is Unique → Large variability

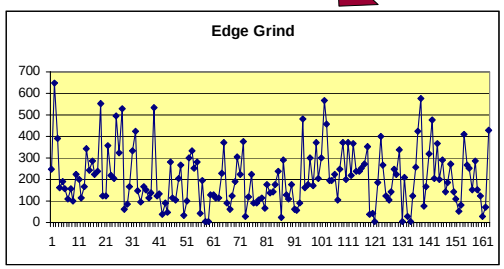


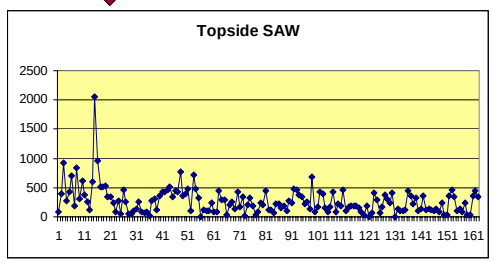


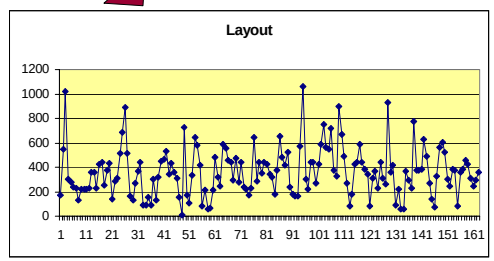








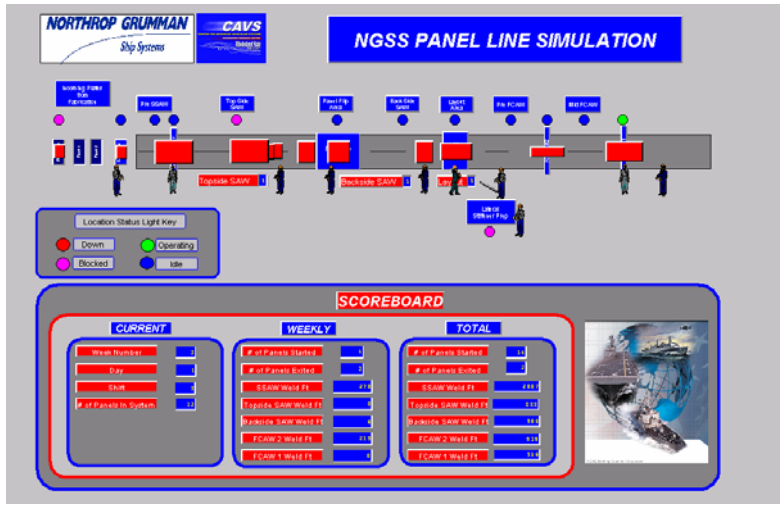




Models Used to Increase Panel Shop Throughput

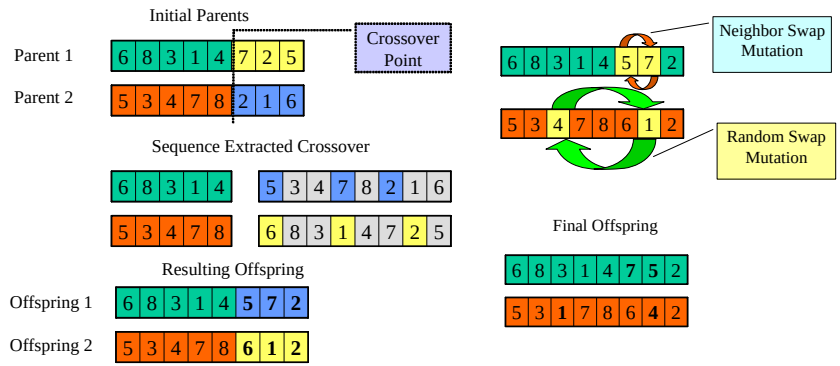
- **Simulation** model to represent behavior of production system and evaluate sequence

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



- **Optimization** algorithm to intelligently generate possible sequences

There are 1.3 trillion possible ways to sequence a 15-panel set



Evolutionary Strategy

Example Impact – Swapping 1 of 42 Panels

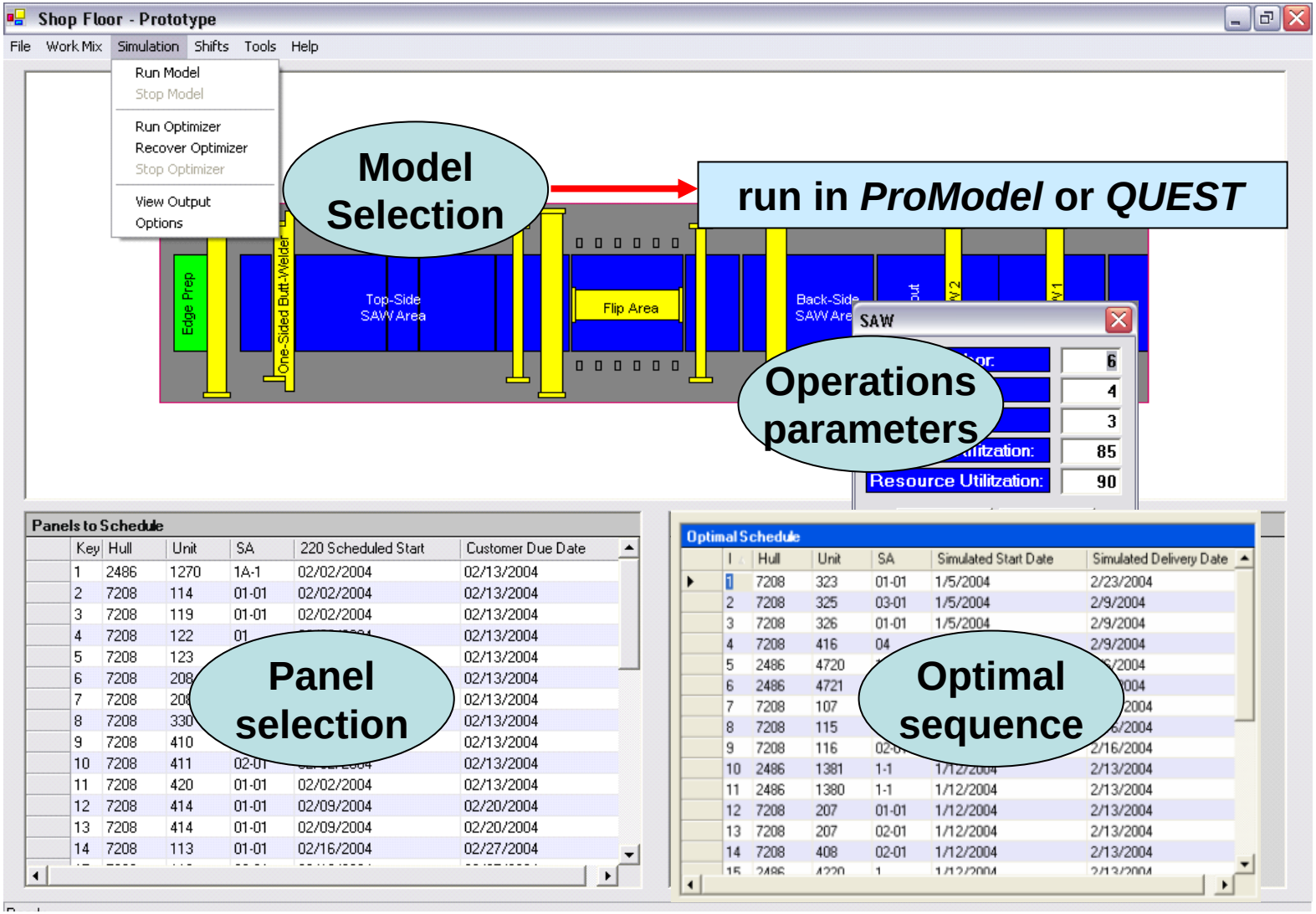
2631	2582	1-A	03/20/06	04/14/06	03/28/06	04/21/06	7.0
2631	2582	3	03/20/06	04/14/06	03/28/06	04/25/06	11.0
2631	2583	M-48	03/20/06	04/14/06	03/30/06	04/20/06	6.0
2631	2583	1	03/20/06	04/14/06	03/30/06	04/26/06	12.0
2631	2583	1-D	03/20/06	04/14/06	03/30/06	04/24/06	10.0
2631	2583	1-C	03/20/06	04/14/06	04/03/06	04/27/06	13.0
2631	2583	1-B	03/20/06	04/14/06	04/03/06	04/26/06	12.0
2631	2583	1-A	03/20/06	04/14/06	04/04/06	05/02/06	18.0
2631	3473	1-B	03/20/06	04/14/06	04/04/06	05/10/06	26.0
2631	3473	1-A	03/20/06	04/14/06	04/04/06	05/09/06	25.0
2631	3473	M-53D	03/20/06	04/14/06	04/05/06	05/11/06	27.0
2631	3473	1-47C	03/20/06	04/14/06	04/05/06	05/11/06	27.0
5215	421	01-01	03/20/06	04/14/06	04/06/06	05/15/06	31.0
							285.00

