Ninth annual software engineering workshop
by F. McGarry and L. Jordan

NASA's involvement in ever larger and more complex systems, like the space station project, supports software engineering research and the exchange of ideas in forums such as the Ninth Annual Software Engineering Workshop, according to John J. Quinn, Deputy Director of NASA Goddard Space Flight Center, during his opening remarks at the workshop, held this November at the Space Flight Center in Greenbelt, Maryland.

The workshop for reporting and discussing experiences in the measurement, utilization and evaluation of software methodologies, models, and tools is organized by the Software Engineering Laboratory whose members represent the Goddard Space Flight Center, the University of Maryland, and Computer Sciences Corporation.

Four sessions addressed the topics of current SEL research, software error studies, experiments with software development, and software tools. Twelve papers, three for each topic, were presented.

One of the major themes was the development, assessment, and verification of software measures applicable to the requirements and design phases of the software life cycle. William Agresti, Computer Sciences Corporation, described a Composite Specifications Model that composes specifications into a functional (data flow) aspect, a contextual (entity/relationship) aspect, and a dynamic (state/transition) aspect. He applied this model in a NASA project and extracted 58 objective measures of the development process that managers, analysts, developers, and customers can use.

Dennis Kafura, Virginia Polytechnic Institute, discussed an effort to define a complete and minimal set of metrics; complete in the sense that all forms of complexity are represented, and minimal in the sense that no redundant (that is, highly correlated) measures appear. He tested this set of metrics, two classes of which may be extracted at the design phase, in different applications and environments.

Dieter Rombach defined a set of design metrics, which was used in six different software projects. He conducted an experiment with nine programmers in a simulated maintenance environment who responded to seeded errors, environment changes, and requirements changes. The results showed that the behavior of a maintenance system can be predicted by examining design documents.

John Gaffney, Jr., IBM, discussed a model implemented on an IBM personal computer that estimates latent (postship) errors based on count of errors found during each stage of the software life cycle. This technique has proved effective in predicting software errors during late phases of development as well as after system delivery.

Another major point of discussion at the workshop was experimentation with and evaluation of software development methodologies. Richard Selby, University of Massachusetts, described an experiment to compare three common software testing techniques: code reading, functional testing, and structural testing. Thirty-two professional programmers from the Goddard Space Flight Center and Computer Sciences Corporation participated. The results showed that code reading is more effective in uncovering faults and less expensive than is either functional or structural testing.

Victor Basili discussed a project to develop and analyze an Ada product in terms of effort and errors. The goals were to evaluate using Ada for the development methodology, to develop a set of metrics for Ada, and to establish a baseline for future projects using Ada. Basili noted that the majority of errors found were syntax errors, which led him to conclude that a syntax-directed editor is almost a must with Ada. He also concluded that training in Ada-based methodology is not only extremely important, but also requires a much larger effort than he had originally anticipated.

Kathy Koerner, Computer Sciences Corporation, reported the results of an industry-wide survey, and an in-house evaluation, of programmer/analyst workstations to automate requirements and design activities. Several experiments conducted at Computer Sciences Corporation indicated that both the Nastec Case 2000 and the Index Technology Excelerator improved productivity in the development and control of software specification and design.

John Knight, University of Virginia, described a large scale experiment using N-version programming to produce fault tolerant software. The project showed that the failures of multiple versions of software are not independent.

In other areas of discussion, Larry Putnam, Quantitative Software Management, Inc., presented the results of empirical studies he has performed to model productivity and other development characteristics as functions of staffing profiles, and he pointed out striking differences between the work environment in the US and Japan. David Levine, Intermetrics, Inc., described the impact of automated and formalized configuration control tools in the support of disciplined development for large scale projects. One tool in particular was useful in preserving the integrity of multiple software versions. R. N. Sum, Jr., University of Illinois, described the application of a heuristic method for testing an operating system. William Farr and Oliver Smith, Naval Surface Weapons Center, described an interactive tool that has been developed in support of several well-known software reliability models for the estimation and analysis of errors.

