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A Return to Merchant Ship Construction: The International Impact of the NSRP and American Technology

IIA-1

Raphael Gutierrez, Member, and Antonio Sarabia, Visitor, Astilleros Espanoles, Spain

SUMMARY

In the mid-eighties, the state-owned shipbuilders of Spain were suffering from many typical shipyard problems, making them uncompetitive. After making a strong reentry in the commercial shipbuilding market, they engaged in a process of reorganization of the entire production system according to modern Japanese practice. The goal was to become competitive with the world's best. The know-how was acquired via cooperative agreements with leading Japanese shipbuilders as well as through the use of American consultants and NSRP-related literature. A comprehensive technological improvement plan has been launched and the initial results are very promising.

INTRODUCTION

In the early and mid-seventies Spain was the third largest shipbuilding nation in the world, in terms of both orderbook and production, ranking only after Japan and Sweden. About half of the large and medium yards were grouped in a state-owned organization, the rest being privately owned. Small shipyards were, in general, privately owned. Export orders comprised the majority of the orderbook. The general mood was optimistic, and shipbuilding was seen as one of the most promising locomotives for the industrial development of the country. There were plans for heavy investment in new facilities, hoping to eventually become the rival of Japan. The industry was competitive on the basis of abundant, cheap labor and a long shipbuilding tradition.

The 1973 oil crisis left the world's shipbuilding industry in disarray as orders almost disappeared. Some countries began to take measures to readapt production capacities and methods to the new environment, but unfortunately Spain was not one of them. See Fig.1. Full speed production continued until the end of the decade, thanks to a very large initial orderbook, long building periods and domestic fleet building programs. A brief market recovery in the late seventies further delayed the realization of how deep the crisis was to be.

SPANISH STATE-OWNED YARDS DELIVERIES 1975-90

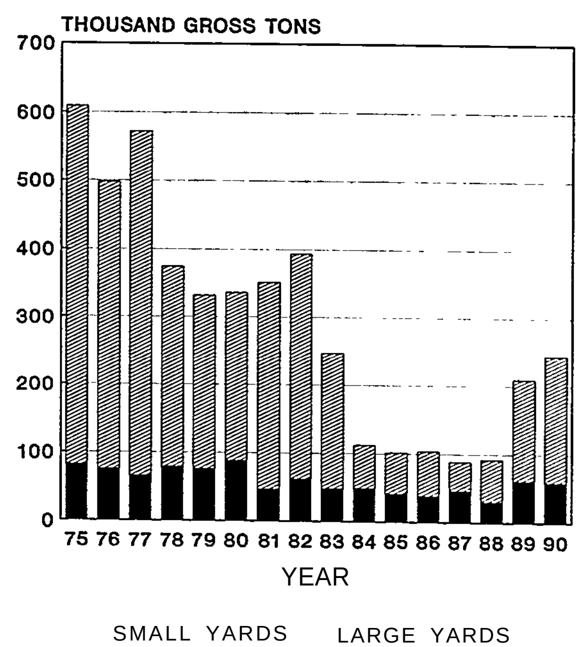

Fig.1

In the early eighties, just after the second oil crisis, disaster finally struck and the Spanish shipbuilding industry found itself hopelessly uncompetitive against new low-cost producers like Korea and some East European countries. Orders disappeared and soon our shipyards were nearly empty. The fall was particularly hard in the case of the large shipyards, all of which eventually became part of a state-owned group in an attempt to save them. Most observers expected the demise of the Spanish shipbuilding industry, following the path of Sweden's several years earlier.

This presentation is about the process of recovery and describes how the state-owned shipyards of Spain managed to re-enter the market. We will specifically concentrate on the way in which our group changed its production system, adopting an advanced manufacturing organization capable of delivering, by the mid-nineties, a performance close to that of the world's shipbuilding leaders.