2631	2582	1-A	03/20/06	04/14/06	03/28/06	04/20/06	6.0
2631	2582	3	03/20/06	04/14/06	03/29/06	04/19/06	5.0
2631	2583	M-48	03/20/06	04/14/06	03/30/06	04/24/06	10.0
2631	2583	1	03/20/06	04/14/06	04/03/06	04/21/06	7.0
2631	2583	1-D	03/20/06	04/14/06	04/03/06	04/20/06	6.0
2631	2583	1-C	03/20/06	04/14/06	04/03/06	04/26/06	12.0
2631	2583	1-B	03/20/06	04/14/06	04/04/06	04/25/06	11.0
2631	3473	M-53D	03/20/06	04/14/06	04/05/06	05/08/06	24.0
2631	3473	1-47C	03/20/06	04/14/06	04/06/06	05/11/06	27.0
5215	421	01-01	03/20/06	04/14/06	04/06/06	05/15/06	31.0
							251.00

12% improvement

Similar solution to adding one welder to first shift for TopSide/BackSide

Intuitive User Interface for Planners & Shop Floor



Various Output Reports for Planners & Shop Floor

Output Viewer - [Reports: Resource Prescription]

File Graphs Reports Window

MainReport

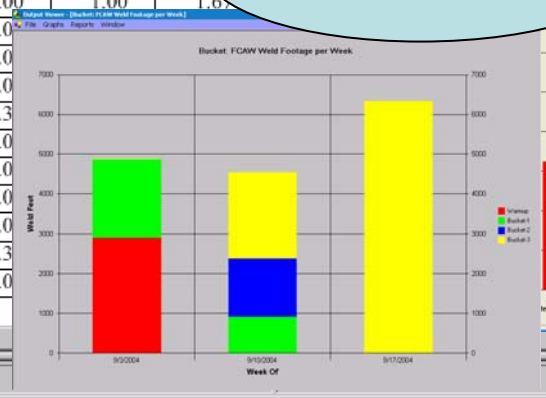
NORTHROP GRUMMAN SHIP SYSTEMS

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							

Performance

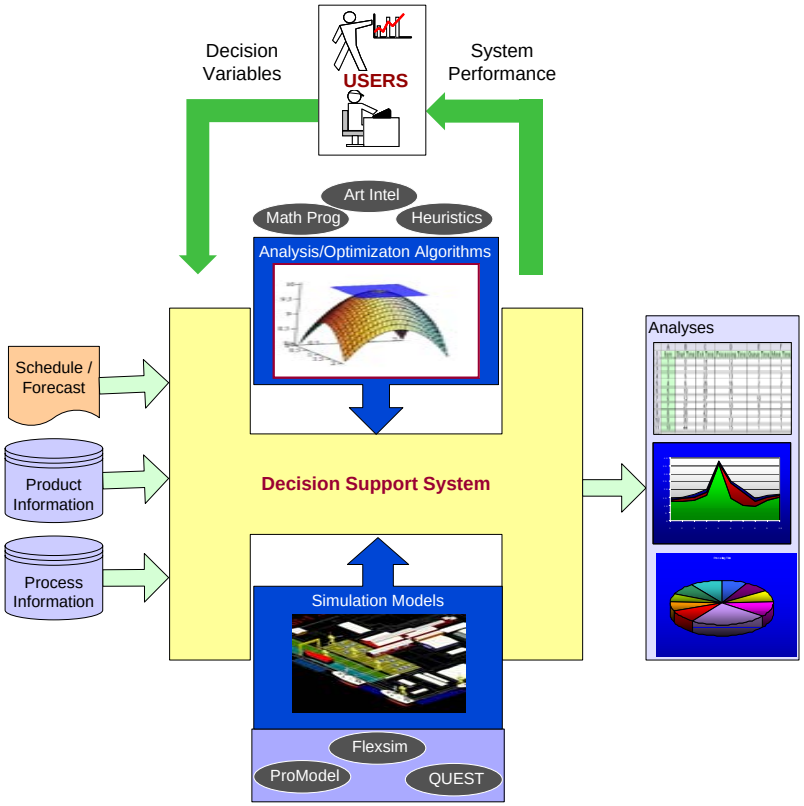


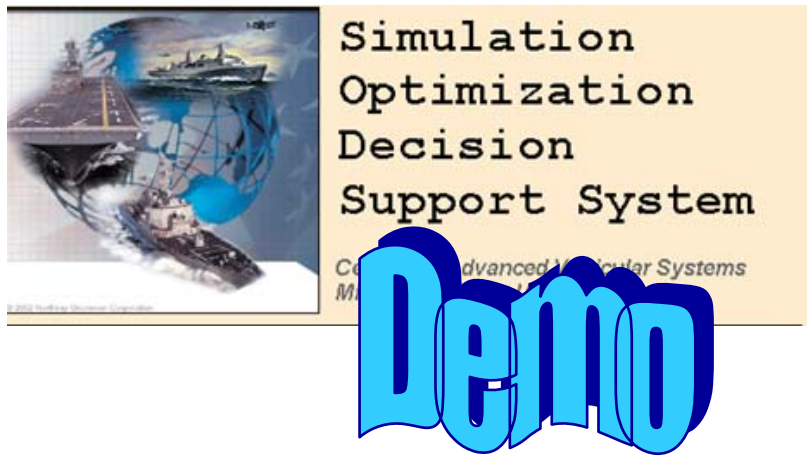
Optimal Schedule

	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

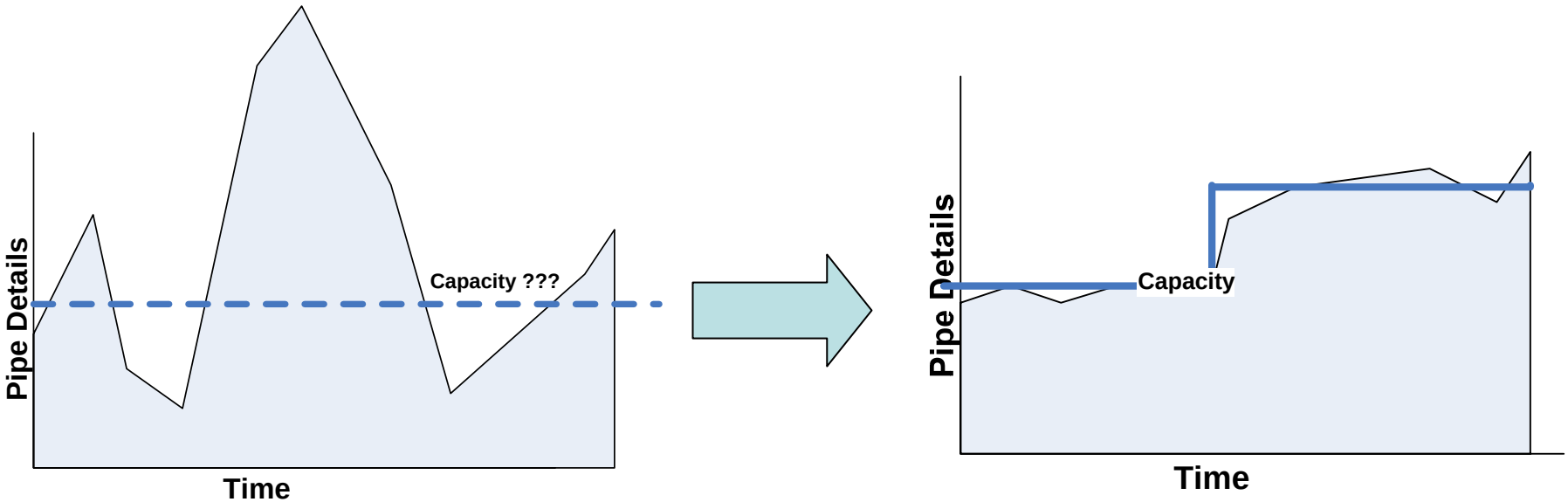
Schedule

Panel Shop DSS
Effectively Links Users With Models & Data



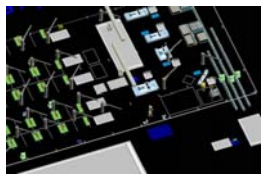


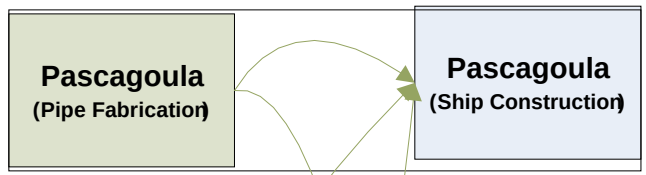
Pipe Shop Problem:
Large Variability in Demand + Unknown Capacity



