97.2 e-Manufacturing: Rationale and Definitions

e-Manufacturing is a transformation system that enables the manufacturing operations to achieve predictive near-zero-downtime performance as well as to synchronize with the business systems through the use of web-enabled and tether-free (i.e., wireless, web, etc.) infotronics technologies. It integrated information and decision-making among data flow (of machine/process level), information flow (of factory and supply system level), and cash flow (of business system level) [5–7]. e-Manufacturing is a business strategy as well as a core competency for companies to compete in today's e-business environment. It is aimed to complete integration of all the elements of a business *including suppliers, customer service network, manufacturing enterprise, and plant floor assets* with connectivity and intelligence brought by the web-enabled and tether-free technologies and intelligent computing to meet the demands of e-business/e-commerce practices that gained great acceptance and momentum over the last decade. e-Manufacturing is a transformation system that enables e-Business systems to meet the increasing demands through tightly coupled supply chain management (SCM), enterprise resource planning (ERP), and customer relation management (CRM) systems as well as environmental and labor regulations and awareness, (Figure 97.3) [4–7].

e-Manufacturing includes the ability to monitor the plant floor assets, predict the variation of product quality and performance loss of any equipment for dynamic rescheduling of production and maintenance operations, and synchronize with related business services to achieve a seamless integration between manufacturing and higher level enterprise systems. Dynamically updated information and knowledge about the capabilities, limits, and variation of manufacturing assets for various suppliers guarantee the best decisions for outsourcing at the early stages of design. In addition, it enables customer orders autonomously across the supply chain, bringing unprecedented levels of speed, flexibility, and visibility to the production process reducing inventory, excess capacity, and uncertainties.

The intrinsic value of an e-Manufacturing system is to enable real-time decision making among product designers, process capabilities, and suppliers as illustrated in Figure 97.4. It provides tools to access

