Simulation Modeling Capabilities

ProModel® Simulation Software

Productivity Solutions

Industrial & Manufacturing Engineering Services

"Your Process Improvement Partner"

328 Kensington Road • Rocky River, OH 44116 • Phone (216) 650-0938

Computer Simulation Modeling

Simulation is a process of creating animated, dynamic models of systems based on time, to predict how it will operate in the real world.

- **When is Simulation an Appropriate Tool?**
  - To determine if a system will fulfill the design objectives and satisfy projected throughput requirements
  - To understand complex Interactions and Interdependencies within a system
  - To develop design and/or process changes to alleviate system constraints and enhance effectiveness
  - To perform comprehensive process designs or redesigns of new systems that do not yet exist
  - When other available analysis tools can not capture system dynamics or process fluctuations.
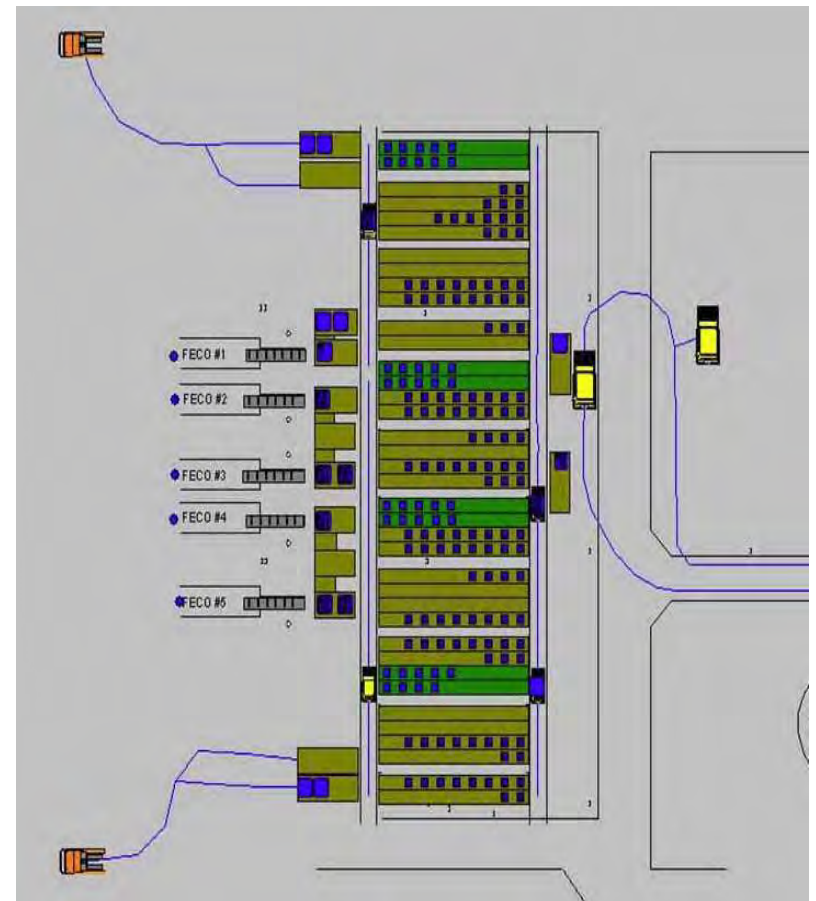
- **Computer models are only as good as the information used in the calculations.**

Simulation Manufacturing Applications

- **Capital Equipment Evaluation:** Identifies profitability, through-put and quality characteristics of competing equipment technologies.

- **Material Handling:** Identifies equipment buffer sizes and scheduling sequence requirements for handling surges in production.

- **Plant Layout:** Uses product mix to evaluate Functional Layout vs. Cellular Layout configurations.

- **Capacity Planning:** Identifies equipment and resource constraints to determine capital investments required to satisfy production requirements.

- **Work-in-Process Reduction:** Quantifies non-value added waiting time within processes. Reducing overall time parts spend in a system.

- **Line Balancing:** Identifies bottleneck operations that can be shortened to smooth production and increase overall line efficiency.

- **Just-in-Time:** Quantifies Day-to-Day order variations to determine process and material handling requirements.

- **Training:** Provides animated graphics for training operators with new or modified systems.

Benefits of Simulation

- **Technical Benefits**
  - **Assist with Capacity Analysis:**
    - Helps to determine process capital investments required for production requirements. Equipment & resource utilization calculations.
    - Identifies and organizes process constraints, bottlenecks and downtimes for existing systems.
    - Determines storage rack capacities, if required at all, to handle surges in production.

- **Project Management**
  - **Provides a High Level of Confidence prior to project Implementation.**
    - Verifies that the process has been thoroughly thought through.
    - Does not interrupt production during process evaluation.
    - Uses statistics to validate calculations
    - Improves predictability of output during high and low production periods.
    - Provides a tool to stabilize output.
  - **Provides a working Runtime version of ProModel software.**
    - Ability to simulate different product mixes or input variables on your own.
  - **Use to visually demonstrate bottlenecks to management for capital expenditures.**
    - Improves management's perception that you thoroughly understand the system requirements.

Modeling Implementation Steps

- **Project Definition**
  - Model objectives, project cost benefit analysis, level of detail, etc.

- **Data Gathering**
  - Data needed, availability of data, assumptions, data integrity, etc

- **Conceptual Model Design**
  - KPIV, KPOV definitions, location & entity definitions, etc.

- **Model Development**
  - Model detail definition, user friendly, document assumptions, etc.

- **Model Verification**
  - Compare model to design specifications, accuracy of animation detail, etc.

- **Model Validation**
  - Compare model output to real system, review assumptions & inputs, etc.

- **Experimentation**
  - DOEs, cause & effect testing, variance reduction testing, etc.

