SIMchronization

Synchronization of Information and Material Flows in Maintenance Supply Chains

universität wien
Faculty of Computer Science

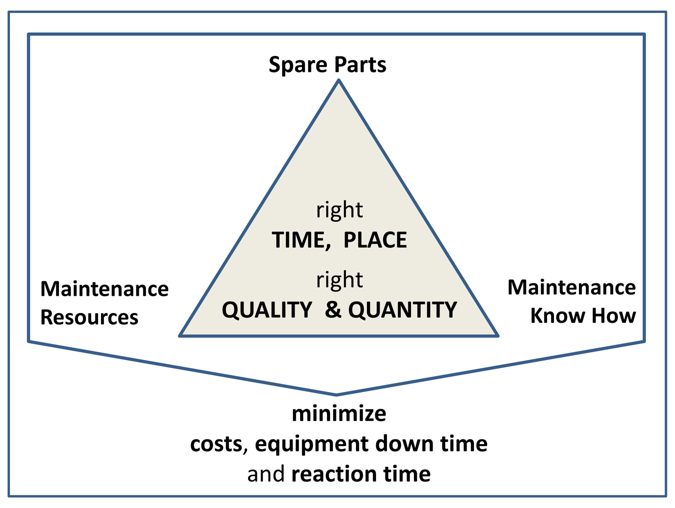
DKE
Research Group: Knowledge Engineering
Christoph Prackwieser
prackw@dke.univie.ac.at

Introduction

Maintenance costs are about 30% [1] of total production costs and this ratio is still increasing [2]. Therefore maintenance management is in focus of optimization efforts.

Cost related maintenance management requirements:

- in **everyday operation** - cause **low resource consumption** which leads to:
  - reduced spare part inventories
  - externalization of maintenance related know how
- in case of **equipment failure** – **react fast and flexible**, provide all necessary repair elements to reduce equipment down time



Approach

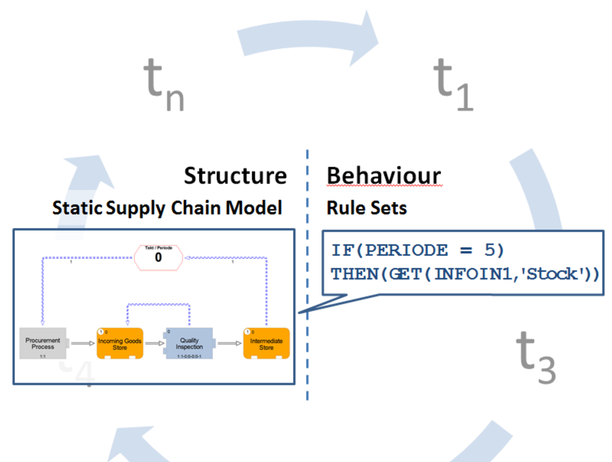
Outage costs are greatly influenced by the duration of the equipment down time [3], which in turn depends on the timely provision of information, spare parts, tools and specialists at the site of the faulty system [4]. This network of information, material flows and process steps, which is necessary to perform all maintenance activities is called the **Maintenance Supply Chain** (**MSC**) [5]. It spreads from the supplier of spare parts and services to the customer, and equipment holding facility. The factors determining the efficiency of an MSC are effective coordination of cross-logistic processes such as material and information flows and a frictionless interface design [6]. Many steps in the material flow can be triggered only by control information, which is in turn a result of previous material movements. The larger a network and the more parts are involved in the logistics process, the more complex is this interaction. To avoid potential deadlocks, to reduce delays in the repair, and to reduce costs caused by inventories, it is important to make the interactions between control information and physical parts transparent and thus uncover optimization potential.

