AVIATION WEEK & SPACE TECHNOLOGY

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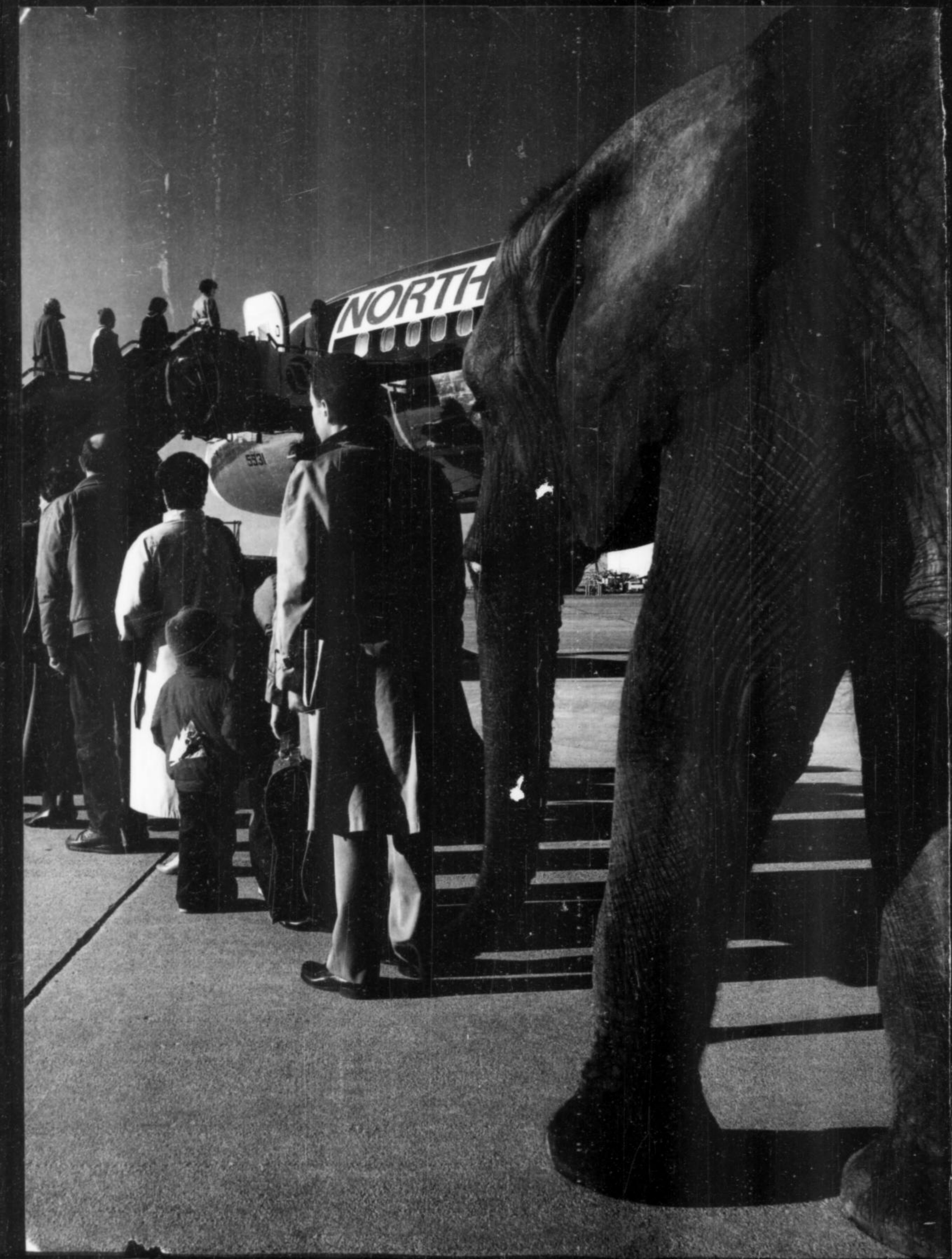
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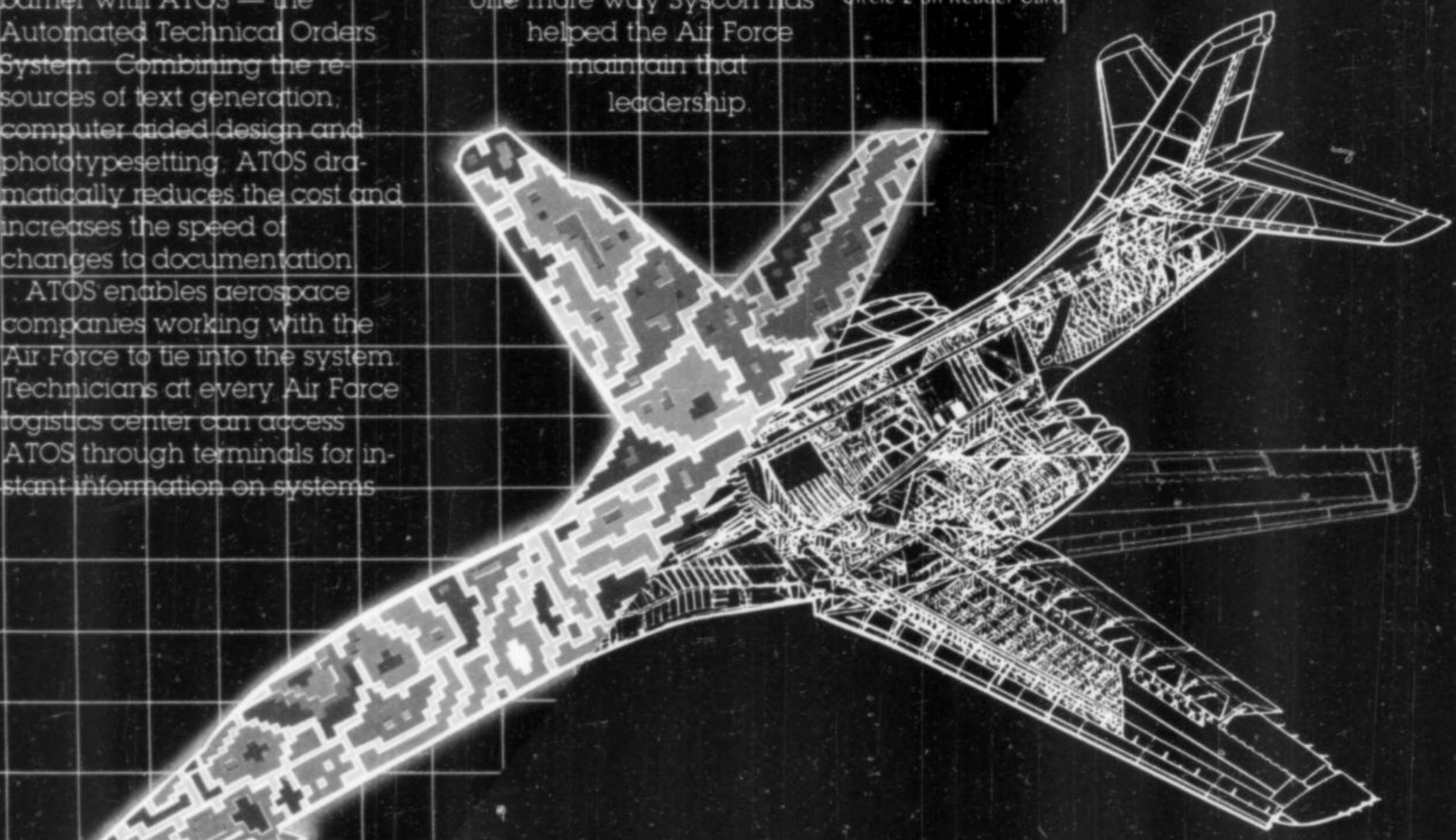

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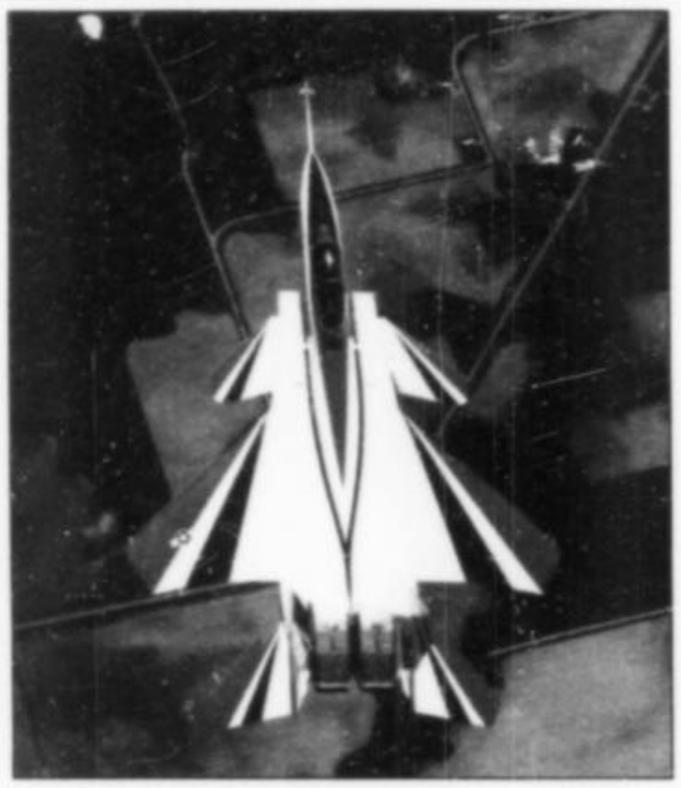

The Air Force/McDonnell Douglas STOL/ Maneuver Technology Demonstrator, equipped with Pratt & Whitney two-dimensional, thrust-vectoring/thrust-reversing exhaust nozzles, is shown during its first flight on May 10. The aircraft is powered by two Pratt & Whitney F100-PW-220 engines. McDonnell Douglas photo by John York.

STOL/MANEUVER TECHNOLOGY DEMONSTRATOR FLIGHT TEST

AGING AIRCRAFT

HEADLINE NEWS

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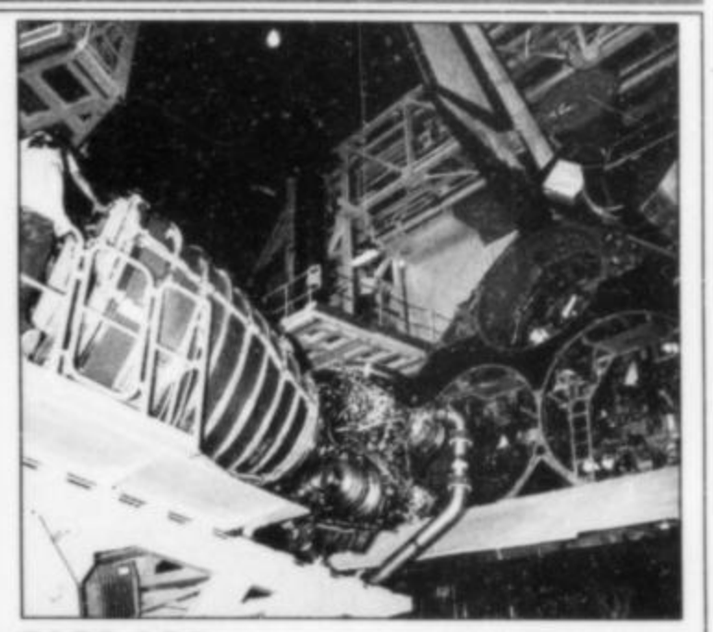

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WHO'S WHERE

Benjamin A. Cosgrove has been designated senior vice president of Boeing Commercial Airplanes.

General Dynamics' Space Systems Div. has appointed **Thomas H. Merrill** director of estimating, **G. E. Johnston** director of division planning and **Michael C. Gass** director of facility services.

Donald G. Gies, Jr., has been promoted to vice president of finance and administration for Dornier Aviation (North America), Inc.

Donald J. Welde has been designated president and chief executive officer of Wilcox Electric, Inc., a Kansas City, Mo.-based subsidiary of Thomson-CSF.

Lockheed Aeronautical Systems Co. has named **James D. Summers** vice president for Washington operations, **E. Lloyd Graham** executive vice president and general manager for programs, and **Tom Burbage** vice president for new business development.

James Goings has been designated vice president of manufacturing for Rohr Industries, Inc., effective June 5. He succeeds **John R. Johnson,** who was promoted to vice president of planning. **Nicholas A. Bucur** has been named vice president of customer support. Succeeding him as vice president of commercial business is **Keith Gentry**. Gentry is replaced as vice president and general manager of Rohr Riverside by **David R. Watson**. **David L. Canedo** has been named vice president of quality assurance.

Michael M. McMillan has been appointed vice president, international operations, for E-Systems, Inc.

James S. Logan, chief of aerospace medicine at NASA headquarters' Life Sciences Div., will join the International Space University, Boston, Mass., as provost, effective June 5.

David Forman and **Alfred Schneider** have joined Weber Aircraft, Inc.'s Special Products Div. as director of engineering and programs director, respectively.

Irving L. Ashkenas has been promoted to senior vice president for Systems Technology, Inc., Hawthorne, Calif. **Donald E. Johnston** and **R. Wade Allen** have been named vice presidents of the firm.

Barbara L. Beyer has been named president and chief executive of Avmark, Inc., a Washington, D. C.-based aviation consulting firm. **John A. Casey** has been designated as vice president-operations.

Stephen A. Gerard has joined Precision Gear, Inc., as vice president of marketing.

Robert E. Hess has been designated vice president of tactical electronic warfare systems at Litton's Amecom Div., replacing **Marc Smirlock**. Succeeding Hess as head of product assurance at the Amecom Div. is **Stephen A. Presti**.

Claude Castonguay and **Harry Steele** have been appointed to the board of Canadian Airlines International, Ltd. Castonquay is chairman of the board and chief executive officer of the Laurentian Group Corp. and Steele is president and chief executive officer of the Newfoundland Capital Corp., Ltd.

Cdr. Robert C. Stephens has relieved

Cdr. John T. Morris as commanding officer of Strike Fighter Sqdn. 132, based at NAS Cecil Field, Fla. **Cdr. John L. Fleming** will serve as the unit's new executive officer.

James A. Robertson, vice president, government relations for Morton Thiokol, plans to retire from the firm.

Tom Olswang has been appointed national sales manager for Narco Avionics, Laguna Beach, Calif.

Michael L. Holtzapple has joined Flight International Group, Inc., as chief financial officer.

Harry B. Traylor has been named president of Unisys Corp.'s Federal Information Systems Div.

Jeffrey L. McKnight has joined Aeronautical Radio, Inc., Annapolis, Md., as chief marketing executive.

Peter Murphy, former chief negotiator for the U. S.-Canada Free Trade Agreement, has been named vice president for international affairs for Cassidy and Associates, a Washington, D. C.-based public affairs firm.

Eugene E. Yore has been promoted to vice president and general manager of Honeywell's Marine Systems Div.

Leonard M. Wasserman has been designated president of Suisman Titanium Corp., Hartford, Conn.

HONORS AND ELECTIONS

K. J. Orlik-Rueckemann has been awarded the AGARD von Karman Medal for 1989 for his contributions to aerospace science and to scientific cooperation among NATO nations. He is the head of the Unsteady Aerodynamics Laboratory of the National Aeronautical Establishment in Ottawa, Canada.

Edward G. Linhart, president and chief operating officer of Precision Aerotech, Inc., has been elected a fellow of the Society of Manufacturing Engineers in recognition of technical and management innovations in the aircraft industry.

The American Helicopter Society (AHS) has named **Joseph Mallen,** retired president of Boeing Helicopters, as the 1989 recipient of the Dr. Alexander Klemin Award in recognition of his technical and administrative achievements. The society designated Sikorsky Aircraft's **Shadow Team** to receive the Grover E. Bell Award and the **NASA/AHS National Rotorcraft Noise Reduction Program** to win the Howard Hughes Award.

Calvin H. Cobb, Jr., has been elected national president of the Navy League of the United States.

The Industrial Fasteners Institute, Cleveland, Ohio, has designated **Harry J. Wilkinson,** president and chief operating officer of SPS Technologies, as chairman of the institute's board of directors. **George F. Wasmer,** president and chief operating officer of Lake Erie Screw Corp., will serve as vice chairman. □

TILTROTOR TECHNOLOGY.

On March 19, 1989 Bell Boeing made aviation history. The revolutionary V-22 – the aircraft that takes off and lands vertically as well as flies across the sky at 350 miles per hour – flew for the first time. And it flew flawlessly. Subsequent flights not only demonstrated how well the V-22 met initial test objectives but that tiltrotor technology is here to stay. We look to the future with great confidence that the V-22 will meet the next milestone . . . conversion to horizontal flight. Tiltrotor Technology. Its time has come.

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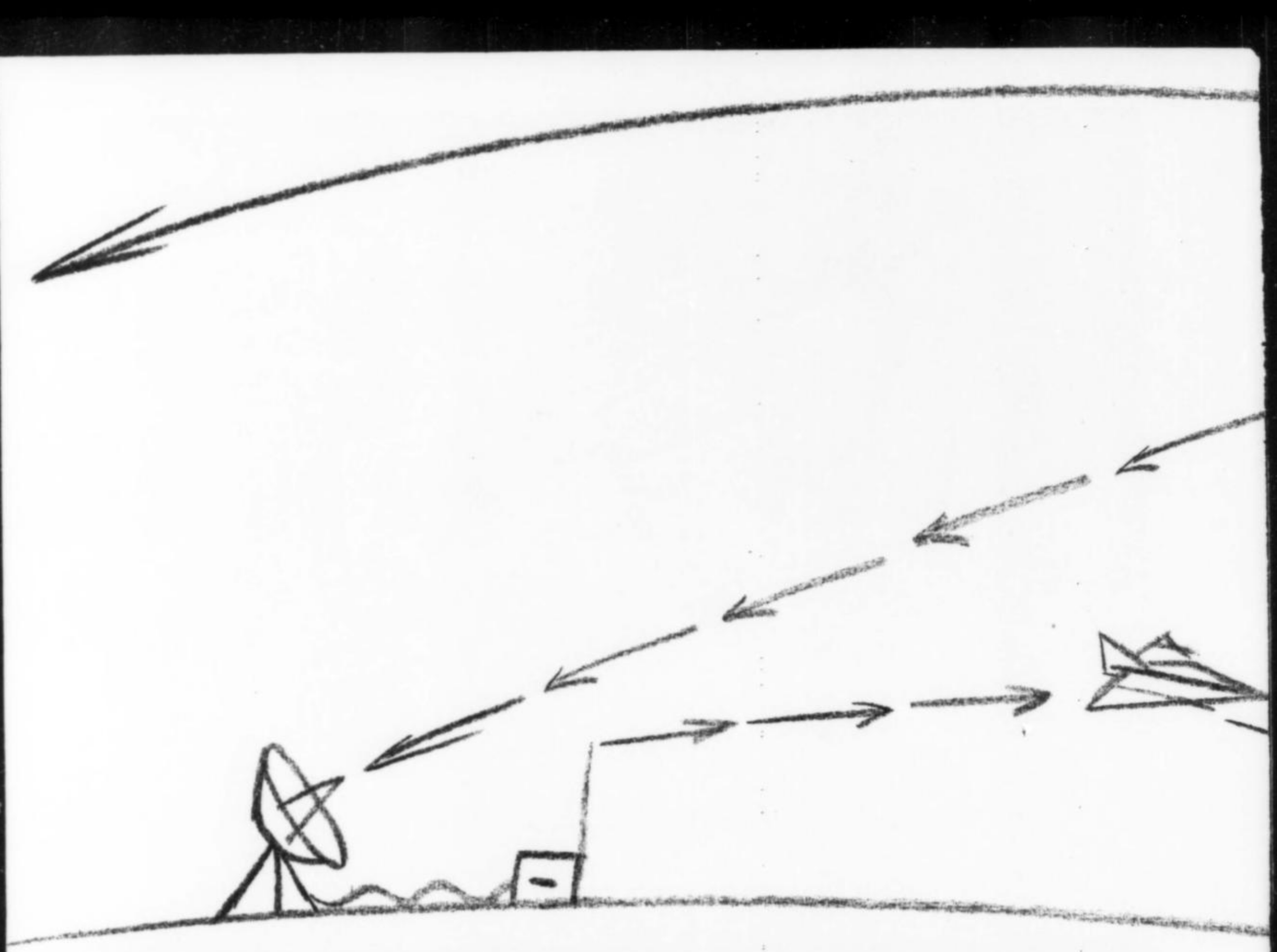
The V-22 Tiltrotor Team

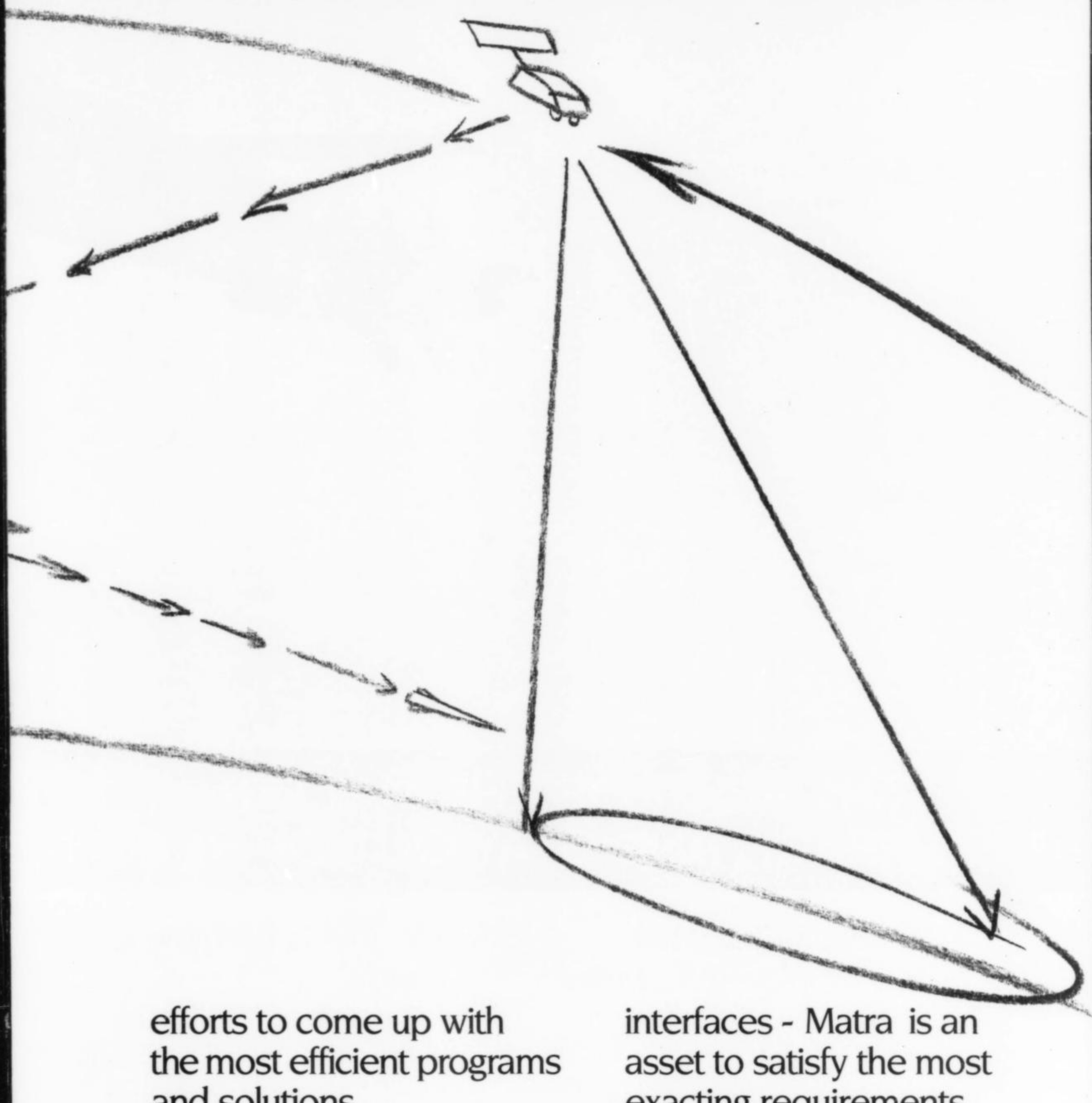
A JOINT SERVICE PROGRAM



THE ROOT OF THE MATTER IS UNPERCEIVED BY THE NAKED EYE

Anticipation, real-time knowledge in order to decide, undelayed optimization of strategic or tactical choices, safeguarding whatever is irreplaceable - such are the great challenges to be taken up by modern forces. As a consequence system capacity is nowadays a winning card for Nations concerned about their safety.

You will find Matra at each step of operational or functional sequences, bending its



efforts to come up with the most efficient programs and solutions.

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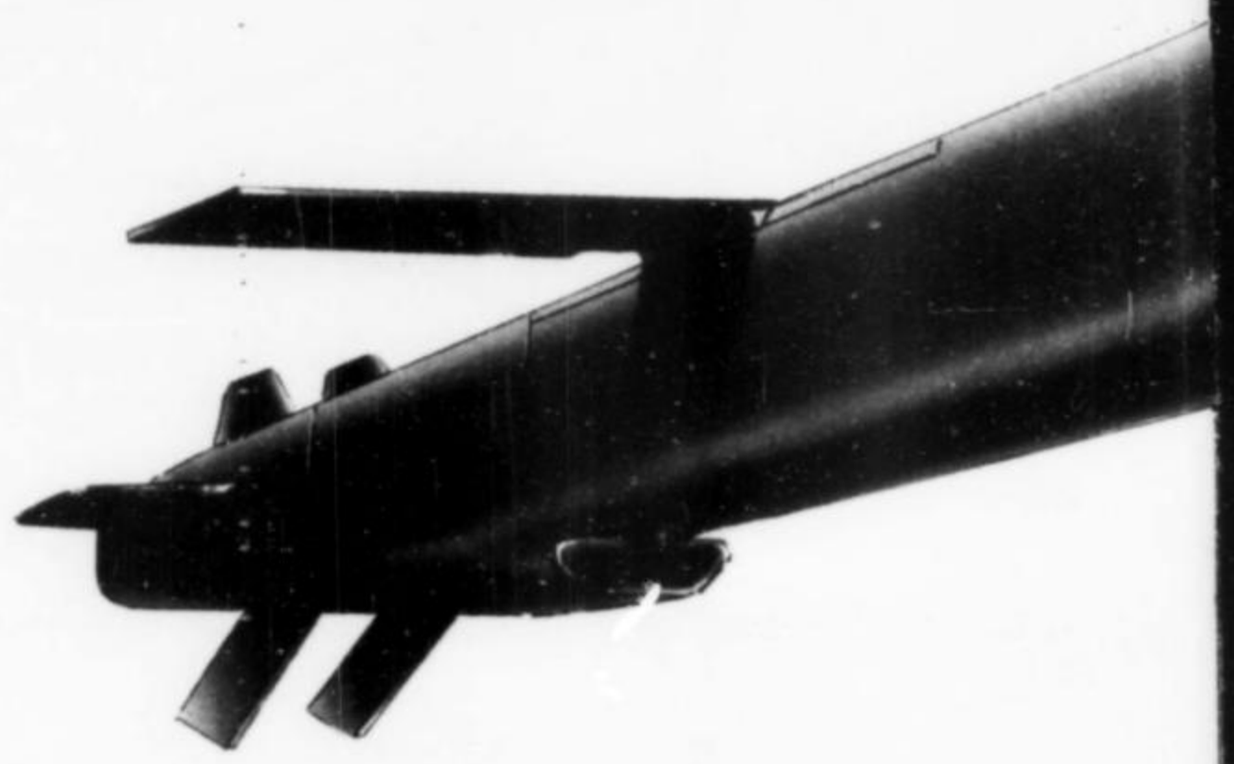

THE ROOT OF THE MATTER IS TO REACH AND STAY OUT OF REACH

Safeguarding whatever is irreplaceable while providing for the safety of pilots and platforms, maintaining efficiency and accuracy in neutralizing the various types of targets has turned into a vital stake.

Apache, first tactical cruising missile in the world, meets both these concerns.

Apache, intelligent and stealthy missile affords self-mid course updating, and covers up to 150 km at very-low altitude. Target search, identification and release of multiple warhead are performed with utmost accuracy.

Apache, adaptable to all current and future generation of combat fighters, a modular system, carries in its payload section such munitions as are best adapted to its assignments (anti-runway, anti-tank, area interdiction).

Developed under Matra's overall control with Aerospatiale as main partner, the Apache range will be available in 1994.

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Launched from an aircraft, Pegasus will employ Hercules solid rocket motors to place in orbit scientific and commercial payloads that weigh up to half a ton. Payload capacity is enhanced by our lightweight composites that make up the vehicle's motor cases, delta wing, fins and payload fairing.

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Our solid propulsion systems are also mainstays of America's tactical and strategic missiles. Hercules powders and propellants are used extensively in a wide range of ordnance. And we lead the nation in the production and use of graphite fiber.

Today, over 75,000 commercial and military aircraft rely on our Simmonds® electronic subsystems for fuel measurement, engine ignition, flight control or instrument display. And Hercules defense electronics range from ECM jammers and MMW seekers to integrated support systems and automated test equipment.

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EDITORIALS

The Sovereign Share

Who is the real target of the terrorist attacks around the world? In most cases, it is not the individual airline nor the passengers under assault. Nor the ships, nor the meeting places. They are pawns in the war of international terrorism, surrogates for the real targets—sovereign governments and their policies.

It is for this reason, primarily, that governments should begin to take a larger share of the security bill. The cost in the U. S. already is excessive. Eight U. S. airlines are paying a total of $500 million a year for security while the Aviation Trust Fund sits with a $7-billion surplus. Security costs are assured of continued growth as expensive new technologies mandated by the U. S. government come on board.

The cost of security around the world is virtually impossible to count. Some nations have assumed more responsibility for security than others, making for a patchwork of programs. Security funds in one country may be located in military or police budgets. In the U. S. and Canada, the airlines are required by government regulations to screen passengers. This has been the case for nearly 20 years, since skyjacking to Cuba was the fashion.

Skyjacking had its own set of dangers, but it is tame when compared with the bloody assaults of today's international terrorism. New tools are needed. Annex 17 of the International Civil Aviation Organization, which sets the world standards for security, is adequate. Implementation is what it needs. It is a shame that the advice of the world airline industry group, the International Air Transport Assn., has not been heeded; however. IATA has called for an international response to terrorism with an advisory body, a team of experts, a police force, a separate court and a detention center. The idea is to take the onus off individual nations victimized by terrorism.

There is a morbid joke told among those close to these issues. "The good news is, the terrorist attack is over. The bad news is, we've got the terrorists." The implication is clear. One terrorist incident breeds another.

Governments have shied away from the recommended militant international response thus far, but it is worth reconsidering. Governments do work together in providing intelligence frequently to one another, an important tool in this battle. But they do not work well enough or closely enough with airlines. Intelligence has been slow to circulate, and even worse, it is not well graded as to its importance.

Providing improved intelligence quicker to airlines is another expense, but it must be borne. Too frequently in the U. S. the government has acted to protect government personnel—making embassies more secure, to say nothing of exclusive distribution of intelligence on threats to aviation. In the U. S., the general fund would be appropriate to finance additional measures. If this is not possible, the Aviation Trust Fund, now with a $7-billion surplus, ought to be tapped.

Survival of the Fittest

Final preparations are under way at Cape Canaveral for the first commercial launch by a large U. S. booster manufacturer. McDonnell Douglas is preparing for the launch in early June of the first commercial Delta, carrying an Indian Insat satellite. The mission will mark a remarkable comeback from the near-extinction expendable launch vehicles faced in the late 1970s, when the U. S. government directed their phaseout.

Following the Challenger accident in 1986, U. S. booster companies decided to embark on risky plans to enter the commercial market. The firms met with difficult obstacles in lessening their dependence on government contracts. But they worked closely with Congress and the Reagan Administration to create the right environment for private launch operations. Today the payoff is close at hand.

The executive branch should share in the credit for helping the booster industry reach this point. And Congress led in providing insurance legislation and establishing rules for commercial use of federal facilities.

But the commercial booster industry is far from a state of permanent security. Foreign competition, an oversupply of launch vehicles and the potential for more policy changes threaten to make the success short-lived. Bush Administration space officials, many of whom are woefully inexperienced in this business, must look beyond this symbolic start and examine the industry's health on a deeper level. The new Administration should be alert to the threats. If it is not, the U. S. probably will see its young commercial rocket industry fade away.

What is left for government to do for the industry? First, it should guarantee that policies remain stable. Second, the agreement with China restricting marketing of the Long March must be monitored closely for compliance. Industry is depending on the government to negotiate fair, enforceable trade agreements with China and Europe. Eventually, such negotiations may be needed with the Soviet Union. The possibility that the Soviets will break into the market with highly subsidized prices continues to haunt the U. S. industry. But Soviet marketing efforts have been naive and unsuccessful.

The government also must endeavor to make its purchase of launch services more like a straight commercial deal. With good cause, industry managers complain that government procurements require volumes of needless paperwork, substantially raising costs. The launch industry also must work harder at becoming truly commercial and weaning itself from overreliance on government. But cooperation among industry, Congress and the executive branch has been good. It should serve as a model for other endeavors in which industry needs extensive government support.

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MARKET FOCUS

NICHOLAS C. KERNSTOCK/NEW YORK

COMMENTARY

Airline stocks have performed well in 1989, climbing about 35% since January as the result of good fundamentals and acquisition speculation. The flood of new aircraft orders, some stretching out as far as seven years, suggests the high degree of confidence in continued strong operating results on the part of airline management and their bankers. Some analysts, however, believe the airline group's share prices fail to reflect several developing problems in the industry. Mark E. Daugherty, airline analyst at Dean Witter Reynolds, Inc., advises selling airline stocks. According to Daugherty, the likelihood of an economic slowdown, developing overcapacity, a peak in fare prices and the financial burden of buying or leasing new aircraft "collectively pose considerable risk for airline stocks." Although some airlines may continue to appreciate, prices for the group may have peaked.

■ **Honeywell, Inc.,** has sold its Tampa-based defense communications and production division to Group Financial Partners, Inc., a Louisville, Ky., holding company. The division specializes in the high-volume production of tactical military communications and information security products. Terms of the sale were not disclosed.

■ **Litton Industries, Inc.,** net income for the third quarter ended Apr. 30 rose to $44.66 million or $1.79 per share from $42.04 million or $1.60 for the year-earlier period. Sales were up to $1.27 billion from $1.20 billion. Litton said its advanced electronics division's third-quarter operating profit declined to $46.26 million on revenue of $544.13 million from $47.70 million on revenue of $603.96 million in 1988.

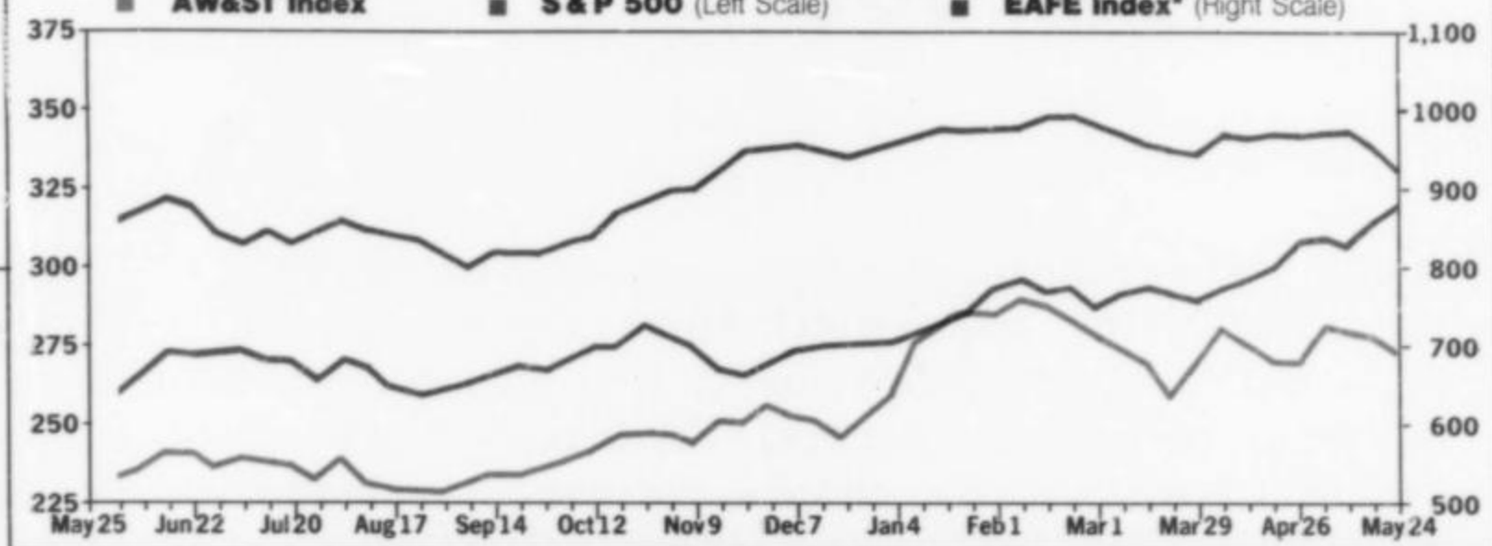
■ **GenCorp's Aerojet** division plans to purchase General Applied Science Laboratories, Inc. (GASL) of Ronkonkoma, N. Y. GASL is a propulsion systems development and test facility and supplies scramjet and ramjet wind tunnel models. The acquisition is intended to reinforce GenCorp's hypersonic research and development effort.

■ **Banner Industries, Inc.,** board of directors approved a 2-for-1 stock split of its Class A and Class B common shares in the form of a 100% stock dividend to shareholders of record June 15. About 3.98 million shares of Class A and 2.67 million shares of Class B stock are affected. Banner agreed to acquire **Fairchild Industries, Inc.,** for $400 million earlier in May.

■ **Air New Zealand** stock will be sold to institutional and private investors and the airline's employees, according to Brierley Investments, Ltd. Brierley purchased 65% of the airline's stock from the New Zealand government in March on the condition that 30%, or 84 million shares, would be placed publicly. **Qantas Airways, Japan Air Lines** and **American Airlines** own the remaining 35% of Air New Zealand shares. □

Data: Data Resources; Standard & Poor's Corp.
** Morgan Stanley Capital International Index for Europe, Australia and the Far East (EAFE)*
All prices listed in U. S. dollars.

WEEKLY MARKET PERFORMANCE June 1, 1988 through May 24, 1989



	AW&ST Index	S&P 500	EAFE* Index
Current Week	273.89	319.73	923.72
Previous Week	278.91	313.94	952.06
Net Change	-5.03	5.79	-28.34
Percent Change	-1.80%	1.84%	-2.98%

Gainers/Losers	Current Week	Net Change	Percent Change
Saab-Scania AB	38¼	1¼	6.20
Pan Am Corp.	4¾	¼	5.56
Ferranti International	1⅝	-⅛	-5.56

Stock Symbol	Company Name	Exch.	Current Week	Previous Week	Net Change	Percent Change	52 Week High	52 Week Low
AEROSPACE								
ALD	**Allied-Signal, Inc.**	NYSE	$ 34⅜	$ 33⅞	$ ½	1.5%	$ 36⅞	$ 31⅜
BA	**The Boeing Co.**	NYSE	79⅛	80⅞	-1¾	-2.2	82⅜	53⅛
	British Aerospace, Plc.	LNDN	10¼	10⅜	-⅛	2.1	16¾	7¾
FEN	**Fairchild Industries, Inc**	NYSE	17¾	17⅝	⅛	0.7	17⅞	9¾
	Fokker	AMST	18½	18¾	-¼	2.0	22¾	11⅜
GY	**GenCorp Inc.**	NYSE	18¼	19	-¾	-3.9	22¾	15⅝
GD	**General Dynamics Corp.**	NYSE	58	57	1	1.8	58⅝	44⅝
GQ	**Grumman Corp.**	NYSE	21⅞	21	⅞	4.2	23⅞	19⅜
LK	**Lockheed Corp.**	NYSE	48	47⅛	⅞	1.9	51	38¾
ML	**Martin Marietta Corp.**	NYSE	46	45⅞	⅛	0.3	46⅞	38¼
MD	**McDonnell Douglas**	NYSE	80⅛	78¾	1⅜	1.7	94½	59⅛
MTI	**Morton Thiokol, Inc.**	NYSE	47	47	0	0.0	50	35⅝
NOC	**Northrop Corp.**	NYSE	25⅞	26⅞	-1	-3.7	35⅞	25⅛
ROK	**Rockwell International**	NYSE	22¼	22	¼	1.1	23½	18⅜
RHR	**Rohr Industries**	NYSE	30¾	32⅜	-1⅝	-5.0	37⅞	25⅝
	Rolls-Royce, Plc.	LNDN	3	3⅛	-⅛	-0.5	3¼	1¾
SNS	**Sundstrand Corp.**	NYSE	67	67⅜	-⅜	-0.6	68½	46¾
TXT	**Textron, Inc.**	NYSE	27⅛	27¼	-⅛	-0.5	29	22¼
UTX	**United Technologies**	NYSE	51⅜	51¾	-⅜	-0.7	53½	34⅞
AVIONICS/MILITARY ELECTRONICS								
ETN	**Eaton Corp.**	NYSE	61½	60½	1	1.7	61¾	46¾
EMR	**Emerson Electric Co.**	NYSE	35⅜	35¼	⅛	0.4	36¾	27¼
ESY	**E-Systems, Inc.**	NYSE	30⅝	30⅝	0	0.0	33½	26¼
	Ferranti International	LNDN	1⅝	1¾	-¼	-5.6	2⅜	1⅝
	GEC, Plc.	LNDN	3¾	4	-¼	-1.6	4¼	3⅛
GMH	**GM-Hughes Electronics**	NYSE	26¾	26¾	0	0.0	30⅞	23½
HRS	**Harris Corp.**	NYSE	30⅜	30¾	-⅜	-1.2	31¾	25
HON	**Honeywell, Inc.**	NYSE	76¼	76⅞	-⅝	-0.8	80¼	56¾
LIT	**Litton Industries**	NYSE	79¾	79⅞	-⅛	-0.2	85¾	68⅛
LOR	**Loral Corp.**	NYSE	32⅝	31¾	⅞	2.8	40½	30½
	Matra	PARI	46⅛	47¾	-1⅝	-0.3	49⅞	20¾
	The Plessey Co., Plc.	LNDN	4¼	4¼	-⅛	1.5	8¾	3
	Thomson-CSF	PARI	31	33⅝	-2⅝	-4.8	39¾	20¾
	Racal Electronics, Plc.	LNDN	7⅝	8	-⅜	-1.6	8	2⅛
RTN	**Raytheon Co.**	NYSE	71¾	70⅛	1⅝	2.3	73⅞	61
TXN	**Texas Instruments, Inc.**	NYSE	43¾	43⅝	⅛	0.3	51¼	34½
TRW	**TRW Inc.**	NYSE	46¼	44	2¼	5.1	49½	40⅝
AIRLINES								
AMR	**AMR Corp.**	NYSE	62⅝	64⅛	-1½	-2.3	65⅝	40
	British Airways, Plc.	LNDN	3¼	3⅜	-¼	-3.8	3⅝	2⅞
DAL	**Delta Air Lines, Inc.**	NYSE	69½	67⅞	1⅝	2.4	71¾	45¾
	Japan Air Lines Co. Ltd.	TOKY	112⅞	118⅜	-5½	-1.9	136¼	24¼
NWA	**NWA, Inc.**	NYSE	105	101½	3½	3.4	107½	39¼
PN	**Pan Am Corp.**	NYSE	4¾	4½	¼	5.6	5⅛	2¼
	Singapore Airlines	SING	7	7¼	-¼	-3.5	7¼	3¼
TEX	**Texas Air Corp.**	Amex	13⅞	13½	⅜	2.8	17⅛	10
U	**US Air Group**	NYSE	46⅛	45¼	⅞	1.9	46¾	30¼
UAL	**UAL Corp.**	NYSE	127½	126¼	1¼	1.0	131½	81
OTHER/DIVERSIFIED								
F	**Ford Motor Co.**	NYSE	47⅜	49¾	-2⅜	-4.8	56⅝	45⅝
	Fuji Industries	TOKY	7¼	7⅝	-⅜	-2.9	7⅝	3⅜
GE	**General Electric Co.**	NYSE	53⅝	52⅞	¾	1.4	54⅜	39
GTE	**GTE Corp.**	NYSE	52⅝	52¾	-⅛	-0.2	54⅛	34⅞
	Mitsubishi Industries	TOKY	7⅞	8¼	-⅜	-1.8	9¼	3⅝
	Saab-Scania AB	STKH	38¼	37	1¼	6.2	41⅛	24¼
	Siemens AG	FFRT	266¼	267	-⅞	2.7	304	266¼
WX	**Westinghouse Electric**	NYSE	61½	61	½	0.8	63⅝	48¼

SCIENCE/SCOPE®

A new process dramatically reduces Printed Wiring Board (PWB) manufacturing time. The process, called Just-In-Time, helped trim the time to manufacture PWBs at Hughes Aircraft Company from four or five months to just ten days. Just-In-Time reduces the cycle times, the time a product spends moving or waiting, by organizing the work flow so everything progresses in unison. Work is planned so that each PWB operation is completed as the next operation finishes its work and is ready to take on the next assignment. All job hardware arrives just in time for the next work to begin on it. Many manufacturing areas at Hughes have adopted similar systems to shorten cycle times.

High-power ion thruster technology may provide propulsion for orbit transfer applications. The technology, under development by Hughes for the National Aeronautics and Space Administration (NASA), will emphasize xenon ion thrusters in the five to ten kilowatt power range. A near-term application of this technology is electrically-powered orbit transfer vehicles that could be used for possible U.S. Air Force and Strategic Defense Initiative applications. Future technology development will concentrate on the multi-kilowatt to one megawatt power range for potential interplanetary applications.

A wireless anti-armor missile with the potential for increased range and velocity over current wire-guided missiles has been demonstrated to the U.S. Army. For the test, a Tube-launched, Optically tracked, Wire-guided (TOW)2 missile, developed and produced by Hughes, was outfitted with a secure, spread spectrum, millimeter-wave data link. The wireless electronic link replaced the fine steel wires used on conventional TOW missiles. The wireless TOW 2 missile successfully flew through cloth net targets at 1,850 meters and 3,750 meters, the maximum range for a TOW 2. Wireless guidance provides the capability for a supersonic, longer-range anti-tank missile because missile range and velocity are not hampered by the length of the guidance wires or the speed with which they can unwind from the launcher.

A small, low-power oscillator uses a microprocessor for improved temperature compensation. The Microprocessor-Controlled Crystal Oscillator (MCXO) developed by Hughes occupies 1.5 cubic inches, and typically consumes less than 75 millowatts, and offers a stability of $\pm$ 0.4 parts per million over the full military temperature range. The MCXO achieves its combination of stability and size by employing a microprocessor to digitally compensate the oscillator frequency over temperature. This digital compensation provides increased performance and stability compared to analog frequency compensation techniques currently in use.

Hughes' Training & Support Systems Group provides a wide range of high technology products and engineering support. We currently have opportunities in the Las Vegas, Nevada area for Measurement Engineers. Responsibilities will include on-site measurements of RF and video gains/losses, AGC/IAGC step responses, RF and pulse spectrums/stabilities/characteristics and simulation of scan patterns. Requires a minimum of 5 years radar measurement and/or troubleshooting experience and familiarity with multiple instruments of the GPIB buss. Appropriate background for work in the defense and intelligence community is preferred. Please send your resume to: Hughes Aircraft Company, Training & Support Systems Group, Dept. S1, P.O. Box 9399, Long Beach, CA 90810-0463. U.S. citizenship required. Equal opportunity employer.

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INDUSTRY OBSERVER

B-2 DAMAGE

ONE ENGINE on a Northrop B-2 bomber suffered foreign object damage during a ground run in mid-May. The incident was caused by unknown debris. The powerplant was removed for repair and probably was reinstalled quickly. The B-2 could make its first flight in late June or early July.

PROPFAN FLIGHTS

THE PRATT & WHITNEY AIRCRAFT/ALLISON 578-DX propfan has completed 13 flights since first flying in April on the McDonnell Douglas MD-80 UHB aircraft (AW&ST Apr. 17, p. 63). Testing devoted to flutter, airframe vibration and climb and cruise performance has progressed faster than anticipated. The final five or six flights could be completed this week.

SDI EMPLOYMENT

STRATEGIC DEFENSE INITIATIVE programs currently employ about 28,000 workers, according to the SDI Organization. That number could grow to 32,000-33,000 next year, based on the $4.6-billion budget request approved by President Bush. The budget and number of new workers would be subject to reductions, however, if Congress decreases SDI spending.

JAPANESE WEAPONS

JAPAN'S Federation of Economic Organization, in a report to the Japanese government, has said more indigenous weapon systems should be included in the nation's five-year defense buildup program, which will start in 1991. The federation said Japan should increase its research and development spending from 2.5% of the total defense budget to at least 5%. The report also stated that Japanese technologies should receive greater protection, especially because of the increasing number of joint U. S.-Japanese research programs.

SHUTTLE AUTOLAND

NASA will intensify its studies of astronaut physiology in preparation for orbiter missions of 16-28 days. The information is necessary to determine whether the agency should upgrade the shuttle's autoland capability or rely on astronauts to land the orbiter after more than two weeks in zero gravity. A more serious obstacle to 28-day orbiter flights is the lack of stowage area for food, clothing and personal hygiene equipment.

SINGAPORE CONSOLIDATION

SINGAPORE'S Sheng Li Holding Group has consolidated its 48 companies, including Singapore Aircraft Industries, into a new company called Singapore Technologies. It includes aerospace, industrial and marine business sectors. The reorganization will help the company compete in international markets.

EARLY RETIREMENT

CONGRESS HAS DELAYED until July 16 the effective date of the procurement integrity law approved last year. The law has prompted many senior executives at the Defense Dept., NASA and other agencies to retire early lest they be prevented from getting jobs in industry. One of the legislation's goals is to prevent the bribing of government employees. But critics contend the Defense Dept.'s regulations to enforce the law are too broad to be workable (AW&ST Apr. 24, p. 33). Industry officials and some legislators said the regulations need to be softened.

LARGER MISSILE

THE GENERAL DYNAMICS/WESTINGHOUSE team may have to increase the size of its advanced air-to-air missile candidate, designed to Navy requirements. Navy officials said problems with the X-band radar are driving the team to a larger design. The missile is 144 in. long with a 5.5-in. dia.

TOP SUM

MCDONNELL DOUGLAS topped the list of companies receiving Defense Dept. contracts for research, development, test and evaluation in Fiscal 1988. The company received $2.16 billion in contracts last year, mainly for work on the Air Force's C-17 transport. Martin Marietta Corp., with $2.03 billion, was second. Other firms in the top five include the Boeing Co., Grumman Aerospace Corp. and Raytheon Co.

BOOSTER STUDY

THE JOINT DEFENSE DEPT./NASA Advanced Launch System (ALS) booster study is working on 84 advanced development projects. The activity includes 32 propulsion developments, 22 operations and procedures assessments, 13 projects associated with avionics, 12 structures-oriented tasks and five projects involving aerothermodynamic characteristics. The ALS program is intended to result in a range of new medium and heavy-lift boosters for the 21st century.

FIVE HITS

THE OERLIKON/MARTIN MARIETTA Air Defense Anti-Tank System (ADATS) has successfully completed a series of tests at White Sands Missile Range, N. M. The system scored five hits in as many test firings against helicopter and fixed-wing aircraft targets. A second series of six firings, including live-fire tests against targets in a smoke environment, has begun. Three fire units have been delivered to the Army. A fourth unit is scheduled for delivery this month.

SPLIT PRODUCTION

BRAZIL'S Embraer and Argentina's Chincul aircraft manufacturing companies have agreed to produce and market single- and twin-engine Piper airplanes within their countries. Embraer, which had been producing a full line of piston-powered models under license since 1980, now will build only the Saratoga SP and the Seneca 3. Chincul will manufacture Piper aircraft from the Super Cub through the turboprop Cheyenne series.

WORK HALTED

LTV Aircraft Products Group has halted work on its Flexible Composites Center at Grand Prairie, Tex. The company had invested about $30 million in the facility. An LTV official said anticipated reductions in defense spending for advanced aircraft are responsible for the decision.

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AIRLINE OBSERVER

MARKET REGULATION

THE U. S. IS CREATING DE FACTO REGULATION of the airline industry by failing to take productive action on capacity constraints, according to Robert L. Crandall, American Airlines chairman and president. Speaking in Washington last week, Crandall said capacity problems were getting worse. "At O'Hare," he said, "our nightmares are coming true," with more delays this year than last. The Federal Aviation Administration resists "even small technical fixes" that would help alleviate congestion at Chicago's O'Hare and other airports such as Washington's National and New York's LaGuardia. Examples included permitting limited air holds—most substantial flight holds today result in keeping aircraft on the ground—and "letting fast planes pass slow ones" on the way to airports. Crandall said legislative progress on larger issues also was slow and endorsed Transportation Secretary Samuel K. Skinner's pledge to develop a National Aviation Policy, particularly if what emerges is not "a toothless political compromise."

PHILIPPINE STOCK SALE

THE PHILIPPINE GOVERNMENT is going forward with a two-year-old plan to sell Philippine Airlines' stock to private investors. Up to 79% of the airline's stock could be sold by 1990, with limited foreign ownership. Philippine Airlines lost money in seven of the last eight years, and Asian aviation experts believe privatization is the only way the carrier, which has debts of about $500 million, will be able to raise money for new aircraft.

LAUDA LOAD

LAUDA AIR LOAD FACTORS are averaging a disappointing 60% one year after beginning scheduled service from Vienna to Hong Kong via Bangkok with Boeing 767-300ERs. Established airlines with more frequent service are experiencing seasonal load factors of 85% or higher on such flights. Sources at the airline attribute the shortfall to the carrier's small size and a weak Vienna hub. An Air Lauda route to Sydney via Bangkok is doing much better, with load factors of 90% and higher. The carrier plans a second weekly 767 flight to Sydney this fall, with an intermediate stop at Thailand's Phuket resort area.

O'HARE SEARCH HAMPERED

THE SEARCH for an experienced professional to serve as Chicago's aviation commissioner is being hampered by a salary limitation. Howard Stanback, who recently resigned as commissioner, was paid about $86,000 a year. Most top officials of larger airports in the U. S. are paid at least six figures. Among the candidates for the post is Louis A. Turpen, San Francisco's director of airports. Turpen was interviewed May 19 in Chicago. The commissioner runs the world's busiest airport, O'Hare International, as well as Midway and Miggs airports.

