# Disturbance management in Large Logistics Networks

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## Abstract

*In nowadays supply chains a high logistics service level is required. Controlled order management needs accuracy and transparency in planning the unexpected. Disturbance management assists enterprises within supply networks in the management of unpredictable events, when they have to interact in short time frames with numerous organisations and persons. Therefore this work provides a fast applicable and economical procurable disturbance management solution with the modules communication, knowledge and technology. This is characterised by a reaction model with flexible workflow modules for standard IT products assisted by structured communication and state of the art knowledge management.*

***Keywords: Workflow Management, Supply Chain Management (SCM), Supply Chain Event Management (SCEM), Order Management (OM), Disturbance Management (DM), Large Logistics Networks (LLN)***

## 1. INTRODUCTION

Changed market conditions, continuous progresses in IT as well as the broad use of integrated IT systems and logistics concepts have constantly risen the degree of cooperation in the supply chain. Cooperation between enterprises in Large Logistics Networks (supply chains) is more than ever a substantial component of business. Particularly small and middle sized enterprises (SME), due to their position in supply chains, often only react on the demand of their customers. Additionally their relatively small market power makes them exchangeable within a supply chain. Only a high reactive and frictionless order fulfilment is a guarantee for staying in business. A substantial part of the business function of order management is spent on the management of unexpected events. This work-controlling task is the most vulnerable topic in order management. It is characterised by a huge variation of duties, responsibilities and collaboration structures in a process environment. If these processes are connected to some kind of breakdown, then this is called disturbance management (dm).

## 2. LARGE LOGISTICS NETWORKS

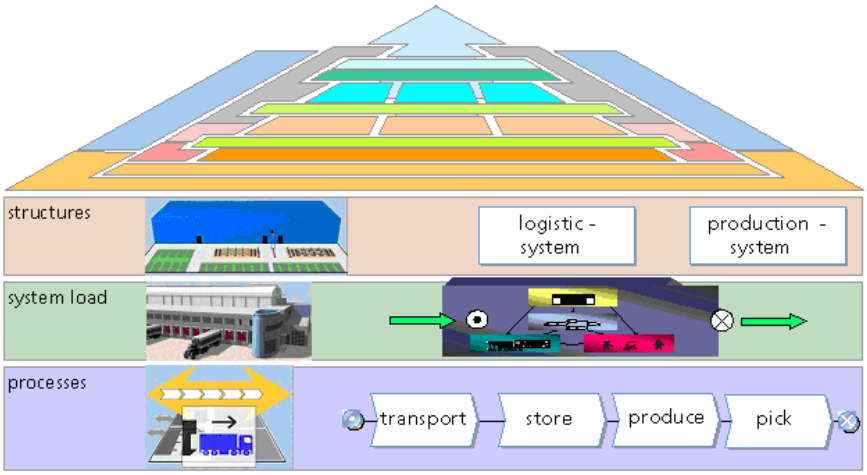


Fig 1: Logistics Task Model [6]

Kuhn [6] divides logistics systems in three levels. All logistics systems contain the basic processes, which are transportation (inbound and outbound), storage (of raw material, auxiliary material, operating material, semi-finished goods and finished goods), production (the transformation of material to (semi-)finished goods) and picking (gathering of product according customer order). Every logistics system owns its current system load, which means the utilisation of system output (of buffer stock, work place, production facility, line, shop floor, plant, supply chain, logistics network). In the organisation of logistics systems Kuhn divides in production systems (Toyota production system) and logistics systems (supply chains, logistics networks). Logistics networks actually consist of enterprises with multiple customer-supplier relationships. This is contrary to a simple idea of a supply chain, where only relationships between forerunners and successors exist. For disturbance management the focus has to be put on the characteristics of logistics networks, because of their huge complexity and disturbance affinity of their processes and relationships.

