

he told the commission. "I kind of thought I was one of the top people working on the program, and I didn't know about that until August of '85." Roger Boisjoly, the firm's senior seal engineer, was unaware on the eve of the launch that water had gotten into rocket joints in the past, and neither he nor anyone else considered the possibility that the seals had been broken by ice.

The agency's standard procedure, according to NASA officials, was to try to resolve most disputes at lower levels and pass only the results along to senior officials, not the flavor of the debate. Stanley Reinartz, a senior official at Marshall, testified that he decided not to tell his superiors about Thiokol's anxieties early on because he "felt it was necessary to get a full understanding of the situation" and later, because the concern "was worked and dispositioned with full agreement among all responsible parties" at his level. "That is the normal course of our operating mode within the center," he said, adding that, in retrospect, this may have been a mistake.

Richard Truly, the new shuttle program director, has promised that "we will not launch again until safety-related issues have been properly addressed throughout the total NASA system." But this will require a lot of money and a measure of patience that Congress and the shuttle's clients may be unwilling to provide. According to the memo from astronaut corps director John Young, not only the boosters but also the external tank, the fuel cells, the landing gear, various engine valves, the auxiliary power units, the computer software, and some satellite motors may need modification to eliminate safety hazards. New weather-related launch criteria will have to be drawn up.

"Flight safety . . . has to have real teeth in it," Young says. "It will not be free." Graham recently put the cost of repairs at \$350 million, and the cost of a replacement shuttle at \$2.8 billion. Meanwhile, the agency has decided to assist in the development of new expendable rockets, which will ultimately weaken further the shuttle's already shaky economic base.

Many of the agency's traditional supporters believe that if the program is to be maintained at a reasonable level, it should no longer be a slave to cost-accounting standards. With increasing urgency, they argue that the shuttle, as a high-risk technological venture of considerable symbolic importance, should be freed, once and for all, from the illusion that it makes economic sense, as well from the accompanying economic and schedule constraints. Though the argument has a peculiar logic to it, in the year of Gramm-Rudman it might not get very far. ■ **R. JEFFREY SMITH**

NAE Elects New Members

The National Academy of Engineering has elected 73 new members and six foreign associates. This brings the total U.S. membership to 1289 and the foreign associates total to 113. The new members are as follows:

William F. Allen, Jr., Stone & Webster Engineering Corp.; **David Atlas**, University of Maryland, College Park; **James E. Bailey**, California Institute of Technology; **David P. Billington**, Princeton University; **Harvey K. Bowen**, Massachusetts Institute of Technology; **Walter L. Brown**, AT&T Bell Laboratories, Murray Hill; **John F. Cashen**, Northrop Advanced Systems Division, Pico Rivera, CA; **Robert P. Clagett**, AT&T Technologies, Inc., Princeton; **Richard R. Conway**, Union Carbide Corp.; **Robert H. Curtin**, De Leuw Cather/Parsons, Washington, DC.

Morton M. Denn, University of California, Berkeley; **Lester F. Eastman**, Cornell University; **Edward A. Feigenbaum**, Stanford University; **John W. Fisher**, Lehigh University; **John A. Focht, Jr.**, McClelland Engineers, Inc., Houston; **John K. Galt**, Sandia National Laboratories; **L. M. Holm**, Union Oil Co. of California, Brea; **Lee A. Iacocca**, Chrysler Corp.; **James D. Idol, Jr.**, Ashland Chemical Co., Columbus; **Anthony J. Iorillo**, Hughes Aircraft Co., El Segundo.

Robert B. Jansen, Spokane, WA; **Edward G. Jefferson**, E. I. du Pont de Nemours and Co.; **Thomas V. Jones**, Northrop Corp., Los Angeles; **Angel G. Jordan**, Carnegie-Mellon University; **Albert S. Kobayashi**, University of Washington, Seattle; **Joseph T. Kummer**, Ford Motor Co.; **Kaye D. Lathrop**, Stanford University; **Yuen-Tze Lo**, University of Illinois, Urbana; **Arthur Lubinski**, consultant, Tulsa, OK; **Chiang C. Mei**, Massachusetts Institute of Technology.

Harold Mirels, Aerospace Corp., Los Angeles; **Joseph B. Moore**, United Technologies Corp., West Palm Beach; **Richard M. Morrow**, Amoco Corp., Chicago; **Joel Moses**, Massachusetts Institute of Technology; **Toshio Mura**, Northwestern University; **Gerald Nadler**, University of Southern California, Los Angeles; **George L. Nemhauser**, Georgia Institute of Technology; **Jack N. Nielsen**, NASA Ames Research Center, Moffett Field, CA; **William G. Oldham**, University of California, Berkeley; **Morton B. Panish**, AT&T Bell Laboratories, Murray Hill.

Jacques I. Pankove, RCA Laboratories, Princeton; **Robert H. Park**, Fast Load Control, Inc., Freeport, IL; **John R. Paulling**, University of California,

Berkeley; **Emil Pfender**, University of Minnesota, Minneapolis; **Robert Plonsey**, Duke University; **John W. Poduska, Sr.**, Apollo Computer Inc., Chelmsford, MA; **Michael Prats**, Shell Development Co., Houston; **Ronald W. Pulling**, Tippetts-Abbett-McCarthy-Stratton, Washington, DC; **Rowland W. Redington**, General Electric Research and Development Center, Schenectady; **Jerome G. Rivard**, Ford Motor Co.; **Chih-Tang Sah**, University of Illinois, Urbana.

Eugene C. Sakshaug, consulting engineer, Lanesboro, MA; **George A. Samara**, Sandia National Laboratories; **Charles D. Scott**, Oak Ridge National Laboratory; **Herbert J. Shaw**, Stanford University; **William H. Silcox**, Standard Oil Co. of California; **Merrill I. Skolnik**, Naval Research Laboratory, Washington, DC; **Ernest T. Smerdon**, University of Texas, Austin; **Ephraim M. Sparrow**, University of Minnesota, Minneapolis; **Dale F. Stein**, Michigan Technological University, Houghton; **Kenneth N. Stevens**, Massachusetts Institute of Technology; **Chung L. Tang**, Cornell University.

Gerald F. Tape, consultant, Bethesda, MD; **Paul E. Torgersen**, Virginia Polytechnic Institute and State University, Blacksburg; **Alexander R. Troiano**, Case Western Reserve University; **Arthur F. Veinott, Jr.**, Stanford University; **Daniel I. C. Wang**, Massachusetts Institute of Technology; **Max T. Weiss**, Aerospace Corp., Los Angeles; **Harold A. Wheeler**, Hazeltine Corp., Greenlawn, NY; **Eugene C. Whitney**, consultant, Pittsburgh, PA; **Sam B. Williams**, Williams International Corp., Walled Lake, MI; **John J. Wise**, Mobil Research and Development Corp., Paulsboro, NJ; **Alden P. Yates**, Bechtel Group, Inc., San Francisco.

The new foreign associates are:

John Argyris, Institute of Astronautical Structures, University of Stuttgart, Federal Republic of Germany; **Donald A. Chisholm**, Northern Telecom Ltd., Mississauga, Ontario, Canada; **Arthur C. Clarke**, University of Moratuwa, Colombo, Sri Lanka; **Bacharuddin J. Habibie**, minister of state for research and technology, Republic of Indonesia, Jakarta; **Anthony Kelly**, University of Surrey, Guildford, Surrey, U.K.; **Yasua Mori**, University of Electro-Communications, Chofugaoka, Chofu City, Tokyo, Japan.