Trend 8:
Optimieren der Manufacturing Supply Chain Prozesse durch einen modellbasierenden Ansatz: ein Weg zu besserer Kapitaleffizienz, höherer Geschwindigkeit, Kostenreduzierung und dynamischer Adaptierbarkeit.
Content

1. Challenge
2. Systemic view
3. Model based approach
4. Methodology & Tool
5. Applications (Examples)
6. Conclusions
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„The complexity of Manufacturing supply chain processes often overwhelms our ability to understand them.“

In this perspective we are challenged to evolve an advanced approach to master it.
An advanced approach is needed that enables users

- to handle dynamic complexity (timely changes of e.g. product portfolio, disposition of operational processes, trade offs…)

- to optimize performance (costs reduction, maximization throughput, OEE, cycle time, process capability…)

- to utilize environment (small order sizes, responsiveness, resources, shift / time regime…)

→ “at the same time” in a “balanced” and “pro-active” way
Such **advanced approach**

- **requires** a **systemic approach**, which concentrates on the whole reference system rather than on segments or single events.

- **calls for understanding the causal structures and generative mechanisms** of the manufacturing supply chain which govern its **system behavior**.

- **must be** based on a **dynamic** rather than static **view** (analytical and synthetic).
Optimieren der Manufacturing Supply Chain Prozesse durch einen modellbasierenden Ansatz

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Optimieren der Manufacturing Supply Chain Prozesse
durch einen modellbasierenden Ansatz, 2. Systemic view

System

KPI, Benefit potentials

Levers

Manufacturing SC process

demand

supply
Optimizing the Manufacturing Supply Chain Processes through a model-based approach, 2. Systemic view

**System elements**

- **KPI, Benefit potentials**
- Optimization of assets & capacity utilization;
- Reduce inventory levels;
- Reduce Cycle Time; Maximize throughput;
- Improve Process capability & robustness;

**Demand**
- Process steps & structure;
- Equipment characterization;
- Process parameters;
- Materials; Resources; ...

**Supply**
- Process design; Policies and principles;
- Dynamic & linkages of processes;
- Product portfolio & product quality;
- Demand (order sizes, scheduling, ...)
Optimieren der Manufacturing Supply Chain Prozesse durch einen modellbasierenden Ansatz, 2. Systemic view

System

KPI, Benefit potentials

Manufacturing SC Process schematics

Process parameters
Equipment characterization

Process steps & structure

Materials
Resources

Levers

demand

supply
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How to evolve Model based approach

Build a model of the real system and provide simulation for determination of the best solution.

Such Model based approach requires

- dynamic and causal process understanding
- consideration of data and expertise
- implementation of policies and principles
- application of adequate methodology
Optimieren der Manufacturing Supply Chain Prozesse durch einen modellbasierenden Ansatz, 3. Model based approach

Methodology Tool

Modelling

data, structure, interactions

Optimization cycle

Model

Simulation results

Implement best solution

Expertise Policies Principles

real system

System elements

KPI, Benefit potentials
Optimization of assets & capacity utilization; Reduce Inventory levels; Reduce Cycle Time; Maximize throughput; Improve Process capability & robustness;

System demand
Equipment characterization; Process parameters; Materials; Resources; Operation regime;

supply design; Optimization policy; Product portfolio & product quality; Demand (order sizes, scheduling, ...)

Levers
Model is simplified but validated representations of the real system.

Model consists all relevant cause-and-effect relationships of the manufacturing SC System components, incl. feedbacks.

Simulation explores the sensitivity of the model behaviour and based on it determines any alternatives and what-if scenarios of the answer to a real problem.

The simultaneous and complementary (multifunctional) consideration of levers and KPI’s enables to optimize the manufacturing SC Process and to determine the best performing solution.
The Model based approach is one and only way to provide solutions in pro-active way.