Large Logistics Networks (LLN) exist wherever a large number of different items are transported across several levels, also using alternating transport carriers or transport modes. These logistics networks are supplier networks, production networks, distribution networks, freight forwarding networks, container cycles, transportation networks etc. The elements of LLN (e.g. according to Dortmunder Prozessketten Paradigma [7] structures, resources, processes and organisations) are linked to each other by a multitude of various relationships. The current developments in LLN provide new structures and legalities. In recent years, a multitude of new network-based enterprise structures such as alliances, joint ventures, supplier networks, fractal factories, segmented factories, extended enterprises, virtual enterprises and process-orientated organisation forms have been propagated and discussed.

## 3. IDENTIFYING DISTURBANCE MANAGEMENT AS A PART OF SCM

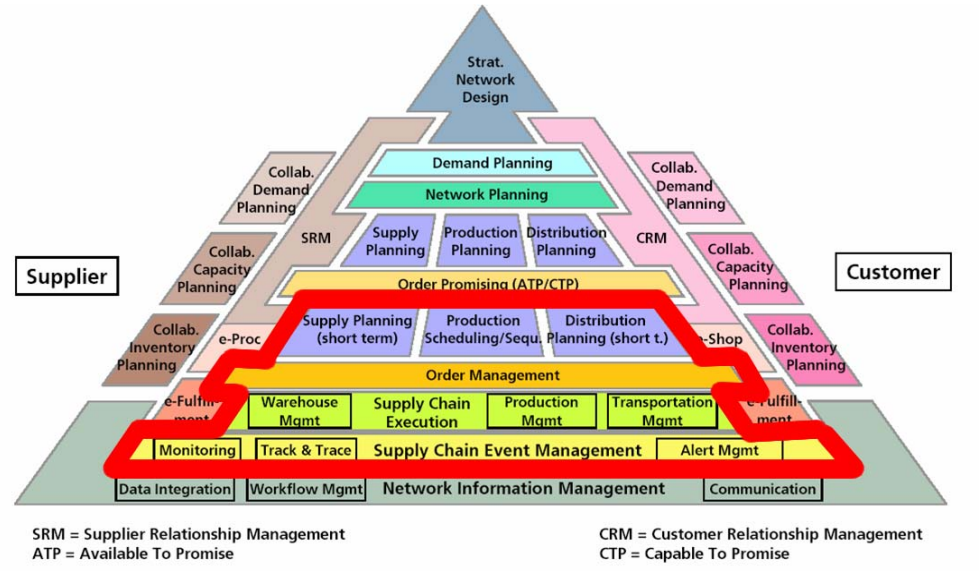


Fig 2: Supply Chain Management Task Model [3]

The specific tasks of planning in LLN are described by the Supply Chain Management Task Model (figure 2). This task model covers both, planning and control and distinguishes different task areas of Supply Chain Management: Design (Supply Chain Design respectively Strategic Network Design), planning (Supply Chain Planning) and execution (Supply Chain Execution). For a holistic SCM concept the Supply Chain Management Task Model assigns the control task to the field of Supply Chain Event Management (SCEM). SCEM is the philosophy of an active material supply and flow monitoring along a supply chain and furthermore a collaborative approach to manage supply disturbances and exceptional circumstances with monitoring, notification, exception handling and measuring. The monitoring function is used to identify problems pro-actively in real-time, supported by simulation and data collection. Disturbances (delays, minor lots) are identified and alerted. The implementation of SCEM in LLN enhances especially the information exchange in the enterprises and within the supply chain. As a result, information regarding stocks, capacities and disturbances are available much easier, cheaper and more reliable in the supply chain. This leads to the strategy in LLN to reduce stocks and buffers between enterprises (for example: just-in-time, just-in-sequence, vendor or supplier managed inventory, collaborative forecasting and replenishment) and within enterprises (pulled production, KANBAN).