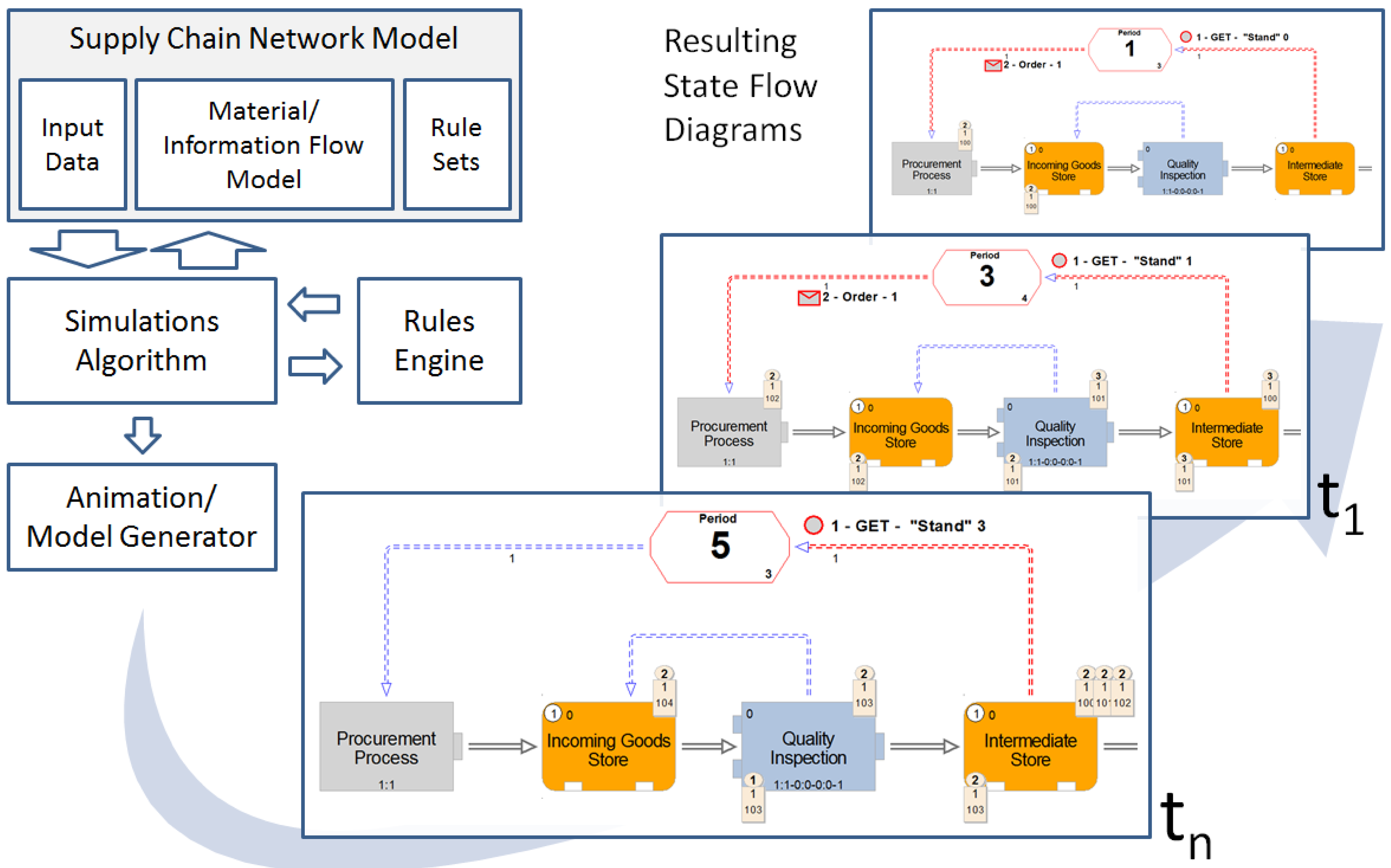
Static Supply Chain Model

The analytical part of the method is based on a combination of a graphical model depicting the supply chain's structure with behavior-describing rules of its objects and involved partners. To describe the static model of a supply chain network we developed a domain-specific graphical modeling language. The names and basic semantics of some of the modeling classes are adopted from the SCOR [7] model's process structure. To model the material flow and describe the processing of logistic parts the following modeling symbols are provided: 'Source,' 'Store,' 'Make,' 'Transport,' 'Deliver,' 'Reader,' and 'Switch.' The class 'Plan' is used to describe both production planning and centralized supply chain control processes. Material and information flow channels connect interacting objects in the network. These channels are used to transfer parts from one object to another or to communicate via messages or calls.

Rule Sets

The behavior of different supply chain partners, especially in case of changing system conditions, is a complex and highly dynamic interplay of actions and reactions. A graphical modeling language alone is not appropriate to model all possible alternatives. Therefore, the static graphical model of the supply chain structure was combined with formal rules, which describe the resulting behavior of supply chain elements in certain situations. We developed a textual rules language that provides useful commands to affect the information and material flow of a supply chain model. For example, in a centralized control scenario a rule set of a 'Plan' object monitors sales volumes of a 'Deliver' object, and sends out corresponding order messages to a 'Source' object via an information flow channel.





