Compiere Manufacturing and Supply Chain Management

Open Source Initiative

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General Objectives

Version 1.0e

For Public Use

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Introduction

System Overview

Compiere Manufacturing (MFG) and Supply Chain Management (SCM) is a planned extension of the Compiere Enterprise Resource Planning (ERP) and Customer Relations Management (CRM) enterprise-level software package. The MFG and SCM extensions will provide manufactures and warehouses with an open source software that enables them to produce and deliver goods in a controlled environment using embedded Compiere planning and control tools – thereby streamlining the manufacturing organization and maximizing sales and profitability.

Project Scope

Compiere MFG & SCM is an Open Source Initiative (OSI) software development project with three primary areas of focus:

- Control of manufacturing operations
- Control of supply chain operations
- Reporting to ERP.

Software with these capabilities will enable manufacturers to effectively execute a manufacturing plan, receive parts, manufacture, store and ship products in the most efficient and predictable manner possible.
It will be capable to work stand alone or connected to an ERP.
It will be capable to extend Compiere ERP & CRM components.

Control of manufacturing operations will drive the shop floor process. The goal in controlling operations is to define manufacturing in terms of process steps and work efforts, create manufacturing orders and drive them all along the manufacturing process. This will allow the manufacturing organization to plan, schedule, and monitor production that occurs on the shop floor.

Control of supply chain operations will drive material movement operations. The goal in controlling supply chain management is to shorten receiving times, delivery times and costs. This will allow the transport organization to plan schedule and monitor transport operations.

Reporting to ERP will allow the management organization to plan, schedule, and monitor production on the shop floor and track product inventory from production line to customer. It will produce data's required for pricing, quality management, traceability and purchasing. It must enable purchasing the smallest quantity of raw material necessary for the manufacturing run, and track material inventory level as they migrate through the manufacturing process : from raw material, to work in process.

About this Document

The Compiere MFG & SCM General Objectives Document provides a general description of long term Compiere MFG & SCM objectives. Associated with this document is The Compiere MFG & SCM Design Document and the The Compiere MFG & SCM Architecture document.

The goal of this document, therefore, is to describe general objectives of a concerted and organized Open Source development effort that will implement a quality manufacturing and supply chain solution.
The basic functional system objectives will be organized in a Compiere *MFG & SCM Modules General List.* Actual description of these Modules is very basic et would have to be completed. We will first implement a subset of this list which will be describe in requirements document.
The material contained in this document comprises of the author's practical experience with manufacturing organizations, personal research, reference material, and a fundamental understanding of Compiere. It is anticipated that others from the Open Source community (particularly the Compiere project) will collaborate and enhance this document significantly once it reaches its final state.
It is important to note that this is document, while in its draft form, is a living document. This means that it is highly anticipated that various revisions will be applied after all interested parties have been provided with the opportunity to review and respond to its contents. This document has been thoroughly reviewed. It has been adapted to respect agreement with other projects coming from Orlando meeting. It establish the project scope for Version 1.0, thereby allowing the Compiere development process to finalize the *General Design*.

Hardware architecture

Compiere MFG & SCM must be capable to work on Windows desktops and servers and on Linux capable Hardware.
Compiere MFG & SCM must support some standard PDA and mobile devices.
It must be capable to work on TCP/IP network in high distributed environments including RF networks.
It must support standard laser and Inkjet printers.
It must support some standard barcode professional printers.
It must be capable to work on modbus PLC networks.

Software architecture

Compiere MFG & SCM must be OS independent.
Compiere MFG & SCM must be database independent.
Compiere MFG & SCM user interface must support standard graphic and Web interfaces.
Compiere MFG & SCM must be able to run using only open source software.

KEY BENEFITS OBJECTIVES FOR COMPIERE MFG & SCM :

- Startup new factories quickly
- Reduce factory cycle-time
- Improve product yield
- Maximize equipment utilization
- Minimized inventories
- Minimize WIP and inventory
- Trace products and capacities history
- Control and improve manufacturing processes
- Control and improve supply chain processes
- Improve personnel productivity
- Improve production quality
- Shortens Time to Market:
  - · Reduces the configuration time
  - · Assistant to configuration with included templates
  - · Comprehensive Service and Training
- Changes made through configuration
- Lower the long-term cost of ownership of MES and total IT costs :
- Software development only necessary for custom requirements
- Upgradable as standards evolve
- Less ongoing maintenance
- Deliver proven dependability for 7 x 24 x 365 operations, Fault tolerant high availability systems design
- Enable timely and effective decision-making
- Hide complexity from users for higher productivity, reduced errors, and easier training
- Run on open platforms
- Support third-party packages through an open "plug-and-play" architecture
- Quickly integrate with automation and 3rd party systems or applications
- Leverage and build on existing Compiere Manufacturing and other MES/CIM investments