NEW PACIFIC AIRWAYS

JAPAN'S MINISTRY OF TRANSPORT has approved three new airways in the central Pacific to help solve congestion and delays of transpacific flights. The three new airways will be open in late July, bringing the total of airways in the central region to five. Air traffic controllers in Japan will select airways based on weather patterns. The new airways are to the south of the current ones.

FARE REDUCTION

JAPAN AIR LINES is proposing to lower fares for international destinations from Japan to lessen differences between the value of tickets issued in Japan and those issued in other nations. The differences have resulted from the strength of the Japanese yen against other currencies. Japan's Ministry of Transport must approve the fare reductions, scheduled for July, to the U. S., Canada and China. New fares would go into effect later to Europe and southeast Asia.

SUBSTANCE ABUSE CONTROLS

THE U. S. FEDERAL AVIATION ADMINISTRATION has proposed a rule giving it the power to deny an application for a pilot's license to anyone with a recent record of driving automobiles under the influence of drugs or alcohol. The agency also would be able to revoke a license, if already held, under such circumstances. The rule would require pilots to report any alcohol- or drug-related convictions within the last three years. Future convictions would have to be reported within 60 days. The rule also proposed automatic expiration of a pilot's medical certificate 61 days after a drug or alcohol offense. The pilot could reapply for the certificate—a prerequisite for flight, along with a pilot's license—but would be required to provide evidence of attending a substance abuse program.

MIDWAY MARKETING

MIDWAY AIRLINES is preparing for two marketing changes—an interline agreement with Air New Zealand and first-class service scheduled to be offered this September. Midway officials are hopeful that the Air New Zealand connection could evolve into an agreement to share a computer reservations system code. Chicago-based Midway now flies to Los Angeles, where it can link with Air New Zealand. Offering first-class service is viewed as a necessity to strengthen Midway's frequent flier program. Upgrading to first class is the most common form of using frequent flier benefits.

COCKPIT RECORDER ADVANCE

THE ELECTRONIC NAVIGATION INSTITUTE of Japan's Ministry of Transport said it has developed an advanced cockpit voice recorder system. The recorder is similar in size to the present one in commercial transports, but can record conversations for 2 hr., about four times longer than the current system, according to the institute. A system capable of recording for longer periods was requested by both the International Civil Aviation Organization and Japanese carriers after the crash of a Japan Air Lines 747SR in August, 1985. The aircraft crashed 44 min. after takeoff, and the first 11 min. of the voice record had been recorded over. Japan's accident investigation board suggested that some important information might have been contained in the early part of the flight.

S U P P O R T

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WASHINGTON ROUNDUP

BELTWAY BANDITS

THE DEFENSE CONTRACT AUDIT AGENCY (DCAA) is questioning the legality of $53.7 million in consulting fees charged to the Pentagon by 27 major defense contractors in 1988. The figure represents 20% of the $269 million in consulting fees the firms charged to Defense last year. The review revealed that consultants' fees for lobbying, foreign sales, and unallowable public relations and advertising activities had been passed on to the government. The majority of the questionable charges, $33.8 million, involved no written agreement between consultants and contractors, the audit agency said. "This type of loosely monitored buddy system is what created the need for last year's Ill Wind investigation," according to Sen. David Pryor (D.-Ark.). He said the findings show that contractors continue to ignore rules governing consultant costs.

THE SOVIET UNION'S PLEDGE to further reduce its conventional forces was welcomed by Western leaders. The Bush Administration continues to downplay the significance of West Germany's demand for reducing—rather than modernizing—short-range nuclear missiles (SRMs). Bush Administration officials said SRMs need not be a priority at this week's NATO summit. Paul Nitze, U. S. arms negotiator emeritus, continues to push the Administration toward the German viewpoint. Nitze questioned the value of SRMs, given the Soviets' numerical advantage. "Any exchange . . . of short-range missiles will be one-sidedly destructive for us and our allies," he said. Nitze pressed for SRM cuts to 200-300 missiles by both sides.

RUSSIAN ROULETTE

SPACE COMMERCE CORP., the U. S. company marketing launch services on Soviet boosters, is formally protesting a NASA decision that excluded it from bidding on a commercial launch services contract. Space Commerce officials argue that their company is 100% American-owned and should be allowed to compete, even though their boosters are Soviet-made. NASA lawyers have interpreted procurement rules to mean that only U. S.-manufactured rockets are eligible, even though the contract calls for launch services rather than hardware production. Space Commerce is charging that NASA has unlawfully restricted full and open competition.

COMMERCIAL SPACE VENTURES must have government help to succeed in the near-term, an advisory group is telling NASA. "As a matter of reality, the space market will remain largely dominated by the government's demand for space hardware and services," Edward Donley, chairman of NASA's Commercial Programs Advisory Committee, said. The panel advised NASA and the White House to set up a national program for space industrial competitiveness to counter growing foreign capability to convert technology into commercial products.

B-2 TAILGUNNER

AIR FORCE BRASS continue to hold the line in defense of the B-2 stealth bomber, and the point man last week was USAF Lt. Gen. Ronald W. Yates, principal deputy assistant secretary for acquisition. Asked about a recent call by former Defense acquisition czar Robert Costello to cancel the program due to cost and quality control problems, Yates told a House subcommittee that the B-2 program does not have technical problems and that the manufacturing capabilities at Northrop are the most sophisticated in the country. Thus far, he said, "we are not displeased with what we have seen come off the production line."

REP. DAN GLICKMAN (D.-Kan.) is picking up some much needed support for his General Aviation Standards Act of 1989 from Transportation Secretary Samuel K. Skinner. Glickman's proposed bill seeks to limit the product liability of small aircraft manufacturers to 12 years. In a letter to Rep. Glenn M. Anderson (D.-Calif.), chairman of the House Public Works and Transportation Committee, Skinner called the U. S. tort liability system covering this aerospace sector "inequitable and unfair." Glickman has tried three times to get the proposed bill enacted.

MR. GOLDWRENCH

AMERICAN AIRLINES CHAIRMAN ROBERT L. CRANDALL thinks the Transportation Dept. should "put aside the notion that it's not nice to talk about the quality of maintenance" among various airlines. Crandall told the Washington Aero Club and Skinner that the agency should create awards for excellence in maintenance. A Golden Wrench Award would be given on a regular basis to the airline with the best maintenance program, with Silver Wrenches going to other carriers having outstanding programs. The winners, Crandall said, could be counted on "to lavishly advertise the results."

WASHINGTON STAFF

NTSB Raps Aloha, Aviation System for Fuselage Failure

JAMES OTT/WASHINGTON

A breakdown in the nation's aviation maintenance system contributed to the in-flight loss of the upper fuselage section of an Aloha Airlines Boeing 737-200, according to the National Transportation Safety Board. The NTSB is primarily blaming the airline maintenance department, but the Boeing Co. and the FAA are implicated.

In a 4-1 decision, certain to influence airline maintenance programs, the safety board cited the airline's failure to detect fatigue damage and disbonding of skin overlap joints—that led to failure of a lap joint—as the probable cause of the 1988 accident.

The safety board said the FAA and Boeing contributed to the accident—both in their actions and their lack of response to a critical safety issue involving early production models of the 737.

Aloha's maintenance program came under fire as deficient and without direction. The failure to detect disbonding of a lap joint and multiple-site cracks occurred in spite of alerts from the manufacturer and the agency as well as the carrier's own experience with similar cracking in other 737s.

Aloha's maintenance program came under fire as deficient and without direction

The safety board found fault with the airline, the manufacturer and the FAA in its assessment of contributing factors:

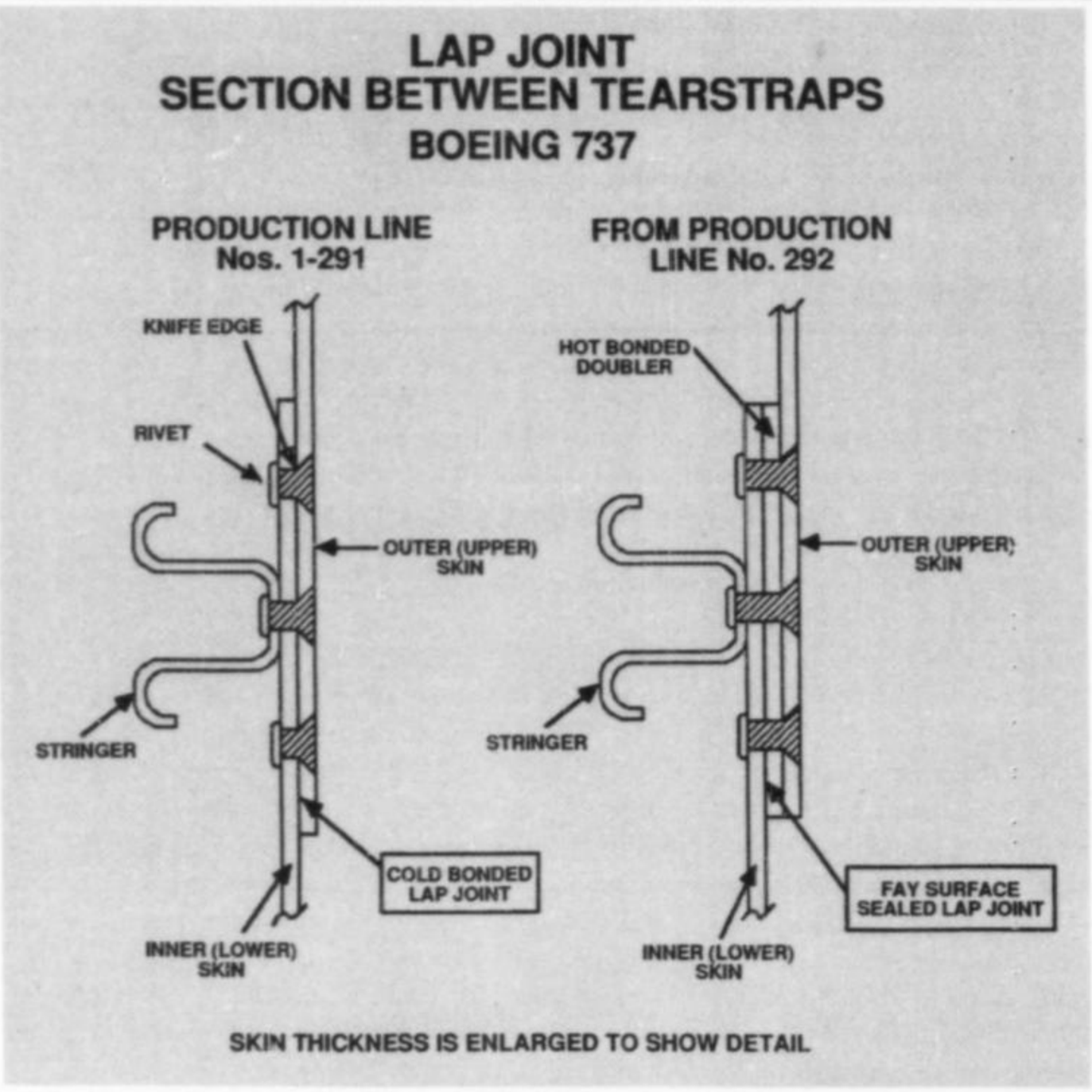
- Aloha management was criticized for failing to supervise its maintenance program.
- The FAA was faulted for poor oversight and for allowing Aloha to accomplish D-checks—in-depth structural aircraft inspections—in 55 short segments instead of the usual 4-6 longer segments.
- The agency was criticized for reducing the scope of a Boeing service bulletin in one of its airworthiness directives concerning the 737 lap joint problem. The directive focused attention on one lap joint in the 737 fuselage instead of six, including the one lap joint that failed.
- Boeing was blamed for not providing a terminating fix to the aircraft problem in the 15 years since it first was defined.

A significant NTSB recommendation to the FAA focused on the need for airline maintenance departments to avail themselves of engineering services. The recommendation stemmed from the board's finding of a lack of engineering expertise at Aloha. The Air Transport Assn. was asked to assist airlines in establishing engineering services needed to distinguish critical maintenance steps from routine work and to aid in interpreting service bulletins and directives.

With Aloha's failures to detect the disbonding and the subsequent effects of stresses on rivets from repeated pressurization cycles—and cracking at rivet holes at multiple sites—the lap joint in the accident aircraft failed at Stringer 10 Left, according to the NTSB analysis.

When the aircraft leveled at 24,000 ft. after takeoff from Hilo, Hawaii, on Apr. 28, 1988, the top half of Section 43 tore away. This exposed the 95 passengers and cabin crew to hurricane-force winds, thrashing metal stringers and flying debris (AW&ST May 9, 1988, p. 92; May 16, 1988, p. 16).

The senior flight attendant, swept out of the aircraft by the sudden decompression, was the only fatality. Her body was not recovered. The flight crew successfully landed the aircraft with one engine out. An attempt by the safety board staff in the draft report to criticize the cockpit crew's performance was rejected by board members as misplaced nit-picking. The draft referred to the crew's failure to go through a checklist, for example.



Boeing was criticized for not providing a terminating fix to the problem of cold-bonded lap joints in early 737 aircraft. The drawing shows changes made starting with Production Line No. 292.

Board member Joseph T. Nall, who headed the investigation at the accident site, dissented from the majority view on the probable cause. He suggested the failure to detect the disbonding and the cracking was more "a system problem" than, primarily, the failure of Aloha's maintenance program. "It was detectable," Nall said, "but it went undetected and that caused the accident. Whether they should have, or if anyone reasonably could have detected it, that's for another forum. I think it is limiting if we relate the probable cause only to the management. It's a broader issue."

Board member John Lauber, who directed the board's hearing in the accident, said the airline had the first responsibility for the maintenance of the aircraft. "One of the lessons learned by the whole industry from this accident," he said, "is the criticality of maintenance and inspection programs." "By all available evidence, [the airline] should have been able to detect the problem. It was the airline that basically had that responsibility."

The loss of the upper lobe was possibly a rare case of a zipper effect, described by the FAA's Tom Swift, the national research specialist in fracture mechanics, in a theoretical paper written in 1987. Swift speculated that cracks could join up from multiple sites and cause a catastrophic accident.

"A worst-case scenario of multiple-site damage," according to James Wildey, NTSB metallurgist, "is if you have a lot of cracks that are undetectable, or visually undetectable, that all of a sudden join up to form a catastrophic failure." A large section of the top lobe was not recovered, hampering the investigation. But Wildey said the recovery of a piece of the fuselage that had lodged in the leading edge of the wing showed repaired and unrepaired "multiple-site damage" in the area of Stringer 4 Right. The cracks would have been present at the time of other repairs in fall, 1987, and would have been detectable by required eddy current inspections. The safety board was unable to determine whether Aloha ever conducted the eddy current inspections, but the records do not indicate they were accomplished.

Evidence at the board meeting showed that the tear-stopping, fail-safe capability of the Boeing fuselage design was negated by the unusual conditions of the Aloha accident. Under normal circumstances, a crack propagates along a line, strikes a tear strap and flaps the skin. This stops the crack and releases the cabin pressure.

Board member Joseph T. Nall dissented from the majority view, asserting that the system failed

The accident aircraft was 152nd on the Boeing production line, one of the first 291 Boeing 737s that used a faulty cold-bonding process for the skin overlap joints. The problem of disbonding and the consequent problem of corrosion and fatigue cracking in the overlap joint were defined by Boeing in a service bulletin on Feb. 8, 1974.

With disbonding, the rivets become the primary means of holding together the two skins of the overlap joint. Boeing understood that the use of countersunk rivets in the overlap was conducive to fatigue cracking and reported that information in the 1974 service bulletin. Knife edges were left in the rivet holes from the countersunk rivets. Stresses concentrated on these knife edges where cracks tended to begin.

According to an official NTSB staff conclusion adopted by the safety board, the lap joint at Stringer 10 Left in the accident aircraft failed as a result of multiple-site fatigue cracks. These cracks were in the skin "adjacent to rivet holes along the lap joint upper rivet row." The tear strap was disbonded at that point and did not function as a tear stopper.

"There was enough fatigue damage along the entire lap joint or tear strap disbonding to effectively eliminate the crack-arresting ability," Wildey said. "When the cracking developed, it continued to propagate longitudinally and never did turn and arrest itself and create a nice, safe flap."

The safety board concluded that Boeing, in 1974, did not realize the implications of multiple-site damage for their cold-bonded aircraft. "A permanent solution was not determined, and corrective action was relegated to repetitive visual inspections and damage repair," according to another safety board conclusion.

Boeing had further evidence that fatigue cracking would result after disbonding, however. In 1984, Aloha reported that cracks had joined in seven of 22 rivets in one of its 737s. Fatigue cracking on Stringers 4 Left and Right was reported on a series of aircraft operating in South America in 1987. At that point, in 1987, Boeing upgraded the service bulletin for repairs to "alert" status.

The safety board concluded that Aloha's maintenance, inspection and corrosion control programs were deficient and that the carrier had "sufficient information" to alert it to cracking problems. Management was faulted for not taking into account the human performance factors of inspection.

CORROSION PROBLEMS

The NTSB staff said Aloha mechanics complained of performing exterior fuselage rivet inspections under great stress, standing on the crown of 737s and wearing safety ropes around their waists that were suspended from hangar high beams.

Members were critical of Aloha for failing to respond to a Boeing service letter on replacement of carbon steel engine control cables with stainless steel cables. Aloha had first reported corrosion problems with the carbon steel cables in a service difficulty report but failed to heed the manufacturer's proposed solution, according to officials.

The safety board was concerned that the FAA's principal maintenance inspector, new to the job in 1988, was "overburdened" with responsibilities. He was assigned to several other airlines and oversaw fixed-base operators as far away as China.

Furthermore, the inspector was neither informed about the age and condition of the Aloha fleet nor trained to deal with the lap joint corrosion and disbonding problems of the 737. He was excluded from a meeting between Boeing and Aloha that dealt with Boeing's evaluation of the Aloha fleet, eroding his efficiency.

Board members said the inspector was excluded under a Boeing policy of client

confidentiality. This policy was put into place because, at a similar session with another airline operator in the presence of an inspector, the airline was charged immediately with a list of FAA violations. Boeing told the NTSB that it preferred confidentiality as a means to develop and maintain an open exchange with airlines.

Aloha informed the inspector of the Boeing assessment fully but after the accident had occurred, according to the board. The inspector was given partial information several days before the accident.

The airline obtained approval from a previous principal maintenance inspector to allow a 55-segment breakdown of D-check work. The approval was granted, safety board investigators learned, in deference to management's concerns for economics and full use of aircraft in a comparatively small fleet. A 55-segment breakdown was viewed as excessive by board members.

"Accidents generally are preventable," Aloha president Maurice Myers said, "but hindsight is always 20-20. I take exception to the probable cause finding that Aloha maintenance should have detected the cracks. We simply don't think those cracks were detectable."

Myers said this position was supported by testimony at the hearing that dealt with the technical and human-factors problems of detecting cracks. "The right answer is that it was a system failure. We would go along with the kind of description that Member Nall was trying to put into place."

The safety board endorsed the aviation industry premise that aircraft may be operated safely without the imposition of a life limit, but noted that airworthiness relies on effective programs of inspection, corrosion control, damage repair and replacement. □

Economic Impact of Aging Aircraft Fixes Remains Unclear

CHRISTOPHER P. FOTOS/WASHINGTON

The FAA's proposed structural modifications to aging Boeing aircraft closely follow the recommendations of an aging aircraft task force, but the economic implications are unclear.

The Airworthiness Assurance Task Force, a joint industry group, projected that up to 1,300 aircraft would undergo the mandatory fixes at a cost of $800 million (AW&ST Mar. 6, p. 64). In its proposed airworthiness directive issued May 18, the Federal Aviation Administration said the AD initially would affect 115 Boeing 727s, 737s and 747s at an estimated cost of $142 million over the next four years.

The directive requires 74 structural modifications to the 727, 58 changes to the 737 and 29 to the 747. Similar rules are to follow concerning fixes to aircraft made by McDonnell Douglas, Lockheed, Airbus Industrie and others.

According to Clyde Kizer, vice president of the Air Transport Assn. and task force secretary, aircraft affected by the rule can be divided into two groups. The first includes aircraft that are at service thresholds or relatively near them. The thresholds are linked to the aircraft's number of flights and chronological age. Aircraft in this group must be modified within the next four years. The remaining aircraft fall into the second group. Airlines operating these Boeing transports must make the required modifications before the thresholds are crossed.

Operators have the option of taking the aircraft out of service when they meet that milestone. This is what makes the ultimate cost of the program so difficult to estimate with certainty.

Decisions will be made on a case-by-case basis. "The FAA says 737 [modifications] will cost about $900,000 per aircraft," Patrick S. Murphy, vice president of operations at Avitas, said. Avitas is an aviation technical services and appraisal company based in Reston, Va. "If you look at the industry, the gut feeling is probably about $1.5-2 million, really. If you have a decently maintained airplane, that's not going to be a problem." If the aircraft has been operated "for 28 years, and it's due a 'D' check, and the engines are run out, that may be an airplane that goes away."

Kizer acknowledged that carriers may decide to dispense with some aircraft, rather than pay the price of modification. "We have always said that the first decision is [to assure] safety. The economic decisions follow that."

The thresholds vary among aircraft. The fixes are required for 727s after 60,000 flights or 20 years, for 737s after 75,000 flights or 20 years and for 747s after 20,000 flights or 20 years.

Some aircraft already near the threshold—those due for fixes within the next four years—may be prime candidates for retirement, according to Murphy. "Four years of normal usage will put it in the range of 87,000-88,000 cycles, if you're looking at 3,000 cycles a year. That's ready for the scrap heap anyway before putting a lot of money in it."

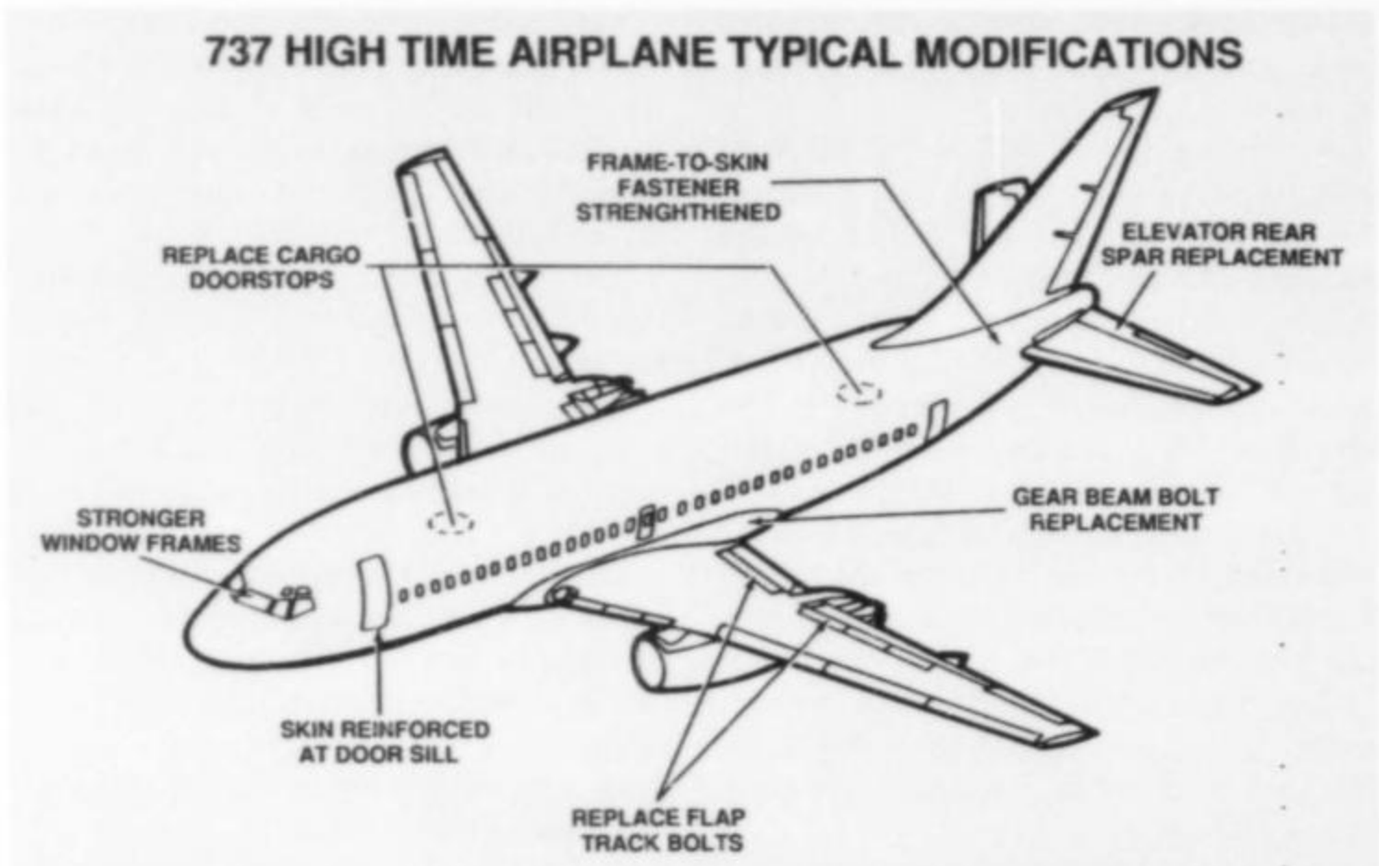
Also unknown is the ultimate effect the required modifications will have on appraisal values. "From that standpoint, we don't see it as a positive, but as a potential negative," Avitas President Lawrence R. Crawford said. "If you do it, it won't add to the value. If you don't, it will subtract."

The task force's Kizer has received some reports of falling market values. "In my mind, that's a temporary response," he said. After the modifications, the affected aircraft "could go another 20 years," according to Kizer, although economic factors probably will prevent that.

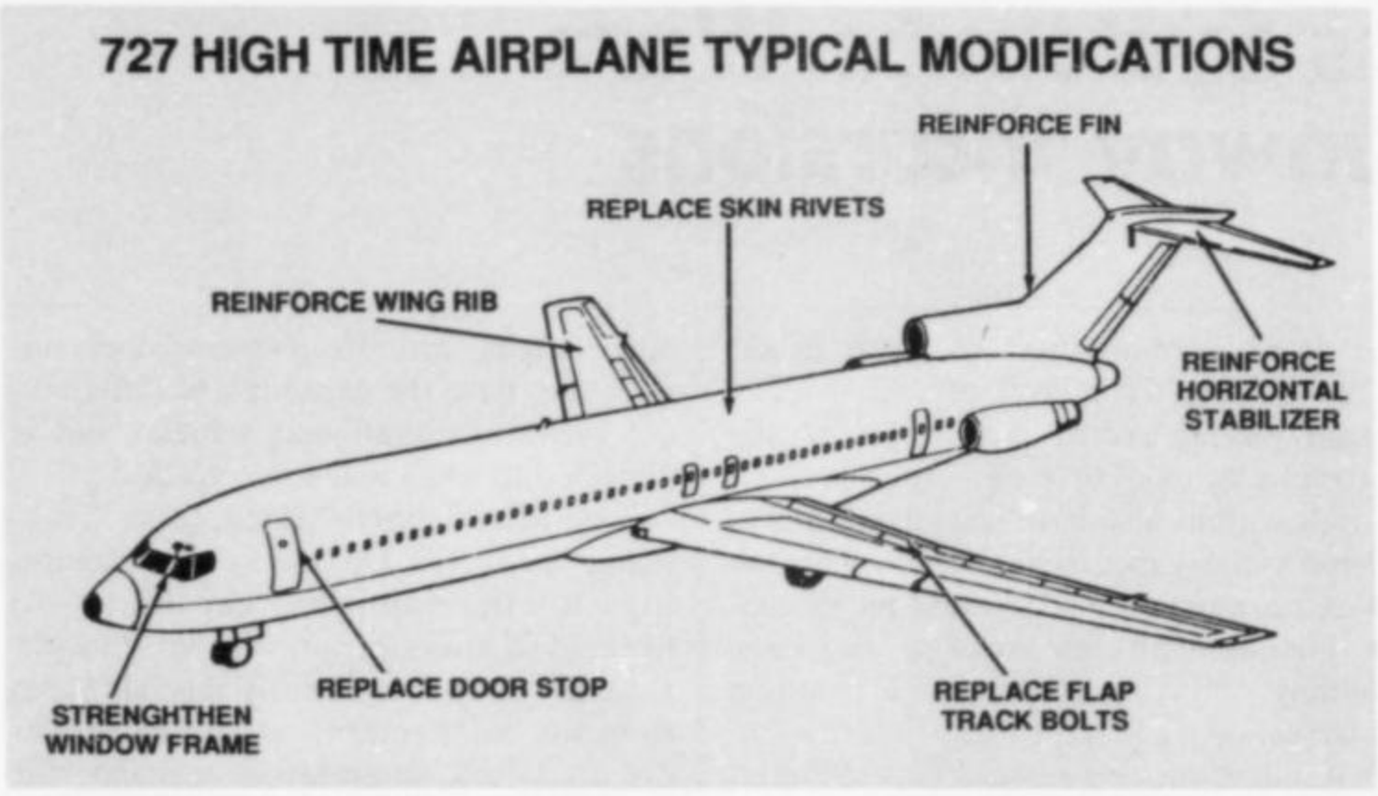
One key factor is the high demand for aircraft. "Unless you want to wait five years for a new aircraft, there isn't anything else to replace them," Kizer said.

Avitas officials said the rule probably will not have an enormous economic impact. "Is it going to cause panic in the market? No," Murphy said.

The force of the rule may be deflected from the airlines, given the recent growth of aircraft leases. "Lessors will have to be much more diligent to make sure they



One way to eliminate concerns over corrosion is to replace suspect parts. On the 737, elevator rear spars, landing gear beam bolts and flap track bolts will be replaced, along with other parts.



Rivet replacement is part of the maintenance program for all Boeing aircraft. Other parts will be strengthened, such as the 727's window frame, where cockpit window posts have cracked.

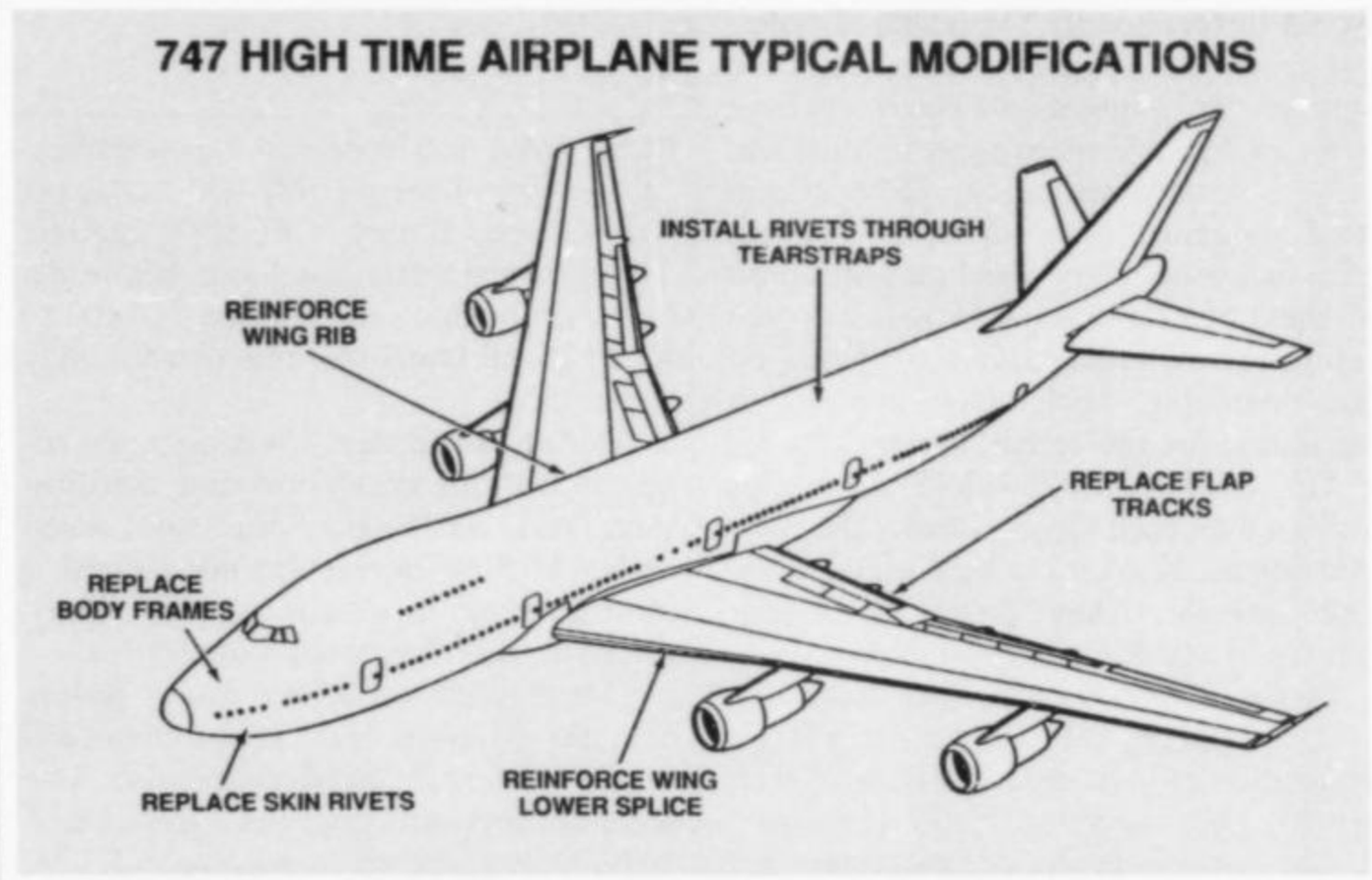
don't get hit with major repairs back in their lap," Avitas' president Crawford said. A leased aircraft could be managed in a way that returns it to the leasing company with high cycles—"and it's the lessor's problem." Many leases do have "nondiscriminatory clauses," however, requiring that leased aircraft be operated in the same way as those owned by the airline.

Kizer suspects the split between leased and owned aircraft will have other ramifications. Leasing companies may be more likely to avoid the cost of retrofitting their aging aircraft. Airlines with owned aircraft, however, may simply "need the lift" not otherwise available in a high-demand market.

Kizer believes some airlines may wait for another task force recommendation, a "corrosion-directed inspection program," before starting the work mandated by the FAA rule. "Of the work that remains [to the task force], the corrosion-directed inspection is probably the most difficult to overcome."

The FAA's directive requiring specific structural modifications is largely consistent with the task force's recommendations, according to Kizer. In line with the task force's recommendations, typical modifications will consist of fuselage rework, strengthened spars in aerodynamic surfaces, reinforced door sills, replaced bolts and stronger window frames. On the 727, the vertical stabilizer will be reinforced, skin rivets will be replaced and bolts in the flap track will be replaced as well, along with many other changes. Rivets will be replaced on the 737 and 747.

Another typical fix, in this case to the 747, consists of replacing body frames in the nose section of the aircraft. These have cracked from time to time after repeated cabin expansion during pressurization. The old frames will be replaced with heavier ones made of longer-lasting metal, according to Boeing. □



Boeing diagram shows some components targeted for replacement or modification. These areas endure repeated stresses from wing deflections and, in the case of flaps, from the high-speed airstream.

Boeing Sets New Mark With Orders Totaling $31.2 Billion

CHICAGO

Four new orders from around the world for Boeing commercial transports, including one worth $3 billion by United Airlines, pushed the company's sales total for 1989 to a record $31.2 billion.

The orders for 562 aircraft this year surpassed the company's 1988 aircraft sales in less than five months.

Chicago-based United ordered 32 Boeing 767-300ER transports that already are designated to serve the carrier's proposed new service to Europe. Half the aircraft are on firm order, with five deliveries scheduled in 1991, two in 1992, eight in 1993 and one in 1994.

Deliveries of the aircraft on option may begin in 1994. All will be powered by Pratt & Whitney 4000-series engines.

"We have to be there before 1992," James M. Guyette, United's executive vice president-operations, said, of the carrier's European plans. That is the year the nations of the European Community are expected to form a single economic bloc.

INTEREST IN 767X

Guyette said United is interested in the proposed Boeing 767X transport, which would have a wider body and a higher capacity than the traditional 767. He said the carrier was "firming the design" with Boeing.

United Chairman Stephen M. Wolf has said the carrier may acquire the 767X, possibly in tandem with another type of aircraft. The carrier is expected to place another order before the end of the year to satisfy its wide-body needs. Additional 747-400s are under consideration. United has placed orders for 15 747-400s.

All Nippon Airways Co. made its second major purchase of the year, ordering 10 Boeing 767-300s and securing options for 10 more. Cost of the firm orders will be about $750 million, with deliveries scheduled to begin in 1990 and continue through 1995. ANA has not chosen engines for its new wide-body transports.

Transavia Airlines of the Netherlands ordered two Boeing 757s and six 737-300s, and secured options on two more 757s. The order is valued at about $430 million. The Amsterdam-based airline chose the CFM International CFM56-3B2 engine for its 737s but has not picked an engine for the 757s. Delivery of the first 757 is scheduled for the first half of 1993.

LAN-Chile will get one new Boeing 767-300 through a new aircraft leasing venture called GATX/CL Air Leasing. This sale is valued at about $65 million. □

Norden Develops System to Warn Controllers of Runway Incursions

BRUCE D. NORDWALL/WASHINGTON

Norden Systems, Inc., is demonstrating a system to help controllers manage the movement of aircraft and vehicles at airports and to warn of potential conflicts.

Norden is developing the system called the Runway Incursion Management (RIM) system as a possible addition to its ASDE-3 high-resolution ground-mapping radar system. The RIM system is intended to predict and give visual and aural warnings of hazardous conflicts. The system might prevent accidents like the Mar. 27, 1977, collision of two 747s on the runway at Tenerife in the Canary Islands, which killed 580 persons (AW&ST Apr. 4, 1977, p. 33).

ASDE-3 is scheduled for installation at 30 major U.S. airports, and is slated to become operational at Pittsburgh International at the end of the year, according to Norden. The ASDE-3 system is designed to give local and ground controllers an accurate picture of traffic on the runways and taxiways. This could be most significant under restricted visibility conditions.

The RIM system would receive radar data from ASDE-3, then analyze vehicle movement and provide alerts on the display and verbal warnings when aircraft or vehicles move toward a hazard. Norden calls these situations runway incursions. To develop the logic to define incursions, Norden worked with tower controllers and used research conducted by Mitre Corp. for the FAA. The RIM system is designed to detect normal situations, such as aircraft holding for takeoff or taking off, a target waiting to cross a runway at a valid crossing location, or a clear runway.

Algorithms also have been developed to detect runway incursion situations such as:

- A runway occupied by multiple targets.
- Two aircraft on crossing runways, landing or taking off toward a common intersection.
- A target moving toward or holding at an invalid entry point for an active runway.
- An aircraft moving toward another target at high speed.
- An aircraft taking off on an inactive runway or in the wrong direction.

It would analyze ASDE-3 radar inputs and provide warnings when aircraft move toward a hazard

The RIM system would add one 2 × 2 × 6-ft. cabinet to the existing ASDE-3 hardware, but the system is designed to benefit from the signal processing already in existence in ASDE-3.

The ASDE-3 microprocessor adjusts the false alarm rate continuously. The process divides airport areas into three sectors of descending priorities: runways and taxiways, adjacent grass within 60 meters and all remaining areas. The RIM software would further specify the points of potential incursion. Targets—whether aircraft, vehicles or animals—detected entering these areas would receive special attention.

In a demonstration, the RIM system used simulated radar data. The system gave incursion alerts based on projections of the targets' locations 5 sec. into the future. These predictions were based on the preceding track. Digitized voices were used for the verbal warnings.

The RIM system overlaid an aircraft symbol over each target. During the demonstrations, Norden has been asking operators whether they prefer raw radar returns or superimposed symbols.

In the demonstration, with a symbol over each target, the operator can select a vector that projects from the front of each symbol, showing velocity and direction.

The symbols in the demonstration are all aircraft. They are also identical, showing no distinction between a 747 and light single-engine aircraft. Norden does not currently have the capability to differentiate between aircraft and vehicles, but is considering a manual input to do so.

The Massachusetts Institute of Technology's Lincoln Laboratories is attempting to develop the capability to distinguish aircraft from vehicles. Lincoln Labs also hopes to identify aircraft types from the radar returns, according to Andre L. Gluck, engineering manager for advance radar systems at Norden. Eventually, the system should get automatic aircraft identification from the FAA's Automated Radar Tracking System and Mode S identification-friend-or-foe systems, Gluck said.

Norden developed the RIM system with its independent research and development funds. It hopes to test the system at Pittsburgh on a not-to-interfere basis. Two to four months of testing, starting in January, would allow the company to refine the software to meet the controllers' needs.

Norden hopes to add the RIM system as an engineering change proposal to ASDE-3. It envisions retrofitting RIM systems at airports that already had ASDE-3 radar systems installed. RIM would be added only to new systems.

Adding RIM systems as a change to the existing contract could speed the capability to the operators. But it also would avoid competition. RIM would sell for about $2 million per system, Gluck said. □

No. 2 X-29 Makes First Flight

EDWARDS AFB, CALIF.

The second Grumman X-29 research aircraft made its first flight here on May 23, piloted by NASA Ames-Dryden's Stephen Ishmael. The 53-min. flight was devoted to systems checkout.

The No. 2 X-29 is configured for a joint NASA/Air Force high-angle-of-attack research program, with a spin recovery parachute and special cockpit instrumentation installed (AW&ST Oct. 31, 1988, p. 36).

In all other respects, it is identical to the No. 1 X-29, which was retired early this year after completing 242 flights.

About 70 high-angle-of-attack flights are planned for the second aircraft, including pitch maneuvering tests up to 70 deg. angle of attack (AOA). The first X-29 was only flown to 22 deg. AOA, according to NASA officials. □

FAA Certifies GE-Powered 747-400

SAN FRANCISCO

The FAA has approved type certification for Boeing's 747-400 transport with General Electric CF6-80C2 engines. The approval came just hours before delivery of the first GE-powered 747-400 to KLM Royal Dutch Airlines (AW&ST May 22, p. 105).

Anthony Broderick, FAA associate administrator for regulation and certification, said certification was not issued earlier because Boeing did not request it until negotiations with European authorities over technical issues were settled.

"There were no safety issues, just a complex wrap-up of a $120-million aircraft delivery," Broderick said. The schedule for certifying the GE-powered 747-400 was tailored to delivery to KLM, and Boeing wants this first aircraft to be the final configuration. □

USAF, LTV Probe Wing Cracks That Grounded Air Guard A-7s

EDWARD H. PHILLIPS/WASHINGTON

The Air Force and LTV Corp. are investigating wing cracks that have grounded 122 A-7 attack aircraft flown by Air National Guard units.

The grounded aircraft comprise more than 30% of the 361 A-7s currently in service with Guard squadrons. An Air Force official said microscopic skin cracks have been discovered in 166 A-7D/K aircraft. He said 40 A-7s have been repaired and returned to flight status. The majority of aircraft with cracks have been in service for about 20 years.

Steven H. Yarbrough, director of engineering for LTV's Aircraft Modernization and Support Div., said the current use of the A-7 in the attack role is "much more severe" than originally anticipated when the aircraft entered operational service. As a result, LTV is "reevaluating the inspection criteria and inspection intervals" used by the Air Force for the aircraft.

The inspection of the wings was prompted by an A-7D accident that occurred on Dec. 28, 1988. The aircraft crashed after making its eighth attack run during bombing practice near Clovis, N. M. It was assigned to the New Mexico Air National Guard at Albuquerque.

According to the Air Force, the aircraft suffered catastrophic failure of the right wing during pull-up after bomb release. The failure occurred at the wing-to-fuselage juncture in the area of the second intermediate spar.

All USAF A-7 aircraft are limited to +5g with symmetrical wing stores like those shown on this two-seat A-7K undergoing aerial refueling. With asymmetrical stores, aircraft are limited to +4g.

EDDY CURRENT INSPECTION

In January, the Air Force issued a time-compliance technical order calling for eddy current inspection of the lower wing skins of all 361 A-7s. The inspections, which concentrated on skin fasteners used in the secondary intermediate spar area, revealed no cracks. This spring the inspections were expanded to include skin fasteners on all five intermediate spars in the area near the wing root.

In April, however, an Arizona Air National Guard A-7D landed with a fuel leak in the left wing. The leak was traced to a large crack in the lower skin, 53 in. outboard from the wing root, near the rear main spar. That part of the wing incorporates an integral fuel cell.

The 13-in.-long crack started at the rear spar and propagated forward to the fifth intermediate spar. An LTV official said the aircraft has been shipped to the company's Dallas, Tex., plant, where the lower wing skin will be removed for laboratory analysis.

Yarbrough said the large crack caused LTV to call for one-time eddy current inspections to look for "any indications of suspect cracks" before any A-7D/K's next flight.

The inspections have been integrated into the Air Force's ongoing Aircraft Structural Integrity Program (ASIP) mid-life inspection. This inspection tracks crack growth and attempts to analyze the causes.

Aircraft that have flown less than 650 hr. since their last ASIP inspection are being checked with eddy current equipment. To accomplish this, 22 flush-head rivets are removed from each wing's lower skin in the vicinity where the 13-in. crack appeared.

The rivets are removed to allow the eddy current probe to be inserted into the fastener holes. The eddy current machines also were adjusted for more precise crack detection. Tests showed that 64 aircraft had cracks from 0.002-0.030 in. long. The remainder had cracks larger than 0.030 in.

Aircraft that have flown more than 650 hr. since an ASIP inspection receive the same check. But additional rivets in the area of the integral fuel cell also are removed for hole inspections using the eddy current method. The inspections require from 8-20 man-hr. to complete, depending upon an aircraft's flight time since the last ASIP inspection.

To validate the Air Force's inspections, LTV dispatched depot field teams from Dallas and the Sacramento Air Logistics Center (ALC), Sacramento, Calif. They have visited seven of the 14 Guard bases with suspect aircraft.

TWO REPAIR PROCEDURES

"We're finding some minor flaws," Yarbrough said, primarily because of the more precise sensitivity of the test equipment. The teams also are checking A-7s assigned to Nellis AFB, Nev.; Edwards AFB, Calif.; the Sacramento ALC, and LTV's facility in Dallas.

A team dispatched to a Guard unit based at Toledo, Ohio, checked 10 aircraft that exhibited crack indications. Eight were cleared for flight after inspection. Two still are being evaluated. Following repairs, the unit carried out a deployment to Europe with 13 A-7s.

LTV has devised two repair procedures, depending upon the size of the crack. To repair the smaller, 0.002-0.020-in. cracks, each hole is enlarged to 0.064 in., using a reaming tool. An oversized fastener then is inserted into the hole. The Air Force has repaired 32 A-7s using this procedure.

For aircraft with the larger, 0.030-0.060-in cracks, the fastener holes are enlarged to ¼ in. using a special tool. A 5/16-in. bushing, chilled in liquid nitrogen, then is inserted into the hole. After the bushing expands to a tight fit, a stan-

dard fastener is installed. If the repair is done in the fuel cell area, an O-ring seal also is used in conjunction with the bushing to prevent leaks. LTV said eight aircraft have been repaired using this method.

FLIGHT RESTRICTIONS

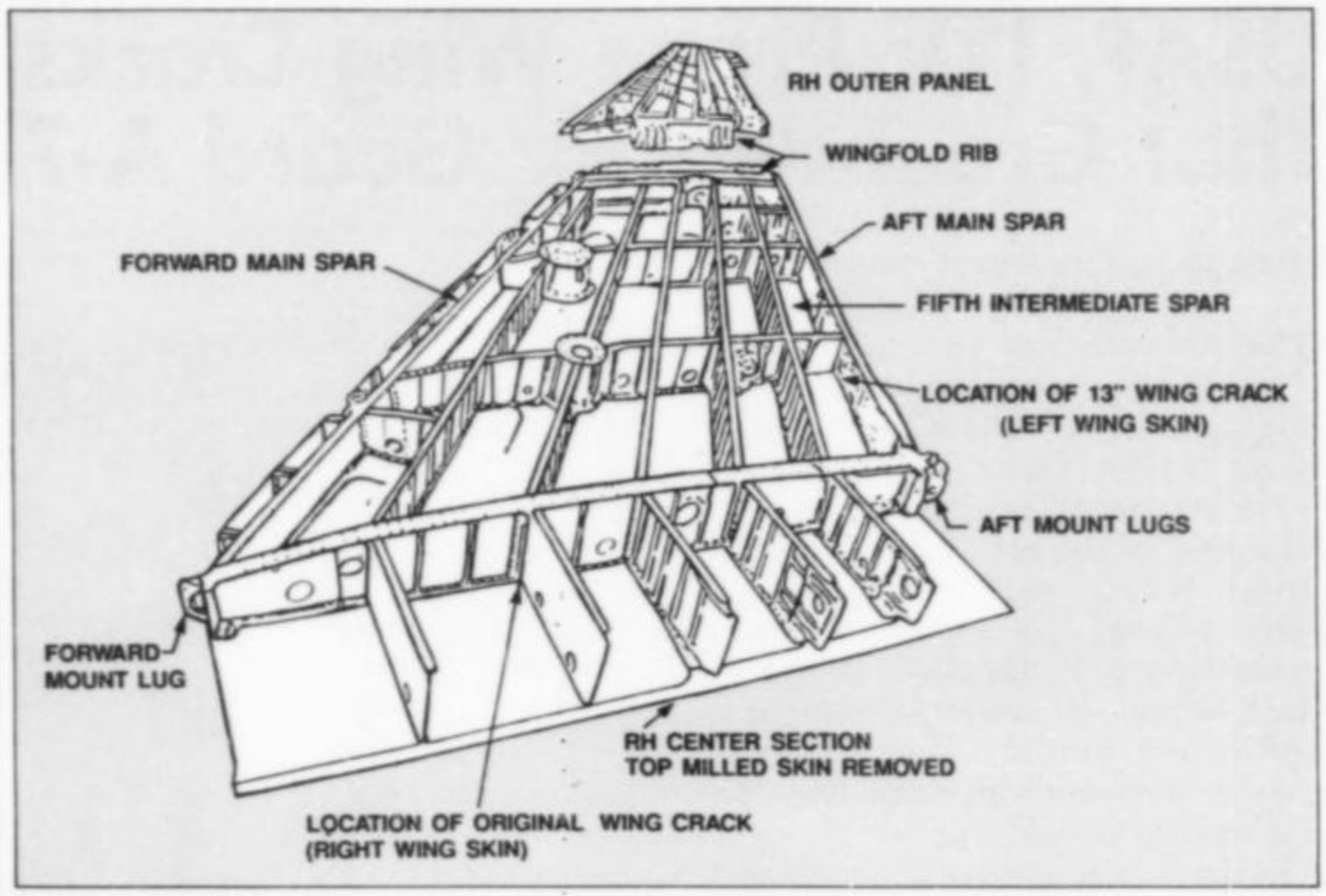
An Air Force official said aircraft with cracks larger than 0.060 in. will be repaired using a steel reinforcing strap. The strap will be installed along the trailing edge of the lower skin. Only two aircraft require new lower wing skins. That fix will cost about $110,000 per aircraft, the official said. No straps have been installed.

"From a safety standpoint, we have the problem covered," Yarbrough said. He said 95% of the affected A-7s can be . .turned to service using the current fixes, with "no effect on the flight envelope." But the Air Force currently is restricting all A-7s to +5g, when carrying symmetrical external loads, and +4g with asymmetrical loads.

Although the cracks are a flight safety problem, an Air Force official said, in time of war the A-7s "could fly, but with the limited g-load" imposed on them. The official said the restriction will remain in effect until more is known about the cause of the cracks.

An LTV official said the cracks "have no effect" on the company's A-7F program. The A-7F is an upgraded version of the A-7D. He said the wings of the two A-7F prototype aircraft already were equipped with strain gauges and other force measurement devices before the skin cracks appeared on the A-7D and A-7K aircraft.

As part of the planned flight test program, an A-7F will be used to document forces on the wing that could be causing the cracks. The Air Force wants to complete repairs by mid-July. The aircraft then will resume normal ASIP inspection intervals. □



Drawing of A-7D/K wing structure shows location of large cracks. A crack at the root rib of the right wing caused the crash of a New Mexico Air National Guard A-7D in December, 1988. A 13-in. crack near the wing trailing edge was found on an Arizona Guard A-7D in April.

Rolls-Royce Developing More Powerful Version Of Pegasus Engine for Third-Generation Harrier

BRISTOL, ENGLAND

Rolls-Royce has begun initial development of a more powerful version of its Pegasus vectored-thrust engine to power a third-generation subsonic Harrier STOVL aircraft. The engine manufacturer believes the new Harrier will be required in the mid-1990s.

The new version of the engine would provide about 3,000-4,000 lb. more thrust than the present Pegasus 11-61, the most powerful version now in existence. The Pegasus 11-61, rated at 23,800 lb. thrust, has not yet flown, but is scheduled to enter service with the U. S. Marine Corps in mid-1990.

Work on the new, as-yet undesignated version of the engine is being undertaken with the cooperation of both McDonnell Douglas and British Aerospace, which manufacture the Harrier aircraft in the U. S. and Britain, respectively.

The new version of the engine is being studied as the powerplant for a subsonic "Harrier 3" aircraft, which Rolls-Royce officials believe will be needed to bridge the gap between the current second-generation subsonic Harrier and the supersonic Advanced Short Takeoff/Vertical Landing (ASTOVL) aircraft which is anticipated in the first decade of the new century.

Brian Evans, head of Rolls-Royce's Pegasus program, said work on the new engine was being carried out with company funding and that the initial target date for service entry would be about 1996.

The modifications needed to provide the additional power would probably be done in two stages, he said. The first stage would involve qualifying the engine to operate at higher temperatures than it now can sustain. The second stage would be devoted to increasing the engine fan pressure ratio. This may involve adding a fourth stage to the present three-stage compressor, he said.

Increasing the thrust of the Pegasus to the 27,000-28,000-lb. range could open a number of new mission possibilities for an advanced subsonic Harrier design.

The current Pegasus 11-61 program has made possible the Harrier 2-Plus, which is capable of carrying a multimode radar and advanced weapon systems. These give it a multirole capability that earlier Harrier versions do not have.

Six nonflight versions of the Pegasus 11-61 are being tested at Rolls-Royce's military development center here and have completed nearly 900 hr. of testing.

Two flight-qualified engines have been completed. First flight is planned for June 9 in a modified British Aerospace/McDonnell Douglas Harrier GR. 5—British equivalent of the U. S. AV-8B.