Decreased stock levels in LLN have led to a more important role of SME. In the past, deviations in the supplier output were eliminated by high stock levels. In this low inventory level environment, a single enterprise can be a critical supplier for the whole supply chain or logistics network. If a single enterprise is falling behind schedule, the output or utilisation of the whole supply chain or supply network is endangered. Taking this into account, the management of events is required for huge enterprises but still more for SME. SME have gained more responsibility in low-inventory concepts, but their original small market power and exchangeability from the supply chain have remained. This background shows the importance of disturbance management in a holistic view on SCM.

Disturbance management covers »planning« and »controlling« of presumable events for which their time of appearance is not predictable. For example, a disturbance in order processing can be caused by a machinery breakdown but also by a delay of a supplier’s

delivery. It is obvious that this kind of disturbances happen, but it not predictable when these events will appear.

In this context disturbance management deals with short-term order management. Figure 2 shows in the frame the field of disturbance management in accordance with the Supply Chain Management Task Model. These are all short term measures from SECM up to short term planning of supply, production and distribution. Especially order management is regarding the interface between different production enterprises (or facilities), different channels and partners of distribution as well as customers to secure a high satisfaction regarding product availability, delivery time and constancy. Short-term means in this case measures which have to be undertaken to avoid and solve deviations with just-in-time or on-demand quality information without changing existing structures.

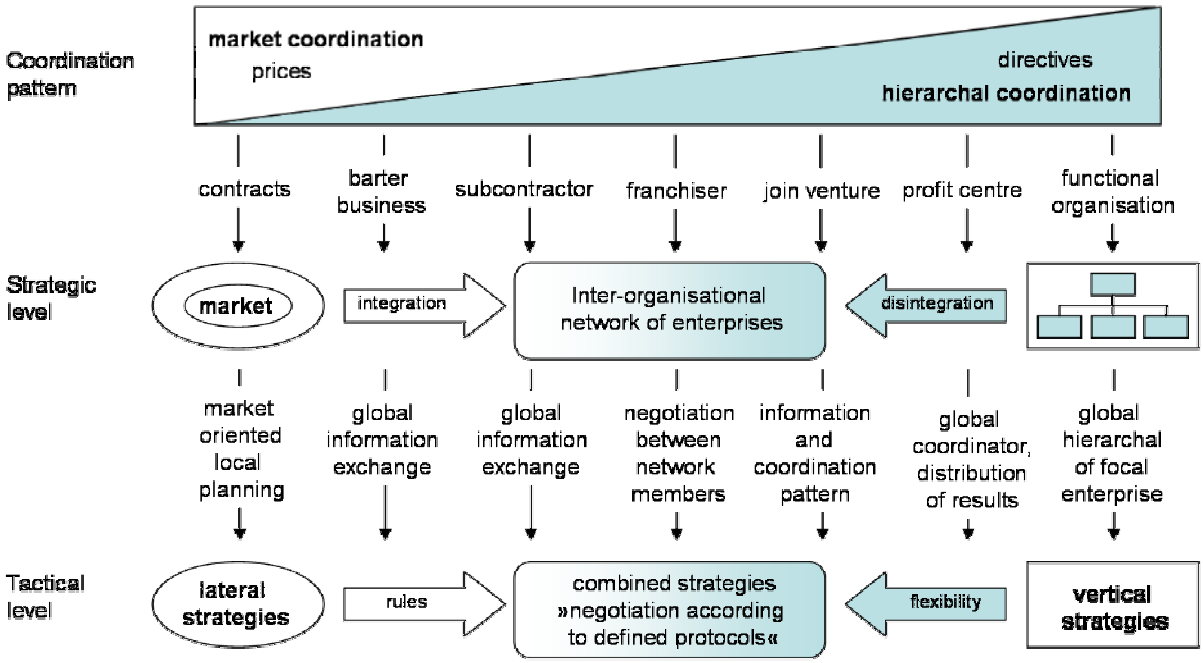

Fig. 3: Lateral / vertical SCM-strategies [1]