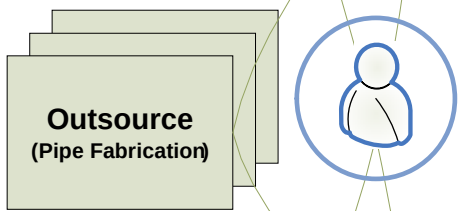
Basic Issue: What, Where, & When to Produce Each PD with an Effective Use of Resources

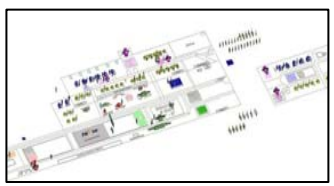
Multiple programs

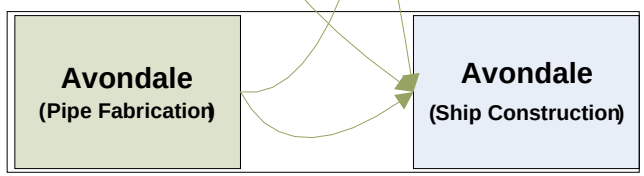




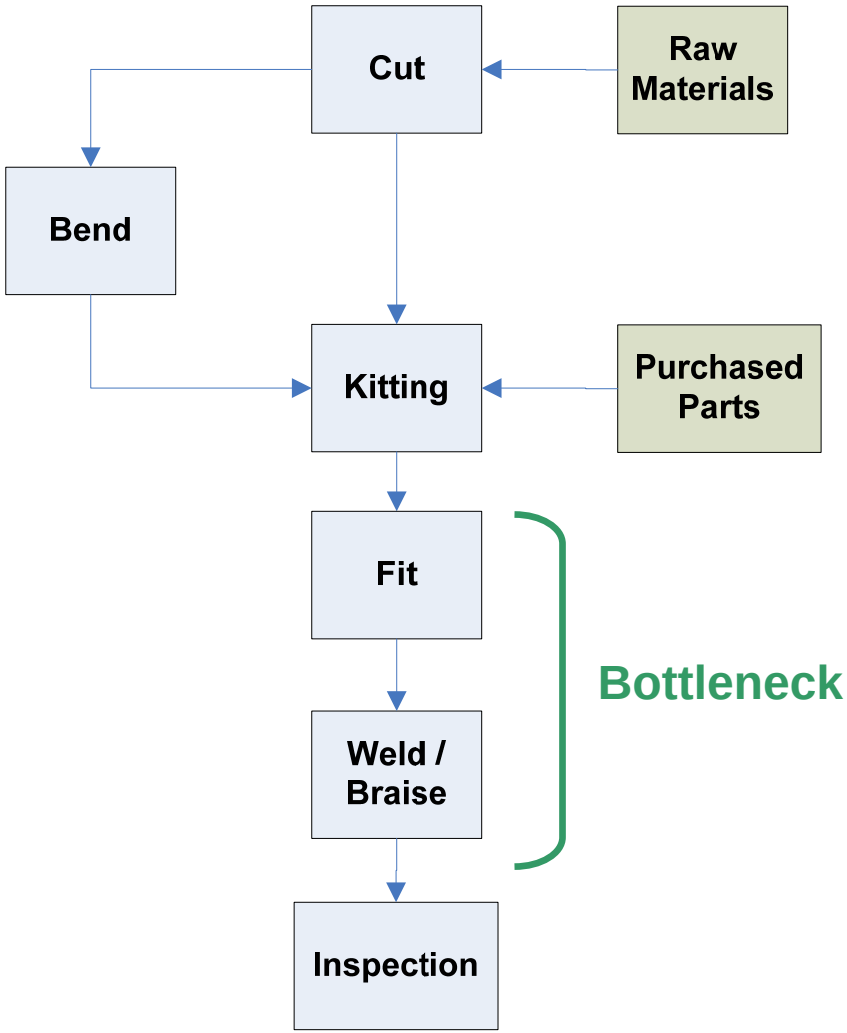
Multiple yards/shops







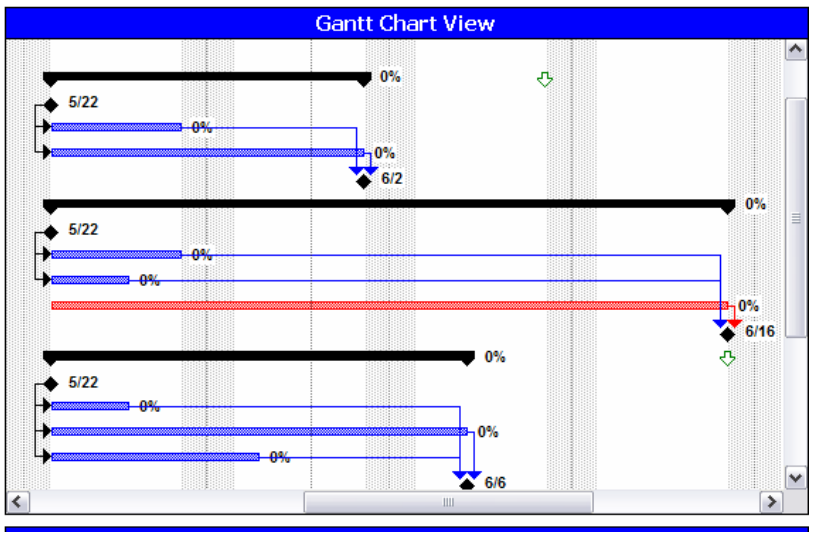
Pipe Shop Operations & DSS Approach

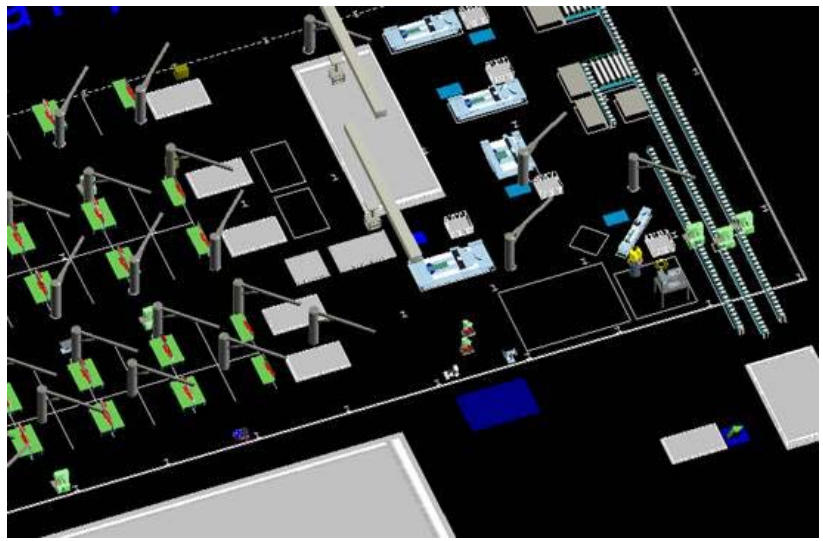


DSS Integrates Two-Levels of Models

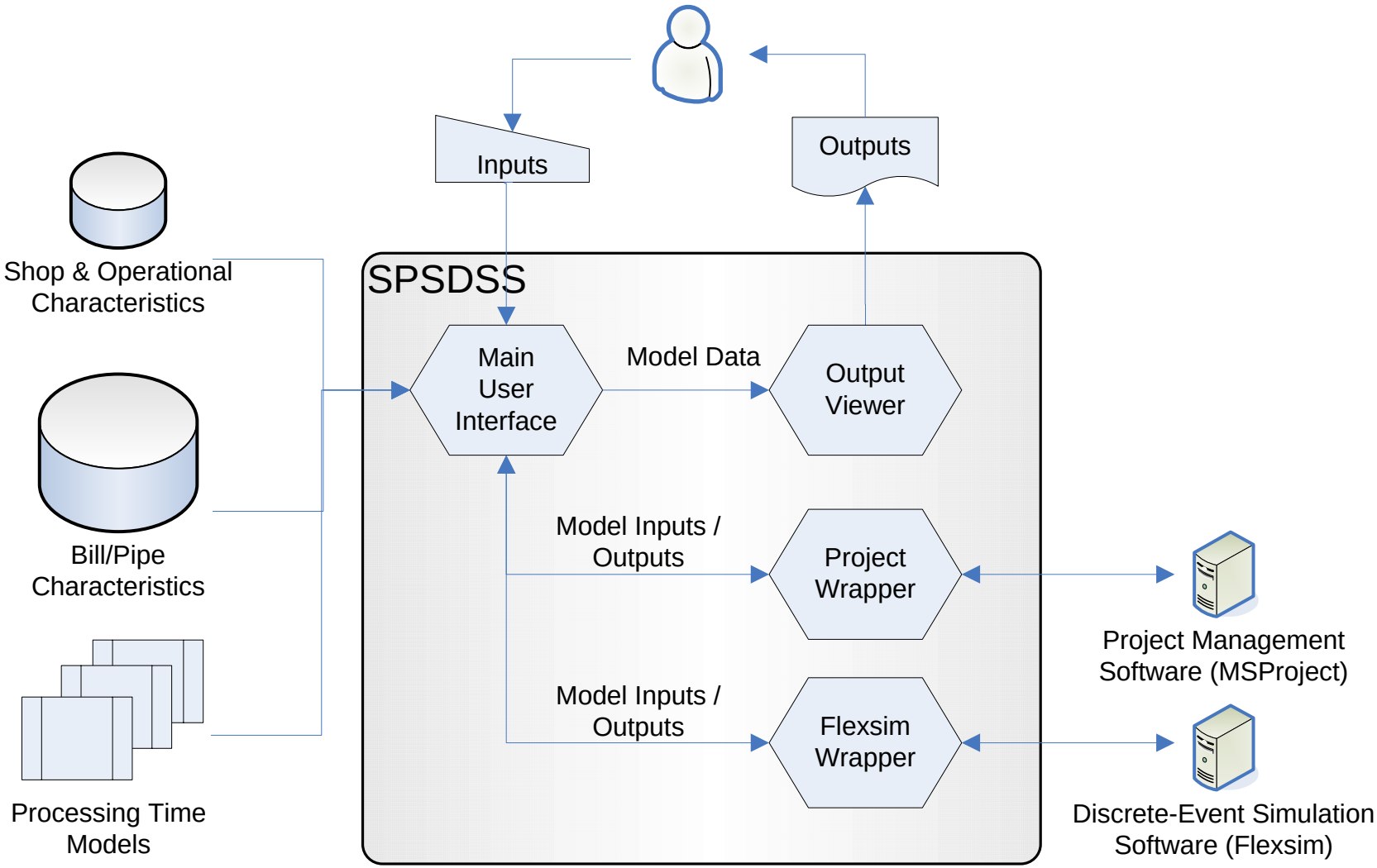
- ***Planning*** Model (high-level)
  - for bottleneck capacity planning and analysis
  - high-level operational trade-offs and production decisions
  - considers each PD as a resource-constrained project
  - scheduling using project management methodologies

- ***Operations*** Model (low-level)
  - assess plan at shop level, including all operations
  - considers interactions, variability, and dynamics
  - establish capacity for high-level model