PRODUCTIVITY IMPROVEMENTS IN THE SEVENTIES

As indicated above, the competitiveness of our yards was based on low-cost production. Productivity, while important, was not one of the most critical factors. High production rates were achieved by the use of large numbers of workers. However, some shipyard managers knew that Spain would lose its low-cost advantage sooner or later, due to the inevitable incorporation of the country into the group of industrialized nations. This had happened before to Japan and had been overcome by the adoption of astonishingly efficient production techniques. Therefore, isolated measures began to be taken to follow the Japanese example, as some major shipyards in Spain attempted to incorporate the latest Japanese shipbuilding technologies. They hired a leading Japanese shipbuilder to analyze their construction processes and give recommendations for improvement. There were learning trips to Japan by senior Spanish executives, and Japanese experts were stationed in the Spanish yards to monitor the application of their recommendations and give advice on daily operations. The late seventies and early eigthies saw the progressive implementation of some advanced Japanese techniques at leading Spanish shipyards, with large gains in production efficiency. Unfortunately, not all shipyards were that progressive and many kept relying on old methods.

PRODUCTIVITY IMPROVEMENTS (OR LACK THEREOF) IN THE EIGHTIES

The years after the second oil shock were very negative for productivity improvements. The numerous workers of past days were now a heavy liability because Spanish laws made any reduction in the labour force via layoffs difficult and expensive. As the orderbook collapsed, shipyards were left with large payrolls, and management had to concentrate efforts on workforce reduction and financial problems. Most shipyard growth, in the fifties and sixties, took place in remote areas of Spain for the purpose of promoting industrialization. In such regions there were no alternate employment opportunities, and the general recession made it difficult for people to find jobs elsewhere. To lure people away from shipyards, the Government sponsored generous severance and early retirement schemes. As a result, many of the best and most experienced people left the industry, but too many others preferred to stay. The labor reduction efforts continue to this day. The overall reduction has been dramatic, from over 35,000 laborers in 1975 to just under 9,000 today. See Fig.2.

In this climate, labor was unsupportive of attempts to improve productivity, as it could further reduce the number of those needed in the future. However, a renewed effort was made to adopt the latest Japanese techniques in the large shipyards. A new agreement was signed in the mid-eighties with a major Japanese shipbuilder for this purpose. The past pattern of trips to and from Japan started again. This time nearly 200 AESA employees travelled to see the Japanese yards. This included more than just top management. Union leaders and senior shop foremen were also engaged in the trips. The program lasted two years and much was learned. However, it was hard to see any measurable effect in our production efficiency. Orderbooks were so meager and available labor force was so large that