The capability to act pro-active opens up additional value proposition - process design - capital efficiency - implementation speed - cost avoidance - risk mitigation

On the purpose, the capability of the applied methodology and tool (SW) has to be of unique performance.
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System Dynamics is a holistic universal applicable Methodology for studying & managing complex feedback systems.

Vensim is a tool (SW) applying SD methodology which enables
- to transform knowledge and data into model
- to build a model of any complex system
- to determine the best performing solution under consideration of the multidimensional optimization policy.
Vensim Models delivers (SOURCE: VENTANA LTD).

Intelligence amid mixed signals by combining human expertise and data to determine the true signal

Focus amid distractions by using cumulative knowledge to highlight new leverage

Consensus amid multiple views by integrating knowledge and reconciling differences

Understanding amid complexity By tracking the interactions of causes and effects, ...

Confidence amid uncertainty by showing the odds and the best ways to influence them while experience deepens
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Depending on **focus** (Process, Purpose, Objectives) there is a wide spectrum of possible **applications**, exemplary:

- **Manufacturing: demand and supply, material & product flows, …**
  - demand & order tracking, WIP / Inventory, throughput, Cycle Time, yield, utilization / OEE, Resources…

- **Manufacturing: processing & technology**
  - process parameter variations and associated risks, impact on product quality…

- **Process development**
  - speed / time to market, cost reduction…

- **Product Portfolio Life Cycle Management**
  - time to market, costs, risks, value generation…
Manufacturing: demand and supply, material & product flows,…

Solid manufacturing & packaging
(coated tablets, Lean / WIP, Cycle Time, …)

Biopharmaceuticals bulk manufacturing & fill & finish
(organizational design /WIP, CT, …)

Liquid fill & finish
(syrup, Design & investment efficiency)

Biopharmaceuticals bulk manufacturing & fill & finish
(PFS, Lean / WIP, SC responsiveness, …)

Packaging & Palletizing area
(demand & performance variations, Eq. design, …)
Manufacturing: processing & technology
Process model and risk based multivariate quantitative investigational analysis and improvement of an API process consisting multiple process steps (Dialysis, Ultra filtration, Distillation, Sterile Filtration)

Process development
Process development and transfer (solid, granulation)

Product Portfolio Life Cycle management
PPLCM Management and strategic governance (LC Phases II to launch (Pilot Study))

For more information about the 3 Ex. above, please contact InSysteA
Manufacturing: demand and supply, material & product flows,…

Solid manufacturing & packaging
(coated tablets, Lean / WIP, Cycle Time, …)

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Packaging & Palletizing area
(demand & performance variations, Eq. design,…)

Ref. M. Janovjak, 15th April 2013
Solid manufacturing & packaging

**Purpose**
Build a model which enables to elaborate the Lean optimized manufacturing and packaging process (one certain coated tablet product)

**Starting position**
Order based packaging installed, rhythm wheel “optimized “ push practice in bulk manufacturing (at each work center)

**Approach Objectives**
Deployment of Pull principle across entire process, optimized campaign size in dispensing & granulation, batch and customer order tracing, back log control, representation of QC & QA process, Eq. utilization

**Optimization Objectives**
CT reduction (responsiveness), Cost Reduction (WIP, Inventories, batch yield)

**Results**
Cost reduction through reduction of WIP / Inventory ca. 300 k CHF/a while maintaining same customer service KPI
Solid manufacturing & packaging

Model Parameterization
Initialization Pre-position batches

Warehouse Dispensing Granulation Tabletting Coating Packaging

Pull Principle across entire process
Backlog control per each process step Scheduling

Batch tracing, QC & QA processing

Simulation 30 days; 90 orders;

Machine Utilisation - (running average)

Yield losses WIP mfct. Idle times
Cycle Times

Eq. utilization

Optimieren der Manufacturing Supply Chain Prozesse durch einen modellbasierenden Ansatz, 5. Applications (Examples)
Manufacturing: demand and supply, material & product flows,…

Solid manufacturing & packaging
(coated tablets, Lean / WIP, Cycle Time, …)

Biopharmaceuticals bulk manufacturing & fill & finish
(organizational design /WIP, CT, …)

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Biopharmaceuticals bulk manufacturing & fill & finish
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Packaging & Palletizing area
(demand & performance variations, Eq. design,…)
Biopharmaceuticals bulk manufacturing & fill & finish
Source: Lee Jones, Ventana Ltd.