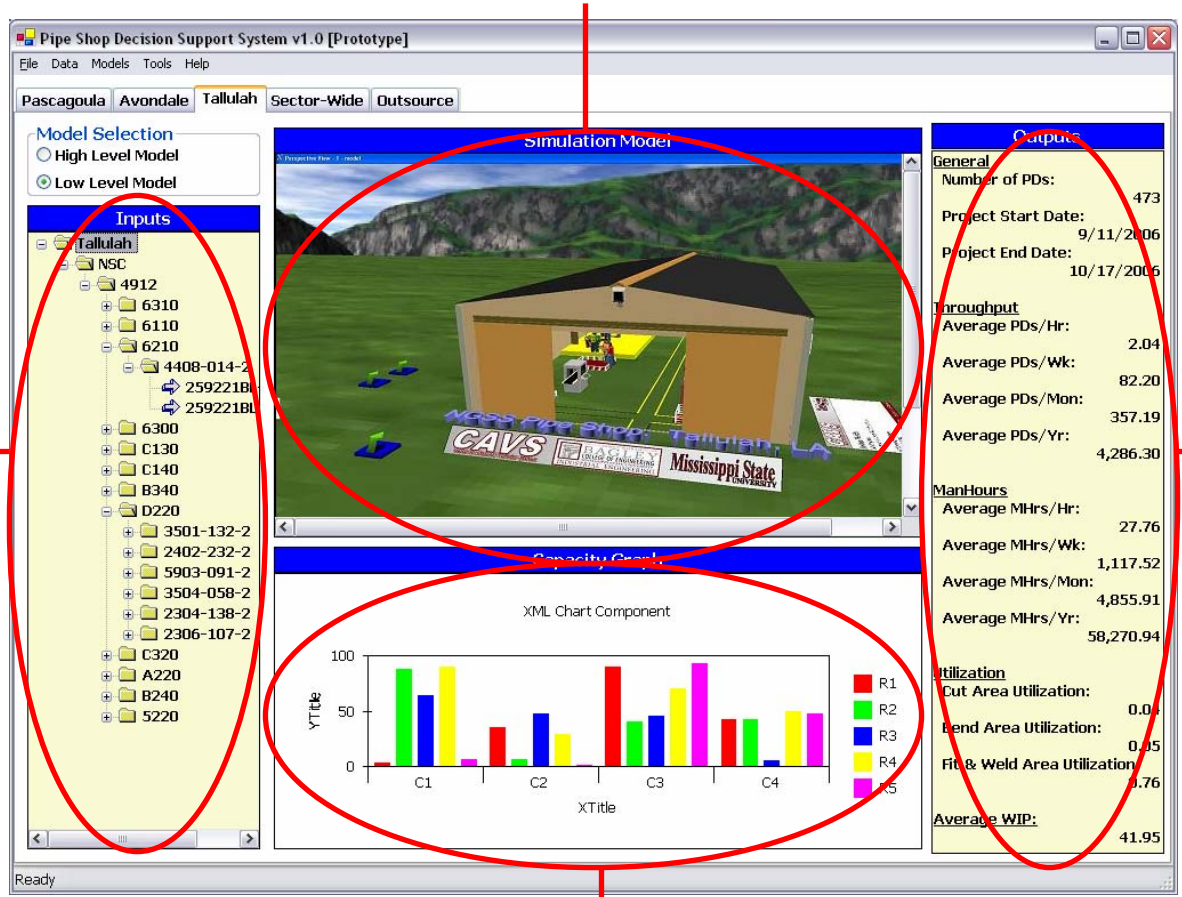


Architecture



Pipe Shop DSS Primary Interface

Current model representation



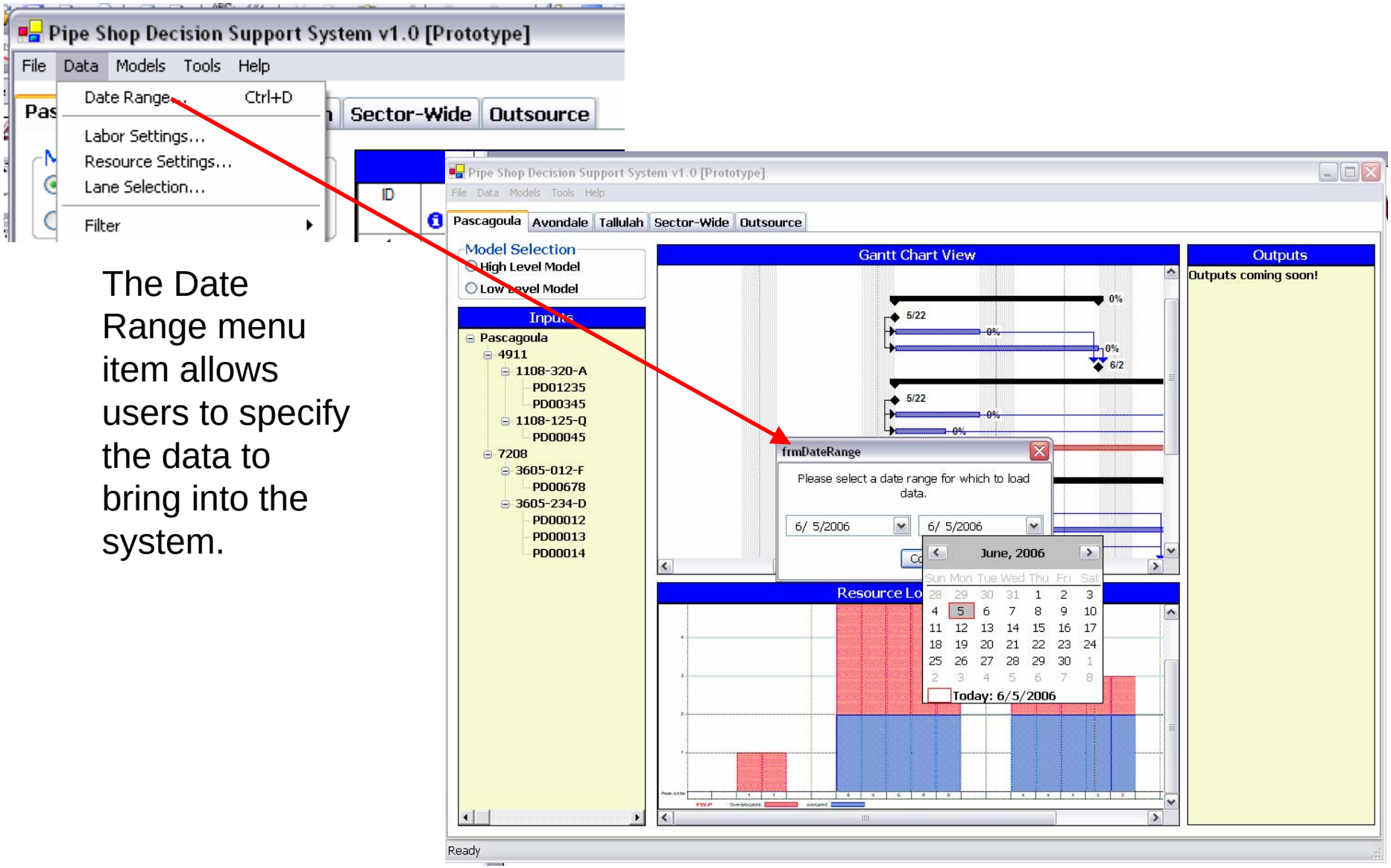
System inputs

Basic system outputs

Model chart or graph output