COMPIERE MFG & SCM MODULES GENERAL LIST

- Capacity Planning
- Shop Floor Management
- Supply Chain Management
- Quality management
- Reporting, including Costing and consumption
- Alert management
- Simulation
- User/machine interface with plug and play manufacturing drivers with graphical verification and certification tool.
- Statistical Process Control on working or simulation data's
- Traceability including lot, component and operations history
- Equipment predictive/preventive maintenance management including
- Control loops managing timing limits, values limits, states or events.
- Equipment Drawings/Layouts
- Document Management and Linking

COMPIERE MFG & SCM MODULES DESCRIPTION

MFG & SCM ADMINISTRATION AND CONFIGURATION.

MFG & SCM Administration is first the Plant definition. A Plant is a place with some production lines, some workshops, some warehouses and some docks. A Plant is divided in zone with restricted access related to security category to which people, materials belong to. MFG & SCM Administration is also in charge of giving a general overview of each site and from this general overview to access to all specific elements when need to access with them actual values or state, them statistical values and them historical data's. MFG & SCM Configuration is mainly a sub menu in general Compiere menu giving access to a full hierarchy of forms screen. From these screens can be enter all configuration parameter's and access to most of statistical values and give search functions in history tables.

Some of MFG & SCM Administration are :

Administration Functions
Plant, Production Lines, Work Centers, Capacities, Warehouses, Work Shop and Docks administration.
Equipment maintenance administration. (including Control Loops administration)
Alarm Management Administration
Web Interface Administration
Reporting Administration
Quality Management Administration
Version management Administration

CAPACITY PLANNING AND COSTING

Parts of capacity planning are :

PROJECTED NEXT DUE DATE

PROJECTED AND ACTUAL CAPACITY PLANNING AND COSTING

Capacity planning can be client of capacities services.

From products list, routing list and times of operations

Capacity costing
Costing by capacity
Costing by owner

Costing by transactions by owner

Costing by zone by owner

Costing by time by owner

Ability to calculate costing base on combinations of above

Capacity planning

Finite capacity scheduling

Seasonality management

Conwip management

Capacity planning need to propose different policies like : Finite Capacity Scheduling or similar techniques to "optimizes" inventory level and capacities load.

Capacities planning should manage seasonality : that mean having different policies for different seasons.

Capacities Planning should be able to manage policies and parameters changes. For that Future policy and starting date should be proposed.

Capacities planning will have to take in count policy selected by user and statistical values of required parameters. User should always be capable to overwrite Statistical values and to specify Low Limit % and High limit %.

SHOP FLOOR MANAGEMENT

Shop Floor Management properties are :

- Production scheduling complying with *Quick Response Manufacturing,* CONWIP, Batches, Discreet manufacturing and customization and eventually with Finite Capacity Scheduling.
- Integrated support for delivery of scheduling error notification
- Multilevel Plant Structures including: Plant, Line, Work Center and Capacity
- Work orders management
- Operations management
- Tasks dispatching
- Operations preview
- Labels printing

PRODUCTS SCHEDULING

The types of Control supported by the Products Scheduling are:

- Discreet
- Quick Response Manufacturing using CONWIP
- Mixed

We require for *Quick Response Manufacturing* instead of JIT, because it can fit to most of type of manufacturing and even for small units.
We require for CONWIP instead of KANBAN for the same reasons and with the same benefits of reduced costs and shortened lead times.
We require for Batches and Discreet Manufacturing because many production needs that.
We require for customization because it enlarge in a dramatic way area use of the software.

The fact is these techniques need a flexible software.

The types of order to be supported by the system are:

- Make to Deliver
- Make to Stock
- Make to Engineering (Quality insurance, Plant maintenance, Projects and Configuration)
- Forecast

WORK ORDERS MANAGEMENT

The types of Control Input required for the Work Orders Management are:

- graphical display and management of Work Orders lists
- graphical rules editor based on Compiere workflow editor allowing user to :
    - Select the Repository database to supply the data.
    - Define the operations list for each work order.
- Others services requests (Products Scheduling etc.)