SPANISH STATE-OWNED YARDS
LABOUR FORCE 1975-90

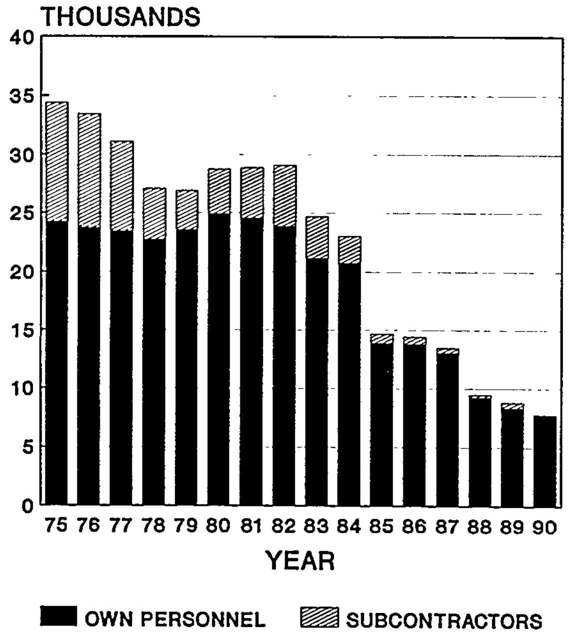

Fig.2

PRODUCTIVITY HISTORY
SPANISH STATE-OWNED YARDS

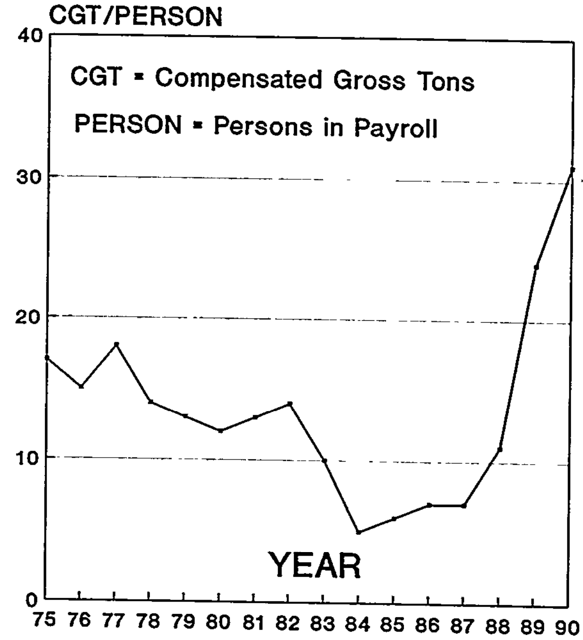

Fig.3

productivity fell to the lowest historical values in 1985-87. See Fig.3.

A definite change took place in 1987, when senior management launched a strong commercial effort to fill-up the building berths and docks. A large specialized salesforce was trained and sent overseas to canvass the world for the few orders shipowners were placing. Marketing was based on sophisticated media and image campaigns, plus untiring travel for contacts with brokers and customers. Also very important were financial engineering teams that were brought in to prepare competitive offers, making the best of Spain's currency, exchange rates and credit schemes. Last but not least, Government support, both political and financial, was secured. The effort paid off; in less than one year we had obtained substantial orders from first class international owners. Taking advantage of a slightly improved market we pursued our efforts and by 1989 we had again a full orderbook.

1. Some details of how this commercial success was achieved were presented in a restricted seminar for students of the University of Michigan. March 27/28, 1991.

In parallel with this commercial campaign, all our factories were brought up to full capacity production. In 1988-89 we restarted large-scale production in our five ship-oriented newbuilding yards and one specialized offshore artifact yard. After the long years of subactivity, our productivity grew rapidly and soon reached levels similar or better than the best before the crisis. We gave a large share of credit for this to the collaboration with the Japanese. However, as we gained speed, our machinery began to rattle. We were very near our practical limits and we were getting good results by working very hard.

THE PRODUCTIVITY CHALLENGE OF THE NINETIES

While we were enduring the years of crisis, our Japanese friends and competitors had kept improving their productivity at an almost incredible pace of 5 to 10% annual cummulative rates. During the eighties, leading Japanese yards had cut in half production manhours for a given ship. We realized that, in spite of our relative improvements in the last years of the decade, we were still very far from the productivity of the world's best. We could not expect to be competitive unless there was strong demand and good prices. At the same time, new trends in the European Economic Community pointed towards the end of all state support for shipbuilding. For strategic reasons, it was obvious that a united Europe would need efficient shipyards, but not necessarily those located in Spain. To ensure our own long-term survival, we needed to further improve productivity until achieving Japanese-level production efficiencies. We had to be profitable not only in a buoyant market, but also during the bad times which would inevitably come after it.

Traditionally, our production technology was developed almost independently by each factory, and often only by the respective production establishment. Efforts in this field were not centrally coordinated and this created a dispersion of effort and a reduced information exchange between factories. To overcome this, management decided in 1989 to concentrate Research and Development efforts in the improvement of the production system, cancelling many technology programs unrelated to this goal. A company senior Vice-President was assigned to lead this work with exclusive dedication and functional authority over all factories. A small new staff was created to coordinate the efforts.

From the initial analysis, the Japanese shipbuilding model appeared unattainable. Many of our own experts thought we could never reach their levels of efficiency due to complex social reasons and our different industrial background. In consequence, there were hot arguments about trying to follow the Japanese shipbuilding example, and many suggested that more modest goals should be set. There was also a tendency to think that shipyard productivity improvements could only come through working harder, or via investments in better facilities or hi-tech equipment, such as covered building halls, automated production lines, CAD/CAM, robotics or lasers, with rather lesser attention being paid to industrial engineering considerations.

In the end, the analysis showed such a substantial gap in productivity between Japan and the next best that our management decided in favour of the Japanese model, no matter how difficult. Any other option, it was thought, would lead to insufficient productivity improvements. Around mid 1989 it was decided to revitalize the Japanese cooperation programs. However, before resuming the trips to and from Japan, a review was made of previous cooperation programs to find out where they were successful and where they could be improved. All work processes were analyzed, starting with the most advanced yard at Puerto Real, and a long list was prepared, including questions to be asked and aspects to be discussed with our Japanese consultants. It was evident from this analysis that a lot had been learned in previous years regarding detailed aspects, and little or nothing in the more general aspects of engineering organization, planning and production control. This was confirmed by a first trip back to Japan in the fall of 1990. A new approach was required. We needed to learn not only what the Japanese were doing, but also why they were doing it.

THE PATH TO PROGRESS

The productivity circumstances surrounding the comeback of our shipyards were in many ways similar to those which led to the establishment of the National Shipbuilding Research Program in the United States. A limited number of our senior executives had followed with interest the developments in the NSRP during the eighties, especially through the NSRP publications and the Journal of ship Production, a truly unique magazine. Some had tried to apply certain concepts discussed in the NSRP literature, but due to external circumstances they were unable to muster sufficient support and their efforts faltered. However, by late 1989 there were more and more people in our organization who believed that an integrated effort similar to the NSRP could be the key for bringing together and understanding the piecemeal knowledge acquired in the previous 15 years about Japanese shipbuilding methods. A decision was made to investigate the program, and its operational concepts.

Some of our R&D staff attended the 1989 Annual Meeting of the Society of Naval Architects and Marine Engineers in New York, followed by a brief SNAME-sponsored workshop on design for production integration led by Prof. Howard M.Bunch, chairman of the Journal of Ship Production Committee and the NAVSEA Professor of Ship Production, University of Michigan. We found strong connections between the areas where our group was planning future research and those covered by NSRP studies. In particular, problems affecting productivity in the

American shipbuilding industry (1) were often relevant to our own case. Our experts were impressed by the fact that most of the material presented-at the workshop had been developped by the NSRP. When they returned to Spain, they recommended the launching of a group-wide R&D program to conceptualize the Japanese shipbuilding model, translate it to our own parameters and later develop a comprehensive scope of detail implementation projects. These goals were very similar to those which originated the NSRP more than ten years before.

Early in 1990 a team again visited the United States and held extended interviews with several individuals concerning modern shipbuilding production concepts and, among other things, the structure of the NSRP and its focus. It was also hoped that the trip would be useful in establishing future contacts with American shipyards for development of areas of mutual interest. To show the importance attached to the trip, AESA's Chairman/CEO led the team. Among those interviewed was Mr. Louis D. Chirillo, shipbuilding consultant and author of some of the most impressive papers and publications we had read, as well as leader of many relevant research projects sponsored by the NSRP. The team also visited Prof. Richard L. Starch, senior author of the textbook Ship Production and professor of Industrial Engineering, University of Washington, and again Prof. Bunch in Michigan. At the conclusion of the meetings, the three Americans were invited to visit the Spanish shipyards and to present their views on modem ship production. This established the basis for an ongoing relationship.

A few weeks later, Professor Bunch and Mr. Chirillo arrived in Spain and first made a week-long tour of the major shipyards, where they had opportunities to talk to many of the managers and to inspect production operations. At the conclusion of their visits, they made a presentation to top level management at the Madrid central headquarters. The presentations summarized the team's thoughts of where and how improvements could be made. They 'also addressed the dynamics of change; the ways that the knowledge might be most effectively incorporated into the production structure. The experts focused their recommendations, at least for the inital stages, towards the improvement of work organization, not facilities. The advice was "work smarter, not harder," and the message was reinforced by numerous slides comparing how AESA did things and how it was done in the world's leading shipyards.

Shortly afterwards, AESA organized two one-week courses for senior and line-level managers in technical offices, production, planning and procurement departments of the two most important yards. Mr. Chirillo and Professor Starch were intructors in these seminars, which were attended by more than 50 people. The main stress of these seminars was the application of group technology in shipbuilding, with the application of zone/stage/type-of-work principles to ship construction.

Because our shipyards are state-owned, we informed the Spanish Administration of the results of our American contacts. As a result, Mr. Chirillo was retained in the position of adviser to the Spanish Private Shipyards Association, with full governmental backing. Due to their small average size and lack of individual ressources, the Association's thirteen shipyard members were being temporarily helped by the Administration through a reconversion period. So, although we have been competitors in some specific cases, we are in fact contributing, and happily so, to the improvement of domestic private yards.

THE GLOBAL PLAN FOR TECHNOLOGICAL IMPROVEMENT 1990-92

In April 1990 the new production policy was made official by the group's top management, and a comprehensive R&D program called the Global Plan for Technological Improvement 1990-92 (PIMET for its Spanish initials) was launched (2). The main objective of the plan is:

> "to organize, promote and coordinate the technological projects of the Factories and the Central Headquarters oriented to improve radically, in the short- and mid-term, the competitive position of the group's companies and to consolidate in the long-term the advances made."

The introduction further states: "In this respect, it is crucial to increase production as a way to increase income and to reduce labor costs as a way to reduce expenses. Both are achieved by technological improvements in the building processes. These improvements are also essential to reduce delivery leadtimes, which in our case are considerably longer than those of our competitors. This additionally entails financial savings and helps to reduce inefficiencies. The reduction in leadtimes is achieved by the adoption of building systems based on the zone-per-stage concept, following the world's most advanced shipyards. These systems also favour the reduction of work content in interim products and finished products, which in turn lead to labor reductions as a consequence of the necessary reorganization of the manufacturing processes." Finally, the presentation clearly establishes the Japanese shipbuilding industry as our model of reference.

The Plan sets forth the following action policies:

1. **Design for Production Integration:**

   1.1 To establish a stepped process for the definition of the vessel with coordinated advance of the design, planning and material management.

   1.2 To reorganize the structure of the technical offices according to the zone-per-stage principle and to improve the quality of contract design.

   1.3 To improve the relationship between technical offices and production departments, procurement departments and planning departments.

   1.4 To develop CAD/CAM applications to support information flows and to produce the required graphic and written information.

2. **Integrated Hull Construction, Outfitting and Painting:**

   2.1 Subdivision of the production processes according to Group Technology logics, in process lanes.

   2.2 Reorganization of production teams in groups, each executing a work package defined by work instructions.

   2.3 Distributing short-term planning responsibilities horizontally to the production sections.

   2.4 Establishing interface relationships between production stages based on a "pull" philosophy.

   2.5 Adapting facilities to optimize process lanes.

3. **Planning and Control by Work Units:**

   3.1 Adapt planning units to process lane and interim product concepts.

   3.2 Involve in planning all parties affected; technical, office, procurement and production managers.

   3.3 Establish reliable production and productivity databases organized according to interim products.

   3.4 Organize material coding schemes according to Group Technology principles.

4. **Continuous Improvement of the Manufacturing System:**

   4.1 Establish a dimensional control system for all processes, based on statistical concepts.

   4.2 Disseminate the basic production engineering techniques among those involved.

   4.3 Set up a production engineering group in each Factory.

   4.4 Formalize and document a building strategy for each newbuilding.

   4.5 Define and develop production systems to be be automated, and the CAD/CAM applications necessary for this purpose.

   4.6 Set up management-by-target procedures and direction-by-objectives pay systems.

About US$ 110 million have been allocated to the implementation of the Plan, of which about two thirds will be devoted to soft-technology aspects, or industrial engineering. See Fig.4. The remaining third will be directed at improving facilities, but only after organizational

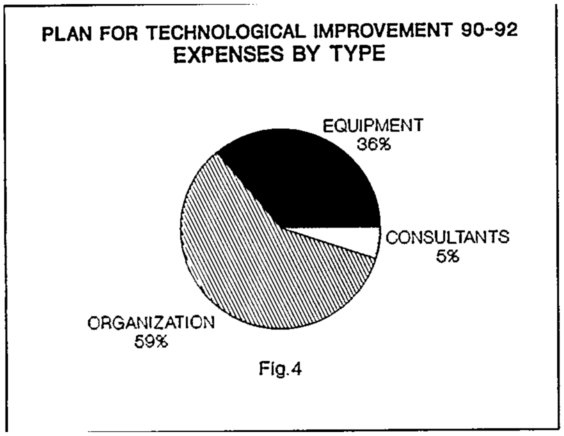

Fig.4

PLAN FOR TECHNOLOGICAL IMPROVEMENT 90-92
Situation of basic projects (May 1991)

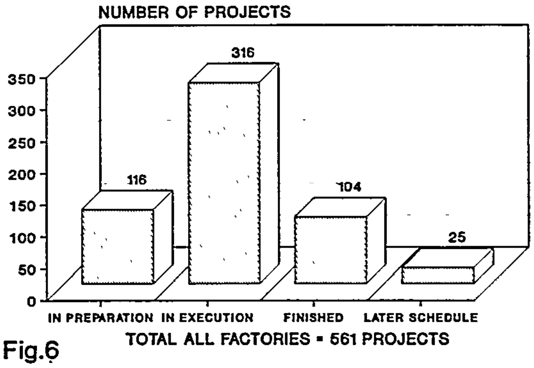

Fig.6

improvements of the respective areas take place. The Plan incorporates 561 initiatives covering the full engineering, planning, procurement and production spectrum. A typical factory has between 60 and 120 projects, depending on size. Grouping the respective budget by type of initiative, a very strong emphasis in soft technologies can be seen. See Fig.5. Some 20% of the projects are already finished, while another 55% are now underway. The rest will be carried out in 1992. See Fig.6.

PLAN FOR TECHNOLOGICAL IMPROVEMENT
PUERTO REAL FACTORY
PROJECT BUDGET BY TYPE

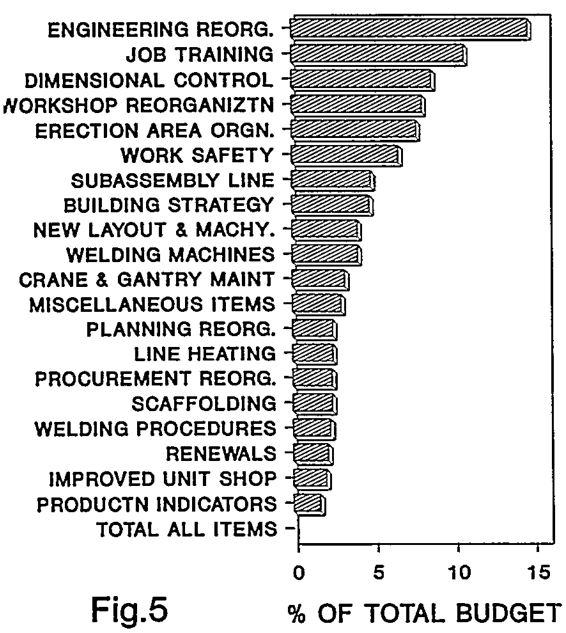

Fig.5

CONTINUATION OF THE AMERICAN AND JAPANESE RELATIONSHIPS

In October 1990, Mr. Chirillo returned to visit our remaining six shipyards, three of which were devoted exclusively to repairs. The following month, Professor Bunch came to Spain again, this time for a presentation to top management on the implementation of change in an industrial environment. This was followed by a one-week design for advanced ship production seminar especially addressed to technical office personnel and attended by 30 persons. By year-end practically all top executives and people in responsible positions within the engineering, planning, procurement and production processes had been exposed to the new ideas. Additionally, the company had implemented a program of acquisition, translation and circulation of selected technical publications, including the Journal of Ship Production and a number of the NSRP manuals which described the Japanese shipbuilding model.

At this time, a much better understanding of Japanese shipbuilding processes exists in our company. This result might have been reached directly by our experts thanks to the abundance of Japanese-supplied material from past and present co-operation periods. However, it was facilitated by the NSRP's identification of the logic and principles of Japanese shipbuilding methods and its clear exposition in an easily readable language.

This has permitted the successful organization of brand-new cooperation agreements with leading Japanese shipbuilders for the implementation of productivity improvement concepts and total quality control (TQC) processes in our group's two most advanced shipyards over a 3-year period. These projects will supplement, and run in parallel with those of the PIMET Plan. The goal is now to put the group on a par with world-class shipbuilders regarding production efficiency. This requires at least duplicating the present productivity levels.

The Japanese experts now visiting our yards are finding a more receptive environment for their ideas, with far more cooperative managers and workers. This is making their task easier and progress is being achieved faster that expected, and certainly much faster that in any previous period of cooperation with Japanese companies. Many of the participants are the same, but we have a new mentality on our side. The rethinking process which has taken place in the last two years is the key to the change in attitudes.

RESULTS

Only about a year after the publication of the PIMET Plan and the visits by the American consultants, each of our newbuilding yards had already developed a Product Work Breakdown Structure (PWBS) based on Group Technology (GT) and Interim Products according to its own unique facilities. For new contracts the yards are now preparing detailed building strategies according to Integrated Hull Construction, Outfitting and Painting (IHOP) principles. Work is classified by GT and process lanes have been formalized. A task group is now introducing line heating techniques for accurately shaping plates and profiles. Engineering departments are now organized according to the zone-per-stage-work-intruction concept and, last but not least, basic designs have been extended in their scopes and are now developed with full attention to production aspects. Each factory has chosen a slightly different path in order to cause minimum disruption to on-going ship construction. But by the end of the PIMET plan, all factories are expected to have reached full development of the new production philosophy.

It is a little too soon to talk of productivity results. Steel is now being cut for the first vessels which will benefit from the new technologies. Their construction will be followed with keen interest to determine the effectiveness of the measures taken in what is already considered within AESA as a new technological era. In one case of series production, leadtime has been reduced considerably, while improving the accuracy of planning. See Fig.7. This is due mainly to improved pre-outfitting and increased modularization of piping and machinery systems. Our global productivity, measured in Compensated Gross Tons (CGT) per man-year has also improved dramatically in the last three years. See Fig.3. Again, this is as much due to full capacity utilization as it is due to better procedures and organization. However, the real improvements are yet to come when the full scope of changes are applied.

Meantime, in anticipation of PIMET-induced productivity improvements, some yard production managers have already accepted manhour targets for new designs which are about 20% lower than the previous levels.

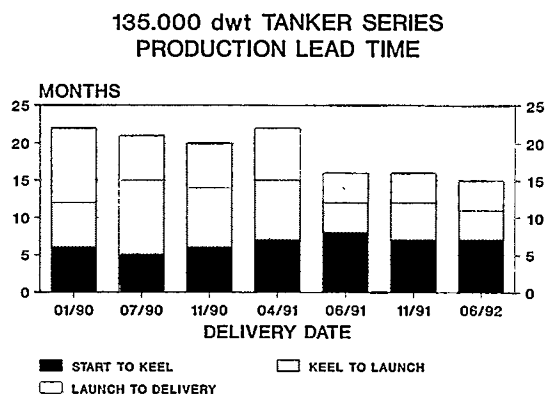

Fig.7

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In retrospect, a very important guide for evaluating the situation of AESA and indicating a direction of movement for AESA's structure was the work related to the NSRP. It provided a useful means for the organized interpretation of Japanese shipbuilding concepts, even to those who were already familiar with these concepts. In the NSRP, AESA also had visible evidence of how a determined effort involving industry, government and academia can effectively set directions for shipbuilding industry attempts to move forward towards significant improvement of its production structure.

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