AN OVERVIEW OF MANSIM PRODUCTS

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ManSim Inc. Products

Overview of Products

The following is an examination of the ManSim Inc. product line, which identifies the users of each product and how the products relate to each other. ManSim Inc. has six products in the marketplace.

- ManSim/X and TestSim/X
- MS/X OnTime and TS/X OnTime
- MS/X Planner and TS/X Planner

Each of these is designed for use in planning and optimizing facility operations, but each is targeted toward a different set of users. Most users would use one or two of the products, with only a few using three or more. While there is a great deal of common data and functional capability shared among the products, each is aimed at a particular purpose, and has the full set of features needed by that user function. This report documents both the commonality and differences among the products, and explains how they provide capabilities for improving manufacturing effectiveness.

The table below shows that the ManSim products (Column 1) are focused on processing on the factory floor and product fabrication. The TestSim products (Column 2) are focused on assembly and testing the completed products.

Facility Process	
Product Fabrication	**Product Assembly And Test**
ManSim/X	**TestSim/X**
MS/X OnTime	**TS/X OnTime**
MS/X Planner	**TS/X Planner**

Table 1: ManSim and TestSim Product Usage

History of ManSim Products

These six products were developed initially for the complexities of the semiconductor industry. The capability to support other complex or simpler manufacturing operations, supply chain flows, and paperwork processes has been demonstrated as well. The products develop a user-built factory model to simulate manufacturing operations in a variety of planning scenarios. All ManSim Inc. products use a table-driven approach for model definition and logic, as opposed to a code-driven approach, providing all users with the same modeling structures and rules. This provides the opportunity for common usage among a firm's production sites as well as a common base for understanding product capabilities for all users and developers of the ManSim products. The ease of use (no programming required) for making changes to tables to modify models of user facilities that simulate solutions or proposed improvements is aimed at serving those responsible for daily operations and timely management decisions. The table-driven approach also provides very fast simulations, providing the opportunity to ask more questions when solving daily problems or improving performance.

Over a period of more than 10 years, manufacturing personnel from the major semiconductor manufacturers used their time and expertise to request and receive enhancements as needed. Annual user conferences, worldwide in scope, provided a focal point for requesting additional enhancements and announcing new improvements. In summary, ManSim Products provide users the benefits of many years of user and developer experience and easily understood models that can be modified by operational personnel for rapid responses to questions.

Let's start with a thumbnail description of each of the products.

1) ManSim/X and TestSim/X

ManSim/X was the first product created by ManSim Inc.; it set in place the foundation for all 6 products. Customers using OnTime and Planner use the same simulation engine. Since the results of any of the tools are only as accurate as the underlying model, each model must be validated against the manufacturing or test/assembly factory it is attempting to simulate. ManSim/X and TestSim/X are well suited to do this validation. Additionally, the major value of any simulation is to reduce or replace experimentation needed to improve operations. ManSim/X and TestSim/X are unparalleled at providing the means to explore the impact of new operating rules, changed equipment sets, changed processing times, improved setup times, improved equipment uptime and utilization, as well as varying manpower availability and skills.

While the models used should accurately reflect the factory, operation of these products is somewhat removed from the actual activity of factory operation and planning. This is the tool of the industrial engineer in sizing of the factory and operational management in exploring proposed changes in philosophy and practice. The factory models for these purposes usually are detailed and complex.

2) MS/X and TS/X OnTime

These products provide the user with the additional capabilities to generate short term plans and schedules with calendar dates. One of the most used functions is dispatch lists. These reports are most often printed out, but in some cases are generated at the request of and displayed via the MES system. A validated model, developed using ManSim/X or TestSim/X, is required for accurate projections. Inventory location and equipment status are very important, and usually need to be updated from an MES system before beginning a series of runs. Due to the relatively short time periods expected for OnTime runs, stochastic events such as equipment failures are eliminated from the simulation to avoid erratic predictions. This model may be more or less detailed than one designed for factory study and analysis (ManSim/X or TestSim/X), and should more closely parallel the steps in the MES system.