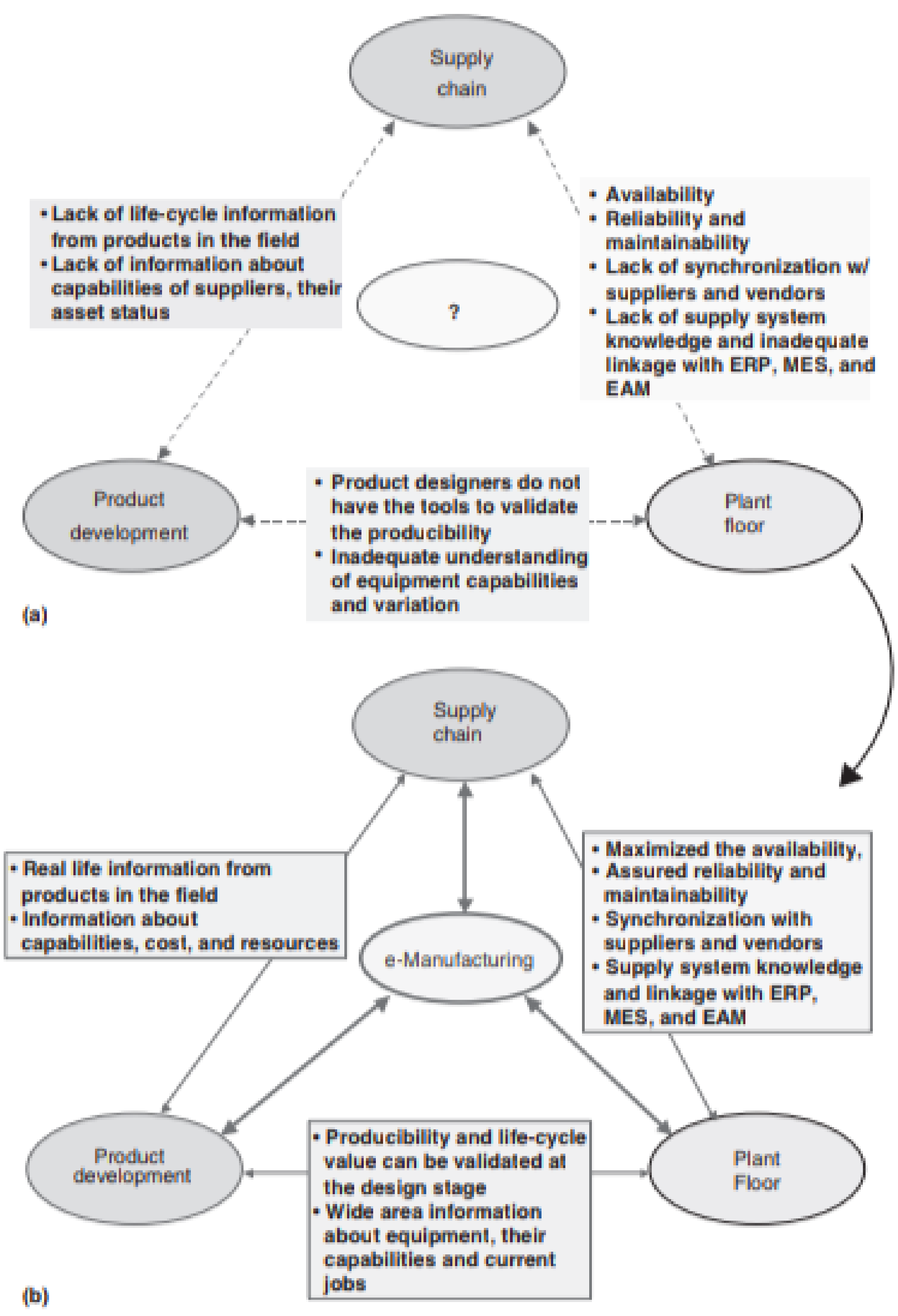

FIGURE 97.2 The transformation of e-Manufacturing for unmet needs.

life-cycle information of a product or equipment for continuous design improvement. Traditionally, product design or changes take weeks or months to be validated with suppliers. With the e-Manufacturing system platform, designers can validate product attributes within hours using the actual process characteristics and machine capabilities. It also provides efficient configurable information exchanges and synchronization with various e-business systems.

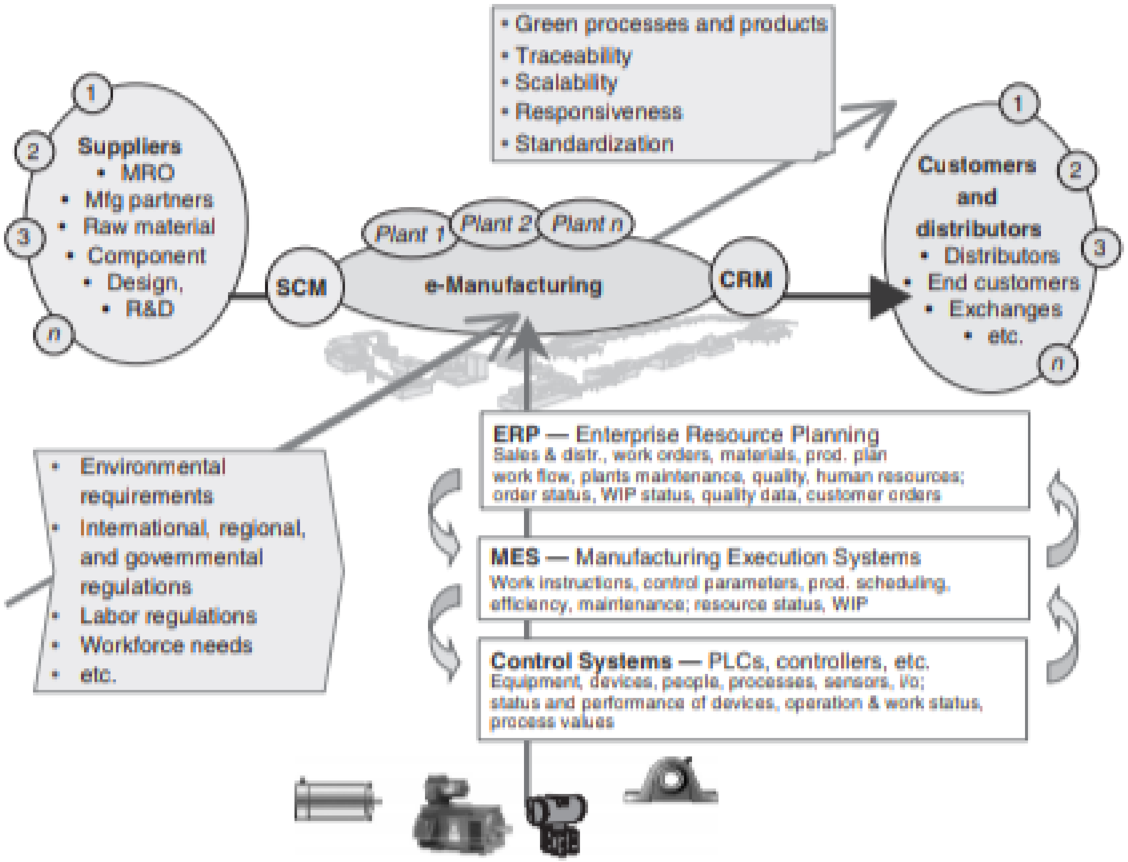

FIGURE 97.3 Integration of e-Manufacturing into e-Business systems to meet the increasing demands through tightly coupled SCM, ERP, and CRM systems as well as environmental and labor regulations and awareness.