The workshop proceedings will be available in March 1985 from the National Technological Information Service. For further information on the workshop, contact Frank McGarry, Code 552, NASA Goddard Space Flight Center, Greenbelt, MD 20771.

ICCP sets 1985 exam dates

The Institute for Certification of Computer Professionals has announced dates for their 1985 examinations.

Due to increased interest in certification, the Certificate in Data Processing and the Certificate in Computer Programming examinations are now offered twice a year. This year the dates are Saturday, May 11, 1985, and Saturday, December 7, 1985. The application deadline for the May 11 exam is April 6, and the deadline for the December 7 exam is November 8.

The 1985 fee schedule is $140 for the CDP and $105 for the CCP exams. For further instructions on how to apply for either or both of these examinations, write The Institute For Certification of Computer Professionals, 2200 East Devon Ave., Des Plaines, IL 60018.
LA PAZ, Bolivia—As a boy, Ivan Guzmán de Rojas would roam among the alpaca herds and mud huts of the high Andes with his father, at the time Bolivia's best-known painter of the Indians known as the Aymaras. “My father would tell me, this is a rich culture,” Mr. Guzmán recalled of the Aymaras. “Don't be fooled just because its appearance is poor.”

Now, 40 years later, Mr. Guzmán says he has made discoveries that support his father's claim, although in an entirely unexpected way. He has concluded that the ancient Aymara language is an ideal tool for the computer.

Mr. Guzmán, a German-educated mathematician, says that because of the unusual structure of the Aymara language, he has been able to convert it into an algebraic code. By using this code as an interface, or bridge, in the computer, he claims to have developed the beginnings of a multilanguage translation system. Several experts who have seen Mr. Guzmán's work say he may be on the verge of a breakthrough in computer linguistics.

The problem of idioms. Computer translation, a field of research in which manufacturers have already invested millions of dollars, has always been hampered by the nature of human language, which is too whimsical and filled with ambiguities and hard-to-translate idioms to be handled easily by a machine.

But Mr. Guzmán's formula, some experts say, deals with language in a mathematical way.

"Basically, I found a way to teach the computer any grammar by using the Aymara syntax," Mr. Guzmán said.

In his home, along one of the capital's steep streets, the soft-spoken, 50-year-old scientist quickly turned passionate when referring to his research into Aymara, which he calls a "hobby that now dominates my life."

"The language is beautiful," Mr. Guzmán said, holding the first known dictionary of Aymara, which was compiled by a Jesuit in the 16th century. "It is a very fine piece of logic, so compact and orderly, so well-conceived, you might think it was designed."

Aymara is related to Quechua—a language more widely spoken by Indians in South America—and is believed to be between three and five millennia old. Mr. Guzmán said Aymara uses no irregular verbs or gender but builds ideas and sentences by adding strings of suffixes to root words.

Language of 2.5 million Indians. Mr. Guzmán said he began his work with Aymara largely in an effort to generate respect for the neglected culture and dying language of 2.5 million mostly illiterate Indians in the highlands of Bolivia and Peru.

Anthropologists and computer experts, he said, at first laughed at his claim that an ancient language was a fine mathematical tool. But as he developed his translation system and outsiders began to show interest, this has taken over much of his spare time.

He works on borrowed computers, usually on weekends or late at night. Although he founded and headed the Institute for Science Research at the University of La Paz, political in-fighting forced him to resign. Since then he has supported his five children by working as a consultant in accounting systems.

Several organizations in the United States, including Wang Computers of Lowell, Mass., have invited Mr. Guzmán to the United States for demonstrations.

"Guzmán's approach is extremely original," said Miguel Brazao, head of one of Wang's research and development divisions. "It is the only program that uses mathematics to go from one language to another. It is based on the algorithmic structure of Aymara. It is small and exceptionally fast and goes much further than the translation systems I'm familiar with."