- **Result Analysis and Reporting**
 - Output & result documentation, reliability and recommendations

Statistical Distributions in Modeling

■ **Statistical distributions are the closest mathematical representation of recurring operations that fluctuate.**

- **ProModel's®, "Stat: Fit" program calculates the best statistical distributions to be used in a model.**

- **Raw data points, from time studies or from history records, are used in "Stat:Fit" to generate several distributions.**

- **Fifteen (15) different distributions are then tested with a Goodness-of-Fit Test and ranked from "best-fit" to "worst-fit" to determine the best comprehensive distribution.**

- **These distributions are then loaded as inputs into the simulation model to represent the statistical fluctuations associated with a process.**

- **The ability to analyze the dynamic interaction (overlapping) of these distributions is a major benefit which simulation programs have to offer.**

Computer Simulation Distributions

Examples of Applications that Distributions Represent

- **Machine set-up times.**

- **Manual processing times.**

- **Mean Time Between Failures Frequencies (MTBF).**

- **Mean Time To Repair Duration (MTTR).**

- **How often and when materials or resources arrive at a machine.**
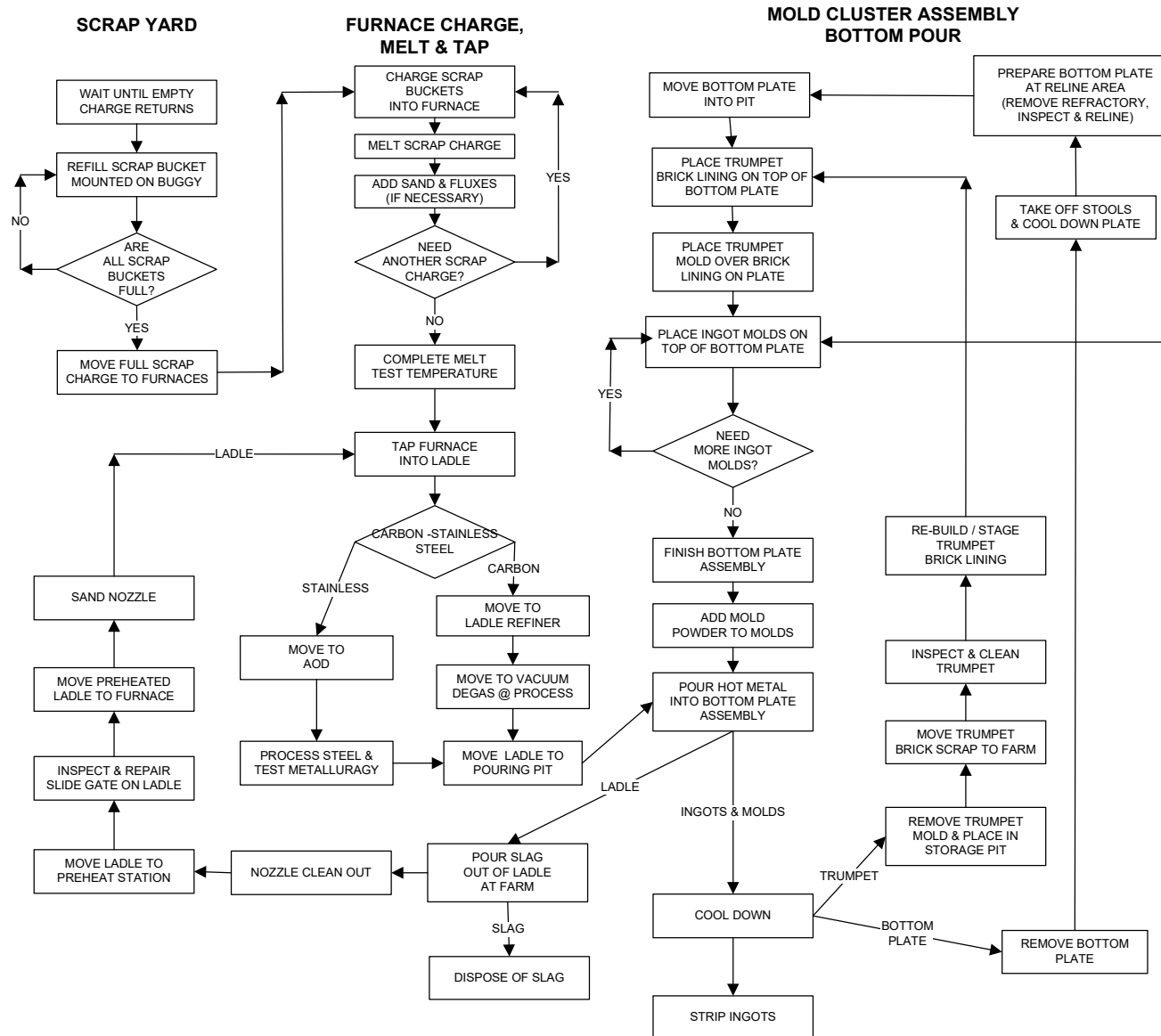
- **How often and when a bad part is generated.**
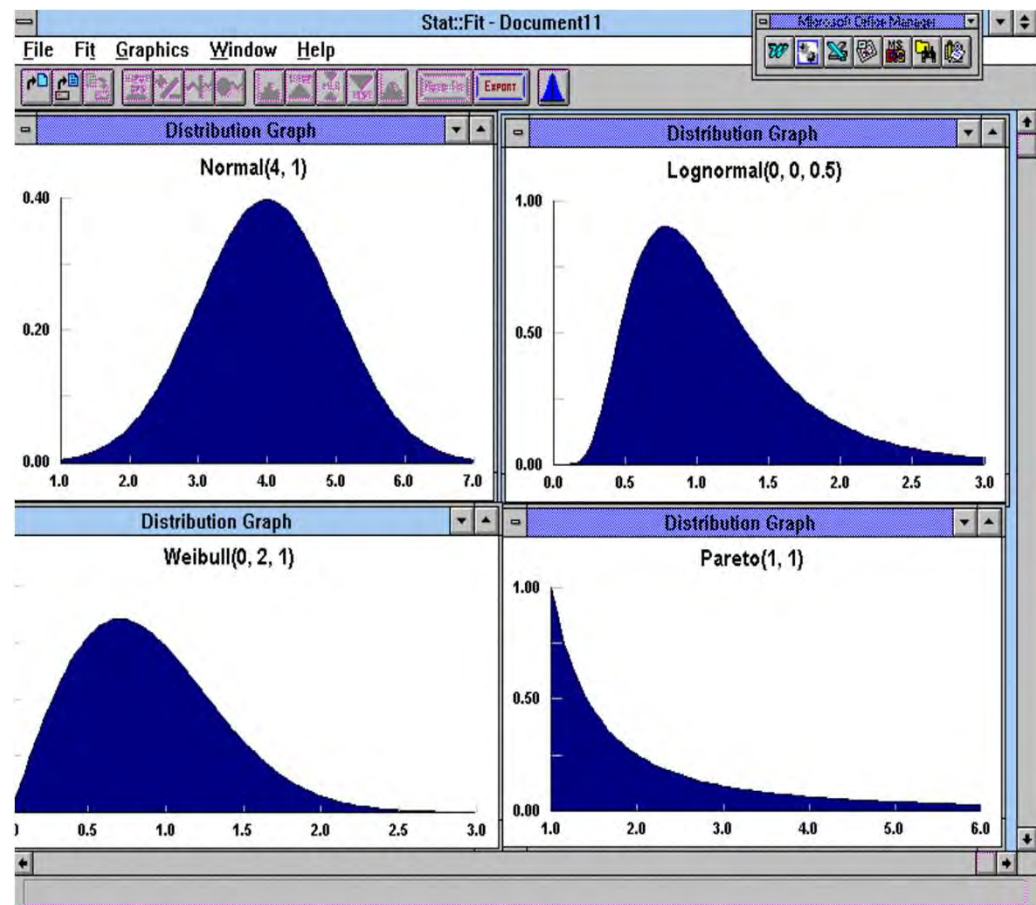
Simulation Process Flow Chart