After initial flight test work in Britain, the program for the engine will move to Edwards AFB, Calif., this October, when a second Harrier—an AV-8B—will be re-engined and flown by McDonnell Douglas personnel.

Production work on operational engines has started in Bristol, and delivery of the first of 40 Pegasus 11-61 engines to the U. S. Marines is scheduled for May, 1990. The engines are scheduled to become operational in the Night Attack version of the AV-8B in July, 1990.

Rolls-Royce is optimistic that other Harrier operators will adopt the Pegasus 11-61 for new or existing aircraft.

Prospective customers include the British Royal Air Force, which could retrofit the engine into its existing fleet of Harrier GR. 5 attack aircraft in the mid-1990s, and the British Royal Navy and the Indian navy, both of which operate British Aerospace Sea Harrier fighters. The Italian navy, which is negotiating for a carrier-borne Harrier version, wants the aircraft to have integral radar capability. □

House Defense Leader Attacks Air Force Plan to Add $1.4 Billion to B-1B Program

PATRICIA A. GILMARTIN/WASHINGTON

Key House defense lawmakers sharply questioned the merits of the Air Force's plan to spend an extra $1.4 billion to improve the penetrating capability of the B-1B bomber.

House Armed Services Committee Chairman Les Aspin (D.-Wis.) grilled a senior Air Force acquisition official last week on plans to upgrade the B-1B electronic countermeasure system in lieu of buying additional B-2 stealth bombers.

Lt. Gen. Ronald W. Yates, principal deputy assistant secretary for acquisition, said that the additional money needed to improve the penetrating capability of the fleet of 97 bombers would be a better investment than procuring several more B-2s.

But Aspin and other members of the procurement and military nuclear systems subcommittee, including Rep. Ike Skelton (D.-Mo.), were not convinced that pouring more money into the B-1B program is a prudent course in the tight budget environment.

During the hearing, Aspin maintained that the Air Force has not made the case for spending an additional $1.4 billion for a 25-30% improvement in penetrating capability for the B-1B, as the service brings along the B-2 bomber.

"I don't see how we can continue to fund the B-2 and pay this kind of money on the B-1 program," Aspin said. He warned Yates that full funding for the B-1B would "come back to haunt the B-2."

B-2 COST ESTIMATES

The fate of both programs may well hinge on the results of the review of escalating B-2 cost estimates ordered by Defense Secretary Richard B. Cheney, Aspin said (AW&ST May 1, p. 28). It is targeted for completion before the House Armed Services Committee drafts on its version of the defense budget.

Congressional concerns about the deficit have spilled over to other strategic programs. Last week, a House coalition moved to oppose all further funding for the Midgetman missile. Other movements are afoot to curtail the Strategic Defense Initiative and B-2 bomber program.

The bipartisan House group came out swinging against the Administration's plan to procure both the 10-warhead, rail-mobile MX missile and the one-warhead, truck-mobile Midgetman missile on grounds that the costs are too high.

The lawmakers, liberal Democrats as well as conservative Republicans, expressed differing views on whether to oppose funding for any new ICBM, either MX or Midgetman. But they were united in their view that the U. S. should not procure both missiles.

A "Dear Colleague" letter circulated by the group noted that the rail-garrison system would cost $5.4 billion to move existing missiles to rails and that Midgetman procurement could cost up to $24 billion.

The budget crisis makes moving ahead with both missiles unwise, Rep. Barney Frank (D.-Mass.) said. He was joined by fellow Democrats Jim Moody (Wis.), Martin Olav Sabo (Minn.), Lane Evans (Ill.), Edward Markey (Mass.) and Charles Stenholm (Tex.) as well as Republicans John G. Rowland (Conn.), Vin Weber (Minn.) and Andy Ireland (Fla.).

"The coalition that you see represented here today demonstrates that the MX-Midgetman tradeoff is a political compromise that lacks a political constituency," Markey said.

In a related move, two senior members of the Senate Armed Services Committee wrote to the chairman and ranking Republican on the committee to make clear that they strongly oppose deployment of the two missiles. In the letter, Sen. Carl Levin (D.-Mich.) and Sen. John McCain (R.-Ariz.) noted that most of their colleagues support one missile or the other but that few believe that the U. S. needs to proceed with both systems.

TWO-MISSILE PLAN

The two-missile plan would cost roughly $47 billion at a time when the U. S. faces a huge deficit and the Pentagon is confronting many years of level or declining budgets, the letter said.

The coalition movement has set the stage for a bitter battle over the Midgetman in the House Armed Services Committee, which plans to draft its version of the defense authorization bill next month. Committee leaders and their counterparts in the Senate backed the two-missile approach in negotiations with the White House.

But the House coalition claimed these committee leaders are out of touch with the majority of members and think they will prevail when the matter reaches the floor. Frank estimated that an amendment to kill the Midgetman during floor consideration of the defense authorization bill would garner upwards of 250 votes. □

USAF Works to Resolve Vibration Problems Encountered in F-15 Captive Carry Tests

WASHINGTON

The advanced medium-range air-to-air missile has had 76 successful firings in 95 tries, but the Air Force still must resolve vibration problems encountered in F-15 captive carry tests.

"It is clear that we need to make some fixes," Lt. Gen. Ronald W. Yates, Air Force principal deputy assistant secretary for acquisition, told members of the House Armed Services procurement and military nuclear systems subcommittee.

Excessive vibration is the lone remaining problem in the advanced medium-range air-to-air missile (AMRAAM) program, he said. The service hopes to resolve the problem before the full-rate production decision planned for September.

Yates said that F-15 captive carry tests showed that the vibration spectrum is high under certain conditions. The Air Force previously disclosed structural problems that were limited to the missile's carriage on the forward fuselage station (AW&ST Oct. 31, 1988, p. 31).

The performance of the missile and the test program has been "extremely solid," Yates said last week. Under questioning, he acknowledged that there have been software changes but said the Hughes/Raytheon missiles now incorporate the "final, full-up software."

A Defense Dept. report from the director of operational test and evaluation submitted to Congress earlier this year noted that the AMRAAM program is significantly behind its original schedule.

The unclassified version of the Fiscal 1988 report said that schedule delays reflect the risk involved in doing concurrent development tests and operational testing.

Missile reliability, multiple targets and software maturity are the major concerns for which corrections have been identified, but these remain to be tested, the report said.

The missile is intended to provide more firepower and combat utility than the AIM-7 Sparrow, which it is to replace. It also is being designed to reduce aircraft and aircrew vulnerability. □

French Equipment Industry

Mr. Savoyen, you are presently Chairman of the GIFAS Equipment Group, the union of French aeronautical and space industries. What is the present situation within your field?

Mr. Savoyen

After several hard years, we now have several real grounds for satisfaction. Perhaps the most encouraging is that in spite of the slump, French equipment manufacturers have reacted with renewed vitality and not only have succeeded in maintaining, but, in many cases, improving their positions.

We have been indeed faced with a host of problems: the plunge in the dollar against the franc and drastic contraction of defence contracts these last years, plus economy problems in countries that have always been our traditional customers. Solutions to these problems were not easy to find and to implement.

Improvements in production efficiency have been spectacular and have to some degree offset part of a more than 30 % penalty due to exchange rates. We have succeeded in maintaining our research and development level, an essential factor upon which the future of our industry depends. We have also penetrated new markets.

What is the difference between the activities of equipment manufacturers and the other branches of the aeronautical and space industry?

Mr. Savoyen

There is no really fundamental difference and neither our interests or policies are significantly divergent from those of the other branches. Of course, we do have our own particularities. The weak point of our profession is its great number of enterprises. Separately they are of course, less financially solid than the big airframe and engine manufacturers. That is a fundamental difference.

It must also be realized that the equipment industry has now grown well beyond simple instrumentation and accessories, its products during the earlier days. Today, it is within our industries that the technological breakthroughs are most frequently made. But at the same time, we are confronted with increasing research cost. Aircraft systems evoluate very rapidly, in fact, much faster than the aircraft themselves. During its existence each generation of fighter aircraft must be equipped with two, if not three entirely new systems if it is to remain competitive on the world marketplace. There is no lack of illustrations and this applies equally to old aircraft or the most recent, from the Jaguar to the F-16, Mirage, etc. It would not be an exaggeration to state that sooner or later, all military aircraft must be so updated.

"We are eager to prove our technological knowhow, our experience and our eagerness to cooperate"

In your opinion, is there something intrinsically French about the equipment industry?

Mr. Savoyen

Yes, I believe that the equipment manufacturers are strongly marked by the historical identity of the French aerospace industry as a whole.

This takes the form of a very high level of development, ascribable to a determination to safeguard national independence. It was the case during the post-war period, and still applies. We have systematically endeavoured to master all the basic technologies and this has given us a real head start in several fields.

Furthermore, we have always had to remain within price levels compatible with the size and requirements of our country. As in the past, this fact opens markets to us in countries whose needs are comparable with our own.

The situation has changed during the past decade. We are fully aware that we must move ahead. The level of technology and financial investments, for example, have become so high that enterprises must now be far bigger than previously to survive. This factor must be particularly stressed and considered. Many military or civil programs – notably, of course, the Airbus program – have been undertaken under European cooperation schemes. It is only logical that partner industries be represented in scale with the investments of their countries and that they be included in the cooperation scheme right from project level. But European preference has never won out over competitiveness, even where this has meant including non-European partners. American participation in the Airbus program remains very high and proves the point.

The French equipment industry certainly faces the same situation as its counterparts in other European, or even, American countries. But how can they adapt to the changes?

Mr. Savoyen

The truth is that each case is different and must be considered on its own merits.

As we have seen, the technological level and industrial capacity of the French equipment industry is very high compared to other European countries and it is already a leading exporter for France, with nearly 60 % of manufactured goods exported. Paradoxically, this fact has sometimes made it more difficult for us to establish European cooperation structures as our enterprises have often feared that they would be sharing expensively won knowhow with others.

Today it is obvious, however, that cooperation and

Everybody Needs Cooperation

pooled efforts have become absolutely necessary. It is now too expensive for any single enterprise, not to say single European country to finance basic technological research alone. Cooperation between equipment manufacturers and mergers are desirable for more than one reason, especially because through such associations, more consequential production units are formed offering more attractive economic advantages to customer nations.

French firms have certainly shown much vitality on this level and much reshuffling may be observed right in France. On the European level equipment manufacturers have established interesting mutual ties to cope with civil and military programs. In all programs we are witnessing the establishment of 2 way or 3 way partnerships to prepare tenders.

There are several shining examples of successful cooperation arrangements, notably the Airbus and Ariane. These are model programs for encouraging follow-up in this direction. Without cooperation these programs could never have succeeded.

Aside from direct applications, another goal is to establish a joint European fund for research in military technologies.

Could this lead to a kind of European integration and the formation of a new block capable of rivalling the United States ?

Mr. Savoyen

I do not believe there need ever be a question of rival blocks. European integration is imperative because it will lead to a more rational utilization of resources and facilities. This would, moreover, be in the interests of the entire Atlantic Alliance. If the much talked about "European Pillar" in the Alliance is to become a reality, the European armament industry will have to unite and become more powerful. At initial stages, priority would have to be given to European sources, if only to create powerful industrial entities, not systematically to compete against the large American groups, but rather, to become their partners. This would be necessary to improve balance in trans-Atlantic weapon exchanges.

Such balance would also have to be based on funding and investments abroad. Today, certain European countries seem to find it easier to obtain authorization from the US government for investing in the United States, than our French firms. All attempts by France to etablish armament investment in the United States are invariably confronted by a labyrinth of political and administrative red tape, both illogical and counter-productive.

How would an " Atlantic Partnership " policy apply in your field ?

Mr. Savoyen

Probably, by favoring multi-directional partnerships and joint equipment proposals for civil and military programs, as is already the case in Europe.

In more than one case, the United States might have chosen an already existing and already operational European weapon system, rather than investing huge sums to develop another. We have seen this happen. Perhaps it would be possible to trade systems to avoid redundant development costs to the interest of all concerned. This would simultaneously give a greater return on investment for already existing facilities. The idea is still embryonic, but worthy of serious thought.

You have mentioned a market for updating existing aircraft. How do you see this market and does it really exist ?

Mr. Savoyen

Indubitably it exists, and the reason is a mathematical apodict: the engines and airframes of fighter aircraft have very long life spans, whereas improvements in equipment come so rapidly and are so significant that aircraft still perfectly operational from shall we say, the "aerodynamic" aspect may be rendered completely obsolete as far as their weapon systems are concerned. Compare a modern aircraft with radar system for electronic countermeasures and navigation against an aircraft made only fifteen years ago. They are light years apart !

Updating is frequently inevitable if only from the economy point of view. This applies to all countries, even in Europe and United States.

To be sure, this is a new market with its specific requisites. Updating demands much experience and solid foundations if a true working patnership is to be established with the customer. The customer service involved is vast, extending from conception phase to integration and even flight testing. Training of customer personnel is yet another aspect that must not be forgotten. Individual economic situation must also be evaluated.

Is it possible to predict the proportion of updating systems against new programs ?

Mr. Savoyen

No realistic answer can really be given to that question. French equipment manufacturers have offered their customers invaluable experience, a full catalogue of equipment and the determination to cooperate. That is why we are present in all the most significant programs. All we can do is remain open and alert to customer requirements, but it is difficult to predict them.

Above all, I should like to stress how essential new programs are for our industry. A program such as the future fighter aircraft ACT/ACM, derived from the Rafale could prove a fabulous opportunity, because it will offer us the chance to develop new generations of more highly integrated, more efficient and more reliable equipment. It is in such projects only that new breakthroughs are made leading to the development of systems that are then proposed for aircraft updating.

The Airbus program, the future Franco-German offensive helicopter and their weapon systems are other programs in which we are eager to prove our technological knowhow, our experience and our eagerness to cooperate.

Do you see the future in an optimistic light ? Have the really difficult problems been solved ?

Mr. Savoyen

One thing is certain, and that is that we have indeed already vanquished some serious problems. I cannot talk of either optimism or pessimism, but rather, of dangers.

Dangers to be avoided involve such considerations as seeing technological Europe organize in a cahotic and inefficient manner. There is also the risk, often cited by our American counterparts, of European protectionism. This danger would easily be avoided if the American authorities opened the American market a bit more to European enterprise and approved joint mergers.

We must not forget that several important projects have been brought to successful conclusions when the determination to win was shared by all parties involved.

Interwiew by Mr. Richard NAZARETIAN-AFEIAN

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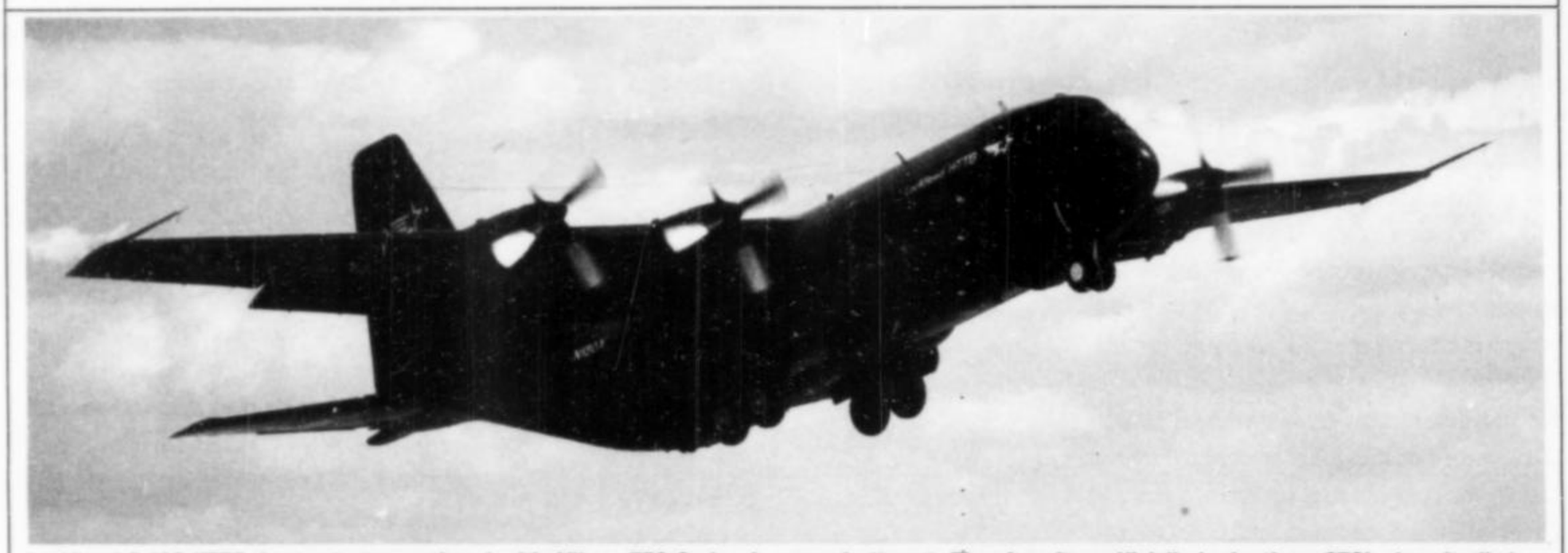
Future C-130 Version May Incorporate STOL Features and Autonomous Capability

WILLIAM B. SCOTT/PALMDALE, CALIF.



Lockheed C-130 HTTB demonstrator, equipped with Allison T56 Series 4 engines, is shown performing a STOL takeoff during a time-to-climb record attempt. The aircraft unofficially broke three STOL aircraft climb records and one weight-to-altitude mark on May 18 and 19.

New STOL-related performance and systems enhancements undergoing flight evaluations on a Lockheed C-130 testbed may be incorporated into a C-130J upgrade version now being formulated by the Air Force.

A future version of the C-130 workhorse is expected to feature larger, more efficient engines, high-sink-rate landing gear, a head-up display and electronic flight instruments. The USAF statement of need—now being drafted—is driven by a desire to reduce maintenance costs of the tactical airlifter fleet rather than by special operations requirements, according to industry officials.

For several years, military special operations force leaders have campaigned for an upgraded C-130 dedicated to airlift, but funding has never been available.

A Lockheed-owned High Technology Test Bed (HTTB) aircraft was scheduled to demonstrate the performance impact of new engines, airframe modifications and systems upgrades to senior USAF Military Airlift Command and special operations officials last week at Scott AFB, Ill. The planned demonstrations closely followed world-class time-to-climb and weight-to-altitude record attempts flown here on May 18 and 19.

Based on unofficial results, the HTTB eclipsed previous propeller-driven STOL aircraft climb records set by the same C-130 in 1985, and established a new mark for carrying the greatest weight to 2,000 meters altitude. Requirements set by the National Aeronautic Assn. and Federation Aeronautique Internationale for STOL aircraft dictated that takeoff and landing on both record attempts be performed in the same 500-meter block of runway. Review and certification of the records by NAA and FAI officials will take several months.

New Allison Gas Turbine T56 Series 4 engines, each capable of producing 5,250 hp., allowed the HTTB to take off and climb to an altitude of 3,000 meters in 3 min. 22.72 sec.; 6,000 meters in 7 min. 20.87 sec.; and 9,000 meters in 13 min. 20.31 sec., based on NAA observations. The modified C-130 carried more than 15,000 lb. of payload to 2,000 meters in about 3 min. Both record attempt flights started at the moment of brake release on the Palmdale airport runway.

The climb record flight was commanded by Frank D. Hadden, chief engineering test pilot for Lockheed Aeronautical Systems Co.-Georgia. Kenny Rooke, Lockheed project test pilot, flew the weight-to-altitude flight.

IMPROVED RELIABILITY FIGURES

The Allison powerplants will increase a standard C-130's rate of climb by 33%, range by 15% and cruise altitude by 22%, based on HTTB tests conducted so far. Greater efficiency and performance was obtained through increased compression, about 3% higher engine operating speed, higher operating temperatures and improved cooling, according to Lockheed and Allison officials. With new six-blade composite propellers now in development, the aircraft's reliability and maintainability figures are expected to improve significantly over current operational C-130s.

The Series 4 engines incorporate single-crystal blades in some turbine stages and ceramic technologies in the combustor section. This allows hotter internal operation, which promotes more efficient fuel burning and eliminates the characteristic C-130 smoke trail. By moving the temperature sensor to the turbine's cooler third stage, thermocouple life is extended.

The HTTB C-130 is an internal research and development effort funded by Lockheed with additional financial support provided by about 60 other companies that fly their new systems on the aircraft. More than $60 million has been invested in about 75 separate R&D projects since the program was initiated in the early 1980s, according to Chet Payne, division engineer for Lockheed's engineering flight test unit.

The program's current objectives are to develop the technologies necessary for a 130,000-lb. C-130 to make a tactical assault-type approach at 6-7 deg. glideslope, and land on a 1,500-ft. unimproved strip over a 50-ft. obstacle. This requires the approach to be flown at 80 kt., maintaining a 14-ft./sec. descent rate, and with no flare before touchdown to ensure pinpoint landings.

Simulator evaluations indicate that a properly equipped C-130 tailored for STOL operations may reduce landing footprints to about 2% of today's C-130s. Although the simulation model included crosswind components, it also assumed zero error in the guidance system. Consequently, real-world flight test results are expected to be less dramatic.

Besides the new Allison T56 engines, HTTB project managers are testing a number of systems and modifications that could enable a next-generation C-130 to meet STOL criteria. These include:

- Aerodynamic modifications such as wing spoiler panels; large dorsal and "horsal" surfaces extending forward from the

vertical fin and horizontal tail; extended-chord ailerons and rudder; powered control surfaces; fast-acting double-slotted flaps, and a fixed-droop wing leading edge. The curved leading edge device is not movable, yet reduces aircraft drag count and gives the best slow-speed performance of any configuration considered, Payne said.

■ High sink rate landing gear. The Menasco-built gear, with a 13-in. longer stroke than standard C-130 struts, is certified for 20-ft./sec. landings at 130,000 lb.

■ Digital flight control system (DFCS). Lockheed analyses determined that a digital system was needed to extend the C-130 flight envelope to the slow speed STOL regime and still ensure acceptable handling qualities. The primary control surfaces are driven through a complex system that mechanically sums pilot, stability augmentation and trim inputs. However, "tabs" added to the surfaces and driven by the DFCS will balance the main controls and provide a "get-home" fly-by-wire capability, according to Hugh Copeland, Lockheed HTTB flight test engineer. Three independent flight control computers, interconnected with fiber optic links, comprise a flight-critical system using fly-by-light technology.

■ An 8,000-psi. hydraulic system. In conjunction with E-Systems, the high-pressure system was designed to use nonflammable chlorotrifluoroethylene (CTFE), which is about 2.5 times heavier than Mil-Std-5606 or other hydraulic fluid. To offset the weight gain, the system pressure is increased from 3,000 to 8,000 psi., which dictates use of thick-walled titanium tubing. The HTTB has three independent high-pressure hydraulic systems that, combined, only use 9 gal. of fluid. The current installation is dedicated to only the fast-acting wing spoilers for test purposes. In addition, the main flight controls are powered by an independent, triple-redundant 3,000-lb. hydraulic system.

■ Autonomous guidance system. Under an Air Force Wright Aeronautics Laboratories contract, Lockheed and its partner firms are assessing autonomous landing guidance concepts based on a head-up display with Flir and other low-light system images projected on it. A Honeywell Mini-Flir and Flight Dynamics, Inc., HUD are being flown now, and a millimeter-wave radar imaging system may eventually be evaluated. Flight Dynamics modified the HTTB HUD to present a display tailored to STOL operations, which also accommodates both 525- and 875-line raster formats. The HUD with STOL approach guidance cues is considered one of the highest priority C-130 upgrades by special operations officials.

The digital flight control system was flown briefly last year with limited gain settings, and full-up flight testing is scheduled to begin this fall after simulator and ground verifications are completed. □

Brazil, China Form Space Launch Venture

EDWARD H. KOLCUM/COCOA BEACH, FLA.

Brazil's Avibras Aeroespacial and the China Great Wall Industry Corp. have formed a joint venture specializing in communications satellite launching, tracking and networking.

Called INSCOM, for International Satellite Communication, Ltd., the new company will combine the satellite launch vehicle experience of the People's Republic of China with Avibras' space tracking, international marketing and management knowledge.

Avibras is the major South American weapons exporter and has developed considerable expertise with a long list of customers for its gun, rocket and missile systems that it has been marketing since 1975. INSCOM said it will sell its products and services to governments and private enterprises worldwide.

China has three launch complexes. Brazil has an operational complex at Natal and is completing construction of another equatorial site. China has been searching for a launch site on the Equator for several years (AW&ST Aug. 24, 1987, p. 40).

Formal announcement of the joint venture along with details of INSCOM products and markets will be made June 15 at the Paris air show by Joao Verdi Carvalho Leite, Avibras board chairman, and U. Ke Li, vice chairman of China Great Wall. At that time, the two companies will say they will compete in the international market with:

■ Launch vehicles. China has three versions of the Long March launcher that Avibras will help market. Brazil's space agency, INPE, which stands for Instituto de Pesquisas Espacias, also is developing a satellite launch vehicle. The original plan was to devote this vehicle solely to domestic use. The new deal with China could open export markets. The launcher, called VLS for Veiculo Lancador de Satelites, does not compete with the Long March. VLS has a capability similar to the U. S. Scout. The four-stage solid propellant vehicle will put 250 lb. into a 460-mi. orbit, or 350 lb. into a 410-mi. orbit.

■ Launch facilities and services. INSCOM says it can adapt different launch facilities to specific mission requirements. Chinese launch facilities are at Xichang, 175 mi. east of the Burmese border; Jiquan in north central China, and a former ballistic missile test site 300 mi. southwest of Beijing (AW&ST July 13, 1987, p. 120). The Brazilian equatorial launch site is near Alcantara at 2 deg. 17 min. S. Lat., 44 deg. 23 min. W. Long. The Natal site is at 5 deg. 55 min. S. Lat., 35 deg. 10 min. W. Long. INSCOM said it is able to provide range network management and technical assistance, and to build ground networks including launch control centers and launch facilities.

■ Satellites. The company said it will offer "different kinds of satellites featuring several advanced technologies, for operations ranging from communications to remote sensing." In a company brochure, INSCOM lists Great Wall communications and navigation satellites and a space physics analyzer.

■ Earth stations and antennas. This is an area in which Avibras has strong experience. The company developed the Ansat-10, a 10-meter satellite communications antenna for Telebras, Brazil's national telecommunications agency, and a military version of the antenna for the Brazilian armed forces general staff (EMFA) as a relay for the military satellite communications system.

China has been attempting to establish a presence in South America for several years. Brazil and China came close to several aerospace agreements two years ago when a Chinese delegation offered Brazil 110 Shenyang F-7s, which are copies of the Soviet MiG-21. The Brazilian air force and airframe industry opposed the plan, and it has been dormant for the last 18 months. □

Launcher, satellite and tracking system are depicted on the logo of INSCOM, the new joint venture that will market these space services.

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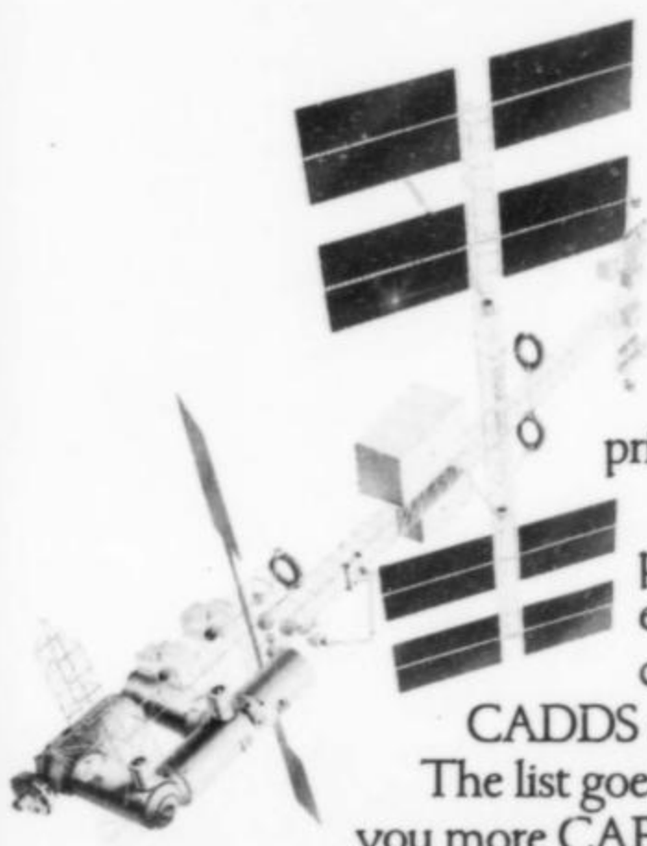

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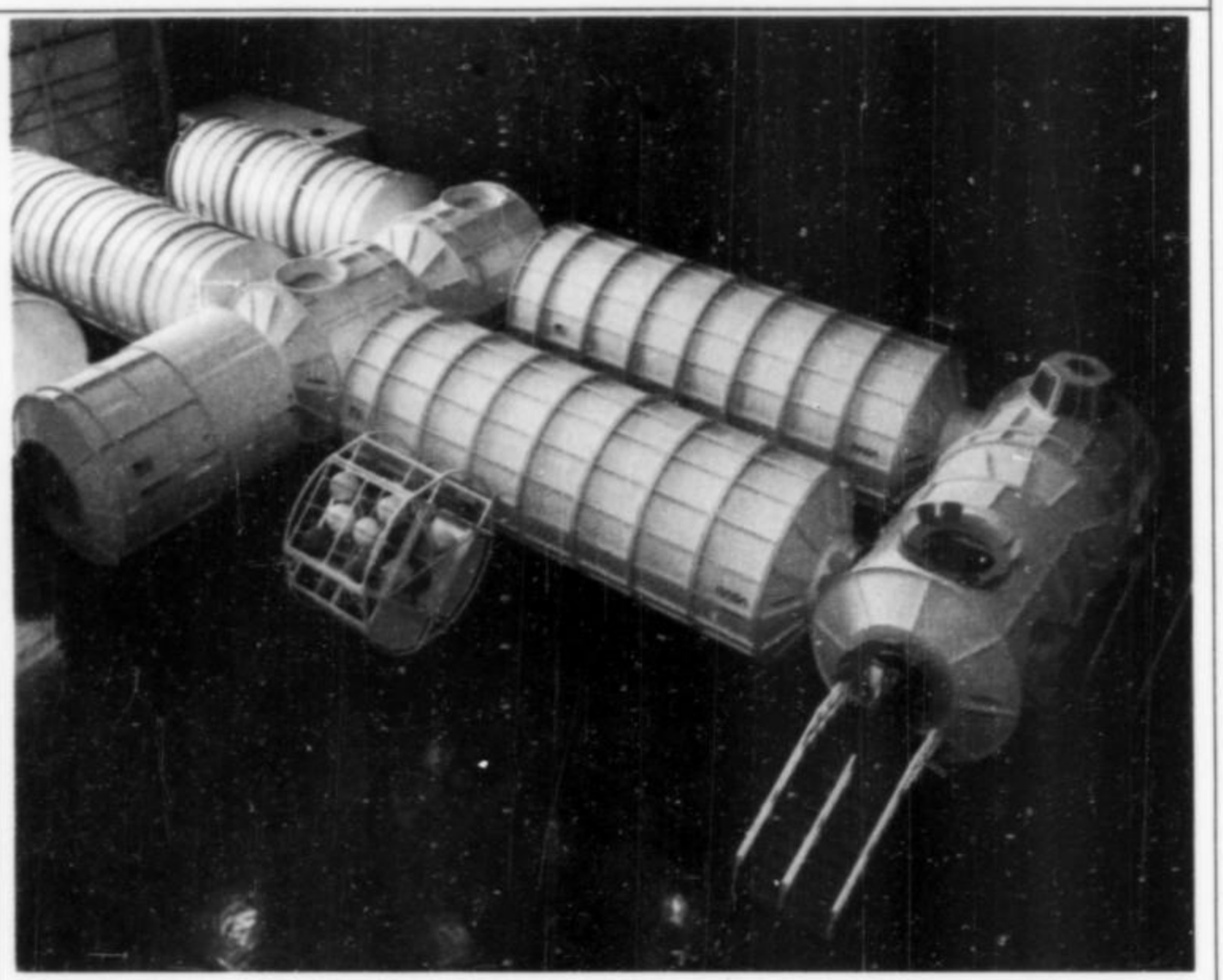
NASA Space Station Faces Scale-Down As Budget, Technical Realities Emerge

THERESA M. FOLEY/WASHINGTON

Unrelieved budget threats and doubts about whether the space shuttle could launch the station as currently designed are forcing NASA's new management team to consider once again down scaling the system.

NASA's space station program has entered a crucial period in which its newly appointed senior management team must contend with budgetary and technical problems inherited from the previous administration. The manned platform is unlikely to survive the transition in its current shape or size, although it may be midsummer or later before changes are identified.



Space station pressurized module mockups are laid out here in their latest configuration at Marshall Space Flight Center. In the mockup, designed by Boeing Aerospace, the U. S. laboratory (front) and habitat (rear) modules in the foreground are full scale, 43 ft. long by 14.5 ft. in diameter. Four smaller nodes connect the modules. The shorter Japanese experiment module and, to its left, the European Space Agency Columbus module, are in the background. A pressurized logistics container and an unpressurized fluids carrier are mounted on the station.

TECHNICAL ISSUES

Many NASA and industry officials expect the station to be scaled back during the coming months. Technical issues that have lingered for years are compounding the station's budget trouble. Several of the issues have resurfaced, renewing long-standing concerns about the station's design.

"I don't expect to see anyone throw out the design altogether, but I would not be surprised to see changes made," Samuel Keller, NASA's deputy associate administrator, said. "In any big system, there are compromises that can be made. I would guess that down scaling will be done."

But E. Ray Tanner, station program director, said his staff is not working with scaled-down configurations or planning to defer station elements to save money. The program office will focus solely on the approved configuration until directed to make changes by NASA headquarters, he said. Tanner refuted assertions by other NASA and industry officials that the current station design is not fully compatible with the space shuttle. A congressional decision not to fund the station fully could force a reduction in size, he conceded, but "I'm not working a down-scaled configuration. That is not a done deal."

The station program office has recommended that the assembly sequence for the station be changed. Tanner said the change would mean that the station would no longer be able to maneuver independently during the first three flights of the assembly sequence. Instead, it would be "totally passive," without the ability to control its attitude or adjust its flight path.

Repackaging of the space station into smaller sections for launch also may be required. The station payload weight may have to be shifted toward the rear of the shuttle cargo bay to be properly aligned with the center of gravity of the vehicle. Tanner said this is a "peripheral issue" that is not driving the station to a design change. But another NASA official said the center of gravity issue is a concern and could contribute to the need to alter the station plan. Changing station packaging to accommodate it could require more launches for deployment and increased on-orbit assembly work.

Another problem involves the pressurized modules, which, when loaded with user equipment, are too heavy for the shuttle to launch. A shuttle flight was added last year to carry equipment that could not be launched in the modules because of weight restrictions. But the problem persists, a NASA official said.

The amount of equipment that can be loaded into the modules for launch has fluctuated from month to month, Tanner said. In some reviews, the situation looks disastrous. But in others, it is acceptable, he said. The current weight numbers are estimates and will not be more precise for another year, when the station's preliminary design review is complete.

The severity of the weight and center of gravity issues is a matter of debate. NASA has planned the station launch based on the shuttle lift capability with the current redesigned solid rocket motor. But that booster, built by Morton Thiokol, will be replaced by an improved motor prior to station deployment.

The advanced solid rocket motor would add 12,000-14,000 lb. of payload capability for some shuttle flights, beginning in 1994. NASA selected a Lockheed/Aerojet team to develop the new motor several weeks ago. If NASA officials base the station launch plan on use of the advanced motor, the module weight problem would be solved, a Lockheed official said. The advanced motor also would help with the shuttle assembly sequence issues.

INCREASE PROGRAM RISK

But NASA managers have refused in the past to base the station design on unavailable launch vehicles and systems. If that policy were dropped, NASA could decide to leave the station design as is, counting on the new motor to be ready in time. But this approach would increase program risk by tying the station schedule to the

successful, on-time development of the advanced motor.

Another way to shrink the station would be to build one pressurized module at a time, instead of two simultaneously. The laboratory module could be built first, followed by the living quarters, when more money is available, according to a station contractor. This alternative would save money in the near term, but cost more in the end and anger the international partners in the meantime, he said.

Reducing the space station to a much smaller, simpler facility is another option. If a less expensive design were chosen, NASA could divert some station money to the development of a Shuttle-C unmanned heavy lift vehicle. In addition to technical concerns, space station users continue to question the adequacy of the design.

Microgravity scientists are uncertain that the space station design will meet their needs. Scientists in Huntsville, Ala., have developed new computer codes to simulate microgravity conditions on the station, as it has been designed. Preliminary analysis has renewed scientists' worries that certain station elements could ruin the microgravity environment for extended periods. The large trusswork, massive power system appendages and extended daily crew exercise periods would create perturbations that could ruin some experiments.

Robert Naumann, NASA project scientist for the Marshall Space Flight Center station work package, said the ability of the station to meet the microgravity criteria will be reviewed in early June. The issue is being worked out between space scientists and station officials, he said.

The station dilemma has become a top priority for the new senior management team put in place by NASA Acting Administrator Richard H. Truly. Truly's aides have adopted the philosophy that reducing the station's content is preferable to slipping the schedule if funds are insufficient. They also are demanding that station managers produce a design that can, without question, be launched on the shuttle. William Lenoir, the former astronaut named to head the station program beginning in June, called for a realistic approach to the funding situation. The station may have to be built "a piece at a time," he said.

The NASA Management Council met May 18-19 to review technical changes recommended following an audit by the station project office in Reston, Va. No decision was reached on the recommendation to adopt solar dynamic power for the station or other issues (AW&ST May 15, p. 28). Instead the council called for additional study.

New political problems for the station also are on the horizon. Truly has begun to review agreements made by earlier NASA officials with Congress and the Administration. If he deems the prior agreements unreasonable or unduly burdensome, they will not be honored, according to NASA and industry officials.

"Truly wants to streamline the agency and make it efficient. He is willing to take on the political consequences" of breaking or renegotiating agreements, a NASA official said.

But Keller said the review was merely to assess NASA's external commitments and that there is no intent to break any agreements.

Commitments made to Congress by earlier NASA officials included a guarantee that the space station would have early scientific utility, the establishment of mandatory power levels for man-tended and permanently manned operations, and assured early launch of the Flight Telero-

Interior of the station laboratory mockup includes experiment racks that can be pulled out for servicing, as the technician here is doing. Behind him is a small maintenance and repair shop. The laboratory would have stowage lockers above and below the rack areas on the walls.

Interior of the U. S. habitat module has separate areas for sleeping and other activities. Astronauts would cook, exercise and perform other duties in the active zone, shown as arranged in the full-scale mockup at Marshall. Cross country skiing and rowing machines are visible.

botic Services. The House and Senate Appropriations subcommittees are likely to hold up work on NASA spending bills until their questions on the direction of station are answered.

Station development requires about $5 billion in the next two years. Another $5 billion-plus per year is needed to operate the shuttle. Together they consume $7-8 billion of NASA's $13.3-billion budget, leaving little margin for other programs—particularly if Congress trims the 1990 budget, as expected. "The station is in deep trouble on the Hill," a NASA official said, predicting that the agency will get only $12-12.5 billion for Fiscal 1990.

NASA has informed Congress that the contemplated reduction in station spending of $400 million for Fiscal 1990 would interfere with its ability to meet its obligations to its oversight committees.

In a recent letter to the Senate Appropriations subcommittee with NASA oversight, the agency identified areas that could be eliminated to meet a budget reduction. Early capability to use robotics and perform useful science, promised by NASA to the House Appropriations Committee, would be deferred. The attached payloads and the polar platform would be delayed for a year.

Planning for operating and using the station would be delayed, although higher operating cost and expensive design changes could result. Reduction of management integration and support would be cut, increasing the risk that program elements will not work together properly. □

Galileo Spacecraft Undergoes System Checks at NASA Facility

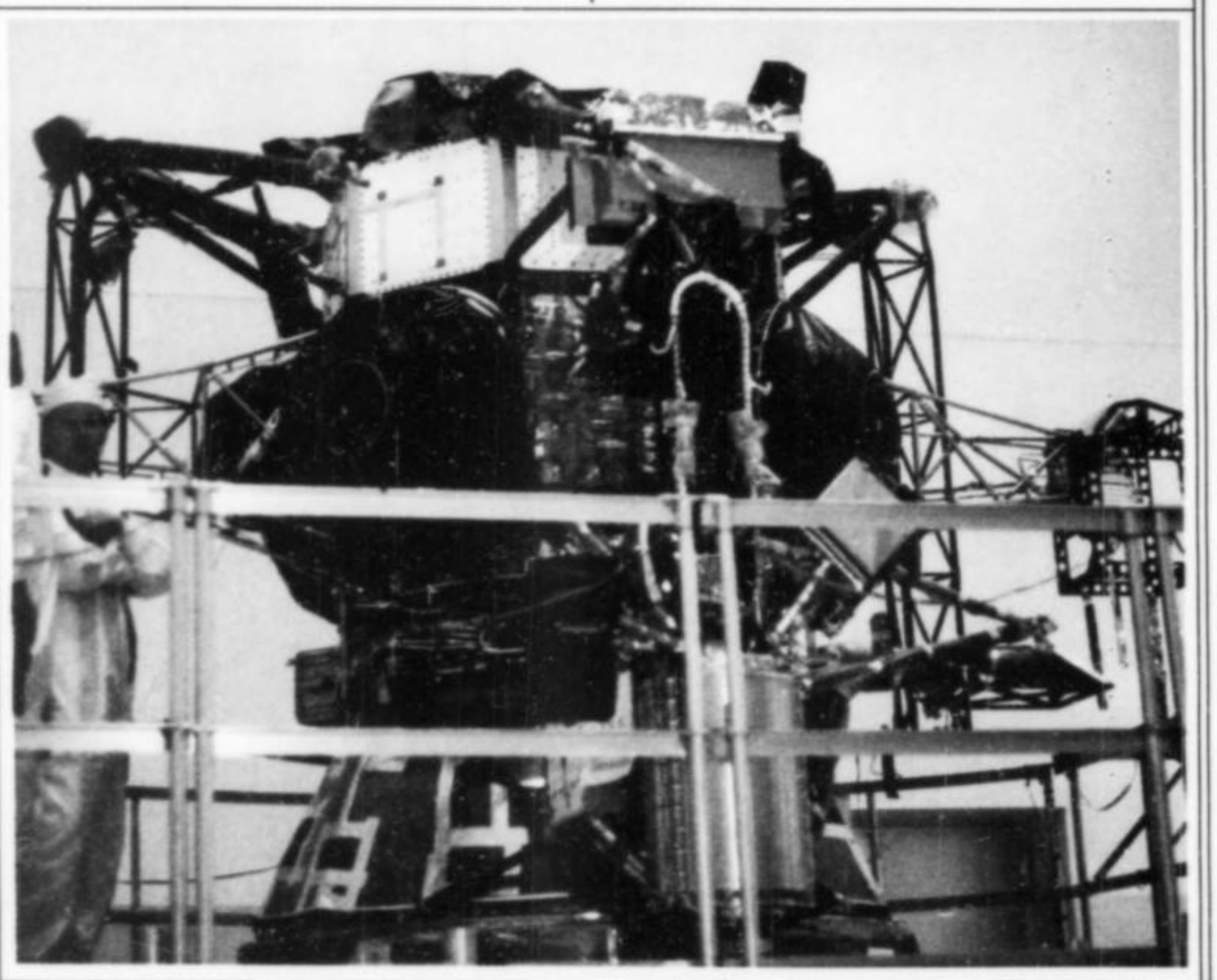
KENNEDY SPACE CENTER

The Galileo Jupiter probe is undergoing initial preparation for launch at the spacecraft assembly and encapsulation facility (SAEF) here following shipment earlier this month from Jet Propulsion Laboratory. The spacecraft and associated systems arrived here in a truck convoy May 16.

Launch is scheduled Oct. 12 in the payload bay of the orbiter Atlantis on space shuttle Mission 34. Galileo will be sent on its flight path by a Boeing Inertial Upper Stage, and the flight will rely on the gravity of Venus and Earth to increase spacecraft kinetic energy enough to reach Jupiter.

The spacecraft consists of an orbiter with 11 experiments, weighing nearly 6,000 lb., and a 750-lb. probe with six experiments. The orbiter has a magnetometer that will be deployed at the end of a 36-ft. boom. Orbiter and probe will separate about 150 days before the Jupiter encounter, which is scheduled late in 1995.

The orbiter will make 10 revolutions of Jupiter in its primary mission and will fly close to one of Jupiter's large satellites on each orbit. En route to the planet, the orbiter will fly by the satellite Io. The probe will enter the Jovian atmosphere at about 5 deg. N. Lat., and scientists hope its instruments will operate for an hour. The German Ministry of Technology is joining with NASA in the project. □



USAF Assessing Liftoff Failure Of Delta 2 Vehicle

CAPE CANAVERAL

The Air Force is assessing the impact of the failure of a McDonnell Douglas Delta 2 to lift off on May 24 with a Global Positioning System satellite. Engineers believe the problem will be traced to malfunctioning ground equipment.

Another try to orbit the second Delta 2 with the second Rockwell Navstar/GPS is expected this week as the Air Force moves to clear a growing backlog of spacecraft awaiting launch here. If the vehicle is launched this week, the schedule impact on the Eastern Test Range will be minimal. A Martin Marietta Titan 4 and a Delta with an Indian satellite are next in line awaiting the GPS launch.

The first GPS spacecraft was orbited Feb. 14 and the Air Force hoped to launch a full constellation of 21 of these advanced navigation satellites at the rate of one every 60 days. Col. Marty T. Runkle, GPS program director, said the first spacecraft "is performing perfectly."

The bulb shape of the GPS payload fairing caused high vibrations in the first Delta 2 launch. Lt. Col. Lee Holljes, deputy medium launch vehicle program director, said the vibration energy is being reduced with adhesive-backed aluminum material that has been attached to the lower part of the fairing structure.

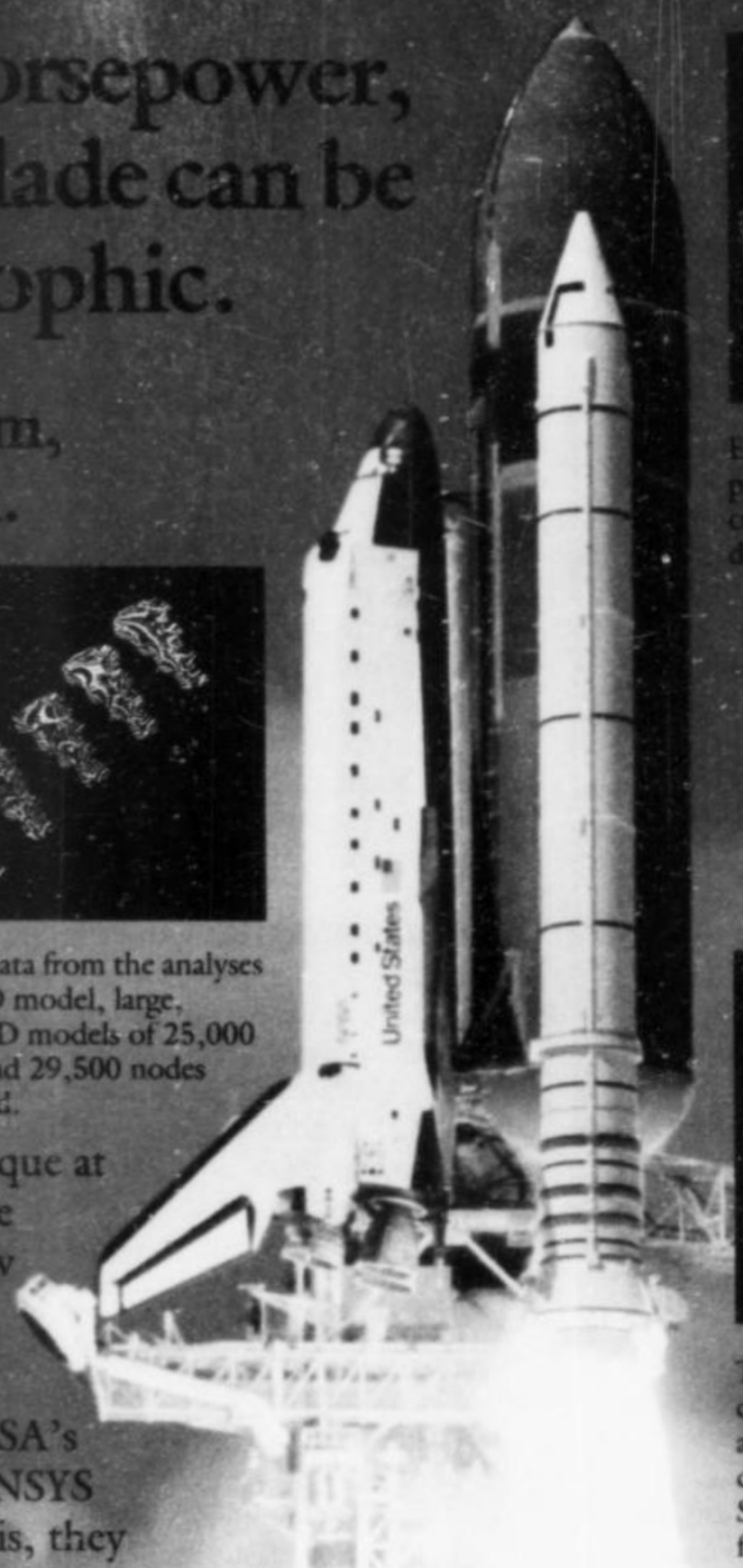
In the attempt last week, the engine controller shut down the system before main engine ignition when the liquid oxygen valve failed to open. Fire spewed from the Vernier engines and the engine controller immediately shut them down when launch pressure failed to build up in the engine chamber. Engineers at first thought the main liquid oxygen control solenoid had failed, but as the investigation progressed the day after the incident, the fault was considered more likely in aerospace ground equipment where moisture could have affected connectors or circuits.

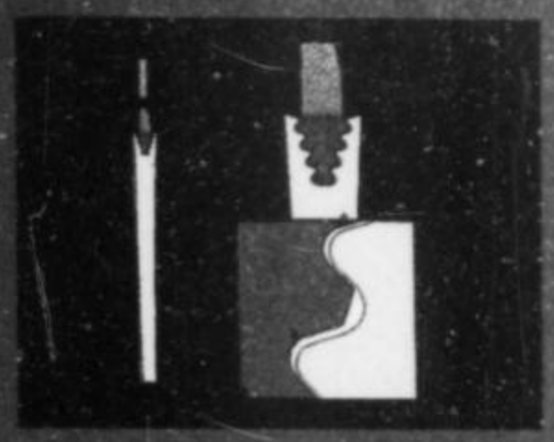
If ground equipment is at fault, the only work will involve cleaning the Verniers and checking consumables and batteries, which should take only a few days.

Lt. Col. Robert Tayloe, launch director, said the vehicle was safed within 1.5 min. after engine shutdown, and that at no time was there a hazard on the pad. He said the main engine sequencer began engine start events 2.3 sec. before liftoff as programmed. Within the next 2.5 sec., engine pressure is supposed to reach 95% of liftoff value, at which time the solid motors are to ignite. In the attempt last week, because there was no liquid oxygen flow, the pressure meters failed to register, which resulted in the shutdown. □

At nearly 74,000 horsepower, a cracked turbine blade can be potentially catastrophic.

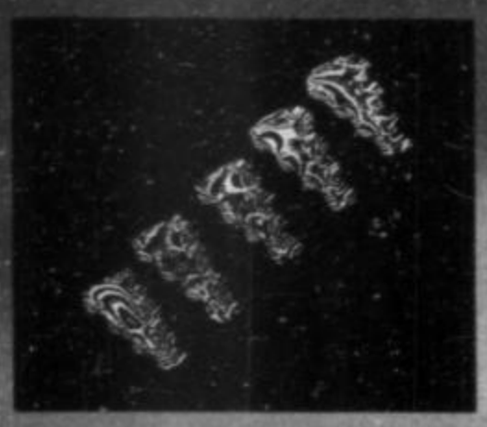
Using the ANSYS® program, NASA eliminated that risk.





Engineers at NASA used the ANSYS program to determine the causes of cracks in turbine blades and to find design solutions to eliminate them.

Turbine blades crack. Some of these cracks are benign, others reduced or eliminated by design. A few, however, grow with every engine test and threaten the safe operating life of the blades.



Using the data from the analyses of their 2-D model, large, complex 3-D models of 25,000 elements and 29,500 nodes were created.

You don't have to be an aerospace engineer to appreciate the strain on turbine blades attached to a rotor spinning at 36,595 rpm, with an airfoil generating 126,000 in-lb torque at 1540°F. Now consider having to determine what causes the cracks in these blades. How can you redesign the blades to produce a positive margin against the cracking?

This is the task that fell to engineers at NASA's Marshall Space Flight Center. Using the ANSYS program (ANSYS) for finite element analysis, they solved the problem.

They were able to show how a crack could occur, thus providing an analytical basis for the engineering changes to the design of the Space Shuttle's main engine, high pressure fuel turbopump turbine blade.

The results of the analysis with ANSYS showed that the original blade design would indeed crack. And that their proposed fix would not. 10,000 seconds of test firings confirmed the ANSYS predictions; they had a new turbine blade design that they were confident to use in the next launch.

Engineers cite the ANSYS program's ease of use,

> *With the ANSYS postprocessor, the engineers at NASA produced graphs, reports and 3-D plots so management could easily understand the results of the analyses.*

ability to handle large problems,

> *NASA's 3-D turbine blade model had 17,500 nodes and 15,000 elements, the rotor had 12,000 nodes and 10,000 elements, and they used 750 gap elements to tie the two together.*

and support

> *Training and hotline support were critical. With a new kind of problem, a new FEA program and a new computer, NASA relied heavily on their ANSYS Support Distributor, Impell Corporation (Norcross, GA), for expert advice.*

as the deciding factors to use ANSYS.

The ANSYS program for finite element analysis: it played an important role in returning the Space Shuttle to safe flight status. And it's giving companies around the world a new competitive edge in their markets.

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Circle 24 on Reader Card

NTSB Report Says Safety Diminished At Coast Tracon

WASHINGTON

A National Transportation Safety Board report charges that the FAA's air traffic control system in southern California has deficiencies that diminish the level of safety.

The report criticized the Federal Aviation Administration for "inadequate, ineffective" management of the system. It singled out problems with the Coast Terminal Radar Approach Control (Tracon) facility at MCAS El Toro, centering on operational errors committed by controllers there.

