How Coordination Process Influence CIM Development

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Introduction

The AIME project is continuing its study of coordination and control issues of organizational information systems through in-depth case studies and a longitudinal survey of manufacturing practice. It is a multi-year study and this paper reprots results from one part of the project.

This paper reports preliminary results from an 18 month case study of a Southern California aerospace manufacturer with a strong reputation for design and manufacturing skill. We found that the strategies for transforming manufacturing processes found in discussions of Computer Integrated Manufacturing (CIM) emphasize the technical integration of information islands, at the expense of other essential aspects of coordination. Coordination processes (including negotiation) can limit the amount of effective technological integration. We argue for an analytical framework of coordination which takes account of the social-organization as well as technological aspects of information systems in organizations.

Does More Computer Integration Necessitate Better Coordination?

Visionaries who promote Computer Integrated Manufacturing (CIM) promise the concepts for achieving "The factory of the future" (Scheer, 1991). The recurring 'leitmotif' for this transformation emphasizes the computerized integration of technical and commercial functions on one side, and integration of planning, execution and control functions on the other. Coordination activities required for the multitude of workers, activities and resources in manufacturing are thus supposed to be based more and more on continuous links of computerized systems. The majority of companies cannot build their production lines with CIM from scratch. They have long-standing agendas of computerization, with many social arrangements and commitments attached to them. Thus 'islands of information' have developed in many cases. CIM-concepts consider these islands as something to be integrated in the overall framework as soon as possible, but they don't provide much guidance and detail.

This paper is based on a case study of AIRTECH, the pseudonym for a Southern California aerospace firm. We examine AIRTECH's current complex social, organizational and technological state, against the background of regulatory, market and customer demands. AIRTECH's staff acquired and developed computerized support for design, drafting, production planning and material control over a 15 year period. These activities for islands of computerization, with particular histories of organizational commitments and constraints. Work in different functional areas is highly interdependent and changes of information in one area (e.g. design) can have repercussions for other areas (e.g. production). Since different functional areas require information, changes made in an upstream island would require changes downstream.

Functional managers are unsure (or even disagree) whether integration of these islands would provide better means to reach upper-level objectives, like cross-functional teamwork and quality commitment. AIRTECH currently shows a high degree of human-dominated coordination. This picture contradicts current portraits of American industrial policy, which depict unabated application of computers to enhance coordination. Managers of AIRTECH view the transformation of coordination and control as a tradeoff between rich and rigid communication. Therefore, in our investigation we emphasize the broad variety of activities and negotiations which constitute coordination processes (see Kling, 1991).

Research Methodology

Our paper reflects intermediary results of a case study in a large California based aerospace company. AIRTECH was chosen as a case study site partially because of their extensive use of leading-edge electronic design and manufacturing technologies, the complexity of their products and regulatory environment, and AIRTECH's reputation and market position.

The data were gained by plant and work-place visits, about 20 semi-structured interviews, meeting observations, and document analysis, conducted over a period of several months in 1991 and 1992. The case study is part of an ongoing multi-disciplinary project on Advanced Integrated Manufacturing Environments (AIME) at the University of California, Irvine. The AIME project explores the challenge information technologies pose to manage organizational change (see Kling, 1987; Kraemer and King, 1989), and their critical role in representing and altering coordination. The focus is on understanding the nature of coordination and control issues within manufacturing enterprises as well as between enterprises and their customers, suppliers and technology vendors.

The Case of AIRTECH

AIRTECH is the largest of five divisions within the Aerospace Group of a large industrial conglomerate. Aerospace Group headquarters provides major computer support on large mainframe systems for its divisions. Located in Southern California, AIRTECH employs about 1200 people. It produces control equipment for airplanes, which can require the integration of sophisticated mechanical, electromechanical, hydraulic, and electronic components. Hydraulic designs of remarkable complexity, as well as manufacturing requirements that push existing machining tolerances to the limits, are common. As one design engineer said, "life is not straightforward at ten-thousandth of an inch tolerances." These exceptionally demanding manufacturing requirements have complicated attempts by AIRTECH's upper management to increase their outsourcing from about 20% to perhaps 50% of their parts.

AIRTECH has around 10 product lines, and the factory is organized as a job shop rather than a dedicated assembly line. (Jobs shops are much more complex to manage than assembly lines.) Their market is composed of several of the major airplane manufacturers in the US, and the Department of Defense. The functions in this division include administration (e.g. finance, contracts), engineering design, and production (e.g. machining control, diverse machine areas). The development of new products is organized by about ten projects, incorporating people from different functional areas.