Small grant from Unesco. Canada's International Development Research Center in Ottawa has published a 150-page monograph that Mr. Guzmán wrote about his findings.

"Academically and professionally the analysis is sound," said Robert Valentin, a center official consulted by telephone. "We supported the work to look at the communication problems between Aymarí and Spanish speakers, but we have no program to support machine translation."

The United Nations Educational, Scientific and Cultural Organization has given Mr. Guzmán a small grant to continue research.

Some skepticism was expressed by professors who had not seen the Aymara method but who said that systems using a bridge language have so far had only limited success.

Daniel Everett, a visiting scholar in the linguistics department at the Massachusetts Institute of Technology and an authority on Andean languages, noted that there had been many efforts to reduce one language to a mathematical form for translation into another tongue, but with only limited success.

A specialist at the International Business Machines Corporation also questioned the value of using an intermediate language, rather than direct translation.

Aymara lacks modern words. The discovery of Aymara's unusual properties happened accidentally in 1980, Mr. Guzmán said, when he was searching for a new way to teach mathematics to Aymara children.

"I heard there were problems," he said. "We have always used foreign models in our educational system, often so alien that they become a joke." But he got into trouble, he said, because he could not figure out Aymara logic.

"So I made a truth table. Two-valued Boolean algebra did not work. I tried three-valued formulas, following the Polish scientist Jan Lukaciewicz. It worked. Then I got drawn in and studied the logical structure and the whole syntax on the computer. Once I had the algorithms formalized, I began translating."

Most of the work, he said, is still to come: the main drawback of Aymara is its lack of modern words, but its structure can easily incorporate modern ideas and vocabulary.

"That will also help the Aymaras communicate with the outside world," he said. "Right now the language is being corrupted by Spanish and eroding quickly."

After finishing the work on his translation system, Mr. Guzmán hopes to get back to his plan to use the computer to translate textbooks into Aymara and to study the Indian thought process.

"I am now convinced that there is a different logic at work," he said. "This may be one reason why American Indian peoples have such trouble communicating with the European cultures around them."

"We need to study this," he added. "It's the key to our culture. If I can use the computer to do this and to protect the language, I'm satisfied. My dream is to get the Aymaras to read in their own language and to use my computer one day to start an Aymara newspaper."

March 1985
Expenditures in calendar year 1985 for research and development in the United States are expected to reach almost $107.3 billion, according to the annual forecast of Battelle Memorial Institute. This represents an increase of $10.3 billion or 10.6 percent over the $97.0 billion that the National Science Foundation estimates was to be actually spent for R&D in 1984.

While much of the increase will be absorbed by continued inflation (estimated at 6.5 percent for R&D in 1985), Battelle forecasts a real increase in R&D expenditures of 3.9 percent. This is slightly lower than the ten-year average rate of 4.2 percent in real R&D effort that has been experienced since 1974.

Funding. Industrial funding for R&D, projected to increase more significantly than government support, will account for 51.3 percent of the total R&D funding. Industrial support is forecast to be $55.0 billion, up 11.4 percent from 1984. Battelle also sees an increase of 10.0 percent in federal support for R&D, for an expected total of $48.7 billion. This is 45.4 percent of the total R&D expenditures for 1985. Funding by academic institutions in 1985 is expected to be $2.28 billion or 2.1 percent of the total, and other nonprofit organizations will provide slightly more than $1.3 billion or 1.2 percent.

The report notes that during the past decade real industrial support of R&D has increased at an average compounded rate of 5.4 percent per year, while federal support has increased at 3.0 percent on average. The trend toward increased industrial support has evolved in recent years, since until 1979 government supported more R&D than did industry.

Performance. Industry will remain the dominant performer of R&D, according to the Battelle report. In 1985, performance of R&D by industry is expected to rise to almost $80 billion, or 74.5 percent of all research performed. This compares with 11.9 billion (11.1 percent) for the federal government, $12.5 billion (11.6 percent) for academic institutions, and almost $3 billion (2.8 percent) for other nonprofit organizations.