Shift supervisors, lead operators, and operators use these products to make the most effective product moves during the shift. Runs are for short durations, and outputs are to be replaced often, at least once a day, or whenever an unplanned event, such as equipment failure, occurs in the actual factory. Operators use these products to make the most effective product moves during the shift. Plans can be generated for lots, equipment, and operators. Model runs are for short spans of time, a few days.

2a) Dispatching with MS/X and TS/X OnTime

Dispatching is defined as a set of planned actions for a given time period. It is especially important to have extremely up-to-date information from which to derive the dispatch list. A dispatch list could be for a lot, a Work Station, or an operator. It suggests what to do NOW and what is planned for the future.

A short interval schedule presents a time-based list (or diagram) of what should be done for the lot/machine/operator, based on a set of "best choices" at each time point. These "best choices" are determined by selected factory rules and options. A machine schedule might look like:

- 10:00-10:30 Process lot 4455
- 10:30-11:10 Process lot 4566
- 11:10-12:00 Perform PM #55
- 12:00-12:20 Wait
- 12:20-13:10 Process hot lot 6610

At 10:00, the dispatch list for the machine would start with lot 4455. At 10:30, the dispatch list would start with lot 4566 and so forth. A single item dispatch list would be the first item in a short interval schedule if run at the appropriate time, assuming the schedule has not been disrupted.

3) MS/X and TS/X Planner Products

These products provide the user with a longer-term planning horizon measured in weeks or months. Again, a validated model is required for the products to be of effective use. As the runs are again long enough for statistical variations, stochastic events such as equipment failures are included in the simulations.

Planner is used to generate the production plan for a factory for the upcoming days, weeks and months. Strategic Planning covering horizons of 1-2 years would determine the long-term requirements for equipment and labor. Production Planning allows backwards scheduling of demands to determine factory starts, taking into account current WIP, inventory and the expected manufacturing environment. Users would include the factory production control (PC) group, and perhaps the production manager. Using the product line demand for the factory, a starts/outs list is generated for the factory, even to the lot level. Accurate inventory figures are also important, but planning is more of a weekly or monthly cycle, so WIP status is updated daily or weekly. Use of this product can help start lots with the maximum assurance that the due dates will be met, especially when used with MS/X or TS/X OnTime. The use of Forecasts and Available-to-Promise capabilities are also available in these 2 products.

3a) MS/X and TS/X Planner for Supply Chain applications

These two products can also support a production plan for a supply chain operation. They are positioned to provide an enterprise-wide rollup that operates across factories. An entire product line with many sources for components and processing can be described and modeled in an overall manner. The goal is to reduce cycle time, maintain customer satisfaction, and minimize costs. Management and understanding of a supply chain operation requires an accurate cycle time by product, best provided by ManSim simulations of production plans. These two products include the ability to define a Bill of Material hierarchy or explosion which is a key component for any supply chain operation.

4) Implementation Approaches

The approach for implementation with these 6 products can be bottoms-up by initially using ManSim/X and TestSim/X, and then progressing to production dispatching and/or planning and/or supply chain management. It can be tops-down by first defining supply chain elements with MS/X and TS/X Planner with historical data and then improving the capability of the supply chain with simulation that depicts actual status and possible outcomes.

Patterns of Use and Users

There are other ways to look at the products, either in tables or graphically. For example, we can look at user community versus the ManSim products being used. Prime use is one where the product is normally used to perform the job, whereas secondary use suggests that the product might be used also.

