• An Application based Methodology for Process Simulation

by

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What's Ahead ...

- Simulation methodology in Practice
- Simulation guidelines
  - Technical guidelines
  - Managerial guidelines
  - Elements of failure
  - Elements of success
- Case Study of Integrated Industrial Engineering Methods with Simulation

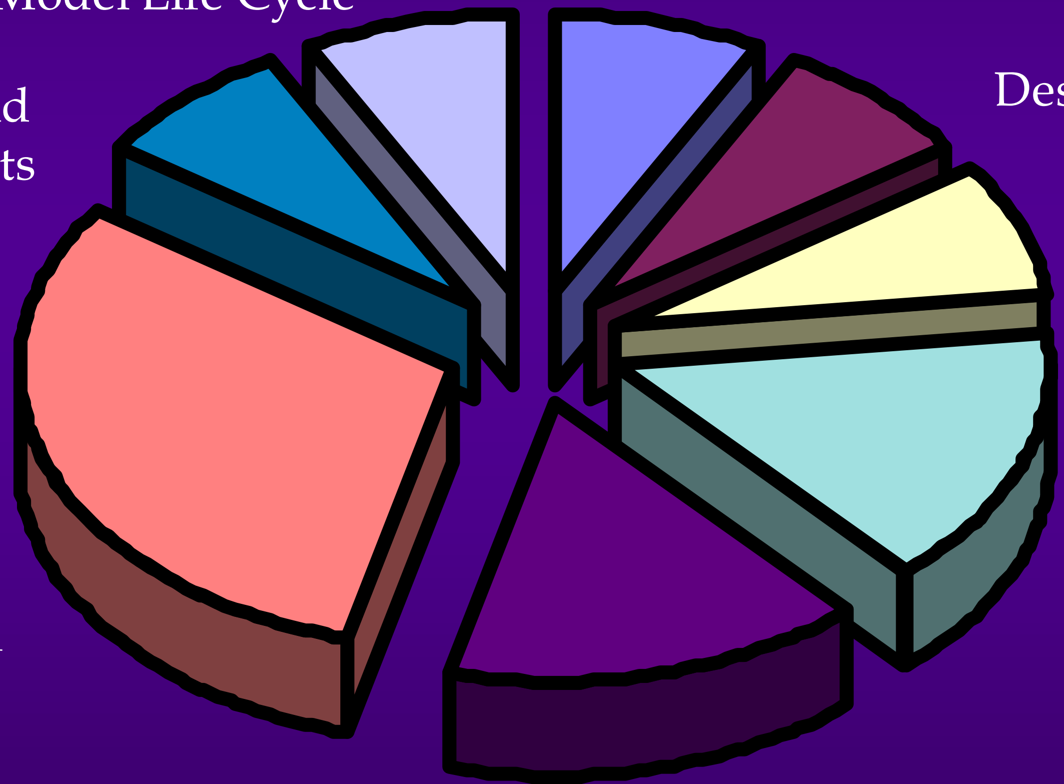
• *Phases of Simulation*

1. Define the problem
2. Design the study
3. Design the conceptual model
4. Formulate inputs, assumptions, and process definition

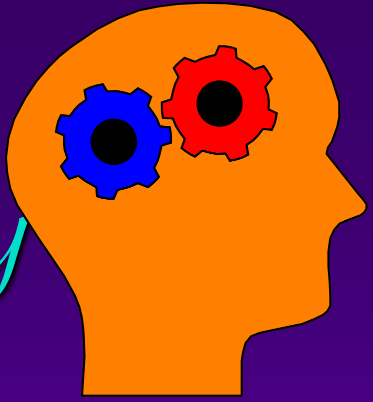
• *Phases of Simulation (cont'd)*

5. Build, verify, and validate the simulation model
6. Experiment with the model and look for opportunities for design of experiments
7. Document and present the results
8. Define the model life cycle

Phases of Simulation (cont'd)



Simulation Methodology



- The eight phases of simulation provide a recipe for analysis success
- Each phase has from 4 to 13 activities for completion
- Each phase has a documentation deliverable associated with it

Phase 1: Define the Problem

- Focus:
  - What questions will we ask the model?
  - What do we want to achieve?
  - What is the scope/boundary?
  - How much work/time will it take?
- Deliverable:
  - Formal proposal document

Phase 2: Design the Study

- Focus:
  - Estimate model life cycle
  - Describe how performance will be measured
  - Determine project timing and priority
- Deliverable:
  - Project functional specification document

Phase 3: Conceptual Model

- Focus:
  - Describe the "real" system in abstract, modeling terms
  - Determine the level of detail
  - Decide on statistical output interpretation
- Deliverable:
  - General model specifications document

Phase 4: Formulate Inputs, Assumptions and Process

- Focus:
  - Process logic definition
  - Analysis of input data
  - List modeling assumptions
- Deliverable:
  - Detailed model specifications document

Phase 5: Build, Verify and Validate the Model

- Focus:
  - Construction and coding
  - Verification and validation
  - Calibration
- Deliverable:
  - Validated base model

Phase 6: Experiment with the Model

- Focus:
  - Determination of cause and effect relationships
  - Identification of major influences
  - Analysis of results
- Deliverable:
  - Simulation Results documentation

Phase 7: Documentation and Presentation

- Focus:
  - Communication of results
  - Communication of methods
  - Maintenance and user documentation
- Deliverable:
  - Final report documentation