Since March, 1988, controllers at the Coast Tracon have recorded nine violations. The eighth occurred on Feb. 13, when a controller allowed two air transports to pass within 2 mi. of each other instead of the required 5-mi. interval. The ninth error occurred Apr. 6, when two large aircraft were allowed to violate vertical and horizontal separation standards.

The safety board also pointed out that since Dec. 31, 1988, the rate of operational errors at the Coast Tracon has been "substantially higher" than at other U. S. air traffic control radar facilities with similar traffic volume. The Coast Tracon provides approach control service for El Toro and MCAS Tustin, the Los Alamitos Army Airfield and John Wayne, Long Beach and Fullerton airports. The facility is rated as a "high activity" site and handles many aircraft operating under instrument flight rules.

The report said "inattention to duty" caused five of the eight operational errors. Three of the incidents involved controllers with less than eight months experience at the facility. Two errors were attributed to lack of proper coordination between the Tracon and other FAA facilities in southern California.

Staffing was cited as the "most critical problem" affecting Coast Tracon's performance, according to the safety board. It said inexperienced controllers frequently work high-activity radar positions. Six-day workweeks and mandatory overtime are commonplace, and the high rate of sick leave is "abnormal."

The report said these and other staffing problems "have existed for several years" at Coast Tracon and that the FAA had documented them. Controllers told the safety board that the 33 × 35 ft. radar room has an inadequate ventilation system, poor heating and cooling, and is too small. The safety board recommends that the FAA increase staffing and review major changes to the airspace structure to reduce controller work load. □

NEWS BRIEFS

FIRST FLIGHT of the Air Force/McDonnell Douglas C-17 aircraft could be delayed by four months, according to a senior Air Force official. Lt. Gen. Ronald W. Yates, principal deputy assistant secretary for acquisition, told members of Congress last week that, while it is not "a fait accompli," a slip in the planned first flight in August to December, 1990, could nonetheless occur. No delays are foreseen in the delivery of the first aircraft or in attaining operational capability.

INDIA HAS COMPLETED the first successful launch of its 2,400-km.-range. two-stage Agni ballistic missile on a flight designed to test the missile's guidance system. The missile was launched from the new Balasore test center in eastern India (AW&ST May 26, 1986, p. 93). It is believed to have traveled a distance considerably less than its maximum range. The launch was postponed several times over the past eight months for technical reasons. The missile is believed to be capable of carrying either a conventional or nuclear warhead.

TURKISH GOVERNMENT has agreed to return a Soviet air force MiG-29 after it was flown to Turkey by a defecting pilot. The aircraft was fully armed with missiles and ammunition for its 30-mm. gun when it arrived in Turkey. The pilot has asked for political asylum in Turkey. Both he and at least one Soviet air base guard were wounded and the aircraft damaged by gunfire during the successful defection attempt.

REP. TOM LEWIS (R.-Fla.) has introduced a bill to require the Air Force to fund WC-130 hurricane reconnaissance aircraft for another five years. The Air Force has agreed to fund the aircraft for one year, using reservists flying out of Keesler AFB, Miss. Lewis and other Gulf and Atlantic coast legislators say the aircraft are an essential supplement to satellites for hurricane tracking. Lewis estimates their annual cost at about $12 million.

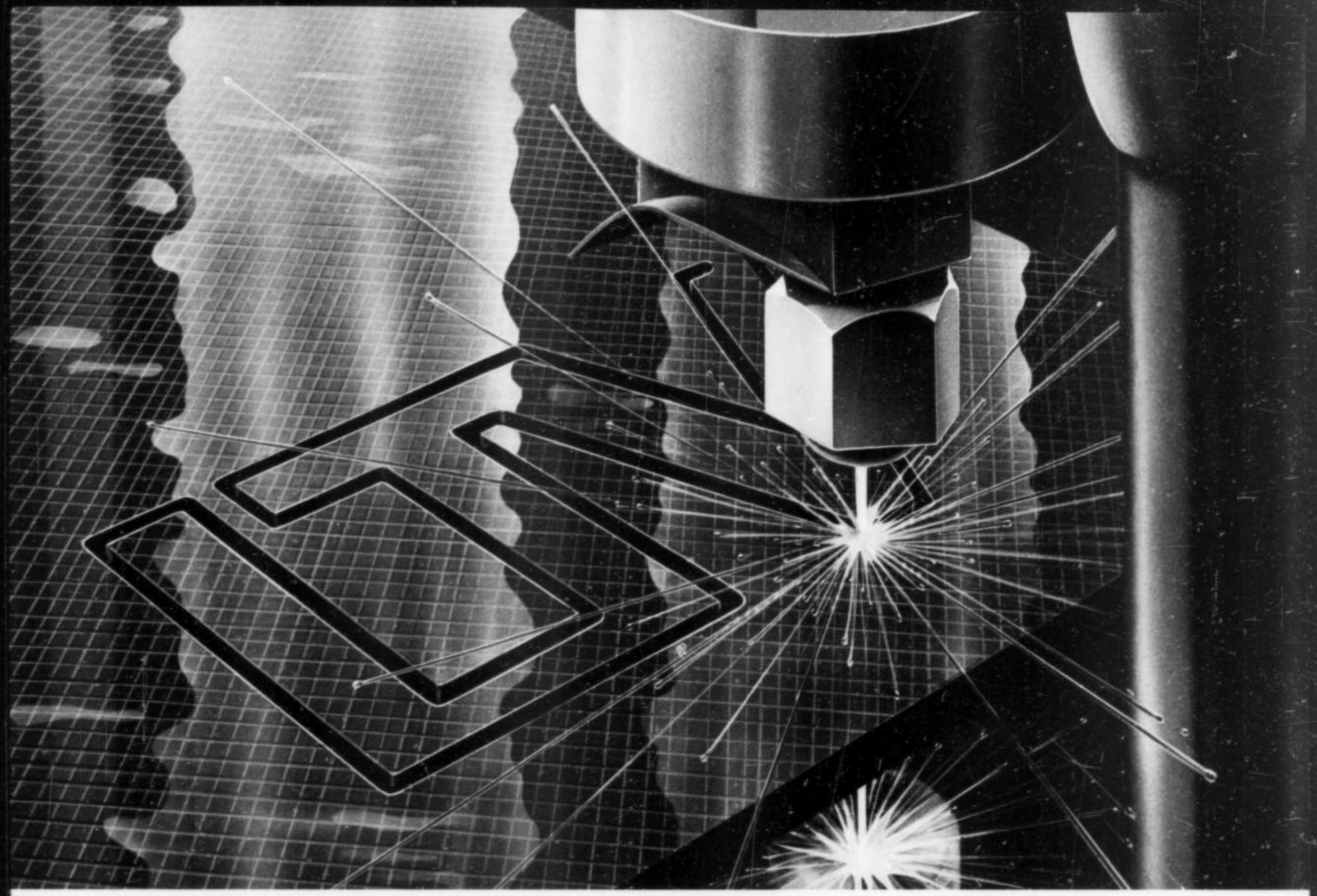
NASA last week rejected a bid protest filed by Hercules over the award of the Advanced Solid Rocket Motor contract to Lockheed and Aerojet. The denial cleared the way for Marshall Space Flight Center officials to begin contract negotiations with the Lockheed team (AW&ST May 1, p. 31). The complaint involved NASA's decision to restrict the best and final offer segment of the bid evaluation, an industry official said. NASA did so because some of the pages in a copy of the Lockheed/Aerojet proposal turned up missing in the midst of the procurement. NASA restricted the final offer segment to prevent unfair competition in areas pertaining to the missing pages, he said. Hercules can appeal the denial with the General Accounting Office, which could delay the procurement a second time.

THE MAGELLAN SPACECRAFT successfully performed a trajectory correction maneuver May 21 by firing four of its eight 100-lb. thrusters. The maneuver—conducted to increase velocity and slightly change the spacecraft's trajectory—was one of three planned maneuvers during its 15-month voyage to Venus. The next maneuver is scheduled for late December and the final change 17 days before the spacecraft goes into orbit around Venus Aug. 10, 1990.

OMAC, INC., has filed plans for reorganization, but it lacks adequate financing to complete certification of the Laser 300 aircraft. A hearing on the reorganization has been scheduled for July 1 in U. S. Bankruptcy Court in Reno, Nev. OMAC filed for protection under Chapter 11 of the U. S. Bankruptcy Code to delay foreclosure proceedings against the company's manufacturing facility in Albany, Ga. (AW&ST Mar. 13, p. 25). David J. Rooney, national sales manager for OMAC, said, "it remains to be seen if OMAC will continue to do business in Albany." He said the prototype Laser 300, which was flown out of Albany in March may return next week. He said the aircraft could resume certification flight tests this summer if reorganization plans are approved and additional financing is secured.

INDONESIA'S IPTN has won FAA airworthiness certification for its domestically built CN-235 transport. The 35-seat twin turboprop is built as part of a production agreement with Spain's Construcciones Aeronauticas S. A. (CASA). The IPTN-built aircraft will be used by domestic airlines and is being marketed internationally.

FORMOSA AIRLINES of Taiwan has ordered one Short Bros. SD360-300 and taken an option on a second for use on routes between Taiwan and nearby islands. The sale brings the total number of Short Bros. 360 aircraft sold world-wide to 150. □



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L T V : L O O K I N G A H E A D

Modified F-15B to Demonstrate STOL, Maneuver Capability

STANLEY W. KANDEBO/NEW YORK

The U.S. Air Force has begun test flights of an F-15B technology demonstrator that could have a substantial influence on future fighter aircraft design and performance.

The aircraft, designated the STOL/Maneuver Technology Demonstrator (S/MTD), incorporates canards; a four channel, digital fly-by-wire, integrated flight/propulsion control system; modified rough field landing gear, and advanced cockpit controls and displays based on those found in the F-15E. The aircraft also is fitted with two Pratt & Whitney-developed two-dimensional thrust-vectoring/thrust-reversing engine nozzles.

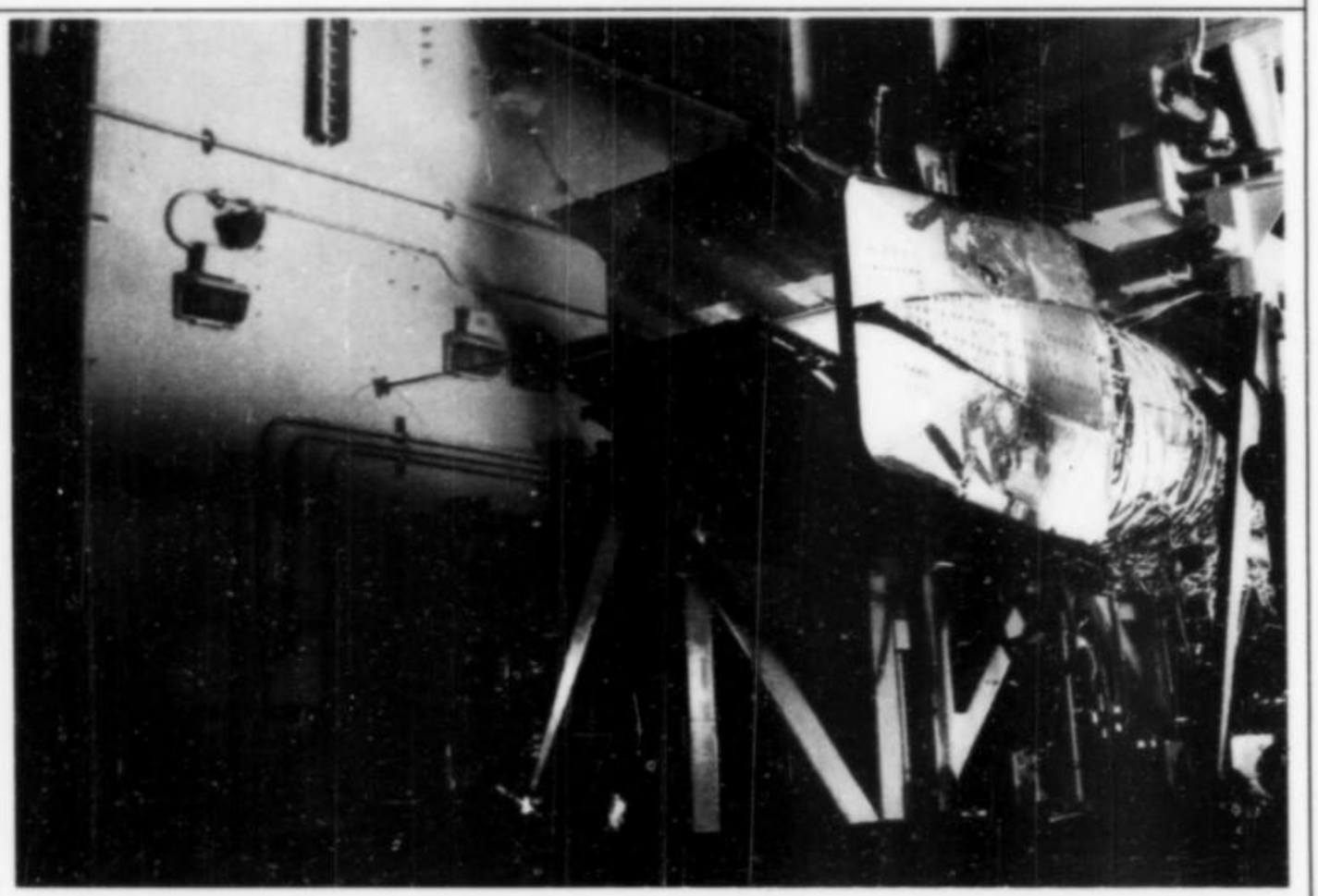
The baseline F-15B used in the program was modified by McDonnell Douglas' St. Louis-based McDonnell Aircraft Div. to land on 50 × 1,500 ft. runways in night or adverse weather conditions (200-ft. ceiling, ½-mi. visibility) in a 30-kt. crosswind. The S/MTD is expected to achieve this performance carrying standard F-15 internal and external fuel loads (AW&ST June 20, 1988, p. 107).

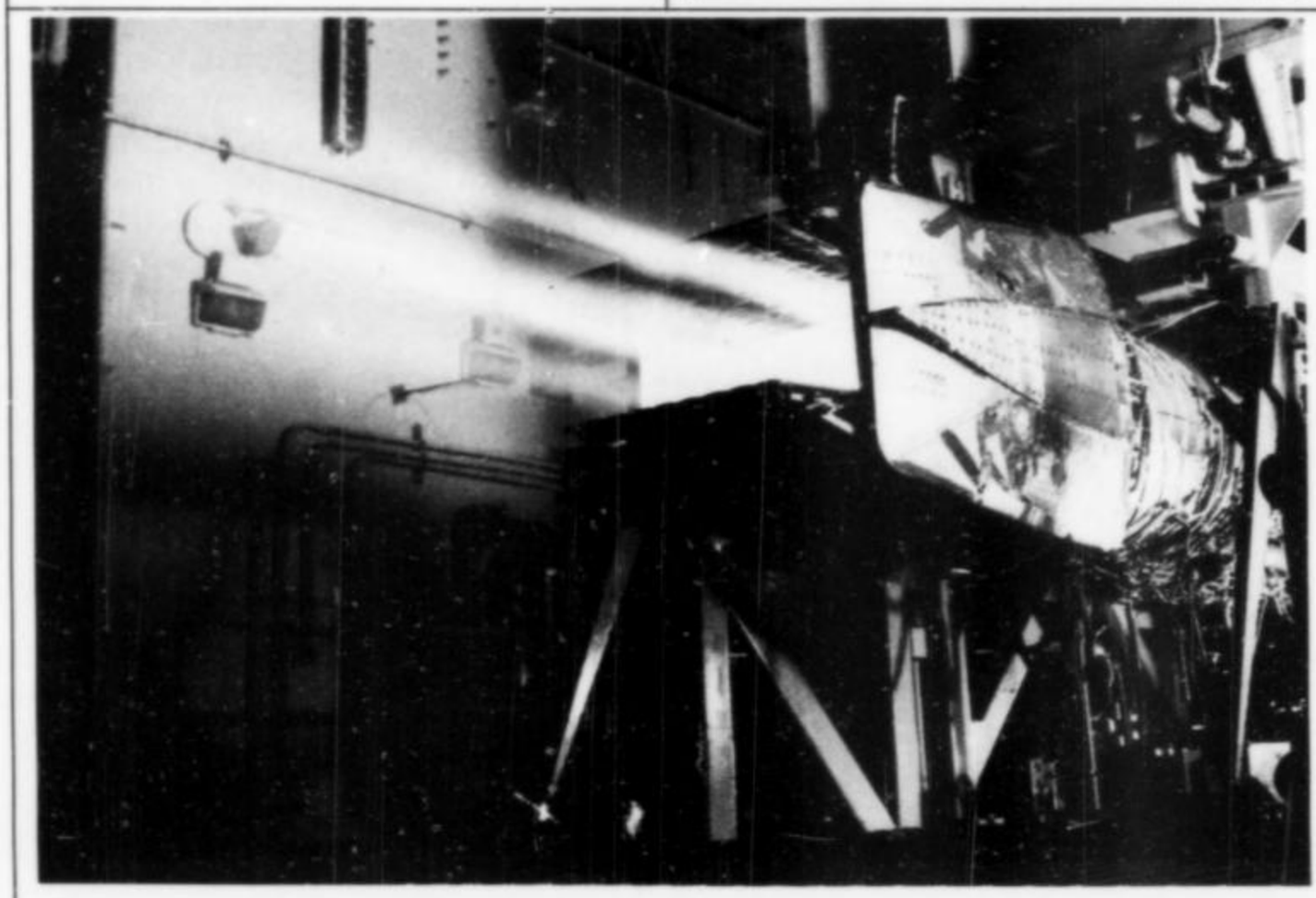
According to the latest program estimates, F-15B modifications are expected to improve significantly the aircraft's flight, takeoff and landing performance (see chart, p. 47). The nozzles developed for the S/MTD could affect the design of future fighters. "When you get exhaust nozzle systems to give pitch and yaw, you can shrink down the tail size of an aircraft and eliminate the need for a speed brake," Roger Bursey, Pratt's STOL program manager, said.

The USAF/industry S/MTD cost-sharing program is valued at about $272 million, with industry contributing slightly less than half of the costs. The industry team includes prime contractor McDonnell Douglas and major subcontractors Pratt & Whitney (nozzles and engines), General Electric (flight control computer and software implementation), Cleveland Pneumatic (landing gear) and National Water Lift (airframe and nozzle actuators).

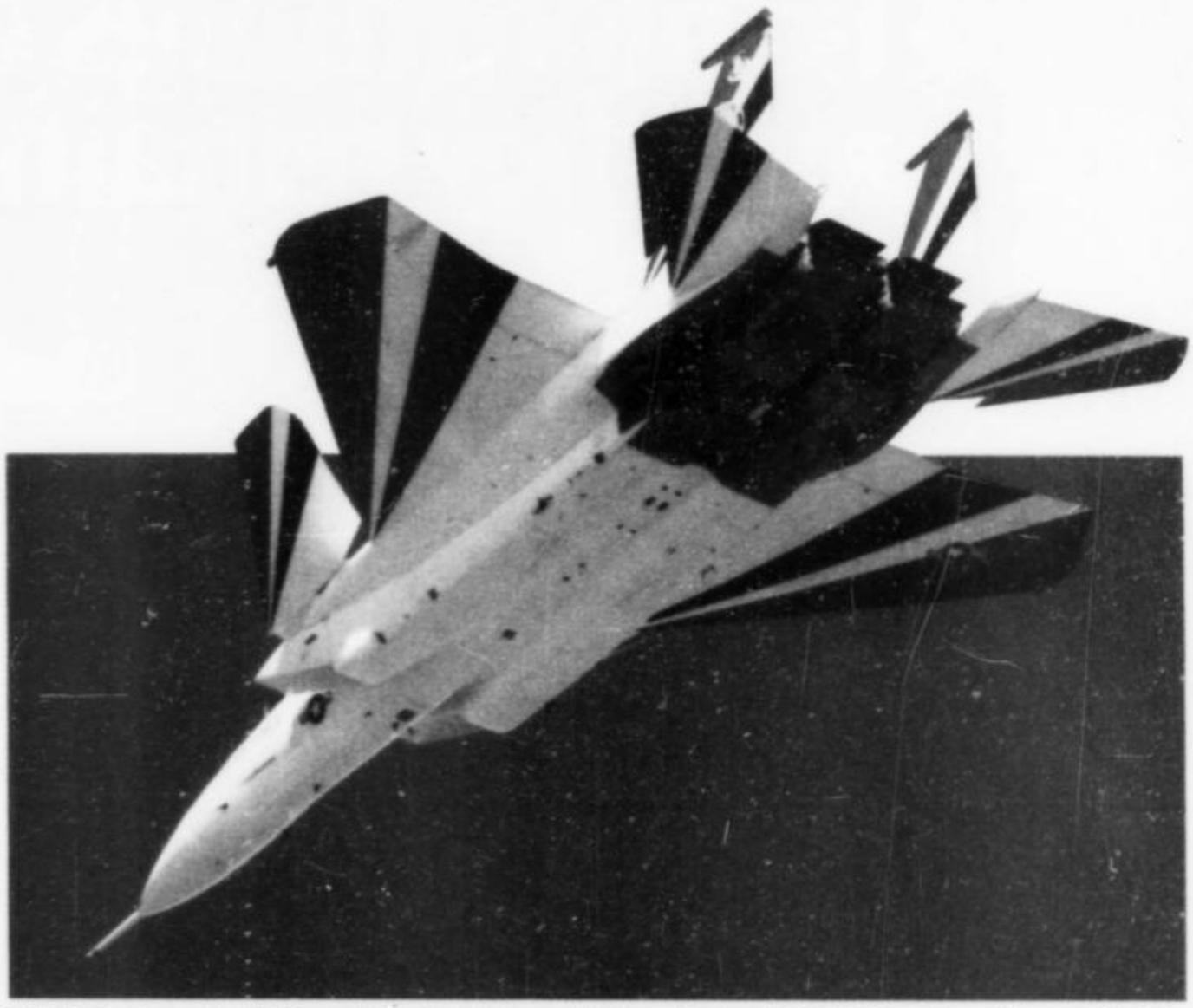
The S/MTD is powered by two Pratt & Whitney F100-PW-220 engines, slightly modified for flight test. The primary propulsion system modifications include the addition of a nozzle controller that communicates with the engine's standard digital electronic engine controller and changes to the engine's fan ducts. The ducts were modified to withstand the pitch vectoring loads that develop when the 2D nozzles are vectored.

Four 2D exhaust nozzles were developed by Pratt for the S/MTD program, two for ground tests—which will total about 350 hr.—and two for flight test. The basic 2D nozzle structure is made of titanium, and the exhaust area of the 2D nozzles is equivalent to that of the stan-





Two-dimensional exhaust nozzle developed for the STOL/Maneuver Technology Demonstrator is shown during tests at Pratt & Whitney's West Palm Beach, Fla., facilities. The nozzle is made primarily of titanium and can be vectored from +20 deg. (top) through 0 deg. (bottom facing page) and down to −20 deg. (bottom) in about 0.5 sec. The program will provide Pratt with experience in developing similar technologies for its F119 Advanced Tactical Fighter propulsion candidate.



S/MTD is flown by McDonnell test pilot Larry Walker during first flight earlier this month. The aircraft's 2D exhaust nozzles were used conventionally during the flight.

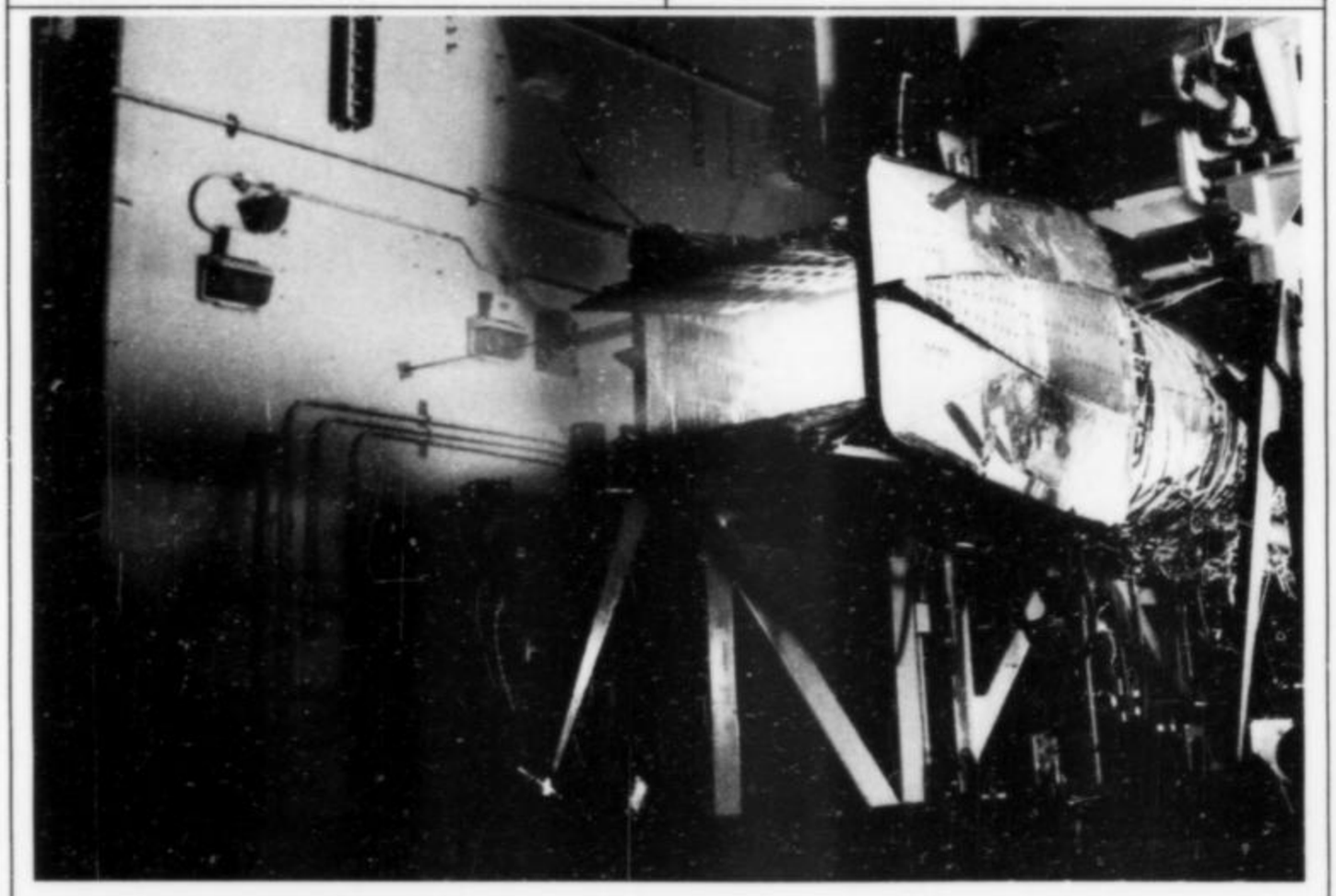
dard F100-PW-220 axisymmetric nozzles at all engine powers. The 2D nozzles can vector ±20 deg. and can be vectored independently in these positions throughout the full thrust capability of the engine.

"The nozzles can be vectored from +20 deg. to –20 deg. in about 0.5 sec. and can go from full afterburner to maximum reverse in about 1.5 sec.," Pratt & Whitney's Bursey said.

Although the S/MTD aircraft is slightly heavier than a standard F-15B and the propulsion plants are slightly heavier than the standard F100-PW-220s, the Air Force, McDonnell Douglas and Pratt & Whitney all believe that significant weight reductions and aerodynamic improvements could be achieved in future systems based on the technologies found in the S/MTD. "The aircraft is a one-of-a-kind testbed that's just starting to explore these technologies. Once some lessons are learned the weights will come down," Lt. Col. Felix Sanchez, U.S. Air Force S/MTD program manager, said.

The S/MTD first flew with all modifications, except the 2D nozzles, last September. Although the original flight-test schedule called for the aircraft to fly at this time with the 2D nozzles, development problems delayed delivery of the components for several months. First flight with the new nozzles occurred earlier this month from McDonnell facilities at the Lambert-St. Louis International Airport (AW&ST May 15, p. 18).

Current plans call for the aircraft to fly to Edwards AFB, Calif., under its own power from McDonnell Douglas test facilities in early June. At Edwards AFB, the S/MTD is expected to undergo a rigorous flight-test program that is scheduled to begin in mid-June. The tests at Edwards will be conducted through January, 1990, and are expected to be flown at a nominal rate of two flights per week. The flight-test program at Edwards may include about 60 flights, a number that may change once the aircraft is cleared for aerial refueling.



According to Ken Token, McDonnell Aircraft's S/MTD program manager, the S/MTD must complete a planned five-flight ferry envelope clearance program at McDonnell before embarking on the flight to Edwards. Token anticipates the ferry clearance program will be completed this week.

"The five flights have several purposes. They are examining handling qualities, ensuring that the engines are operational within the ferry flight envelope and verifying that the aircraft's software and hardware are operating properly for the flight to Edwards," Token said. In addition to systems checks, the aircraft is being flown with a centerline auxiliary fuel tank. The nozzles will be vectored in flight over a range of about ±3-4 deg. with the aircraft at 20,000-ft. altitude and 150 kt. The aircraft's flutter envelope also is being checked at several test points, out to a maximum flight condition of Mach 0.95 at 5,000 ft.

Once at Edwards the aircraft will begin a series of flight tests that will examine nozzle pressures, aircraft loads and handling qualities. All of these early tests will require nozzle thrust vectoring only. Afterburning flight and thrust reversing will follow later. This incremental, confidence building approach is the standard for a successful flight-test program, according to Sanchez. But problems discovered during ground tests of the nozzle also are partially responsible for some of the early flight limitations, Sanchez added.

"Ground tests of the nozzle at Pratt & Whitney showed that the nozzle's conver-

The more things change the more they remain the same.

A pilot guides a fragile biplane into the skies of the early twentieth century. Within one lifetime, an astronaut performs medical research at a space station in Earth orbit.

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gent flap liner limited use of the engine's afterburner. We also had a bearing failure in the mechanism that works the nozzle's thrust reverser. Although both problems have been corrected—a new nozzle liner has been developed and the bearing has been redesigned—the new bearing won't be incorporated into the flight-test nozzles until late July," Sanchez said.

An F100-S/MTD nozzle combination undergoing altitude testing at the NASA Lewis Research Center has incorporated the new liner, but the new bearing is still unavailable. To conduct thrust reverser tests under altitude conditions on the ground before they are attempted in flight, the reverser on the engine at NASA-Lewis will be locked in the open position.

"We expect to receive the new bearings soon and will install them near the end of June on the engine now being tested at NASA-Lewis. We'll then use this engine/nozzle combination to conduct thrust reverser engagement and disengagement tests on the sea-level test stand at Pratt & Whitney [in West Palm Beach, Fla.] in early July," Sanchez said. Once the dynamic reverser tests are completed, Pratt plans to perform accelerated mission tests with the engine/nozzle combination.

Changing the nozzle bearings at Edwards is expected to take 6-7 weeks, which could halt S/MTD flight test until August. The program can ill afford a delay since flight test is funded only to January, 1990. To maintain the pace of the flight-test program, conventional engines may be installed in the aircraft, so that rough/soft field tests can be performed during this period, Sanchez said.

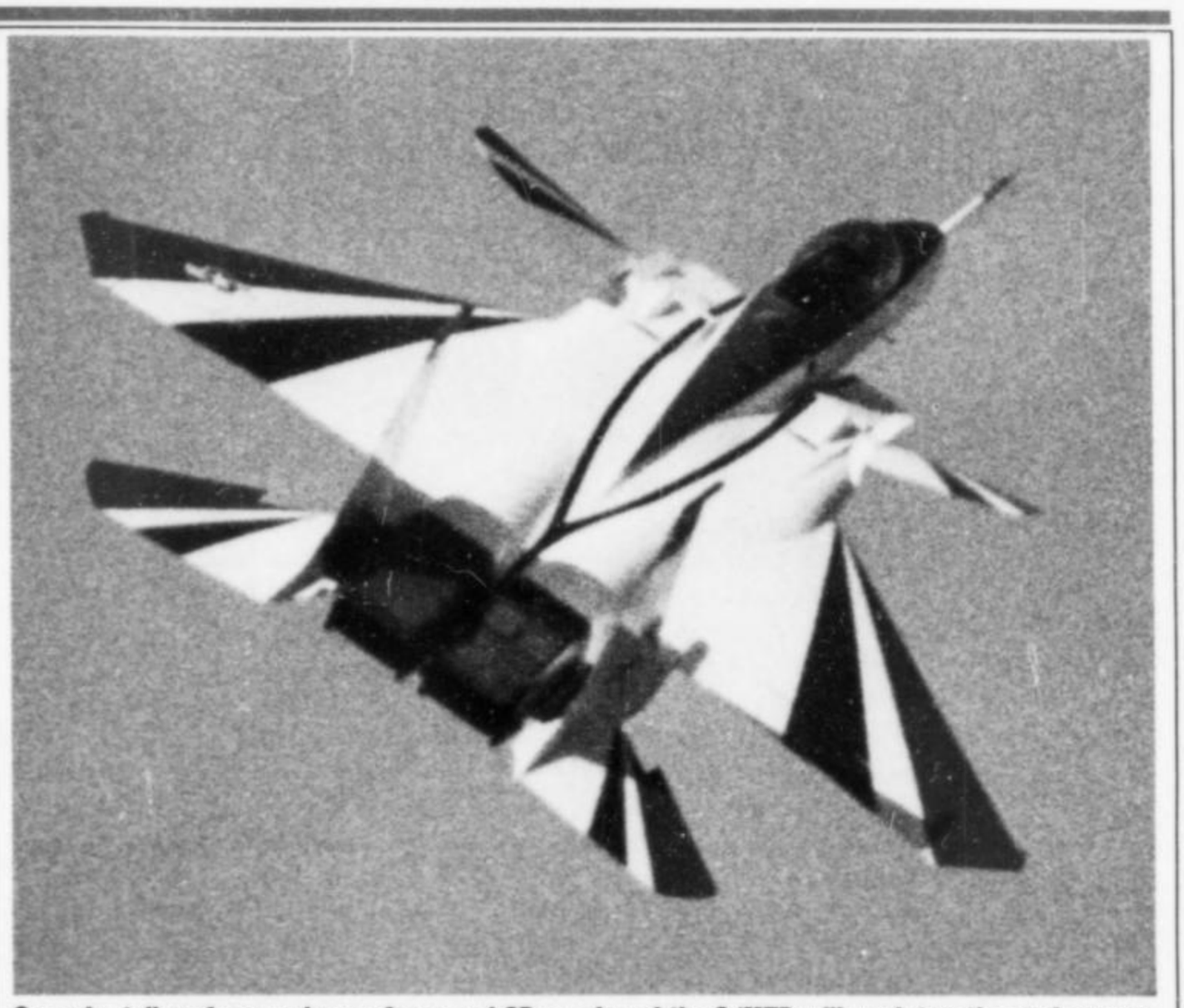
Other tests scheduled for the S/MTD include auto-guidance and STOL-landing tests. Although the formal flight-test schedule is still in development, "the STOL landing tests will probably be conducted in the September/October time frame," Sanchez said. These tests will examine the S/MTD's dynamics with the aircraft in ground effect. They also will be used to develop engine scheduling to minimize hot gas ingestion and to verify flight-control schedules. "Being able to land the aircraft on the 50 × 1,500-ft. strip is a key goal of the program," Token said.

Auto-guidance tests, which will allow accurate landings without the use of ground navigation aids, also are a flight-test priority. During these tests, the pilot will identify a distant landing strip and designate a landing point using a high-resolution ground map displayed on a cockpit CRT. Aircraft systems will then provide the pilot with azimuth and elevation steering commands on the S/MTD's head-up display. The commands will allow the pilot to fly a glideslope for touchdown on the previously designated landing point.

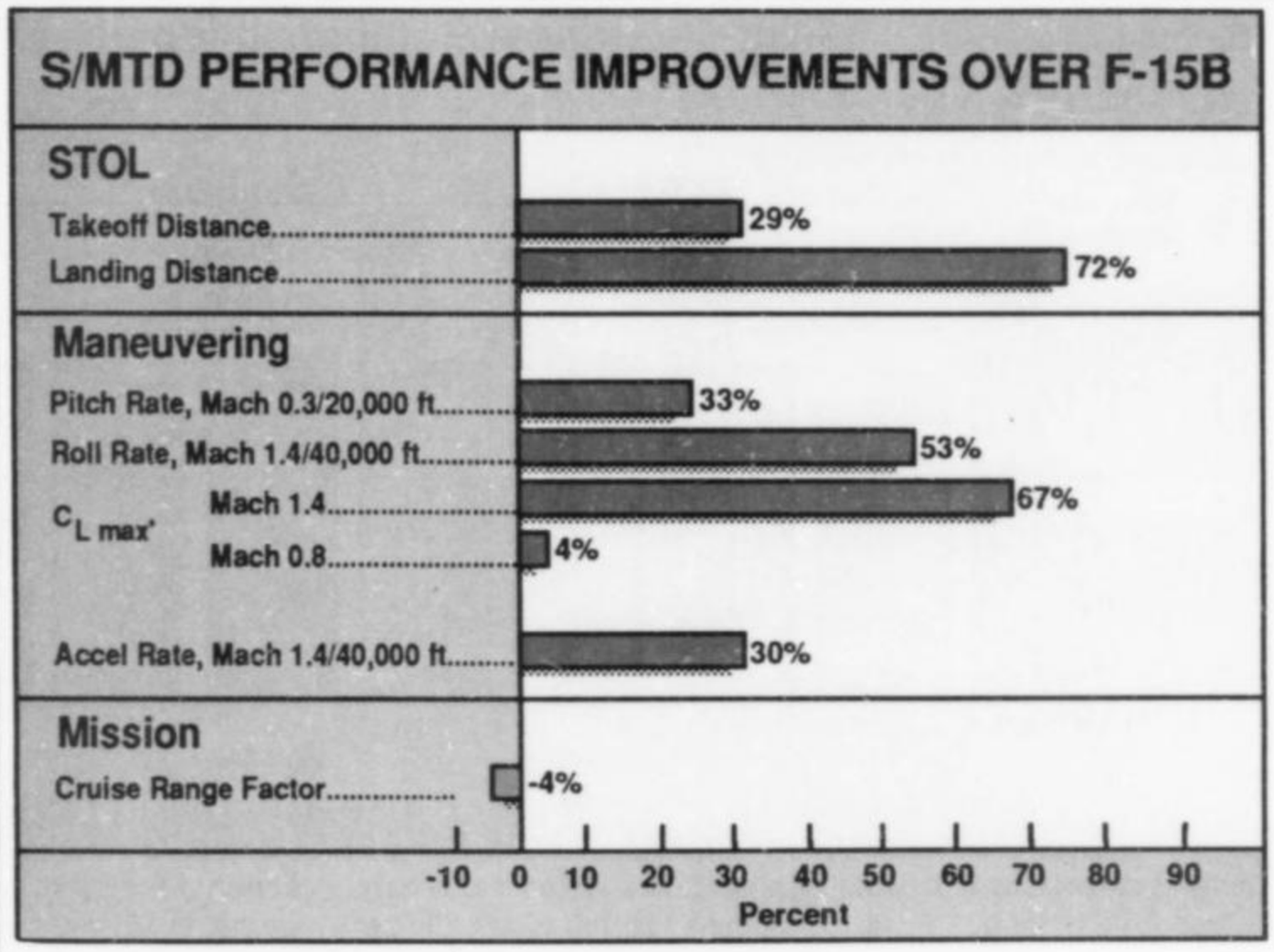
During the tests, the map display will be generated by a Hughes APG-70 radar, and the steering commands will come from the aircraft's central computer. The computer will use data from the S/MTD's inertial navigation system, APG-70 radar and Lantirn navigation pod to develop steering commands. Aircraft modifications for these tests will require the removal of the S/MTD's nose boom and the installation of the APG-70 radar and Lantirn pod.

"We've completed software development for the auto-guidance tests and worked the software in simulators here [at McDonnell] and at Wright-Patterson AFB. We also did a fit and function check of the APG-70 radar in the S/MTD on the ground earlier this year, while the 2D nozzles were being installed in the aircraft," Token said.

In addition to envelope expansion and technology demonstration, the S/MTD will be used to develop techniques for employing the 2D thrust-vectoring/thrust-reversing nozzles in combat. "We've allocated a block of 10 flights near the end of the flight-test program to demonstrate the utility of this technology to the Air Force. Since these technologies are applicable to future fighters, we need to know how we can use them," Sanchez said. "Given the importance of this mission, we may expand this block to 14 flights." □



Canards, tail surfaces, wing surfaces and 2D nozzles of the S/MTD will work together to increase performance of the modified F-15B.



Wall Street Upbeat on Airlines, Gloomy About Defense Stocks

NEW YORK

Financial issues confronting major aerospace markets are the subject of AVIATION WEEK & SPACE TECHNOLOGY's second annual financial survey. The team that analyzed the performance and prospects of leading U. S. aerospace, avionics, military electronics and airline firms was headed by Business Editor Nicholas C. Kernstock in New York, and included Business Flying Editor Edward H. Phillips in Washington, Bureau Chief Bruce A. Smith and Engineering Editor Michael A. Dornheim in Los Angeles, Northeast U. S. Bureau Chief David Hughes and San Francisco Bureau Chief Richard G. O'Lone.

Conflicting financial fortunes characterize the various segments of the U. S. aerospace industry as it heads into the 1990s. Business conditions range widely, from boom and bust to stagnation. In relative terms, both the "strong" and the "weak" sectors of the industry share the same challenge—turmoil.

With only six months remaining until the new decade begins, Wall Street is sanguine about the airline industry's stock prospects. But it remains wary of defense contractor stock performance as the national military budget continues its slow yet steady shrinkage.

Mergers and acquisitions in the avionics and military electronics business swell even as growth of programs flattens. Airline stocks are higher because of improved financial performance and takeover speculation.

NASA and Defense Dept. space programs are still winning appropriations from Congress, but some space station funding is in question. The Strategic Defense Initiative research program is being scaled down as a whole, with most projects slipped but not canceled.

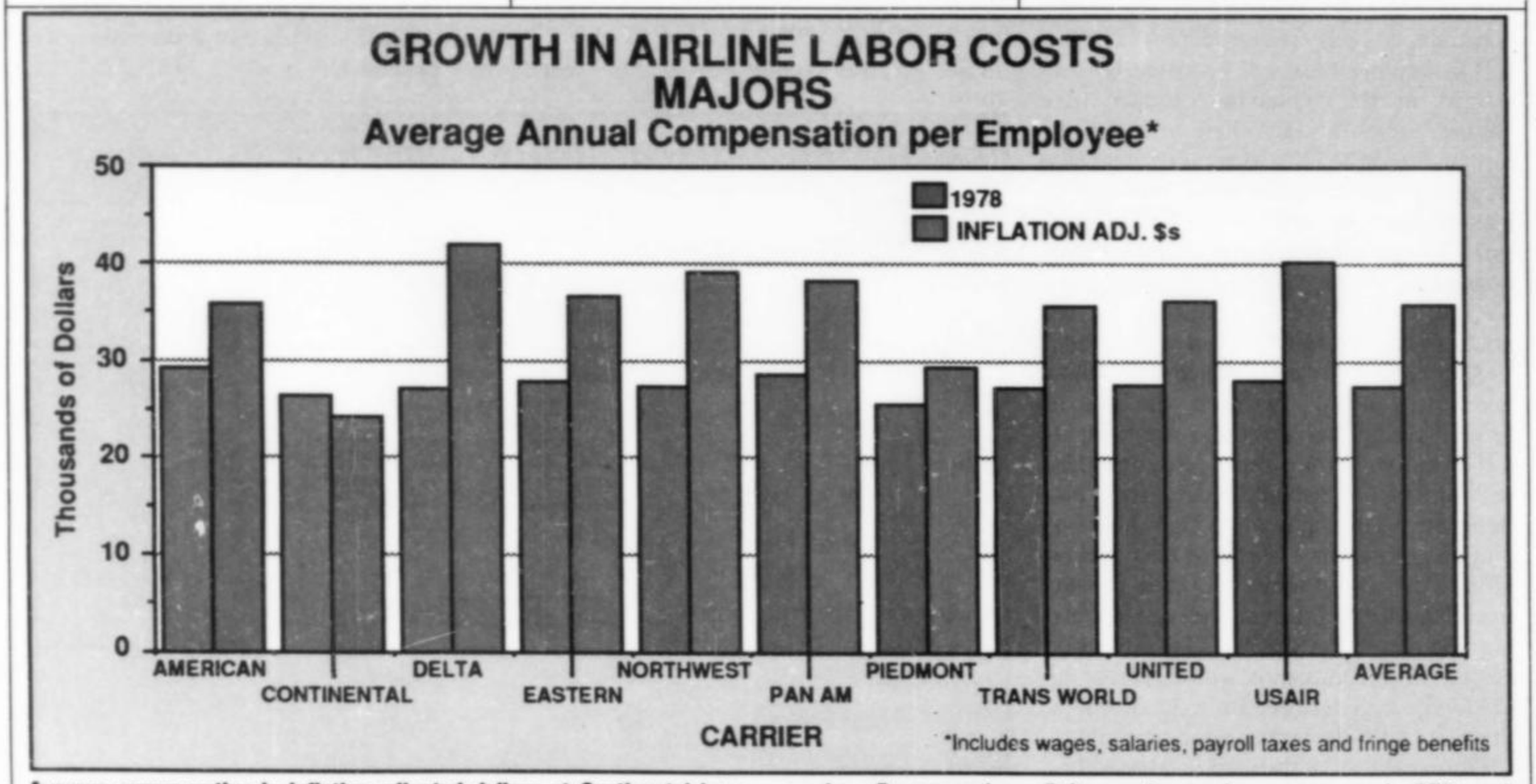
The commercial space industry continues to stagnate as companies struggle to find customers and financing.

Jerry Cantwell, aerospace anaylst for Werthein Schroder & Co., sees no increases in defense spending during the first Bush Administration. Pentagon procurement policy applied "too much pressure for competition for competition's sake," Cantwell said. "There is no evidence that the Pentagon is ready to deal with the issue that defense companies need to make profits and that profits are good."

Meanwhile, defense stocks are trading at discounts reminiscent of 1971. According to Cantwell, the good news is that "the valuation collapse of these stocks is behind you."

Topics discussed in this special report include:

- Declining defense spending and procurement programs are raising questions about the weakening of the U. S. defense industrial base. Lower profitability and higher risks have led many companies to reduce their presence in defense contracting or drop out entirely.
- Electronics is playing an ever increasing role in military systems, but the emphasis is shifting toward software development and systems integration. The wave of defense electronics acquisitions seems likely to continue as contractors compete for a piece of the shrinking defense budget.
- The end of large military aircraft programs, such as Rockwell's B-1B and Lockheed's C-5B, and the poor prospects for new projects have prompted defense contractors to make large cutbacks in skilled and semi-skilled workers. Some of these workers are being absorbed by the expanding commercial aircraft industry, but training costs are rising.



Average compensation in inflation adjusted dollars at Continental have declined 9.4% in the last decade, falling from $26,400 to $24,200 per worker. By comparison, Delta employees have seen nearly 55% real growth, to $51,400 current, or $41,900 (1978 dollars), from $27,100.

■ Although buoyed by record-breaking commercial transport orders, U. S. airframe builders and their suppliers are still ramping up slowly. Capacity constraints and quality and cost control problems are forcing a reevaluation of expected delivery rates for new programs and delaying the anticipated surge of earnings at commercial aerospace companies.

■ U. S. airline profits continue to improve as the industry has overcome the uncertainties caused by deregulation. Higher revenues and retained earnings at the airlines and a positive outlook for traffic growth are driving an aircraft shopping spree of unprecedented proportions.

Boeing continues to dominate among the commercial airframe builders, garnering a 62% market share of revenues from new transport aircraft sales. That market share is expected to increase to 65-66% over the next three years, according to Phil Friedman, aerospace analyst at Drexel Burnham Lambert.

While Boeing is working to expand its production capacity to meet the flood of new orders, delayed deliveries have angered some customers and quality control questions have tarnished the company's image. But steadily rising operating margins and a strong orderbook bode well for continued share price appreciation, Friedman said.

DEPRESSED EARNINGS THIS YEAR

McDonnell Douglas also has benefited from rising airline purchases, capturing a 19% market share of 1988's worldwide sales. Problems with MD-80 deliveries, largely the result of parts shortages, and MD-11 certification delays will probably continue to depress earnings through 1989, however. Changes in production systems and costs associated with employment increases also contributed to the firm's loss of 25 cents per share from continuing operations in the first quarter of 1989 versus a $1.33 gain in the same period in 1988.

Investors are also concerned about McDonnell Douglas' exposure to declines in defense appropriations. Military contracting revenues, more than 60% of the company's total, are considered vulnerable and its stock has lagged behind the shares of other commercial aerospace firms.

Defense companies, in general, are losing favor on Wall Street. Many report difficulties in raising capital at a time when research costs are increasing and budget problems have interrupted government payments to contractors.

Since May 30, 1988, the S & P 500 stock index has increased by more than 23% but share prices of companies identified primarily as defense contractors have not kept pace, trading at a 25-40% discount to the broader market. Northrop, Grumman and General Dynamics stocks appreciated only 5.5-6.7% in the past 12 months, reflecting, in part, the negative outlook on

Full production of Martin Marietta Lantirn targeting pods, shown on board this F-16C, has been approved. Navigation pod production should reach 10 per month in 1989.

5-Year Growth in Capital Spending

PERCENT PER ANNUM

AEROSPACE	
Textron Inc.	29.122
UNC Inc.	27.463
Hexcel Corp.	26.401
Boeing Co.	18.833
Morton Thiokol Inc.	17.560
Parker-Hannifin Corp.	17.490
Rohr Industries	17.489
General Dynamics Corp.	16.610
Fairchild Industries Inc.	15.688
GenCorp Inc.	13.121
LTV Corp.	12.294
Eldec Corp.	7.996
Grumman Corp.	6.384
Hercules Inc.	5.626
United Technologies Corp.	4.647
Lockheed Corp.	2.258
Rockwell International Corp.	0.202
Martin Marietta Corp.	-0.001
McDonnell Douglas Corp.	-0.001

AIRLINES/SERVICES	
Atlantic Southeast Airlines	92.548
Hal Inc.	74.121
International Lease Finance Corp.	66.285
PS Group Inc.	57.499
Midway Airlines Inc.	54.82
Comair Inc.	37.657
WorldCorp Inc.	29.762
AAR Corp.	25.549
PHH Corp.	25.069
UAL Corp.	21.802
Air Cargo Equipment Corp.	16.26
Ryder Systems Inc.	16.126
FlightSafety International	14.952
Oregon Metallurgical Corp.	14.648
National Technical Systems Inc.	7.880
Wyman-Gordon Co.	3.399
Curtiss-Wright Corp.	1.457
Texas Air Corp.	0
Delta Air Lines Inc.	0

AVIONICS/MILITARY ELECTRONICS	
Sun Microsystems Inc.	129.097
Mark IV Industries Inc.	102.08
Galileo Electro-Optics Corp.	79.498
Convex Computer Corp.	68.123
Integrated Device Tech. Inc.	56.747
Orbit Instrument Corp.	56.521
Cypress Semiconductor Corp.	47.091
Pacific Scientific Co.	44.529
ECC International Inc.	40.474
SCI Systems Inc.	39.222
Logicon Inc.	37.923
ARX Inc.	37.716
Teleflex Inc.	34.631
AEL Industries Class A	34.297
Analysis & Technology Inc.	33.887
Evans & Sutherland Computer Corp.	33.5
Frequency Electronics Inc.	30.909
Flow General Inc.	29.241
Digital Equipment	25.431
Servo Corp. of America	24.266
Apple Computer Inc.	24.14
Loral Corp.	23.248
Perceptronics Inc.	20.78
UTL Corp.	18.893
Nichols Research Corp.	18.049
Pall Corp.	15.584
Diagnostic/Retrieval Class A	15.176
Intel Corp.	14.626
Emerson Electric Co.	8.137
Datron Systems Inc.-Calif.	7.659
Whittaker Corp.	7.469
TRW Inc.	7.077
Raytheon Co.	6.128
Litton Industries Inc.	5.591
Moog Inc.	5.358
Sparton Corp.	4.362
AMP Inc.	3.687
Tyler Corp.	3.526
Softech Inc.	3.406
EDO Corp.	3.265
Fluke (John) Mfg. Co.	3.142

defense appropriations and the overall profitability of government defense contracts. The result has been a reluctance to bid on Pentagon programs with marginal profit potential or onerous conditions.

The industry segment where a small incremental increase in defense appropriations over the foreseeable future seems certain is defense electronics. Merger and acquisition activity continues to increase as electronics companies combine to achieve competitive "critical mass" and platform builders, such as Lockheed, diversify to replace declining aircraft revenues.

In spite of the positive outlook for the group, however, stocks of some major players are trading below year-ago prices. Litton Industries, at about $79.50 per share recently, is down 4.4% from its closing price on May 25, 1988, and TRW, Loral, Eaton Corp. and Texas Instruments have also dropped. Depressed share prices make strategic acquisitions even more likely, but pressure on current—as well as future—profit margins could mount as competition increases.

NASA's aggressive funding requests to Congress have paid off in a steady growth of its budget. According to a General Accounting Office report on NASA and Defense Dept. space funding, the space agency has averaged annual increases of about 15% since 1981, when it received $4.99 billion. This year's appropriation is about $10 billion in 1981 dollars, or double the amount in 1981.

A heavy backlog of military, commercial and scientific payloads should mean a 10.3% increase in sales of launchers, services, engines and propulsion units and R&D expenditures. But congressional and Administration support for NASA is a hostage to the federal deficit. A serious recession, rising inflation and interest rates or worsening of the savings and loan crisis could doom the agency's programs.

The Defense Dept. space budget is considered more secure but will be flat to slightly higher. Strategic Defense Initiative research is being scaled back, but SDI programs are generally a small portion of the total business of the companies involved.

Aerospace industry labor costs are rising, even as large numbers of workers are laid off. The expenses associated with recruiting and moving employees with specialized or scarce skills have increased. Training new workers also has become more important and expensive.

Lockheed's loan of as many as 670 employees from its Georgia C-5B facility to Boeing is an unusual solution to a recurring problem. Boeing will use the workers on its 747-400 production line for up to six months. Boeing expects that the cost of moving and housing will be more than offset by reduced training costs and higher productivity of the Lockheed workers.

