X-Lab's Design and Manufacturing Process Integration: Theoretical Review and Study Case

Maurício de Souza Leão e Marcelo Amaral,
Technology Innovation and Industrial Organization Area (ITOI) of Production Engineer Program (PEP/COPPE)
Federal University of Rio de Janeiro (UFRJ), Brazil.

Abstract *- The objective of this paper is to study how is structured the integration between the design and planning process departments at X Technology Laboratory. The aim is to identify technologies, and methods of information organization, to distinguish organizational structures that improve communication and integration, and to analyze the team's organizational learning.*

This paper contains a theoretical review, that served as a basis to the questionnaire used in the case studied; a detailed study case, in X Lab; and the final comments.

The conclusion is that, although the enterprise has already implemented a CAD system it is backward in terms of integration. Nevertheless, it occupies an average position inside the manufacturing sector, as the other 25% of all enterprises in the same situation.

Theoretical Review

The objective of this review is to make a brief explanation, in a theoretical and historical perspective, about the evolution of design and manufacturing integration process. Our approach goes from aspects as process and product manufacturing, information system's evolution and integration, organizational structure and culture, and others.

Since Industrial Revolution, design's optimization and scale production have deserved a special attention. Design, is an activity that makes a description of something that yet does not exist, however it's able to be builded (1). There are many others definitions that conceptualize design, as sociology of innovation, that consider it a social process of artifact build. Design is constituted by four fundamental aspects: organization, context, conditions and discourse. We can too classify design problems based on the product process cycle stages: innovation or invention, where occur the initial product conception; project conceptualization, with material choice; configuration, involving the method choice; and project parameter definition, including finishing and detailing. Among the project characteristics, we can detach: the utilization of interactive method, based on convergence rule, or direct method (methods of synthesis x redesign); the incremental project; the re-mapping, that involve simple changes, with more information; hierarchical structures; decomposing problems; recursion, when problems can't be subdivided; and own references. CAD process aspect can associate project problems and the solution and show your characteristics.

The design have to be understood as a process where the uncertainty level decreases according to its evolution toward a solution (2). Moreover raw-material keeps changing, and problems emerges, as explain and represent knowledge used by design to find a solution and how codify the process attempted to structure incomplete specifications. The design is an activity that encompasses many stages and problems, where the purpose of the computer ways and concurrent engineering is to optimize this stage improving the communication and raising product quality.

Design can be seeing as an dynamic activity that involves an interaction between technical, processing and organizational factors, which exit depends on flow of information between sources. The result can be evaluated by data volume assembled and interpreted by design activities, and the capacity to synthesize facilitated by means of understanding how information changes in the different prototypes. According to the dynamic process of the kinds of information, the organic management structures are needed to the complex or creative projects situations, whereas mechanic management structures are more adequate to incremental or intensive projects situations. To choice the best way of managing project process, we must consider that there are different kinds of product project engineering, as well as, different kinds of structures and organizational management. That is: incremental project, with routine process, less level of information, less problem frequency, task simplicity; complex project, with bigger participants number, bigger systems, coordination growing, higher information necessity; creative project, where appears new components, occurs new situations, rich and qualitative information necessity, no standardized procedures; intensive project, with creative and complex combination projects elements; designers, clients and departments interdependence; and hybrid project, with a combination of mentioned projects.

Some paradigms have been proposed to describe the design process: the project as a research,

that considers the project as an variable set, each one with values set, being characterized as a generation and test process; the project as optimization, objectifying design quality measurement; the project as compilation, being a mapping process; and the project as restriction satisfaction, that attend the values and project functions characteristics.

