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TASK FORCE ON APPLIED MATHEMATICS

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Tomás Garza relates how the Research Center for Applied Mathematics, Systems and Services became the Research Institute for Applied Mathematics and Systems, and what is the type of work that is being developed there.

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The Research Institute for Applied Mathematics and Systems ((IIMAS) *Instituto de Investigaciones en Matemáticas Aplicadas y en Sistemas*) of the National Autonomous University of Mexico ((UNAM) *Universidad Nacional Autónoma de México*) lodges approximately 100 researchers and technicians, says its director, doctor Tomás Garza. What should be emphasized — continued Garza — is the novel structure of the IIMAS, as there are almost no other institutions in the world covering fields so dissimilar.

Doctor Tomás Garza studied Mathematics at the Faculty of Sciences of the UNAM. He attended the University of Cornell for two years and the University of London for three; in the latter he obtained his doctorate in Statistics. Upon his return to Mexico, he took charge of a teaching program in *El Colegio de México* (The College of Mexico) and, at the end of 1970, he again joined the UNAM as assistant director in the area of research in the then newly created *Centro de Investigaciones en Matemáticas Aplicadas, Sistemas y Servicios* ((CIMASS) Research Center for Applied Mathematics, Systems and Services.)

— *What was the status of Mathematical Research in those days?*

— Traditionally, the interest in Mathematics in the Univer-

* Numbers in the margin indicate pagination in the foreign text.

sity had been oriented to its more abstract aspects, fields that are very difficult and in which the most prominent mathematicians are working. Those difficulties were increased in Mexico due to its incipient scientific development, the lack of experience of local mathematicians, the isolation, and the difficult access to the bibliography of the most recent studies. The study of what could have been called Applied Mathematics was completely abandoned; it was only at the Faculty of Engineering where these topics were touched upon in a tangential way, and then only to solve specific problems.

— *How did the CIMASS come into existence?*

— You see, due to a fortuitous circumstance, the *UNAM* was the first Latinamerican university, or firm, to have a computer, about 1958. Furthermore, as another product of chance, between 1970 and 1971 there was a gathering of people that had studied branches of science overseas, these fields were very little known in Mexico (statistics, computation, the Theory of Probability, differential equations) and they decided to work together. It was a heterodox group that did not follow the orientation of professional mathematicians, nor was it influenced by engineers. Then came the time when university officials decided to create the Research Center for Applied Mathematics, Systems and Services (CIMASS), that would fulfill a double function: i.e. supply computation services to the university community, and start performing autonomous research in several disciplines, which was later to be called Applied Mathematics. I was appointed as assistant director in the area of research.

The group developed rather quickly, and the CIMASS was divided into a research section (CIMAS) and a service section (the *Centro de Servicios de Computo* (Center for Computation Services)), although it was still one center. The university's concept of a *center* is an incipient group trying to develop a new area; the

center is created by a resolution of the headmaster, and as such, it may, also by a resolution of the headmaster, disappear, if conditions make it necessary. The center is to be flexible, and it will be maintained only if it gives signs of being adequately directed and structured. If so, it will deserve to be formalized within the university and transformed into an institute, which, according to the University's by-laws will have a certain implicit permanency. And, as a matter of fact, the research center, founded in 1973, was promoted to the status of research institute in 1976 by university legislation, and now its name is Research Institute for Applied Mathematics, and Systems (IIMAS).

— *What were the objectives of IIMAS in the beginning?*

— This will lead us to talk about the researchers' duties. /8
In fact I may answer your question as follows: from the beginning we tried to do research work. When we started in 1971, my colleagues and I did not worry about performing very transcendental research work; what we had to do was to insure the long term survival of the group. It was not easy, it is never an easy task to start a group, especially in such a large structure like this university. The birth of this group provoked much suspicion, even certain hostility, I would say, on the part of some other groups. One of the reasons for this, I believe, was quite legitimate: i.e. it was to be a new burden to the resources assigned to research. Therefore, we started a very ambitious plan for the formation of human resources. We called upon mathematics and physics students in their first years of study, and occasionally on engineering students, in order that they would associate with us as research assistants. The title was their only payment, since there were no funds to pay them a salary. It was a sort of proselytism, almost to a personal level. We were able to assemble about twenty young persons, very well chosen: i.e. good students, enthusiastic and responsible, which allowed us to assume that in the end they were to be integrated into the original group. We were very suc-

cessful, since many of the Institute's current researchers come from that group of assistants. This has permitted us to enjoy, in a way, a *esprit de corps* like the french would say. The people that work at the Institute are deeply rooted. It is very rare to have a change, as is frequently observed elsewhere. There are more people wishing to enter than wishing to leave.