Basic Information Flow

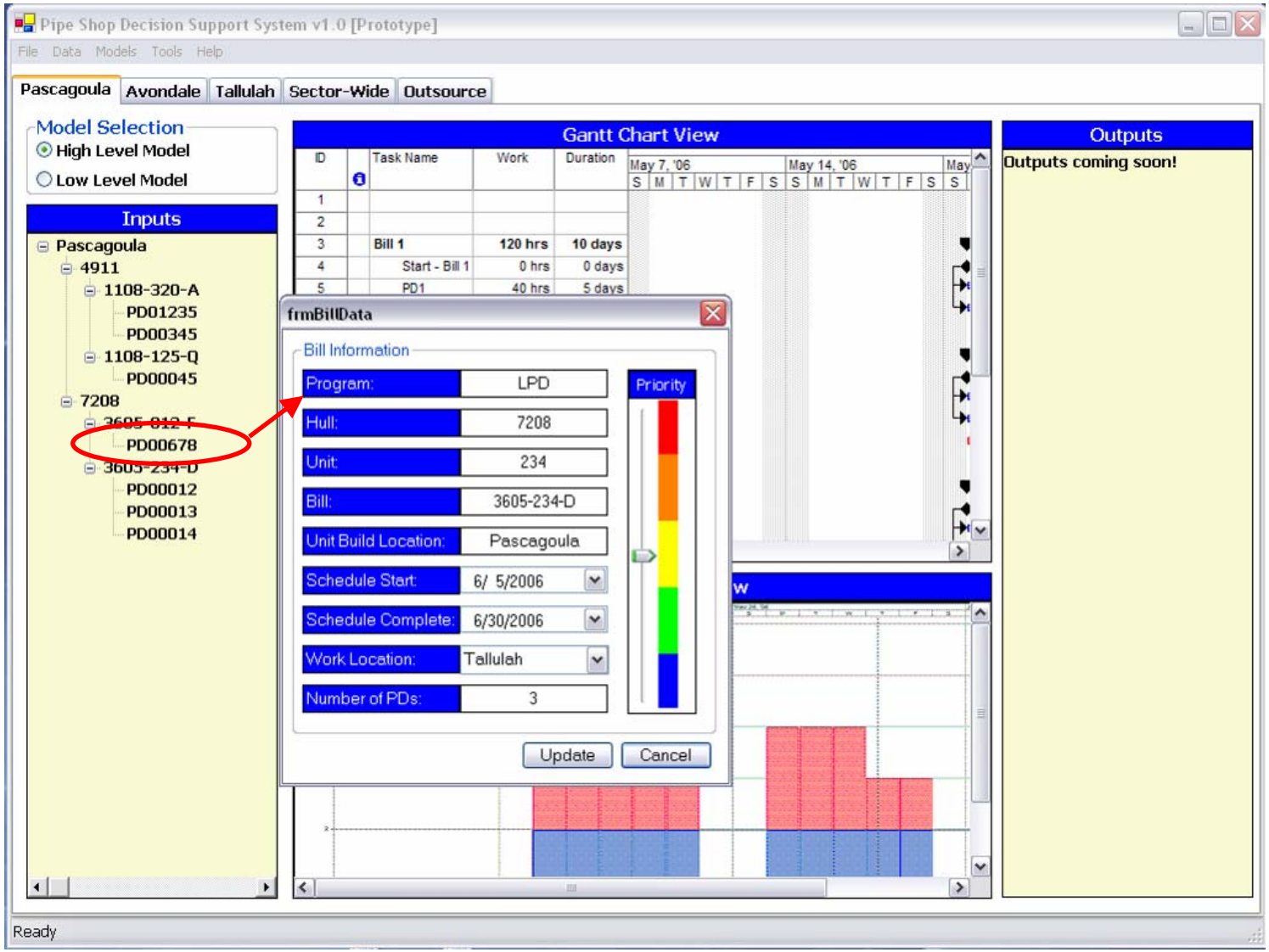
Interface to Extract Data from Central Database



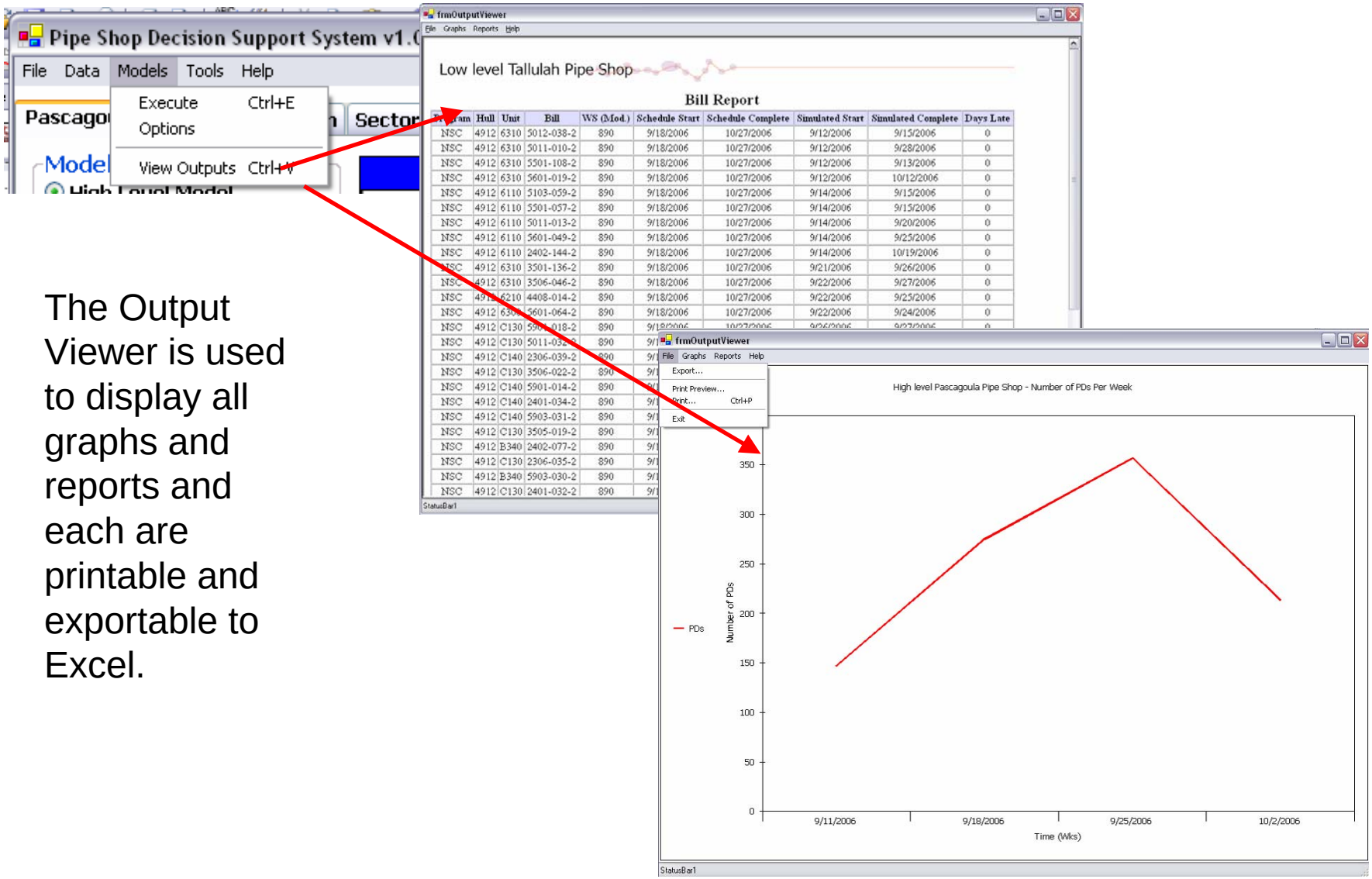
The Date Range menu item allows users to specify the data to bring into the system.