Shortages of several skill classifications persist, especially among computer software and other electronic technicians.

Labor costs (as a percentage of total operating expenses) at major U. S. airlines have been decreasing moderately since 1986. Rising industry profit margins and a long-term shortage of pilots may put upward pressure on wages.

As their cost structures mature, the airlines are expected to maintain margins by raising fares and eliminating discounts. A recent decline in domestic revenue passenger miles suggests, however, that ticket price increases already may be slowing traffic growth.

Airline stocks have reacted sharply to takeover fears as well as labor and financial misfortunes. Of the major companies, only USAir and Delta Air Lines remain attractive acquisition targets.

International operating lease companies have emerged as a major force in the airline industry. These companies now account for about 20% of the orders and options for new aircraft worldwide. Nearly half of the aircraft delivered in the U. S. last year were leased. According to Tony A. Ryan, CEO of GPA Group, Ltd.—the largest operating lease company—the percentage of leased aircraft will increase. He envisions a day when separate companies will own the aircraft and other companies will operate them. □

5-Year Change In Return on Assets

PERCENT

AEROSPACE/DEFENSE COMPANIES	
Hi-Shear Industries	5.436
GenCorp Inc.	4.754
Fairchild Industries Inc.	3.660
UNC Inc.	2.785
Textron Inc.	1.345
Martin Marietta Corp.	0.781
Hexcel Corp.	0.403
Rockwell International Corp.	0.167
Eldec Corp.	-0.001
McDonnell Douglas Corp.	-0.272
Allied Signal Inc.	-0.427
United Technologies Corp.	-0.835
Parker-Hannifin Corp.	-0.901
Morton Thiokol Inc.	-1.074
Grumman Corp.	-1.920
Rohr Industries	-3.486
General Dynamics Corp.	-3.531
Lockheed Corp.	-3.580
Hercules Inc.	-3.624
Boeing Co.	-3.666
Fansteel Inc.	-4.169
Sunstrand Corp.	-4.862
Northrop Corp.	-5.942
LTV Corp.	-10.572

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Measures of Financial Performance

	Exch.	Fiscal Year	Yearly Sales*	% Change	Net Income*	% Change	Earnings Per Share	Book Value Per Share	Cash Flow Per Share	Common Shares*	Quarterly Dividend	Return On Equity	Return On Assets	Capital Spending*	S&P Bond Rating
AEROSPACE															
United Technologies Corp. (UTX)	NYS	12/88	18000.1	4.8	659.1	11.4	5.05	36.88	9.70	131	1.60	13.7	5.2	875.3	AA-
Boeing Co. (BA)	NYS	12/88	16962.0	9.4	614.0	27.9	4.02	35.27	2.98	153	1.60	11.4	4.9	690.0	(-) A
McDonnell Douglas Corp. (MD)	NYS	12/88	15069.0	10.2	350.0	11.8	9.13	83.40	25.64	38	2.82	11.0	2.9	654.0	A
Rockwell Intl. Corp. (ROK)	NYS	09/88	11946.3	-1.5	811.9	27.8	3.04	14.14	0.23	261	0.72	22.0	8.8	554.8	AA
Allied Signal Inc. (ALD)	NYS	12/88	11909.0	7.1	463.0	-10.1	3.10	22.09	5.30	148	1.80	14.2	4.6	602.0	A
Lockheed Corp. (LK)	NYS	12/88	10590.0	-5.6	442.0	1.4	10.37	41.73	13.57	59	1.60	17.9	6.7	380.0	A+
General Dynamics Corp. (GD)	NYS	12/88	9551.0	1.5	379.0	-13.3	9.03	46.10	15.15	42	1.00	19.7	6.2	515.9	AA-
LTV Corp. (QLTV)	NYS	12/88	7324.7	-3.4	-890.6	NM	-30.94	-49.59	-6.30	105	0.00	NM	-14.5	413.0	D
Textron Inc. (TXT)	NYS	12/88	7279.4	1.6	272.1	4.2	2.67	NA	6.54	85	1.00	11.4	2.2	217.8	BBB
Northrop Corp. (NOC)	NYS	12/88	5797.1	-4.2	-30.9	NM	2.22	21.40	3.56	47	1.20	-3.1	-1.0	254.2	NA
Martin Marietta Corp. (ML)	**NYS**	12/88	5727.5	10.7	319.8	38.6	6.75	22.73	9.89	53	1.10	26.6	9.6	338.9	A+
Grumman Corp. (GQ)	**NYS**	12/88	3591.3	6.4	86.5	219.6	2.50	23.90	5.72	33	1.00	11.1	3.4	118.1	BBB+
Hercules Inc. (HPC)	NYS	12/88	2802.1	4.1	120.4	-85.3	2.55	44.58	5.50	46	2.24	5.9	3.6	251.0	A
Morton Thiokol Inc. (MTI)	NYS	06/88	2316.4	16.6	159.4	15.5	3.04	22.38	4.23	48	0.92	15.0	8.3	163.0	AA-
Parker-Hannifin Corp. (PH)	NYS	06/88	2251.7	15.7	106.5	25.1	2.20	17.36	4.00	49	0.84	12.6	6.1	123.9	A
GenCorp. Inc. (GY)	NYS	11/88	1891.0	16.8	55.0	205.6	2.19	-1.13	2.33	32	0.60	NM	4.5	122.0	BB-
Sundstrand Corp. (SNS)	NYS	12/88	1477.3	8.2	-50.1	NM	-4.15	26.47	-0.03	19	1.80	-8.5	-3.2	87.9	A
Rohr Industries (RHR)	NYS	07/88	906.8	36.7	32.5	20.7	1.85	21.34	3.18	18	0.00	8.7	3.7	51.2	BBB
Fairchild Industries Inc. (FEN)	NYS	12/88	538.7	18.7	15.5	34.8	1.37	4.80	2.06	14	0.20	19.5	3.5	24.2	B+
Precision Castparts Corp. (PCST)	OTC	03/88	414.4	27.0	36.8	73.4	2.27	9.53	2.74	17	0.08	23.1	12.4	26.9	NA
UNC Inc. (UNC)	NYS	12/88	400.4	12.6	7.7	-14.2	1.42	7.93	1.76	17	0.00	5.8	1.9	41.0	B
Hexcel Corp. (HXL)	NYS	12/88	399.2	14.3	16.1	25.4	2.33	18.36	4.54	7	0.44	12.8	5.2	46.5	BB-
Fansteel Inc.-DEL (FNL)	NYS	12/88	207.0	17.4	2.2	NM	0.25	7.93	1.15	9	0.40	3.2	1.5	13.3	NA
Eldec Corp. (ELDC)	OTC	03/88	104.1	4.7	4.7	-14.5	1.10	9.47	1.98	5	0.00	9.6	5.7	4.5	NA
Hi-Shear Industries (HSI)	NYS	05/88	78.5	-0.5	4.9	1.0	0.84	11.01	1.43	6	0.44	7.6	6.0	10.1	NA
AVIONICS/MILITARY ELECTRONICS															
Digital Equipment (DEC)	NYS	06/88	11475.4	22.2	1305.6	14.8	9.90	59.47	13.26	126	0.00	17.4	12.9	1517.6	AA+
General Motors-Class H (GMH)	NYS	12/88	11001.0	5.0	783.4	16.9	2.01	58.81	3.59	128	0.72	10.4	6.6	533.0	NA
Raytheon Co. (RTN)	NYS	12/88	8192.1	7.0	489.6	10.0	7.35	31.96	11.24	66	2.20	23.1	10.3	421.3	AA
Honeywell Inc. (HON)	NYS	12/88	7148.3	6.9	-434.9	NM	-10.22	40.14	-7.01	43	2.10	-25.1	-8.5	327.7	A-
TRW Inc. (TRW)	NYS	12/88	6982.0	2.4	261.0	7.4	4.29	26.00	7.57	60	1.72	16.7	5.9	417.0	A-
Emerson Electric Co. (EMR)	NYS	09/88	6651.5	7.8	528.8	13.2	2.31	12.51	3.30	225	1.12	18.8	10.5	235.5	AAA
Texas Instruments Inc. (TXN)	NYS	12/88	6294.8	12.5	366.3	42.6	4.05	21.36	8.91	81	0.72	16.3	8.3	628.1	A+
Litton Industries Inc. (LIT)	NYS	07/88	4863.9	10.1	167.0	20.9	6.33	46.15	18.79	25	0.00	14.2	3.3	230.1	BBB+
Apple Computer Inc. (AAPL)	OTC	09/88	4071.4	53.0	400.3	84.0	3.08	8.17	4.36	123	0.40	39.9	19.2	144.0	NA
Control Data Corp. (CDA)	NYS	12/88	3628.3	7.8	1.7	-93.2	0.03	24.97	5.52	42	0.00	0.2	0.1	256.9	B+
Eaton Corp. (ETN)	NYS	12/88	3468.5	11.5	227.7	10.4	5.69	33.29	CF	35	2.00	19.7	7.5	186.7	A
Intel Corp. (INTC)	OTC	12/88	2874.8	50.7	452.9	158.0	2.51	11.52	3.75	181	0.00	21.8	12.8	477.5	A
Zenith Electronics Corp. (ZE)	NYS	12/88	2685.7	13.7	5.3	NM	0.45	18.84	2.08	27	0.00	1.1	0.4	32.9	B+
Amp Inc. (AMP)	NYS	12/88	2669.7	15.2	319.1	27.8	2.96	14.16	4.22	107	1.20	21.0	13.4	220.3	AAA
National Semiconductor Corp. (NSM)	NYS	05/88	2469.7	32.2	62.7	NM	0.48	9.41	2.05	108	0.00	6.2	3.5	198.9	B+
Harris Corp. (HRS)	NYS	06/88	2062.6	-0.8	65.4	-22.6	2.50	24.94	3.64	39	0.88	6.7	4.0	81.2	A-
Amdahl Corp. (AMH)	ASE	12/88	1801.8	19.7	213.8	50.6	2.08	9.51	3.35	106	0.10	21.2	11.1	278.9	NA
Loral Corp. (LOR)	NYS	03/88	1440.8	108.8	74.3	29.4	3.01	17.31	6.43	25	0.72	17.0	5.3	50.9	BBB+
E-Systems Inc. (ESY)	NYS	12/88	1439.0	17.3	74.6	23.5	2.40	15.89	3.57	31	0.50	15.2	9.8	53.7	NA
Tektronix Inc. (TEK)	NYS	05/88	1411.9	1.1	-16.7	NM	-0.55	17.67	2.13	28	0¢	-3.4	-1.6	78.1	A-
EG&G Inc. (EGG)	NYS	12/88	1406.3	11.2	68.7	23.8	2.30	11.07	3.12	30	0.68	20.7	12.7	27.9	A+
Arvin Industries Inc. (ARV)	NYS	12/88	1313.3	0.5	16.5	-65.4	0.01	19.29	2.44	19	0.68	4.0	1.6	38.4	BBB

Fiscal year data are latest available audited results from 10-K and corporate annual reports, as compiled by Standard & Poor's Compustat Services Inc.

AEROSPACE/DEFENSE FINANCIAL REPORT

	Exch.	Fiscal Year	Yearly Sales*	% Change	Net Income*	% Change	Earnings Per Share	Book Value Per Share	Cash Flow Per Share	Common Shares*	Quarterly Dividend	Return On Equity	Return On Assets	Capital Spending*	S&P Bond Rating
Figgie International -CL B (FIGI)	OTC	12/88	1200.2	14.0	61.9	25.4	9.03	49.23	13.72	7	1.20	16.9	6.1	65.1	BBB
Varian Associates Inc. (VAR)	NYS	09/88	1170.6	19.1	27.8	29.9	1.27	20.81	3.51	22	0.26	6.2	3.2	43.2	NA
Perkin-Elmer Corp. (PKN)	NYS	07/88	1165.5	5.0	60.0	NM	1.61	16.15	2.71	45	0.68	8.3	4.4	83.6	NA
General Instrument Corp. (GRL)	NYS	02/88	1155.5	46.7	66.2	258.3	2.01	16.45	4.64	33	0.50	12.0	6.1	70.5	BBB
Computer Sciences Corp. (CSC)	NYS	03/88	1152.4	11.7	43.5	35.0	2.73	21.36	4.73	16	0.00	13.1	6.6	37.6	BB+
Advanced Micro Devices (AMD)	NYS	12/88	1125.9	12.9	19.3	NM	0.11	8.07	2.09	80	0.00	3.0	1.8	131.9	B+
Sun Microsystems Inc. (SUNW)	OTC	06/88	1051.6	95.6	66.4	83.0	0.90	5.11	1.51	72	0.00	18.0	8.8	117.3	B+
Fuqua Industries Inc. (FQA)	NYS	12/88	933.6	37.9	76.7	21.9	4.29	18.89	5.97	21	0.32	19.2	6.7	29.0	B
SCI Systems Inc. (SCIS)	OTC	06/88	774.2	40.0	19.0	18.8	0.91	7.27	1.80	21	0.00	12.5	3.9	42.8	BB-
Cray Research (CYR)	NYS	12/88	756.3	10.0	156.6	6.5	4.99	23.14	7.15	29	0.00	23.1	15.8	156.7	BBB
Computer Associates Intl Inc. (CA)	NYS	03/88	709.1	56.8	101.8	179.0	1.29	6.31	2.28	79	0.00	20.4	12.1	18.9	BB-
Tyler Corp. (TYL)	NYS	12/88	664.6	6.5	14.6	-13.5	1.11	2.40	0.74	21	0.06	28.3	4.2	21.6	B+
DynCorp. Inc. (DYN)	NYS	12/88	555.6	14.0	-14.9	NM	-2.83	4.33	0.09	5	0.00	-63.4	-4.3	9.4	NA
Scientific-Atlanta Inc. (SFA)	NYS	06/88	508.6	2.7	29.7	22.3	1.25	9.90	1.76	24	0.12	12.5	9.4	10.1	NA
Whittaker Corp. (WKR)	NYS	10/88	499.1	16.8	23.1	81.8	3.30	29.17	6.87	7	1.00	11.6	5.3	15.4	NA
Bell Industries Inc. (BI)	NYS	06/88	431.6	20.9	12.8	283.8	1.96	18.40	2.97	6	0.28	11.0	6.7	6.4	NA
Pall Corp. (PLL)	ASE	07/88	429.2	11.4	57.4	19.4	1.55	8.65	2.04	37	0.48	17.9	10.1	45.7	NA
M/A-Com Inc. (MAI)	NYS	09/88	424.2	-2.7	18.4	NM	0.65	8.81	5.30	25	0.24	8.5	3.8	23.2	BBB-
Mark IV Industries Inc. (IV)	NYS	02/88	403.0	38.2	17.0	66.9	1.71	8.56	2.99	11	0.00	18.4	2.8	9.0	B-
Cubic Corp. (CUB)	ASE	09/88	364.9	2.0	12.2	54.2	1.70	15.88	1.95	7	0.42	10.4	4.8	9.9	NA
Communications Satellite (CQ)	NYS	12/88	358.9	7.6	61.9	247.3	3.35	33.14	7.46	17	1.32	11.2	5.3	192.7	A
Dataproducts Corp. (DPC)	ASE	03/88	345.2	1.9	-20.2	NM	-0.98	9.47	-0.19	20	0.16	-10.8	-6.6	7.4	NA
Kollmorgen Corp. (KOL)	NYS	12/88	344.8	14.5	14.1	4840.3	1.34	8.50	2.60	10	0.32	15.8	6.3	15.8	NA
Teleflex Inc. (TFX)	ASE	12/88	323.6	19.9	24.0	22.1	2.22	12.74	3.35	11	0.40	17.6	9.1	15.1	NA
United Industrial Corp. (UIC)	NYS	12/88	315.0	5.9	16.9	17.9	1.29	8.01	1.87	13	0.64	16.1	6.5	13.6	NA
Singer Co. (5573B)	OTH	12/88	301.9	-84.1	-38.2	NM	-2.06	2.12	-3.00	21	0.00	-47.5	-8.6	9.6	CCC+
Moog Inc. -CL A (MOG.A)	ASE	09/88	296.9	-3.3	-16.4	NM	-1.66	9.99	-0.42	8	0.00	-20.7	-5.4	14.3	NA
Watkins-Johnson (WJ)	NYS	12/88	292.2	10.6	20.6	15.8	2.46	15.98	3.92	8	0.40	15.4	9.8	11.6	NA
Flow General Inc. (FGN)	NYS	06/88	244.0	17.1	5.5	NM	0.61	6.63	1.30	9	0.00	9.3	3.1	6.5	NA
Fluke (FKM)	ASE	09/88	224.5	8.8	12.4	519.4	1.35	15.92	2.30	8	0.20	9.4	7.0	15.7	NA
Logicon Inc. (LGN)	NYS	03/88	217.6	6.2	9.1	49.4	1.93	13.45	1.98	5	0.36	15.0	10.6	3.8	NA
Sparton Corp. (SPA)	NYS	06/88	206.2	-8.1	11.2	11.5	1.41	8.97	2.24	8	0.52	15.8	9.8	7.5	NA
Genrad Inc. (GEN)	NYS	12/88	205.9	6.2	-6.2	NM	-0.38	3.99	0.52	17	0.00	-9.3	-3.2	12.4	B-
Pacific Scientific Co. (PSX)	NYS	12/88	180.9	15.2	-4.7	NM	-0.74	10.12	0.57	6	0.40	-8.4	-3.1	14.3	NA
Burr-Brown Corp. (BBRC)	OTC	12/88	176.7	25.8	11.5	169.5	1.19	8.00	2.74	10	0.00	15.1	8.7	21.3	NA
Aydin Corp. (AYD)	NYS	12/88	169.7	13.7	8.4	-4.9	1.66	15.15	2.70	5	0.00	11.0	5.7	3.5	NA
Canadian Marconi Co. (CMW)	ASE	03/88	168.0	NA	17.9	-13.2	0.75	7.91	1.19	24	0.23	9.5	7.2	11.6	NA
Cypress Semiconductor Corp. (CY)	NYS	12/88	139.4	80.4	20.8	80.8	0.56	5.09	1.09	36	0.00	11.2	8.5	39.8	NA
Adams Russell Inc./Mass (AEI)	ASE	09/88	138.0	5.6	0.2	-83.7	0.04	14.80	1.77	5	0.00	0.3	0.1	8.4	NA
EDO Corp. (EDO)	NYS	12/88	137.9	8.3	4.8	-31.5	1.54	7.99	2.48	5	0.28	10.9	2.9	8.6	B
Unitrode Corp. (UTR)	NYS	01/88	135.1	-9.6	-20.0	NM	-1.45	7.57	-0.49	14	0.00	-19.1	-13.1	10.8	NA
Evans & Sutherland CMP Corp. (ESCC)	OTC	12/88	129.6	-3.6	0.8	-94.6	0.22	11.60	1.08	8	0.00	0.8	0.4	32.7	B-
Avantek Inc. (AVAK)	OTC	12/88	123.5	-23.4	-25.3	NM	-1.68	6.52	-1.60	18	0.00	-21.8	-17.0	16.9	NA
Integrated Device Tech. Inc. (IDTI)	OTC	03/88	121.1	55.6	11.6	351.6	0.46	3.57	1.05	24	0.00	13.4	7.6	27.9	NA
Tech-Sym Corp. (TSY)	NYS	12/88	120.4	8.8	6.6	-20.8	0.70	12.61	1.84	7	0.00	7.9	5.4	3.1	NA
AEL Industries -CL A (AELNA)	OTC	02/88	119.6	10.4	2.1	-36.0	0.51	13.45	1.39	4	0.00	4.0	1.9	8.3	NA
Convex Computer Corp. (CNVX)	OTC	12/88	105.6	51.6	5.7	4.2	0.34	3.63	0.59	18	0.00	9.0	3.6	16.1	NA
Titan Corp. (TTN)	NYS	12/88	104.9	-1.6	-14.3	NM	-0.95	2.66	-0.68	13	0.00	-41.5	-18.4	2.3	NA
Dynamics Research Corp. (DRCO)	OTC	12/88	92.9	1.5	4.1	9.1	0.81	4.00	1.21	5	0.00	20.2	9.9	1.4	NA
C3 Inc. (CEE)	NYS	03/88	90.1	12.4	13.4	219.4	1.34	9.51	1.93	10	0.00	14.4	11.7	6.4	NA

**In Millions*
NM=not meaningful

Earnings per share includes nonrecuring items
Quarterly dividend at most recent or indicated rate

AEROSPACE/DEFENSE FINANCIAL REPORT

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ARX Inc. (ARX)	NYS	06/88	86.7	43.0	5.2	-14.6	0.61	7.16	1.30	8	0.00	8.6	4.4	7.4	B-
Sierracin Corp. (SER)	ASE	12/88	81.6	12.0	3.1	91.2	0.92	6.04	1.53	3	0.00	15.2	7.5	1.7	NA
Optical Coating Laboratories (OCLI)	OTC	10/88	81.2	16.9	3.0	23.0	0.27	4.65	1.27	7	0.00	9.1	3.5	6.6	NA
Analysis & Technology Inc. (AATI)	OTC	03/88	79.3	13.4	2.8	49.6	1.33	8.86	1.09	2	0.15	15.6	7.7	3.6	NA
Floating Point Systems Inc. (FLP)	NYS	10/88	70.8	-16.0	-27.8	NM	-3.10	4.59	-1.48	9	0.00	-64.3	-32.4	4.7	NA
Miltope Group Inc. (MILT)	OTC	12/88	68.3	11.2	1.6	NM	0.27	3.71	0.29	6	0.00	7.2	2.7	3.0	NA
Alpha Inds (AHA)	ASE	03/88	62.2	-11.2	-3.2	NM	-0.45	7.10	0.17	7	0.00	-6.3	-4.5	3.8	NA
Diagnostic/Retrieval -CL A (DRS.A)	ASE	03/88	61.5	15.5	3.7	8.2	0.66	5.62	1.08	6	0.00	11.7	5.3	2.5	NA
EECO Inc. (EEC)	ASE	12/88	60.9	25.4	-3.4	NM	-3.31	2.94	0.11	4	0.00	-29.0	-6.2	2.0	NA
Frequency Electronics Inc. (FEI)	ASE	04/88	59.3	64.6	3.8	-20.4	0.67	12.18	1.07	6	0.00	5.6	3.6	4.9	NA
Stanford Telecommunications (STII)	OTC	03/88	57.2	3.4	0.7	-75.1	0.15	5.62	0.67	5	0.00	2.7	1.9	3.3	NA
Perceptronics Inc. (PERC)	OTC	03/88	57.0	48.3	1.4	NM	0.44	2.42	0.73	3	0.00	16.8	5.2	1.7	NA
Helix Technology Corp. (HELX)	OTC	12/88	55.2	12.3	3.7	7.2	1.45	8.05	2.15	3	0.68	18.1	11.6	1.9	NA
Softech Inc. (SOFT)	OTC	05/88	48.7	11.8	1.0	NM	0.34	5.81	0.75	4	0.00	4.8	3.5	1.4	NA
Intermetrics Inc. (IMET)	OTC	02/88	47.4	-0.8	1.4	305.6	0.63	3.37	1.23	3	0.00	11.8	6.3	0.6	NA
EAC Industries (EAC)	ASE	01/88	45.8	18.4	0.1	NM	-1.05	7.05	3.21	2	0.00	0.6	0.2	1.2	NA
Radiation Systems Inc. (RADS)	OTC	06/88	44.3	1.2	4.0	29.9	0.79	9.98	1.04	5	0.10	8.2	6.4	1.3	NA
ECC International Inc. (ECC)	NYS	06/88	44.2	16.2	4.4	18.2	1.14	5.11	0.92	6	0.20	15.5	8.7	3.3	NA
Electronic Associates Inc. (EA)	NYS	12/88	42.7	31.2	0.2	-38.6	0.05	3.10	0.32	3	0.00	1.7	0.7	0.4	NA
Nichols Research Corporation (NRES)	OTC	08/88	42.6	11.3	2.3	31.3	0.68	4.76	0.60	3	0.00	15.2	10.5	1.1	NA
Orbit Instrument Corp. (ORBT)	OTC	06/88	41.8	7.4	3.8	2.1	0.44	6.09	0.49	10	0.00	6.5	4.9	1.1	NA
Bowmar Instrument Corp. (BOM)	ASE	09/88	39.7	0.6	-0.9	NM	-0.21	NR	0.03	NR	0.00	-19.1	-3.8	0.6	NA
Galileo Electro-Optics Corp. (GAEO)	OTC	09/88	35.0	-4.3	-0.9	NM	-0.11	8.04	0.28	6	0.00	-1.7	-1.5	11.6	NA
IRT Corp. (IX)	ASE	03/88	34.4	-19.3	-12.3	NM	-2.56	-0.54	-2.00	5	0.00	NM	-38.1	1.5	NA
Venturian Corp. (VENT)	OTC	12/87	32.9	-9.7	0.9	-11.9	0.89	20.85	1.32	1	0.00	4.6	3.2	0.3	NA
Datron Systems Inc.-Calif (DTSI)	OTC	03/88	32.3	43.6	2.3	64.8	0.82	6.88	1.17	3	0.00	12.0	6.8	0.9	NA
Genisco Technology (GES)	ASE	09/88	28.9	-25.8	-12.4	NM	-4.62	NA	-3.38	3	0.00	-873.7	-63.0	1.3	NA
Anaren Microwave Inc. (ANEN)	OTC	06/88	24.5	-15.6	0.2	-89.0	0.05	6.43	0.40	4	0.00	0.7	0.6	0.4	NA
Utl Corp. (UTLC)	OTC	06/88	23.0	22.2	-10.0	NM	-1.60	4.33	-2.62	4	0.00	-55.7	-17.7	1.2	B-
Ramtek Corp. (RMTKE)	OTC	06/88	22.9	-4.2	NR	NR	NR	-2.73	NR	4	0.00	NR	NR	NR	NA
Elxsi Corp. (ELXS)	OTC	12/88	20.4	-18.9	-10.6	NM	-0.12	0.18	-0.09	90	0.00	-66.7	-50.1	1.4	NA
Servo Corp. of America (5885B)	OTH	10/88	20.4	22.9	-0.1	NM	-0.14	10.46	0.43	1	0.00	-1.3	-0.6	0.9	NA
Espey Mfg & Electronics Corp. (ESP)	ASE	06/88	13.1	-0.8	2.0	48.0	1.79	16.51	2.03	1	0.60	10.7	9.9	0.3	NA
Eip Microwave Inc. (EIPM)	OTC	09/88	11.3	-39.9	-1.6	NM	-0.71	2.03	-0.19	2	0.12	-35.1	-18.9	0.7	NA
Western Microwave Inc. (WMIC)	OTC	09/88	11.0	-14.5	-0.8	NM	-0.50	3.22	-0.11	2	0.00	-15.5	-10.7	0.2	NA
Verdix Corp. (VRDX)	OTC	03/88	6.4	18.5	0.1	NM	0.01	0.46	0.13	11	0.00	1.4	0.9	0.4	NA
Sigma Research Inc. (SIGR)	OTC	06/87	5.3	-49.0	-5.3	NM	-2.71	-1.09	-2.33	2	0.00	NM	-156.4	0.1	NA
AIRLINES/SERVICES															
UAL Corp. (UAL)	NYS	12/88	8981.7	8.1	599.9	NM	37.87	56.75	68.52	22	0.00	48.9	9.0	1372.5	NA
AMR Corp.-Del (AMR)	NYS	12/88	8824.3	22.6	476.8	140.3	7.92	53.54	19.04	59	0.00	14.5	4.9	1185.9	A
Texas Air Corp. (TEX)	ASE	12/88	8572.9	-0.6	-718.6	NM	-18.88	-5.47	-1.14	41	0.00	NM	-8.8	448.9	B
Delta Air Lines Inc. (DAL)	NYS	06/88	6915.4	30.0	306.8	16.3	6.30	44.99	12.52	49	1.20	13.9	5.3	1330.6	A
USAir Group (U)	NYS	12/88	5707.0	90.2	165.0	-15.2	3.81	47.28	9.03	44	0.12	8.0	3.1	644.0	A-
NWA Inc. (NWA)	NYS	12/88	5650.4	9.9	135.1	31.2	4.63	56.09	16.96	29	0.90	8.3	3.1	585.7	BBB+
Ryder System Inc. (R)	NYS	12/88	5029.6	9.1	134.7	-28.0	2.40	18.71	9.44	80	0.60	8.5	2.2	1224.6	A
Trans World Airlines (TWA)	NYS	12/88	4361.1	7.5	249.7	451.3	NR	-5.21	NR	26	0.00	NM	6.1	81.1	B-
Pan Am Corp. (PN)	NYS	12/88	3569.0	16.8	-96.9	NM	-0.51	-2.12	0.83	144	0.00	NM	-4.5	218.5	B-
PHH Corp. (PHH)	NYS	04/88	1618.3	18.0	18.7	-52.6	2.60	18.82	33.06	17	1.12	5.9	0.5	25.9	A+
Southwest Airlines (LUV)	NYS	12/88	860.4	10.5	58.0	187.5	1.84	18.15	4.44	31	0.14	10.2	4.4	264.5	A-
Alaska Airgroup Inc. (ALK)	NYS	12/88	814.4	14.7	37.5	181.3	2.37	19.59	5.14	16	0.20	12.2	5.1	128.0	BB-
America West Airlines Inc. (AWAL)	OTC	12/88	775.7	34.8	-12.2	NM	0.51	3.74	1.98	16	0.00	-21.1	-1.9	143.3	CCC+
HAL Inc. (HA)	ASE	12/88	354.0	18.4	-8.8	NM	-4.48	2.31	0.92	2	0.00	-193.8	-5.2	15.6	NA
AAR Corp. (AIR)	NYS	05/88	347.6	16.6	21.2	38.2	1.34	9.48	1.36	16	0.44	14.1	7.5	9.3	NA
Midway Airlines Inc. (MDW)	NYS	12/87	412.0	18.8	3.9	–65.1	0.60	7.95	2.87	10	0.00	4.8	1.4	74.8	NA
Braniff Inc. (BAIRD)	OTC	01/88	297.4	24.2	-12.2	NM	-0.99	2.72	0.14	12	0.00	-36.4	-11.7	14.4	NA
Wyman-Gordon Co. (WYMN)	OTC	12/88	271.6	-12.5	5.9	-59.2	0.81	14.27	1.95	18	0.80	2.3	1.7	32.8	NA

**In Millions*
NM = not meaningful

Earnings per share includes nonrecuring items
Quarterly dividend at most recent or indicated rate

It took 12,947 successful unmanned operational flight hours to create an Impact.

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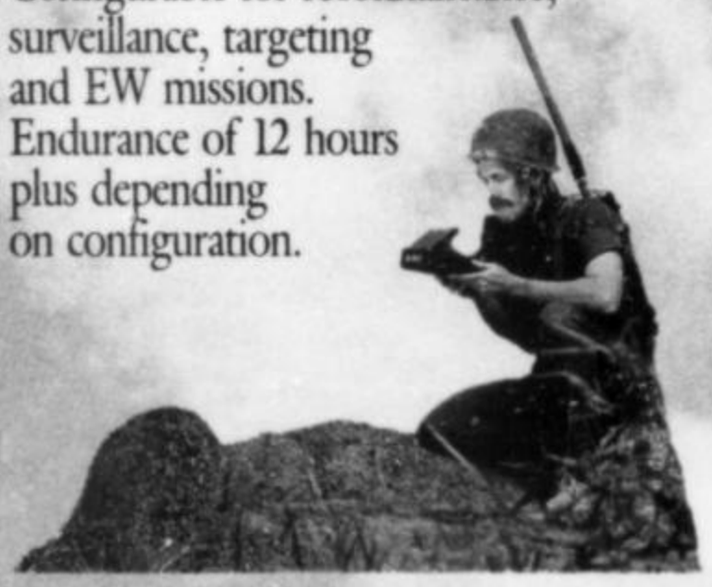
Facing the critical requirements of the defense arena, Unmanned Aerial Vehicles (UAV's) have evolved into a vital necessity in operations and battle management. From the outset, Israel Aircraft Industries has led the defense industry in that evolution. Developing, designing, manufacturing, integrating and supporting missionized UAV systems – and proving them, in AirLand and seaborne applications with the Israel Defense Forces, U.S. Defense Forces and other armed forces.

IAI. The company that developed the Scout UAV. Then, the Pioneer. And now the next generation – the IMPACT series.

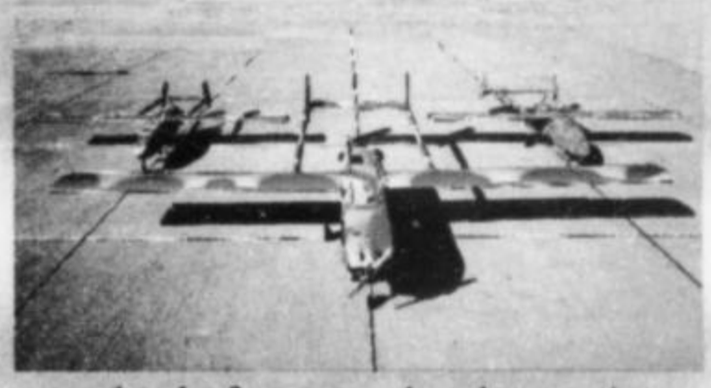
One version of IMPACT is the JIMPACS (Joint Improved Multi-Mission Payload Aerial Surveillance Combat Survivable) system.

JIMPACS is now a candidate for the military's Joint Service UAV – Short Range Program.

JIMPACS – a 1,000-pound multi-mission UAV system with long-range capability. Configurable for reconnaissance, surveillance, targeting and EW missions. Endurance of 12 hours plus depending on configuration.



IAI's UAV total system capabilities extend beyond the JIMPACS vehicle: Avionics. Operationally selected missionized payloads – including TV, TV/FLIR, day and night Laser designation, active and passive electronics. Ground control at



every level of command and operations. Takeoff and landing systems. Standard or protected communication links. Training and most important – integration of all components into a UAV system that works. JIMPACS. A total system based on IAI's proven UAV technologies and field experience.

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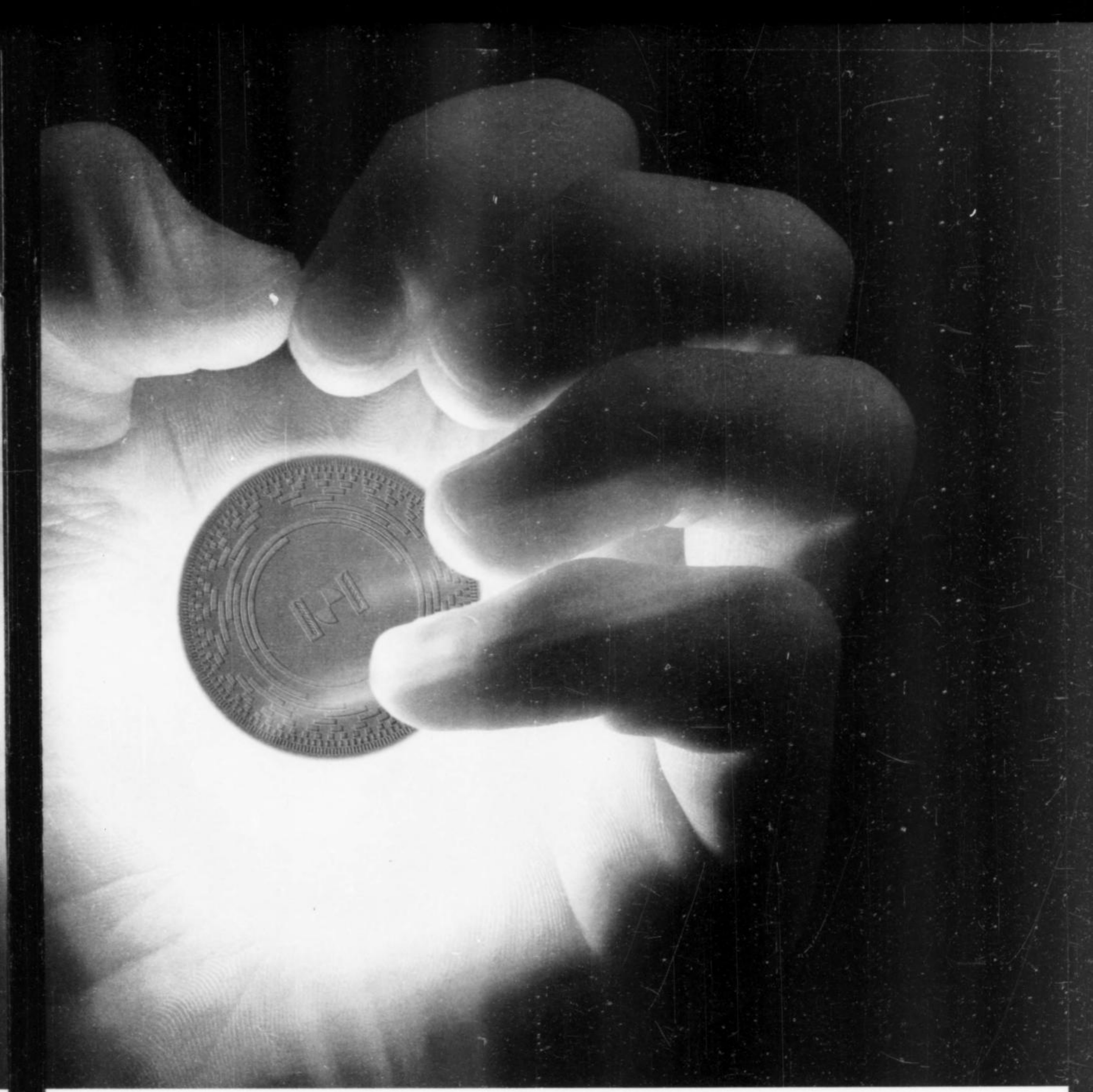
"It also may lead to computers that



are 100 times faster and more powerful than today's best. And there's even the possibility that photonics could improve everyday products such as television sets, telephones and other electronics-based appliances."

—*Glen E. Miller*
Senior Principal Engineer
Boeing Electronics High Technology Center

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BOEING

AEROSPACE/DEFENSE FINANCIAL REPORT

	Exch.	Fiscal Year	Yearly Sales*	% Change	Net Income*	% Change	Earnings Per Share	Book Value Per Share	Cash Flow Per Share	Common Shares*	Quarterly Dividend	Return On Equity	Return On Assets	Capital Spending*	S&P Bond Rating
PS Group Inc. (PSG)	NYS	12/88	216.1	-36.2	60.7	1419.9	6.23	41.10	9.76	7	0.60	22.0	8.8	43.7	B+
Barry Wright Corp. (BAR)	NYS	12/88	201.7	-2.0	1.3	-84.4	0.14	4.92	0.92	10	0.60	2.7	1.0	5.2	NA
Intl Lease Finance Corp. (ILFC)	OTC	11/88	195.5	12.9	43.4	-8.6	1.14	7.73	3.64	32	0.08	12.4	2.5	743.6	A-
Air Wis Services Inc. (ARWS)	OTC	12/88	177.3	21.8	11.3	95.7	2.18	10.94	CF	8	0.00	12.7	5.5	18.6	B
FlightSafety International (FSI)	NYS	12/88	175.3	28.9	50.0	19.6	1.48	8.09	2.43	34	0.16	18.3	11.1	38.7	NA
Curtiss-Wright Corp. (CW)	NYS	12/88	171.0	3.6	26.0	-7.5	5.62	48.95	7.21	5	1.60	10.6	8.0	20.8	NA
WorldCorp. Inc. (WOA)	NYS	12/88	167.5	16.5	8.6	-58.8	1.03	-6.09	1.06	10	0.00	NM	6.7	31.4	B-
Atlantic Southeast Airlines (ASAI)	OTC	12/88	137.1	15.1	11.5	2.3	0.92	7.42	2.44	12	0.00	12.6	5.0	35.4	NA
Comair Holdings Inc. (COMR)	OTC	03/88	87.6	40.4	5.1	NM	0.55	5.83	1.58	9	0.32	10.0	6.3	19.6	NA
Oregon Metallurgical Corp. (OREM)	OTC	12/88	75.5	46.0	5.6	404.5	0.61	3.19	0.98	9	0.20	19.0	9.8	6.3	NA
National Technical Sys Inc. (NTSC)	OTC	01/88	29.1	35.8	1.2	933.0	0.21	1.79	0.53	6	0.00	11.8	5.0	2.4	NA
Air Cargo Equipment Corp. (ARCE)	OTC	12/87	23.1	70.1	2.2	102.0	0.86	3.28	1.15	3	0.00	26.3	16.5	0.2	NA
Polaris Resources Inc. (POLAE)	OTC	12/87	3.2	-35.1	-0.5	NM	-0.04	-0.06	-0.03	14	0.00	NM	-50.1	0.0	NA
OTHER/DIVERSIFIED															
General Motors Corp. (GM)	NYS	12/88	120387.0	7.2	4632.1	30.4	7.17	57.81	19.44	613	3.00	13.0	2.8	6559.4	AA-
Ford Motor Co. (F)	NYS	12/88	92445.6	15.7	5300.2	14.6	10.96	43.87	18.51	491	3.00	24.6	3.7	4781.8	AA
Intl Business Machines Corp. (IBM)	NYS	12/88	59681.0	8.0	5491.0	4.4	9.80	66.99	17.84	590	4.40	13.9	7.5	5390.0	AAA
American Tele & Telegraph (T)	NYS	12/88	51974.0	1.2	-1669.0	NM	-1.55	10.68	1.88	1074	1.20	-14.6	-4.7	4028.0	AA
General Electric Co. (GE)	NYS	12/88	49414.0	2.6	3386.0	59.8	3.75	20.47	6.47	902	1.64	18.3	3.1	3681.0	AAA
Chrysler Corp. (C)	NYS	12/88	35472.7	21.2	1050.2	-18.6	4.66	32.53	11.97	233	1.20	13.9	2.2	2015.7	BBB
Du Pont (DD)	NYS	12/88	32917.0	8.0	2190.0	22.6	9.11	64.08	18.41	239	4.20	14.1	7.1	4001.0	AA
Amoco. Corp. (AN)	NYS	12/88	21150.0	4.8	2063.0	51.7	4.00	25.80	8.50	517	1.90	15.5	6.9	3697.0	AAA
ITT Corp. (ITT)	NYS	12/88	19355.0	6.4	858.0	-20.9	5.70	58.05	9.80	134	1.48	10.7	2.0	524.0	A
Eastman Kodak Co. (EK)	NYS	12/88	17034.0	28.0	1397.0	18.6	4.31	20.90	8.45	324	2.00	20.6	6.1	1914.0	A-
GTE Corp. (GTE)	NYS	12/88	16459.8	6.7	1224.7	9.5	3.58	24.91	12.16	326	2.68	14.2	3.9	3087.0	A-
Xerox Corp. (XRX)	NYS	12/88	15994.0	5.9	388.0	-32.9	3.50	52.22	12.38	103	3.00	7.2	1.5	508.0	A+
Tenneco. Inc. (TGT)	NYS	12/88	13234.0	10.8	-1.0	NM	5.48	24.93	8.34	127	3.04	-0.0	-0.0	688.0	BBB+
Westinghouse Electric Corp. (WX)	NYS	12/88	12499.5	10.3	822.8	11.4	5.66	26.36	8.24	144	2.00	21.7	4.9	421.8	AA
Goodyear Tire & Rubber Co. (GT)	NYS	12/88	10810.4	9.1	350.1	-31.9	6.11	35.30	11.67	57	1.80	17.3	4.1	743.7	BBB-
Unisys Corp. (UIS)	NYS	12/88	9902.0	1.9	680.6	17.8	3.58	22.24	8.98	159	1.00	13.7	5.9	669.9	A-
Hewlett-Packard Co. (HWP)	NYS	10/88	9831.0	21.5	816.0	26.7	3.36	19.35	4.11	234	0.34	18.0	10.9	648.0	NA
Union Carbide Corp. (UK)	NYS	12/88	8324.0	20.4	662.0	185.3	4.88	13.34	9.77	138	1.00	36.1	7.8	671.0	BB+
Motorola Inc. (MOT)	NYS	12/88	8250.0	22.6	445.0	44.5	3.43	26.02	7.16	130	0.76	13.2	6.6	873.0	AA-
Teledyne Inc. (TDY)	NYS	12/88	4522.7	6.5	391.8	3.9	34.03	191.10	53.73	11	4.00	18.3	7.6	98.0	A
FMC Corp. (FMC)	NYS	12/88	3286.9	4.7	129.2	-32.4	3.60	-6.53	10.75	34	0.00	NM	4.7	186.5	BB
Brunswick Corp. (BC)	NYS	12/88	3282.0	6.3	193.1	14.4	2.20	10.97	3.88	87	0.44	20.3	9.2	179.2	A-
Owens Corning Fiberglas (OCF)	NYS	12/88	2831.0	-2.1	197.0	-10.5	4.51	-15.18	8.34	40	0.00	NM	12.3	127.0	BB
Goodrich (GR)	NYS	12/88	2416.7	19.4	209.9	150.2	7.42	41.45	11.47	25	2.00	18.2	10.1	180.5	BBB
Olin Corp. (OLN)	NYS	12/88	2308.0	19.6	98.0	25.6	4.63	33.32	10.48	21	1.80	14.3	5.1	147.0	BBB-
Corning Inc. (GLW)	NYS	12/88	2121.5	1.8	292.4	54.6	2.34	17.56	4.11	89	0.80	18.7	10.1	258.6	A
Manville Corp. (MVL)	NYS	12/88	2062.2	6.6	89.1	-45.7	-10.83	7.39	1.60	39	0.00	11.2	3.7	141.1	BB
Sequa Corp. -CL A (SQA.A)	NYS	12/88	1712.6	49.5	71.5	40.7	6.04	NA	15.31	10	0.60	10.2	3.7	98.8	BB-
Colt Industries Inc. (5489B)	OTH	12/87	1641.6	1.6	75.0	-15.9	2.15	-30.81	3.55	31	0.00	NM	7.4	33.9	B
Timken Co. (TKR)	NYS	12/88	1554.1	26.3	65.9	538.7	2.34	34.31	6.59	28	0.92	6.8	4.1	78.9	AA
Penn Central Corp. (PC)	NYS	12/88	1546.5	22.6	94.1	170.4	1.46	24.92	2.02	71	0.10	5.3	3.9	36.0	BBB-
Harsco Corp. (HSC)	NYS	12/88	1279.0	9.4	31.1	-50.9	1.17	15.94	3.19	26	1.20	7.4	3.5	69.0	A
Harnischfeger Industries Inc. (HPH)	NYS	10/88	1208.6	24.1	32.5	149.9	0.51	14.16	2.19	33	0.20	7.1	2.7	35.4	NA
Raychem Corp. (RYC)	NYS	06/88	1094.7	15.9	125.3	70.2	3.69	19.68	5.53	37	0.32	17.3	10.9	84.5	NA
Ogden Corp. (OG)	NYS	12/88	1087.8	20.5	57.8	6.9	1.44	10.74	2.04	40	1.25	13.6	2.6	304.9	BBB
Ball Corp. (BLL)	NYS	12/88	1073.0	1.8	32.7	-45.6	2.17	17.92	2.99	24	1.08	7.8	3.7	100.6	NA
Pennwalt Corp. (PSM)	NYS	12/88	1023.6	21.0	48.3	-10.3	14.34	28.53	7.41	8	2.40	21.4	5.1	46.7	BBB-
Interlake Corp. (IK)	NYS	12/88	892.2	8.4	39.6	-27.3	3.75	26.66	6.65	10	1.50	14.7	6.0	49.1	BBB+
Kaman Corp. -CL A (KAMNA)	OTC	12/88	767.2	8.5	25.3	4.8	1.42	10.01	2.30	18	0.44	14.2	6.0	19.5	BBB-
Bell & Howell Co. (5570B)	OTH	12/88	588.7	0.8	-37.8	NM	-7.56	18.08	NR	3	0.00	-69.6	-4.6	NR	B+
Union Corp. (UCO)	NYS	06/88	131.0	11.4	3.8	92.7	0.88	5.75	1.37	7	0.00	9.7	3.7	5.5	NA
Cade Industries Inc. (CADE)	OTC	12/88	61.9	12.5	-4.0	NM	-0.23	0.53	-0.30	17	0.00	-43.7	-9.2	2.9	NA
Clabir Corp. (CLG)	NYS	01/88	0.0	NM	-162.3	NM	-16.46	NA	-1.59	11	0.00	NM	-337.4	1.9	NA

**In Millions*
NM – not meaningful

Earnings per share includes nonrecuring items
Quarterly dividend at most recent or indicated rate

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Thomson-CSF is one of the world's leading suppliers of integrated avionics and onboard systems for both civil and military applications, as well as a leader in flight simulators.

The Rafale – France's new combat aircraft for the Nineties and beyond – exemplifies the broad range of our products. We are responsible for the fighter's radar program and the integration of its electronic warfare system and are also a major partner for its visionics, optronics and smart weapons. The Rafale's electronically scanned radar will be among the world's most advanced providing simultaneous air-to-air firing and automatic terrain-following capabilities.

We offer customers a full choice of systems for combat, maritime patrol and SIGINT for fixed- or rotary-wing aircraft. These systems are designed to provide the most advanced defensive and offensive capabilities for all missions.

In commercial aviation, we produce specialized systems that cover a wide spectrum of aircraft avionics and electronics requirements including fly-by-wire – and soon fly-by-light – electronics, instrumentation, and essential systems for the generation of electrical power. The Airbus A320's new technology flight instrument panel – the world's most advanced – was entirely produced by Thomson-CSF.

THOMSON-CSF. THE BIGGEST EUROPEAN COMPANY

BIG ON THE GROUND

AIR TRAFFIC CONTROL – AIR DEFENSE – WEAPONS SYSTEMS – COMMUNICATIONS – C^3I

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Ever since we installed our first radar back in 1937, we've never stopped improving our ground systems for airspace surveillance. Over the past 30 years we've delivered approximately 3500 radars around the world. Today Thomson-CSF is one of the world's leading suppliers of major systems in air-traffic control and air defense. With our subsidiary Wilcox in the U.S., we are the world's No.1 producer of navigation and landing systems.

In air defense and ordnance, we possess all the resources necessary to develop and support the weapon systems you need to meet your most complex requirements. We are also involved in cooperative programs with NATO countries, e.g., the development of a family of anti-missile systems, a new generation of air defense systems, the Multifunctional Information Distribution System (MIDS), the NATO Identification System (NIS), and NATO's Air Command & Control Systems (ACCS).

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At Thomson-CSF, we're a major systems supplier. We've got the assets and resources, the experience and the expertise, to design, develop and produce every kind of major military and civilian airborne and ground system, whether original equipment or retrofit.

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The bottom line: we're present on the leading edge of every avionics and aeronautics technology, we're airborne, we're ready to take on the future.

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Globally, cooperation is a commitment at Thomson-CSF. Brazil is one example. The U.S. is another. Recently we've teamed with several leading American contractors to help meet the evolving requirements of U.S. defense. At the same time, worldwide, we're collaborating with dozens of other companies in as many countries.

The Paris Air Show in June at Le Bourget is your big chance to see the Thomson-CSF of 1989. And its flight plan for the Nineties and beyond. And what it could mean for you.

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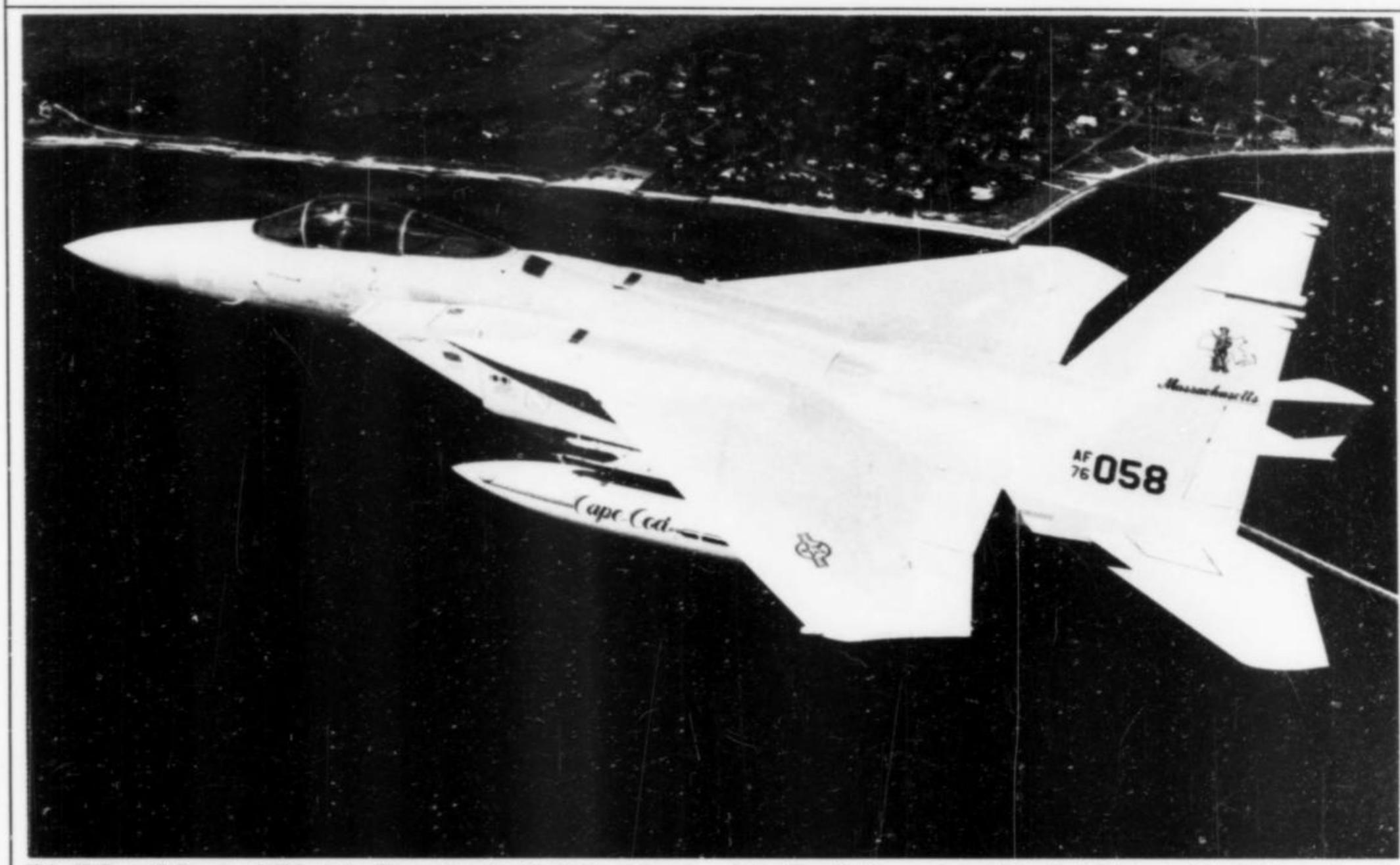
POLARIS EXPANSION

Contractors Grapple With Low Stock Prices, Peak Cash Needs

LOS ANGELES



This McDonnell Douglas F-15A of the Massachusetts Air National Guard is used to intercept Soviet Bear bombers flown between Russia and Cuba. The Air Force advanced tactical fighter is intended to replace F-15s first deployed in 1974.

