

Case Study

Aerospace Research: Vector Supercomputer at CIRA

Summary

CIRA has developed an interesting scientific project thanks to a supercomputer NEC. The purchase of a multimillion Euro expensive supercomputer is justified by the undoubted benefits for the wellbeing and the safety of the public.

NEC SX-6 vector supercomputer was the right tool for CIRA's tasks because it prevents accidents, helps Italian industry to develop innovative products and nourishes researchers' motivation.

Company's Background

The Aerospace field is clearly a high technology area. The availability of advanced technologies in addition to the capability to develop them continuously has always been considered by every country a basic requirement for the growth and a lasting success of the aerospace industry. CIRA (Italian Aerospace Research Centre) was incorporated in July 1984 and became operational in 1989 to meet the necessity of progress and innovation of Italy's aeronautics and space activities.

CIRA is a highly sophisticated and leading-edge technological institution. It is a joint-stock consortium: the Italian Space Agency (ASI, 31%) and the National Research Council (CNR, 21%) own since 1998 the majority of the shares; other relevant shareholders are the regional government (Regione Campania) and the main Italian Aerospace Companies.

The joint participation of private and State organisations makes the objectives of CIRA consistent with the national strategic goals and the companies' needs, contributing to the economic and social development of the country.

CIRA was assigned by the Italian Government to identify and take up the National Aerospace Research Program [PRORA], which was defined with the National Research Program [PNR], the National Space Plan [PSN] and the requests of the industrial and research arena, taking in account the perspectives in the fields of aviation and space on a world-wide scale.

The Italian Government also contributes to financially support management costs of the facilities designed and built within the PRORA program and the research and personnel training costs.

The remaining financial resources necessary to manage the Centre come from orders and contracts requested by the market.

Consistent with its mission, CIRA supports training and expertise in the aerospace field

The accomplishment of these objectives involves:

- The development of research projects in synergy with the entrepreneurial and scientific community
- The participation to international co-operative study projects
- The improvement of modelling, simulation and testing on ground and in flight, through the purchase and growth of hi-tech demonstrators

- The promotion of collaborations with national and international research centres to encourage synergies with existing testing facilities and laboratories
- The utilisation of the acquired technical competencies to offer the International Aerospace Community experimentation, certification and research capabilities
- The recruitment and training of recent university graduates and researchers.

CIRA is located in Capua, 50 km north from Naples. The plant is situated in a region, Campania, in which there is a remarkable presence of industries operating in the aerospace field such as Alenia, Fiat Avio, Alfa Romeo Avio, Vulcan Air, Piaggio, Magnaghi, Tecnam and others. Moreover, there are two Universities, “Federico II” and “La Seconda Università di Napoli”, which include the faculty of Aerospace Engineering, the Academy of Aeronautics and the Air Force Academy for Non-Commissioned Officers.

The Challenge

CIRA has a significant tradition in employing vector computing. In the early days, it firstly installed an ETA 10, one of the very few in Europe, which was never in real production because of lack of software and the early demise of the Eta Company; later on, it adopted a number of CONVEX “mini-supercomputers” which were effectively used.

In addition, CIRA’s staff was forced to use a mid-range super-scalar server due to a dramatic stagnation in the aeronautics and space activities and a lack of a national strategy in this sector. This situation generated a dramatic drop in the CIRA’s staff motivation, as there were no major research programs and no innovative computational facilities.

The Solution

The very first step that CIRA took under Mr. Sergio Vetrella, new President in 1999 and Professor in aerospace engineering at the University of Naples, was an aggressive reorganization program to bring to CIRA enthusiasm and zeal, experience and expertise, motivation and incentive, visibility and international recognition.

To fully meet structure’s technical requirements, Mr. Vetrella identified and acquired a new High Performance Computer. After comparing performances on applications from several qualified vendors, a NEC SX-6 vector supercomputer was selected.

CIRA SX6 has a theoretical Peak Power of 32 Gflops (that is, 32 Billions of Floating Point Operations per second) achieved with only 4 SX6 Processors. It is however to be noted that Sustained Computing Speed is usually only a fraction of the Theoretical Peak Power of a Supercomputer. CIRA’s SX6, like others of its class, because of its architecture and of its vector capabilities, has one of the best ratios Peak/Sustained in the world. That is, comparing it to a cluster of personal computers, SX6 can easily be tens of times more efficient and effective when it comes to “real world” applications. Other Aerospace Research Centres in Europe are using NEC SX Vector Supercomputers, like DLR in Germany, ONERA in France and NLR in The Netherlands: all of them however are using so far NEC Systems of the previous generation (SX5),

which puts CIRA with its SX6 at the forefront of Aerospace Research in Europe, from a computational point of view.

Other main features of the NEC SX-6 are extensions to operating system and middleware for support of the enhanced multi-node.

The contribution of SX-6 to CIRA has been very important. Crash tests are a combination of numerical simulations and physical tests. The use of a supercomputer and of proper crash simulation codes is key to reduce the total time (preparation of the test, physical test, analysis of results) to a few weeks instead of months. LISA (the CIRA Laboratory for Impact Tests on Aerospace Structures; it is among the largest such test facilities in the world) performs on average a dozen tests a year.

Accuracy, completeness of the calculations, memory, synchronization of computing activities and time-to-solution are key for aircraft's and space vessels' security, efficiency and effectiveness and, last but not least, for commercial competitiveness.

Theoretically, adding up thousands of Personal Computers, it could be obtained a combined power equal or even greater than the one of a supercomputer. In reality, however, a cluster or network of Personal Computers cannot, in most cases, compete with a supercomputer when it comes to efficiency, to through-put, to expensive needs of intel-processors communication link among the PC's and to application parallelization. An SX supercomputer can, on some specific computational problem, be 30/40 times faster than a large cluster of PC's.

Though, on a much smaller scale, the NEC SX-6 installed at CIRA is using similar technology as the gigantic supercomputer installed in Japan and known as "The Earth Simulator", the mightiest and fastest computer in the world.

The Result

The already intensively used NEC SX-6 computational resource has revitalised Italy's aerospace research. It has been instrumental in bringing into operation the largest and most up-to-date Icing Wind Tunnel [IWT] in the world; ranked second and third are the IRT - NASA Glenn and BRAITT of Boeing Seattle, respectively.

CIRA IWT is specifically designed for simulating extreme icing conditions for turbo-prop airplanes. For example, the European ATR, a French-Italian project for Regional Air Transport - many ATR42 and ATR72 are in service today all over the world - suffered two dramatic accidents in its early days of operation, from unusual icing conditions encountered during flight. Because of its capability of simulating proper flight altitudes and large droplets, CIRA IWT is the only facility of its kind, which follows punctually, the FAA directives for anti-ice certification.

CIRA runs two other record testing facilities, the PWT, Plasma Wind Tunnel for space vehicles re-usability and aerodynamic heating during re-entry, and the Laboratory for Impact Tests on Aerospace Structures, [LISA].

Pasquale Schiano, head of computational laboratories of CIRA, says: "Computer simulation on the SX-6 optimises the test schedule. Tests validate the computational codes, and thus simulation remains a significant part of the process, as not all the conditions can be reproduced inside the tunnel. The availability of an efficient up-to-date supercomputer helps motivation, as it makes the

staff feel that they can perform their research work at the same level-playing-field as those of other aerospace research institutions”.

Better results in lesser time are crucial in today’s aerospace industry. Supercomputers can do this: hours instead of years in designing and virtually testing new aircraft will result in more significant advances and greater safety for passengers. Such supercomputer represents a real break-through in the Italian aerospace research. It made it possible to efficiently and effectively design, develop and exploit some of the most powerful, effective and sophisticated aerospace test facilities in the world.

And last but not least, researchers, engineers, mathematicians, physicists and all employees in general feel they now have an instrument that can quickly turn their ideas into methods and algorithms.

With the exception of the InterUniversity Consortia for High Performance Computing, CILEA (Milan), CINECA (Bologna) and CASPUR (Rome) and of some public Institutions like ENEA and INGV (National Institute for Geophysics Vulcanology – another NEC SX user) there are not so many large High Performance Computing Centres in Italy. CIRA represents one of the most significant achievements in this field , when it comes to acquiring a Supercomputer with the specific aim of serving Industrial (Aircraft Manufacturers) and Public (Aerospace Research) need of coping with state-of-the-art scientific and technological progress.

The Author of the Solution

NEC Corporation (NASDAQ: NIPNY, FTSE: 6701q.l, TSE: 6701) is one of the world’s leading providers of broadband and mobile Internet solutions dedicated to meeting the specialised needs of its diverse and global base of customers. Ranked as a Global Fortune 500® company and one of the world’s top patent-producing companies, the NEC group delivers tailored solutions in the core technologies and services required in a networked world, ranging from advanced semiconductor solutions, to large-scale mission critical systems, systems integration, and broadband and mobile technologies. The NEC group employs more than 146,000 people worldwide and had net sales of approximately ¥4.695 billion in the fiscal year ended March 2003. For additional information, please visit the NEC home page at <http://www.nec.com>.

NEC has distributed high performance computing systems in Europe since 1987 and provides wide-ranging support services and system integration. NEC’s product portfolio includes SX series supercomputers, TX series high performance servers and NEC’s trusted Linux clusters, which are mainly used for scientific and technical computing tasks in industry and research. NEC High Performance Computing Europe (HPCE) was founded in February 2003, formerly known as NEC European Supercomputer Systems, established in 1989. The European headquarter is in Düsseldorf, with branch offices located in Paris, London, Amsterdam, Lugano and Milan. NEC’s competence center for Linux technology and third party application tuning and support has its offices in Stuttgart. For additional information, please visit: <http://www.hpce.nec.com>

The Future Steps

The world-wide demand for air transport is growing fast. European employment levels in manufacturing, operations and airports have reached 2 million people. Civil and military markets are projected to reach a volume of several hundreds of billion dollars, in the next years. Today's world is characterised by globalisation of markets and greater mobility of individuals, for both work and leisure. Air transport is already and will turn into a progressively more significant economic and industrial area.

Paradoxically, due to this success, the sector is now facing important trials critically menacing its future development: environment, safety, comfort and industry competitiveness.

Research centres like CIRA will be asked to accept the social challenges of sustainable development and air transport safety.

Thanks to the important role of mediator of NEC, the Director of "The Earth Simulator Centre on Japan" [ESC-JAMSTEC], Professor Sato, and the President of CIRA, Professor Vetrella, have signed an agreement of scientific co-operation that provides for Italian researchers the possibility to use the Earth Simulator. This can be possible because the two Supercomputers utilise the same processors, so that software and know-how can be integrated and the software can be optimized in vector processors of the two Supercomputers. The deal grants researches and expeditions on health variations and on earthquakes, the development of regional models to inquire into changes in the environment and to combine numerical studies and experimental observations for a complete and easy comprehension of health alterations. CIRA will apply these inquiries to Mediterranean region. Joined publications, workshops, lectures and conferences will spread to public and to scientific community the goals attained.

Professor Sergio Vetrella, CIRA and ASI President, asserts: "In Italian National Space Plan 2003-2005 one of the four strategic axis is the multi-sectorial support with mission oriented research plans. These studies are targeted to widen the basis of aerospace technologies' knowledge, to contribute to solve problems linked to sustainable development and to global health changes.

Specifically, one of the thematic areas of this plan is dedicated to hearth observation to increase the knowledge of the system, developing more and more precise models for prevention, control and management of natural and unnatural phenomenon, with specific attention to natural calamities, as landslides, floods, woods' fires."

Furthermore, very soon NASA will visit CIRA to establish a co-operation agreement based on the use of CIRA PWT (Plasma Wind Tunnel) for Shuttle vehicles testing. The ASI Wind Tunnel will also be used by NATO for tests on the new NH90 European Helicopter.