

# Chapter 3.7

## Collaborative

### Industrial Automation:

#### Toward the Integration of a Dynamic Reconfigurable Shop Floor into a Virtual Factory

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#### ABSTRACT

This chapter summarizes our latest results concerning the development and the industrial application of the emerging “collaborative industrial automation” technology and its powerful meaning for facilitating the integration of a dynamic reconfigurable shop floor into a virtual factory. It argues, in this respect, that having a conglomerate of distributed, autonomous, intelligent, fault-tolerant, and reconfigurable production units, which operate as a set of cooperating entities, is one promising platform to achieve both local and global manufacturing objectives. Furthermore, the authors hope that understanding the underlying scientific and technological background through the development and industrial application of the

collaborative automation paradigm will not only inform the academic, research, and industrial world of an emerging control and automation paradigm, but also assist in the understanding of a new vision of the manufacturing system of the 21<sup>st</sup> century [a mix of collaborative units, i.e., people, software systems, processes, and equipment (hardware), integrated into a virtual factory].

#### PRODUCTION SYSTEMS

##### New Structures, New Markets, New R&D Challenges

The recent production technologies reflect a worldwide trend toward batches of small and

medium size, and part/product families of increasing variety. The importance of products' intangible elements has increased considerably, e.g., software, built-in service capabilities, online maintainability, etc. Customers have more individualistic desires and participate in the design and production processes (Camarinha et al., 1999; Kief, 1992; Kusiak, 1986; Tzafestas, 1997).

The tendency shown in Figure 1 often comes in conflict with the demand for high productivity, i.e., on production-time/time-to-market minimization, on simultaneous improvement of machine utilization, and on flexibility of the whole production environment when it is integrated in a global network of related enterprises (virtual enterprise) (Neubert et al., 2001).

The process of globalization forced traditional manufacturing systems development and operation to evolve to inherently multidisciplinary tasks. Manufacturing paradigms such as mass customization generated rapid changes in the economic, technical, and organizational manufacturing environments. Under this new vision, a complicated mix of people, software systems, processes, and equipment (hardware) constitutes the manufacturing system of the 21<sup>st</sup> century (N.N., 1998, 2000, 2002; Neugebauer et al., 1999). The research and development (R&D) activities linked to the management and control of such complex systems are, as a consequence, a multidisciplinary task grounded in knowledge of manufacturing strategies, planning, and operations, and in the integration of mechatronics, communication, information, and control functions across the entire supply-chain (intra- and interenterprise levels) (Zurawski, 2004).

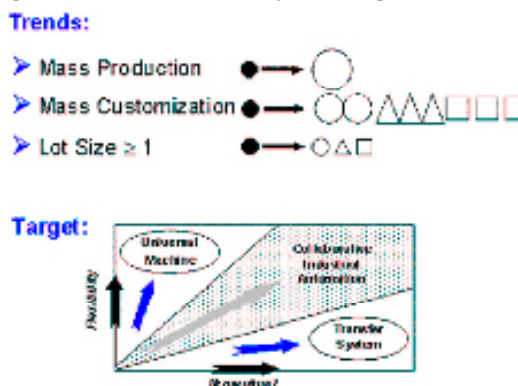
## From CIM/PWS to Heter-Archical Automation

New revolutionary manufacturing concepts and emerging technologies, which take advantage of the newest mechatronics, information and communication technologies and paradigms,

and address many of the fundamental problems described above, are being researched and developed since the last decade of the 20<sup>th</sup> century. The computer-integrated manufacturing (CIM) and the plant-wide systems (PWS) concepts have been promoted as solutions that can somehow deal with all of the above-addressed challenges, e.g., more flexibility in product spectrum and processes, agility of the production system, more responsiveness and integration of hardware and software components (Rathwell, 2001; Williams et al., 1998; <http://www.pera.net/>). Nevertheless, this centralized and sequential manufacturing planning, scheduling, and control mechanism is increasingly being found insufficiently flexible and agile to respond to changing production styles and highly dynamic variations in the product requirements. Moreover, its construction always risks the requirements of huge investment, long lead times, and generation of rigid systems due to large size and centralization. Such a centralized hierarchical organization leads normally to situations where the whole system is shut down by single failures at one point in the CIM hierarchy (Pimentel, 1990; Rembold et al., 1993). For this reason, before the CIM idea made its way into practice, its original approach changed from the mainly centralized model to a decentralized one.

One promising architecture, in this respect,

*Figure 1. Trends in manufacturing*



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