The stock market usually assigns a lower value to the shares of aerospace companies that do business primarily with the Defense Dept., reflecting Wall Street's concern about a declining defense budget and Pentagon policies and practices that hurt profitability.

As a result, defense contractors find it more difficult to raise money from their undervalued stock, at a time when cash requirements are at a peak to fund cost-sharing development programs. Also, the low stock value makes the companies more vulnerable to takeovers.

"Those companies that, let's say, have a 10-25% defense business, are curtailing it—they're selling it off or putting it out of business. They can't see the opportunities," John B. Campbell, Northrop senior vice president for finance, said.

Some of the companies that remain committed to government contracting have realigned their operations to better survive in what they perceive to be the profitable niches. And companies are making a statement by not bidding on projects that have unfavorable terms.

Northrop did not bid on 14 contracts in 1988 because it felt the government's proposed terms and conditions were unsound. Northrop has lost hundreds of millions of dollars in recent development programs. Other contractors have likewise been more selective in their bidding.

The contracting environment in the past pushed companies into situations they now have second thoughts about

The mood of desperation to win contracts, combined with the willingness to endure harsh terms for victory, is tempered now that the effect of these harsh terms is being felt.

The two issues causing the largest problems are fixed-price development contracts and contractor funding of sizable portions of development programs. Companies are increasingly leery of funding development as it becomes more apparent that some programs may never go into production. The Army's LHX helicopter provides an example: The two competing contractor teams have each invested on the order of $100 million, but now the program is threatened with cancellation.

Hughes' fixed-price development of the AMRAAM missile cost the company a quarter-billion dollars, and Northrop's losses of similar magnitude are largely due to fixed-price development contracts.

Although the General Accounting Office and the Pentagon are concerned about the inability of defense contractors to raise money, industry officials are taking a wait-and-see attitude. Large fixed-price development contracts are still being awarded. Last October, the Navy awarded Lockheed a fixed-price contract to develop the P-7A antisubmarine warfare aircraft.

Competing teams are now under $691-million (Fiscal 1985 dollars) contracts for the demonstration/validation phase of the Air Force advanced tactical fighter (ATF). The contract amount is inadequate to design and build two flying prototypes for each team and to prepare for the subsequent full-scale development award in December, 1990, so each team is investing hundreds of millions of dollars

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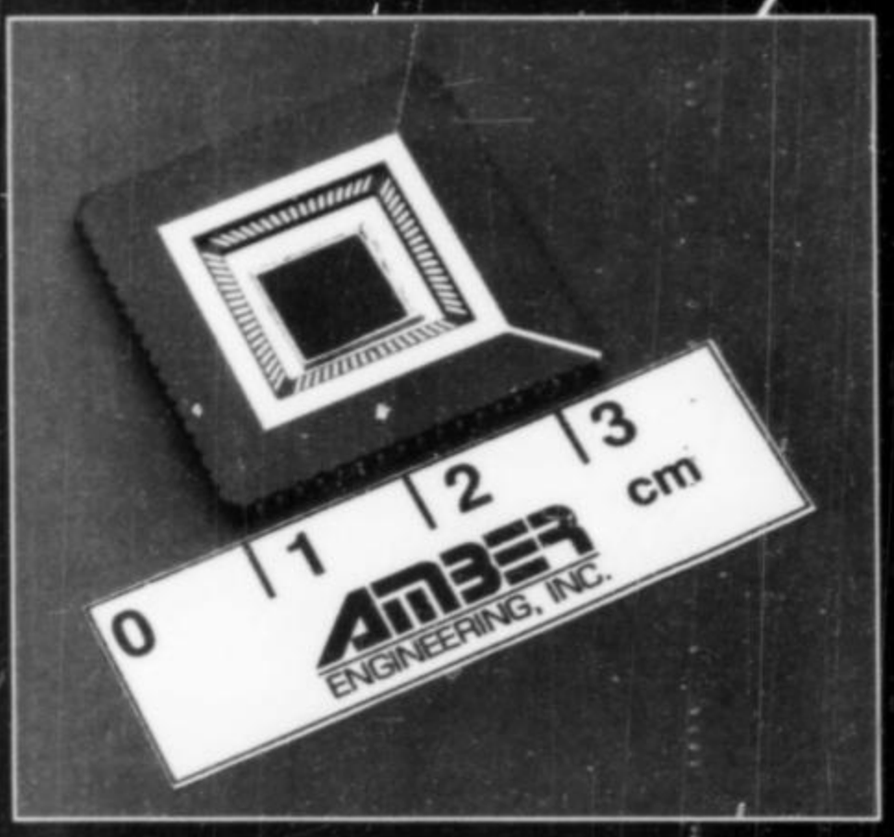

"off-the-shelf" delivery.

Amber Engineering has long been known as one of the premier developers of Infrared Focal Plane Components and test equipment for aerospace and military applications. The new 128 x 128 InSb Focal Plane Array is a product of this heritage of custom design, and offers a highly economical design solution for large area, high-resolution applications.

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Complete with uniformity-compensating drive electronics and a laboratory dewar, the new 128 x 128 FPA offers designers a new price/performance standard. The new unit is a second generation, high-performance multiplexed array of MWIR infrared detectors— a hybrid design in which the detectors are fabricated from implanted Indium Antimonide and mated to CMOS signal processing integrated circuits. It features adjustable frame rates up to 1 KHz, and intermeshed multiplexer architecture to facilitate signal processing. Custom packaging is available for both array and electronics.

This new 128 x 128 focal plane array is the threshold of a new era in systems design...sophisticated "off-the-shelf" components that offer new freedom and new horizons for specialized applications. Amber researchers have also developed 128 x 128 HgCdTe and 256 x 256 InSb arrays, to be available by the third quarter of 1989. Call or write Amber Engineering for data sheets and design consultation.

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Financial Leverage of Aerospace/Defense Companies

DEBT/EQUITY RATIO

Fairchild Industries	4.567
Textron Inc.	4.264
McDonnell Douglas Corp.	2.730
Grumman Corp.	2.280
General Dynamics Inc.	2.183
Northrop Corp.	2.128
Allied Signal Corp.	2.062
UNC Inc.	2.043
Martin Marietta Corp.	1.764
Lockheed Corp.	1.683
Sunstrand Corp.	1.658
United Technologies Corp.	1.643
Rockwell International Corp.	1.494
Hexcel Corp.	1.469
Rohr Industries	1.356
Boeing Co.	1.333
Fansteel Inc.	1.103
Parker-Hannifin Corp.	1.060
Morton Thiokol Inc.	0.803

of unrecoverable funds for nominally a 50% chance of winning the $60-billion ATF program. Lockheed's ATF investment was about $40 million in 1987, $80 million in 1988, and is expected to be $80 million in 1989 and much less in 1990.

Early this year, the Air Force stretched out ATF full-scale development by one year, but the contractor teams expect the new schedule will be reflected in contract negotiations for that phase. "If they had proposed to slip the prototype phase, then you would have had people screaming and yelling, because this is the phase where we are putting in a lot of money, and it would be very expensive to slip that," a Lockheed official said.

"There's a better understanding, both in government and industry, that the kinds of programs like ATF where you have very substantial up-front investment by industry itself—some of which will be lost since not everyone's going to be a winner—can only be done to a certain extent," Vincent N. Marafino, Lockheed vice chairman and chief financial and administrative officer, said. "We need to invest in new technologies and research and development. We cannot do that if in fact we're attempting to invest heavily in peculiar programs and specific developments.

"In the 1960s, we had the idea of total package procurement, where we had the same kind of fixed-price development programs," Marafino said. "It turned out that they caused a great deal of difficulty, not only from the financial standpoint, but from a product standpoint to the customers. They became a bit more popular as competition got a little bit tougher and the government thought that an up-front commitment by the companies would make them more aggressive, would control costs a little bit better. I think that there are lessons being learned all the time, and that these things go in cycles. I think they are turning the other way now, there is a recognition that there is a limitation of resources."

The contracting environment in the past pushed companies into situations they now have second thoughts about. "It was the name of the game. All contractors were certainly signing up for it," Campbell said. "In our case, we signed up to the contract, and I'd have to say, maybe we weren't as smart a businessman as we should have been. We did change our policy internally where the CEO does now approve the form of a contract on a program."

Companies' cash requirements have increased in the 1980s. Northrop has had to increase its working capital by $1 billion over the last seven years, Campbell said. During this period it spent about $350 million of its own money on R&D in support of government programs, and over $2 billion on new buildings and equipment. The company took a $1-billion writeoff on its failed private initiative to develop the F-20 fighter and was forced to borrow money to cover $187 million in accounts receivable owed it by the Air Force on the ATF program in 1988.

"The government tying up our working capital is the real issue," Campbell said. □

Ratio of Current Assets to Current Liabilities

PERCENT

AEROSPACE/DEFENSE COMPANIES	
Hi-Shear Industries	4.405
Rohr Industries	3.523
Eldec Corp.	2.910
Hercules Inc.	2.793
LTV Corp.	2.583
UNC Inc.	2.561
Hexcel Corp.	2.453
Grumman Corp.	2.452
Parker-Hannifin Corp.	2.314
Fansteel Inc.	2.144
Fairchild Industries Inc.	2.120
Morton Thiokol Inc.	1.891
General Dynamics Corp.	1.777
Sunstrand Corp.	1.663
United Technologies Corp.	1.614
Martin Marietta Corp.	1.421
GenCorp Inc.	1.411
Rockwell International Corp.	1.297
Allied Signal Inc.	1.286
Boeing Co.	1.277
Northrop Corp.	1.080
Lockheed Corp.	0.913
McDonnell Douglas Corp.	-0.001
Textron Inc.	-0.001

Defense Electronic Industry Expects Little Sales Growth

DAVID HUGHES/BOSTON

Defense Electronics industry officials expect little sales growth for several years as defense budgets shrink and competition intensifies.

The electronic content of the U. S. Defense Dept. budget is expected to grow only from $53 to $55 billion annually (1989 dollars) by 1998, according to the Electronic Industries Assn. 10-year forecast.

Despite this slowdown in the rate of growth, electronics remains a critical component of overall defense spending. For example, software is rapidly becoming an important area of spending in defense electronics. The Defense Dept. is spending tens of billions of dollars on computer software each year. Exactly how much is being spent in this area is open to speculation because software costs are not tracked in overall defense spending or by individual program. Software is being used to integrate complex weapons systems and is often the key element in determining whether a system will work properly.

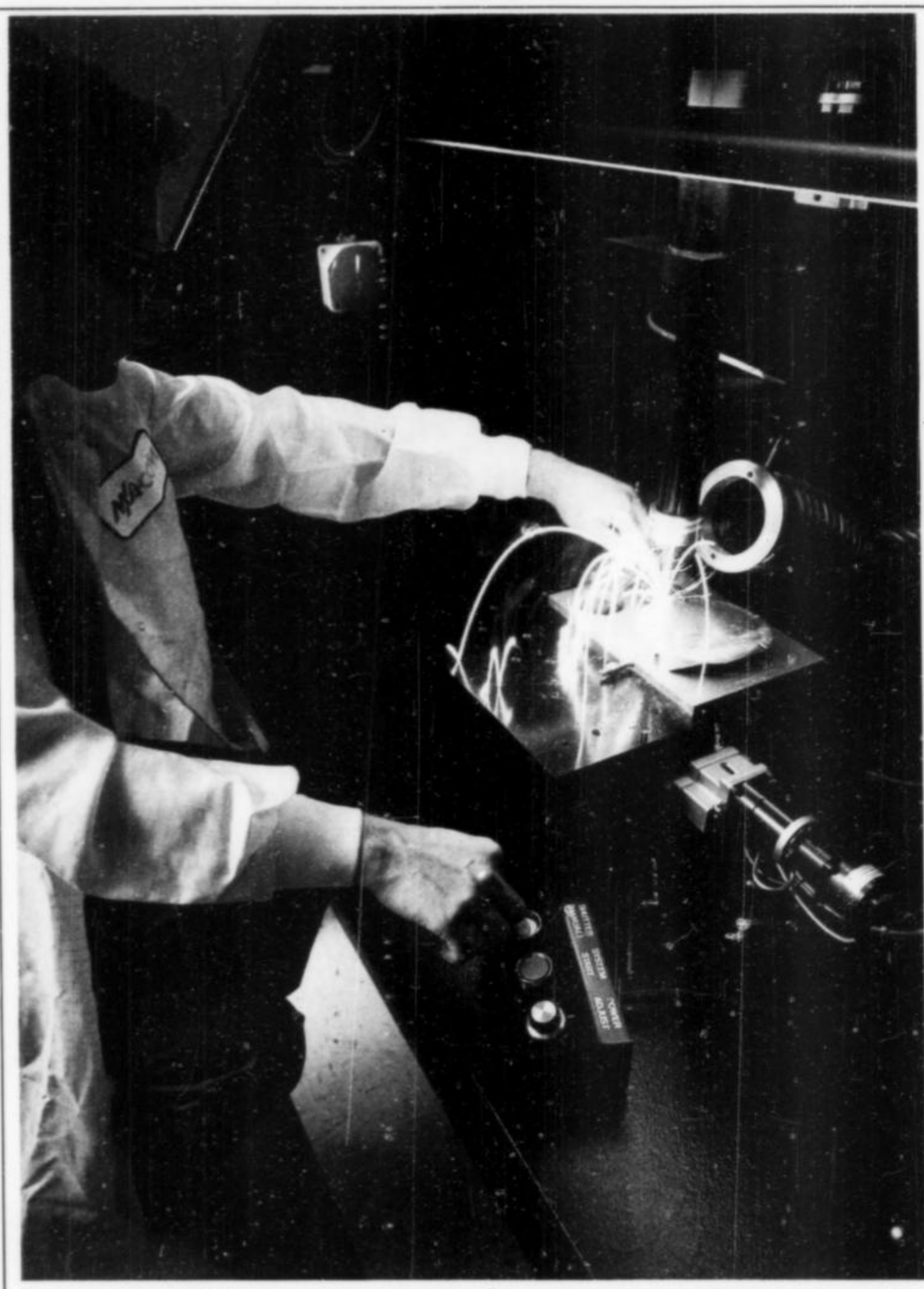
The importance of electronics in new weapons systems is demonstrated by the fact that more than 50% of the value of future military fighters will be represented by electronic content. The figure is 60% or more for space systems and is already as high as 85% for tactical missiles.

ELECTRONIC INTEGRATORS

A study by Booz Allen & Hamilton, Inc., identifies electronic systems integrators as the most profitable performers in the aerospace defense industry when measured by return on assets (ROA). ROAs for these firms are at the 25% level, a full 15% above the ROA ratio achieved by platform integrators and firms involved in building airframe structures. Electronic integrators are doing well because their sales are increasing, and they have less money invested in assets than airframe manufacturers do.

This point has not been lost on top managers at airframe companies like Lockheed Corp.

One reason the defense electronics field is becoming more crowded is that companies like Lockheed are diversifying to address such areas as military avionics, which they have traditionally left to avionics suppliers (AW&ST Apr. 24, p. 92). Lockheed plans to build a military avionics business unit into a profit center at Sanders Associates in Nashua, N. H., an electronic warfare system supplier it acquired in 1986.

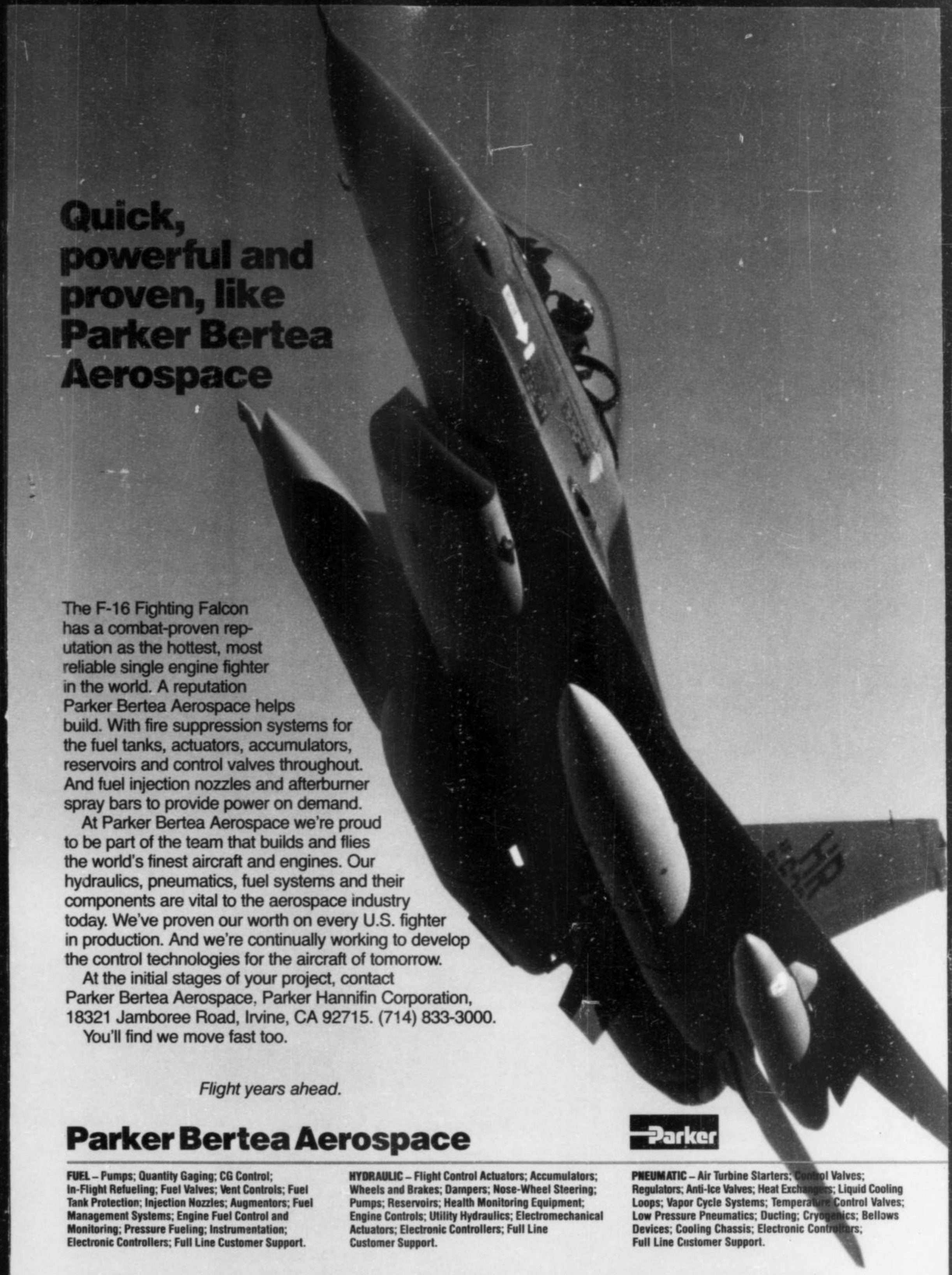


Operator in M/A COM's Advanced Semiconductor Div. performs laser welding to seal a package containing a microwave assembly for use in the Advanced Medium Range Air-to-Air Missile.

The avionics initiative is aimed not only at providing electronics for the Advanced Tactical Fighter but also at supplying liquid crystal displays for retrofit into fleets of aging military transports. Lockheed officials estimate that the need for these improvements presents an opportunity for $2-4 billion worth of business over the next five years.

Jean A. Caffiaux, senior vice president of the Government Div. of the Electronic Industries Assn., said the need to update weapons systems will generate additional defense electronics business. "With the cuts [in overall defense spending], the Defense Dept. will have to get improved performance by upgrading existing systems," Caffiaux said in explaining why he sees the proposed spending cuts on defense as not as much a threat to electronics as to other types of businesses.

Val P. Peline, president of Lockheed's Electronic Systems Group at Nashua, N. H., which oversees Sanders and several other Lockheed electronics operations, said his firm is finding that more competi-



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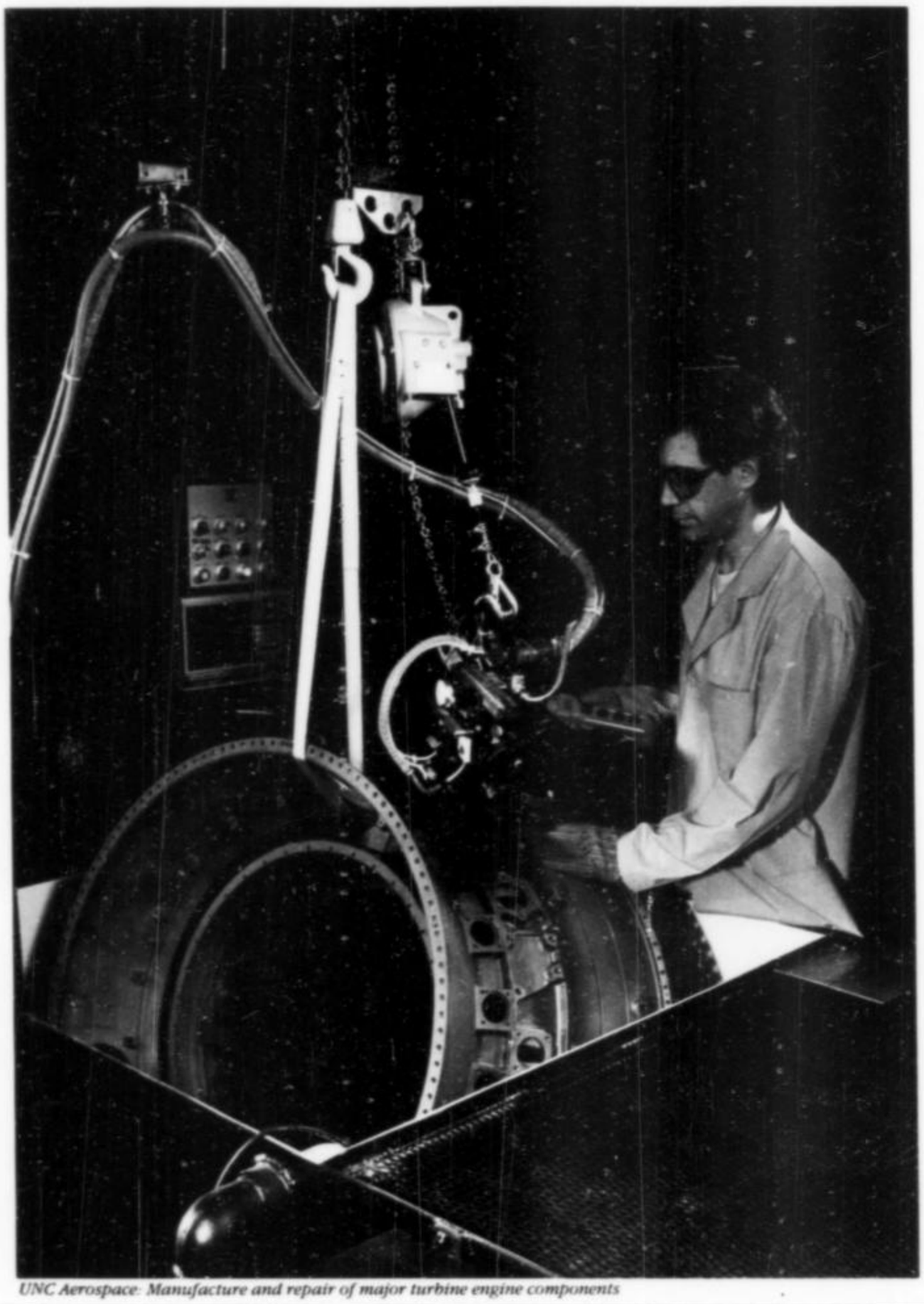

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Circle 68 on Reader Card

tors are vying for programs in categories they have not pursued in the past. New entrants will frequently bid a price below what is profitable just to get established in a business area.

With so many programs being decided purely on a cost basis once the bids are determined to be technically acceptable, the importance of being a low-cost supplier is becoming increasingly evident. "Low engineering and manufacturing cost is the number one item you need to win," according to Peline. He said his philosophy is to stress profitability over growth to ride out the current downturn in the defense spending cycle.

SECOND SOURCING

Other factors working against profitability in the business include second sourcing of production awards, reduced buys and even stretchouts in the request for proposals (RFP) cycle. In some cases, it now takes as much as 12-15 months to go from the delivery of a bid to a decision by the government.

It is expensive for competitors to keep teams of people assembled to work on a particular project, so the delay in the RFP cycle drives up the cost of doing business.

Regarding mergers and acquisitions, Peline said he expects to see fewer non-defense firms buying defense electronics concerns. The predictions two years ago were that industry sales would grow at an annual rate of 16%. Now that the outlook is for little if any growth, the acquisitions that do occur are likely to be made by defense firms looking to fulfill a business strategy or to add a product that fits in their existing lines. But firms are unlikely to pay premium prices for defense electronics firms as they have in the past few years.

Interest in capitalizing on growth is driving a wave of mergers and acquisitions that has made once obscure defense electronics firms well known names in financial circles. Medium-size firms are acquiring small ones only to realize that they may be next in line for acquisition by a larger competitor.

At a symposium sponsored by the Electronic Industries Assn., Peter Aseritis of Booz Allen & Hamilton said merger and acquisition activity will increase in defense electronic firms. "Being a defense electronics analyst, eight of my companies have disappeared in the last $2^1/_2$ years. Remember names like Sanders, Hazeltine, Syscon, Argo Systems, Electrospace, Tracor, BDM, Atlantic Research? I followed all of these as independent companies. Now they still exist . . . but they they are not independent entities. I think that [trend] is going to continue."

Merger and acquisition activity involving defense electronics firms is beginning to move across national boundaries as firms seek to grow larger in order to compete on a global scale. One case that

Companies By Five-Year Growth Trend in Revenues

PERCENT PER ANNUM

Convex Computer Corp.	237.091	USAir Group	28.524
Verdix Corp.	228.320	EECO Inc.	28.391
Sun Microsystems Inc.	152.947	Frequency Electronics Inc.	28.078
Cypress Semiconductor Corp.	146.251	IRT Corp.	26.020
Cade Industries Inc.	132.707	Dyncorp Inc.	25.836
America West Airlines Inc.	96.939	Diagnostic/Retrieval Systems	25.000
Integrated Device Tech. Inc.	89.910	SCI Systems Inc.	24.942
Mark IV Industries Inc.	86.338	Alaska Airgroup Inc.	23.643
Texas Air Corp.	57.830	Brunswick Corp.	23.201
Perceptronics Inc.	57.529	NWA Inc.	23.041
Nichols Research Corp.	48.421	Analysis & Technology Inc.	22.984
Computer Associates International	44.514	PHH Corp.	22.801
Sequa Corp.	44.438	Titan Corp.	22.603
Harnischfeger Industries Inc.	43.873	Hexcel Corp.	22.516
Atlantic Southeast Airlines	40.768	ECC International Inc.	21.622
Precision Castparts Corp.	40.256	Arvin Industries Inc.	21.535
Cray Research	37.807	Unisys Corp.	21.006
International Lease Finance Corp.	35.274	Ryder System Inc.	20.872
Textron Inc.	32.465	Digital Equipment Corp.	20.844
Midway Airlines Inc.	32.250	Dynamics Research Corp.	20.417
Comair Holdings Inc.	32.187	Teleflex Inc.	20.411
UNC Inc.	32.017	Burr-Brown Corp.	20.303
Orbit Instrument Corp.	31.770	ARX Inc.	19.969
HAL Inc.	31.309	Galileo Electro-Optics Corp.	19.826
Loral Corp.	31.039	Amdahl Corp.	19.687
Stanford Telecommunications	31.035	Evans & Sutherland Computer Corp.	18.945
Apple Computer Inc.	28.537	Pacific Scientific Co.	18.210

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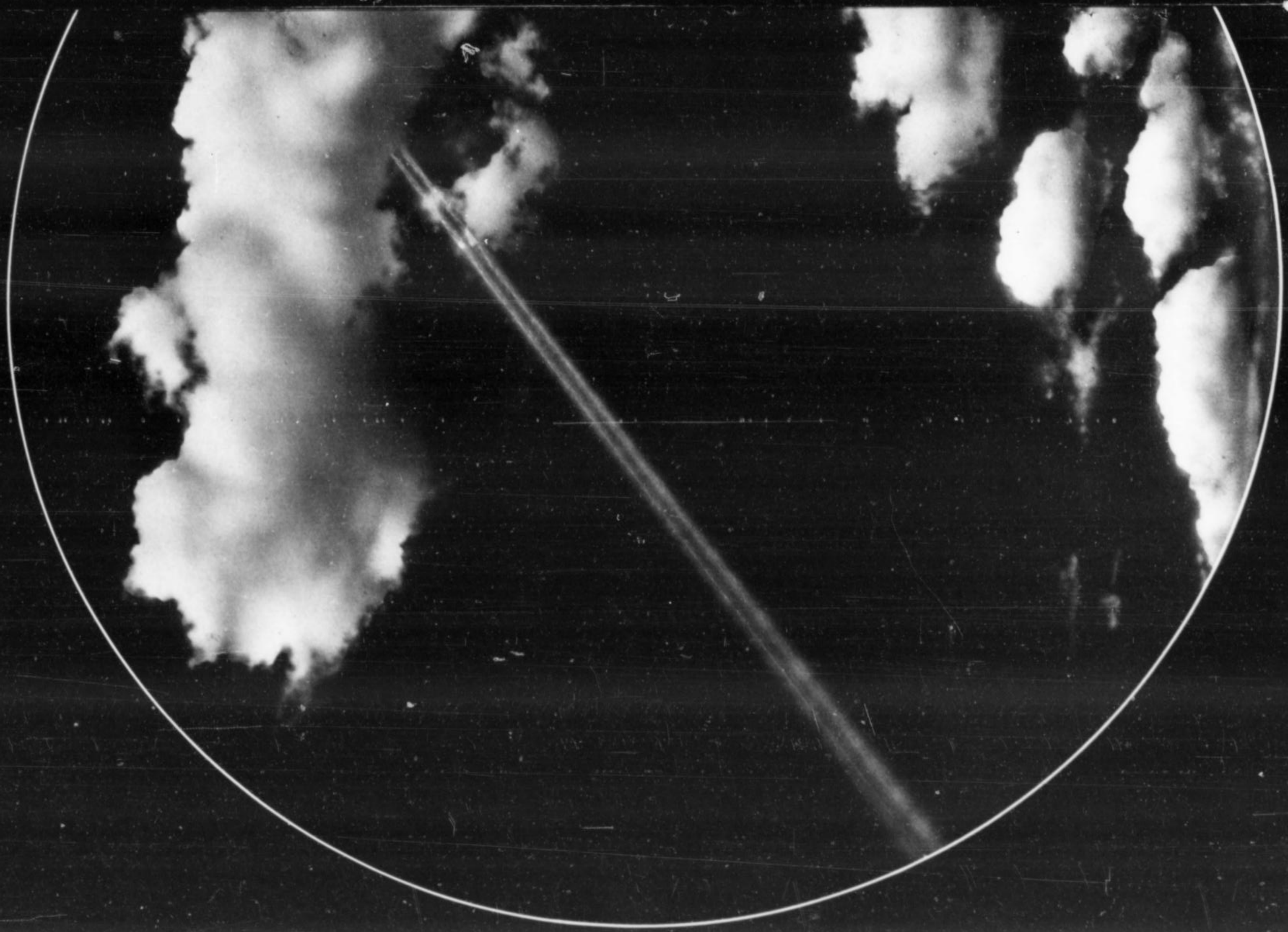

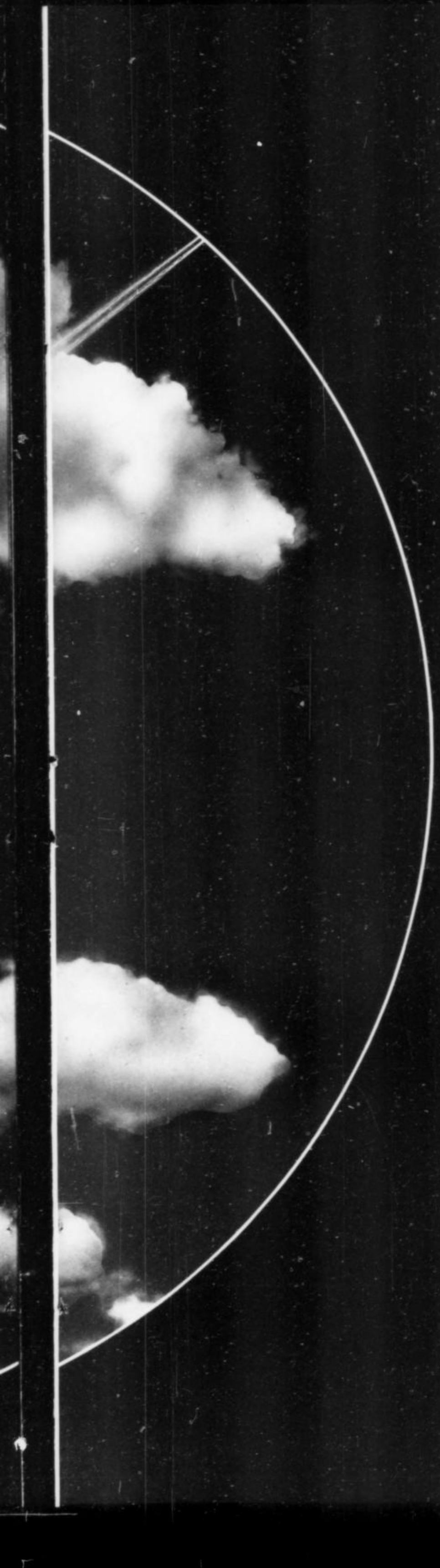

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CASA - Spain
CASMU - (Aeritalia and SNIA-BPD) - Italy
MBB - Federal Republic of Germany
Rockwell International - United States

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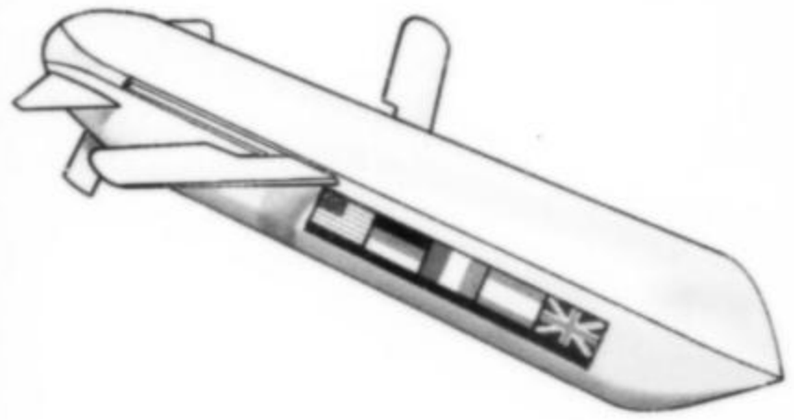

FIVE NATIONS. ONE TEAM.

Alliance Defence Corporation

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illustrates the current situation in defense electronics is the attempt by GEC-Siemens to take over Plessey.

Plessey Co., Plc., in England has been acquiring small firms in North America to expand its penetration of the U. S. and Canadian defense markets. The company acquired the Singer Electronic Systems Div. of the U. S. for $310 million and Leigh Instruments, Ltd., of Canada for $100 million (Canadian) last year.

JOINT VENTURE

The firm also acquired Sippican, Inc., of the U. S. for $80 million in 1987. The British company makes radar, avionics, communications equipment, underwater systems and traffic control systems. Over half of Plessey's defense electronics sales are now generated overseas.

At the same time, Plessey has become a takeover target by General Electric Co., Plc., (GEC) (no relation to General Electric in the U. S.) and Siemens AG of West Germany. The two bidders for Plessey have gone so far as to form a joint venture called GEC-Siemens, Plc., to pursue the takeover.

An earlier attempt by GEC on its own to take over Plessey did not succeed, although the two firms did agree to form a joint venture to pursue telecommunications business together in a company called GEC Plessey Telecommunications, Ltd.

Now the question arises whether the British Ministry of Defense will permit Plessey to be sold to GEC-Siemens. The English Monopolies and Mergers Commission has just approved a new bid by GEC-Siemens, Plc., provided the acquiring companies agree to certain stipulations, which will be spelled out in detail during negotiations between the Ministry of Defense and the two companies. The sticking points include the following:

- GEC must agree not to acquire any interest in or control over the management of the Plessey Radar and Defense Systems or Plessey's traffic control activities. GEC has business of its own in these areas, and the concern is that a combination with Plessey would reduce competition in these areas.
- GEC and Siemens must agree to provide access to the technology and licenses for production of Joint Tactical Information Distribution System (JTIDS) to competing companies designated by the British Ministry of Defense. Plessey acquired the Singer Electronic Systems Div. (ESD) of New Jersey last year and ESD is a prime contractor on the $2-billion JTIDS program for the U. S. Defense Dept. This unit is now known as Plessey Electronic Systems Corp. GEC is the prime contractor in Britain for JTIDS, so the concern is that combining GEC-Siemens and Plessey would provide a JTIDS monopoly in the United Kingdom.
- GEC and Siemens must satisfy national security requirements that only British citizens work in positions of top management of defense, research and de-

5-Year Growth Trend In R&D Spending

PERCENT PER ANNUM

AEROSPACE	
Hexcel Corp.	23.267
Sunstrand Corp.	23.045
Textron Inc.	21.049
General Dynamics Corp.	20.626
Martin Marietta Corp.	20.020
McDonnell Douglas Corp.	16.621
Boeing Co.	14.957
Lockheed Corp.	13.494
Morton Thiokol Inc.	13.354
Parker-Hannifin	13.013
Rockwell International Corp.	11.365
Allied Signal Inc.	9.487
LTV Corp.	9.084
Hi-Shear Industries	3.947
Hercules Inc.	0.140
AVIONICS/MILITARY ELECTRONICS	
Sun Microsystems Inc.	111.282
Mark IV Industries Inc.	95.525
Cypress Semiconductor Corp.	85.926
IRT Corp.	77.385
Integrated Device Tech Inc.	72.705
Computer Associates International. Inc.	54.470
Tech-Sym Corp.	51.740
Convex Computer Corp.	51.397
UTL Corp.	51.230
Loral Corp.	47.996
Logicon Inc.	41.447
Evans & Sutherland Computer Corp.	40.561
Cray Research	38.557
Apple Computer Inc.	37.325
Galileo Electro-Optics Corp.	30.427
Stanford Telecommunications	29.743
Digital Equipment	20.847
AEL Industries Class A	20.419
Pacific Scientific Co.	19.990
ECC International Inc.	18.654
Sparton Corp..	18.011
Diagnostic/Retrieval Class A	17.574
National Semiconductor Corp.	17.072
Emerson Electric Co.	16.965
Anaren Microwave Inc.	16.741
Burr-Brown Corp.	16.434
Intel Corp..	16.285
Moog Inc.	16.075
Sigma Research Inc.	15.620
Pall Corp.	14.805
Advanced Micro Devices	14.781
Amdahl Corp.	14.655
Miltope Group Inc.	13.886
Avantek Inc.	13.093
Unitrode Corp.	12.247
Helix Technology Corp.	11.596

velopment and semiconductor activities.

GEC and Siemens officials have 40 days to negotiate the details of the above contractual agreements, or undertakings as they are called in Britain, to the satisfaction of Ministry of Defense officials. Only when these negotiations are satisfactorily completed can GEC-Siemens make a renewed bid for Plessey. The company would then have 60 days to conclude the purchase.

Plessey officials, on the other hand, remain poised to fight any additional offer made by GEC-Siemens.

SKYNET 4 SATELLITE

Last month, Plessey won a major contract for the United Kingdom's Military Satellite ground facilities to support the Skynet 4 satellite. After winning the award from GEC-Marconi, a Plessey official explained the win in part as an example of how the firm is thriving as an independent company.

"That we have won this order is a reflection that fleet-footed specialists, like ourselves, are making it harder for our conglomerate competitors to keep up with us," according to Cyril Teed, managing director of Plessey Defense Systems, Christchurch, England.

Research and development has always been a priority with Plessey. Over the past five years the firm has spent more than $2 billion in this area. The company is also acquiring other firms to provide it with the enabling technology to develop systems.

Dr. William P. Sommers of Booz Allen & Hamilton said defense electronics firms can not afford to invest in research and development in all areas and maintain leadership.

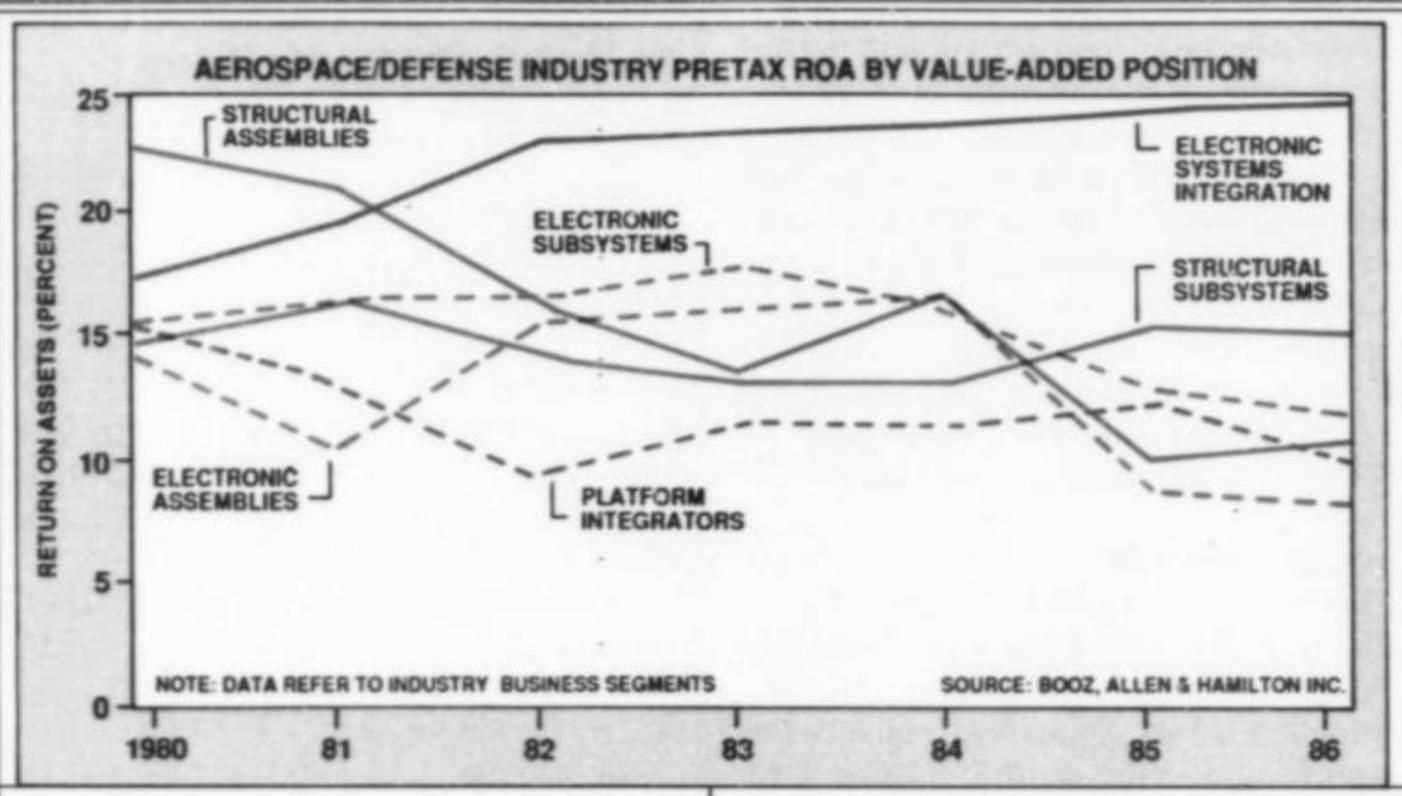
Instead, firms must pick and choose their opportunities. "There just isn't enough money to go around," according to Sommers.

Semiconductor design and fabrication is an area in which heavy investment is warranted.

ASIC MARKET SECTOR

For example, in 1987 Plessey acquired the semiconductor operations of Ferranti, Plc., bringing together two organizations involved in producing application specific integrated circuits (ASICs). The ASIC market sector is expected to grow by over 50% by 1990, and Plessey officials now claim it is the leading company in the United Kingdom in the semiconductor industry.

Many defense electronics firms have



developed a captive gallium arsenide fabrication capability for making custom devices. In Boston and surrounding cities there are at least five gallium arsenide fabrication facilities and one silicon Very High Speed Integrated Circuit (VHSIC) facility operated by various companies.

Only some of the gallium arsenide facilities are involved in working on the Defense Dept.'s Microwave/Millimeter Wave Monolithic Integrated Circuit (Mimic) program. The rest of the facilities are supporting the need for components or subsystems for their respective firms.

VHSIC, MIMIC FACILITIES

For example, Raytheon Co. has $90 million invested in its VHSIC and MIMIC facilities at Andover, Mass., while Sanders Associates in nearby Nashua, N. H., is producing monolithic microwave integrated circuits at a $34-million facility (AW&ST Feb. 22, 1988, p. 56).

Both Raytheon and Sanders are planning to insert devices into their products. In the case of Raytheon, some of the first products to benefit may be missiles made by the firm's Missile Systems Div.

At Adams Russell, Inc., in Waltham, Mass., there is another 8,000 sq. ft. gallium arsenide facility. The company has less than $5 million invested in the facility, which company officials said was sufficient.

Some firms have recently decided to close their gallium arsenide plants due to an industry-wide overcapacity. Two other microwave component manufacturers, Alpha Industries, Inc., of Woburn, Mass., and M/A COM, Inc., of Burlington, Mass., have substantial gallium arsenide facilities.

The $60-million M/A COM facility contains 50,000 sq. ft. of Class 100 clean rooms. It is producing 40 3-in. wafers a week and it has the capacity to produce more than 100 wafers a week. Alpha has a $25-million facility with 7,000 sq. ft. of Class 100 clean rooms.

Harris Corp. of Melbourne, Fla., is another firm that is expanding its role in semiconductor fabrication. The company acquired General Electric's semiconductor operation last year and added over $400 million a year in sales on top of the firm's $2.1 billion a year in overall sales including defense electronics.

William M. Braselton, Jr., vice president of business development for Harris, said the firm is now the largest supplier of integrated circuits to the U. S. government. □

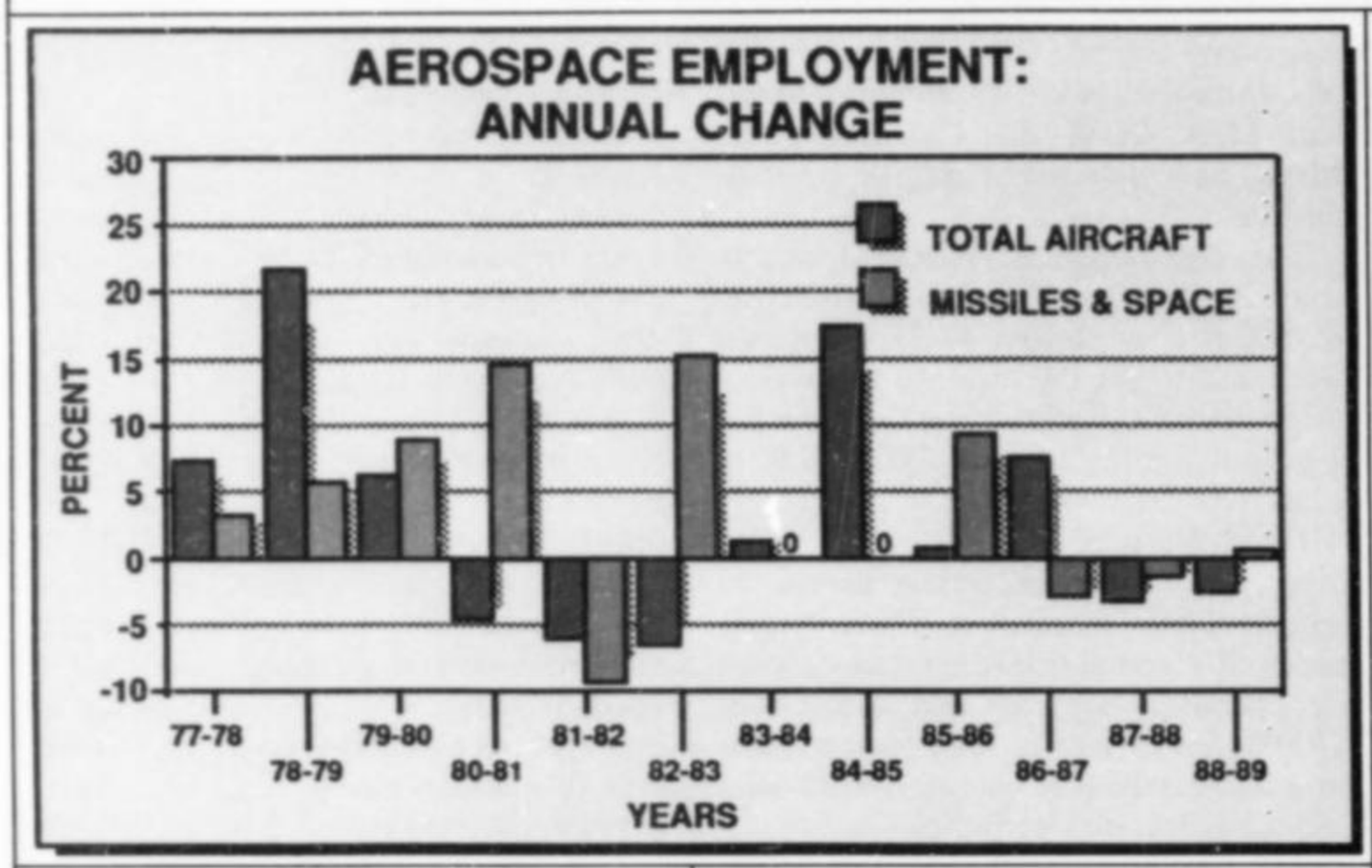
Turnover Rate Of Accounts Receivable

PERCENT

AVIONICS/MILITARY ELECTRONICS	
ECC International Inc.	9.829
Computer Associates International Inc.	9.162
Raytheon Co.	8.807
General Motors-Class H	8.499
Texas Instruments Inc.	8.355
Bell Industries Inc.	8.003
Apple Computer Inc.	7.796
Helix Technology Corp.	7.641
EG&G Inc.	7.572
National Semiconductor Corp	7.365
Eaton Corp.	7.339
Cray Research	7.073
TRW Inc.	7.032
SCI Systems Inc.	6.859
Stanford Telecommunications	6.717
Sparton Corp.	6.713
Espey Mfg. & Electronics Corp.	6.706
Mark IV Industries Inc.	6.670
Emerson Electric Co.	6.469
Tech-Sym Corp.	6.424
Advanced Micro Devices	6.400
AMDAHL CORP	6.263
Bowmar Instrument Corp.	6.247

Reduced Spending on Military Aircraft Spurs Decline in Aerospace Employment

WASHINGTON



Employment in the U. S. aerospace industry is declining, despite a shortage of workers in some skill areas.

The main reason for the decline is reduced spending for military aircraft. That sector lost about 28,000 employees last year, 6% of the total workforce and the largest decrease registered in the industry.

In 1988 the aerospace industry employed 1,306,000 people, but in 1989 the number could decrease to about 1,290,000, according to the Aerospace Industries Assn. (AIA).

The military aircraft sector registered the largest decrease last year, losing 28,000 employees, or 6% of the total workforce.

SKILLED, SEMISKILLED WORKERS

Employment of skilled and semiskilled production workers, the largest group in the aerospace workforce, declined 4%, to 432,000, in 1988. In 1989, the AIA expects another 1% decrease in the number of workers involved in military aircraft manufacture.

Last year purchases of aircraft by the federal government decreased 4.5%, to $65.6 billion. Of that amount, $7.1 billion is attributable to the conclusion of two major programs—the Rockwell International B-1B bomber and the Lockheed C-5B heavy lift transport.

Norman Gleit, staff vice president, labor relations and corporate personnel for Lockheed, said the company had laid off about 10,000 workers at its Lockheed-Georgia facility since the C-5B program ended in April. Gleit said some of those workers are employed by other aerospace companies, especially those located in the western U. S.

The West Coast accounts for 42% of industry employment. New England and the western North Central states account for the second- and third-highest concentration of workers, with 14% and 11%, respectively.

Carl M. Pascale, manager, economic data service for AIA, said surveys indicate many workers attempt to find employment in states such as California and Washington, where major aerospace firms such as Lockheed, Rockwell International and Boeing Commercial Airplane Co. are located. Although wages are higher there than in the eastern and southern U. S., the cost of living is higher, too.

According to the Association, more than 42% of aerospace workers employed in the U. S. in 1988 were located in the Pacific states. More than 37% are involved in production labor. About 46% are engineers and scientists.