Product► ▼User Community▼	ManSim/X TestSim/X	MS/X-TS/X OnTime	MS/X-TS/X Planner	Planner Supply Chain
Industrial/Tool Engineer	Prime		Secondary	Secondary
Shop Floor		Prime		
Production Management	Secondary	Prime	Secondary	
Factory Production Planner			Prime	Secondary
Product Line Planner			Secondary	Prime
Corporate Tool Planner	Secondary			Prime

Table 2. Usage of ManSim Products

Factory Simulation Capability

ManSim Products are based on a discrete-event simulator. It simulates physical objects that have finite states and transitions between them. They are called discrete-events because they spend much more time in a given state than in the transition time.

Simulation models more accurately predict the behavior of real world manufacturing systems than calculations based on static data derived from history. Subjecting these static data inputs to the effects of stochastic variability improves knowledge of the viable ranges of facility performance. Event simulation (simulation of the time domain) expands this knowledge further by creating and estimating the queues and delays that are generated by part flow variability and processing time variability for different products and their lot sizes, as well as the impact of resources (the capability and availability of personnel and machines).

Event simulation accurately reveals the impact and dynamics of concurrent constraints that can only be approximated with static data and history. The result is a much better understanding of the key factors in any given facility (or process) that impact the capability to meet goals (capacity) in a timely fashion (cycle time). The impact of adjustments to resources and policies can be quickly understood and experimented with using the discrete-even simulation capabilities of ManSim's product set. A typical run of a complex factory or Supply Chain involves only minutes, sometimes seconds. Thus, many questions that managers and operating personnel have may be asked and answered in a short time when solving problems and generating new operational approaches.

Overview of ManSim Product Usage of Simulation to Model a Process or Factory

The benefits of simulation are provided by generating a feasible capacity model, facilitating bottleneck analysis, improving equipment utilization, generating meaningful dispatch lists, and determining accurate product start and completion times based on order due dates. In addition, simulation tools allow the cost of resources, capacity expansion alternatives, and the current facility operations to be quantified in great detail. The software does this by **modeling** the following **resources**:

- Equipment
- Personnel who operate and maintain the equipment
- Processes required to assemble and test each product
- Products and their subcomponents
- Operating rules controlling the interactions between these elements
- Planned factory Operation (shifts, days)

Products that are started in the facility, move into queues waiting for available resources and are then routed to product-dependent equipment by dispatch algorithms, load rules, and setup rules. ManSim Products operate by maintaining a current list of **scheduled events**. These include:

- Processing completions
- Equipment failures, repairs, preventive maintenance activities
- Product starts
- Factory operation times
- Personnel availability

As events occur the modeled facility undergoes **state changes**. Statistics are collected and new events scheduled. The frequency of these events is controlled by variables defined in the model, such as

- Product start rates and flow through process steps
- Equipment failures rates
- Processing step capabilities and specifications

A spreadsheet-like interface allows the factory floor and work flow to be defined in a manner appropriate to each factory. Tables are completed describing the facility's products, structure, and flows along with their associated operating rules. **Programming is not required** to build a model. The table-driven approach for describing a model's elements and logic allows the process of creating and maintaining a factory floor model to be easily understood and maintained by the users and creators of the models. This facilitates a user's capability to make model variations that analyze capacity requirements and create manufacturing process improvements.

All ManSim Products can be used to assess the impact of factory design and operating policies on product throughput, cycle times, and work-in-process (WIP). Key facility performance factors which can be studied include:

- Dispatch rules, lot start polices, and shift schedules
- Equipment setup and loading
- Lot size, PM, product mix, rework, and yield rates
- Number of facility personnel required, as well as their skills
- Quantity and capacity of processing equipment required and their reliability
- Equipment reliability and repair time changes
- Equipment shortages and utilization
- Operator and maintenance personnel scheduling

Unique capabilities found in MS/X and TS/X Planner products include:

- Optimize on-time delivery by automatically adjusting start date.
- Determine demand management using multiple demand types with differing priorities.
- Maintain inventory levels including WIP, safety stock, reservations, and finished goods.
- Determine required lot start schedules to ensure the right quantities.
- Ability to work with forecasting and strategic concerns
- Define what is "Available to Promise" during the order management process