Interface to Modify Pipe Detail Attributes

Double-clicking on an input brings up related information about the selected object.



Example Output



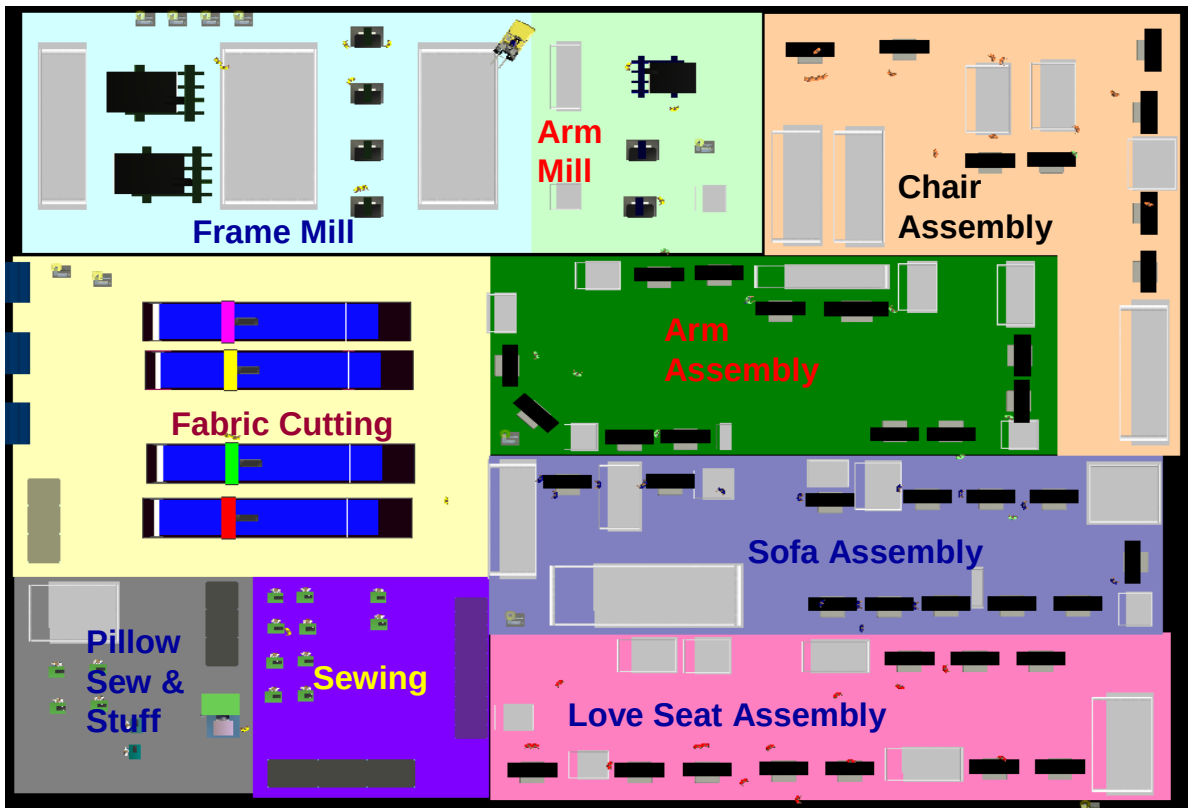
The Output Viewer is used to display all graphs and reports and each are printable and exportable to Excel.

Lean Manufacturing Flight Simulator

- **Objective**: Improve ***intuition*** about the implementation of ***lean manufacturing*** within the furniture industry. This will be accomplished by …
  - Reviewing basic principles of lean manufacturing
  - Providing the user with the ability to "experiment" with a ***simulated plant*** (i.e., manufacturing flight simulator).
  - Enhancing the understanding about relationships between key plant decision variables and performance measures.

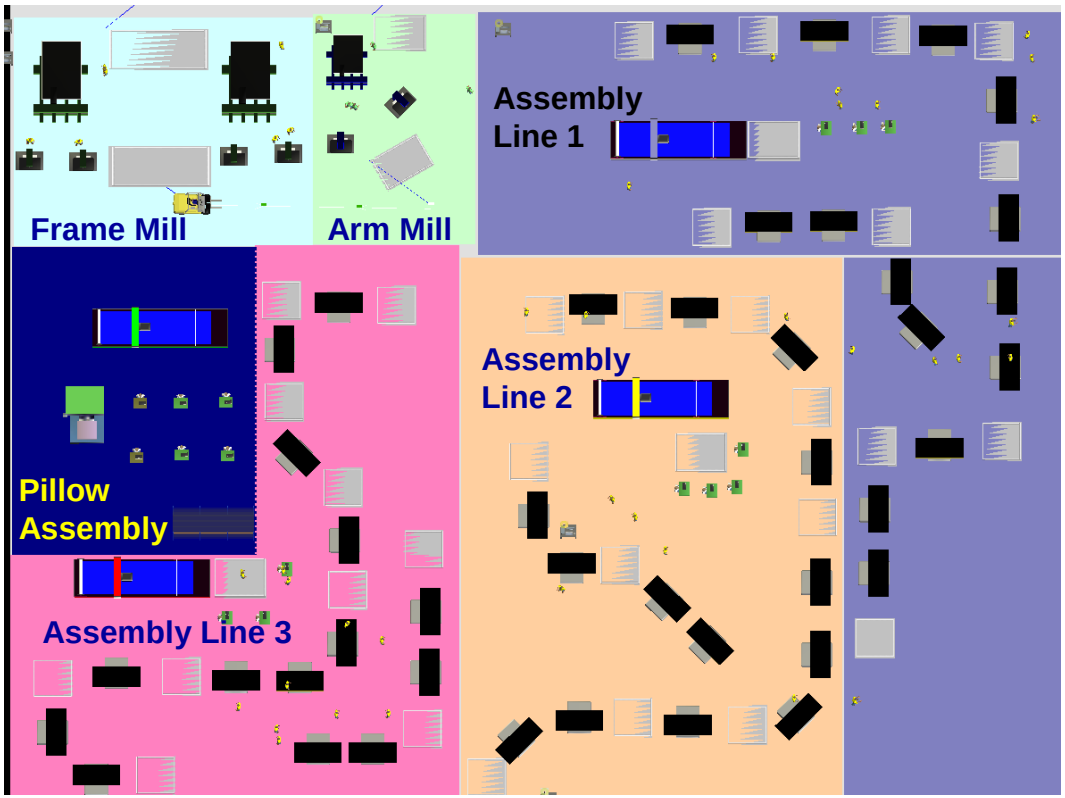
Characteristics of a Traditional Plant

- Producing to forecasts and mixes that maximize plant efficiencies.
- Similar functions grouped together
- Individual department measures focus on internal efficiencies
- Quality problems are only detected at inspection stations
- Set-up times and equipment downtimes are “givens”



Characteristics of a Lean Plant

- Focus is on throughput
- Workers are flexible and move as needed
- Dependencies between work station are exploited and managed
- Fabrication & Assembly are managed jointly.
- Significantly reduced reliance on mechanism for material movement