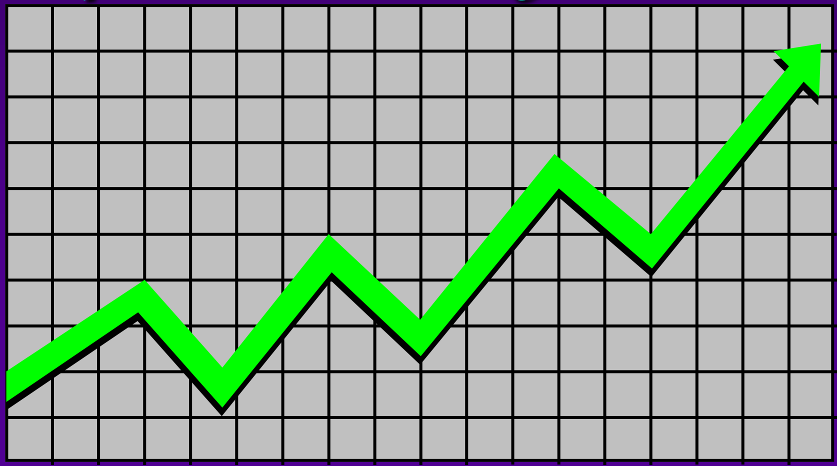
Phase 8: Model Life Cycle

- Focus:
  - Field validation tests
  - User friendly I/O interfaces
  - Model training and responsibility
- Deliverable:
  - Formal proposal document

Input Data Analysis

- Why is it important?
  - G-I-G-O (Garbage In …)
  - Need to accurately capture individual component behavior
  - Need to identify "patterns" that describe the variability of system components

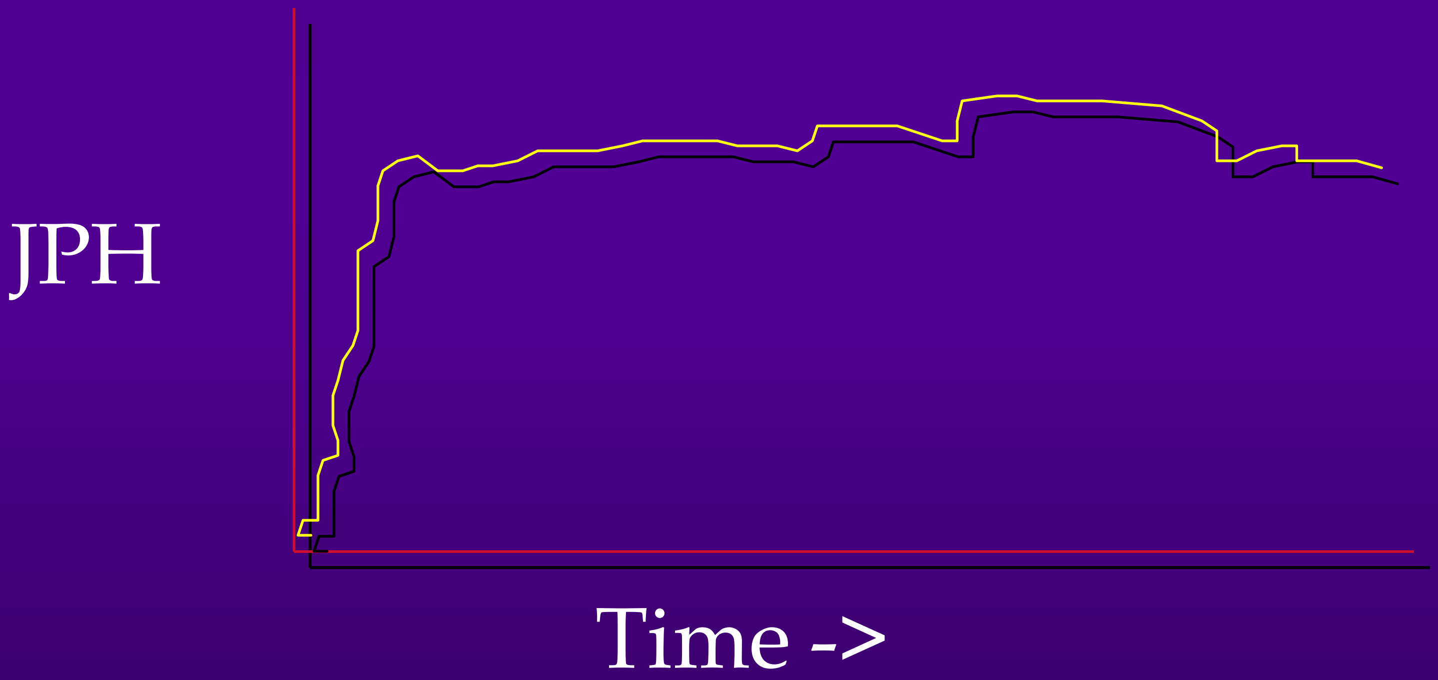
• *Simulation Output Analysis*



- Run Length
- Replications
- Output Analysis
- Bottleneck Analysis

• *Run Length (cont'd)*

- Warm-up plot



Bottleneck Analysis

- Compare the busy, idle, down and blocked time of each work station
- Compare the average number of parts in each buffer and on each conveyor segment
- Perform sensitivity analysis to identify which parameter has to most impact

Bottleneck Analysis (cont'd)