The role of computer in the design can be concentrated basically in the calculation functions, product, process and storing/record data system and visualization. The CAD application was developed firstly as a finite element method, dynamic simulation systems and optimization, after was being utilized as graphic and geometric method and, recently, as algebraic manipulation, spreadsheets and combinations. However, in the last years grow the adoption of CAD technologies by enterprises has increased due to reliance upon their promises, but most of the enterprises have not obtained the success they aimed it (3). The CAD systems are composed by proceeds collections, that allow the execution of functions, as: numeric methods, that allow the calculation functions execution (as manipulation functions that evolve interpolation, extrapolation, integration, differentiation, and others), matrix manipulation, differential equations integration and algorithms optimization; graphics collections, that allow the visualization, print and images and texts storing; geometrical collections, that allow to create and manipulate data structures that contain geometrical information; the interfaces package that are management softwares as windows manager, menu manager, and interactive-device manager, that allow systems and peripheric communication; the data manager, that work data systems; and the data structure tool box, that create and manipulate an variety of data structures inside a CAD program. Theoretically, the use of CAD has shown many advantages, but in the practice this is not been experimented. However, it's possible to verify that the real potential of automating the task design is to modify and make good use of projects or objects which are already utilized (standardizing projects and programs), and not to be used in the creation phase without utilizing what already exists. In the relation to the complete utilization of 3D projection, it's possible emphasize the rare necessity of 3D utilization, and its complexity.

Moreover there are many factors that turns difficult the CAD and CAM integration is difficulted by many question, like the little communication existent between project and manufacturing, the incompatibility among systems and the lack of understanding of CAD designers with CAM exigency. In the other hand the CAD and CAE integration promise hasn't either occurred due to its high cost, its complexity, and because design engineers have more trust in physical models than abstracts analyses results. And neither has the use of paper in design process decreased because, paper is still the main way of communication through the process and, rarely, the suppliers and the costumers have compatible CAD systems; besides, systems don't support work group.

The conclusion is that the main reason why CAD is being underutilized is the lack of integration, either technical organizational. The learning curve of CAD potential utilization has been slow and the enterprises pay little attention to organizational and human resources before implementation, as communication development protocols between different CAD systems, and the data transmission problems in commons telephonic lines and the complexity of data download from CAD to analyze programs, due to the need of different forms. And too due the implantation model, that encompasses: basic, where the system is used as drawing, visualization and communication instrument; integrated, the system is used in a articulated form between the design activities, with the rest of conception activities of undertaking, incorporating managerial and organizational proceeds; and linked to the business, which is a deepening of integrated model and related with office business, linked to the product and client kind, enabling the simultaneous project development.

The correct understanding of CAD resources will provide to the professional modify your method and amplify your performance scope What is recommended that enterprises must examine their design task and select the adequate CAD system characteristics to the correct level of social integration. The structure of design process can be divided in three phases: conception, analysis and detailing, that are connected and creates a network where information goes in all directions. In an architectural project, the basic stages are program definition, preliminary studies, preliminary sketch and executive project. The CAD in architecture is applied essentially in project sector and in product planning, being used in your geometrical definition and graphic representation. In phase is concentrated the higher objectives, when are implanted the CAD/CAM systems, because from the varied and numerous entrances, it can be obtained well defined output formats and distinct categories, as human instruction lecture and machines. In the analysis is where problems are solved or optimized with many variables in a complex interactive model, the engineers analyses, the graphics capacities to the models generation and where more are developed softwares in agree with interest application. The conception are characterized by difficulty of specification and quantify the output forms, is the area where the most benefits can be occur

Process planning can be defined as the development logical sequences of production operation to obtain a piece, to save time and money, beginning in the project production stage, where definitions are done. From this point, comes the pieces or products planning production, that is consummated when the specifications indicates how it is done and when it is to be done, having the detailing. The choice of less expensive process to be used, depends on the volume and the relative costs value of every alternative presented. Informations can be created, following

procedures, as planning preparation; organizational data specification; determination of the pieces, of the manufacturing process, and of the operations and our sequences; machinery and tools selection; work conditions determination; time manufacturing calculation and specification; sketch elaboration; and numeric control program. The process planning is the link between design and manufacturing. It's a key point to warrant integration, high productivity and engineering quality, and hasn't followed the development of the other areas. The specifications are normally summarized in task paper, that are complemented by operation paper, which gives details of every operation. It starts in marketing and/or sales sector, when a new product development is requested, going through PCP, with the technical characteristics, to obtain a process planning that can be followed by croquis of several stages, project, gadget specification, tool list and numeric control program. In the general it is placed between the design and the factory floor, and side by side to PCP. Its function is to specify the changes supported by raw-material until it come to a final product, allowing to calculate the fabrication time and giving data to manufacture budget elaboration, this area produces information to the others.