— *How did IIMAS progress later on?*

— IIMAS has grown in a very spontaneous way, but, at the same time, in a very natural way. There has not been artificial creations, since each new area appeared because the conditions were already set for it to occur. A series of systematic studies were begun on topics that were practically never touched upon before in Mexico, such as the Theory of Probability, and numerical analysis. We have specialists in fields that can hardly be accepted as belonging to applied mathematics, ranging to experts in essentially practical matters, for example, digital electronics (that which deals with problems related to computers, to distinguish it from telecommunications electronics) and inbetween we have a great variety of fields, since the fertilization of ideas is something very big. Problems have appeared and have simply been resolved due to the fact that the occupants in the adjoining offices had completely different specialties. I am convinced that the effect of a well organized task force is much larger than the sum of its components taken individually. It occurred to us that a very effective way to develop the work of the group would be to pose extremely complicated problems; the solutions to which were not to depend on one person alone or even on specialists in one area. Problems in which persons with different backgrounds and specialties would intervene.

— *On what basis did you choose to work on projects such as the one on Remote Perception, or on the Sismological Network, and some others at the IIMAS?*

— The projects that you have just mentioned, such as the one on Remote Perception, are simply samples of intricate problems. Remote Perception technology involves aspects that range from the launching of a satellite up to the processing of images for their analysis. We had to gather persons that knew computation, electronics, more or less abstract-mathematics, statistics, persons that were able to solve those problems. Why did we choose those projects? I would say because they were there; it was very casual. They are interesting projects of course, but there was no external motivation from someone that proposed them to us for a solution. Rather, they were borne out of the interest of one or two persons within the Institute.

— *Are there other centers or institutes in Mexico, where the type of research being performed here at IIMAS on Applied Mathematics is also carried out?*

— In Mexico there are no other properly called institutes where Applied Mathematics are being developed, actually there are very few centers where any kind of mathematics research is being performed. There is the Mathematics Institute of the UNAM, the Research and Advanced Studies Center of the National Polytechnic Institute (*Centro de Investigación y Estudios Avanzados del Instituto Politécnico Nacional*) and the groups, more or less incipient, of the Iztapalapa Unit of the Metropolitan Autonomous University (*Unidad Iztapalapa de la Universidad Autónoma Metropolitana*). I feel it is not necessary to mention the rest, because they are either isolated individuals or their research is at a very elementary level. I think that only at IIMAS there is Applied Mathematics research. But not only that, there is not another center in Mexico with the variety of things we perform here, from rather abstract aspects of applied mathematics to concrete questions. Not one center, I believe, maintains a group of specialists so heterogeneous.

— *At the international level, is the IIMAS research competitive in its quality?*

— I think it would be worthwhile to give an explanation before answering. Your question, the way you put it, is well phrased: *competitive in quality*. What is quality in research? Quality in research means clarity in the definition of the problem; information on the development and solution of the problem worldwide, that is, access to specialized literature, with its knowledge and domain; methodologic responsibility, that is, adequate selection of techniques that have to be employed to solve the problem. All these, is what a would call quality in research. Now comes the answer. Under the terms of that quality, I would say that the personnel of IIMAS that work on problems that may be internationally compared, are, in effect, in a more or less competitive situation. Under no circumstances would I dare to say that the Institute has specialists of the highest international recognition, but certainly the fact that the results of research performed here are being published in magazines with international prestige, indicates that yes, we are in a competitive situation /9 and that the IIMAS is already being recognized as a serious research center.