- General characteristics of a bottleneck work station
  - Lowest blocked time
  - Lowest idle time
  - Highest busy time
  - Upstream buffers are mostly full
  - Downstream buffers are mostly empty
  - Upstream workstation are blocked
  - Downstream workstations are idle

Simulation Guidelines

- Technical guidelines
- Managerial guidelines
- Elements of failure
- Elements of success

Technical Guidelines

- Clearly define objectives
- Diagram process flow
- Understand the model life cycle
  - New vs. existing systems
- Start with a simple model, add complexity later as needed

Technical Guidelines (cont'd)

- Get users involved in model building
- Be familiar with the data collection process - question the data
- Verify the model by making deterministic and extreme condition runs
- Validate the model against actual data

Technical Guidelines (cont'd)

- Be conservative in determining the experimental conditions
- Use ranges (based on statistical calculations) rather than point estimates
- Use time based plots for the major performance metrics
- Start documentation from day one of the study

Managerial Guidelines

- The project team should involve all key decision-makers on the problem
- Identify one main user for the study and get his/her time commitment for the study
- Make sure the main user (engineer) is involved with the study in all phases of the simulation project

Managerial Guidelines (cont'd)

- Make it clear to the project team what type of results can and cannot be expected from the study
- Report results as soon as possible and as often as possible
- Work with many milestones throughout the project

Managerial Guidelines (cont'd)

- Make sure all parties involved with the study hear about the results
- Get input and resolve conflicts before going to the next step of the study
- Control and document changes to the project

Managerial Guidelines (cont'd)

- Focus more on the objective than on the model
- There is no end to more detail and experimentation
  - Stop at the detail level necessary to produce accurate estimation of performance measures

• *Elements of Failure*

- Modeling for animation only
- Modeling for the model's sake
- No predefined performance metrics
- No documentation of communication of underlying assumptions and logic

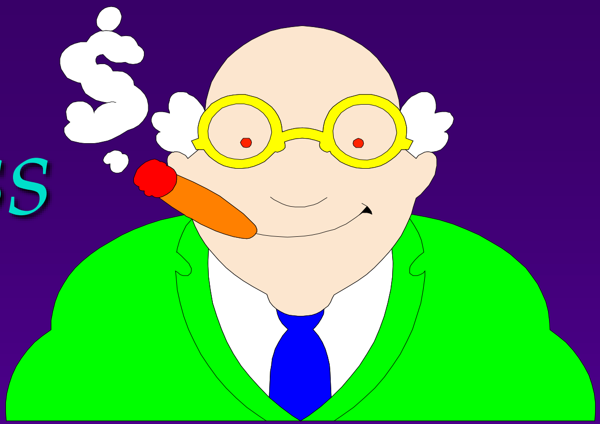
Elements of Failure (cont'd)

- Improper input data statistical analysis (or none)
- Improper statistical methods (or none) for comparison of alternatives
- No pre-definition of scope and objective

Elements of Failure (cont'd)

- Improper level of detail (usually too much)
- No pre-definition of system boundaries

Elements of Success



- Ask the question:
  - "What do I want to know from this simulation and how will I measure it?"
- Draw firm system boundaries
- Determine the correct level of detail
- Decide what scenarios you want to evaluate

Elements of Success (cont'd)

- Project Management
  - Use a proven, structured methodology
  - Stick with it
  - Use a PM tool for planning and tracking
  - Keep notes on what you did right and what you did wrong
  - Document everything

Case Study: Material Flow and Indirect Labor Study

Agenda

- **Overview**
- **IE Studies**
- **Static and Dynamic Simulation**
- **Results and Conclusions**

Case Study: Material Flow & Indirect Labor Study

Overview

Overview

A major study was performed at a manufacturing plant to identify opportunities for efficiency improvements:

- The study generated recommendations for indirect labor and material flow improvements for current and future state operations.
- The recommendations provided input to management about resource improvement proposals for local Union contract negotiations.
- Various indirect labor assignments were evaluated including material handling equipment, i.e. forklift drivers, tugger drivers, crane operators, die setters, and stock chasers.

Case Study: Material Flow & Indirect Labor Study

Overview

Overview

Various data collection and analysis techniques were used in the project:

- Traditional IE studies for the development of time standards.
- Material flow analysis using static simulation.
- Dynamic resource simulation under varying production schedules.
- Resource evaluation using forklift and tugger monitoring system.
- Bar coding techniques for improved operational efficiencies.