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SCRAP STEEL COMPANY
Melt Shop Simulation Model

MELT SHOP Flow Chart
(Ladle Refine & Vacuum Degas)

Revision: -
5/20/99

SCRAP YARD

- WAIT UNTIL EMPTY CHARGE RETURNS
- REFILL SCRAP BUCKET MOUNTED ON BUGGY
- ARE ALL SCRAP BUCKETS FULL?
  - NO
  - YES
- MOVE FULL SCRAP CHARGE TO FURNACES

- SAND NOZZLE
- MOVE PREHEATED LADLE TO FURNACE
- INSPECT & REPAIR SLIDE GATE ON LADLE
- MOVE LADLE TO PREHEAT STATION

FURNACE CHARGE, MELT & TAP

- CHARGE SCRAP BUCKETS INTO FURNACE
- MELT SCRAP CHARGE
- ADD SAND & FLUXES (IF NECESSARY)
- NEED ANOTHER SCRAP CHARGE?
  - YES
  - NO
- COMPLETE MELT TEST TEMPERATURE
- TAP FURNACE INTO LADLE (LADLE)
- CARBON - STAINLESS STEEL
  - STAINLESS
    - MOVE TO AOD
    - PROCESS STEEL & TEST METALLURAGY
  - CARBON
    - MOVE TO LADLE REFINER
    - MOVE TO VACUUM DEGAS @ PROCESS
    - MOVE LADLE TO POURING PIT
- NOZZLE CLEAN OUT
- POUR SLAG OUT OF LADLE AT FARM
  - SLAG
  - DISPOSE OF SLAG

MOLD CLUSTER ASSEMBLY BOTTOM POUR

- MOVE BOTTOM PLATE INTO PIT
- PLACE TRUMPET BRICK LINING ON TOP OF BOTTOM PLATE
- PLACE TRUMPET MOLD OVER BRICK LINING ON PLATE
- PLACE INGOT MOLDS ON TOP OF BOTTOM PLATE
- NEED MORE INGOT MOLDS?
  - YES
  - NO
- FINISH BOTTOM PLATE ASSEMBLY
- ADD MOLD POWDER TO MOLDS
- POUR HOT METAL INTO BOTTOM PLATE ASSEMBLY (LADLE)
- COOL DOWN
  - INGOTS & MOLDS
  - STRIP INGOTS
  - TRUMPET
  - BOTTOM PLATE
  - REMOVE BOTTOM PLATE

- PREPARE BOTTOM PLATE AT RELINE AREA (REMOVE REFRACTORY, INSPECT & RELINE)
- TAKE OFF STOOLS & COOL DOWN PLATE
- RE-BUILD / STAGE TRUMPET BRICK LINING
- INSPECT & CLEAN TRUMPET
- MOVE TRUMPET BRICK SCRAP TO FARM
- REMOVE TRUMPET MOLD & PLACE IN STORAGE PIT

Example of Simulation Input Worksheet

Numerical Input Summary Sheet
(Shaded Rows Represent Information Not Modeled, Documented FYI)