Experimentation Parameters

- **Product Mix –** percentage of the forecast / demand assigned to each product type
- **Setup Time –** time required to setup between product types
- **Defect Rate –** percent of products that are defective from a processor
- **Downtime –** frequency and duration of downtimes
- **Processing Time –** mean processing time for a given processor
- **Queue Capacities –** capacity levels of WIP areas

Performance Measures

- **WIP -** overall Work-In-Process of the number of units in process
- **Lead-time -** average time that an order takes to complete all operations
- **Throughput -** actual production rate in terms of completed units for each hour
- **Efficiency -** average across all workstations of the percentage of the actual to theoretical production rate
- **Performance to Schedule -** percentage of scheduled demand achieved
- **Travel -** average number of feet traveled by each unit produced
- **First Pass Quality -** percentage of units that complete production with no re-work

“Points Game”

- Users are budgeted a given number of points to spend on improving each system.
- Users can use run experiments to determine where to focus improvement initiatives.
- Users can apply points to key model areas to:
  - improve set up time
  - reduce defect rates
  - reduce downtime

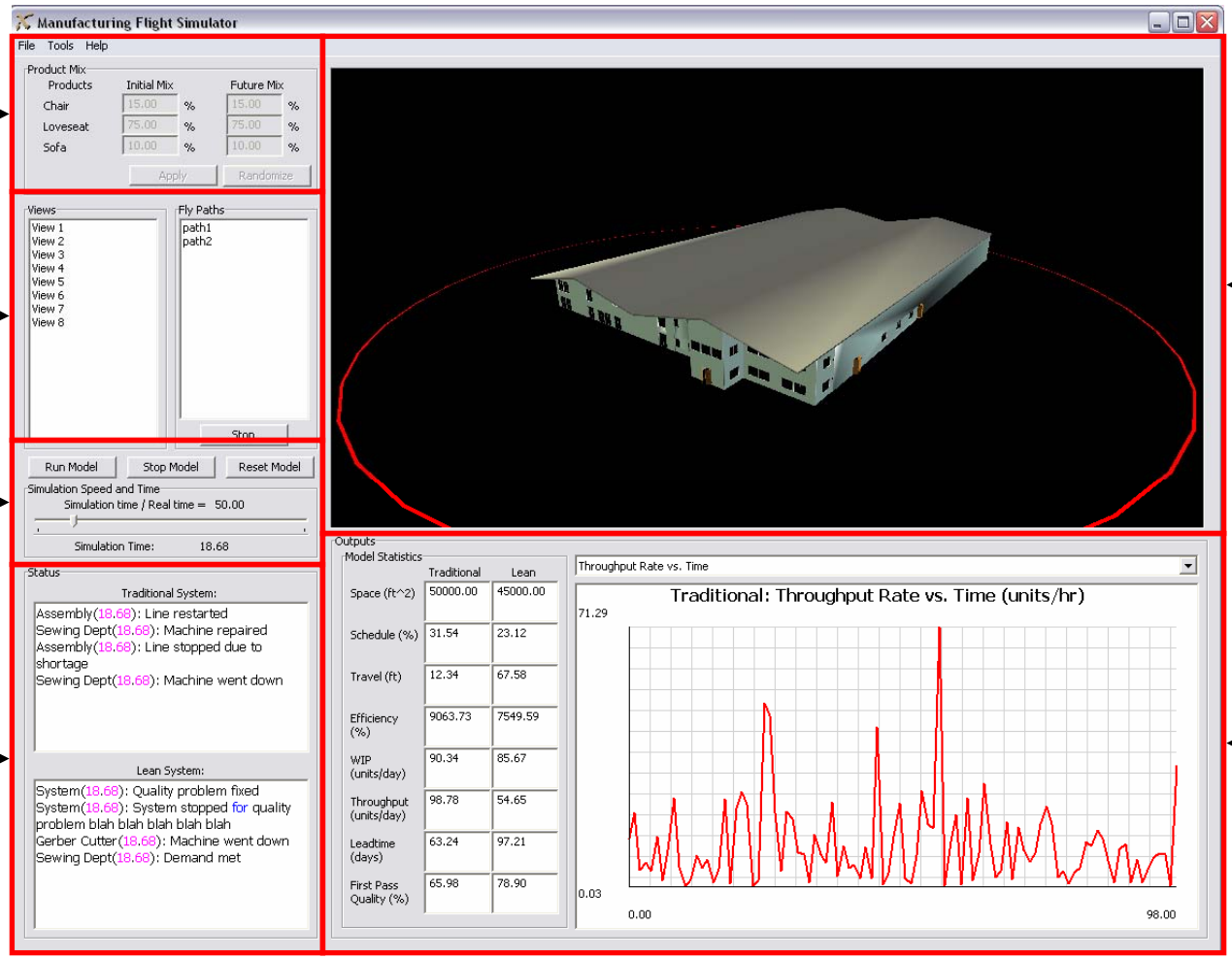
Manufacturing Flight Simulator Main Interface

Product Mix Settings

Views and Fly Paths

Model Controls

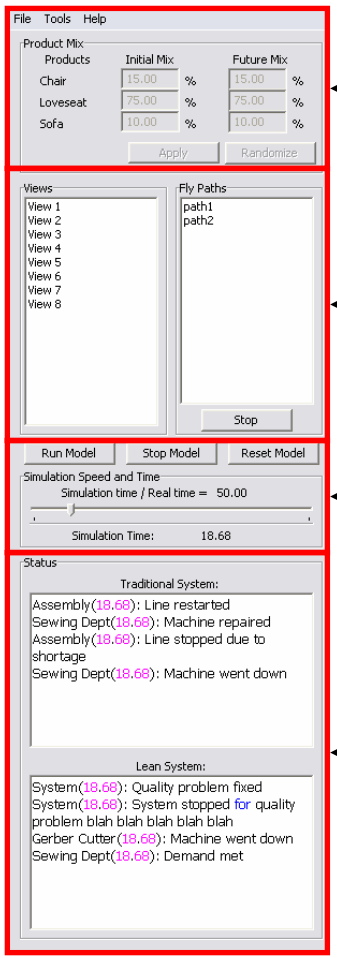
Status Window



Simulation Model View

Output Panel

Manufacturing Flight Simulator Interface



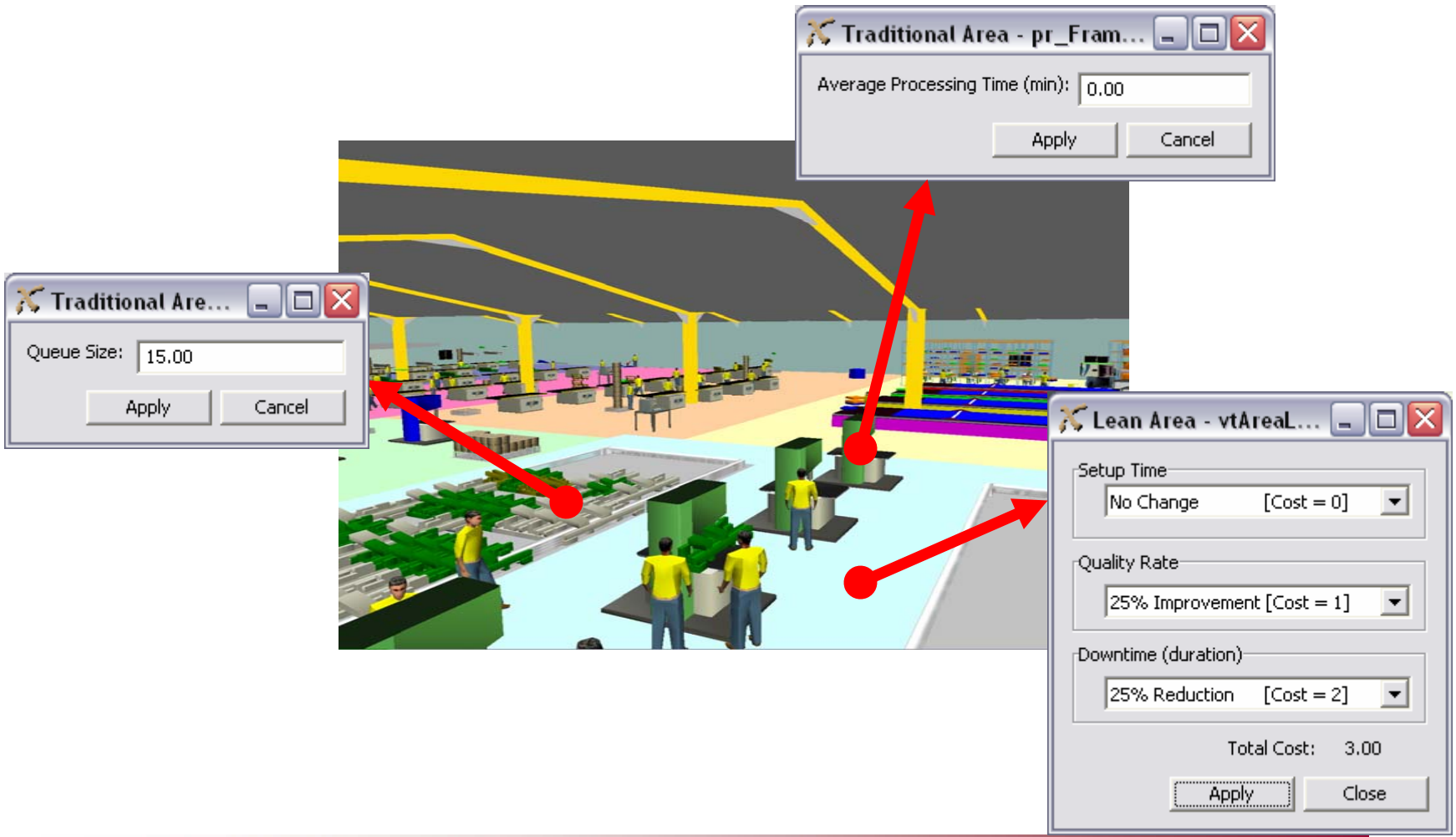
Product Mix Settings – allows users to set the production mix for the simulation model. If the future and initial mix values differ, the model changes the product mix required during the execution of the model.