In the face of declining revenues, fewer contracts, and increased foreign competition with comparable quality, changes at AIRTECH are driven by a mixture of external demands and internal managerial visions, which cannot be easily aligned to the specific organizational actions taken. The efforts to proactively ignite organizational changes at AIRTECH follow a business philosophy which is known as World Class Manufacturing (cf. Schonberger, 1986). These efforts were initiated mainly by upper management. The current major efforts focus on the development of cross-functional project teams, concentration on the company's key competencies, improvement of production, reduction of inventory and lead time, introduction of manufacturing cells, and the attempts to outsource machining in non-key areas. Externally, government regulators and commercial customers urge the development of certain procedures --

e.g. a review board to assess the rework of manufactured parts. Another strong demand is increased compliance with quality standard inspection programs. Some of AIRTECH's controllers require state of the art tolerances, and have very high risks of component failure. The firm faces financial penalties if certain controllers exceed specifications, and subsequently struggles to balance weight reduction, safety requirements, project time and costs.

Information Systems Islands

The role of information technology within the organizational frame of AIRTECH shows several salient features. The overall structure of information systems is 'balkanized' into functional islands. Due to an earlier corporate merger, the Aerospace Group owns and operates two large IBM308X mainframes, one for engineering analysis and one for production applications. AIRTECH has also approximately a hundred workstations, Pcs, Suns and Macintosh computers, connected on a set of LANs. There exists the 'classical' split between the central information systems department, which is located on corporate group level, and the divisional IS support group. The organizational split is amplified by a 9-mile separation of the two IS departments. The volume of central IS support is limited to two percent of the divisional revenues. AIRTECH's divisional IS group considers this constraint to be responsible for the huge backlog of up to two years of programming requests. Lastly, three main islands of information systems have developed in AIRTECH over time. They could be viewed as main components to be coordinated for future CIM-concepts. We will concentrate here on an overview of these islands and their surrounding coordination processes. All of these features had to be considered for any strategic approach to CIM-development at AIRTECH.

Computer Aided Design (CAD): A major problem for designers was visualizing peculiarities of manifolds with a complicated topography. The current system, CATIA, runs on a mainframe computer and allows designers to reuse the original 3D-geometry information for machine tooling. CAD provides part lists and the geometry for some of the control tools. The electronic exchange of designs with customers has not taken place, nor was the internal link to machining developed at great length. CATIA operates primarily as a stand-alone system, except for a few links to the NC-machine area. Output of the system consists primarily of prints of drawings, which are stored in a locked printroom.

Material Requirement Planning (MRP): Production scheduling is done at three levels: with a master schedule for yearly and monthly forecasts, via the MRP system, and with shop level detailed work station scheduling (see CAPP). The current MRP system has been in place since about 8 years. Its use is mandatory for all of the Aerospace Group's five divisions, and it runs on the same mainframe as does the CAD. MRP is driven by order entry demands, and it is the key system for coordinating purchasing, material management, and shop floor management. No electronic links have been developed between CAD and MRP. Results of capacity plans are downloaded to a PC database to be manipulated by AIRTECH's programmers, and go to shop floor coordinators.

Computer Aided Production Planning (CAPP): The CAPP-system for work scheduling uploads transaction files to the MRP database. It is based on Macintosh-systems, which cannot act as CATIA-terminals, so that no drawings can be downloaded. Manufacturing engineers sketches intermediate stages of a part during the production on a Macintosh. The sketches travel with a job. Besides the sketches, these 'travelers' to the shop floor contain information about part identification, the NC processing, outsourcing information if required, and code for the current job status.

A Sea of Coordination Processes

In this situation, CIM-proponents would focus on developing closer computer links between these three islands. For instance, if critical parts are specified during design, engineers could send early warnings for test and production groups; the drawing geometry in CAD could serve for production control; the availability of product outlines and designs could be used for cost estimating, and master production planning on MRP. The MRP-system could provide a direct link for information about outsourcing to CAPP. All these links would in turn require the development of common data structures and storage for all three areas. But the underlying assumption of economic rationality, which presupposes that lower transaction costs can mainly be realized by introducing computerized links between areas of coordination, underestimates the social complexity of a company like AIRTECH. The dynamics of change depend much more on AIRTECH's institutionalized social arrangements that make a single governing vision of integrated systems very unlikely. Coordination processes between functional areas, rather than information islands, shape and limit changes in organization.

The two IS groups illustrate our point. The Group IS may neither have the skills nor interest to implement CIM-links between the islands. Its remoteness does not facilitate much insight into the specific preferences of AIRTECH's staff. Its programmers also might not even have the expertise to develop appropriate CIM solutions. (The divisional IS staff asked them to help link their MRP to a PC database and was given a crude and time consuming solution. In this approach, the MRP system printed reports to disk. These were downloaded at AIRTECH onto a PC, and then data was read from the page images. This is far more cumbersome than would be providing access to the underlying data structures or the data in a common file transfer format.)