Description	Discrete or Distribution	RTI Macro	Increase w/ Ladle Increase	Avg.	Units	Stat:Fit Format	ProModel Format	Information Source
Scrap Loading Cranes								
1) Time to fill 1 Charge Box w/ 1 Crane	Discrete	No	Yes	20.8	min			Time Study
Charging Crane Downtime								
1) Crane Down Time Frequency	Discrete	Yes	No	267	heat / DT			Mike Harris
2) Crane Downtime Duration	Discrete	No	No	8.0	hrs / DT			Mike Harris
Desulfur								Mike Harris
1) Torpedo Pour Time	Discrete	Yes	Yes	9.5	min	(1 car fills 2.8% (2.88 min), 2 cars 80.9% (8.72 min),3 cars 16.3% (14.55 min) of heats)		Time Study
2) Desulfur Process Time Only	Dist.	Yes	Yes	7.8	min	Gamma(4,3.49,1.1)	4+G(3.49,1.1)	Database - M.S.
3) Overhead (Testing,Move Lance,Etc)	Discrete	Yes	No	8.4	min			Time Study Calc.
Deslag Operation								
1) Time to Deslag Hot Metal	Dist.	Yes	Yes	5.9	min.	Weibull(4,3.13,2.18)	4+W(3.13, 2.18)	Time Study (Video)
BOF Operation								
1) Charge Scrap Metal	Discrete	Yes	Yes	1.4	min.			Time Study
2) Charge Hot Metal	Discrete	Yes	Yes	2.0	min.			Time Study
3) Oxy Blow Time	Dist.	Yes	Yes	17.5	min.	Logistic(17.6,0.712)	17.6-0.712*LN((1./U(0.5,0.5))-1.)	Database - M.S.
4) OG Stop to Tap Start Time	Dist.	No	No	4.9	min.	Log-Logistic(2,2.43,2.09)	2+2.09451*(1./((1./U(0.5,0.5))-1.))**(1./2.43234)	Database - M.S.
5) Scrap Rock Time (100% heats)	Discrete	No	No	0.5	min / rock			Time Study
6) No. Heats / Full Furnace Cycle	Discrete	No	No	32	heats / cycle			San Smith
Tapping								
1) Tapping Time	Dist.	No	Yes	4.6	min	Weibull(2,3.2,2.88)	2+W(3.2,2.88)	Database - M.S.
2) Dump Slag Pot Frequency	Dist.	No	No	2	heats/pot	Normal(1.5,.25)	N(1.5,.25)	Steve Jones
3) Slag Dump Time	Discrete	No	No	3	min			Time Study
Allot Station								
1) Fill Sand Plug	Discrete	No	No	0.53	min			Time Study
2) Alloy Test Time	Discrete	No	No	0.87	heats/pot			Time Study
Degas Operation								
1) Lower Vessel, Seal Take Temp	Discrete	No	No	1.0	min/ladle			Mike Harris
2) Degas Process Time Only	Dist.	Yes	Yes	21.6	min	Log-Logistic(1,1.48,7.49)	1+20.4*(1./((1./U(0.5,0.5))-1.))**(1./15.2)	Database - M.S.
3) Break Vaccum, Raise Vessel	Discrete	No	No	3.0	min/ladle			Mike Harris
4) Freq. Cooled Down Occurs (Before)	Dist.	Yes	No	10.7%	% heats	Pearson 5 (-0.0633,0.99,2.92)	-0.0633+P5(0.99, 2.92)	Log Book
5) Cool Down Time (Before)	Discrete	No	Yes	2.6	min.			Database - M.S.
6) Freq. Cooled Down Occurs (After)	Dist.	Yes	No	7.6%	% heats	Log-Logistics(1,1.48,7.49)	1+7.49*(1./((1./U(0.5,0.5))-1.))**(1./1.48)	Log Book
7) Cool Down Time (After)	Discrete	No	Yes	1.9	min.			Database - M.S.
8) Frequency of Refractory Spray	Dist.	Yes	No	33%	no. heats	Normal(3,.8)	N(3,.8)	Log Book

SCRAP STEEL SIMULATION MODEL ASSUMPTIONS

General Model Parameters
- Model 2 months of production
- Available Production Uptime:
  - 24 hours / day, 21 Shifts / week
  - 49 weeks / year
- All preventive maintenance will not affect capacity.
- Cycles are equipment limited not labor limited. Labor breaks are not modeled.
- Scrap availability is limited by railroad availability only.
- All material handling movements are based on an average of observed times, not rated speeds, and are discrete values in the model.
- The model ends with the ingots leaving the teeming aisle.
- The foundry pouring will not be modeled. The time for a ladle to be emptied will be modeled.

Scheduling
- Product Mix Information:
  - 100% of the carbon and low carbon steel will be processed at the LMF and Degas before being poured.
  - All (100%) stainless steel goes to the AOD.
  - Zero percent (0 %) of the stainless steel will be processed at the LMF with the initial model. The program will allow this percent to be changed. If changed, the processing time at the LMF will be the same as the 2nd pass carbon steel processing time.
- Scheduling Sequence Information:
  - Only 1 furnace will be running at a time during the week
  - The following product mix and scheduling sequence will be modeled continuously. The heat / week column will be a Run Time Interface (RTI) variable in the program which can be modified to adjust product mix. The sequence, number of product categories (9), pour rate and cool time are not RTI variables which can not be modified. (See next page for chart.)

Computer Simulation Modeling Results

- **Simulation classifies the times that affect Machines/Locations, Operators/Resources or Parts/Entities for easy analysis**

- **Identifies the utilization of machines and resources for easy capacity analysis**

- **Identifies Where Production Is Lost or Hindered for potential production improvements**

