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Ramping Up for Agility: Development of a Concurrent Engineering Communications Infrastructure

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The A-PRIMED (Agile Product Realization for Innovative Electro MEchanical Devices) project, at Sandia National Laboratories (SNL), demonstrated new product development in 24 days accompanied by improved product quality, through the application of agility enabling technologies and practices (Nagel & Dove, 1991). To achieve this success, a concurrent engineering communications infrastructure was developed that provided electronic data communications, information access, enterprise integration of computers and applications, and collaborative work tools, comparable to the vision expressed by Nagel and Dove (1991) in the *21st Century Manufacturing Enterprise Strategy*. This paper focuses on four characteristics of an agile enterprise's communications infrastructure and describes how A-PRIMED accomplished each through attention to technologies, processes and people.

A-PRIMED encompassed a design-to-production enterprise that crossed 20 SNL organizations, with team members dispersed across 12 buildings in Albuquerque, NM and Livermore, CA. Initially, electronic data communications were non-existent for most team members. Often, files, stored on magnetic tape, were walked from building to building, burdensome file conversions and data reentry were common, and limited channels existed for routine day-to-day communications. Through the concurrent engineering communications infrastructure described in the following sections, an enterprise technically disposed to continue traditional production processes was transformed into one that exemplified key characteristics of an agile enterprise.

Electronic Data Communication Networks - Working within a dynamic, fast-paced environment that required extensive collaboration demanded that widely dispersed team members work together with an efficiency comparable to if they were located in the same building, if not the same room (Virtual Co-Location). A- PRIMED first analyzed the information flow requirements of an agile enterprise (Forsythe & Ashby, 1994) and then utilized central and local network support to deploy project-wide, ethernet-speed, electronic data communications along with applications sharing

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software (Interactive Collaborative Environments or ICE), e-mail and an enterprise-wide product data manager (PDM). However, for virtual co-location, it was essential that team members have a sufficient personal acquaintanceship to enable free exchanges, despite the unfamiliarity of the new technologies. Various mechanisms were employed to first, establish personal familiarity (e.g., team training and project planning) and later to sustain it (e.g., monthly all-hands meetings, weekly lunches, social events).

Cooperative Work - A-PRIMED emphasized a cooperative design process whereby engineering disciplines affected by design decisions were integral participants in making those decisions. Cooperation permeated all aspects of the A-PRIMED product realization process, with specific steps incorporated to assure concurrence was obtained early in design, before precious time and resource commitments had been made. Such extensive collaboration required an awareness and appreciation of the interests and contributions of each discipline. Early in the project, each discipline was given the opportunity to briefly educate other team members regarding their discipline. Likewise, in collaboratively developing the project plan, product realization process and product data management scheme, each discipline shared their interests in an open forum that served to enhance the general awareness and appreciation team members had for other disciplines.

A-PRIMED worked to improve software support for cooperative work. With ICE, designers working at their desktops, with only a moment's notice, could open a shared CAD representation of a design which they and other team members could view, and freely manipulate from within the CAD application (Ashby & Lin, 1994). In this way, ICE enabled collaborative design and decisions, making team members who otherwise would have only been reviewers, co-designers. Likewise, animated illustrations of machining and robotic assembly processes allowed Manufacturing and Assembly to more readily and clearly communicate their concerns to designers. Aside from technical capabilities, other improvements focused on ease of use taking into consideration human factors affecting the productivity of collaborative work tools.

Enterprise Integration of Information Technologies - A-PRIMED sought to remove information bottlenecks and improve the continuity of information flow through the enterprise. Information was transmitted via multiple channels depending on urgency, content and distribution (e.g., phone, voice-mail, fax, e-mail, ftp, PDM, http). Mail reflectors were established for e-mail distribution, the PDM provided team

members automatic notification of file and design changes and information dissemination points were clearly identified by the product realization process. Furthermore, the criticality of human components of the infrastructure was addressed by identifying and establishing close working relationships with central and local network support personnel, resulting in their being included as members of the project team.

Agility was enhanced by a seamless flow of information between software applications, and between software and production hardware. Burdensome file conversions create intolerable delays for the production process and waste valuable human resources. The A-PRIMED position has been that the cognitive resources of project personnel should be directed toward the challenges of design, analysis and decision, and not spent on mundane activities such as data entry or recoding. Through development of software routines that translated between software applications and some standardization to compatible software applications, the A-PRIMED production process was seamless, from beginning-to-end.

Information Management and Access- An agile enterprise must function in an information intensive environment where information accessibility, currency and reusability are critical. A-PRIMED implemented an enterprise-wide PDM to provide an information repository from which information could be easily stored, located and retrieved. The organization of files within the PDM paralleled the product realization process incorporating the parametric design approach and interrelationships between various product data, as well as other information (e.g., requirements/specifications, analysis and test results, process control data). In the same manner that the product realization process was developed through a collaborative process, the PDM structure was designed by the project team following a user-driven design process (Forsythe & Ashby, in press). Facilitated by a human factors practitioner, each team member directed the interface design for those portions of the PDM relevant to their discipline.

A-PRIMED created a production process capable of developing a unique electro mechanical device in 24 days. Testing showed quality gains in that devices that would typically require fine tuning following assembly, functioned correctly the first time and exhibited greater robustness than similar devices produced during previous production efforts. To attain this success, A-PRIMED made a substantial commitment to its infrastructure, a commitment that was evenly balanced between technology, processes and people.