The types of Control required for the Work Orders Management are:

- Create
- Delete
- Move
- Change priority
- Hold
- Free

The types of Work Orders are:

- Standard
- Repetitive
- For CONWIP use
- Requisition

You can use the work order to specify:

- What is to be produced
- Quantity
- When product is to be deliver
- Type of order
- Serial number
- Destination

Work order management properties

- Graphical display and management of work orders lists
- Dynamic and static BOM and routings (Dynamic allows BOM and routing adaptation for each work order)
- Re-entrant process flows - Lots can visit the same equipment multiple times.
- Batching - The timing and grouping of lots

OPERATIONS MANAGEMENT

The types of Control Input required for the Operations Management are:

- graphical display and management of operations lists
- graphical rules editor allowing user to :
    - Select the Repository database to supply the data.
    - Define the task list for each operation

    - affect capacities from work center to this task using rules
    - Attach a dispatch rule and define the criteria to be used for the rule (due date, priority, hot lots, etc.). using detailed criteria's
- Others services requests (Work Orders manager etc.)

The types of Control required for the Operations Management are:

- Create
- Delete
- Move
- Change priority
- Hold
- Free

Operation management properties

- CONWIP- Schedulers want to keep an ample supply of WIP in front of critically constrained capacities without building up excessive queues.
- Multiple criteria rules based Triggering Mechanism to pass from one operation to another- Criteria such as recipe matching, queue time limits, and equipment

TASKS DISPATCHING

Task Dispatcher

Scheduling

Scheduling using routing's task list

Scheduling managing capacity availability, priority and proximity.

Scheduling capable to use rules.

Time standards

Standard time by task

Comparison of standards vs. actuals

Tasks Logging

Timestamp start/stop for all tasks

Visibility by capacity

Visibility by transaction(s)

LABEL PRINTING

- Create label format
- create label from format on one side, data on another side.
- Dispatch labels to the good printers
- Barcode management on standard and “barcode printers”

OPERATIONS PREVIEW

SUPPLY CHAIN MANAGEMENT

Parts of supply chain management are :

RECEIVING MANAGEMENT

- Components receiving and tracking
- products receiving and tracking
- Interface to inventories

Receiving

Receive against a PO

ASN receiving

Blind receipts

Unknown receipts (no item or PO available)

Integrated delivery confirmation

Support batch delivery confirmation

Support returns

Signature capture

Detailed Logging

Reason codes for missed deliveries

Damage identification on receipt

Quality sampling and auditing

Receive against a generic license

Receive and generate smart license

Receive without a license

Receive returns w/out a disposition

Receive returns vs. a disposition

Receive transfers without orders

Prompt for open POs upon receipt

Receivers

Option to create receiver by PO

Option to create receiver by load

Option to pre-print receiving labels

Check

Reconcile PO lines with receipts

Multiple operators on a single receipt

Capture lot upon receipt

Display special instructions

Attach graphic of exceptions

User-defined license attributes (i.e., catch weight, owner)

Verify/audit product in staging

Put-away

To quality control

To random storage

To forward pick - if open replenishment

To staging

Cross-dock receipt to single order

Cross-dock receipt to multiple orders

To returns by vendor class

Storage logic association to UOM

Ability to split a single license plate receipt between replenishment and put-away

Ability to store by owner

Reports

Receiving exceptions

Receiver list

Productivity by user

O/S/D report by PO by Load

Vendor report card

Open POs

Yard and appointments

Appointment scheduling

Dock door assignments

Project labor required to unload

Ability to unload trailer w/out details

Ability to RF-direct yard moves

Ability to track demurrage by owner

Ability to systematically assign docks

Ability to systematically assign yard locations

Full trailer visibility

Trailer position in yard or dock

Trailer contents

Pending trailer moves

SHIPPING MANAGEMENT

- Shipping scheduling and control
- Packaging, container, pallet and truck management.
- Lots management
- Products and orders tracking and traceability
- Emergency orders management
- Packing slips.
- Interface to Compiere inventory and invoices management