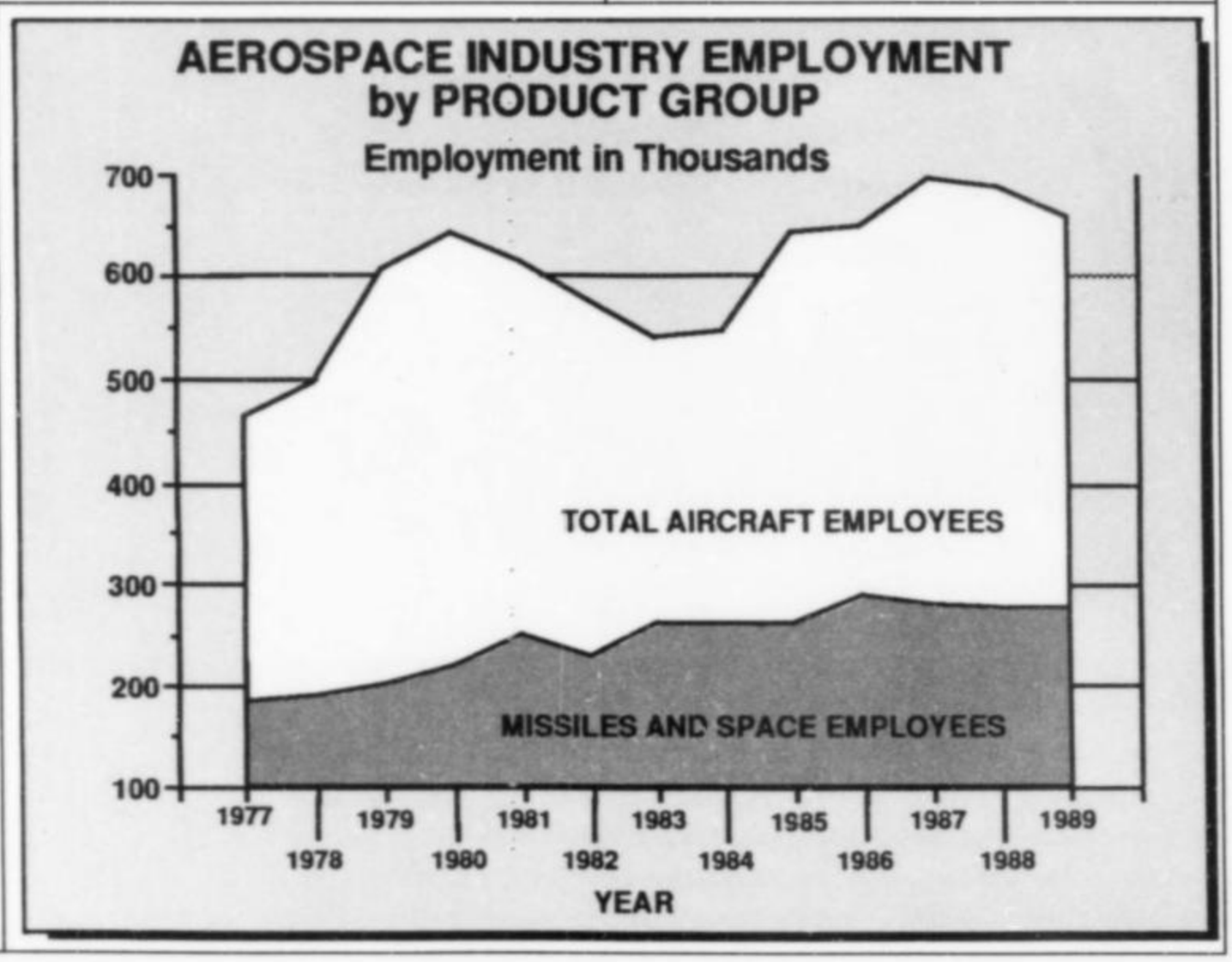
DISPLACED AEROSPACE WORKERS

Although some displaced aerospace workers are finding employment in western states, there is no evidence to suggest that companies are leaving the Northeast and north central U. S. to relocate in the West.

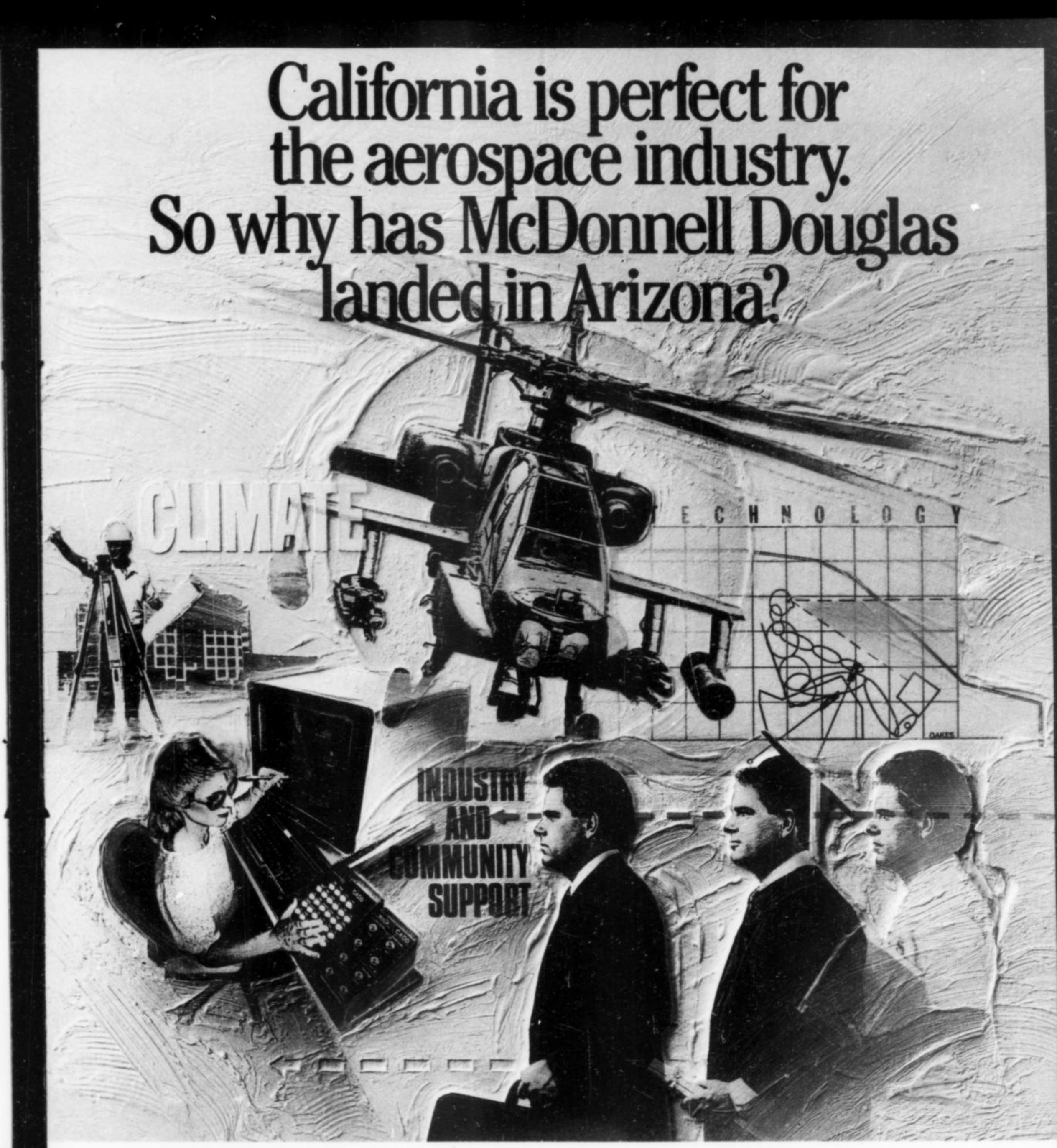
Wages for skilled and semiskilled aerospace workers are increasing slightly each year. The increases are being driven by cost of living raises, however, not by hikes in hourly rates.

James C. Coleman, staff vice president, personnel relations, for General Dynamics Corp., said wages for production-line workers have "stayed flat" in the past few years. Instead of using guaranteed wage increases for its senior workers, Coleman said, the company awards those employees large lump sum payments. Entry-level workers receive wage increases and a small lump sum payment.

Gleit said wages at Lockheed for semiskilled and skilled workers are increasing "by virtue of an older, more stable workforce" and the longevity of workers in



California is perfect for the aerospace industry. So why has McDonnell Douglas landed in Arizona?



Could it be the state next door has just as much to offer? The McDonnell Douglas Helicopter Company made their decision after evaluating 22 other locations, so the answer has to be "yes."

Some of the factors that swayed their decision include a high quality engineering labor base — (Metro Phoenix is already home to over 40,000 aerospace employees). Existing support industries. And affordable, plentiful land opportunities.

Plus, when McDonnell Douglas employees were offered an opportunity to move to the Valley of the Sun, they jumped at the chance. A little detail that says quite a lot for the area's quality of life.

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their particular jobs. Average seniority for workers at Lockheed is about 16 years, according to Gleit. He said the federal government is beginning to question pay rates for workers with lower skill levels, indicating that the rates may be too high for the work they perform.

A Raytheon official said wages for production workers building electronic components and missile systems "are increasing." The official said, however, that most of the increase is linked to Massachusetts' low unemployment rate and high cost of living.

MISSILES AND SPACE SEGMENT

Employment in the missiles and space segment of the industry declined 1.4% in 1988, to 275,000 employees. That number could increase to about 277,000 workers in 1989, if the military services procure additional missile systems. The U. S. space station also would provide additional employment for the industry. NASA could cancel the station, however, if Congress fails to allocate sufficient funding (AW&ST May 8, p. 24).

As spending for military aircraft decreases, "there're fewer funds to go around," Coleman said. He said General Dynamics has "a very, very low rate" of layoffs, but that the company will have to wait until final budget reductions are made before knowing how serious workforce reductions could be.

Those workers being laid off by military aircraft builders are forming a growing pool of labor that can be tapped by other aerospace companies. Boeing, which has a large backlog of orders for its line of commercial transport aircraft, is hiring displaced workers. Lester L. Miller, employment manager for the Boeing Commercial Airplane Co., said the company "has been fortunate" in being able to employ adequate numbers of production personnel to help meet demand.

Since the loss of jobs in the aerospace industry is affecting semiskilled and some skilled workers rather than engineers and scientists, there is little evidence that the industry is losing research and development talent.

Coleman said that there "may be a brain drain," but that General Dynamics has no firm evidence to prove it is occurring. Miller said Boeing does not have a problem retaining its engineers, but is "concerned about the future" if the number of graduating engineers continues to decline.

In 1988, U. S. universities and colleges bestowed 71,386 bachelor degrees in engineering—a 5.7%-decrease from 1987, according to the American Assn. of Engineering Societies, Inc. The number of graduate engineering degrees awarded increased 5.2% in 1988, compared with 1987, however.

Reductions in the Defense Dept.'s budget for highly technical programs, such as the Strategic Defense Initiative, could weaken the industry's technology base.

Pascale said growth in the aerospace industry now is "tied to commercial aircraft" instead of military aircraft. The U. S. commercial air transport fleet is growing. Employment of semiskilled and skilled workers should increase in the next 3-5 years.

Boeing and McDonnell Douglas are tapping the labor pool of laid-off workers to build transports

At the end of 1988, U. S. air transport manufacturers had an order backlog of about $59 billion. Employment grew 7% last year, to 94,300 workers.

Although a pool of experienced labor currently exists in the U. S., some companies are having difficulty hiring workers with highly specialized skills. Rockwell and General Dynamics officials said they have a minor shortage of conventional and numerically controlled machine operators.

General Dynamics also lacks tool and die makers. Electronics technicians are in short supply as well, according to Coleman.

Rockwell said it is experiencing a shortage of aircraft assemblers, but the company expects more assemblers to become available as other defense-related companies lay off additional personnel. Miller said Boeing is not finding enough experienced flight line electronics technicians to handle demand. Raytheon also said it has a shortage of electronic systems and software technicians, with 180 openings for such personnel.

A Raytheon official said, "we try hard to recruit locally." The company is hiring displaced workers from local electronics firms that are either merging, downsizing or restructuring their business bases. "When we recruit production workers, it's at the lowest levels, where our wage and benefit package is highly competitive," the official said.

To attract workers and be competitive, virtually all major aerospace companies continually are reviewing their benefits packages as well as their wage structures. General Dynamics, Rockwell and Boeing said their benefits are competitive and plan no major changes. Lockheed is using an employees stock option plan (ESOP) along with tuition reimbursement and other employee programs. An official for one major military aircraft manufacturer said that prospective workers with spouses, but without children, are becoming more difficult to hire if a company cannot also find work for the spouse. Coleman said, however, that General Dynamics is placing increased emphasis on recruitment of college engineering graduates. Coleman estimates the company could hire 1,600-2,000 engineers annually for the next seven years. He said the recruiting effort is being aimed primarily at students specializing in computer science, mathematics and chemistry.

INCREASE IN MINORITIES

Although the majority of aerospace workers is male, the number of females employed in the industry increased more than 4% between 1977 and 1987, according to Pascale. He said more minorities also are entering the field, as their numbers in the U. S. population increase.

In addition to hiring skilled workers, most aerospace companies also conduct in-house training courses to upgrade employee skills. The cost of that training is increasing, however, primarily because of higher wages being paid to instructor staff and the cost of certifying that a worker can properly perform a task.

"Just having a good mechanical sense isn't good enough anymore," according to Gleit of Lockheed. The complex nature of equipment and techniques commonly used within the aerospace industry demands more knowledge than the average worker has, according to Gleit. To pro-

5-Year Growth Trend in Sales

ANNUAL PERCENT

AEROSPACE COMPANIES	
Precision Castparts Corp.	40.256
UNC Inc.	32.017
United Technologies Corp.	28.524
Textron Inc.	22.603
Hexcel Corp.	22.516
General Dynamics Corp.	14.121
Parker-Hannifin Corp.	13.751
Sundstrand Corp.	13.731
Northrop Corp.	13.614
Fairchild Industries Inc.	11.531
Boeing Co.	11.526
Morton Thiokol Inc.	10.432
Hi-Shear Industries	10.179
McDonnell Douglas Corp.	10.070
Grumman Corp.	9.913
Martin Marietta Corp.	9.514
Rockwell International Corp.	8.371
Lockheed Corp.	8.251
Allied Signal Inc.	8.204
Rohr Industries	7.912
GenCorp Inc.	7.508
LTV Corp.	7.251
Fansteel Inc.	4.159
Hercules Inc.	1.349
Eldec Corp.	-1.335

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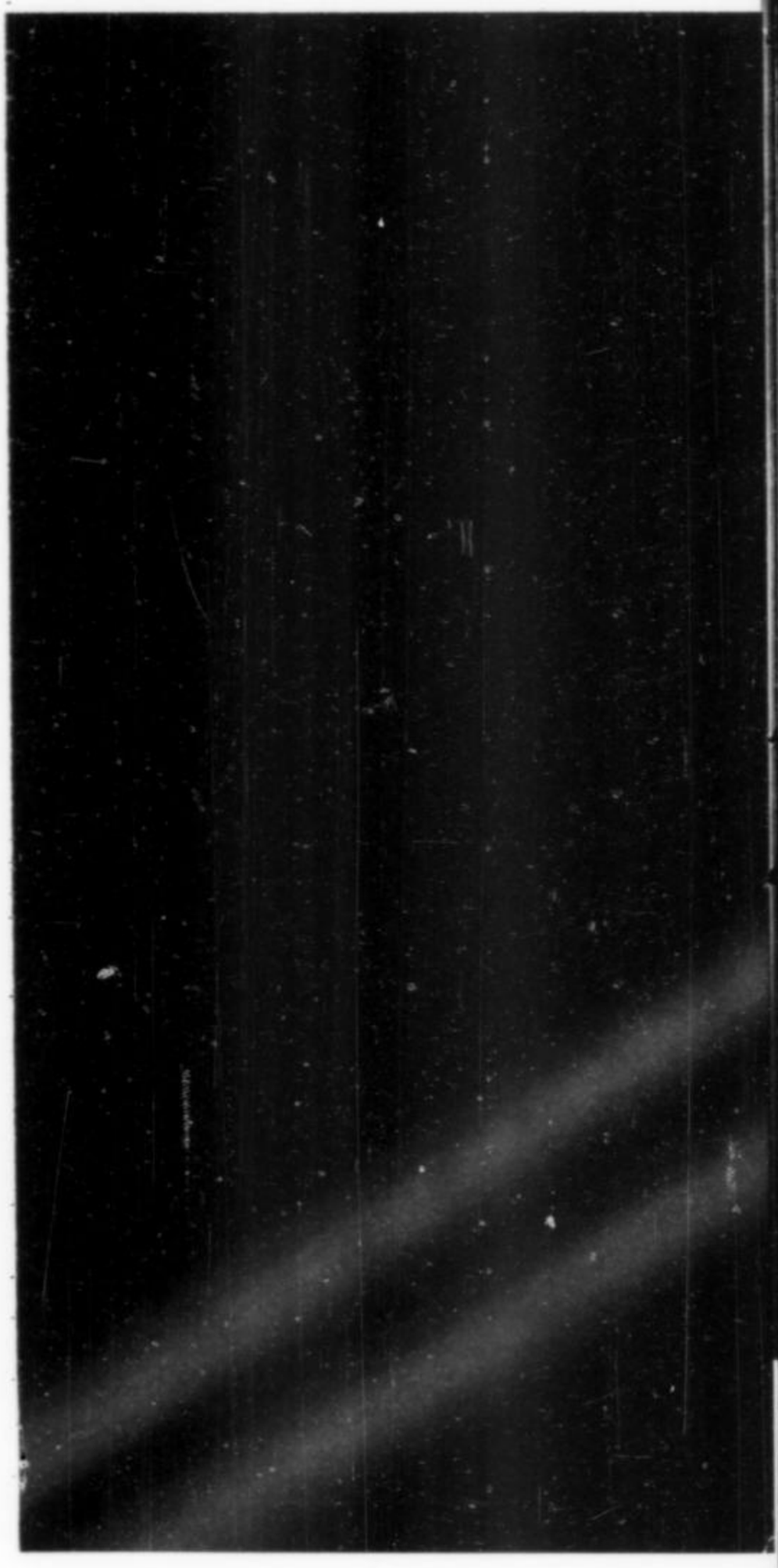

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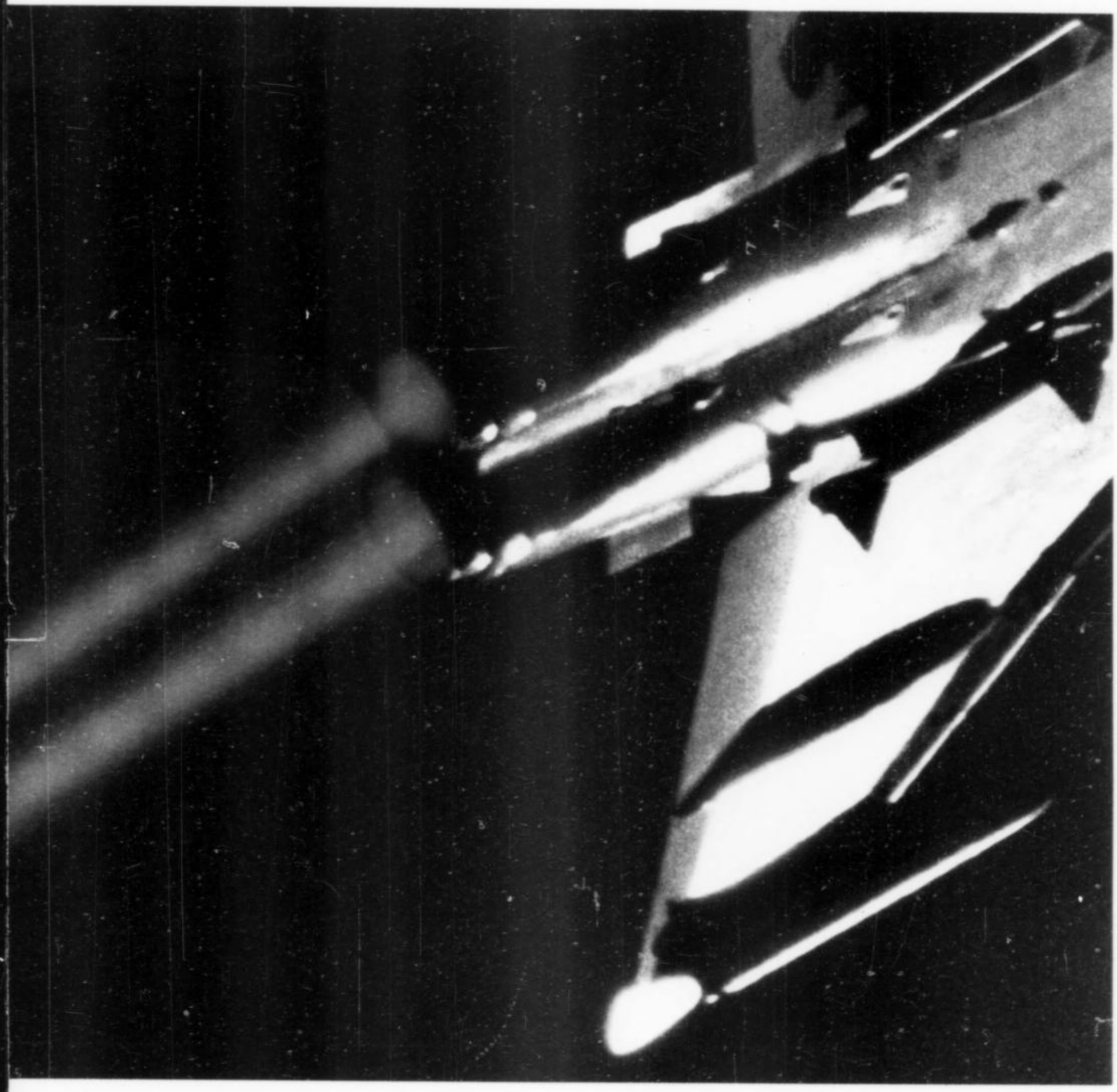

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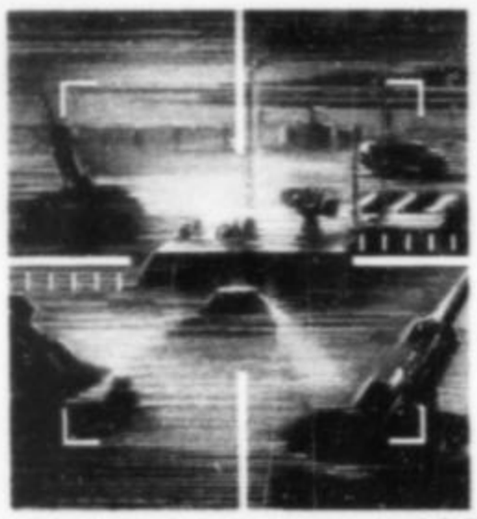

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vide proper training on such equipment, companies must invest in the hardware necessary to teach the worker a new skill.

Raytheon said it is spending more money now to train personnel than in recent years. To maintain high quality and product reliability standards, "we do more training than ever before," a personnel official for Raytheon said. Lockheed, General Dynamics and Rockwell also said they are spending more money to help their employees maintain skill levels and to train workers in new technologies and manufacturing procedures.

HELICOPTER SEGMENT

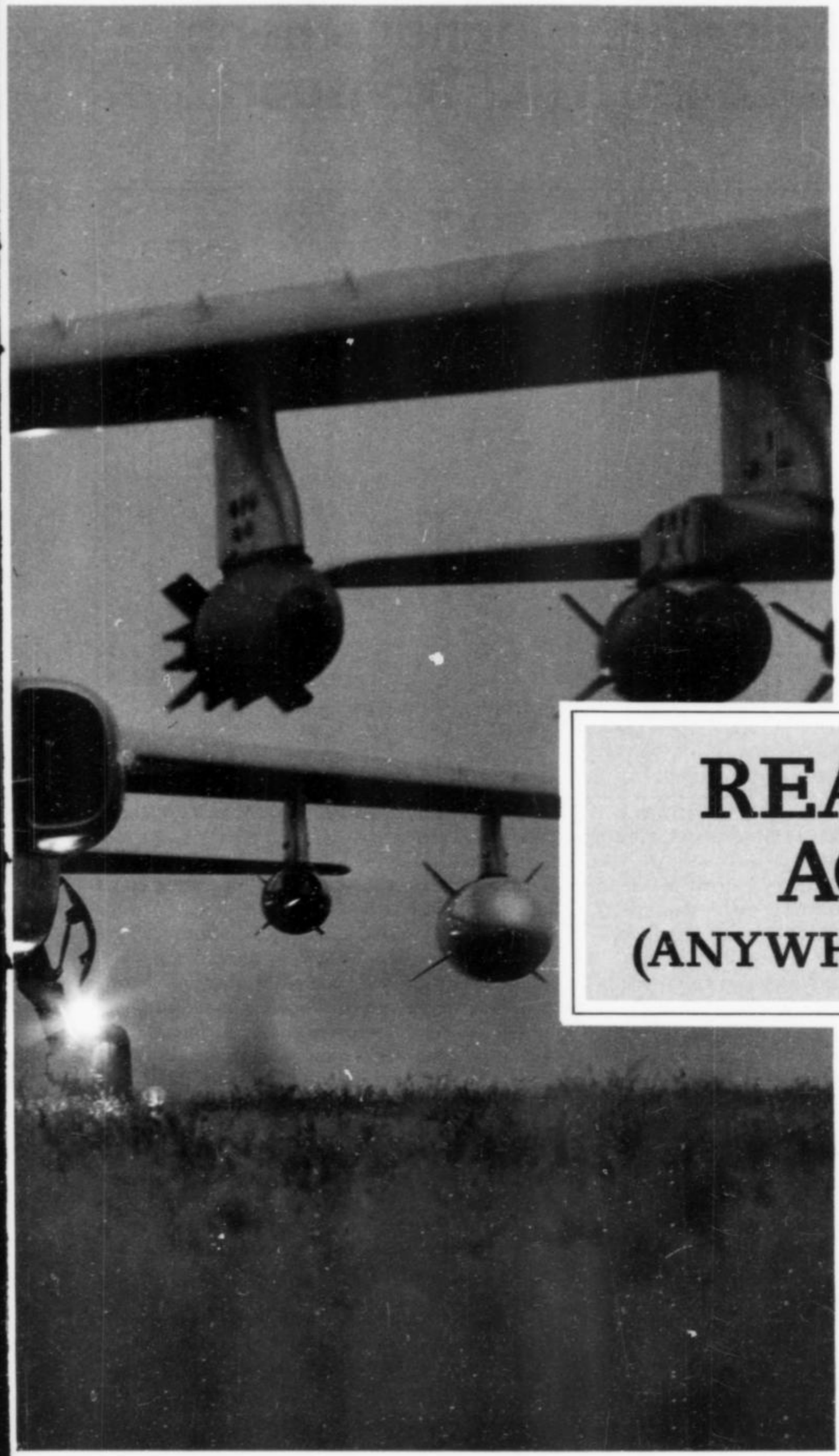
The helicopter segment of the industry could experience a slow recovery, beginning this year. The AIA said increased sales to military and commercial customers could boost employment to about 30,700 employees in 1989. Total employment decreased from 37,300 workers in December, 1986, to about 29,200 in June, 1988.

The general aviation industry has reduced production of new aircraft drastically since 1981 because of poor market conditions. The industry is poised for a possible recovery, however. Beech Aircraft Corp., Piper Aircraft Corp. and Cessna Aircraft Co. are planning to hire additional workers this year. All three firms project increased production of single- and twin-engine, piston-powered light aircraft and turbonrop- and turbofan-powered business aircraft. □

Aerospace Companies Sales Per Employee

SALES IN DOLLARS

LTV Corp.	188780.812
General Dynamics Corp.	165818.812
Sundstrand Corp.	133049.875
Northrop Corp.	129979.750
McDonnell Douglas Corp.	124105.375
Hercules Inc.	123341.500
Lockheed Corp.	122004.562
United Technologies Corp.	119894.687
Hexcel Corp.	114051.375
Morton Thiokol Inc.	113549.000
Grumman Corp.	112228.312
Boeing Co.	110862.750
Allied Signal Inc.	108708.312
Fairchild Industries Inc.	107975.500
Rockwell International Corp.	106511.187
UNC Inc.	106274.875
Eldec Corp.	103662.625
Fansteel Inc.	102564.875
Textron Inc.	95384.562
GenCorp Inc.	92908.562
Martin Marietta Corp.	84851.562
Rohr Industries	82440.062
Hi-Shear Industries	78524.937
Precision Castparts Corp.	74139.687
Parker-Hannifin Corp.	67710.000



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Airlines Prosper Under Tight Management; Leasing Transforms Commercial Transport

NEW YORK

The financial condition of most U. S. airlines continued to improve in 1988, primarily as the result of successful yield management and effective cost and capacity controls.

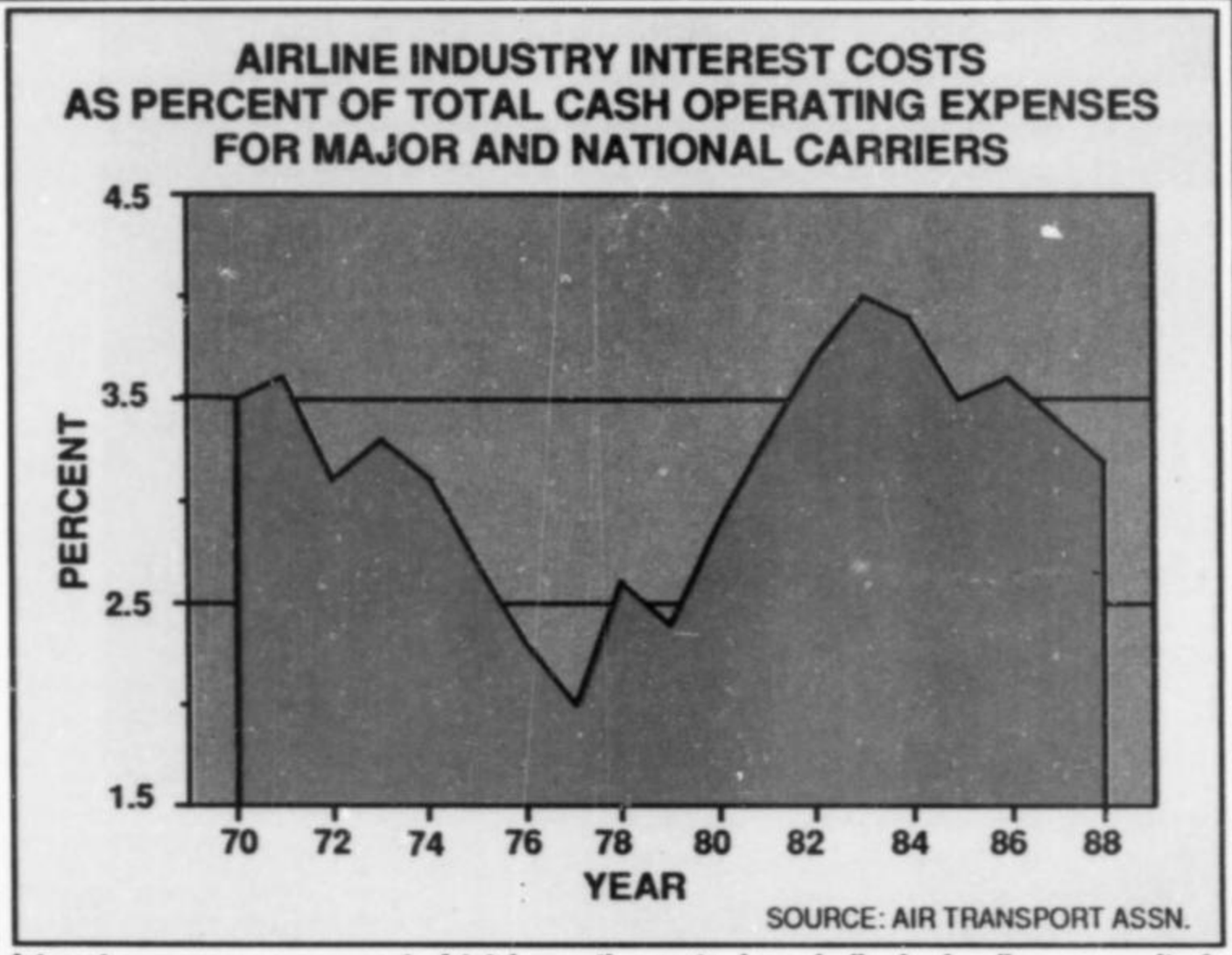
Aircraft fleet replacement and expansion programs accelerated, funded internally by positive cash flows. Aircraft lease financing and operating lease companies emerged in 1988-89 as major forces in the U. S. and international airline industry.

Last year, competitive factors, labor relations and the threat of hostile takeovers demanded more attention from airline managers, government regulators and the investment community.

Industry traffic growth was a modest 4.4% for the year, and U. S. domestic traffic was only 0.8% higher than in 1987. Revenues were up, however, at all but Texas Air's Continental Airlines and Eastern Airlines, while net profits increased at six of the nine major air carriers.

The trend of higher revenue passenger mile yields, aided in part by low fuel prices for most of the year, continued throughout 1988 and into 1989. Although fuel prices rose significantly at year-end, they are expected to be more than offset by higher fares. An expected 6% traffic increase and 5% capacity growth in 1989 are likely to keep load factors high.

Combined operating revenues of the major airlines exceeded $48.7 billion, and operating income after expenses was more than $42.6 billion.

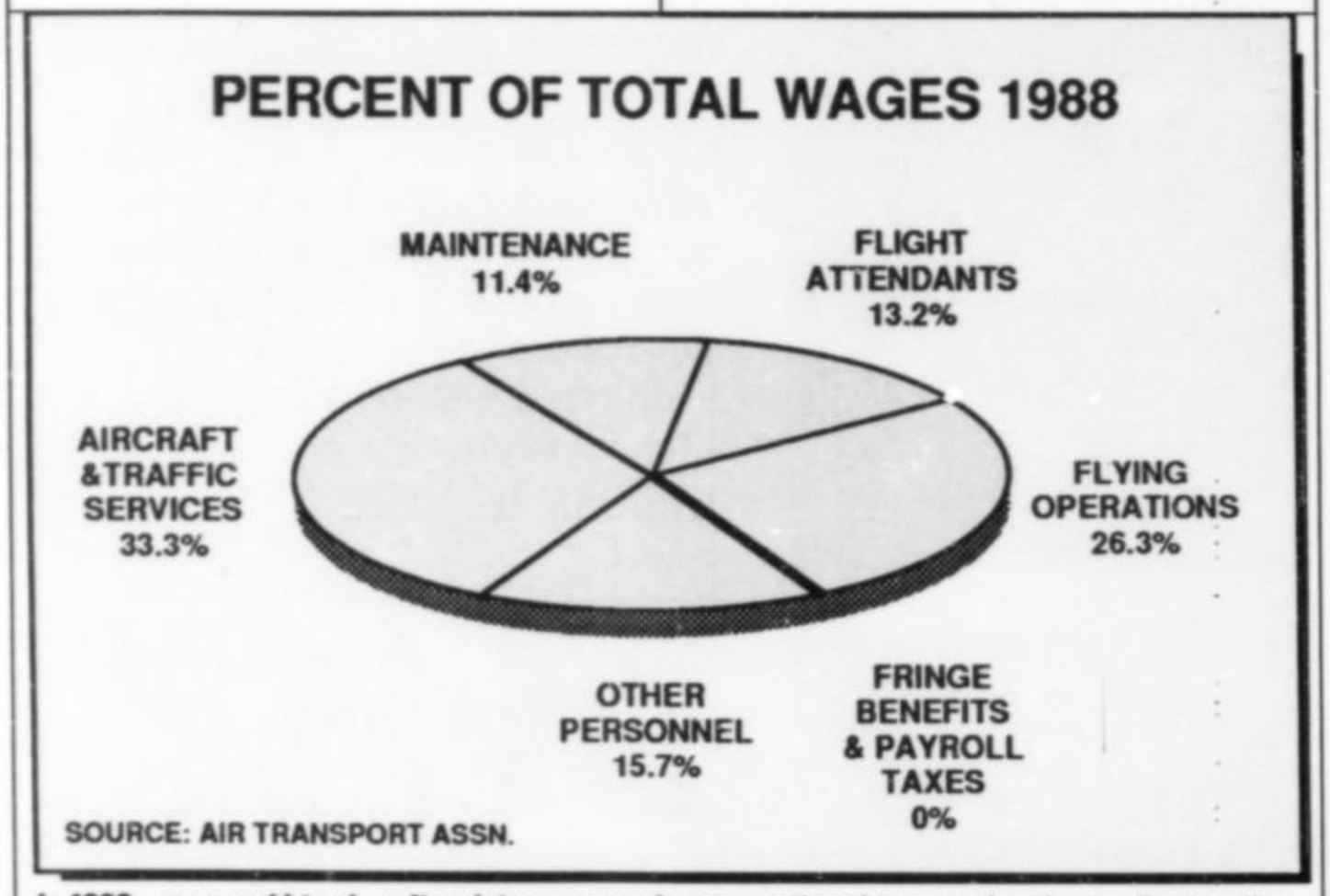


Interest expenses, as a percent of total operating costs, have declined primarily as a result of increases in other expenses, rather than from reduced borrowing.

AMR Corp., parent of American Airlines, earned more than $800 million from operations and almost $477 million net after taxes. This is more than the entire industry earned in nine of the last 13 years. Year-end results showed a 22.6% gain in annual revenues and a 5.8% increase in net profits. United Airlines, Delta and Northwest also posted increases in revenues and operating and net profits.

Although USAir led the industry with an increase of 90.2% in revenue growth, operating and net profit margins were down because of difficulties in integrating its acquisition of Piedmont Airlines.

Texas Air reported a record loss of $719 million or $18.88 a share on revenues of about $8.56 billion. The losses depleted Texas Air's consolidated cash reserves still further and reduced the company's net worth to a nearly $6-per-share deficit. Eastern Air Lines first quarter strike and subsequent bankruptcy filing created a windfall for competing Delta and USAir.



In 1988, wages paid to aircraft maintenance employees continued to comprise the smallest portion of the total wage costs for U.S. airlines.

LEASING'S ROLE GROWS

Regional airline revenue passenger miles increased by 16.8% to 2.42 billion, and the average load factor for the regional group was 46.2%.

Strong cash positions and the availability of outside financing has allowed some airlines to embark on equipment expansion and replacement programs of record size.

The use of leases as a means of financing is growing and accounted for almost 50% of last year's 511 aircraft deliveries in the U. S., according to Joseph J. Steuert, managing director of Paine Webber Capital Markets' aircraft financing team.

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B. Government
☐(08) 1 Civil ☐(09) 2 Military ☐(10) 3 Space

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6	36	66	96	126	156	186	216	246	276	306	336
7	37	67	97	127	157	187	217	247	277	307	337
8	38	68	98	128	158	188	218	248	278	308	338
9	39	69	99	129	159	189	219	249	279	309	339
10	40	70	100	130	160	190	220	250	280	310	340
11	41	71	101	131	161	191	221	251	281	311	341
12	42	72	102	132	162	192	222	252	282	312	342
13	43	73	103	133	163	193	223	253	283	313	343
14	44	74	104	134	164	194	224	254	284	314	344
15	45	75	105	135	165	195	225	255	285	315	345
16	46	76	106	136	166	196	226	256	286	316	346
17	47	77	107	137	167	197	227	257	287	317	347
18	48	78	108	138	168	198	228	258	288	318	348
19	49	79	109	139	169	199	229	259	289	319	349
20	50	80	110	140	170	200	230	260	290	320	350
21	51	81	111	141	171	201	231	261	291	321	351
22	52	82	112	142	172	202	232	262	292	322	352
23	53	83	113	143	173	203	233	263	293	323	353
24	54	84	114	144	174	204	234	264	294	324	354
25	55	85	115	145	175	205	235	265	295	325	355
26	56	86	116	146	176	206	236	266	296	326	356
27	57	87	117	147	177	207	237	267	297	327	357
28	58	88	118	148	178	208	238	268	298	328	358
29	59	89	119	149	179	209	239	269	299	329	359
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☐(06) 6 Materials ☐(07) 7 Space Technology

B. Government
☐(08) 1 Civil ☐(09) 2 Military ☐(10) 3 Space

C. Services
☐(11) 1 Airport ☐(12) 2 Financial/ Insurance/Legal ☐(13) 3 R&D

D. Job Function
☐(14) 1 Management ☐(15) 2 Engrg./ Design
☐(16) 3 R&D ☐(17) 4 Production/ Opers.
☐(18) 5 Maint./Overhaul ☐(19) 6 Procurement

E. Purchasing Authority
☐(20) 1 Recommend
☐(21) 2 Specify ☐(22) 3 Approve

F. Annual Dollar Volume ($ Mil)
☐(23) 1 Under $50 ☐(24) 2 $50 to $150
☐(25) 3 $151 to $500 ☐(26) 4 Over $500

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H. Are you currently a subscriber? ☐(29) 1 Yes ☐(30) 2 No

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14	44	74	104	134	164	194	224	254	284	314	344
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16	46	76	106	136	166	196	226	256	286	316	346
17	47	77	107	137	167	197	227	257	287	317	347
18	48	78	108	138	168	198	228	258	288	318	348
19	49	79	109	139	169	199	229	259	289	319	349
20	50	80	110	140	170	200	230	260	290	320	350
21	51	81	111	141	171	201	231	261	291	321	351
22	52	82	112	142	172	202	232	262	292	322	352
23	53	83	113	143	173	203	233	263	293	323	353
24	54	84	114	144	174	204	234	264	294	324	354
25	55	85	115	145	175	205	235	265	295	325	355
26	56	86	116	146	176	206	236	266	296	326	356
27	57	87	117	147	177	207	237	267	297	327	357
28	58	88	118	148	178	208	238	268	298	328	358
29	59	89	119	149	179	209	239	269	299	329	359
30	60	90	120	150	180	210	240	270	300	330	360

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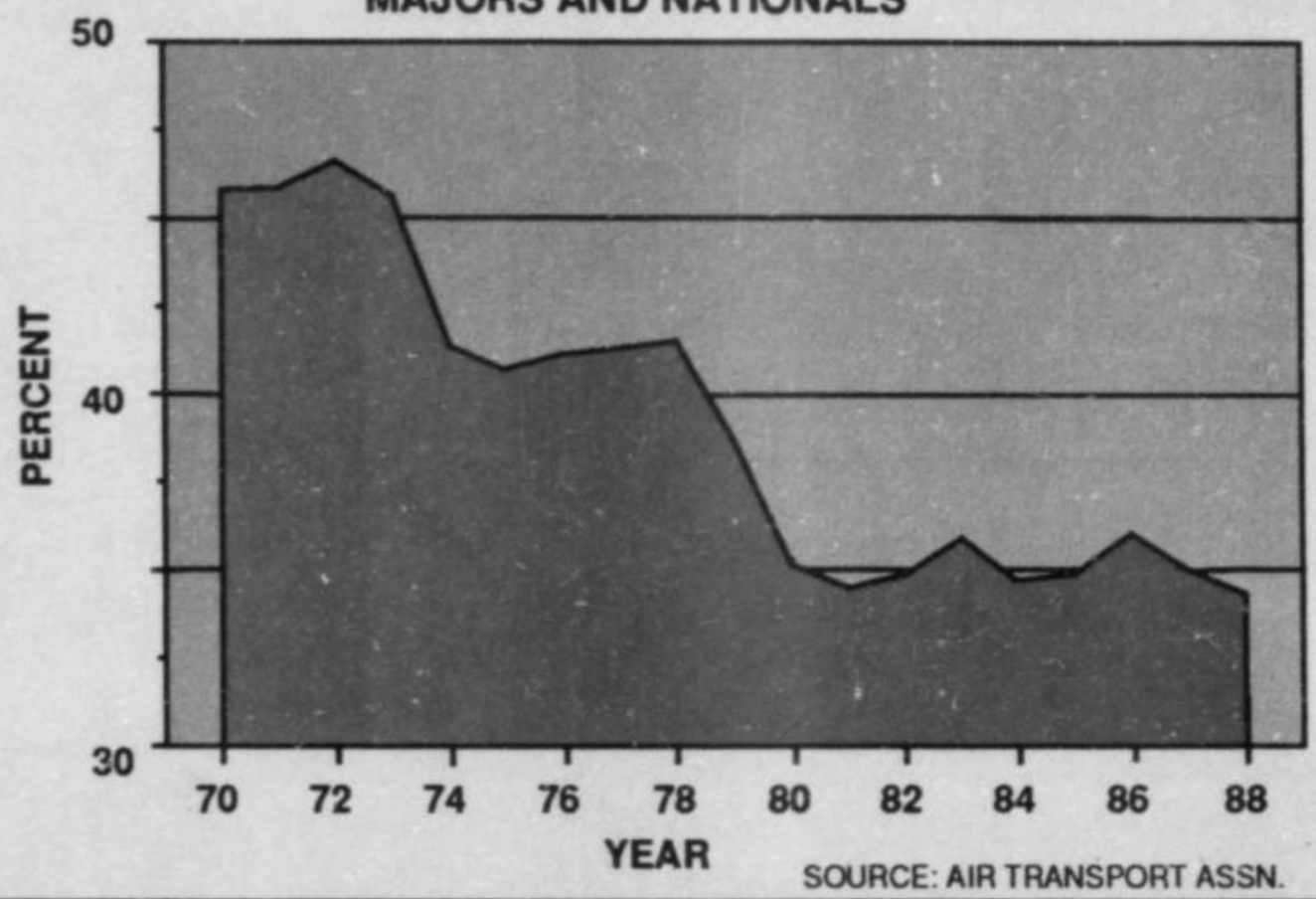
Strong cash positions and the availability of outside financing has allowed airlines to embark on expansion programs of record size

AIRLINE INDUSTRY LABOR COSTS

AS A PERCENT OF TOTAL OPERATING EXPENSES MAJORS AND NATIONALS



Labor, as a percent of total operating costs, has decreased 7.2% in the last decade despite an increase in average compensation per employee and average numbers of employees.

Internationally, about 18% of the aircraft purchased in 1988 are on some type of lease and the number is increasing rapidly.

Last year, deliveries of new wide and narrow-body aircraft and used transports were valued at a total of $45 billion. Of that, more than $20 billion was on lease. Steuert said that Paine Webber arranged about $3 billion of lease financing in 1988.

Institutional investors, such as pension funds and international banks, are major sources of capital for the boom in aircraft purchases. Attracted by strengthening industry fundamentals and solid demand projections of 12,000-13,000 commercial transports worldwide by the year 2000, these investors are actively soliciting the airlines with financing packages.

Peter J. LeBeau, a vice president at Irving Trust Co.'s aerospace division, said lease financing has become attractive to the airline operators for several reasons:

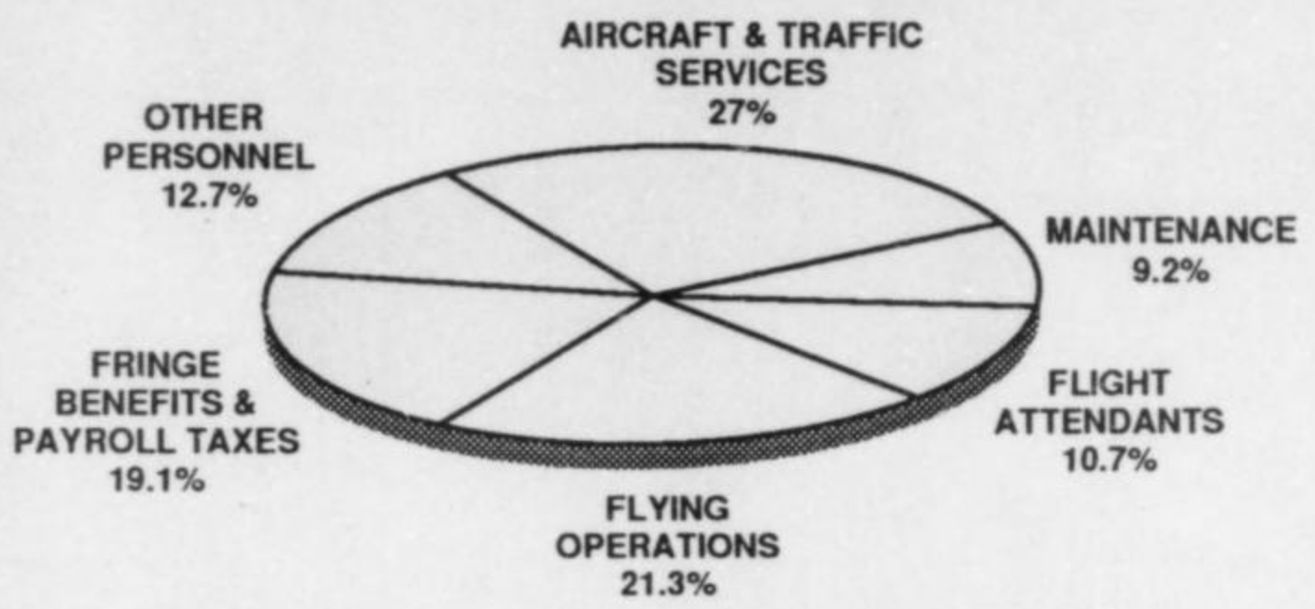
- Leasing requires little or no capital outlay by airlines that cannot afford to buy new aircraft or have weakened credit. Also, if an the airline does not have to borrow to buy aircraft, interest costs are lower.
- Leases are an off-balance sheet liability. They are not listed as debt and do not increase an airline's financial leverage.
- Leases give airlines more flexibility in the size and type of aircraft they operate. At the end of a lease's term, an airline can select a larger aircraft as strategic plans or prevailing conditions require.
- Because of the current manufacturing backlog of transports, an airline may not be able to obtain a new aircraft when needed. The only source of delivery positions may be a leasing company.
- The airline does not bear the residual value risk of owning the aircraft. Although historically most aircraft hold their value well, the risk that the value may decrease is passed on to the leasing company.
- As a capital equipment-intensive business, an airline can generate large tax write-offs through depreciation of aircraft and may not be able to use all of its available tax benefits. By leasing, the tax advantages of owning an aircraft accrue to the lessor and the airline may benefit indirectly in the form of lower lease payments. Because the alternative minimum tax provision of the Tax Reform Act of 1987 limits the amount of income a company can shelter, airlines balance the numbers of owned and leased aircraft. Generally half to three-quarters of a fleet is leased.

According to LeBeau, the major risk of leasing is that the airline does not enjoy the significant profit that can be made from the sale of an aircraft.

For the industry as a whole, average interest costs as a percentage of total cash operating expenses have been in a downward trend since 1983. Steuert said this is a result of higher retained earnings at the major airlines and increased off balance sheet financing as well as the decline in interest rates.

With a large portion of assets and corresponding liabilities not reflected on balance sheets, airlines may appear healthier than they are. Both Moody's and Standard & Poor's rating services add lease

PERCENT OF TOTAL COMPENSATION 1988



SOURCE: AIR TRANSPORT ASSN.

This breakdown of airline industry compensation expenses in 1988 includes wages to employees as well as payroll taxes and medical insurance and other benefits.

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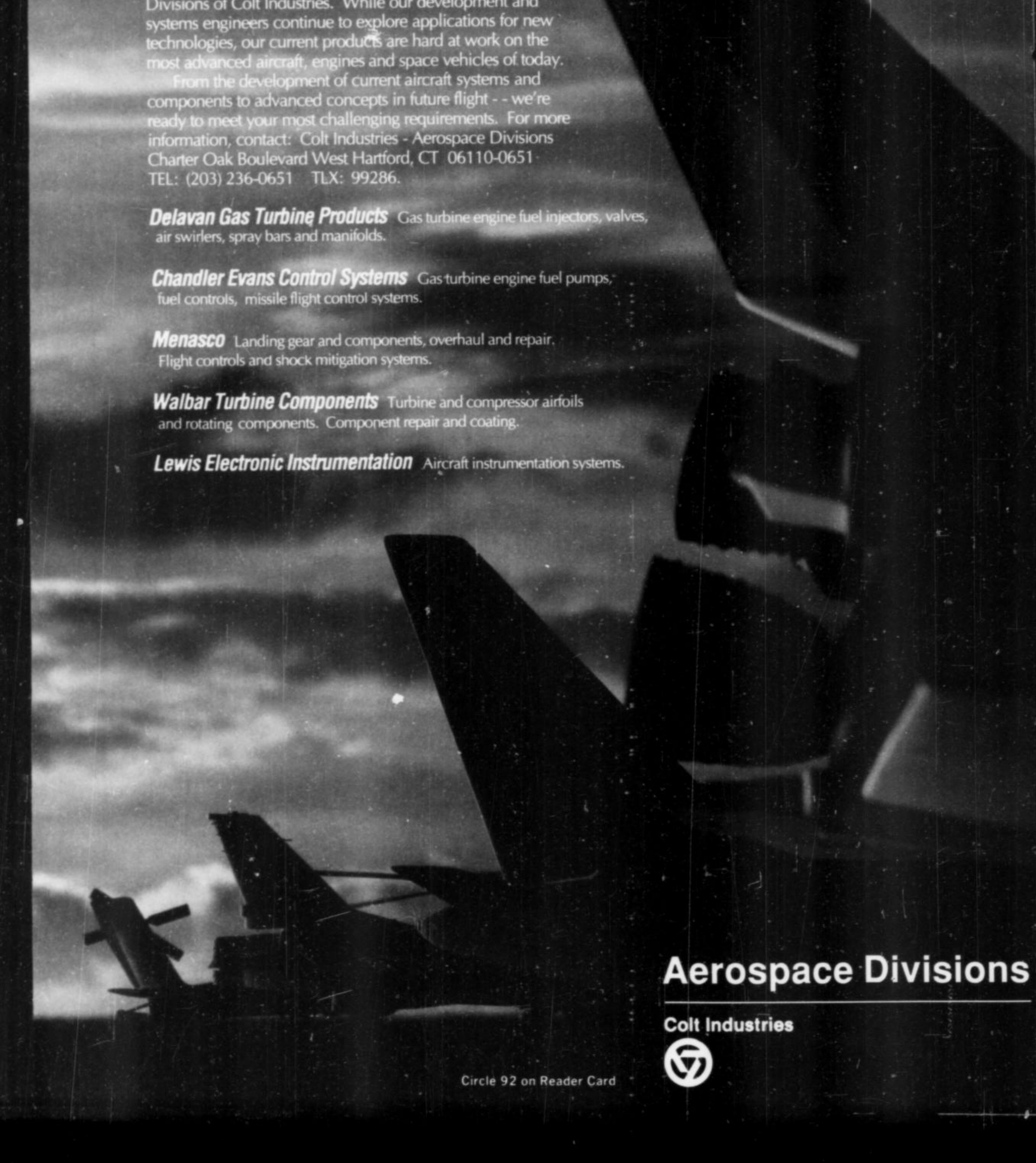
Lewis Electronic Instrumentation Aircraft instrumentation systems.



Aerospace Divisions

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obligations back into the balance sheets of airlines they rate.

Most leases for new aircraft in the U. S. were long-term, full-payout or financial leases. In this type of lease, the service provided by the lessor is limited to financing the aircraft. The lessee has all other responsibilities related to possession of the equipment, such as maintenence, insurance or taxes. The lease is usually 20 to 25 years and is amortized, or paid out, over its term. The payments are roughly equivalent to the cost of the aircraft less an assumed residual value.