The purpose of the computer process planning concept is to select and define the stages of product manufacture. The result is a process plan (manufacturing task, process paper or operation paper) that is used to program the machines. Given the great number of procedures, the excess of papers, the little design/manufacturing integration, and documentation imprecision, lead to low productivity in the sector and the demand of a tool to help. Considering the Computer Assist Planning Process (CAPP), the engineering papers are removed and a database that can be consulted by everyone inside the enterprise, it permits programming modification or easier information recuperation, as well as making a CAD/CAPP/CAM system possible, which is the first step to implement CIM system. It's possible to stress the importance of product project in the process determination to be used and the establishment of the least cost production. When the process is already, the process planning to manufacturing must be detailed. This toll help the search to select and define the product manufacturing stage details, obtaining as result an process plan that is used in machine programming, in the product manufacturing, and in the time of delivery definition, giving to PCP the operation sequence, to equipment utilization and enterprise capacity to attend the client demand definition. Helps in the strategic plan through the future demand simulation. Some characteristics can be observed to the final cost reduction, as the possibility of parts or pieces junction; the decrease of specification tolerance, with adjustment improve; the design simplification; and the reduction and facilitation of piece work, reducing the material to be removed. One solution to this problem would be train everyone in others qualifications, and keep relations and communications between project and production engineer.

CAPP technology has arisen with the idea of the neck of bottle in the engineering process planning sectors and integrate the enterprise sectors that have found modernization (4). This technology improves the design life by capacity of project production, as though as the use of his equipment. Among the reasons of it's application, we can mention the integration with others sectors that already use computer, as CAD/CAM and PCP integration. Its application must be specific to every enterprise, being preceded by standardization of the function, creating a wide planning base to automate some functions. The limits are the technical quality of the tool (computer and program), immediate costs, personal training needed and the software flexibility to particular solution.

We have as central point, among CAPP ambients, the GRP that allow an adaptation of existent structures to create new planning pattern, the CAD systems integration to graphics manipulations, the MRP systems integration through information about operations sequences, equipment and times and the system distribution through computer network. The CAPP ambient can dispose new developments to attend the usuary needs and the new technologies, as the budget and cost calculation with quickness and security; the assembly planning due to standardization possibility; the database management systems who carry advantages with integrity and security; the graphical interface, through windows 3.1 e NT ambient; the client-server technologies, with the SGBDs association; the quality warranty, with inspection and tolerance; simultaneous engineers operations with sector reorganization in virtual teams and/or autonomous with multifunctional people, where every team can make parallel activities without affect the work of others and enabling access at whole information; the growing of automation degree and the automation of planning time calculation; and the specifics solutions that was mentioned previously. In the case study presented, it was demonstrated that CAPP application result in great advantages to enterprises, like productivity growth, time reduction in the process elaboration, information update also serving as tool to techniques as reengineering, simultaneous engineering, TQC, ISO9000, among others. In the conventional planning one worker lose sixty three percent of your time writing the plan and twenty percent in the information recuperation, due the imprecision in the documentation that wasn't actualized. What decreases productivity, that is defined as a aggregated value to enterprise, removing materials, energy, information, yonder people of society and obtaining costs. The growth of the productivity can be promoted by perfect information flow, by gradual implantation of computer system and adapting the workers to change that will occur. Whole participants involved must have access to all information that needs. Its updating is needed to assert

the quality in the decisions, being needed dispose of precise data about the process in real time.