Case Study: Material Flow & Indirect Labor Study

Overview

Overview

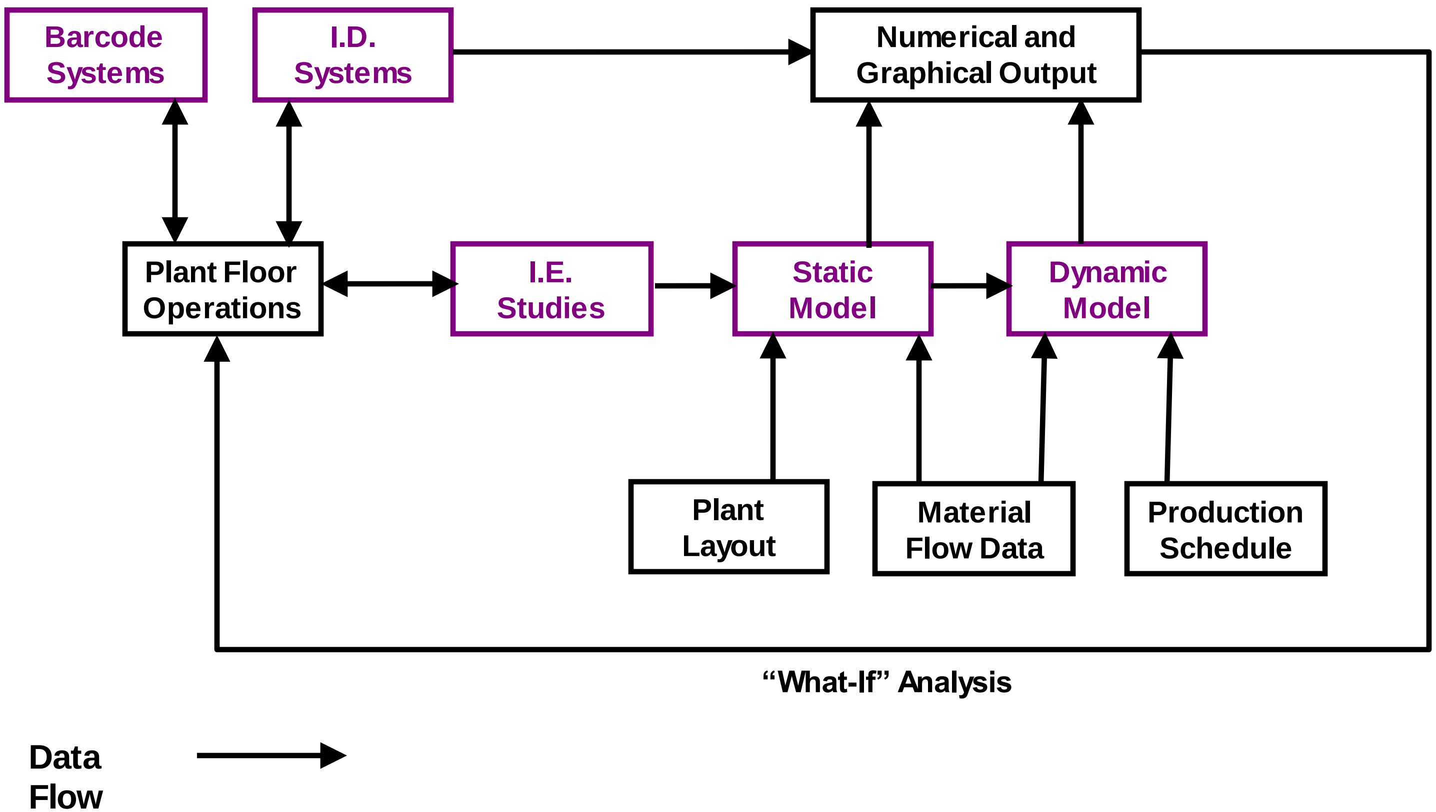
The planning and operation simulation tools developed by PMC for this study provide the following benefits:

- Allows **change impact evaluation** for various indirect resources for both the short-term and long-term planning horizons.
- Tools are usable by trained plant personnel for what-if studies related to both current-state **schedule fluctuations** and future-state **program changes.**
- Material flow model interfaces with plant AutoCAD layout and can be effectively updated as changes occur to the layout.

Case Study: Material Flow & Indirect Labor Study

Integrated Approach Flow Diagram

Integrated Approach to Indirect Labor Analysis



Case Study: Material Flow & Indirect Labor Study

Project Savings

- **Summary**
  - (21) Worker Assignments could be re-allocated on an immediate basis.
  - (14) Worker Assignments could be re-allocated with implementation of infrastructure improvement recommendations and analysis of ‘residual functions’.
  - (24) Worker Assignments could be re-allocated with Union consent, if classification changes are implemented.

  These re-allocations represent a potential savings of $ 4.15 Million, in addition to the associated equipment and maintenance cost savings.

Case Study: Material Flow & Indirect Labor Study

IE Studies

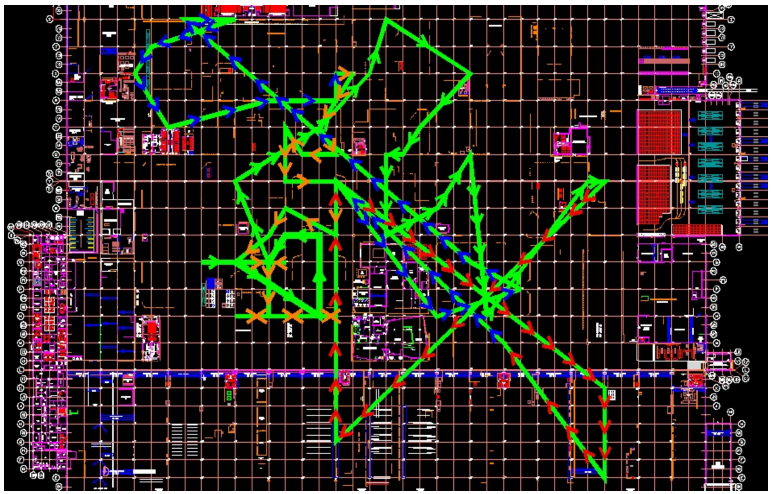
- **Overview**
- ***IE Studies***
- **Static and Dynamic Simulation**
- **Results and Conclusions**