Purpose
Assess impact of change from functional to process-oriented organization given;
• Random demand stream for multiple products
• Shared production lines
• Alternate physical locations of packaging

Approach
Study current system and build ‘as is’ SC model; validate
Identify performance and structural changes when moving from functional to
process-oriented organization (‘to be’)
Modify model/parameter values to represent multiple ‘to be’ options
Evaluate impact on KPI such as delivery performance, stock holding and cycle
times, and determine possible benefit potentials

Results
Reduction in cycle time of (~25%) and stocks (~33%) while maintaining same
customer service KPI
Biopharmaceuticals bulk manufacturing & fill & finish
Source: Lee Jones, Ventana Ltd.

Production campaign drives by pulled scheduling

Order data and WIP informs scheduling

Orders and order tracing drives order data

Orders drives packaging schedule

Order tracing

Pull bulk for packaging

Product pushed through packaging to finished goods and delivery

Primary contained product

Availability of FTE and Materials, packaging line capability influence packaging performance

WIP

Order

Materials

OEE

FTE

Ref. M. Janovjak, 15th April 2013
Manufacturing: demand and supply, material & product flows,…

Solid manufacturing & packaging
(coated tablets, Lean / WIP, Cycle Time, …)

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Biopharmaceuticals bulk manufacturing & fill & finish
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Packaging & Palletizing area
(demand & performance variations, Eq. design,…)
Purpose
Assess the costs reduction potential of currently coupled line and determine the possible benefits in the case of decoupling of the line.

Starting position
Order based SC installed, optimized rhythm wheel controlled manufacturing ("push"); planned project for line decoupling;

Approach Objectives
Determination of the solution with biggest cost reduction potential, incl. decision support for project realization. Lean optimization, batch and customer order tracing, representation of QC & QA process, Eq. utilization;

Optimization Objectives
Cost Reduction (WIP / Inventories, change over costs)

Results
Cost reduction Lean optimized current coupled line: 25 %
Cost reduction Lean optimized decoupled line (planned project): < 30 %
Planned project cancelled due to insufficient rentability (cost avoidance 250 kCHF)
**Liquid fill & finish**

<table>
<thead>
<tr>
<th>Costs (%)</th>
<th>Filling</th>
<th>Packaging</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inventory</strong></td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
</tr>
<tr>
<td><strong>Change over</strong></td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
</tr>
</tbody>
</table>

- **Fill** + **Pack**
- **Fill**  ➔ **Pack**

*(Simulation period = 500 days)*

- **Coupled line**
  - Rhythm wheel Push (current)
  - Pull (lean optimized)
- **Decoupled line**
  - Push on Fill; Pull on Pack
  - Pull on Fill & Pack
  - Pull on Fill & Pack and QC parallel

Cost reduction 25%  
Cost reduction potential < 30%
Manufacturing: demand and supply, material & product flows,…

Solid manufacturing & packaging
(coated tablets, Lean / WIP, Cycle Time, …)

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Packaging & Palletizing area
(demand & performance variations, Eq. design, …)
Biopharmaceuticals bulk manufacturing & fill & finish

**Purpose**
Build a model which enables to elaborate the Lean optimized manufacturing SC process

**Starting position**
Order based SC installed, BB Cycle Time focused project implemented

**Approach Objectives**
Deployment of Pull principle, optimized batch and customer order tracing, back log control, representation of QC & QA process, Eq. utilization