Picking

Planning

Create waves through pre-defined criteria

Accept pre-determined waves via download

Automatically build waves based on rules

Manually override priority of an order

Ability to cartonize on order import

Ability to pre-manifest pick containers

Ability to include orders in waves

Ability to include order lines in waves

Ability to include order line quantities in waves

Ability to wave for specific trailer sizes

Ability to define reservation rules by customer

Ability to calculate metrics on simulated wave

Ability to release waves by pick type (i.e., pallets first)

Ability to release waves by zone

Ability to auto-create work orders for wave shortages upon release

Ability to wave by pick method (i.e., batch pick)

Ability to wave by owner

Kiting

Bill of material (BOM) capability

Kits exploded during release

Directed assembly

Multi-level BOM support

Ability to backflush consumed parts

Ability to identify scrap

Ability to un-kit

Ability to track WIP in assembly

Ability to associate cost to assembly

Ability to request kiting from user

Monitor the progress of a wave

Workload monitoring by wave by order by item

Visibility of required wave replenishments

Calculations of remaining time by wave

Calculations of new work vs. existing work

Replenishment

Created by min/max

Created based upon released orders

Created based upon day's demand

Created via user request

Replenishment picks in reverse put-away sequence

Support cascading replenishments

Ability to hold allocation-based replenishments

Pick work queues held until replenishment work done

Rotation

User-configurable rotation rules

FIFO

LIFO

FEFO

Select stock by lot number

Customer-specific rules

Pick option

Single-order picking

Batch picking (multiple orders per picker, separated at pick location)

Pick and pass across zones

Bulk picking (multiple orders per picker, separated at pack or conveyor/sort)

Configurable number of pickers per order

Equipment-based picking

Zoned picking, enable picking forwarding.

Use combination of the above options on same order

Picking approach

User-directed

Pick confirm by exception from user

Pick to list

Pick by label

Display special picking instructions

Honor item mixing rules (i.e., haz mat)

Ability to dynamically change pick transaction priorities

Unpick option

Pick sequencing

In location flow

In user-defined flow

Honoring aisle contention

Packing/Shipping

Cartonization

Determine optimal carton size

Determine optimal carton contents

Graphically display carton packing orientations

Support system-directed packing

Display special packing instructions

Loading

Direct loading regardless of order continuity

Direct truck loading by order integrity

Direct loading by route/stop integrity

Parcel manifesting

Support for UPS

Support for FedEx

Other support (list)

Print compliant labels

Rate shopping

Support for bundling

Support for LTL rating

Support online carrier communications

Support for 100,000+ parcels/day/site

Reports

Bill of lading

Packing lists

Customer-specific paperwork

Hazardous material manifest

Unship option

WAREHOUSE MANAGEMENT

- Slot management
- FIFO management
- Rules base management
- Graphical access to components and products using various keys.
- products movements

Warehouse Management

Select best location based upon user-defined rules

Allow user to override location

Record overrides in exception log

Location mapping

Zones

Special requirements (e.g. freezer)

Mapping of acceptable capacities by zone

Ability to relieve inventory based upon merchandise verification to a certain location type

Reports

Full location report

Empty location report

Warehouse location utilization report

Integrated WMS slotting

Slotting based on historical information

Slotting based on forecasted information

Provides visibility to exception conditions

Creates move transactions based upon review

Alters storage/pick/repl. logic based on re-slotting

EQUIPMENT PREDICTIVE/PREVENTIVE MAINTENANCE MANAGEMENT

- At this step only for future use. We create database definition, to avoid problem when we will implement this module.
- Workshop are production lines, associates product_Type enable to identify repair and maintenance activities in the product table.
- As products are identified, maintenance and repairs routing are identified by product_Type and associated production line.
- Repair orders are work orders
- Repair work orders can be identify by the same manner using product_Type and associated production line.
- Inspection plan are batches
- All this to avoid to be oblige to develop something big, only reuse manufacturing elements.

Equipment and software Maintenance Management

Equipment maintenance visibility by : Plant, Production Lines, Work Centers, Capacities, Warehouses, Work Shop and Docks administration.

Alerts based on inspection plan.

Alerts based on Control Loops values

Alerts based on difference between actual time and standard times values, for tasks, work orders, requisition orders.

QUALITY MANAGEMENT

- Control operations quality result
- Control shipping sequence and product quality
- Control components quality
- Collect data for SPC module and reporting.