Due to the growth of global competition, the ability of the companies had to be fortified to introduce new products, or shortening the design time requested, development and manufacturing of new products, increasing a costs reduction emphasis, quality and meeting client's needs. The eighteen's was characterized by high enthusiasm with quality programs top-down, and CIM (computer integrated manufacture). The new prescription focuses the organizational and behavioral change in the new product introduction areas. The project departments are divides in teams has four basic elements in your philosophy, that are: responsibility, confidence, multifunctionality, and experience and ability. Although CAD/CAM systems and the databases are being important help, don't replace people meetings. To the teams formation we can obtain the members from many departments with diverse experiences, developing participation and propriety sense aiming to achieve to put in practice the changes and the success needed. This teams works with individual specifications, with interaction and integration, but with responsibility function's and areas to individuals or groups, that formalizes the communication between the parts. The different emphasis of activities could change in the design process, according to the kind of product to be developed. The project team's objective is to conceive products that represent higher value to the client and less cost to the firm, through the good product specification, good quality of process interfaces and informations. In this case its needed an effective integration between all the departments sectors, people, talents and knowledges, to brings about the solutions, so that the enterprise would be able to take advantage of the opportunities.

We can conclude that design is an activity that involves coordination and cooperation between people. For it is very important to create structures and adequate the engineers curriculum to make this process easier. The design to integration quality results in reductions in the coordination, measurement, machine programming, set-up time and reworking (5). The author performed a research and found several key actions to promote a design-manufacturing coordination in the modernization process, as: members training, new organizational structures coordination, job rotation, and continuous people dislocation between design and manufacturing. Forty three percent of the visited plants adopted some new organizational structure to make the integration, and that was more used the inter-functional team, which many times was responsible for the coordination, however, in some cases the team has a leader. The research examined the connection between the use of new coordination mechanisms to integration in domestic plants and the many performance results, these were, better design and manufacturing coordination, growing of familiar flexibility, rapid change and flexibility, and growing in the investment return. The satisfaction can be used as indicator of how are occurring the transition process to simultaneous engineering. The process of global integration and the actual coordination level are the principals factors to measure the satisfaction degree. Other form to verify the success is the total quality improvement, however this kind of result don't help to manage the integration process.

Another fact is that to solve a problem it is important to understand the three areas: tasks, CAD integration and organizational integration. The laters are bounded together. Designs without task and with high uncertainty and specification to each component leads to a need of high communication level and a great number of informations to be processed. The problem is to heighten the organizational capacity of processing information when the tasks uncertainty grows. The solution requires information systems or the creation of laterals relationships, so that is possible to explore the integrative potential. The use of blocks occur in almost all offices, blocks with attributes in less than the half, no graphics information in sixty percent, data linked only in ten percent. Accordant growing the complexity of proceeds exist one reduction in utilization of resources of automatic information recuperation. The CAD implantation patterns has three levels: basic, to draw, visualization and communication, with automation of some tasks, in project detailing and presentation, without integration with the rest; integrated, evolve the project conception with the rest business activities, incorporating managerial and organizational proceeds; and full, is one deepening of integrated level and is related with the office business enabling standardization in detailing showing better efficiency.

The firms implement structures to identify design phases, procedures controls and interactions, however, this structure doesn't recognize qualitative differences in the design, as relative importance, cost level and management structure. The organizational structure, the report procedures (formal or informal), the decisions centralization, the technical and functional specialization, the uncertainty and other things that determinate the project success or failure.

The organizational culture, that is an complex set of values, opinions, suppositions and symbols, that define the way trough the firm that lead the business, is recognized as a higher difficulty to the firm opportunity to grow design-manufacture interface. The literature about organizational culture isn't much conclusive, because it's concentrated in some general aspects without looking at the subcultures. So is the literature about engineer culture limited (6).