Extent & Areas Covered

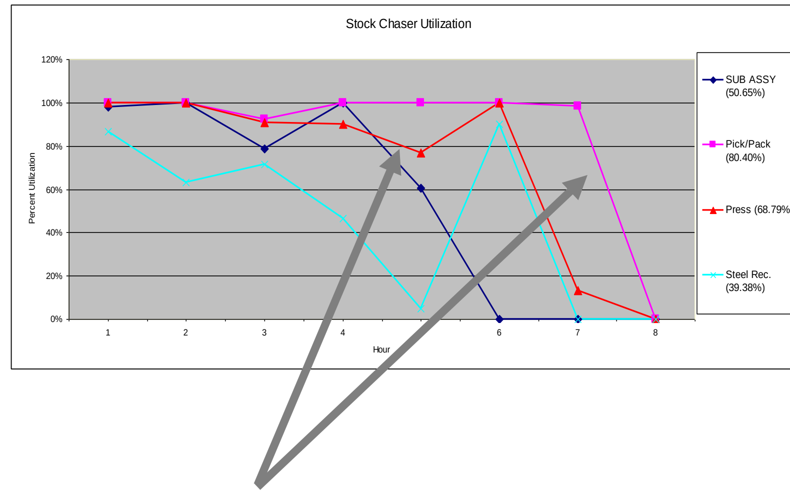
- Validated and updated plant's existing databases pertaining to Material Handling.
- Developed time-elements and established time-standards where applicable.
- Time studies covered (7) different Indirect Labor classifications throughout the plant.
- (95) time studies executed over all 3 shifts.
- Developed & updated standard work instructions based upon equipment used and required work practices.

Case Study: Material Flow & Indirect Labor Study

IE Studies - Snapshots



IE studies captured actual indirect labor movement patterns and provided the foundation for computational analysis.



IE studies provided insight into changing utilization of some resources over time

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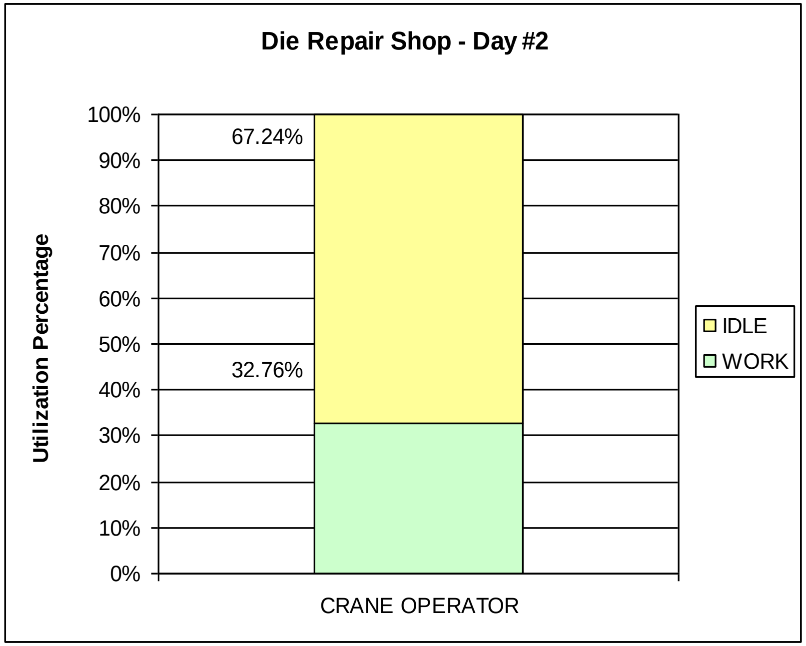
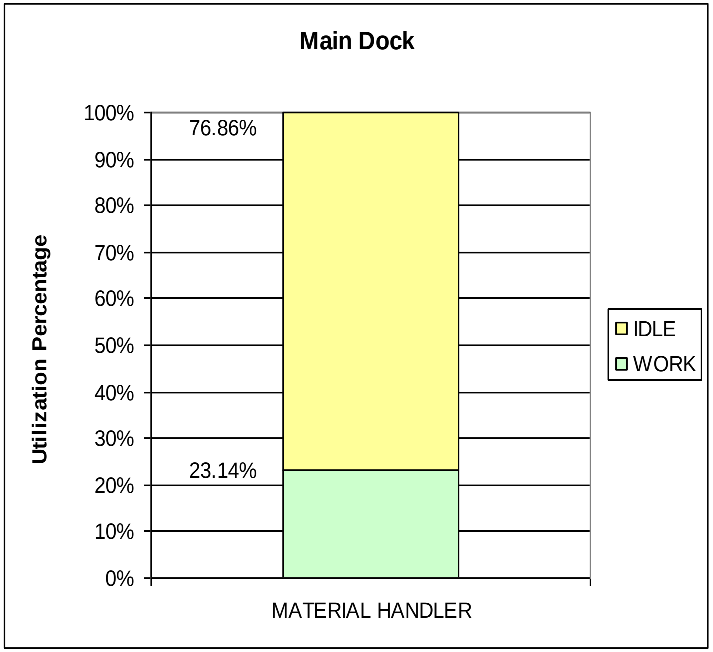
IE Studies – Sample Data





Time studies highlighted low utilization resources and presented opportunities for re-allocation

- **Overview**
- **IE Studies**
- ***Static and Dynamic Simulation***
- **Results and Conclusions**

Simulation Overview

Diverse sources for input data:

- Part numbers (Bill of Material, Pressroom Line-Up)
- Production quantities (Production Report)
- Production schedules (Pressroom Line-Up)
- Part routings (Plant personnel and I.E. studies)
- Containers per trip (Plant personnel)
- Load / Unload times (I.E. studies)
- Indirect Labor Worker Assignments (Plant personnel)
- Storage locations (Plant personnel)
- Container Information (Online Systems, Plant personnel)
- Shift Schedules and Available Minutes Per Shift (Plant personnel)

Static Simulation Overview

Static Model uses Flow Path Calculator in conjunction with AutoCad

- Provides capability to incorporate all material flow data into single database and calculates material handling utilizations.
- Generates graphical output for flow analysis useful for identifying wasteful long-distance moves.
- Creates congestion plots to highlight heavy traffic areas in the plant.
- Output useful for identifying and evaluating opportunities to combine driver assignments and reallocate drivers.
- Provides a tool for performing what-if scenarios to evaluate both short-term and long-term opportunities.

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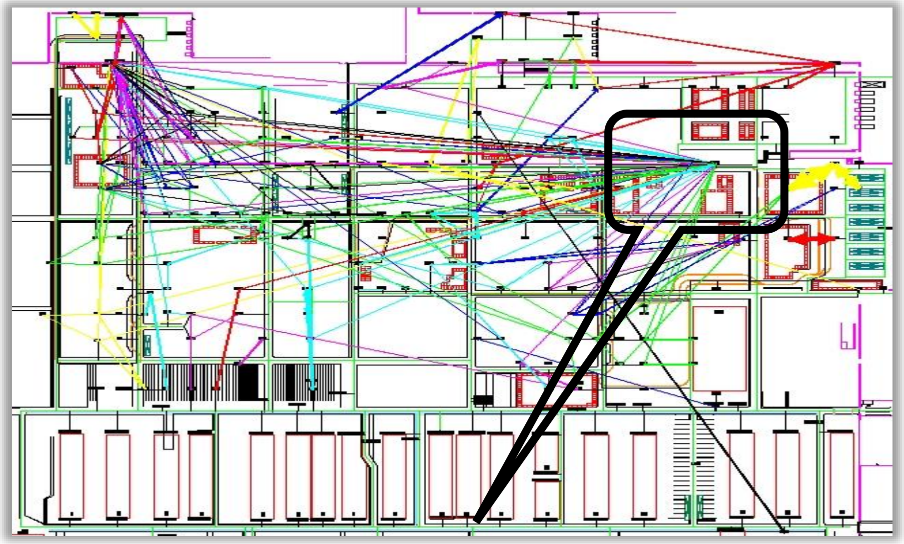
Static Simulation Flow – Subassembly Hilos

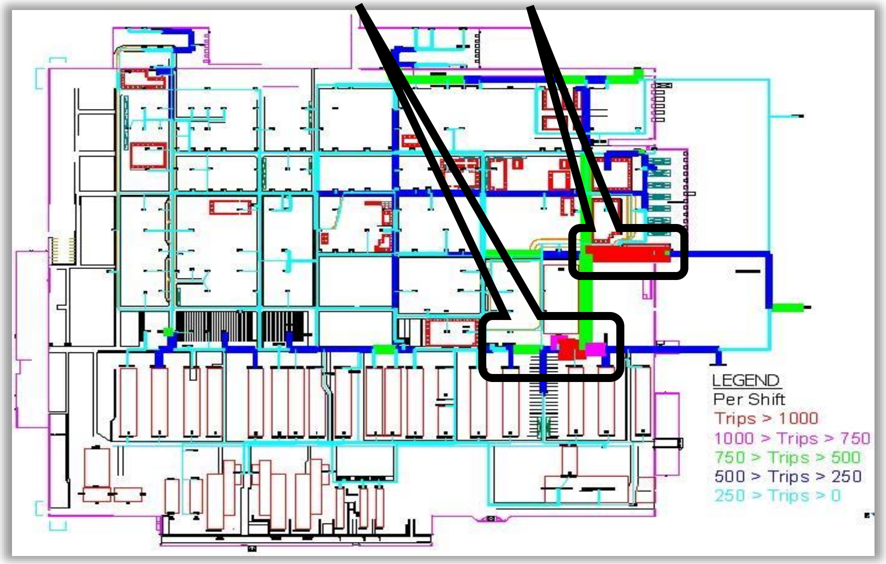
STRAIGHT FLOW

CONGESTION DIAGRAM



Example of long-distance material handling moves identified within the plant using Static model (in this case for bulk purchased parts).

High-traffic congestion areas highlighted using Static model.