Quality Control

Quality Control status

Holds by item

Holds by lot

Holds by location

Reports

Quality Control Inventory visibility

Quality Control on tasks, work orders, requisition orders, deliveries, receipts.

Vendor performance statistics

REPORTING

- Create reports to view Repository data for a period on working data's, alerts data's or simulation data's
- Delivery reports by XML files, e_mail, pager, preview and printers.
- zoom on information
- Annotate graphs for presentations and reports.
- Save tables as text to import into other applications.
- Costing and consumption
- Animate temporal reports by updating the graph event-by-event over a period of time.
- Filters based on plant area, line or work center
- Track Information for the Manufacturing organization : To enable to the manufacturing organization, costs are controlled by purchasing the minimal materials needed and by streamlining, production – utilizing minimal personnel and equipment capacities. As define in the Colorado License Plate Factory Case Study and Functional objectives information required are :

Table 3–1 Tracking Information For the Manufacturing Organization

Information	**Description**
People and Organizations	Customers, Suppliers, Distributors and Internal Staff.
Tacking of Parts	Parts Needed for Manufacturing
Design Engineering	Recording Specifications of Parts and Products Designed and Manufactured
Product and Parts Configurations and Bill of Materials	Inventory Control Information Needed to Manage Raw Materials, Work in Process, and Finished Goods
Order, Shipping, and Invoicing	Information for Both Customers and Vendors
Material Requirements Planning (MRP)	Allows Manufacturers to Forecast how much raw materials and goods they will need.
Fixed Assets Management	Track Purchase, Depreciation, Major Equipment and Other Significant Assets of the Enterprise.
Process Plan	Information to track how products will be manufactured
Manufacturing Operations	Information to track the usage of Materials, Labor, and Overhead
Cost Accounting	Information to Allocating Costs of Manufacturing
Financial Management	Budgeting and Accounting for Internal Organizations
Human Resources	Information on Tracking Employee Information

The Data Model Resource Book, Volume 2, pp 28, Len Sliverston

ALARM MANAGEMENT

Alarms Management

Alarm management connected to Equipment and software Maintenance Management

Alarm management outputs to : e_mails, pagers, fax, XML/FTP

Built-in escalation profiles

Built-in resolution strategies

Ability to automatically change scheduling upon exceptions

Delivers device alerts, process alarms, and system events to enterprise users and applications

Allows users to filter information according to their specific needs

Extended alarm configuration depending on : days, hours, events levels, events types.

SIMULATION

- All functions can be simulate by use of “Simulation controllers”.
- Simulation controllers can be plug in place of standards manufacturing devices to provide a dynamic simulation of the control system.
- Simulation controllers can be added for training or testing purpose.
- Simulation controllers can support the same parameters than corresponding manufacturing devices. So that devices may be configured offline.
- Full simulation (only Simulation controller) can be run with special time factors.

USER/MACHINE INTERFACE

- Provide a standard interface to enable users and/or machine front ends to connect
- Plug and play connections of front-ends (manufacturing drivers)
- Graphical interface to control and certificate front ends

SPC

- Production ratios
- Quality ratios
- Defects ratios
- filter by plants, production lines, work centers, capacity

TRACEABILITY

- Give access to history information.
- Filters on Plants, lines, works centers, capacities, Lots, parts, periods etc.

EQUIPMENT PREDICTIVE/PREVENTIVE MAINTENANCE MANAGEMENT

- Predictive/Preventive Maintenance Scheduling
- Fault and Performance Analysis including MTBF, MTTR, Pareto
- Spare Parts Inventory/Purchasing
- Maintenance Cost Analysis
- Budgeting and Forecasting
- Activity Types and Causes
- Solution Codes
- Failure Analysis Codes
- Maintenance Instructions including Images and Documents
- Safety and Special Instructions
- Checklist Steps with online entry of actions and data
- Projected and Actual Elapsed Time
- ETA Estimates

CONTROL LOOPS

- Control loops are automatically monitored on a continuous basis and any degradation in loop performance, variability or detection of an abnormal condition in a measurement, actuator, or control block is automatically flagged-- without additional configuration.

COSTING AND CONSUMPTION

- Give access to cost information's.
- Filters on Plants, lines, works centers, capacities, Lots, parts, periods etc.