The project development learning is based in procedures, that are specifics changes, detailed sequence of activities or regulating this developments tools and methods, that is teaching of engineers and development of new abilities; process, that is an general change of activities sequence and developing structure phases; structure, that is formal organizational changes; and principles, summing the

set of ideas and values used to orient the decisions in development. It is one of the most difficulties found by the organization, because requires efforts, attention and disposition to make difficult choices, in order to build organizational process, chiefs abilities, tools and methods with more efficiency and quality. This is the natural result of design development effort. With learning by doing at every new experience people increase its problem solution's repertory, however, it requires attention in task transmission, drawing out conclusions about cause-effect connection (7).

Case Study

The interview was done on Wednesday, august 20. We intended to make this interview as informal meeting independent of prepared questionnaire why we believe that this way would bring answers more rich.

This case study will focus on the infusion bomb, that serve to transport medicine, injecting the specified dose in the patient. It's made by X's Lab, a multinational enterprise operating in Brazilian pharmaceutical sector. The X matrix wasn't considering the country as promising or strategic, but your vision change recently why your internationals competitors, that already was in Brazilian pharmaceutical segment, came to the Brazilian equipment segment. At some time, the main enterprise attended to the factory, leaving the enterprise more linked to your decision, what can be viewed as an loss of autonomy. The Brazilian firm has approximately six hundred products, and near to six millions dollars of monthly budget. The participation's percentage of infusion bomb in the sales are little, almost irrelevant, however, the real business is on the futures sales of products necessary to the functioning of the bomb. Altogether, the bomb may be responsible for about twenty of budget.

The physical proximity is a very important sector characteristic. In the one side there is the development, in the other side the manufacturing and the management in the center of them, which helps integration very much. There isn't a industrial engineering in this sector, the development goes until product engineering and manufacturing start from here, with manufacture tasks. This happens due to the size sector, which employs fifteen people nowadays, five in development (three engineers, two designers and the trainees). Although there is a linking at the organizational level, the whole process very informal, and also involves a great tacit knowledge. There is no link equipment among development sectors and manufacturing, which is made by handicraft in the assembly line.

The X has gone though a recent reformulation in its mainframes system exchanges for interlinked network systems be the server, which allow the complete systems to helps all the manufacturing stages. The enterprise CAPP system is made with SAP. At this program is placed the needed quantity of products to be produced, in agree with sales department, and the program explode the product, making the components list, verifying stocks and making purchase order, so as planning products time and needs. Whole system of development sector use computer, as AUTOCAD to mechanical parts and PCAD to electronic parts. There is available form standardized, as no conformity register and reunions proceedings. The enterprise have internal and external e-mail and institutional home-page, however they fear the lack of security. Internet makes communication and shopping faster, as the access to actualized specifications manuals, very useful when a new product is being developing. It has been possible to be closer to what is being done in the main enterprise by Internet, but they haven't got much contact yet.

Nowadays, due to the process certification by ISO-9001, it has become vital to write reports and records about technical decisions and necessary changes in the project, but the informality tend to be compromised. This procedure tries to formalize part of tacit knowledge within the participants from each group and allow its transmission. The procedures recording increases the amount of work and needs the help of computing systems, as the circuit board. In the past, when this circuit was developed, the details were not stored for it was an easy task to be done, but nowadays the sketch of this board is done in the computer and automatically stored.

According to the enterprise, new products comes, in the most of the time, from a new proposal by the marketing department. In a few cases, comes from the customers, as doctors, or the development is done by the enterprise. In the most part of times, whole born from verification of a market necessity, through on formal or informal research. One time identified the need, the marketing area produce one project that follow to finance department valuation (possible economics and strategic results), and are allocated resources to development. According to department, the medical equipment usuary yet is away of technology. They don't have vision of technological possibilities, being the opportunities perceived by technical people in contact with the hospital ambient. Some times one investment aren't economically justified, but is strategic by enterprise, other times they are constrained to make the investment by legal character, as in the case of legislation changes. The financial support to develop a new product is released according to the need of the product. Up to 1996, local prediction was enough, nowadays there is a global budget in the group, from people expenses to the level of investment needed, everything has to be approved in advance, and the basic research is not done in this sector of the enterprise, but only the final development. Briefly, the introduction process of a new product is characterized by five phases: identification, marketing, finances, development and manufacture.