In the planning and steering of LLN Hellingrath/Witthaut [1] distinguish between lateral and vertical SCM-strategies. Vertical SCM-strategies are dominated by a single and focal enterprise, which is organising the relationships within the logistics network and so the communication flows regarding information about stocks, capacities and demands top-down. In lateral environments the planning state is achieved by coordination between enterprises on the same hierarchical level. Networks with combined strategies exists, where enterprises or subsets of them work close together on the basis of contracts. This idea for modelling the communication in LLN can also be adapted to disturbance management to differ vertical and lateral disturbance management. Vertical disturbance management is dominated by a focal enterprise. The coordination takes place by exchange of information about disturbances, but due to the distinguished position of the focal enterprise, the room for activity is limited for the depending enterprises. This means that information is mainly directed towards the focal enterprise, mostly organised by contracts; in return the information flows back to the depending enterprises are not as huge. Lateral disturbance management is characterised by equality with the participating enterprises. The coordination of disturbances takes place on a collaborative level, where no partner is in advantage or disadvantage. This means the

information about disturbances is shared with in the supply chain or supply network. Conditions between the lateral and the vertical strategy are achieved if enterprises cooperate occasionally by extra agreements.

## 4. TASKS FOR DISTURBANCE MANAGEMENT

The information flow in the supply chain is organised according to the lateral or the vertical strategy. Within enterprises the choice of strategy is the same. One (person or organisation) organises the disturbance management for the vertical strategy. For lateral strategy different organisations must collaborate on the same hierarchical level. Sub classes of lateral within enterprises are, if there are organisational units that work closer together, for instance on the basis of service level agreements.

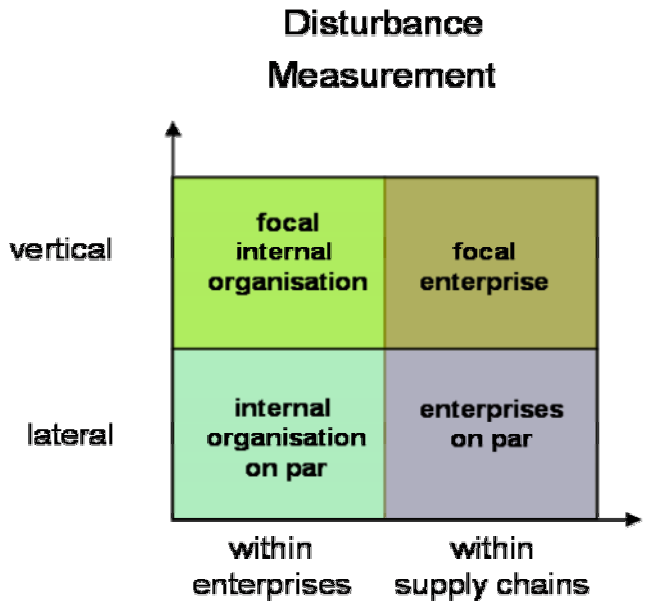


Fig. 4: Lateral / vertical disturbance management

The subject of disturbance management is defined as a degree of functional nonfullfillment that has a noticeable effect on a planned or defined process [4], further this is called disturbance. Disturbances have in common that their occurrence is possible, but actually there is no chance to forecast the time of occurrence. Examples for these types of disturbances are inbound problems, like machinery breakdown or material unavailability at a station (machine) or supply chain regarding problems, which affect the output of the whole supply chain, like running out of stock or the impossibility of parts delivery, due to a breakdown of means of transport.

Disturbances differ from failures. Failures are defined as an improper feature deviation from a targeted performance. In the disposition process a disturbance relevant for disturbance management is an unplanned result that differs from an expected and planned environment; this means by talking about planning processes, affecting the planned processes or the process standards. Disturbances are all events which prevent a process to deliver an economic result. They are noticed plan deviations in execution of production, procurement and distribution.

Disturbance management is the active steering task to solve the un-planned situation by initiating a plan adjustment or leading the exception back into the planned environment.