EQUIPMENT DRAWINGS/LAYOUTS

- Graphical web access to plants facilities.
- Give access to Plants, lines, works centers, capacities

DOCUMENT MANAGEMENT AND LINKING

- Document management complying to ISO 9000 requirements.
- Give access to current release of document in a distributed area.

SYSTEM objectives

- Compiere compatible, all functions existing in Compiere will be used when possible to facilitate integration.
- User configurable objects
- User definable parameters
- Configurable user security

- Version control for objects
- Message based API
- SQL access to all data

GLOSSARY

Plants

Plants contains :

- Lines groups
- Warehouses
- Shipping resources
- Receiving resources
- Management resources

These are used along with bills of material and routings, Plants are the largest group of capacities which will be managed

Lines

Lines identify Production Line or Shipping Lines:

- Work centers groups
- Subcontract supplier

These are used along with work orders.
Production lines are capable to manufacture whole products.
Production Lines assumes also shipping.

Work Centers

Work Centers identify :

- Capacities groups
- Subcontract supplier

These are used along with bills of material and routings, Work centers are used in task list operations. Task lists are for example routings, maintenance task lists, inspection plans.
Work Centers are capable to do a whole operation.
Work Centers can be Production, Shipping or Receiving centers.
Shipping and Receiving centers can be associated to a group of Dock doors.

Data in work centers is used for

- Scheduling

Operating times and formulas are entered in the work center, so that the duration of an operation can be calculated.

- Costing

Formulas are entered in the work center, so that the costs of an operation can be calculated. A work center is also assigned to work center category which determines the accounting of the costs

- Capacity planning

The available capacity and formulas for calculating capacity requirements are entered in the work center. Work center s must be capable of checking in and staging inventories. Inventory levels must deplete and increase as raw materials, work-in-process, and finished goods move throughout the manufacturing process. Plant managers need to have the ability to monitor inventory levels at each work center.

- Simplifying operation maintenance

Various default values for operations can be entered in the work center.
In Compiere the Work Center and Work Center Category are created into Production Planning and Control Rules. In Work Center Category is define in Customizing the work center, determines which data

can be maintained in the work center and determines the accounting of the costs .

The data is grouped of the following way :
- Basic Data
- Assignments (Accounting of the costs)
- Capacities
- Scheduling
- Default values
- Hierarchy

Capacities

Capacities identify :
- Machines
- Trucks
- Employees
- Subcontract supplier

Capacities are capable to do a whole task.
Capacity types are used along with bills of material and routings
The capacity data includes:
- Capacity type
- The Work Center where the capacity is located
- Standard values for determining operating time, setup time, move time, operating time, unitary cost and grouping size.
- Tasks which can be carried out by this capacity
- Description of production resources and tools
- Inspection characteristics

The capacity type data includes:
- Capacity type name
- machine or operator
- list of tasks that this capacity type can assume.

Routing

A routing is a description of which operations (process steps) have to be carried out and in which order to produce a material (product). As well as information about the operations and the order in which they are carried out, a routing also contains details about the work centers at which they are carried out as well as about the required production capacities (includes jigs and fixtures).

The Routings can be defined as:
- Routing
- Rate routing

a routing is used as a source for creating a work order by copy and eventually customization.

Structure
A routing is composed of a header and one or more sequences. The header contains data that is valid for the whole routing. A sequence is a series of operations which are carried out during production (see Routing graphic)

If a bill of material (BOM) has been assigned to a routing, you can assign routing components to the BOM. In general the BOM assigned to a routing is the material BOM for the material to be produced by the routing.

Operation

A Operation is used in a routing, to describe the activity that is to be carried out during a process step.

The operation data includes:

- Material components
- Tasks list

From tasks list you will find which workCenters can execute operations and therefore which capacities and which work center taking in count the work order production line. These informations are used to determine dates, capacity requirements and costs for a production process.

Quick Response Manufacturing

At the heart of QRM are recent advances in computer modeling of the shop floor. Using sophisticated but easy-to-use software, it is possible to create a picture of the shop floor in approximate but still useful form. The software addresses important trade-off such as lot sizes versus set-ups. It also models "real-life" factors such as scrap and rework. Using the software, a picture can be built of how things are today - and importantly, why are they the way they are?

This type of software represents a heavyweight breakthrough in our ability to manage manufacturing operations. It has the same importance to Operations that CAD has to Design. Production management should welcome this new ability to portray their operations for a better understanding of the underlying mechanics, and I predict that future use of such software will be as universal as CAD.