Ideally, the development team should be formed by at least one person from each technical area (development, manufacture, quality control and technical assistance), it should make an effective link

between development, manufacture and the other parts. However, the enterprise reduced the staff, due to financial problems. So that the staff that remained had to work hard to increase manufacturing level and consequently the whole development process of new products was affected. Since 1994, it has been the aim to increase the automation process keeping the same staff. This integration tends to improve the firm because now is enable to have profit from automation investments done before, like the implementation of data system, quality system and others. Moreover, teamwork isn't done in the sector because the staff is small, so it turns communication easier and simpler, as everybody work on all projects, doing hardware and software simultaneously. Every person made your work, however people ends up acquiring knowledge of the another area.

The first version of the infusion bomb project result from market need and it took about a year and a half to be developed, from conception to prototype. In 1991, they identified the changes that had to be done. The second version took the same time, but the complexity of the product was much higher, as well as the cumulative knowledge, as it came from something that already existed. The development of the project finished in the same year, what was considered very fast.

When there is serial production, several problems are detected such as the variation of the quality of the components, size and tolerance limit. The alterations are generated by the technical needs or by the identification of development possibilities in the product or process, that is, in a particular manufacturing line, a great number of small changes that can be made, as little adjustments in the product which can be pieces specifications or in the assembly routines. The project is developed, mounted and tested in a prototype, only the head of the series is finished. One product with the pieces specifications already approved by quality control. This proceed was done in development, being that any problem can be corrected in the project, now with ISO-9001 certification, is necessary do this product in a assembly line, because certification validate the product and the manufacturing routine. All the pieces are purchased of external suppliers, the enterprise don't make this components because the production scale is small (four hundred units by month, coming in the maximum at eight hundred machines).

After finish the product and placed in the market the success wasn't immediate, detached some time, until the process stay stabilized. The product quality depend of this stabilization, because when are tested in laboratory, are obtained differents results of when produce in series. In the laboratory they try foresee all possible defects and client use conditions, but always appear something not foressed and some change are needed.

Conclusion

This work was focusing in the infusion bomb project. One fact that help us in our research was that the product development is being the base to the ISO certification process. The objective of this final part is compare the theoretical review with case study showing some considerations about project and manufacturing integration. We used an interview to make the case study, and a questionnaire, based on the ETTLIE's work (5), to make this comments. Beginning by two questions series are attributed values to the answers and so gauged the classification that suggest conclusions. The questionnaire that was sended to X and the answers are resumed in the end of this work. To this author it must be done with many people in the enterprise and after must take a mean value to any question, this serve to show the vision between differents sectors and people of the same sector, however in the studied case, due to equip size, we don't find necessary make more than one.

To verify the degree of project and manufacturing integration the text indicates that we give values to the questions three, four, six, eight and ten, being three to "yes", two to "in course" and one to "no". With this values the enterprise reach seven points, which by the author, qualify them as an delayed unity in integration, however taking some actions, being needed to negotiate with others parts of the enterprise, as high level managers. In the second part of questionnaire, that care of integration "satisfaction", excluding the questions five, six and nine, and giving values to the other questions (three to "yes", one to "no" and from one to five to question ten) the enterprise reach seventeen points in twenty three possible. The conclusion is that, although the enterprise has already implemented a CAD system it is backward in terms of integration. Nevertheless, it occupies an average position inside the manufacturing sector, as the other twenty five percent of all enterprises in the same situation.

Whether the classification proposed by ETLLIE (5) is applicable in Brazil raises some questions. We believe that only the differences in the industrial development model and in the rhythm of technology absorption will be necessary make adaptations in the classification. However, if the objective is to make a comparison in international level this classification is perfectly correct.

The origin in the X's planning process occurs in marketing, as well as suggested in the theoretical review. In relation to the conflict between the cultures of project engineers and manufacture engineers, we can affirm that it didn't occur in the studied enterprise, due so the little staff responsible by the two areas, the informal integration existent, and by the fact that the prototype is done in the project area and only after it is transferred by production line helps in this integration.