**Optimization Objectives**
CT reduction (responsiveness), Cost Reduction (WIP, Inventories)

**Results**
Cost reduction through reduction of 4 batches of 24 in WIP → Inventory cost reduction ca. 2’000 k CHF/a
Biopharmaceuticals bulk manufacturing & fill & finish

Results:
- Cycle times at each process step
- Mean Cycle times stacked
- Total product demand & available supply (released filled product prior sec. packaging)
- Customer order backlogs (duration, # of orders, at delivery)
- Stock levels WIP at product and at process step (Lt., # of syringes)
- Yield / CONC
- Equipment utilization (OEE)
Manufacturing: demand and supply, material & product flows,…

Solid manufacturing & packaging
(coated tablets, Lean / WIP, Cycle Time, …)

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Biopharmaceuticals fill & finish
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Packaging & Palletizing area
(demand & performance variations, Eq. design,…)
Packaging & Palletizing area

Purpose
Determine performance of packaging area and needed size of conveyor system and palletizer and provide sensitivity analysis of impact of variation of order sizes and lines performance on results.

Starting position
Upgrade of existing production.

Approach Objectives
Deployment of random functions to simulate variations of
- order sizes
- lines performance
- change over and line clearance

Optimization Objectives & Results
- Determination of impact of the shift to smaller orders sizes on performance and throughput
- Determination of material flow (cases) and palettizer utilization (mean, St. Dev.)
- Model design adaptable to extended scope (scheduling, order control, WIP...)

Optimieren der Manufacturing Supply Chain Prozesse durch einen modellbasierenden Ansatz, 5. Applications (Examples)
Packaging & Palletizing area

Packaging line outflow in cases

Packaging line outflow accumulated in cases, conveyor system & transport to Palletizer

Palletizing process as flow rate into buffer in front of Palletizer and warehouse

Palletizer performance & utilization

Randomized order size and line performance and determination of batch duration and processing time

Batch control cycle with determination of cumulative # of batches and change order execution data

Randomized duration change order and share fraction based decision of change order activity
Optimieren der Manufacturing Supply Chain Prozesse durch einen modellbasierenden Ansatz, 5. Applications (Examples)

Packaging & Palletizing area

Simulation period
30 days; 1'574 orders
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Innovative Systemic Applications

Benefit of deployment of model based approach with System Dynamics Vensim

- Enables to master complex manufacturing SC processes and to harvest even “very high hanging fruits” not achievable with other approaches.

- Leverages user to be in position to elaborate and select optimized solution and making sustainable decisions with minimized risk and maximized benefit.

- Results in paradigm shift to facilitate pro-active management of complex manufacturing SC processes.

Over all, the universal applicability of the applied methodology & tool opens up to build a platform for a flexible and effective governance to master future challenges.

Ref. M. Janovjak, 15th April 2013
Thank You!
Backup slides
Correctness and validity of the model

- **Structural fit** (structure of the causal relations between variables and sub-processes)

- **Behavior correctness** (the behavior of the real system is appropriately reproduced by the model, i.e. dynamic and logical behave, equation & operating point)

- **Plausibility and consistency of results**
  (qualitative and quantitative, extreme conditions)

- **Validity for application** (it the model is appropriate for the domain in which it is to be used and conforms with purpose, i.e. based on comparison of the experimental values and simulation results, the model enables required changes and must provide requested answers, i.e. problem solving results)
Methodology capabilities and tool characteristics (in extracts)

The methodological capability and the tool characteristics determine the power of the context of the modelling & simulation

- **The methodological capability**
  - modelling of the dynamic processes
  - modelling of the complex feedback systems
  - application field universality
  - suitable for study and practical management
  - practical to knowledge mgmt.

- **The tool characteristics**
  - wide range of mathematic functions
  - easy to model and validate
  - high calculating capacity
  - high capability to provide multivariate analysis and simulation
  - easy customisable front-end cockpit
  - powerful and easy customisable graphical presentation
  - integrated data management (data collection, bi-directional IM/IT integration, …)