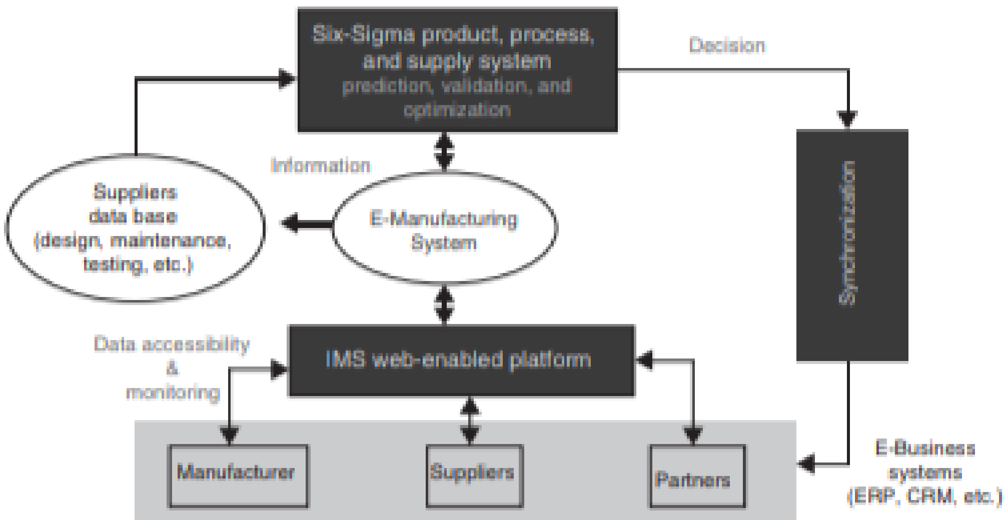

FIGURE 97.4 Using e-Manufacturing for product deign validation.

97.3 e-Manufacturing: Architecture

Currently, Manufacturing Execution Systems (MES) enable the data flow among design, process, and manufacturing systems. The ERP systems serve as an engine for driving the operations and the supply chain systems. However, the existing structure of the ERP and MES cannot *informate* (i.e., communicate the information in real-time) the decision across the supply chain systems. The major functions and objectives of e-Manufacturing are: (1) enable an only handle information once (OHIO) environment; (2) predict and optimize total asset utilization in the plant floor; (3) synchronize asset information with supply chain network; and (4) automate business and customer service processes. The proposed e-manufacturing architecture in this position paper addresses the above needs.

To address these needs, an e-Manufacturing system should offer comprehensive solutions by addressing the following requirements: (1) development of intelligent agents for continuous, real time, remote, and distributed monitoring of devices, machinery, and systems to predict machine's performance status (health condition) and to enable capabilities of producing quality parts; (2) development of infotronics platform that is scalable and reconfigurable for data transformation, prognostics, performance optimization, and synchronization; and (3) development of virtual design platform for collaborative design and manufacturing among suppliers, design, and process engineers as well as customers for fast validation and decision making. Figure 97.5 illustrates the proposed e-Manufacturing architecture and its elements [5–7].

Data gathering and transformation: This has already been done at various levels. However, massive raw data are not useful unless it is reduced and transformed into useful information format (i.e., XML) for responsive actions. Hence, data reconfiguration and mining tools for data reduction, representation for plant floor data