Under these circumstances, the Aerospace Group IS manager might accept an agreement with AIRTECH, if they requested CIM-support. But the Group IS would probably charge so much for the service that the division would rather develop their own systems. (We found this pattern in AIRTECH.) Computerization across the islands requires effective coordination. This kind of coordination which involves subtle negotiations cannot be computerized! This becomes clearer when we describe two of the institutionalized coordination processes, engineering change control and scrap management. They show that information systems should be seen in a web of social relationships (cf. Kling, 1987; Kling and Iacono, 1989), or as we characterize it here, as integrative elements in a sea of surrounding coordination processes.

Change Control Board (CCB): The requirement to coordinate upcoming change actions and to improve control over the results may partly be due to the complexity of the product. But AIRTECH has also to react to demands from customers regarding control procedures for changes. Usually, changes are initiated by an engineer who redlines a copy of the original prints and gives it to a draftsman. Depending on the magnitude of the change, drawings are either renumbered or new drawings are created, and an Engineering Change Order (ECO) is set up. At this stage two controls come into effect. The ECO has to be approved by the customer's representative, and it also goes to the manager of a CCB, responsible for ECO management. This manager assigns an engineer to review the ECO for technical correctness. The ECO always has to contain a "good enough" justification for the proposed change. For each ECO, the manager then sets up an ad hoc committee by deciding which functional areas need to be included. She also provides a written change management plan to major customers and the government. Her main tasks during this procedure are to insure that all changes are documented, to control upcoming demands for further changes of the same part, and to 'cluster' changes, to exclude small last-minute changes that will annoy the customer.

Coordination activities occur in setting up an ECO and describing its technical features. Both issues involve interpretations and entail negotiations between the CCB manager and engineers rather than merely soliciting formal statements which justify proposed changes. The timing and volume of changes are usually handled with an awareness of the customer's likely reactions.

Scrap review board (SRB): Scrap management is part of AIRTECH's emphasis on quality improvement. It is coordinated by the SRB, which includes representatives of major customers and AIRTECH. Some customers give the company authority over making SRB decisions. Usually 20-25 review jobs are managed by SRB. But due to a new government auditor who enforced regulations rigidly, about a hundred jobs were currently under review during our study. Besides SRB, customer representatives and government regulators are also involved in daily production issues like documentation and periodic audits. The procedure of scrap management is initiated by 'tagging' a part, indicating that corrective action is required. Since a customer representative is involved, this is the entry point of government regulations into AIRTECH's production activities. The rework procedure is started by the engineering department, which reviews the items in question and assesses if they can be reworked. If so, engineers may add additional operations which can increase lead time.

The coordination issues involved in the process concern the criteria which justify a job as worthy of tagging. By tagging a part, manufacturing problems are formally recorded. The procedure makes such decisions -- as well as their potential negligence --highly visible. The interpretations in the decision process are likely to be influenced by the position of the decision-maker. Company representative and contractors have different perspectives than AIRTECH's staff. One informant characterized this as a "worldview clash" which is built into the review procedure. SRB also provides feedback between the production process and planners through information about the status of parts.

Summary

Change Control and Scrap Control processes connect organizational departments as well as departments and customer representatives. They can easily transcend internal and external organizational boundaries. Given the control and immediate presence of AIRTECH's customers in the production process, these coordination processes allow negotiations and flexible handling of external regulations. This is possibly their most important feature. Using a highly structured information system would render decision-making more rigid, simply by enforcing its explicitness.

The coordination processes are dominated by face-to-face communication, and AIRTECH's managers are not enthusiastic about supporting communications with computers. Indeed, nobody seems to argue in favor of a more tightly integrated information system structure. AIRTECH invests into further enhancing computing islands, rather than in building computerized bridges between them. Introducing more computer power to support coordination processes and promoting the integration of functional areas is not often discussed by AIRTECH's staff. Conflicting interests may hinge on organizational structures, as is in the case of the confrontation of centralized Group-level information systems support and divisional computerization efforts. In the cases of the review boards it is unclear how a required multiperson interaction could be substantially improved by computer technology without making the process more inflexible and prone to conflict.

Conclusion

Current concepts of how to coordinate manufacturing processes in the face of new demands for product quality and production flexibility focus on principles of technological integration through CIM. Theories of integration, though, tend to neglect the complex and historically grown reality of advanced manufacturing organizations (Kling, Kraemer, Bakos, Allen, Bakos, Gurbaxani and King, 1992; Kling 1987). The CIM emphasis is on shared databases and computerized workflow, and has important elements of technological utopianism (Dunlop and Kling, 1991). Our portrait of the three islands of information systems does not exclude further development using computerized links. But the future integration of the islands would not necessarily lead to closer integration in a technical sense. A hybrid system of human-computer coordination could very well be more appropriate. It is necessary to examine coordination, negotiation and computerization in a social framework which does not reduce the complex production requirements to their informational representation. We need a good body of carefully articulated empirical case studies of computerized manufacturing firms to better understand the strengths and limitations of alternative computerization strategies.

Note: This report is based on (Beuschel and Kling, 1992).

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