Simulation

To reveal the dynamics of a supply chain network a discrete simulation algorithm is applied to the static model and the behavior-describing rules. The simulation algorithm considers a priority and event sequence, periodically reads out the rule set of an object and forwards it to a rule engine. The rule engine evaluates the rule set immediately and returns the output to the simulation algorithm. As a result message-like production orders, or inquiries, are created and corresponding parts are moved by the simulation. During the simulation the flow of parts through the supply chain is animated. After a simulation run the report generator provides quantitative data, like lead time and activity based costs. To support the understanding and the communication of newly designed or modified supply chains, the simulation's model generator creates a state flow diagram for each individual period. A state flow diagram includes information flows (messages and calls are depicted in red) and material flows (parts are depicted in beige) numbered according their occurrence in the respective period.

Implementation

To evaluate the approach a prototype was implemented by using the meta-modeling platform ADOxx®. The modeling classes and their attributes were created within the software and the simulation and animation algorithm combined with the rules interpreter were implemented by using the scripting language of the platform.

ADOxx® is a registered trademark of BOC Information Technologies Consulting AG

Literature

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3. Alcalde Rasch, A.: Erfolgspotential Instandhaltung: theoretische Untersuchung und Entwurf eines ganzheitlichen Instandhaltungsmanagements. Erich Schmidt, Berlin (2000)
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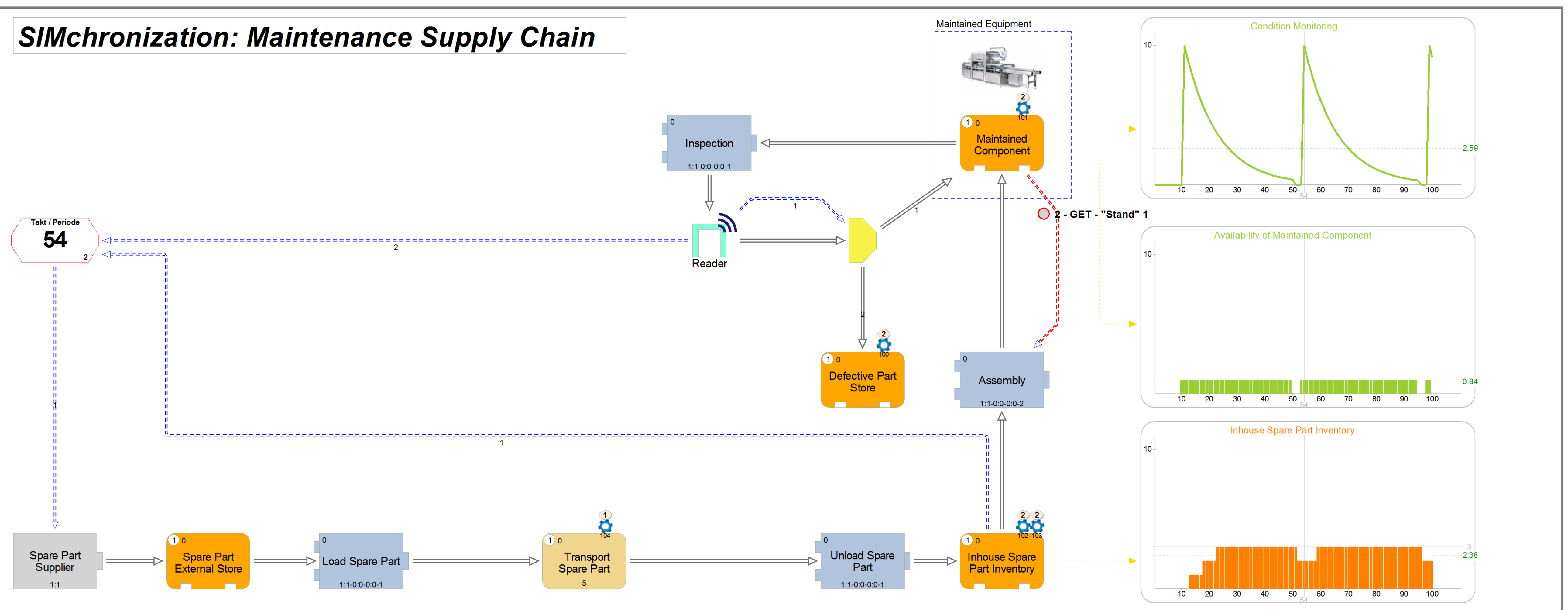
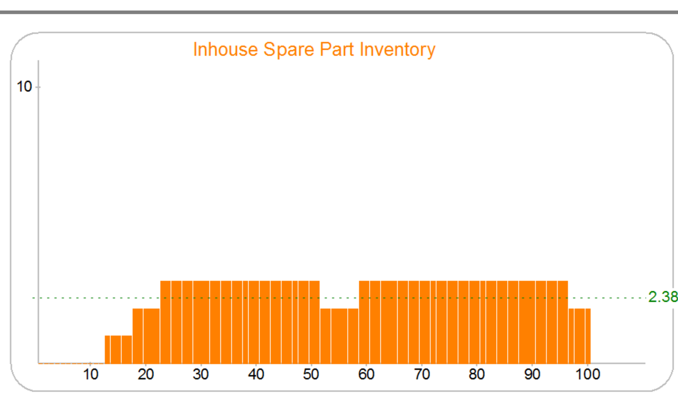
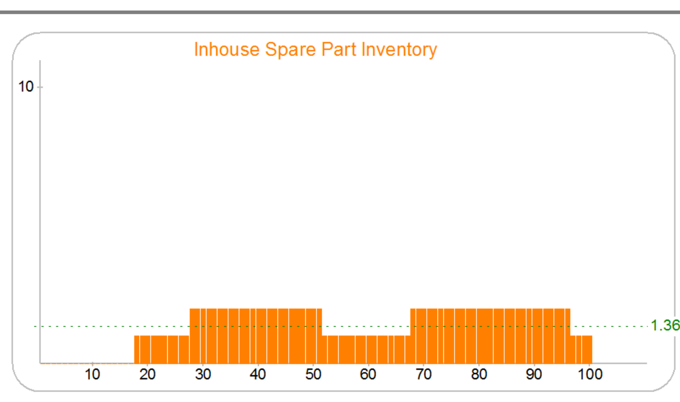
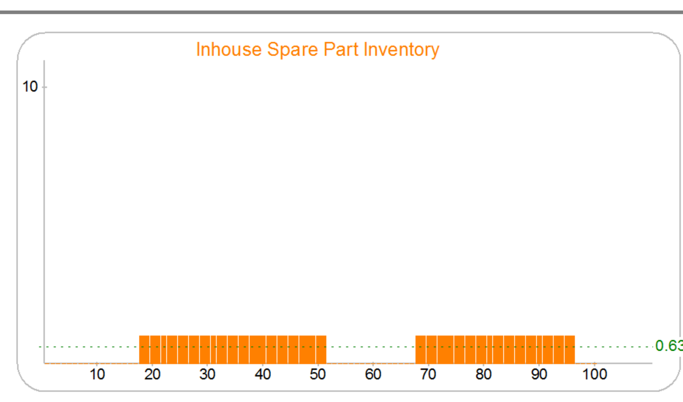
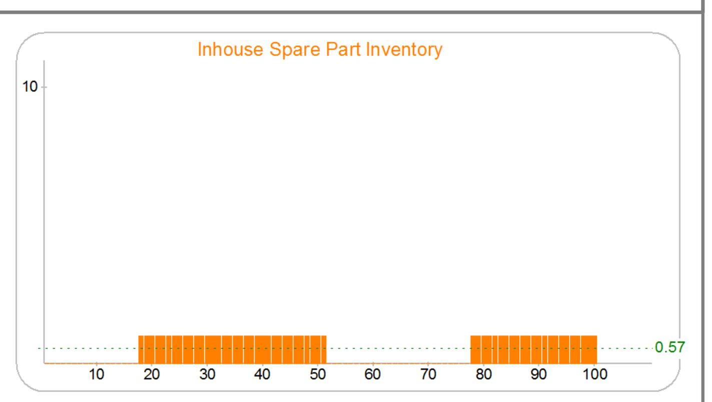
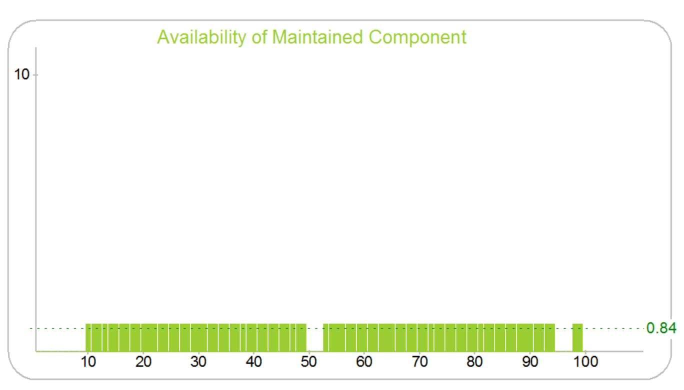
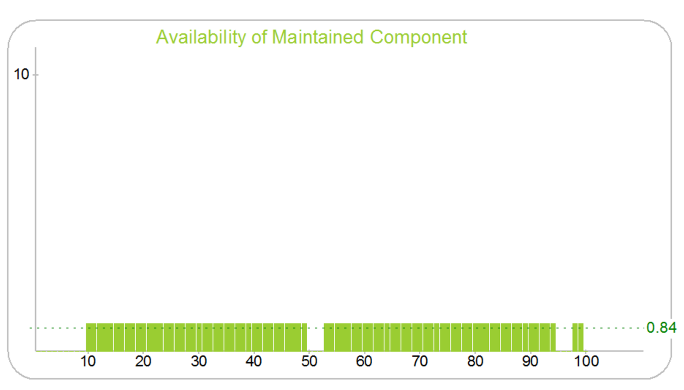
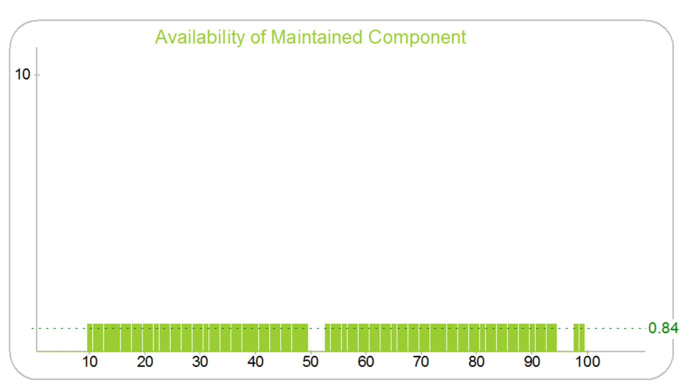
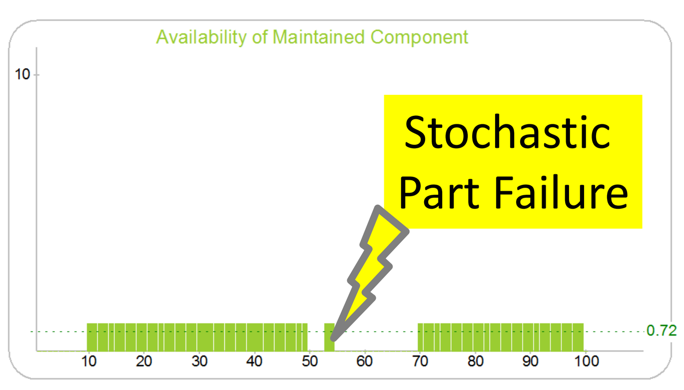
Application Example

