Abstract
The paper addresses a conceptual framework for collaborative product design and related manufacturing system development, operations and maintenance. The framework consists of (1) a conceptual model for collaboration among autonomous manufacturing work systems and (2) an ICT platform which supports collaborative operations over the web. The framework improves visibility, understanding and control of the processes involved and on a practical level provides a platform on which geographically distributed operations can be conducted effectively. The system is developed as an integrated prototype web application. The case study presents the implementation of the concept in the development, operations and maintenance of manufacturing cells for die-casting of aluminum and magnesium components for automotive industry.

Keywords:
Manufacturing system, Distributed manufacturing, Virtual coordination

1 BACKGROUND AND MOTIVATION
There is a steady growing pressure on companies, urged by the world wide competition, to streamline operations involving product and product related manufacturing system design, product manufacturing and system maintenance.

The picture of a stand-alone company that is linked to its customers and suppliers only by delivery and procurement of products is no longer valid [1]. The customer-supplier relationship has undergone a substantial transformation from the traditional, simple buy-sell relationship toward the current one, which is focused on partnership.

To realize these trends and to improve the efficiency and effectiveness in business and manufacturing activities the collaboration has been recognized as one of the most critical factors [2]. E-collaboration and collaborative systems have opened the possibility for geographically dispersed teams to work together by supporting communication, coordination and cooperation [3].

In order to reach the competitive level of performances in terms of reactivity, productivity, product quality and system availability, companies, especially SMEs, are motivated to form business coalitions in order to react jointly to emerging business opportunities, to gain the synergetic effects and a competitive advantage by sharing of competencies and risks, and to form flexible and goal-oriented temporary cluster structures.

In order to develop a conceptual framework for collaboration within the networks, the Adaptive Distributed Manufacturing System (ADMS) approach was introduced [6]. ADMS is based on the concept of Complex adaptive manufacturing systems (CAMS) [7] and on the concept of dynamic production clusters [8].

Within CAMS the basic building blocks are defined in terms of elementary work systems (EWS) [9]. The EWS consists of a process, process implementation device, and a competitive advantage by sharing of competencies. These forms are being developed. These forms enable companies to focus on their own competencies. On the other hand, they acquire complementary expertise and resources over collaborative networks. Thus, companies cooperate vertically along supply chains and horizontally among peers [4].

Research is focused on collaborative product design, and related manufacturing system development and its operations. These processes and their interrelations are complex due to incomplete data and knowledge, combinatorial explosion of states, and dynamic changes in the environment [5]. They are performed by several partners in timely and geographically distributed manner.

Let us consider the relationship between a customer and a manufacturing equipment supplier. The customer is primarily focused on a product which he delivers just-in-time to his customer. Therefore, he requires not just a manufacturing equipment supplier but a partner who would develop, manufacture, install, put the equipment into operations and, later on, who would offer support in operations in terms of process optimization, maintenance, system improvement, upgrading, reconfiguration, etc.

In the paper a conceptual framework for collaboration in a network is proposed. It is implemented in an industrial network interconnecting a die-casting producer, a manufacturing system manufacturer and various service providers.

2 ADAPTIVE DISTRIBUTED MANUFACTURING SYSTEM (ADMS) CONCEPT
New organizational forms and structures such as production networks, virtual enterprises and production clusters are being developed. These forms enable companies to form business coalitions in order to react jointly to emerging business opportunities, to gain the synergetic effects and a competitive advantage by sharing of competencies and risks, and to form flexible and goal-oriented temporary cluster structures.

In order to develop a conceptual framework for collaboration within the networks, the Adaptive Distributed Manufacturing System (ADMS) approach was introduced [6]. ADMS is based on the concept of Complex adaptive manufacturing systems (CAMS) [7] and on the concept of dynamic production clusters [8].

Within CAMS the basic building blocks are defined in terms of elementary work systems (EWS) [9]. The EWS consists of a process, process implementation device, and a human subject [9]. EWS possesses the competence and capabilities to perform a particular manufacturing process.