To cluster disturbances two dimensions are relevant, firstly the disturbance source or initiator, secondly the time of appearance in the order fulfilment process. The disturbance source (external institution, capacity, process, and environment) is pre-defining and limiting the possible solution space regarding the context of the disturbance initiator. The time of appearance in the order fulfilment (transport, store, produce, pick) process is pre-defining and limiting the solution strategies depending on the remaining buffer time in the process. [4]

The task for disturbance management is to provide a structure in which disturbances can be managed controlled according to their initiation and their time of appearance in the process and respecting lateral and vertical organisational forms. According to the Supply Chain Management Task Model these are tasks of alerting, monitoring and tracking of disturbed units, machines, orders, stocks, materials etc. and the short term management of distribution, production and procurement. Because of the fact that for all of these tasks in a mid- and long-term view responsible people, organisations and IT-systems exist, the task of disturbance management is reduced to enable a structured communication between those instances and providing an applicable solution according to the solution area and the time of appearance of the disturbance.

## 5. COMPONENTS OF DISTURBANCE MANAGEMENT

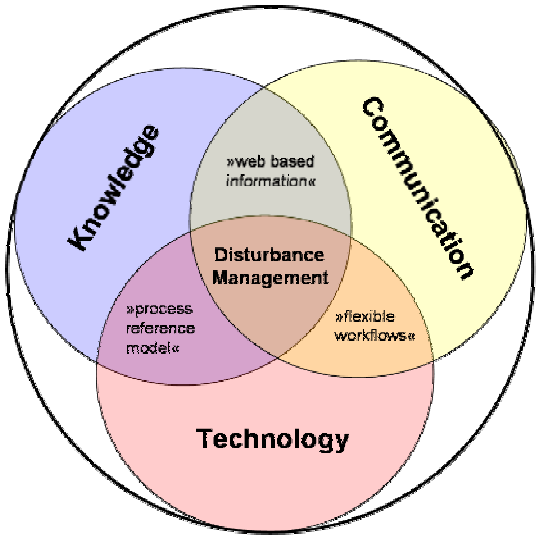


Fig. 5: Components of disturbance management

Disturbance management consists of three components in respect to provide a stable process environment and to enable definition of solution proceeding for common disturbances with link to former solutions. The components of disturbance management, communication, technology and knowledge, achieve in cooperation a crucial improvement for the handling of noticeable functional non-fulfilments affecting planned or pre-defined processes.

**»Communication«** defines organisation, duties-and-responsibilities, communication-processes and communication-rules in disturbance management.

The organisation defines in a first step which partner in the logistics network is part of or affected by disturbance management. The crucial organisational units responsible for order management are procurement, production and distribution which have to be linked organisationally by a cross-organisational department to avoid frictions in the order processing and the communication flow. Employees with scheduling tasks in the departments of procurement, production and distribution are concentrated in one organisational unit providing on one hand a strong connectivity along the order fulfilment process within the enterprise and on the other hand a strong connectivity between the order management and the single departments.

The process ensures the connectivity of the duties-and-responsibilities derived from the reference organisation in a process reference model. The duties-and-responsibilities define the tasks which are part of a disturbance management. The process reference model is defining how the work between the participants is organised. Communication-rules define how different kinds of disturbances have to be communicated and how this communication is organised and designed between. These tasks are provided in a reference task model. Duties-and-responsibilities consist of change management, information management and bottleneck management. Change management enfolds the responsibility for manufacturing order change up to the initiation of shipment. This takes into account the change of order dates and order structures up to the (manufacturing) order cancellation. At the same time an information management must communicate towards the internal and external order stakeholders all deviations of dates, in quality and in promised product features in case of non-fulfilment, for example to the distribution department or the exact external customer. A bottle neck management refers to the allocation of rare materials, resources, machines and employees affecting the order fulfilment in case of disturbance appearance.

The reference processes are in the state of development. Therefore a substantial questionnaire is processed right now with SME in different parts of the supply chain and different branches to achieve an industry spanning process picture. Basing on that, communication-rules are defined to structure the communication disturbance management between the individuals in the processes where a positive work environment is stressed by time-critical decisions, in case of conflicts between members of the disturbance management or cultural barriers. A result from this is a framework of rules on the basis of service level agreements. This depends in huge parts on the identified processes.

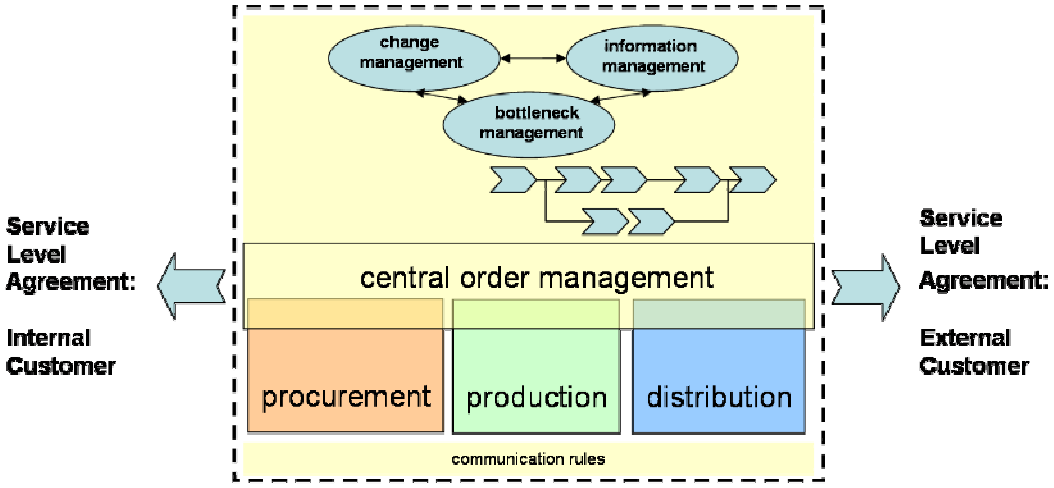


Fig. 6: Disturbance organisation

**»Knowledge«** describes disturbance definitions and classes, reference solution strategies and solution classification in disturbance management.

Disturbance definitions are predefined reference descriptions for main events or disturbances in logistics networks in analogy to disturbance classification. This defines which events have to be solved with the instruments of disturbance management. Therefore a set of predefined disturbance classes is defined in which an event can be grouped and special solutions strategies can be attached. The reference solution strategies consist of predefined solutions on the basis of the disturbance classes. Reference solutions are predefined, but in the daily use they will be selected depending on the actual state on basis of the disturbance classes. Disturbance classification is an evaluation instrument to review the impact of the disturbance on the logistics networks and the quality of the defined solution. This ensures qualified rating. Disturbance classification helps to decide which solution strategy has to be taken to solve a disturbance class, if more than one solution for a disturbance class exists. It also helps to review the impact of a disturbance on the output of the logistics system. Two classification systems have to be developed, one to measure the disturbances and one for the measurement of the solutions.