- **Output statistics can be downloaded into spreadsheets for additional analysis or reports**
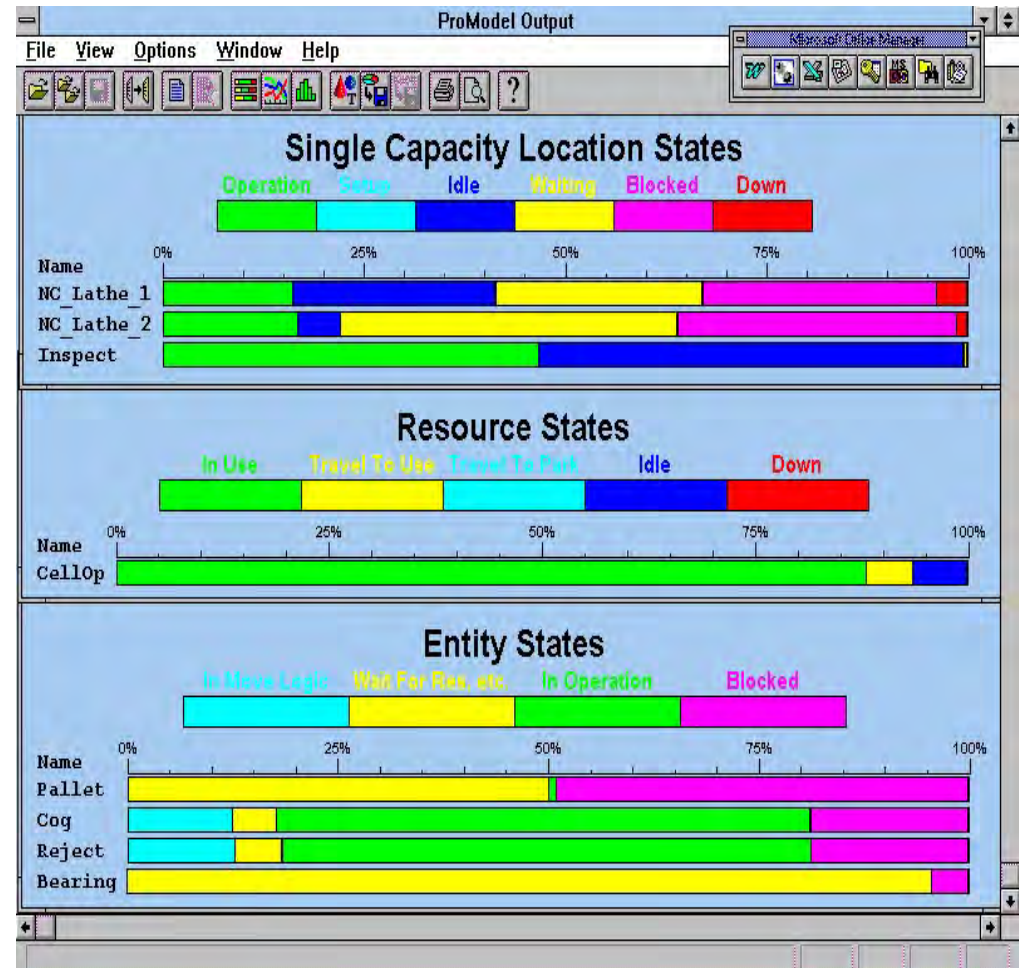
- **Simulation Modeling organizes time and money related process activities in a comprehensive model for design, technical analysis, training assistance and marketing purposes.**

- **Simulation Modeling incorporates process fluctuations with distributions to most accurately model dynamic systems.**

- **Simulation Modeling segregates the gross times that machines, resources/operators and parts use into different utilization categories for easy analysis.**

- **Simulation animated graphics improves communication during design stages, highlights bottleneck areas, reduces training time and helps sell appropriation requests to upper management.**

- **Simulation Modeling provides a high level of confidence prior to project implementation.**
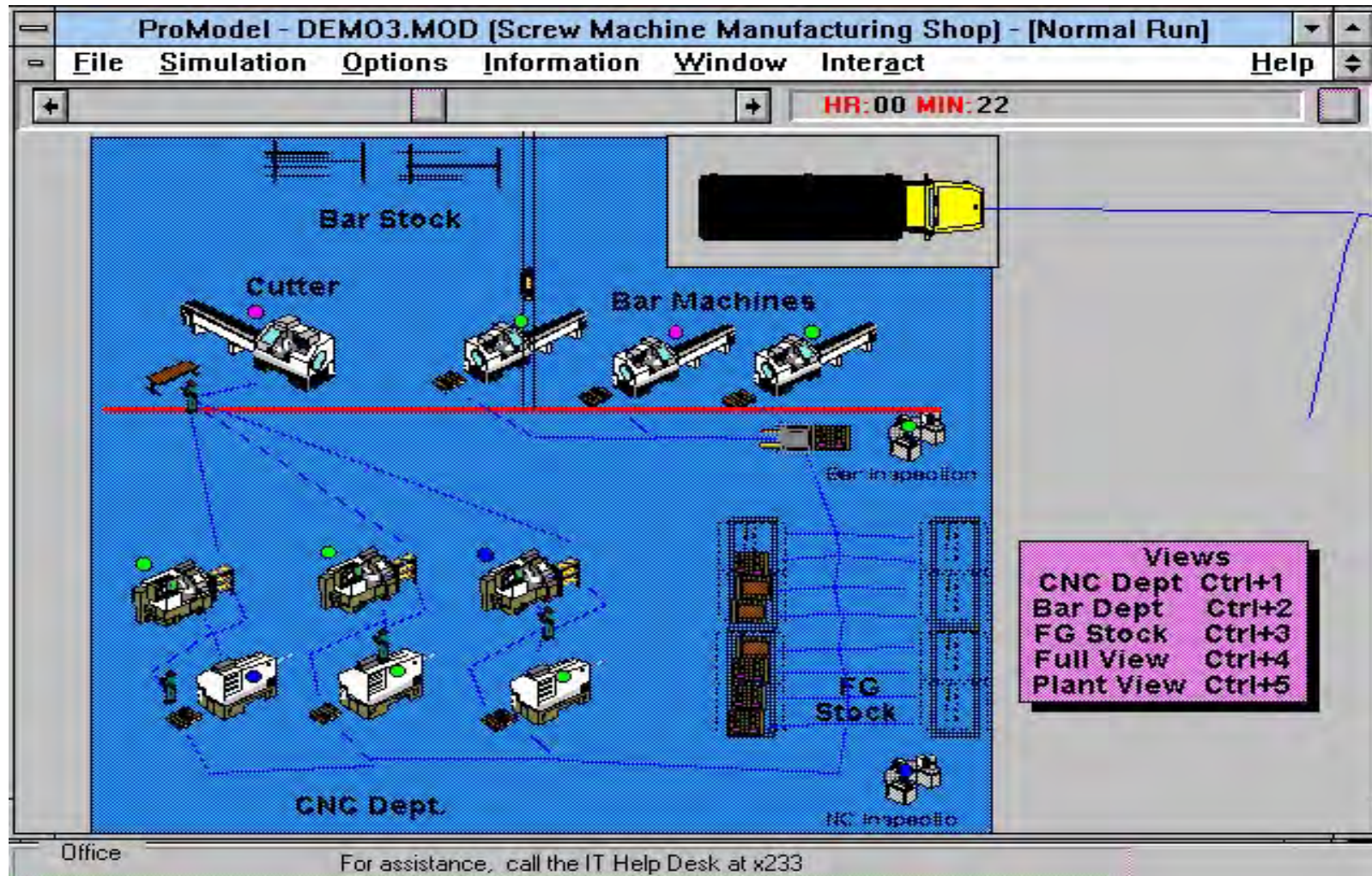
Computer Simulation Modeling