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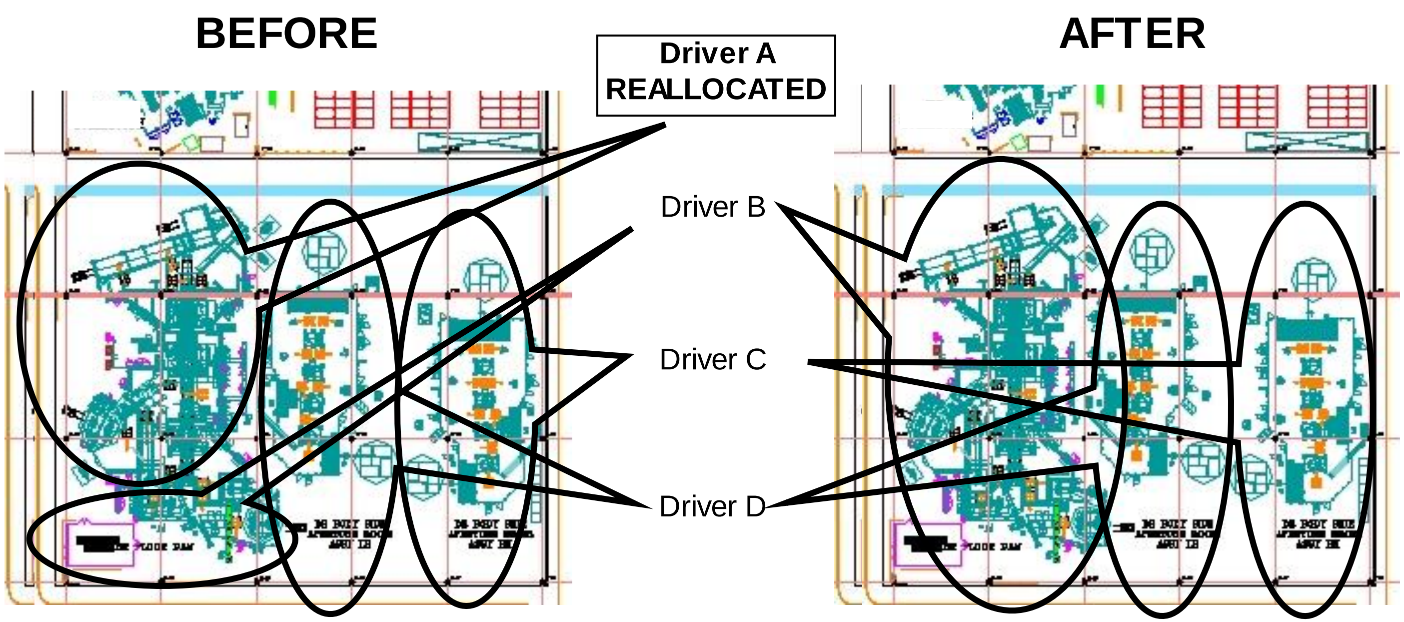
Static Simulation What-If Scenario Example



DRIVER	Utilization % (before)	Utilization % (after)
Driver A	85.88	0.00
Driver B	56.20	90.22
Driver C	55.27	88.51
Driver D	58.77	77.38

- **Dynamic Simulation Overview**

Dynamic Model uses discrete-event simulation software with Excel Interface

- Useful for evaluating the press room material handling resources including forks and tuggers where utilization fluctuates widely depending upon the press schedule.
- Generates time-based charts that quantify the utilization of resources over time thus highlighting opportunities for material handling improvement in a dynamic environment.
- Provides tool for evaluating and planning manpower required for current and future changes to the pressroom lineup schedule.

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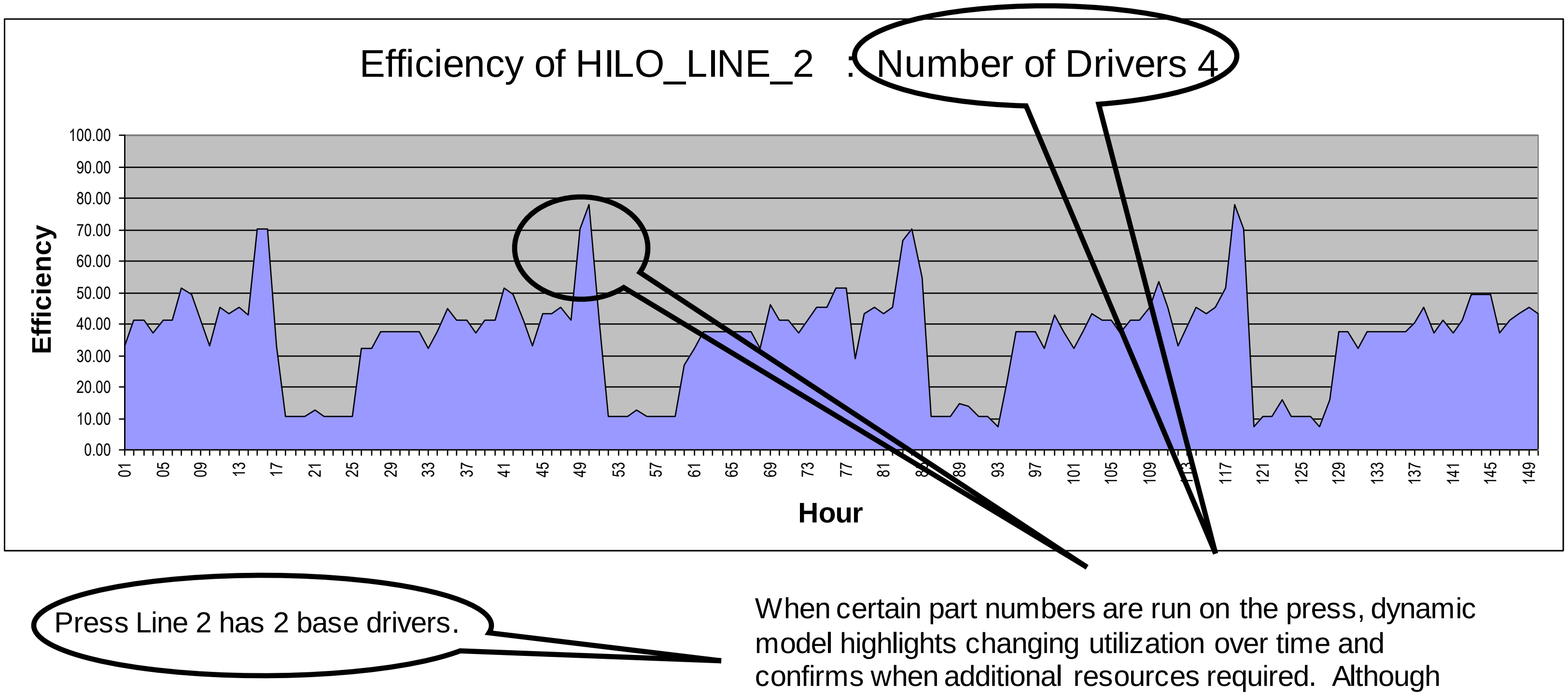
Dynamic Model Output Example