Goal	To reduce average spare part inventory by providing constant level of equipment availability
MSC	• the maintenance object and its condition function; • inspection and repair task; • a 2-stage procurement supply chain from spare parts supplier to in-house storage; • centralized supply chain control system.
Model Parameter	• transport time from supplier to in-house spare part inventory takes 7 (1 + 5 + 1) periods; • repair task takes 2 periods; • every 5th period an inspection of the condition of the maintenance object takes place; • inspection task takes 1 period.



	Basic Scenario	1. Adjustment of Inventory Policy	2. Adjustment of Inventory Policy	2. Adjustment of Inventory Policy
Spare Part Inventory Policy	for every defective part a new spare part is ordered + check every 5th period: if inventory level <= 2 then 1 spare part is ordered	check every 10th period: if inventory level <= 1 then 1 spare part is ordered	check every 10th period: if inventory level = 0 then 1 spare part is ordered	check every 10th period: if inventory level = 0 then 1 spare part is ordered
In-house Spare Part Inventory				
Availability of Maintained Component				 Stochastic Part Failure
Results	avg. inventory: 2.38 availability: ok	avg. inventory: 1.36 availability: ok	avg. inventory: 0.63 availability: ok	avg. inventory: 0.57 availability: not ok

Contact:
Christoph Prackwieser, prackw@dke.univie.ac.at

http://www.simchronization.com