Modeling of a Steel Melt Shop Facility
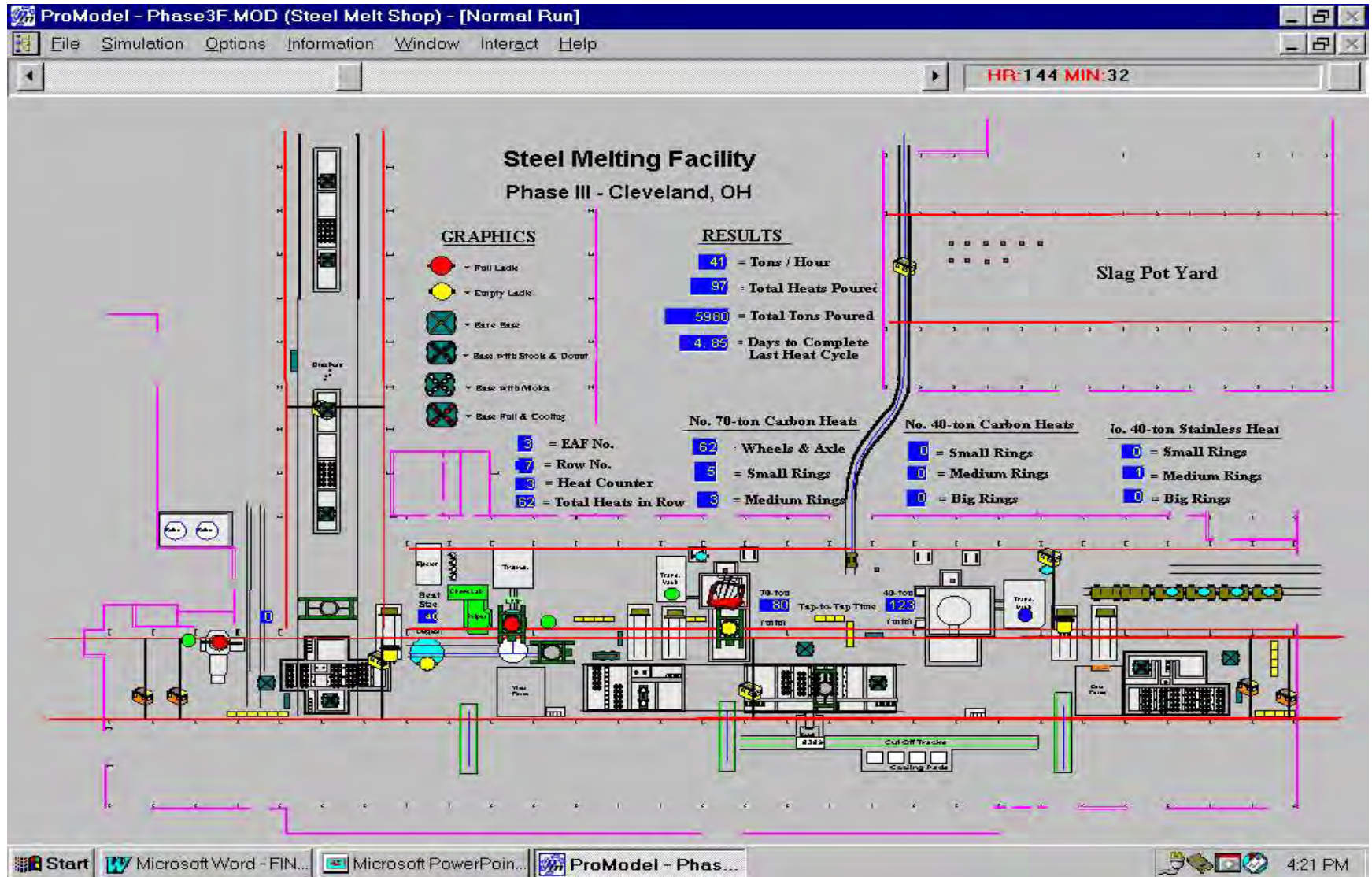
Objective: Maximize throughput and verify capacity by identifying bottlenecks.
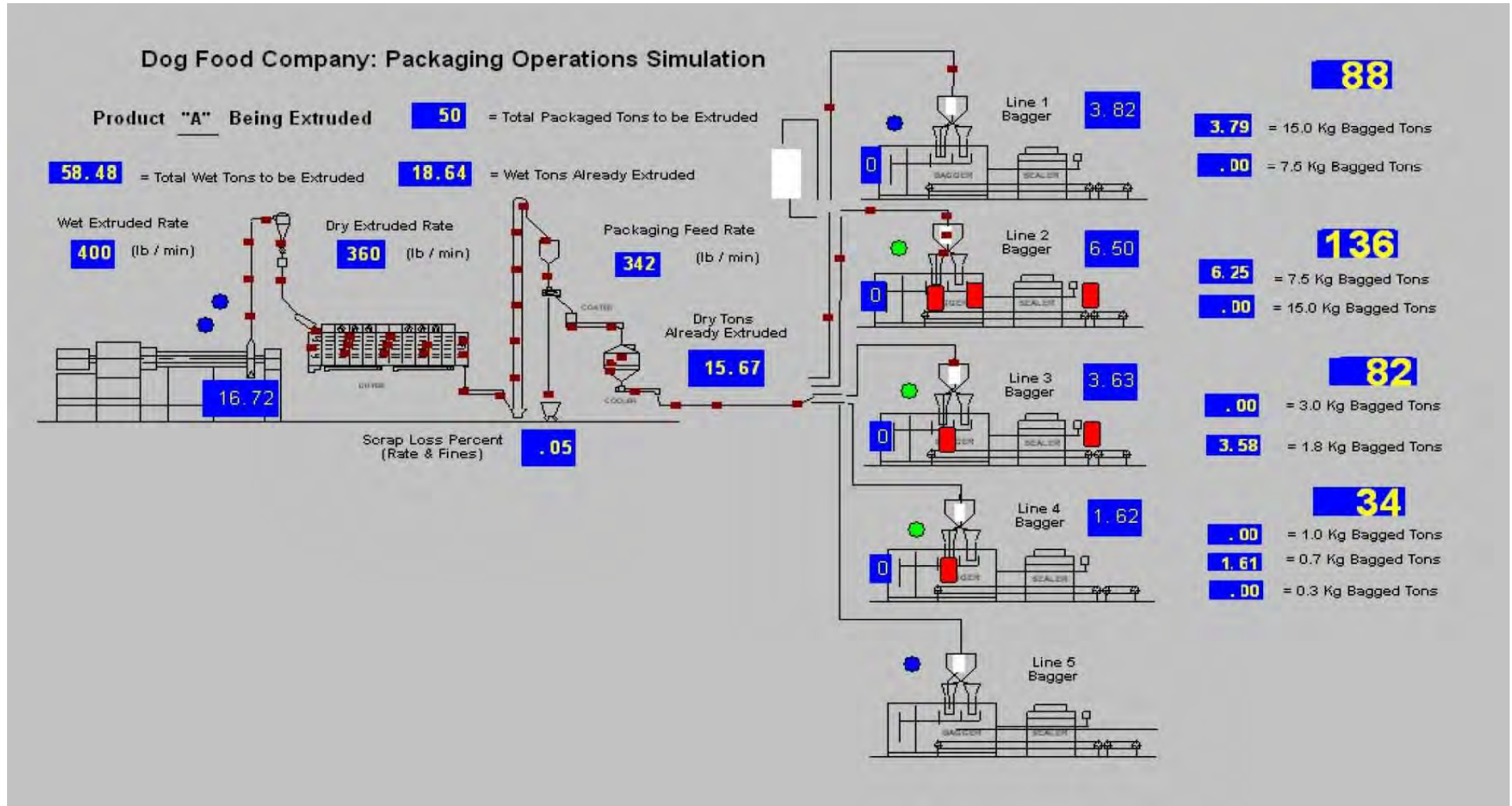
Computer Simulation Modeling