The forecast notes that federal funding supports research performance in all four sectors. Currently, about one fourth goes to support R&D conducted by the government itself; slightly more than half goes to industry; approximately one fifth goes to colleges and universities; and the rest, about one twenty-fifth, goes to other nonprofit organizations.

Industry absorbs almost all of its own funds, either performing the R&D itself or contracting with other industrial performers. Its contracts and grants to nonprofit organizations are slightly less than those to colleges and universities. The nonprofit organizations finance both themselves and academic institutions about equally, and colleges and universities use up all the funds they originate.

Government. Four government agencies dominate the federal R&D scene and are expected to account for 91.1 percent of total federal R&D funding in 1985, compared to 90.9 percent of funding in 1984. The make-up of this funding, however, will change significantly in 1985. Table 1 shows comparisons between the 1985 and 1984 among the key agencies. The forecast notes that increases in defense spending primarily are directed toward the acquisition of major weapons systems and the R&D that will necessarily support them.

The space shuttle program has become almost fully operational, with the result that NASA R&D support is expected to undergo a shift to other NASA objectives. Specifically, a major new thrust will be directed to a working space station. Total NASA R&D budget, while representing a smaller share of total federal support, will continue to grow slightly.

The report says that energy funds will decline for research on alternative energy sources, but not for energy programs in direct support of national defense. Stabilization of prices has reduced the apparent short-term urgency for R&D in support of new sources, although selected conservation programs will continue to be funded. Energy projects involving short-term or low-risk R&D likely will be financed by industry.

The report also anticipates that R&D dollars will continue to support the biological sciences areas. However, continuing de-emphasis will be found on research in the "soft" sciences, including those areas which support the environmental, ecological, and socioeconomic impact investigations presently mandated by law.

Table 1. Estimated percentage of federal R&D funds.

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<th>1984</th>
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<td>Department of Defense</td>
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Industry. Industrial support of research is growing in fields related to electronics, communications, advanced machinery, and in those fields most directly influenced by the need for more energy-efficient products and processes. R&D will be heavily self-funded in the manufacturing industries, where, on the average, less than 32 percent of the total will be supported by the federal government. The nonmanufacturing industries do relatively little R&D, yet 40 percent of the support for this activity will be provided by the federal government.

As part of the forecast, Battelle estimated the industrial versus federal support for R&D performed by several broad industrial sectors. In 1985, Battelle expects the aerospace industry to retain leadership in total R&D, with funding of approximately $20 billion. Of that, 75 percent will be funded by the federal government.

The electrical machinery and communications industries are forecast to have the second largest total R&D support with almost $17 billion. Of that, two thirds will be industrially funded.

The forecast links much of the significant increases in industrial support to three factors. First, the general economic climate has continued to improve and industry is responding to new opportunities foreseen in both the short- and long-term. "As greater emphasis is being placed on industrial productivity, revitalization, the growth of the 'information society,' and the expansion of the consumer and industrial markets, it is anticipated that sales and profits—both early indicators of R&D fund availability—will be increasing in the near term," the report concludes. "However, recent slow-downs may suggest that the rate of growth in R&D may decrease over the next two years."

Second, there has been a relaxation of selected real and perceived barriers to cooperative research programs, resulting in the creation of multi-company-supported R&D programs at universities and nonprofit organizations, as well as dedicated research centers supported by groups of companies. Finally, there are early indications that new forms of venture capital financing and other initiatives may be having an influence on total R&D spending.

Costs. The forecast also compares the four performing sectors in terms of their relative costs of R&D. The cost increases are associated with general inflation but, to a larger extent, also result from increasing sophistication and complexity of research.

During 1985, the overall cost increase for all R&D is estimated to be 6.5 per-
percent. By sectors, the increases will be distributed among government, 9.7 percent; industry, 6.0 percent; colleges and universities, 7.7 percent; and other nonprofit organizations, 41 percent.