The real value of such modeling is through "What-ifs". A "What-if" consists in taking the model of today's situation and trying a major change. The consequences of the change should be churned out by the software. Therefore trying various "What-ifs" should tell management what is the most practical change to proceed with at this point. (Ideally the software should *recommend* an optimum action but this level of sophistication hasn't yet been achieved.)

The ultimate value of the software is to guide management towards greatly reduced lead times. This is possible due to a logistical reality : Now, if lead times could be reduced to equal the order fulfillment time, then the system of operation is very often changed to Make-to-Order. Lead time is the total time needed to manufacture, and fulfillment time is based on how long the customer is prepared to wait.

The software must still allowed Make-for-Stock, where Finished Goods stocks are needed for order fulfillment.

QRM recognizes that many industries are non-repetitive, where the JIT paradigm of level production schedules with stable mix is inappropriate. Some have so many combinations of products and services that production cannot be conducted to a level plan. An alternative paradigm is required, in which the product must be customized to each order in a mode of rapid response. The system must be able to handle surges in volume or mix, continuing to turn out orders to the same service level. The implication is that fixed assets must be less intensively utilized in order to increase material velocity and responsiveness - in other words, there must be adequate spare capacity. QRM is also aware that the KANBAN system advocated by JIT may not be the best system for such a manufacturer. There are alternatives in the form of CONWIP, OPT and MRP.

Unlike JIT, QRM also recognizes that whenever an industry manufactures to order, it must have an explicit scheduling system so as to establish the priority of one order over another at all operations. And for those industries also, finite capacity scheduling techniques can be important. What do we mean by this? Well, if there is very expensive equipment which must be run to a high utilization, there has to be a schedule which optimizes the use of the capacity. This optimization means mixing and matching jobs on the capacity in a manner causing a deviation from the due date priority of the orders. QRM seeks to establish a whole system of manufacture which not only optimizes flow but addresses scheduling where this is needed.

A final aspect of the QRM approach is a uniform treatment of both change due to continuous improvement, and 'normal' business change, due to the ability to incorporate both in modeling software.

An example of continuous improvement could be a quality improvement which reduces scrap, while a 'normal' business change could be new product introduction.

CONWIP

Recently, an alternative to KANBAN has emerged, called CONWIP. The idea behind CONWIP (Constant WIP) is that a new work order is introduced to the line whenever a work order departs. Unlike KANBAN, CONWIP isn't part number specific, and the new work order can be for different part numbers, as long as a common measure of WIP exists. Thus, a constant amount of WIP is in the line, or to put it differently, WIP is capped.

To be efficient shop floor Control software must warranty that :

- The priority of work orders must be maintained, firstly at point of release to the line, and subsequently to maintain the priorities within the line.
- The system may not be sensitive to bottlenecks.

Customization

Customization is the making of product to the customer's specific requirements. The customer has ordered a product with certain characteristics unique to her. For example, a custom car with a seat designed around the customer's body characteristics would be a case of true customizations.

In a weaker sense, customization is the scaling of certain product dimension to the exact requirement of the customer. For example, making a bicycle frame to the exact height by cutting the tubes to the nearest millimeter to suit the rider's body. Apart from the dimensions, the tubes would be standard product.

An even weaker form of customization is the meeting of diverse needs through variety. This variety in some instances is provided by options and features which are "add-ons" to the basic product. In other cases, variety is built into the product; for example, different colors of car bodies.

A better solution, without reducing customer choice, is to hold a standard product which is customized in a final production operation. This is only possible if the difference between one model and another can be introduced at a late stage. Then, the extra Safety Stock is required only for optional parts, not for the whole product.

This solution can often be implemented even when a make-for-stock scheme is used, where standard product is shipped from finished goods inventory (FGI). A simple customization operation may mean dramatic reductions in stock levels.

Finite Capacity Scheduling

A common form of manual scheduling is the wall-chart. Across the top of the chart is a time scale, marked of in units of days, or perhaps shifts. Down the left hand side are capacities such as machines or operators.

Operations are indicated on the chart using colored sticky strips of paper. The length of the strip relates to how long operation will take on the given capacity.

Finite Capacity Scheduling (FCS) automates this process. Software display what is just like the wall-chart.