Unique capabilities found in MS/X and TS/X OnTime products include:

- Generation (as often as required) of short term (1-3 days) detailed factory activity schedules.
- Ability to include initial factory state and planned changes to resources and policies when creating the short term schedule.
- Provide short term schedules for operator, operation or lots
- Quick regeneration of short term factory schedules in response to unplanned events or as needed

Benefits provided to the User of ManSim Products

ManSim Products can benefit all levels of personnel including high-level managers, planners, engineers, manufacturing personnel, and operators on the factory floor. Having a model that simulates and closely resembles their production facility provides a unique guide for understanding what has to be managed and how it can best be accomplished. This approach is a significant improvement over using static values from history to predict outcomes. Successful solutions and meaningful improvements are the result.

Below are a few examples of the benefits that ManSim products provide:

Benefits for Facility Operations Management

- Understand the dynamics and limits of the production facility to set reasonable production goals.
- Move quickly to respond to unforeseen events in the facility by rescheduling short term production plans.
- Respond to unforeseen changes in product demands, cancellations, mix or volume.
- Effective utilization of Operation and Maintenance personnel

Benefits for Management and Planners

- Can change lot priorities to meet customer orders with short lead times.
- Easy reallocation of product lots for cancellations and unexpected changes.
- Rapid analysis of expected shipping performance over selected time periods.
- Forward visibility and control over the factors driving the monthly profit and loss performance.

Benefits for Continuous Improvement efforts for Lean Manufacturing goals

- Using facility simulation, areas to focus on for improvement can be examined and goals set. (setup times, personnel skills, operational policies and rules, resources for capacity, etc.)
- Using different factory loading (volume, mixes, timing), the outcomes of different resource strategies, operational changes, and policies can be evaluated.

These benefits provide responsiveness to production issues, feasible production plans, and improved competitiveness.

Defining Facility Operations (Components and Operating Policies)

ManSim products separate factory models into two complementary sets of data: Facility Components that describe the structure of the Facility and Facility Operational Policies that define the rules for operating the facility.

Facility Components	Facility Operational Policies (Partial list)
Areas	Shifts, Quantity & Skills of Personnel, Work Breaks
Work Station	What to Select from Queue (Dispatch Rules)
Equipment	How to Load, Setup Rules, PM Strategy
Product Definitions	Release plan, Lot Size, Due Date, WIP allowable
Process Definitions	Alternate paths, rework paths, preferred equipment, sample size, lot splitting, buffer size
Production Periods	Facility Operational Dates, Shutdown dates, Periods for reporting
Hardware	Product support hardware (masks, probe cards, load boards, etc.)

It is strongly recommended that users begin with simple models and incorporate detail as needed over time. When defining facility specifications and operation policies, fields left blank in the data tables for model description will default to appropriate values allowing the user to select the level of simulation detail required. Arbitrarily incorporating more detail than necessary may increase the effort required to initially develop and maintain a model.

Overview of Facility Components used when creating a Facility Model

Area Definition Overview

At the highest level, a factory is modeled as a set of Work Areas. Areas contain Work Stations and defined quantities of personnel. The personnel can be both operators and maintenance types. Personnel can be assigned specific skills associated with Work Stations. The hours and days of operation (i.e. shifts) are part of an area's definition.

Work Station Definition Overview

A Work Station is comprised of one or more units of equipment. The relationship between process equipment and process steps is established by referencing the Work Station name at each process step. If a Work Station is defined within a Work Area, personnel within that Work Area are available to operate equipment at that Work Station. Work Stations can be assigned to more than one step in a process. Product queues are before Work Stations.

Equipment Definition Overview

Equipment capacity can be defined either by the parts per hour processed (serial equipment) or by the number of lots or parts that can be processed at a time (batch equipment). The reliability of the equipment can be defined by mean time between failures (MTBF) and mean time to repair (MTTR) or percent availability. Two types of setup are included; product change and process step specification change. These two types of setup can occur concurrently.