From 1972-1985, costs of all R&D, as an average, are estimated to have risen by 142.6 percent. Increases in the individual performing sectors—over this same time period—are expected as follows: federal government, 148.9 percent; industry, 137.2 percent; colleges and universities, 174.3 percent; and other nonprofit organizations, 147.2 percent.

**Long-term outlook.** As part of the forecast, Battelle also examined R&D trends during the past and identified what impact they may have on the future. The report concludes that over the past few years, federal support tended to shift toward more "development" and less basic and applied "research." However, within the category of basic and applied research, there is a small—but perhaps significant—trend toward increasing the basic research component. In addition, industrial support of basic research is expected to increase, largely through cooperative programs between universities and consortia of industries.

Further information on the Battelle Memorial Institute's 1985 research and development forecast is available by writing Battelle Columbus Laboratories, 505 King Avenue, Columbus, OH 43201.

**Taiwan gears up software export capacity**

Can Taiwan develop into a major supplier of software to the world market? In the past, reports the January issue of *Asia On-Line* magazine, Taiwan's infant software industry consisted only of undercapitalized, struggling software houses that more often than not were devoured in the cutthroat domestic market. But skilled engineers and systems analysts with American education and work experience are now putting their management and technical knowledge to work in the industry to take advantage of growing world demand for software products.

While Taiwan's software exports are still relatively small—an estimated $4-$5 million in 1984—industry analysts say the sector is following the pattern of the island's hardware manufacturers, and exports are set to take off in this decade. Software exports, according to a recent government study, will reach $350 million by the end of the decade.

**DPMA grants awards to business, education**

The Data Processing Management Association and its Education Foundation have announced that applications are available for its International Awards, aimed at honoring computer science students, educational institutions and businesses.

DPMA, the world's largest organization representing computer management professionals, established this collaborative annual awards program with its education foundation in 1984. Their aim is to recognize the outstanding efforts of students, the educational institutions, and the organizations representing business and industry that have made significant contributions to the data processing education process.

Three categories of awards within the 1985 DPMA and DPMA Education Foundation International Awards Program include:

- **Business and Industry.** Recognition awards are made to those business organizations that exemplify excellence in continuing development of information systems professionals.

**Softcon panels to discuss ways to survive shakeout**

Surviving the shakeout in the computer industry still concerns software professionals, according to the advance program schedule for Softcon 1985, which will be held at the Georgia World Congress Center in Atlanta, Georgia, March 31 to April 3.

One panel discussion, entitled, "The Software Publisher's Shakeout Survival Guide," suggests that "software publishers who ignore the challenges being presented in the software marketplace are likely to face the total and unrecoverable collapse of their businesses." Market strategies, management strategies, and cash strategies to survive the shakeout will be explored.

Essentially the same discussion will be offered software merchandisers: "Survival Strategies for Software Merchandisers (or, How to Avoid Being a Victim in the Shakeout)." In addition, a panel discussion on "The Outlook for Software Merchandising in the '80s" asks, "How many major contenders will be in the race?"

Perhaps not coincidentally, the spring and fall Softcons of previous years have been merged into this year's single conference. "Given the huge oversaturation of computer shows today, we felt it was in the best interest of Softcon to focus on a single, annual spring event, rather than diffuse it across multiple shows," explained Bill Mahan, spokesman for Northeast Expositions. "If we can produce a strong attendance in Atlanta, the show will become firmly entrenched as the premiere spring event in the computer industry, with Comdex/Fall being the major fall event."


Other panel topics looking to the future include "Telecommunications Today and Tomorrow," "Expert Systems and Artificial Intelligence: Wave of the Future or Empty Promise?" and "The Future of Business Graphics on Microcomputers."

Three separate conferences will run simultaneously throughout the show, each designed for distinct audiences: distributors and merchandisers; corporate and institutional buyers; and software publishers and developers.

Further information about the conference is available from Northeast Expositions, 822 Boylston Street, Chestnut Hill, MA 02167; 617/739-2000.