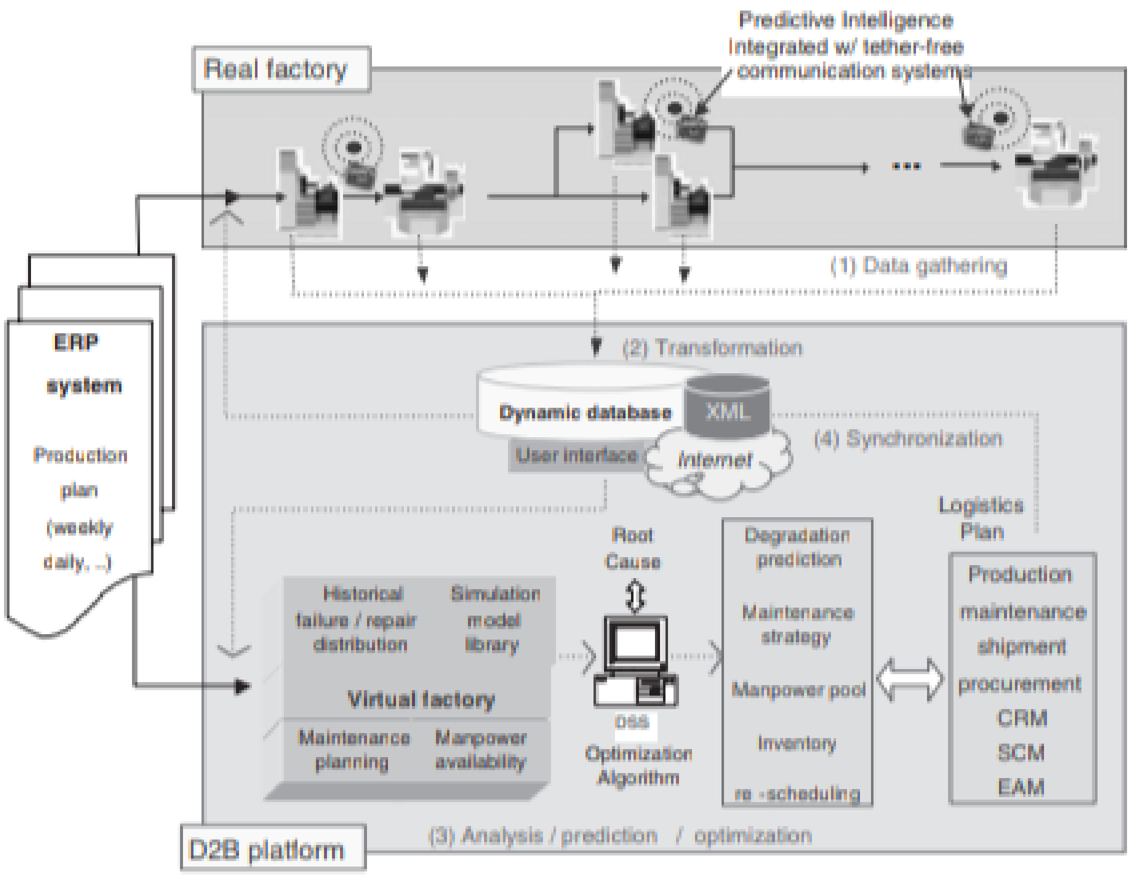

FIGURE 97.5 An e-Manufacturing architecture that comprises (1) and (2) data gathering and transformation, (3) prediction and optimization, and (4) synchronization [5].

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need to be developed. An infotronics platform, namely, Device-to-Business (D2B™) has been developed by the Intelligent Maintenance Systems (IMS) Center. To make pervasive impacts to different industrial applications, existing industrial standards should be used (i.e., IEEE 802.xx standard committees, MIMOSA, etc.)

Prediction and optimization: Advanced prediction methods and tools need to be developed in order to measure degradation, performance loss, or implications of failure, etc. For *prediction* of degradation on components/machinery, computational and statistical tools should be developed to measure and predict the degradation using intelligent computational tools.

Synchronization: Tools and agent technologies are needed to enable autonomous business automation among factory floor, suppliers, and business systems. Embedded intelligent machine infotronics agent that links between the devices/machinery and business systems and enables products, machinery, and systems to (1) learn about their status and environment, (2) predict degradation of performance, (3) reconfigure itself to sustain functional performance, and (4) informate business decisions directly from the device itself [1–7].

Under this architecture, many web-enabled applications can be performed. For example, we can perform remote machine calibration and experts from machine tool manufacturers can assist users to analyze machine calibration data and perform prognostics for preventive maintenance. Users from different factories or locations can also share this information through these web tools. This will enable users to exchange high-quality communications since they are all sharing the same set of data formats without any language barriers.