Process Definition Overview

A process indicates the sequence of steps through which a lot must flow. For each step, the process specifies the Work Station to be used for processing and optionally the process time, rework percentage, rework path, yield, scrap, operation code and/or description.
There is no limit to the number of steps that can be defined for a process or for the total number of processes within a model. Multiple products can use the same process. This is often recommended to reduce the number of processes to model, validate, and maintain.

Product Definition Overview

The ManSim product set allows an unlimited number of products to be defined in one model. The **Product Definition** specifies the process used, the lot size in parts, priority, and an optional product start rate. Products can also be defined in a Bill of Material hierarchy or explosion.

Production Periods

An unlimited number of Production Periods can be defined by entering the number of calendar days worked for each period. Holidays and shutdowns can also be defined by period. Product Starts or Demands can then be entered by period and used by setting the appropriate simulation options. Product outs and WIP levels will be reported by period.

Hardware

Hardware in ManSim Products can represent load boards, probe cards, burnin boards and other product or process specific requirements such a jigs, fixtures and masks. Products can only be processed if the required equipment, operators, and hardware are available.

Modeling Facility Operations – Overview of the Basic Flow

Once the Facility components have been defined, the simulation of the facility follows the **basic flow** discussed below.

Facility Operations are driven by policies such as lot release procedures, lot dispatching rules, and rules for equipment loading and setup. The lot release procedures indicate when a lot of a given product is to be released into the factory. Upon release, the lot is placed in the queue at the first Work Station and step of its process.

When Equipment within the Work Station with lots in queue becomes idle and an operator within the associated Work Area is available, lot processing can take place. A **Dispatching Rule** calculates priorities for all lots in the queue and the lot with the highest priority satisfying the load and setup rules will be selected. If operators are not defined for the work area, it is assumed there are always enough operators for lot processing.

For equipment with a batch size greater than one lot, the **Equipment Load Rule** controls whether a partial load is allowed or full loads are required. If multiple lots are simultaneously processed on a piece of equipment, normally they must all consist of the same product. Options allow lots from multiple products to be processed concurrently on specified equipment or at specified steps. The **Setup Rule** indicates how the current setup state for equipment will be checked for processing a new lot, and determines if a changeover will occur.

The lot will be processed for the duration of the specified processing time, incremented by a setup time, if required, and an optional random delay. Upon termination of processing, one of three cases occurs:

1) An entire lot will be scrapped or reprocessed depending on the scrap/rework probability and rework path.
2) The lot will be placed in the queue of the next Work Station.
3) If the lot is at the last process step, it will be removed from the system and indicated to be a “lot out”.

The equipment will then either be placed in the idle state ready for further processing or in the down state for repair or possibly Preventive Maintenance (PM) depending upon its MTBF status or PM planning. Failures can also occur, if desired, during lot processing, in which case, the entire lot is placed back in the queue or optionally allowed to finish.

In addition to the basic flow and key model policies and values described above, there are many additional model values for defining and developing operational policies. These concern product flow and path selection options. These policies can affect product starts, product location, product movement, and product processing.

The ability for departments directly responsible for daily operations to easily modify the model values discussed above and below with simple changes to tables, without the need to write or modify programs is a central feature of the ManSim product set. In addition, model runs execute quickly so that many model value adjustments can be tried and evaluated to see the effects of a range of policy changes on facility operations. This provides a powerful tool for operations management and personnel to respond to problems and improve performance.

Product Flow	Policy options for Product Flow and Path Selection (Partial List)
Starts	Planned lot starts, constant rate, from customer demands
Location	Initial work in process (WIP), maximum WIP allowed in front of a Work Station
Movement	Factory workload regulation, Work Station workload regulation
Processing	Alternate processing paths, preferred equipment, mandatory equipment, splits

Starts (Release Control) Policy Options

Constant rate – Fixed Weekly starts distributed evenly over time
Random Starts - Fixed Weekly starts distributed randomly (Poisson) over time
By Production period
From Demands by production period
Lotstarts File - Lot starts planned for the facility by date and time
By Day and Time - Product starts planned for the facility by date and time
From Customer Orders and Forecasts by production period
Order Mapper Generated starts
    Allocation of lots to orders, demands and forecast
    Regeneration of start dates and times to minimize lateness

Location Policy Options

Product Inventory
    From File
    Generated by Model Run
    From ending values of Previous Model Run
    From CIM System (this is really same as From File)
    None
Maximum Wip - Total Factory WIP allowable
Part Buffer at Work Station - Manage maximum WIP at a Work Station
Inventory Buffer at a step - No further movement if zero demand
Inventory Bank at a step - Accumulate product below a certain priority
Kanban - Use KanBan cards to limit WIP within several steps
Lookahead (TestSim)
    Products at a Work Station can have their flow controlled by the amount of WIP present at a downstream Work Station.

Movement Policy Options

Factory Workload Regulation
    Total starts are regulated by the amount of workload flowing to, queued in front of, and processing at all Work Stations that have a value for "Maximum Workload"
Workload Regulation at Work Station (Lookbehind)
    Total starts for a specific Work Station are controlled by the amount of workload flowing to, queued and being processed at steps prior to the Work Station.
Lookahead (ManSim Product Set)
    Products at a preceding Work Station can have their flow controlled by the amount of Workload present at a downstream Work Station.

Processing Policy Options

Alternate Processing
This allows the execution of a process to be controlled by parameters associated with each lot. Conditional branching may be implemented to add flexibility to part flow. These parameters can be defined for product, equipment, or process steps. Lots can be selected for special processing required for particular machines. The impact of potential process changes can be evaluated and long term engineering experiments can be modeled.

Specified Equipment - Product can only be processed by specific equipment
Preferred Equipment - Sequential List...use equipment listed at the top first, etc.
Backup Equipment - When all the other equipment is down or the queue in front of the Work Station exceeds defined size
Same Equipment – Force lot to use same equipment each time it visits specific Work Station
Splitting - Five types of splits are possible
Conditionals - The elapsed time spent by a lot between steps could force it back for reprocessing
Step Priority - Lots waiting to perform a high priority step will be selected ahead of lots waiting for a normal step
Work Station Priority - Higher priority gets quicker personnel support
Equipment subsets - Subsets are normally used to dedicate equipment to specific process steps
Fail when busy - Allows a lot to either finish before failure, or be rerun after repair of the equipment
Hold Hardware - A lot using hardware at a given step will hold the hardware until it reuses it at a later step
Hold Equipment - Lots using equipment at a given step will hold the equipment until it reuses it at a later step

Stochastic Capabilities

The application of variation to key values used in a model will define the operational ranges of the modeled facility. The results of the model runs with variation can then be used to evaluate facility structure and policy rule changes and proposals.

ManSim products offer the capability for stochastics for the following key modeling values:

- Process Time
- MTBF/MTTR
- MTBA/MTTA (Operator Assists)
- Parts Per Hour
- Process Delay
- Yield
- Rework (% Lots, %Parts/Lot)
- Scrap
- PM Duration
- Lot Size
- Setup Time By Type
- Setup Time By Spec
- Equipment Percent Up
- Transport Times
- Personnel Absence
- Equipment Parameters by Product
    - Parts Per Hour
    - Setup
    - MTBA/MTTA
- • Product
    - Revenue by Part
    - Cost by Part
    - % Hot Lots

Variation of values over different time periods to support the introduction of new products and learning curves can be input for the following modeling values:

- • Yield
- • Rework
- • Scrap
- • Parts Per Hour
- • Process Time