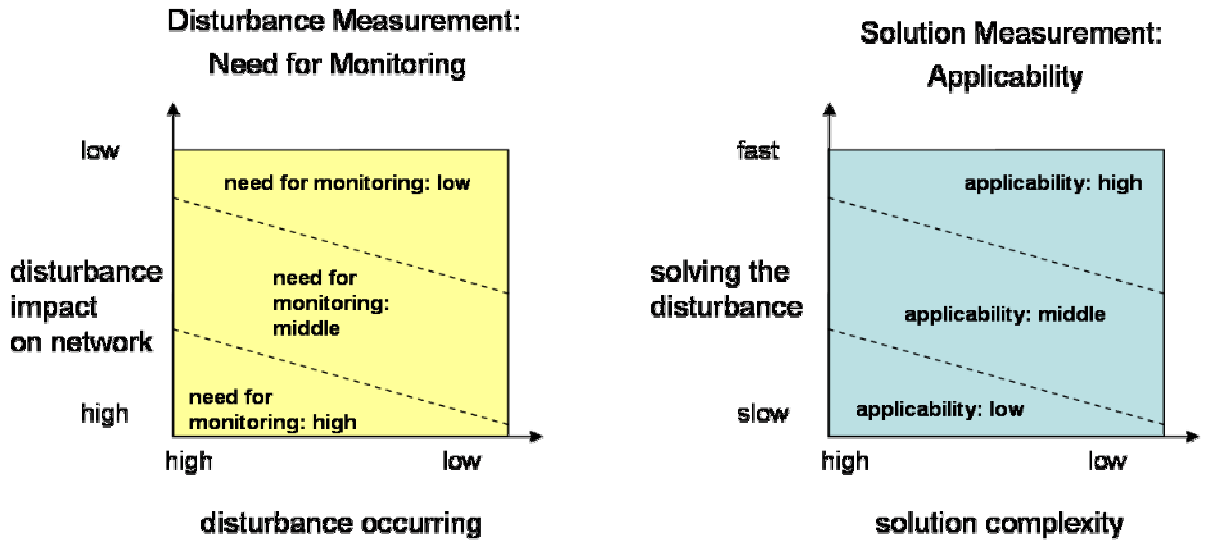


Fig. 7: Measurement

The component **»Technology«** provides the IT support for disturbance management. For the knowledge component an independent definition for disturbances, disturbance classes and solution strategies have to be developed to allow exchangeability between different use cases and applications. Therefore a single disturbance object is defined consisting of disturbance description, derived class, depending solution strategy and describing attributes. Attributes are the participating roles or organisational units, the probability of re-occurrence and disturbance classification. For the communication component a communication model a proper and frictionless collaboration will be provided to achieve interconnections between the participants on basis of workflows. Workflows are capable to assist processes, which depend on huge knowledge and bring the information in the right quality to the right workplaces in a structured way.

## 6. IT-SUPPORT FOR DISTURBANCE MANAGEMENT

For the needs of disturbance management, especially in lateral environments, workflows have to be flexible to fit and replace the old means of communication. Therefore the AiF* launched the project "Realisation of a flexible workflowmanagement-system for order and disturbance management". It's the goal of the project to facilitate and to improve the work within the disturbance management in supply chains for time critical decision making between many partners. Therefore the current processes of disturbance management are being analysed to see, which processes are capable to be assisted by flexible workflowmanagement-systems. This secures a customer orientated frictionless order management and reliable information logistics. Expected results are:

- Duties and responsibilities for disturbance management in huge enterprises and SME which can be assisted by a flexible workflowmanagement-system
- Reference organisation for workflow assisted disturbance management
- Flexible workflowmanagement-system prototype
- Catalogue of configurable workflow patterns
- Training and piloting of a flexible workflow system

Especially SME as tier-3 and tier-4 supplier are victims of huge deviations in demand and of short-term customer requirements (»bullwhip effect«). In this situation an insufficient disturbance management leads to competitive disadvantages. With the results from Flex-WFM improved service levels and improved competitive situations will be achieved and sunk cost based on disturbances can be avoided. Workflows have been chosen to process steering in the disturbance management. For improvement, this project will apply workflows for disturbance management without leaving the needed flexibility behind. Therefore a tool box with configurable sub-workflows will be defined to allow the description of complex processes, e.g. initiating additional supply, notification of participants. These workflows modules with huge connectivity and module-architecture are the basis to achieve cross-enterprise cooperation needed for disturbance management in logistics networks. Currently the project is in the stage of sub-processes identification and reviewing. Therefore a detailed questionnaire in several German SME is progressed right now to achieve a clear view on the disturbance management in SME in different branches, for example automotive supplier, cold rolling industry and product manufacturer. The XML (extended mark-up language) subset XPDL (extended process definition language) has been chosen for process description to describe the processes in an application neutral language. XPDL is an official process definition language provided by the Workflow Management Coalition (WFMC) [8]. Many workflow systems own XPDL interfaces, so processes defined in XPDL are re-usable in many workflow engines. The projects workflow models will so be re-usable.

XSL (extensible style sheet language) and thereof the XSLT (XSL Transformations) has been chosen for web based presentation. By using the XSLT language the information existing in the XML description can automated be transformed to presentation. But more off with the use of XML documents the context of the information is machine readable. This owns the advantage that the information consisted in the XML documents, stays also in the presentation layer in context. With this a automated solution selection is possible, the used information regarding disturbances and solution strategies can be shared, edited and published easily within an organisation, an enterprise or a logistics network. It provides support of the disturbance solution selection by providing connections between planned or executed solution strategies with the current state. On appearance of a known event the user will be supported in detecting the disturbance class and the connected solution strategy.

## 7. OUTLOOK: SCM-DESIGN IN RESPECT OF DISTURBANCE MANAGEMENT

The discussed disturbance management concept is short term orientated because of the need for fast disturbance solutions. The capability of archiving and documenting the disturbance solutions broad with combination of communication, knowledge and technology allows reviewing the appearance of reoccurring disturbances. So the disturbance management is able to leave the short term level and switch to mid-term for local process improvements and to the long-term view to enhance the SCM-strategy and organisation for the logistics network.

In the mid-term view enterprises are able to analyse and correlate disturbance reasons appearance over the time and take a look on concrete process enhancements. This is the basis for business process restructuring (BPR) projects which can be done more exactly and goal-oriented. Additional benefit is that these projects can now be reviewed exactly. By comparing the re-occurring disturbances before and after a BPR project the benefit of the project is obvious.

In the long-term view enterprises are able to switch to the supply chain level or logistics network level. Like in the mid-term view the information of re-occurring disturbances and events can lead to the improvement of processes. On the supply network level the organisation concepts and SCM strategy can be questioned by combining information about re-occurring disturbances. With an active disturbance management enterprises own knowledge about (re)-occurring disturbances. So the dependencies between SCM-strategies, SCM-organisation and the assessment dimension allow the review of the SCM-organisation. The relation of strategy and organisation is at present the state of the art, re-occurring disturbances can be interpreted as impacts on the assessment dimension. There is for example a strong connection between the SCM-strategy »central planning« and the organisation form »4PL logistics service provider«. This means that this combination of a strategy and a organisational concept leads to an optimal efficiency of the planning process. In a third dimension, the assessment dimension, different quality figures will be numeralised. According to the combination used in the example, SCM-strategy »central planning« and SCM-organisation »4PL logistics service provider«, a high level of the trust potential in the supply chain can be assumed.

## 8. CONCLUSION

Active disturbance management will improve the process quality and will reduce required process time for the implementation of solutions as well as disturbance costs in Large Logistics Networks. Especially SME benefit from an improved capability in disturbance management. For the implementation of a concept based on a flexible workflow management for disturbance management, affordable new workflow tools are needed. The Flex-WFM project is providing these tools.

With active disturbance management enterprises will be mid-term in the position to implement a continuous improvement process which is measurable by reviewing the re-occurring disturbances. In the long-term view enterprises, if capable to identify and cluster reoccurring disturbances, can derive the optimal SCM-strategy and SCM organisation for its

logistics network. By over viewing the actual organisation and strategies, enterprises are able to initiate changes towards an optimal solution for strategies and organisation.

In close cooperation with the AiF-founded »Flex-WFN« project and results from the SFB 559 in the future, it will be possible for large logistics networks to re-define their structure on basis of re-occurring events within the network depending on the lateral or vertical environment.

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