Moreover, by knowing the degradation of machines in the production floor, the operation supervisor can estimate their impacts to the materials flow and volume and synchronize it with the ERP systems. The revised inventory needs and materials delivery can also be synchronized with other business tools such as CRM system. When cutting tools wear out on a machining center, the information can be directly channeled to the tool providers and update the tool needs for tool performance management. In this case, the cutting tool company is no longer selling cutting tools, but instead, selling cutting time. In addition, when the machine degrades, the system can initiate a service call through the service center for prognostics. This will change the practices from MTTR to MTBD (mean time between degradation) [10–13]. Figure 97.6 shows an integrated e-Manufacturing system with its elements.

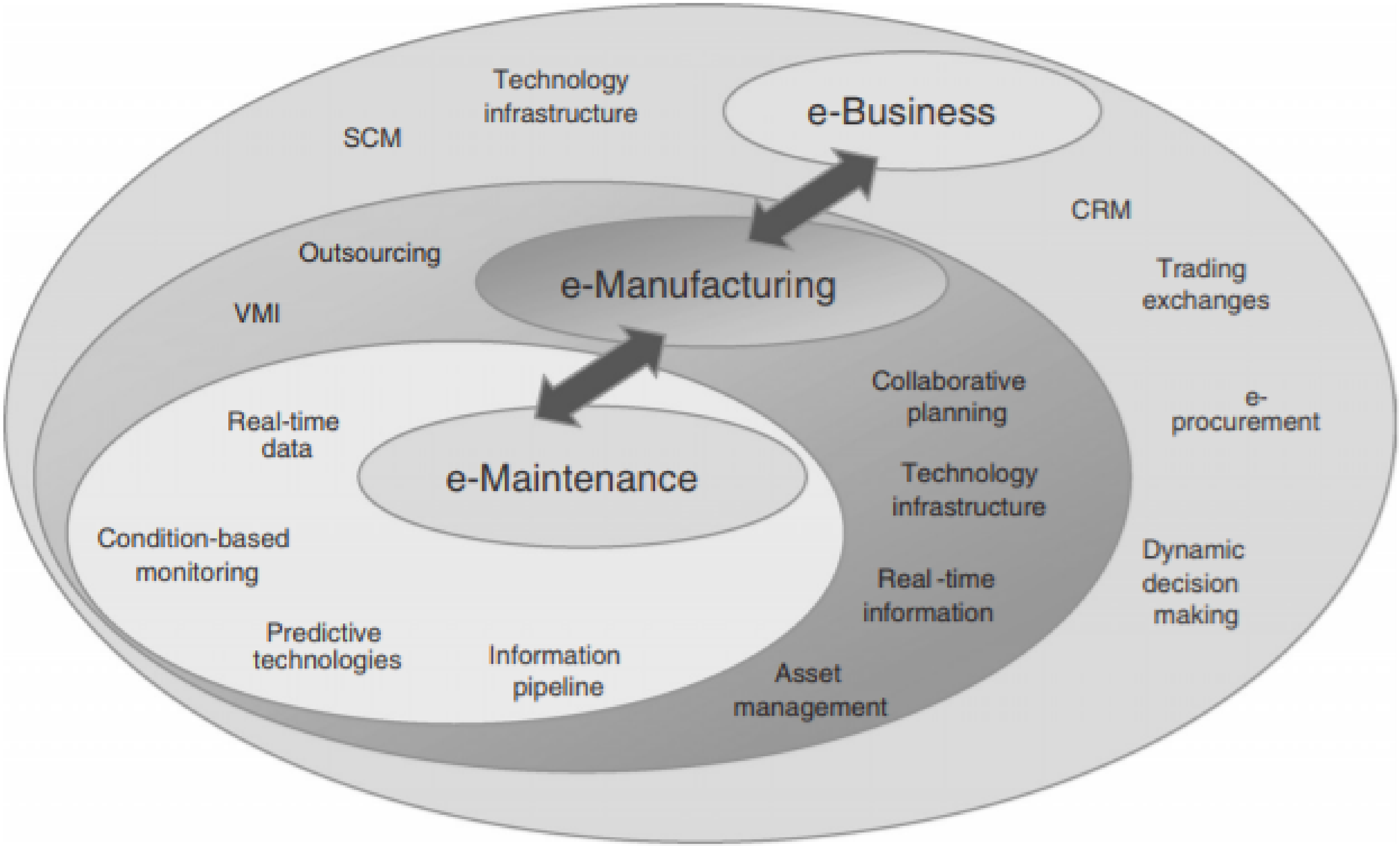

FIGURE 97.8 e-Manufacturing and Its Integrations with e-Maintenance and e-Business.