ADMS is structured as a network of building blocks – autonomous work systems (AWSs), as defined later on, and represented by agents. Thus it represents an organic structure of interrelated agents which are acting in parallel and/or in series, or in both ways, and are driven by cooperation and competition on various levels [7]. This approach synthesizes the agent structure as a decision network. The AWSs are interconnected via corresponding agents into the network and thus constitute the ADMS. Within the system the market mechanism stimulates the building of dynamic manufacturing structures for particular manufacturing objectives.

The ADMS approach promotes autonomy and self-interest of AWSs, and system adaptability by self-organization and distributed decision-making [10]. The latter is performed collaboratively. Here, collaboration implies the communica-
tive, cooperative, coordinative and collective characteris-
tics which enable transparent, flexible, simultaneous, syn-
chronized, jointly shared, and continuously integrative
system operations. The autonomy of an AWS is character-
ized by its particular competence in terms of knowledge,
experiences and resources, as well as the responsibility for
decisions about its own actions.

Figure 1 reveals a conceptual framework for collaborative
ADMS system operations. On the baseline, i.e. operational
level there are heterogeneous and redundant AWSs which
are capable to perform various manufacturing processes,
such as design, process planning, machining.

The key elements of an AWS are: manufacturing opera-
tions, management and control, and measurement sys-
tems for inputs and outputs. Measurements support moni-
toring of real-time performance for important changes,
threats and opportunities, for management of operations
and prediction of appropriate actions for best operating
results, for local decision making, as well as for providing
visibility on the coordination level.

The coordination level coordinates a product specification
process with the market/customer and suppliers on one
side and AWSs operations on the other side with the ob-
jective to optimize an overall system performance. The
coordination process is governed by strategic goals de-
defined by stakeholders of the network on the strategic level.

Let us examine the example of an AWS. Figure 2 reveals
the functional model of AWS. The management function is
responsible for coordination, organization and optimization
of work. It sets objectives and priorities for operations and
resources within AWS autonomously. It also communi-
cates and coordinates AWS activities with other AWSs
over the coordination level.

The scheduling function provides schedules of operations
according to objectives, optimization criteria and con-
straints set by the management function, and current
states of the AWS.

The operation planning function prepares instructions and
additional information for operations based on product-
related information. Here specialized knowledge is needed
for a localization of process-related information according
to the AWS particularities.

The AWS operation includes all necessary activities to
perform a process and performing of the process itself on
EWS. There is at least one EWS in AWS.

An information flow rate is particularly high in manufactur-
ing operations. Therefore, the role of the monitoring func-
tion is of decisive importance for proper decision making.

Figure 2: Autonomous work-system model.

The monitoring process measures and collects data about
events and states in operations related to products, proc-
esses, resources and quality. It provides progress reports
and diagnostics of malfunctions.

This information is available for decision making in AWS
locally and over the web for the coordination and other
decision making entities, e.g. project management and
plant management.

The key issue for the implementation of the AWS concept
is the development of an autonomous and integrative in-
formation system supporting the mentioned functionalities.
The development of such web-based information system is
given in [11].

The described structure of AWS is generic and can be
applied to any AWS performing manufacturing operations.

3 COLLABORATIVE DESIGN AND OPERATIONS

The ADMS framework represents a generic solution for
collaborative product design and related manufacturing
system development and its operations.

Figure 3 reveals the model for collaborative product devel-
opment and manufacturing in a distributed environment.
Two distinct phases are characteristic, namely (1) product
design and related manufacturing system design and (2)
operations.

In the first phase product development activities from
product specification, conceptual, detailed and process
design to prototyping are performed [12]. Next, a corre-
sponding manufacturing work system based on the product
definition is developed. It can be either a reconfiguration of
an existing manufacturing system or a completely new
development.

The second phase, i.e. operations, starts once the first
phase is accomplished. The production is driven by the
market demand. To maintain a high level of operation
performances, such as constant product quality, high pro-
ductivity, reliability and system availability, an adequate
operations support is provided by various services.

These include process support, tooling support, system
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات