











# Computational Fluid Dynamics and Aerospace Engineering

By Richard Greenblatt  
and Stephen Pottier

The past 1987 and the city of Bonn seem to have been good for applied and industrial mathematics. Five major organizations—ICIAM, IMA, IAM, and IFMA—played a decisive role in making possible the First International Conference on Industrial and Applied Mathematics in the French capital. The conference not only was an impressive success, with about 2,000 participants from all over the world, but also generated a positive momentum for representation of applied mathematics in the European role. As a consequence of the extraordinary event, similar organizations will soon exist in Europe, particularly in Italy and The Netherlands, as

well as in other regions, such as Japan and South America.

With the advent of supercomputers in the U.S., in Japan, and more recently in Europe, new computing facilities are now available to scientists and engineers for the large-scale numerical simulation of three-dimensional flows in aerospace engineering. Such capabilities are not only complementary to the other competitive tools, such as wind-tunnel experiments and analytical approaches.

The importance of numerical analysis was clearly demonstrated at ICIAM. Speakers discussed the numerical solution of the nonlinear partial differential equations that arise in very large internal and external three-dimensional flow computations involving turbomachinery, aerodynamics, and aerospace applications.

Many sessions—invited lectures, workshops, and contributed papers—were devoted to the increasing importance of supercomputing. As mentioned by one of the invited speakers, J. Barker, head of aerodynamics at Airbus Marcel Dassault/Breast Aviation, new self-consistent methods of fluid structure interaction during the steady phase of high Mach numbers and high angles of attack. These conditions are essential for computational analysis of reentry flows, involving the Euler, the Navier-Stokes, and the Boltzmann equations. For example, all of them with real gas effects including nonequilibrium chemistry. Powerful computing facilities will be required to find the numerical solution of the coupled system of equations, which will lead to better aerodynamic and aerothermal design, especially when low viscosity experiments are not available or are inadequate to provide the necessary data.

A number of workshops dealt with various fluid dynamic problems using sophisticated numerical solvers with fully implicit, semi-implicit (ADI) and splitting operator techniques with data decomposition, or explicit schemes accelerated by analogical techniques. Specific contributions were presented at several sessions from several three-dimensional studies in turbomachinery, missiles, and rockets, fully three-dimensional civil and military aircraft with separated aerodynamic regions in the transonic and supersonic regimes, and space vehicles operating at high Mach numbers.

Other topics of major interest in aerospace engineering, including turbulent viscous flows and combustion problems, were considered in sessions in these fields, with spe-



Left to right: Augusta Lomax, Janet Meyers, Jacques Pottier, and Charles Pottier.

cific emphasis on growing methods based on gas lattice or lattice automata theory. Encouraging numerical results paved the way for the solution of complex turbulent problems of subsonic and supersonic or at different sizes, with the ultimate goal of protecting the development of new technologies for advanced engineering.

The use of supercomputers requires the formulation of new algorithms to take advantage of new architectures. W. Hachtel emphasized this topic in his lecture on algorithms and other related mathematical aspects. In several workshops, diverse development methods and associated practical numerical algorithms with parallel features were extensively developed.

Acceleration of convergence using the above methodologies with finite differences, finite elements, or finite volume approximations was also considered in the context of structured two-dimensional grid generation and optimization.

Experimentation of the accuracy of the solutions was very often obtained locally, only when the available data of the flow—density, velocity profiles, or time, boundary layers, and vortices—could be used

self-validation of the results based on physical criteria or a potential criterion and comparison to existing data techniques.

It is clear that the above conditions, that the very complicated problems arising in aerospace applications have not been well studied or solved numerically at the present time, despite the increasing availability of supercomputer facilities. Solution of such problems will require development of the scientific community, not just computational tools.

It is our hope that scientists and engineers participating among from the first ICIAM, and forthcoming ones in the next years, will contribute to better understanding and provide more accurate and efficient numerical tools for the difficult problems encountered in aerospace engineering. For example, the high-tech design of space vehicles like Shenzhou in Europe and the Orion in the U.S.

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## Vortex Flows: A Challenging Problem in Fluid Dynamics

By Egon Krause

Fluid flow problems—as indicated by their appearance in 14 of the 18 invited lectures, 12 of the 18 workshops, 20 of the 111 contributed papers, and 10 of the 115 papers of ICIAM '87—continue to be one of the most challenging problems in aerospace engineering. This problem has been motivated by the advent of supercomputers, as demonstrated by A. Madsen of Princeton University in the first invited lecture of the conference.

Madsen stated that the solution of vortex flow problems can be described with numerical solutions of the three equations of motion for steady state. In his presentation, Madsen explained the theoretical background of the four solution techniques and presented several examples of flow solutions. He particularly demonstrated the accuracy for an analytical versus numerical and numerical studies in

three-dimensional and two-dimensional cases.

The full complexity of three-dimensional vortex flows, whose aerodynamic shapes was discussed in a presentation, explained by L. Tang of the Canadian Institute of Mathematical Sciences, York University. In his paper, he presented some of the most recent developments for three-dimensional vortex flows, which was described in detail.

H. W. M. Hulsbeek of the National Aerospace Laboratory The Netherlands, described some basic ideas of flow solutions in three-dimensional flows, which were described in detail. He presented some of the most recent developments for three-dimensional vortex flows, which was described in detail. He presented some of the most recent developments for three-dimensional vortex flows, which was described in detail.

Dr. H. W. M. Hulsbeek and C. Tang of the NASA Ames Research Center analyzed the complex vortex flow structure generated by the blades of a turbine engine.

At the conclusion of the workshop, the consensus was that complex three-dimensional vortex flows can now be tackled with the aid of supercomputers, but the complexity of coupling analysis with numerical investigations was also emphasized.

Egon Krause is director of the Aero-Engineering Section, Research and Development, DLR German Aerospace Establishment, Bonn, former Institute of Aeronautics.

At a meeting in Bonn on July 8, 1987, the ICIAM '87 Steering Committee decided that the next international conference on industrial and applied mathematics should take place in the East Coast of the United States in July 1991 and suggested ICIAM offer to host the conference. ICIAM is the acronym for the International Council for Industrial and Applied Mathematics.





## Farewell Address

Huifang Hsiao  
President of ICIAM

ICIAM '87 is coming to an end. Let us take a few minutes to reflect on the ICIAM experience—past, present, and future.

The enormous emphasis of applied mathematics and its growth over the interdisciplinary convergence were the factors that led people from all over the world to share this time working in these diverse fields could come together, to learning in their own ways and to changing ideas, then would share as creative partners of the current and future, and ideas of developing new in applied mathematics.

Thus, a world conference on applied and applied mathematics has been organized to share the same idea in many different countries. About three weeks ago this event began to take shape. Two large-scale events coordinated and divided to hold the first week conference in Paris in 1987.

All things have their special difficulties. In the American program was held in the center. The French and the American countries already had the program done at the work. And there were several changes. Would we succeed in organizing the approximately 500 participants? Would we succeed in making the conference successful? Would we succeed in making the conference successful? The conference has succeeded in bringing us the world, and in particular, to the end, about 1,000 participants from about 30 countries have gathered here.

An excellent program had to be scheduled in 14 days and work. There were 24 invited lectures in symposia, workshops, and 100 presentations in symposia, but for the first time and found the French very efficient. The final number of participants 500 exceeded the organizers' early forecasts, and there were no seats. I am very pleased to report that the program was very successful.

The conference is not yet over. We have the first week and final.

learned and experienced during this week has been there. There were many important ones held a year ago. We have enthusiastically enjoyed the spirit of the air. I am because members where we meet and when the problems are.

This is the time to say a few words of thanks. The preparation and execution of a conference at this time place an enormous burden on the organizers. I am following the organizational structure by following the following order:

—Dr. McKenna, chairman of the program committee, which has organized the entire program of the conference.

—Professor Brown, chairman of the working committee, which has organized the entire program of the conference.

—Professor Lichten, chairman of the local organizing committee, and Dr. L. L. Brown, managing secretary of ICIAM, who have been working on the local level.

—All, but not all, and 1988. Mathematics, University of Illinois, who are responsible for the organization and execution of the conference. They have been working on the local level, and they have been working on the local level. They have been working on the local level, and they have been working on the local level.

In concluding these words, we should not forget the people who gave of their time, energy, and effort to make this the best of the best. I am, especially for the success of the conference, I am sure to be remembered.

Take a few words about the future. There were many feelings from the beginning that this conference was the best of a series. This feeling was shared by many participants. The great spirit of the future will be given to you by the ICIAM Executive Committee.

I would like to thank the organizers of the conference, the staff of the conference, and the staff of the conference. I am very pleased to report that the program was very successful.

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(1987-1988-1989)

This represents the influence of the conference. The influence of the conference is to be felt in the future. The influence of the conference is to be felt in the future. The influence of the conference is to be felt in the future.

The first year of the ICIAM '87 conference was a very successful one. The conference was held in Paris, France, and it was a very successful one. The conference was held in Paris, France, and it was a very successful one.

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