- **Sample Model Output for HiLo Group servicing two lines**



When certain part numbers are run on the press, dynamic model highlights changing utilization over time and confirms when additional resources required. Although Press Line 2 has 2 base drivers, currently up to 4 HiLo's may be utilized to service Press Line 2 for "worst" case part numbers.

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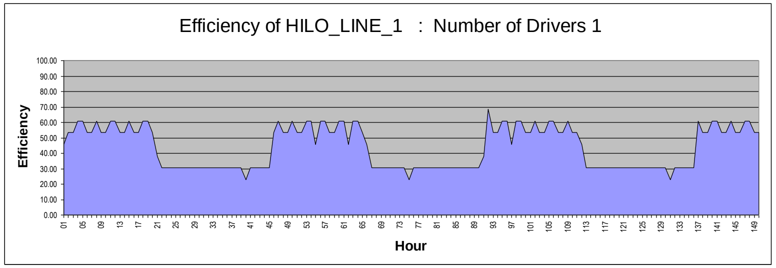
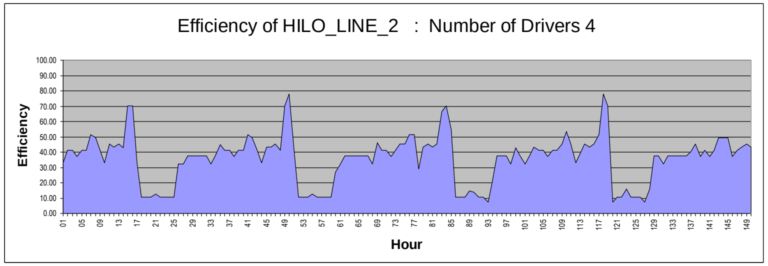
Dynamic Model What-if Example

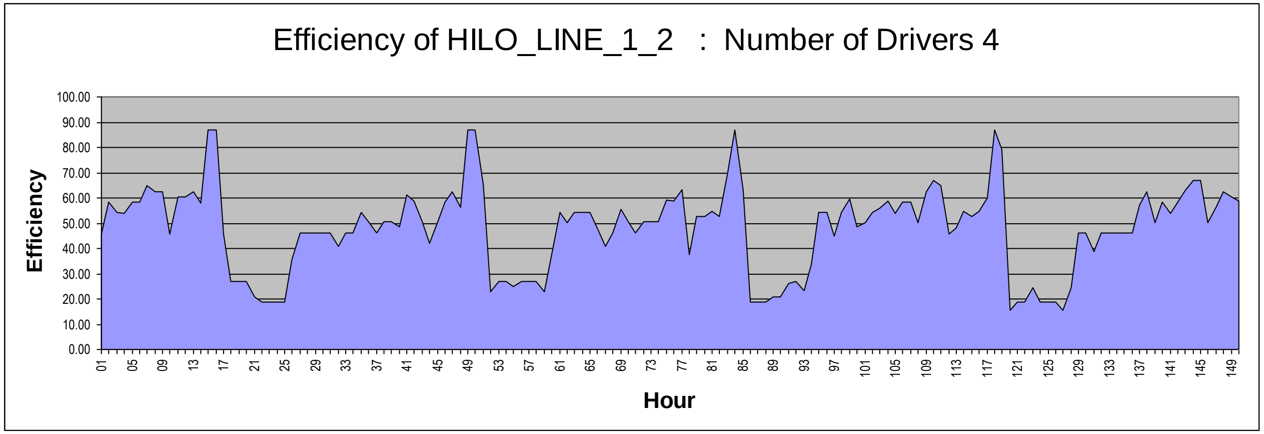
- **What-if: Combine coverage for two Press Lines**

Before





After



Dynamic simulation evaluates the impact of combining coverage for multiple press lines.

In this case 1 driver can be reallocated.

Case Study: Material Flow & Indirect Labor Study

Results and Conclusions

- **Overview**
- **IE Studies**
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Case Study: Material Flow & Indirect Labor Study

Results and Conclusions

- **Results and Conclusions**
  - Opportunity to reallocate 59 material handling people presents potential savings of $4.15 Million.
  - Integrated approach utilized various analytical and IT tools in a comprehensive manner to evaluate indirect labor resources, including personnel and equipment
  - Tools can be utilized for ongoing efficient analysis of indirect labor resources required by changing production conditions in the plant from both short-term pressroom schedule changes to long-term program changes.