Views and Fly Paths – allows users to maneuver through the simulation model

Model Controls – allows users to control the execution of the simulation model

Status Window – displays status messages from the simulation (e.g. machine breakdowns, machines coming back online, and whether production was meet for the day)

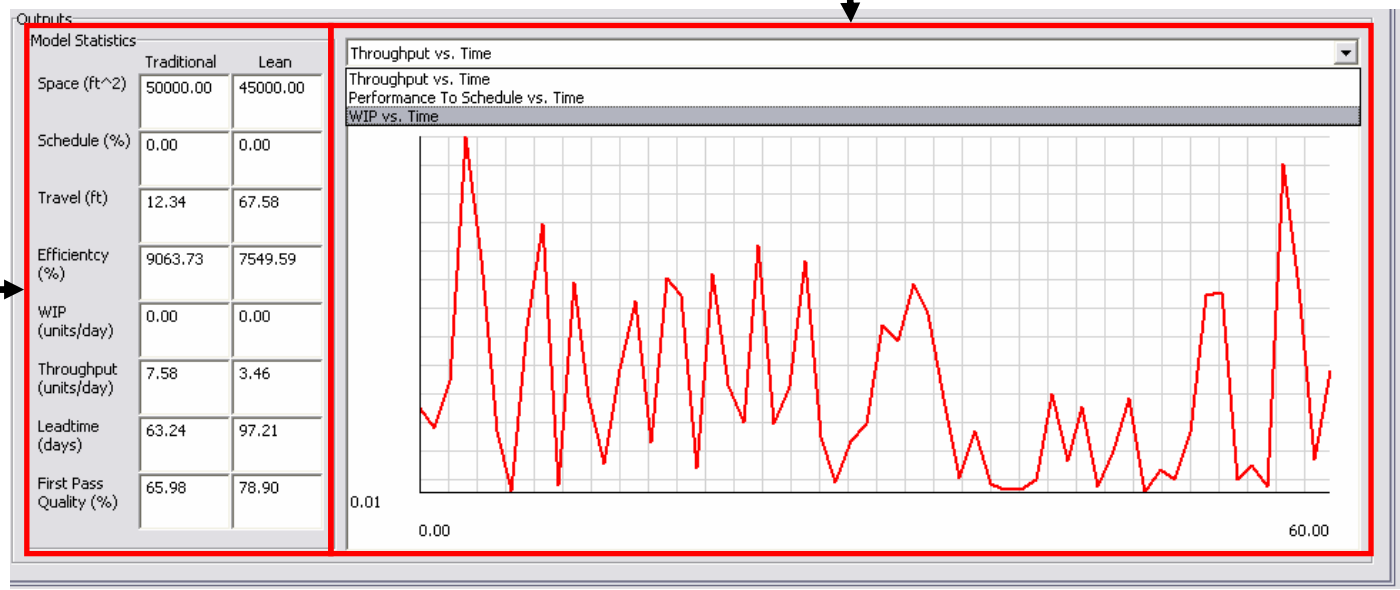
Simulation Model View



Output Panel

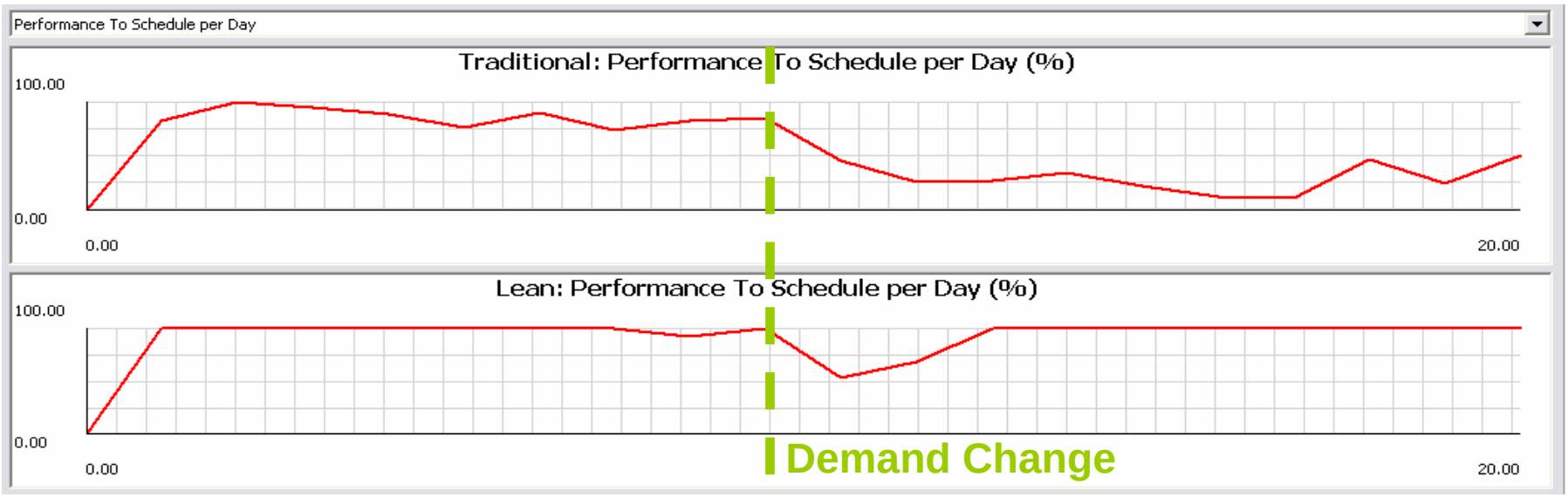
Model Statistics – displays summary statistics as the model runs

Graphical Data – displays data over time as the model runs. The user can view different graphs by selecting them in the drop down box.



System Benefits

- Ability to experiment on a more complex system
- Ability to compare global metrics such as equipment efficiency, total WIP and performance to schedule
- Ability to see how the systems react to a major change in demand

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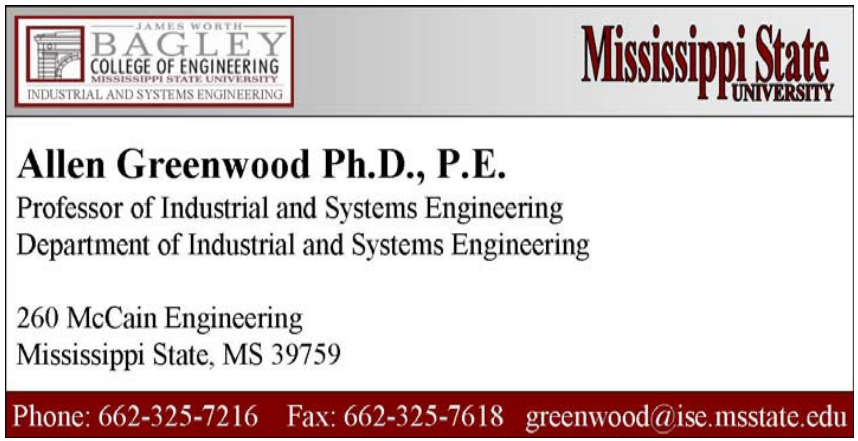
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