The CAD/CAM integration process by computer ways not occur in X. The enterprise don't count with CIM because doesn't have CAM. The production is a manual assembly line, however the project area is highly computerized. We can conclude

that despite of the software's use the area is integrated, in the most part by its dried out organizational structure and by the physical proximity although doesn't realize team work. The computer is used in the supporting activities (inter-sector communication by report, petitions and document change, projects recording and recovering, research in pieces catalogue and others).

Table 1 - Interview Questionnaire and Answers

Questions	***Answers***
Firm use a computer-assisted project management program to deploy this system. What?	*Yes, Microsoft Project*
Firm achieve CAD/CAM integration. For what percent of production?	*Not Yet*
Have people who area trained in DFA or DFM. Who and for what?	*No*
A manufacturing representative is required to sign off on design reviews for new products on this program?	*Yes, product discharge*
Design engineers work directly with the operating personnel to solve product problem?	*Yes*
Firm have developed and implemented new structures in order to coordinate design and manufacturing?	*Wasn't developed any particular structure, but different areas participate.*
R&D for manufacturing is contracted out to other firms?	*No*
Job rotation between design and manufacturing engineering is practiced?	*No*
Manufacturing engineers can make changes in the product design?	*They can't do, but can and must suggest*
Personnel from design engineering are sometimes moved to manufacturing engineering or vice-versa?	*No*
Our product and tolling design are developed simultaneously ?	*Yes*
Firm use compatible CAD systems for product and fixture design ?	*Autocad to mechanical and P-Cad to electronic*
Firm have a design-manufacturing team ?	*Yes*
A group is responsible for coordinating design and manufacturing? What is the group called? Does the group report to engineering, to manufacturing, or to another unit?	*No. Exist one group responsible by development and other by manufacturing. They have to report to unit management.*
Firm have a team that is responsible for product design and development which includes representatives from areas outside of design and manufacturing, as marketing. Who is on this team?	*Yes. Technical Assistance and Quality Control.*
Firm have implemented new policies or practices in order to integrate design and manufacturing. What are these policies or practices?	*Yes. The participation of diverse areas in the development process*
Our design engineers met with the system vendor to obtain advice on process design ?	*Yes*
are paid on the same scale as manufacturing engineers?	*Yes*
There is a line in the budget for manufacturing R&D or its equivalent ?	*No*
Design and manufacturing engineers work together in the design phase?	*Yes*
What measures do you use to evaluate the success of design-manufacturing integration?	*Firm hasn't control of this article*
How successful has this integration effort been?	*Well successful in some aspects*

References

(1) NAVEIRO & O'GRADY (1997). Dicast: Um Sistema Inteligente Para Auxílio ao Projeto de Peças. 19 pages. Mimeographed.

(2) SLULER & R.J.EBERT (1992). "Prototypes for Managing Engineering Design Processes", in: SUSMAN, G. I. Integrating Design and Manufacturing for a Competitive Advantage. Oxford University Press. Cap. 8, pg. 123-139

(3) LIKER, J. K., FLEISCHER, M., ARNSDORF, D. (1992). "Fulfilling the Promises of CAD", in: Sloan Management Review. Winter Edition 1992, pg. 74-86.

(4) ROZENFELD (1994). "Sistema CAPP: Seus Conceitos, Casos Práticos e Desenvolvimento", in: Revista Máquinas e Metais. Março de 1994, pg. 124-142.

(5) JOHN ETLLIE (s/d) "Methods That Work for Integrating Design and Manufacturing", in: Issues and Oportunities. Cap 3, pg. 53-77.

(6) ROSENTHAL (s/d) "Bridging The Cultures of Engineers: Challenges in Organizing for Manufacturable Product Design", in: Issues and Opportunities. Cap 2, pg. 21-52

(7) WHEELWRIGHT & CLARK (s/d) "Learning From Development Projects", in: Revolutionizing Product Development. Cap. 11.