Modeling of an Machine Shop

**Objective:** **Minimize labor while maximizing equipment utilization.**

Simulation Modeling Example

Modeling of a Dog Food Packaging Operation

Objective: Minimize silo capacity requirements with flexible packaging stations.

Computer Simulation Modeling

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Modeling of a Shipping & Receiving Department
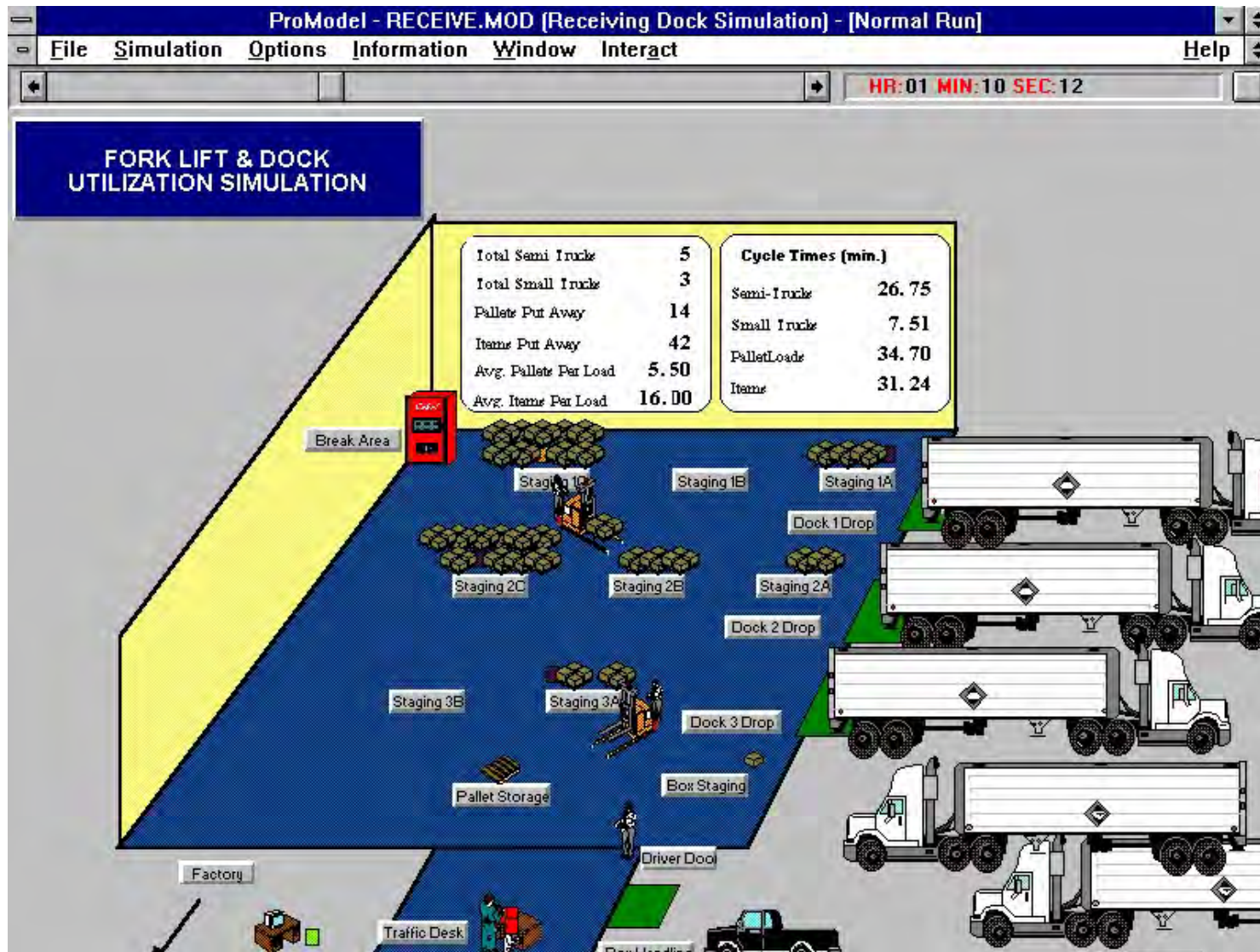
Simulation Modeling Experience