— *And what are the necessary qualifications to get published by a magazine with international prestige?*

— A series of requisites, one of them is that you should be working with problems not yet solved. Last year approximately forty-five articles from the Institute were published by serious international magazines in several areas. Half of the research team is dedicated to the study of unsolved problems and the other half is trying to understand the already solved problems and trying to find applications in the local environment. For example, once, when I was explaining to a distinguished Mexican official about what the Remote Perception project consisted of, he told me:

"My friend, that has already been done by NASA," his intention was to make me aware, perhaps, of the fact that we were wasting our time, trying to solve that problem. But to me, his words were very flattering; if we have here the technical capacity to solve a problem previously solved by NASA, then we are O.K. You see, the reason is that many of these results are not in the public domain, as is the case with a great portion of the technology developed in the United States or in other advanced countries.

The second group of people, the one that is not dedicated to compete in the "major leagues", but rather to deal in problems already solved in order to develop technology here, has great importance, because it takes us out of the position we were in before. To illustrate this I would like to tell you that practically any of the different technologies that are already of common use in Mexico (such as electric energy, railroad transportation, the automobile, the airplane, and television) were developed over fifty years ago. However, even though we assume that we know how to do all those things, we cannot do them. Simply, it is not being done. That is why it is very important to cross the line between know-how and being able to do it, pass from one to the other. There lies, in part, the value of the research centers in Mexico, and it is a part of what we want to do, I don't know with how much success.

— *What has been the effect of IIMAS existence, and the fact that research in the field of applied mathematics is being carried out in Mexico? What are the implications for the future?*

— It would be extremely presumptuous for me to say that the existence of a research group such as ours has contributed changes in the country's situation. If you wish a very honest answer, I would say that it has not modified anything. Here, we are approximately 100 researchers and technicians, in what ways can we change the general aspect of our country? In no way. However,

I believe that we should look at this as a seed. What should be pointed out is the novel structure of the IIMAS, as there are almost no institutions in the world that cover fields so dissimilar. We have a department called the Mathematics and Mechanics Department, where there are around six to eight mathematicians that perform very abstract studies, occupying themselves with problems related to functional analysis, or quantum mechanics, or problems on physical mathematics. Within the same organization and building, there are numerical analysts, statisticians, computation and electronics specialists, in brief, a variety of individuals nourished from the same budget, that make decisions and many times solve problems together. In spite of its originality, in IIMAS we are only one hundred people, while in the United States, for example, there are approximately 200 to 300 centers for research in the same fields. These numbers suffice to show that it would be very risky to say that such a small group like ours is going to have an effect in a short period of time. If we preserve the structure and work rhythm that we have at present, and we worry about contributing to the formation of more and more specialists, it is possible that in twenty or twenty-five years the effect of what is being done here will be perceptible. I think that the existence of center such as this one is absolutely necessary. However, it is not, by far, sufficient. We are performing our work because we know it is very important, but it is not the most important one, and certainly, it is not the only one.

— *In reference to the preoccupation in the formation of specialists, are there postgraduate courses at IIMAS?*

— Yes, that aspect of the training preoccupies us very much. We are, I would say, desperately trying to train individuals, and we are doing it at several levels. We are continuing with the plan of attracting very young students as our associates so that they may learn at a very early age. We also participate, individually in teaching at schools such as the Faculty of Sciences

and the Faculty of Engineering. We have, likewise, designed training programs in a special way for individuals that may wish to come here for six months or one year to learn a specific technique. And, finally, we are in charge of two teaching degree programs, one in statistics and the other in computation.

— *Do you have interchange programs with other universities or research centers abroad, so as to be able to employ researchers in fields you are interested in?*

— Yes, we have very close contact with universities worldwide, particularly in the United States and Canada. The purpose is to exchange experiences in the areas where the two institutions involved are working on. Foreign specialists come here, or our personnel travels abroad to study for more or less extended periods. We are very satisfied with these relationships, because now, in effect, they are carried out in a relatively equal level. We deal in equal terms with our American, Canadian, and European friends, and there is no sign of the odious paternalism noticeable in the international relations of many of our country's institutions, where the Mexicans are the meek and the foreigners are the sages who come to teach them. For me it is a pleasure to say that in our case, we have always tried to deal on an equal basis.

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