FCS "optimizes" the loading of simulated work orders on to a simulated shop floor. The resultant lead times as predicted by the FCS software can be much shorter than MRP lead times.

The practical uses of FCS are:

- To release and prioritize work orders.
- To quote due dates to customers.
- To act as a Capacity Planning tool : does a new set of orders can be accepted with current capacities, or do capacities need to be increased?

Finite Capacity Scheduling uncover bottlenecks and allow preventative action to be taken; it adapts future workload to the available capacities; and it models different capacity levels (for example, to determine the effect of purchasing a new machine).

In Finite Capacity Schedulers, there are at least two possible and sometimes combined solutions:

1. Basic rule used to prioritize the workload is to prioritize the work orders by Due Date. This dispatching rule allow the finite capacity scheduler to produce a schedule in a dramatically reduced amount of computer time, but the amount of work involved in each job is ignored.

2. Introducing QRM and CONWIP rules give more accurate forecasts without overloading computer time.

Finite capacity schedulers will produce quite respectable if not absolutely optimal solutions by these means.

Another problem is that things change so quickly that a schedule is soon invalid. What may have changed?

- More jobs may have appeared and require scheduling.
- The initial few days of the schedule may have gone wrong, for example due to machine problems
- Priorities may have changed - customers may ask for increased priorities on their orders.

The schedule will not suddenly become invalid it will tend to lose its validity progressively. The schedule is highly valid *at the start and can be used in the short term.*

As Finite Capacity Scheduler need to be re-run frequently - daily, for example and because each run of the Finite Capacity Scheduler needs an up-to-date status on all orders, job information must be efficiently collected from the shop floor, using a Shop Floor Data Collection system.

Multiple objectives.

There are multiple and conflicting objectives to be met - particularly the objectives of

- meeting ship dates
- minimizing changeovers or set-ups
- minimizing WIP

However, QRM and CONWIP rules mentioned earlier help considerably to meet theses objectives.

Scheduling Objective Conflict and Trade-offs.

The objectives of due date priority, set-up minimization and minimizing WIP/lead time are in conflict. In other words, making one better makes another worse.

For example, scheduling two jobs back-to-back means upsetting priorities (and risks missing due date

deadlines), because one of the jobs has to move out of sequence.

On the other hand, set-ups can be minimized without missing deadlines if there is plenty of lead time and slack. But this can only be obtained by early job release, which worsens the objective of minimizing work-in-progress.

For this reason, adapting QRM and CONWIP rules (if they correspond to your type of manufacturing) instead of “in house” rules will optimize the result.

Kanban

KANBAN, a technique for work release, is a major component of the JIT philosophy. It was first developed by the Toyota Motor Company.

If a capacity needs a part, it sends a signal (usually a card) to the up-stream station which makes the part to send some more. At the beginning it was implemented without computers assistance and mainly between different lines of a same plant.

I made the first electronic large implementation of KANBAN between two plants in 1988 between Citroen plant in Rennes and Inoplast a bumper manufacturer (I realize the complete design and the implementation of part supplier software side). During year 1989 many of part suppliers of Citroen start using that system and it is still i use now.

Lots and Batches

At the opposite of KANBAN you have Lots or Batches. A "lot" is a quantity of a part which is made all together or on a product point of view or on an operation point of view, it is also call "batch". Batches can be created by human action or by process.

In first case it correspond to what is also called "run".

In second case all products going through that operation before the lot as a whole moves to the next operation. Although each item is made one at a time, the whole lot has to wait until every item has been through the operation.

Reasons for Lots or Batches

- **Batches for process constraints**

  Some manufacturing operations are designed to work with multiple pieces being processed in a batch.

- **Batches for material handling**

  Some material handling operations require pieces to move in a batch. Since it would not be economic to move a small item singly by fork truck, a lot of the items must be formed before the move can take place.

- **Traceability**

  In some industries such it is important to be able to trace a sample back to the original batch in

order to look at the records of how the batch was produced.

- **Set-up**

  If a machine makes more than one product, and a machine setup is needed in switching from one to another, then the larger the lot size, the fewer setups would be required (over a year, for example).

One main difficulty in Bathes is Lot Sizing. Sometimes software bring assistance to this process.

Tasks

It is the smallest capacity activities typically handle by the Compiere MFG & SCM. They are handle by capacities.

Tasks milestones validation of rules required or not depending on configuration.