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- ## Capacity Verification:

  A Steel Melt Shop used simulation to verify the throughput capacity for each of 3 phases in a $30 million upgrade. Quantity of ladles, number of pouring pits and required material handling equipment for each phase was also determined with simulation.

- ## Throughput Increase:

  Bottlenecks limiting a 10% increase in throughput were identified in a capacity analysis when a Steel Melt planed on increasing ladle sizes 10%.

- ## Machine Design:

  Simulation was used to help design a modular, highly automated, 900 pcs/min processing line. The number of pieces of equipment and processing times were all changeable variables that helped the design team perform experiments. Meantime-Between-Failure (MTBF) and Mean-Time-To-Repair (MTTR) equipment specifications were established for over 350 pieces of equipment. Downtime costs were also calculated for each failure mode.

- ## Increased Equipment Utilization:

  Increased packaging line utilization for an international snack food company with several different package sizes. Accumulators were sized to handle fluctuations in material flow.

- ## Material Handling Throughput Verification:

  Simulation was used to show that an automated multilevel conveyor storage bank system with AS/RS and AGV interfaces was not capable of meeting design specifications before implementation.

Perrego Simulation Modeling Projects

- ## Corning Glass – Shizuoka, Japan

  Modeled the melting and finishing operations of a flat screen glass manufacturer concentrating on cycle time, conveyor movement times, MTBF and MTTR times. ProModel® was integrated with an Excel® spread sheet to allow the ability to modify over 350 input variables and download results into charts and graphs.

- ## Standard Steel, Burnham, PA

  Provided Industrial Engineering services to design a 3 phase, $30 million melt shop upgrade with a new 70-ton Electric Arc Furnace (EAF), new Ladle Refining station, new Degas station, upgraded 40-ton EAF and pouring pit configurations. The project included simulation modeling to identify process improvements and capacity verification, design of pouring pit configurations. Preparation of an appropriation level report describing the new facility, probable cost of construction, proposed project schedule with an operating and maintenance cost comparison of the new and old layout configurations was also provided.

- ## AK Steel, Middletown, Ohio

  Provided a capacity study and identified bottleneck operations associated with a planned ladle size increase from 225 to 240 tons. The project included extensive simulation modeling that required process flow diagrams, time studies, analysis of historical data and process documentation. Three areas of process improvements were identified for a 10% increase in production.

- ## General Motors Corp. - Defiance, Ohio

  Provided a capacity analysis, material flow study and detail design specifications for automated handling equipment in the core manufacturing and assembly area. Coordinated the installation of vendor's equipment and relocation of Owner's equipment.

- ## Pepperidge Farms - Ohio

  Provided a blending and packaging system improvement study, including ProModel® computer simulation modeling for evaluation of production equipment, conveyors, accumulators and staffing.

Simulation Modeling Projects

■ **Corning Glass Fiber Optics – Saskatoon, Canada**

Modeled the coating and bundling of fiber optic cables to determine how many additional lines were necessary to double capacity.

■ **Standard Steel – Cuyahoga Heights, Ohio**

Modeled a new $100 million Electric Arc Furnace (EAF) melt and casting facility to identify throughput capacity for various product mixes and identify bottlenecks. ProModel® was integrated with an Excel® spread sheet to allow the ability to modify over 200 input variables and download results into charts and graphs.

■ **The Timken Company – Canton, Ohio**

Used modeling to help develop and verify a new scrap metal yard layout and supply logistics to the melt shop that resulted in reducing operational costs several hundred thousand dollars annually.

■ **IAMS Company – Ohio**

Used simulation modeling to develop several flexible packaging lines that reduced the number of WIP silos from 6 to 3 saving $3 million per plant duplication.

■ **V&M – Ohio**

Used simulation modeling to verify throughput on a 1,000,000 sf facility, assist with process design,, identify bottlenecks and design WIP location allocation.

- **Onsite ProModel® training courses.**

- **License lease options.**

- **One stop shop for industrial engineering and simulation modeling capabilities. Eliminates the middleman and minimizes project completion times.**

- **Fifteen years of experience building simulation models for various industries.**

- **Ability to integrate Excel® spreadsheets for easily tracking multiple inputs and output variables.**

- **Locally located.**

- **Demonstrated Performance in Manufacturing**

- **Quality Services = Long - Term relationships**