VARIOUS LEASING METHODS

A very popular lease arrangement is called a Japanese tax lease. Joint ventures between U. S. companies, such as American Airlines and McDonnell Douglas Finance Corp., and Japanese firms, buy and lease aircraft for 10-12-year terms. The Japanese partner takes Japanese tax benefits, and generally the lease is structured so that the U. S. partner can take U. S. tax benefits as well. The market for this type of lease is expected to be several billion dollars this year.

A relatively small number of new aircraft are on short and intermediate-term operating leases, generally from 2-5 years in length. Operating leases are used primarily to purchase older Stage 2 aircraft for short periods with the intention of replacing them with new aircraft when the lease ends. America West Airlines began operations in 1983 with $70 million worth of aircraft on operating leases.

Outside the U. S., operating leases are widely used to acquire new aircraft, especially by newly privatized international airlines such as Lufthansa, British Airways and Singapore Airlines.

Operating lease companies have become a more visible force in the industry. Large orders for new commercial transports such as International Lease Finance Corp.'s (ILFC) $6.6-billion order in March, and GPA Group, Ltd.'s recent $16.8-billion order for 308 aircraft, demonstrate the financial power of this rapidly growing industry segment. These two firms, together with Ansett Worldwide of Australia, own or control more than 1,300 delivery positions worth an estimated $71 billion that extend as far as 1997.

ILFC, which posted a 19% increase in revenues to $213.2 million and a 12.9% rise in sales to $195.5 million, has a $2.1-billion portfolio of 62 aircraft with an average age of less than three years. ILFC plans to add 40-45 aircraft per year between 1990 and 1995, accumulating a portfolio of 350 aircraft by 1995.

Other operating lease companies also are expanding their fleets aggressively, confident that retirement of aging aircraft and a continuing growth of worldwide airline traffic will provide a market.

Paine Webber's Steuert expects the market will be firm. "Almost all the new aircraft deliveries lately have been for expansion rather than replacement," he said. In a year or two, the airlines will begin replacing their older transports and leasing companies will supply a sizable portion of the needed aircraft.

Big leasing firms' purchases of delivery positions far into the future are not necessarily high-risk ventures, according to Louis L. Gonda, ILFC's executive vice president.

"It is only a perceived risk," he said. "It is measured by the experience and competency of the people placing the orders. If they are not experienced people, then it is risky. It needs entrepreneurial skill. If you know what you are doing, you measure and balance your risk."

Gonda expects a pause in the big leasing firm purchases, with future orders depending on the rate of traffic growth and how the airlines handle replacements. Lead times are stretching so far that 1994-95 deliveries "now are beginning to look near-term," he said.

ILFC said it had placed the bulk of its orders for the foreseeable future and is taking a more conservative attitude. "We are basically conservative and don't place orders for the sake of placing orders," Gonda said. □

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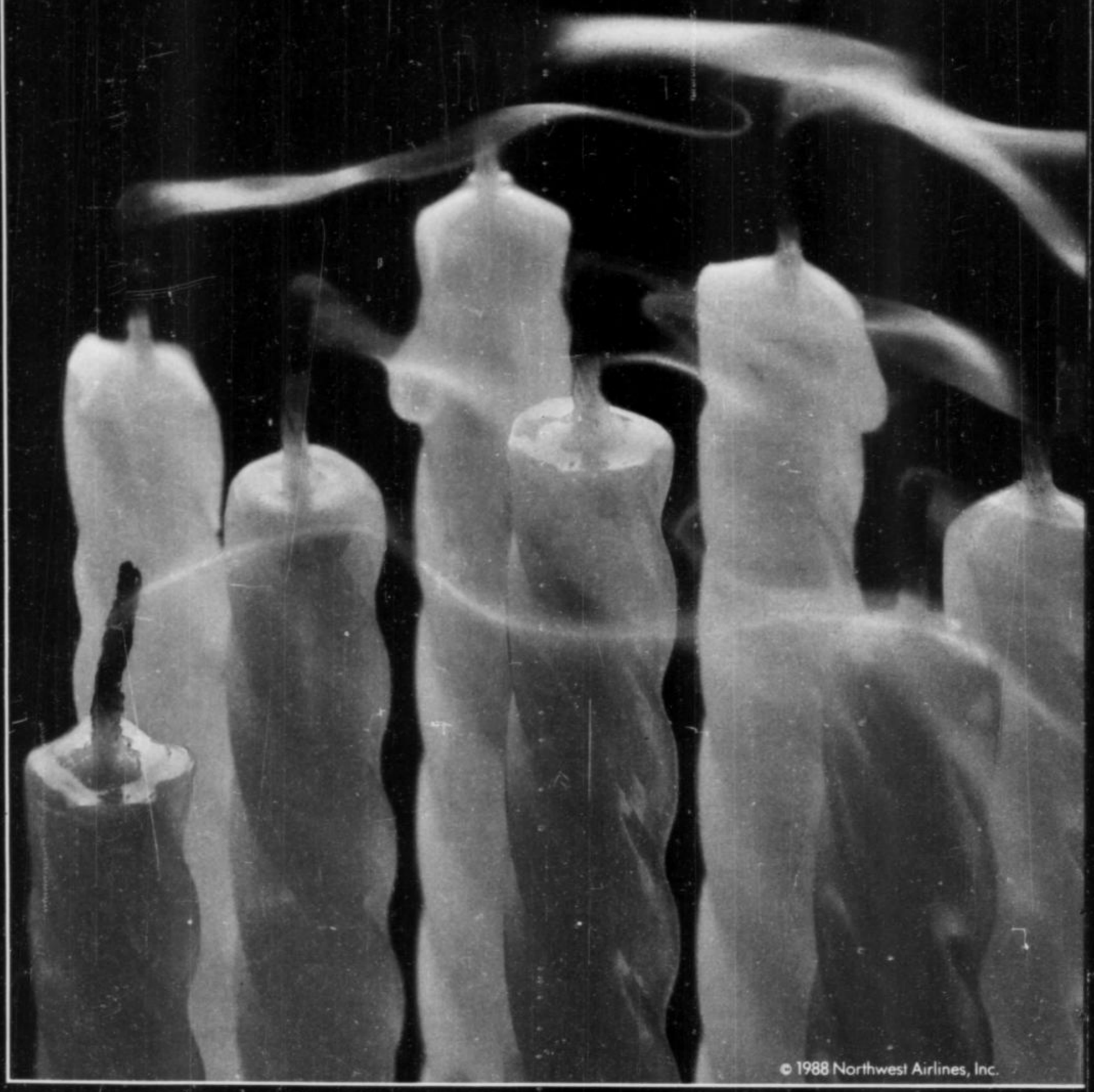


LOOK TO US NORTHWEST AIRLINES

Airframe Makers Exploit Boom By Adding Production Capacity

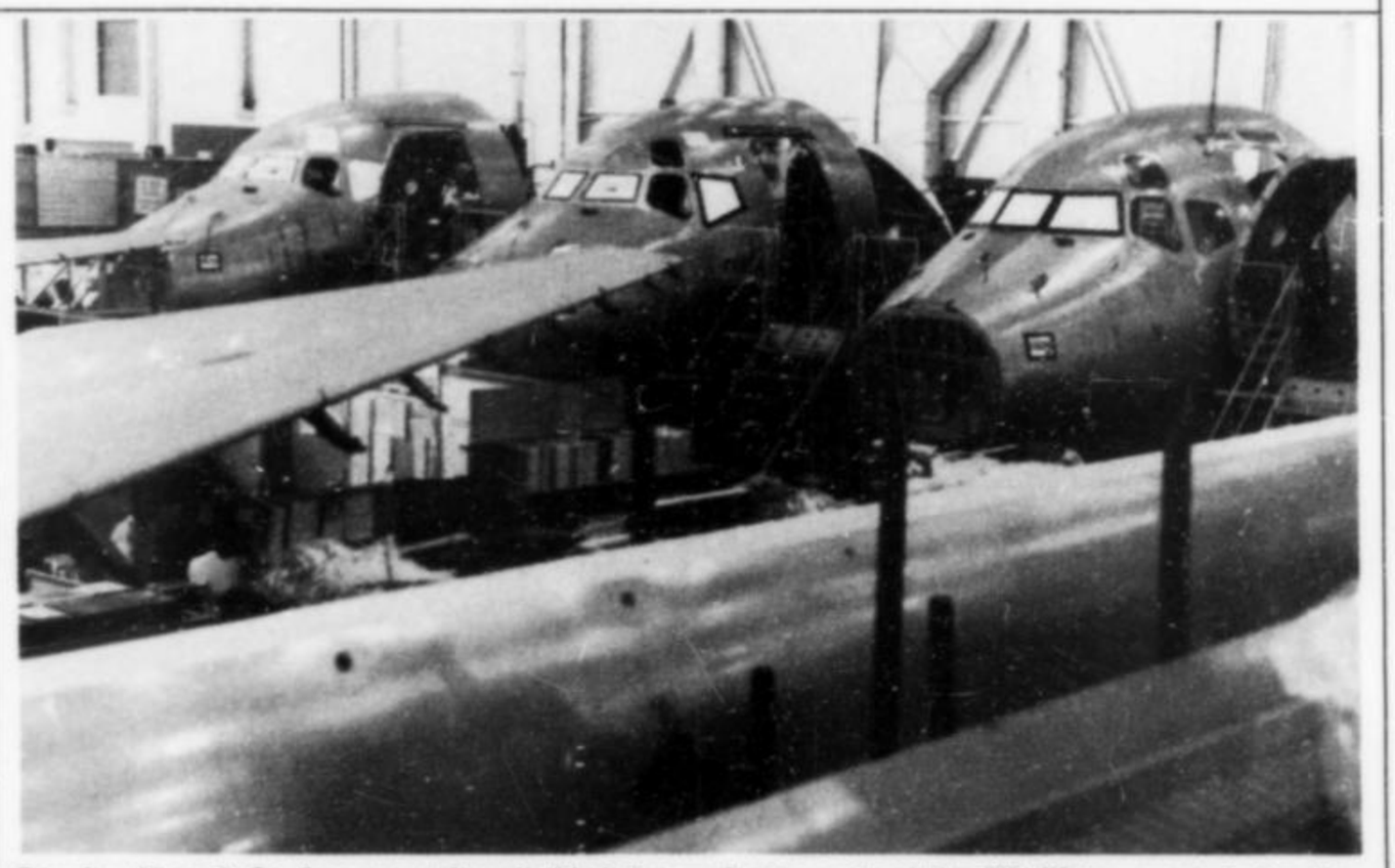
U.S. airframe manufacturers are making substantial investments aimed at expanding capacity and solving internal problems so that they can realize maximum financial benefits from the unprecedented boom in commercial air transport orders.

The investments are being made to hire and train new production workers, add plant and equipment and expand orders for long-lead parts and materials to support significant increases in aircraft production rates.

Such decisions usually are weighed carefully in this cyclical industry because of the sizable investments involved and their negative effect on near-term profits. There also is a long lead time between a decision to boost production and an increase in aircraft delivery rates—and profits—at the end of the production process.

The present market, however, has left little doubt about the necessity to increase production output. Sales are expected to remain strong well into the 1990s unless they are affected by a major external influence such as a sharp oil price increase or a widespread and severe economic downturn.

The market is being generated by the rapidly-growing air travel industry, the replacement of aging aircraft fleets and decisions by some carriers to proceed with acquisition plans which had been put on hold due to deregulation. There also is a desire on the part of airline and leasing company customers to secure the earliest possible delivery positions.



Douglas Aircraft Co. has more than doubled the production rate of the MD-80 transport during the past seven years due to increased demand. Target production rate is 2.5 aircraft per week.

Boeing Co. appears well-positioned to reap the financial rewards of the current boom in airline equipment orders, provided it can bring its production problems under control and acquire the additional capacity needed while keeping a tight rein on costs.

Boeing records delivery of an aircraft as a "sale," and this year Boeing Commercial Airplanes will deliver nearly 400 transports—"the highest peacetime delivery rate in aviation history," according to Richard R. Albrecht, executive vice president. At the same time, the company will most certainly set another record for new orders in 1989, as by May it had nearly reached the $30.1 billion it booked during the entire record year of 1988.

Earnings jumped 28% last year, fueled largely by the surprisingly robust commercial transport market. The backlog surged to an astonishing $53.6 billion last year from the previous record high of $33.2 billion registered at 1987's end, and the total has jumped again in the first quarter to $59.3 billion—88% of it for commercial customers.

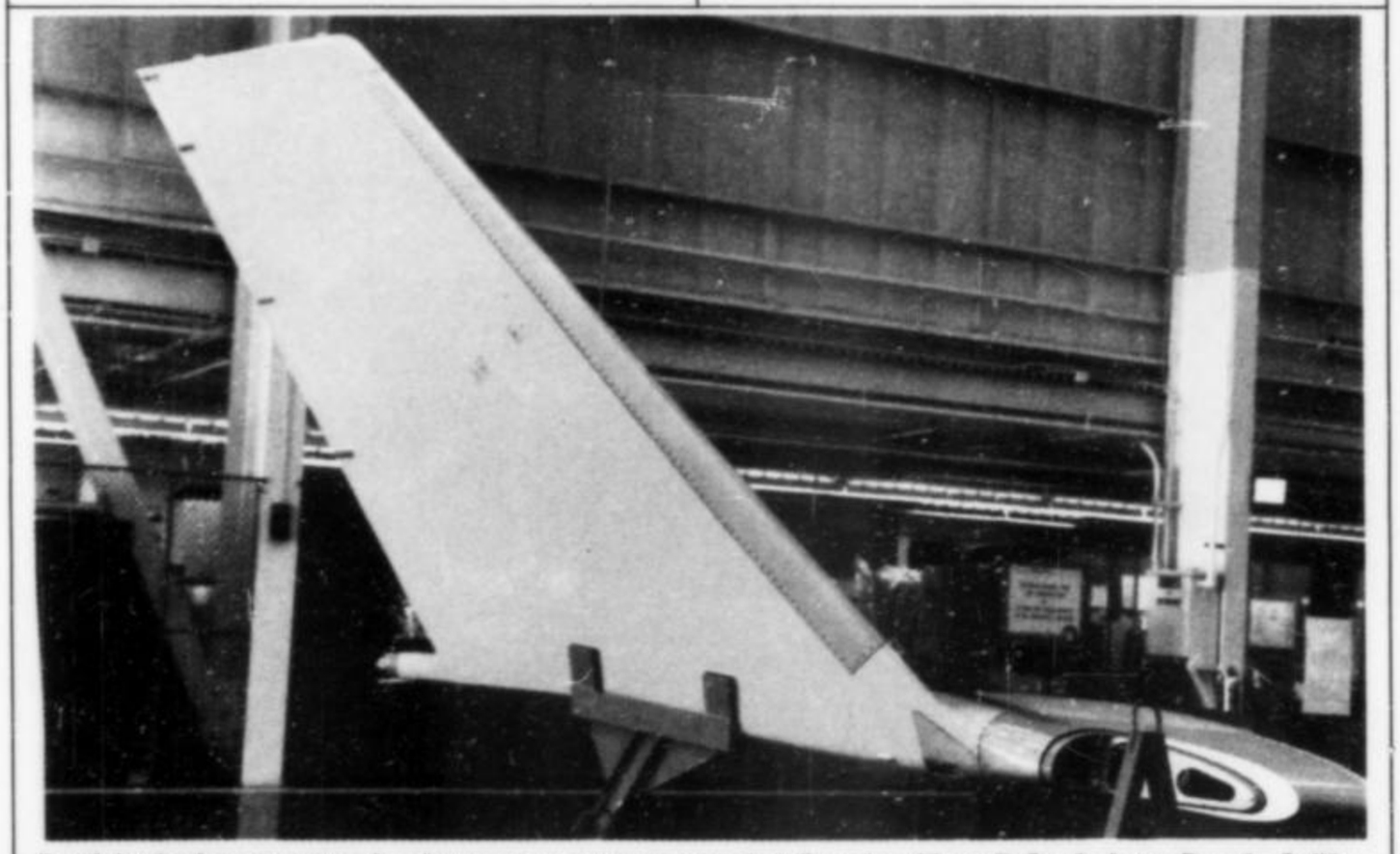
FORECAST IMPROVES

Total corporate sales jumped $1.5 billion to $17 billion in 1988, and a hefty increase to the $22-billion area is projected for this year, due primarily to the heavy delivery schedule for commercial transports. From the long-range view, the company has enough confidence in the continued growth of world air traffic that this year it added $100 billion to its forecast of the total market between now and 2005 (AW&ST Mar. 20, p. 197).

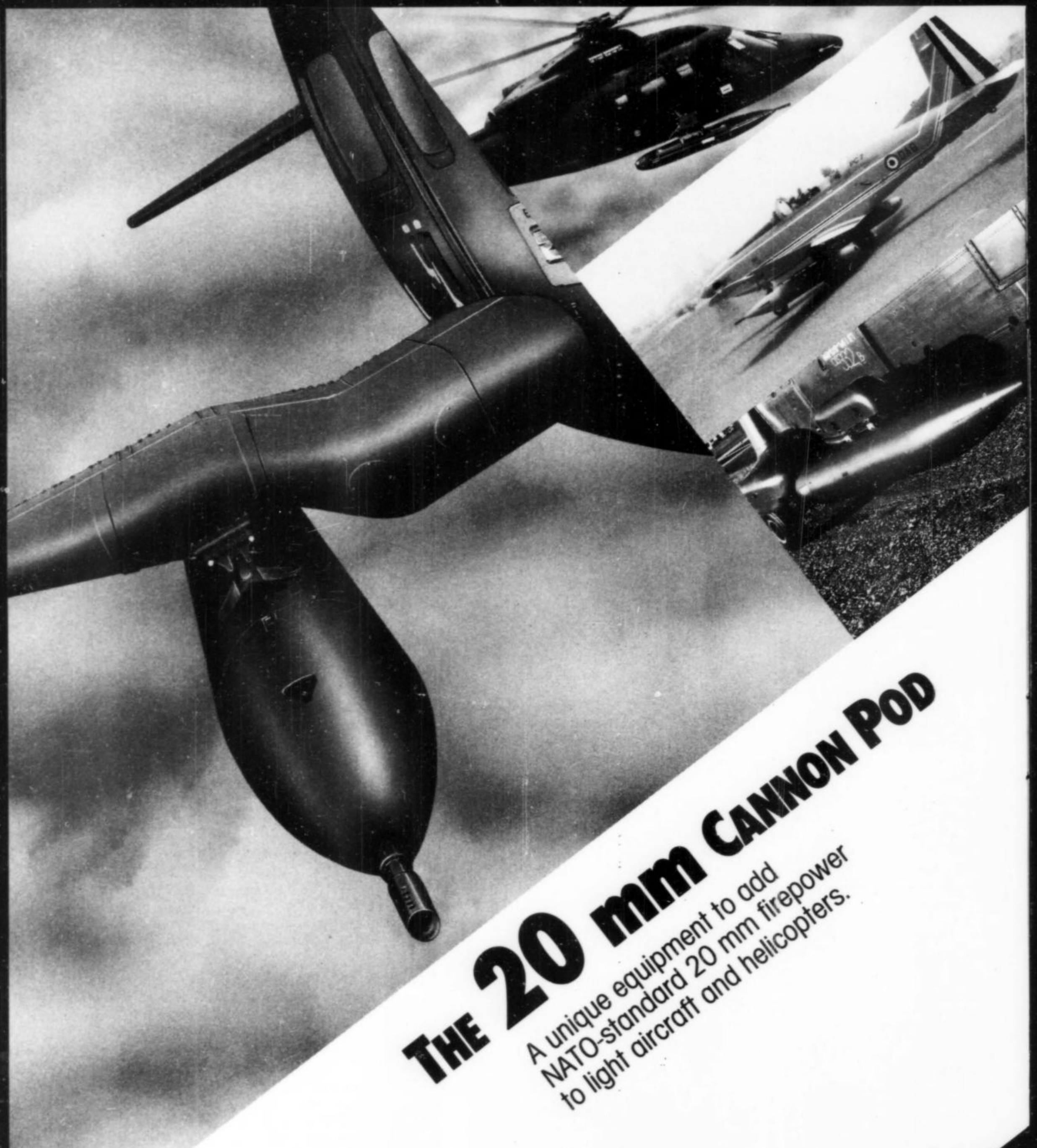
Similarly, McDonnell Douglas commercial transport sales reached record levels last year, with firm orders for 203 MD-80s and 43 MD-11 transports. The strong MD-80 market has continued this year with firm orders for 85 of the aircraft through April.

Jerry G. Brown, McDonnell Douglas senior vice president for finance, said record sales are the result of pent-up demand to modernize fleets, the increasing soundness of the airline industry and procurement decisions that were postponed due to deregulation.

"From a financial perspective, I think



Partial winglet structure is shown on a support stand at Douglas Aircraft Co. in Long Beach, Calif., in preparation for installation on the first MD-11 transport, scheduled for completion this summer.



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the most important factor has been the gradual strengthening of the financial position of all of the airlines of the world so that they are capable of buying equipment to their needs," Brown said. In the past, he added, airlines generally were limited to buying as many aircraft as they could with the amount of financing they could raise at the time.

DOUGLAS MAKES CHANGES

Douglas Aircraft Co.'s response to the increasing demand has been to raise the MD-80 production rate, increase the number of production workers, develop off-site production facilities, expand its use of subcontractors and begin a total reorganization of its management structure.

These changes, other development work and slow deliveries have had a negative effect on profits. The Douglas transport segment, which includes the C-17 program, last year had revenues of $4.5 billion and operating earnings of $127 million for a sales margin of only 2.6%. The previous year, Douglas earnings were down 11% despite higher revenues.

Operating profit margins for Boeing Commercial Airplanes, as a percentage of sales, have hovered in the 4-5% range for the past three years, representing a recovery from the hammering they took in the late 1970s. Starting in 1978, the margins plunged steadily from about 11% in 1978 to around 1% in 1982, and they hovered in the 1% area until recovering somewhat to about 4% in 1985.

First Boeing 767-300ER (extended range) transport for SAS is shown during a pre-delivery test flight over the Pacific Northwest. Boeing is scheduled to deliver nearly 400 aircraft this year.

In addition to competition from Airbus and McDonnell Douglas, pricing pressures have been generated by the changing composition of the market, with the proliferation of alliances and mergers among airlines and the privatization of government-owned carriers. The recent emergence of leasing companies as major aircraft purchasers also puts pressure on prices and adds an element of risk to the airframe manufacturers. "In many cases, the leasing companies order aircraft for delivery far into the future, with standard small initial deposits, and far in advance of receiving airline commitments to place the equipment," the company said.

These are among the additional challenges that Boeing must meet in order to take maximum advantage of the opportunities presented by the order surge:

- Get control of deliveries. Company officials have warned that the 747-400 delivery recovery program has "substantial risk," and that it will be a major challenge to deliver some 28 aircraft in the last quarter, as now scheduled. The delays have angered some of its best customers and could result in Boeing paying penalties.
- Manage the buildup skillfully. Boeing is increasing production rates on all four of its commercial transports—an enormously expensive and risky endeavor. Much of the company's planned expenditure this year of $1.1 billion for new and expanded facilities is intended to support this buildup. While the planned expansion would support rates even greater than those currently scheduled, any further hikes will come only after intense scrutiny. Company President Dean D. Thornton said recently that the depth of the demand must be measured carefully before hiking a production rate.
- Avoid shortages. Boeing already is feeling the pinch as galley and lavatory manufacturers—generally the same for all airframe companies—struggle to meet the surge in demand. While Boeing's delivery problems so far are confined to the 747-400, it could spread to other products if the suppliers fall behind.
- Avoid further quality problems. The buildup already has caused "serious workforce dilution problems," the company has said. What Boeing does not need now is the surfacing of additional quality problems, which it had been struggling with for more than a year.
- Make reasonable settlements with its unions. Negotiations start this fall with Boeing's major unions, which will be intent on sharing in the company's good fortunes.
- Decide wisely on a new program. Boeing is seriously considering launching

Operating Margin Before Depreciation

PERCENT

AEROSPACE/DEFENSE COMPANIES	
Textron Inc.	16.949
Morton Thiokol Inc.	14.540
Rockwell International Corp.	13.414
Sundstrand Corp.	13.352
Parker-Hannifin Corp.	12.504
Hexcel Corp.	11.656
UNC Inc.	11.466
Eldec Corp.	10.986
Hercules Inc.	10.772
Allied Signal Inc.	10.530
Martin Marietta Corp.	10.394
GenCorp Inc.	10.312
Lockheed Corp.	9.773
Rohr Industries	9.297
Fairchild Industries Inc.	9.288
LTV Corp.	8.976
McDonnell Douglas Corp.	8.886
General Dynamics Corp.	8.884
United Technologies Corp.	8.451
Hi-Shear Industries	8.199
Fansteel Inc.	7.765
Boeing Co.	5.984
Northrop Corp.	4.589
Grumman Corp.	0.391

Inventory Turnover of Aerospace Companies

TIMES PER YEAR

General Dynamics Corp.	21.377
Martin Marietta Corp.	11.103
Lockheed Corp.	8.947
Northrop Corp.	8.073
GenCorp Inc.	7.501
Rockwell International Corp.	5.982
Morton Thiokol Inc.	5.522
LTV Corp.	5.365
Textron Inc.	4.951
Hercules Inc.	4.818
Allied Signal Inc.	4.480
Boeing Co.	4.435
Hexcel Corp.	4.337
Fairchild Industries Inc.	4.051
Grumman Corp.	3.923
Fansteel Inc.	3.843
Parker-Hannifin Corp.	3.669
United Technologies Corp.	3.160
UNC Inc.	3.045
McDonnell Douglas Corp.	2.877
Hi-Shear Industries	2.600
Eldec Corp.	2.301
Sundstrand Corp.	2.258
Rohr Industries	2.055

a new 767 derivative this year and is leaning toward the configuration utilizing a new body and wing—practically an all-new aircraft. In responding to what the company perceives as market demand for larger and larger transports, Boeing must decide whether 1989 is the proper launch year, and whether it should go the new-aircraft route—the most expensive of the alternatives.

In mid-1982, Douglas Aircraft was facing a bleak commercial aircraft business. The company received a scant five firm orders for the MD-80 during the entire first half of that year. The firm order backlog was 21 aircraft. The DC-10 was experiencing the same kind of drought with a firm order backlog of four DC-10s and eight Air Force KC-10 tanker aircraft.

It is the stark contrast between conditions then and now—in addition to the order surge of the past few years—which has been a major factor behind the heavy production strain at Douglas Aircraft. Added to that commercial load has been the development and production work the company has conducted for the Navy on the T-45 trainer and for the Air Force on the C-17 transport.

The MD-80 picture began to change dramatically shortly after mid-1982 with several key orders. During a rapid growth period that followed, Douglas certified three new models of the MD-80 series, conducted a propfan technology readiness program and developed the MD-11, C-17 and T-45.

The workforce jumped from 12,000 to 44,000 employees in six years. The company had what it considered a skilled and experienced workforce in 1982 with few employees having less than 10-15 years of experience. Rapid expansion, however, resulted in 65% of the employees having only about two years of experience in aircraft assembly. The company is investing $25-30 million per year in the training of employees, who spend an average of 5% of their workweek in various types of training sessions.

Profits also have been affected by the opening of three new facilities in Utah, Georgia and Ohio to take the pressure off the Long Beach, Calif., production facilities.

REORGANIZATION ORDERED

Another significant expansion possibility for Douglas could come with the stretch MD-11 program, which may be started this summer. Douglas is studying three options for the program: an agreement with another contractor to assemble the aircraft at that company's facilities, development of a new final assembly facility by Douglas at a new site, or trying to squeeze in assembly of the aircraft at Long Beach. Lockheed Corp.'s Georgia facilities could be used for the initial option.

Perhaps potentially the most significant response by Douglas to the present commercial transport market is the complete management reorganization and change in the company's production philosophy (AW&ST May 15, p. 16).

The reorganization changes Douglas from a functional to a product-oriented company in a move aimed at providing product organizations—and groups within those organizations—with the authority and tools to achieve their goals. Those organizations also will be directly accountable for their performance.

The changes are viewed with concern, however, by some Douglas officials because of their severity and their timing when the company is behind schedule on its three transport programs. "At a time when you need complete focus and motivation, [the changes] disrupt, demoralize and turn people off," according to one manager. Another source said the changes are "bringing things to a complete standstill."

It is far too soon to determine to what degree the dramatic reorganization will enable Douglas to reach its production and profit goals. The transition process will not be complete until the end of next month, and some observers believe it may be another year before the initial results can be measured. □

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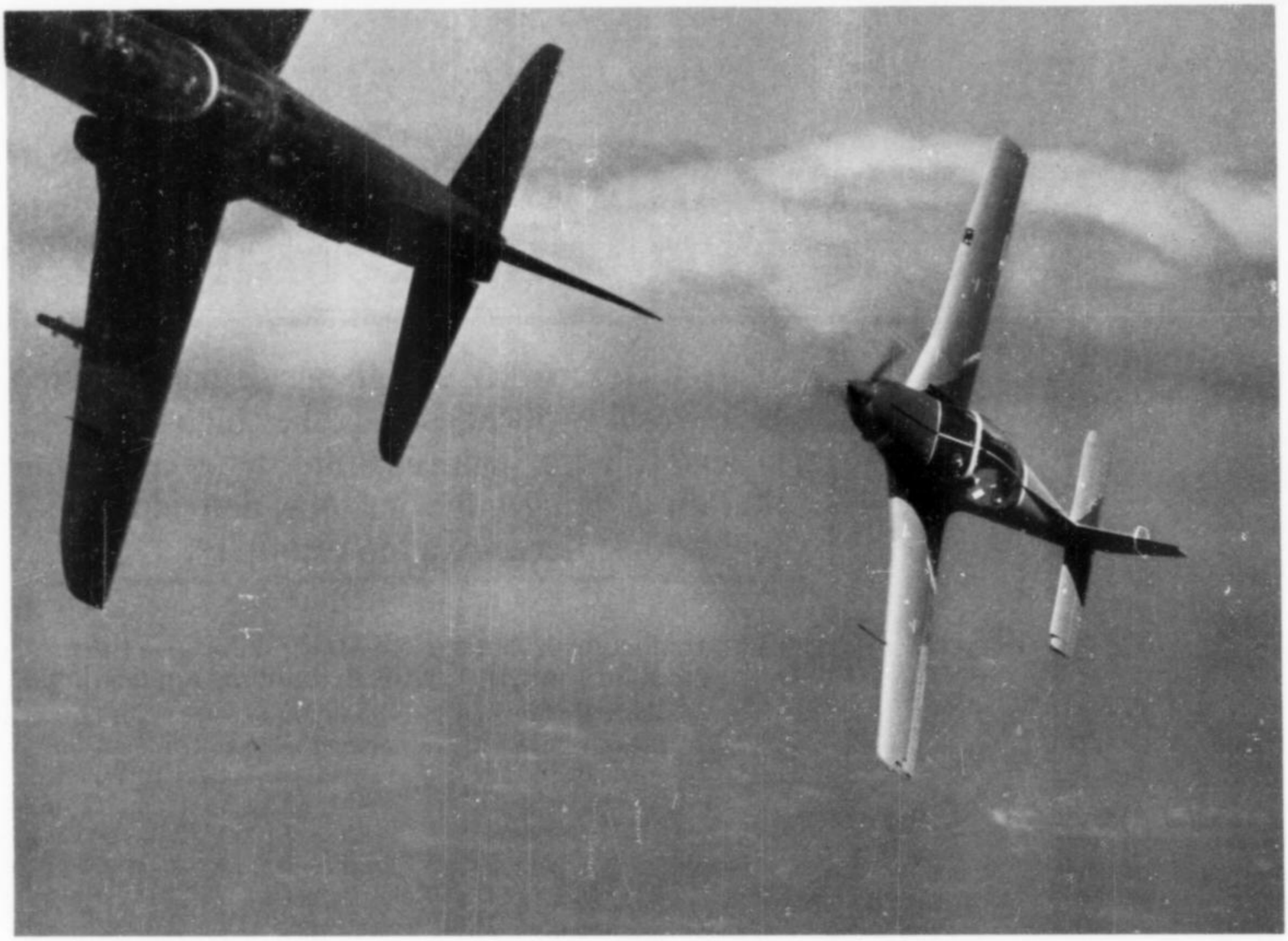

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NASA Mobilizes Technical Team to Ready Orbiter Columbia for Military Launch

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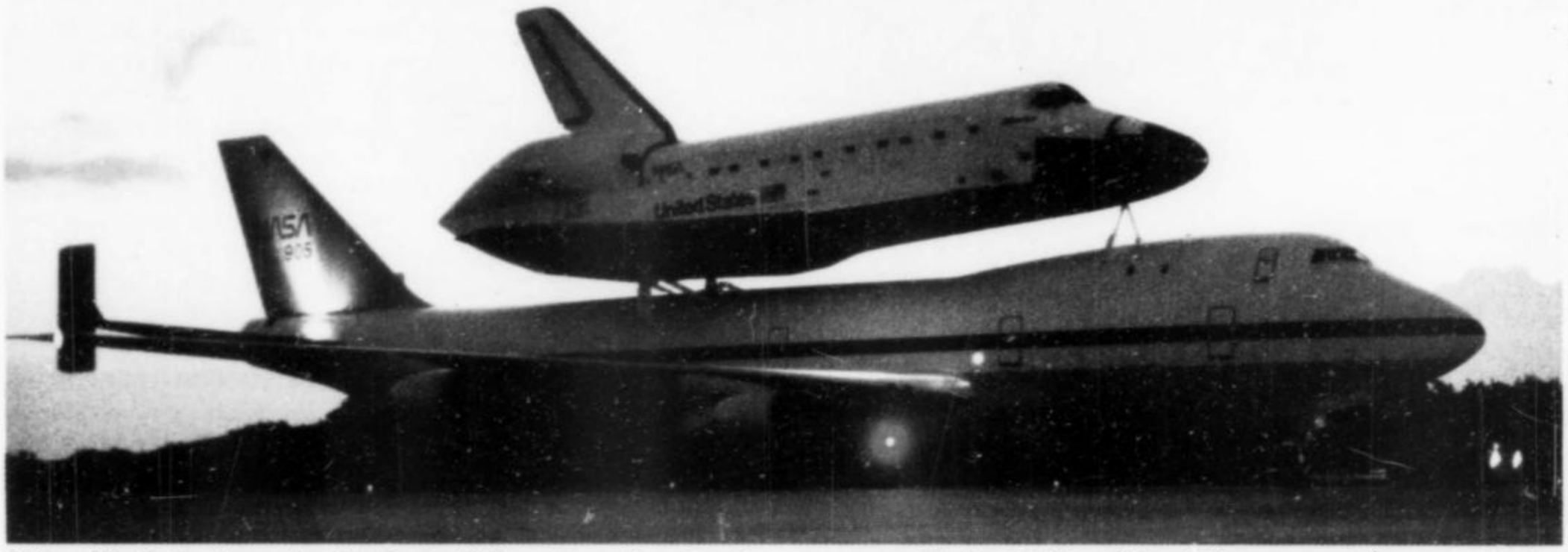


Orbiter Atlantis is shown atop the Boeing 747 carrier on its return to Kennedy Space Center following deployment of the Magellan Venus mapper on Mission 30. The orbiter will be processed to carry and deploy the Galileo Jupiter probe on Mission 34, scheduled in October.

NASA and its space shuttle contractors are focusing manpower and management priorities on the orbiter Columbia to meet a July 31 target launch date for shuttle Mission 28.

NASA already has reduced its 1989 shuttle launch schedule by eliminating a Defense Dept. mission in August, and the agency is eager to demonstrate that it is capable of bringing Columbia to flight standards and maintaining the upcoming launch target date for its military payload. Most Defense Dept. missions were shifted to expendable launch vehicles after the shuttle accident in January, 1986.

The upcoming shuttle mission will mark the first space use of Columbia since Jan. 12, 1986, the flight immediately before the Challenger accident. After Challenger, all orbiters were grounded until Sept. 29, 1988, with the launch of the orbiter Discovery on Mission 26. Columbia was the orbiter on the first five shuttle flights beginning Apr. 12, 1981, but has flown only once in the past 5.5 years. It has spent most of the past three years in storage, with the other orbiters getting precedence.

To meet the launch target, technicians here face a formidable work load. As of last week, 3,000 individual components remained to be installed in or on the orbiter; 20-25% of 253 modifications were not completed, and about 150 work shifts of test and checkout were on the schedule. Columbia is in the Orbiter Processing Facility. There is no contingency time in the plan to tow it to the Vehicle Assembly Building on June 23, which is being viewed as a highly optimistic date. There are six days of contingency time once the flight hardware reaches the launch pad, where it is scheduled to move June 30.

"That number 3,000 appears staggering, but none of the items are big components," according to Robert B. Sieck, shuttle launch director. "All the functional elements are already installed, with few exceptions. The big pieces are all there.

> *NASA is eager to demonstrate that it can maintain the upcoming launch target date for its military payload*

All the avionics components are in. What remains are piece parts—blankets, brackets, panels.

"We have several significant tests to accomplish in the next couple of weeks. We finished the main propulsion system. We'll go into a minimum of three days of flight control testing. Then we can really concentrate on closeouts and testing other systems," Sieck said.

"In parallel, we'll be involved in payload bay activities and will finish the final closeouts about the middle of June. These closeouts will probably include some tile work."

When NASA resumed tile bonding on Columbia last year, the agency estimated that there would be 2,100 tile cavities. Sieck said that more than 2,200 tiles already have been bonded and 150 remained to be bonded as of last week.

As the oldest orbiter, and because of its heavy flight history, Columbia has required more work, more inspections and more certification procedures than the orbiters Discovery and Atlantis in the return to flight process.

Columbia also is the heaviest orbiter. It has a dry weight of 157,284 lb. without the three main engines, which is about 6,000 lb. heavier than the other two orbiters. With the engines it weighs 178,289 lb. Weight of Discovery with engines is 171,419 lb., and Atlantis, 171,205 lb. Columbia landing weight ranged as high as 220,027 lb. on the sixth of its seven missions. Following that flight, shuttle Mission 9 launched Nov. 28, 1983, Columbia spent the next 18 months at the Rockwell plant in Palmdale for removal of ejection seats and 250 modifications to update it. Landing weight on its last previous mission was 210,161 lb.

NASA accountants calculated that it took 3.1 million man-hours to process the orbiter Discovery for Mission 26, the first post-Challenger flight. This included activities in the Orbiter Processing Facility, Vehicle Assembly Building, launch pad, as well as the documentation to certificate the work. Atlantis was processed in 1.6 million man-hours for Mission 27; it took 1 million man-hours to process Discovery for Mission 29, and an estimated 900,000 man-hours for Atlantis on Mission 28.

By last week, Columbia was approaching the 1.5-million man-hour mark and Sieck estimated the total time would be less than the 3.1 million hr. for Discovery

on Mission 26 and more than the 1.6 million for Atlantis in the following cycle. Pre-Challenger processing times averaged about 400,000 man-hours, Sieck said. The lowest was the Challenger turnaround for Mission 8, which took 200,000 manhours.

In the post-Challenger era, NASA has not set a time goal for orbiter processing, Sieck said. "What we are trying to do is better analyze and understand what goes into it."

Sieck said Columbia is unique among the orbiters in that it is undergoing the last nonstandard processing flow. "Once we get this behind us, we can concentrate on the best way to turn orbiters around, to maximize resources."

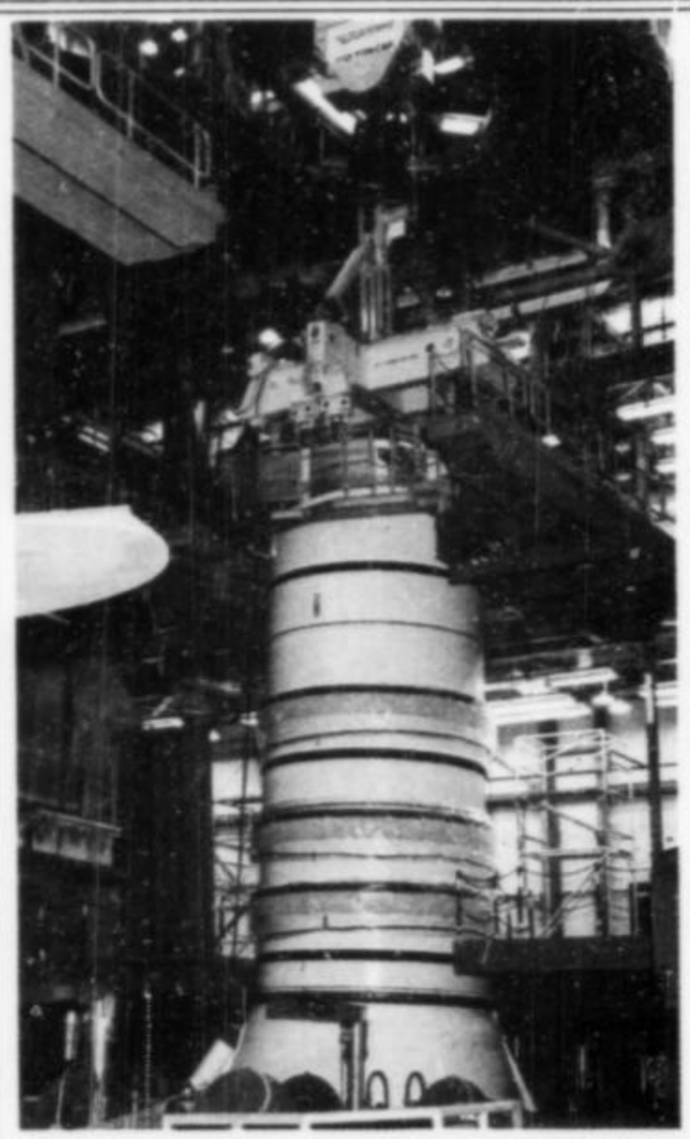
With the return of the orbiter Atlantis here on May 15 from its Mission 30 Magellan deployment, virtually the entire Lockheed Space Operations Co. workforce has been assigned to Columbia. Six months ago, Columbia was third in line to get manpower, parts and modifications. Today it is first and there is little activity involving Discovery or Atlantis.

Lockheed has senior managers overseeing Columbia processing. L. H. Yount, vice president and director of Kennedy support, led the crew for about eight months. He was replaced two weeks ago by William F. Edson, Jr., vice president and director of operations control. John Thomas, who directed the shuttle solid booster redesign team for NASA after the Challenger accident, has been hired by Lockheed as vice president and Kennedy site director. His initial responsibility will involve the Columbia processing job.

On the NASA side, a second flow director has been added to the Columbia processing contingent. John J. Talone, Jr., who has been the Discovery flow director, now heads the second shift for Columbia. Ann D. Montgomery is the Columbia flow director for Mission 28 and heads the first shift.

"We are not changing our organizational structure. We are not taking shortcuts in the processing," Sieck said. "What we have done is assign some of our experienced people to the Columbia flow."

The reason all of this is necessary is simple, according to Sieck: "We're giving Columbia maximum effort now because it has been the third priority vehicle in the return to flight activity. It was the vehicle you had to find a facility for to work on. It was the last to get the parts for flight modifications. So, we built up a large backlog of work, and now we're pushing hard to complete it."



Left aft segment of the solid booster for shuttle Mission 29 is lowered in place in the Vehicle Assembly Building at Kennedy. Each booster has four segments.

NASA is sensitive to accusations made in Challenger investigation reports that continuing parts shortages resulted in cannibalizations that threatened flight safety. Sieck said that 17 parts were cannibalized from Columbia for other orbiters, and only 10 of these were functional parts, or hardware required for flight. Key cannibalized parts that affected the program were those that were checked out and ready for flight, Sieck said. Once they were taken, they were invalidated and required recertification.

MASTER EVENTS CONTROLLER

Sieck said the most notable item cannibalized from Columbia was a master events controller that replaced a failed controller in Discovery for shuttle Mission 29. Other functional components cannibalized from Columbia to replace missing or failed components on Discovery or Atlantis were:

- Remote sensor assembly.
- Display driver unit.
- Surface position indicator.
- Gaseous nitrogen accumulator.
- Water spray boiler.
- K_u-band distribution assembly.
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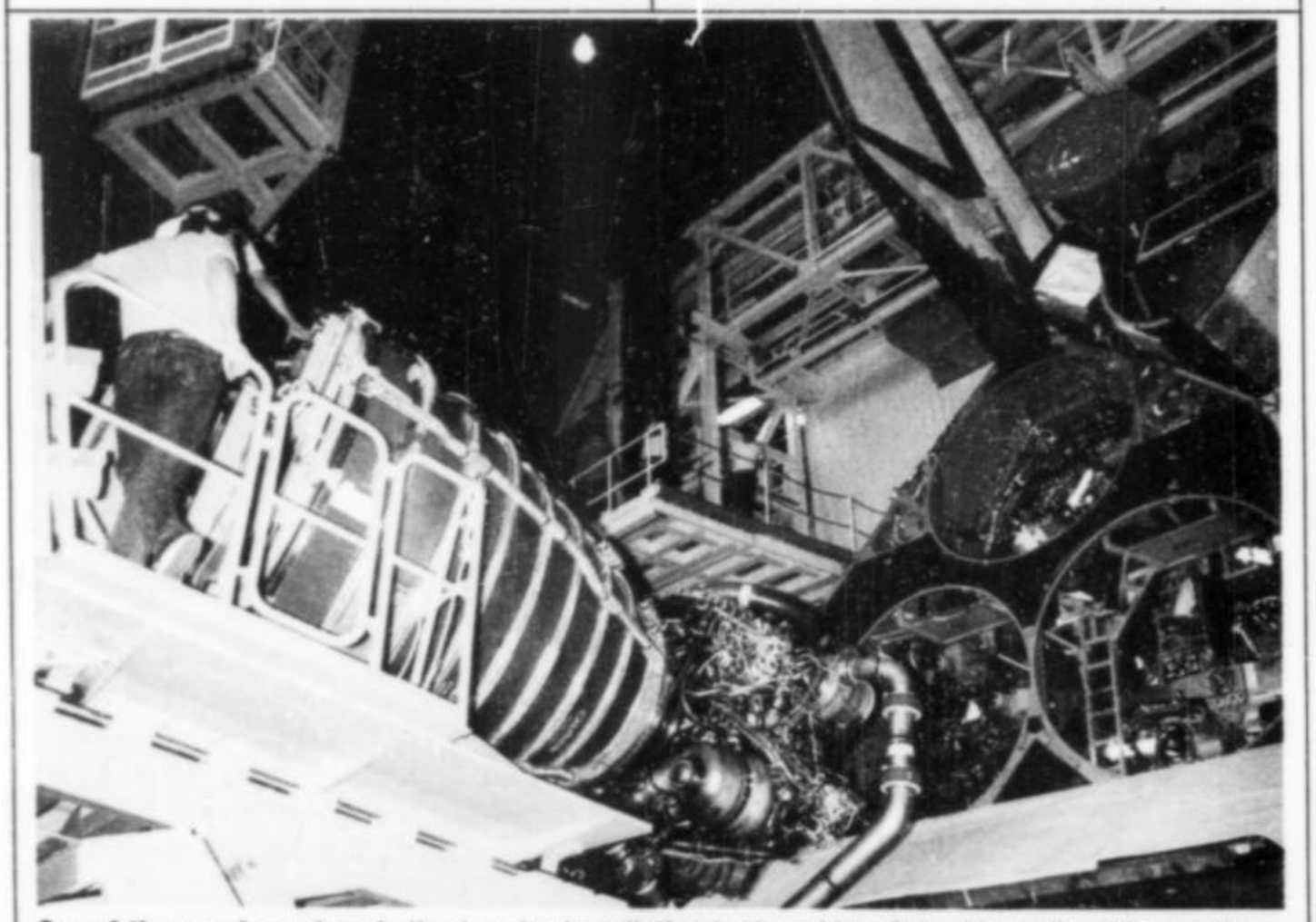
- Liquid hydrogen actuator.
- Modular auxiliary data system pulse code modulator.

Nonfunctional items cannibalized ranged from a duct purge to insulation covers.

"The delay in processing Columbia is not from cannibalization," Sieck said. "But you could say the delay is due in part to the fact that all the hardware did not arrive last year and was waiting on the shelf to be installed. That's what we would like to have had."

Albert C. Martin, Rockwell vice president and general manager of Florida operations, said the idea that Columbia was simply a "donor ship" for the other orbiters is not accurate. Rockwell is orbiter contractor. Martin said the vehicle "was missing a lot of parts because we removed them for modifications and upgrades. The modifications were those that NASA and Rockwell deemed necessary to improve reliability, safety and maintainability."

Sieck said the manpower shortage experienced here 3-4 years ago no longer exists since Lockheed has increased its workforce in the critical skills—shop floor, quality control and engineering. Workers have improved with each flow since shuttle missions resumed, and they'll soon "be card-carrying experts," he said. □



One of three main engines is lined up for installation in the orbiter Columbia earlier this month as the orbiter is processed for flight. The payload bay will carry a secret Defense Dept. spacecraft.

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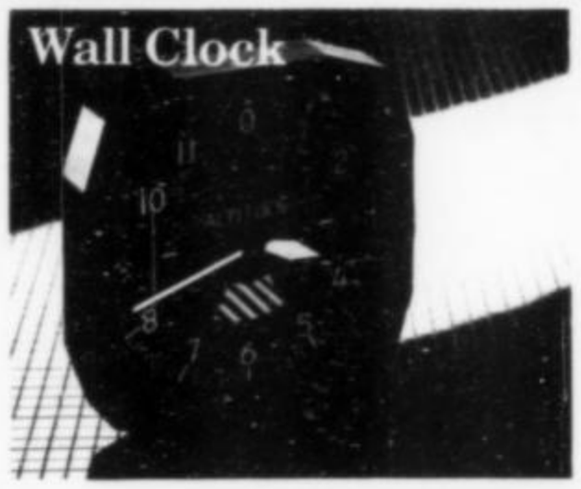

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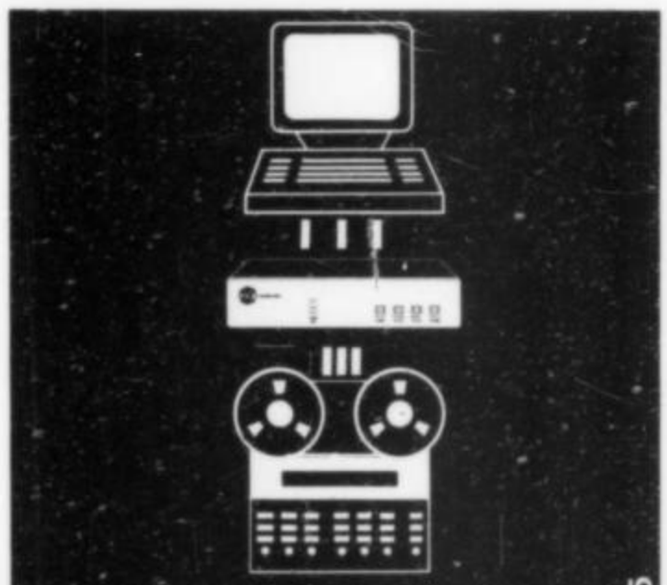

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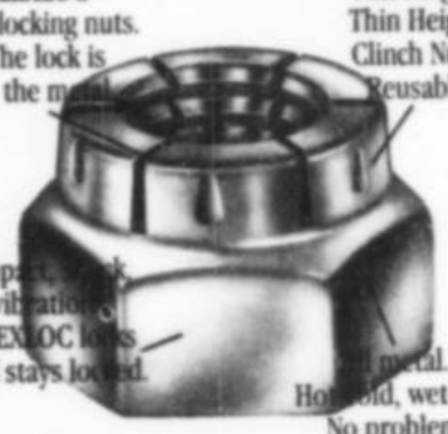

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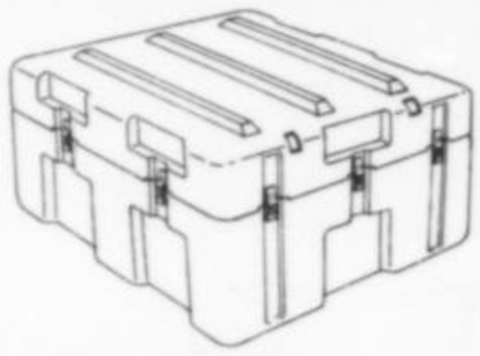

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Airborne Surveillance Will Give Forest Service Real-Time Fire Maps

BRUCE D. NORDWALL/WASHINGTON

The U. S. Forest Service plans to use an aircraft equipped with dual-band infrared sensors and Navstar Global Positioning System satellite navigation receivers to locate fires and data-link the information to the ground.

The Firefly system, under development by the California Institute of Technology's Jet Propulsion Laboratory, is intended to both pinpoint hot spots and locate perimeters of forest fires. But the biggest advantage over earlier systems will be the ability to deliver a map of the fire to the commander on the ground in near real time.

Under the current system the aircraft has to land and deliver a photo of the infrared image. The incident commander, or fire boss, often gets the photo hours later at the fire camp.

The Firefly is intended to provide the big picture so that the commander can plan strategy for the next 12-hr. fire fighting shift, according to William McCleese. He is the assistant director of fire and aviation management for the Forest Service's Washington, D. C., headquarters.

INSTALLATION IN TWO AIRCRAFT

The system is to be installed in two twin-engine Forest Service aircraft, a King Air and a Merlin. Each has an IR system that uses 1960s technology. Cost was an important design factor, so JPL planned to use as much commercially available equipment as possible. JPL estimates that two complete systems, including development costs for software and integration, will cost about $4 million.

The Firefly is scheduled to be completed in 1992. Its modular design will allow it to be installed incrementally, as an upgrade to the existing systems. The first element of the new system is scheduled to be installed for use during the summer of 1990.

J. David Nichols, the Firefly project manager at JPL, described the program to the International Society for Optical Engineering's Aerospace Sensing Conference, held recently in Orlando, Fla. NASA and the Forest Service jointly sponsored the JPL forest fire advanced system technology study that led to the Firefly design. In addition to near-real-time information, the fire fighters needed a system with both wide field of view to map the perimeters of large fires and the ability to locate small hot spots.

Identifying fire boundaries requires a cross track field of view of at least 80 deg., according to Nichols. To sense a 600C hot spot only 1 sq. ft. in size from 10,000 ft., the design specifies detectors with instantaneous fields of view of less than 2.5 milliradians.

The design will use a dual-band, infrared line scanner, operating in the 3-4.8-micron and the 8.5-12.5-micron band. The bispectral IR would allow the system to reduce false alarms in detecting hot spots. High long-wave IR sensitivity in the second band is necessary for terrain imaging. Detectors in both bands are to be sensitive to temperature differences of less than 0.2C.

The biggest advantage will be the ability to deliver fire maps to the ground commander in near real time

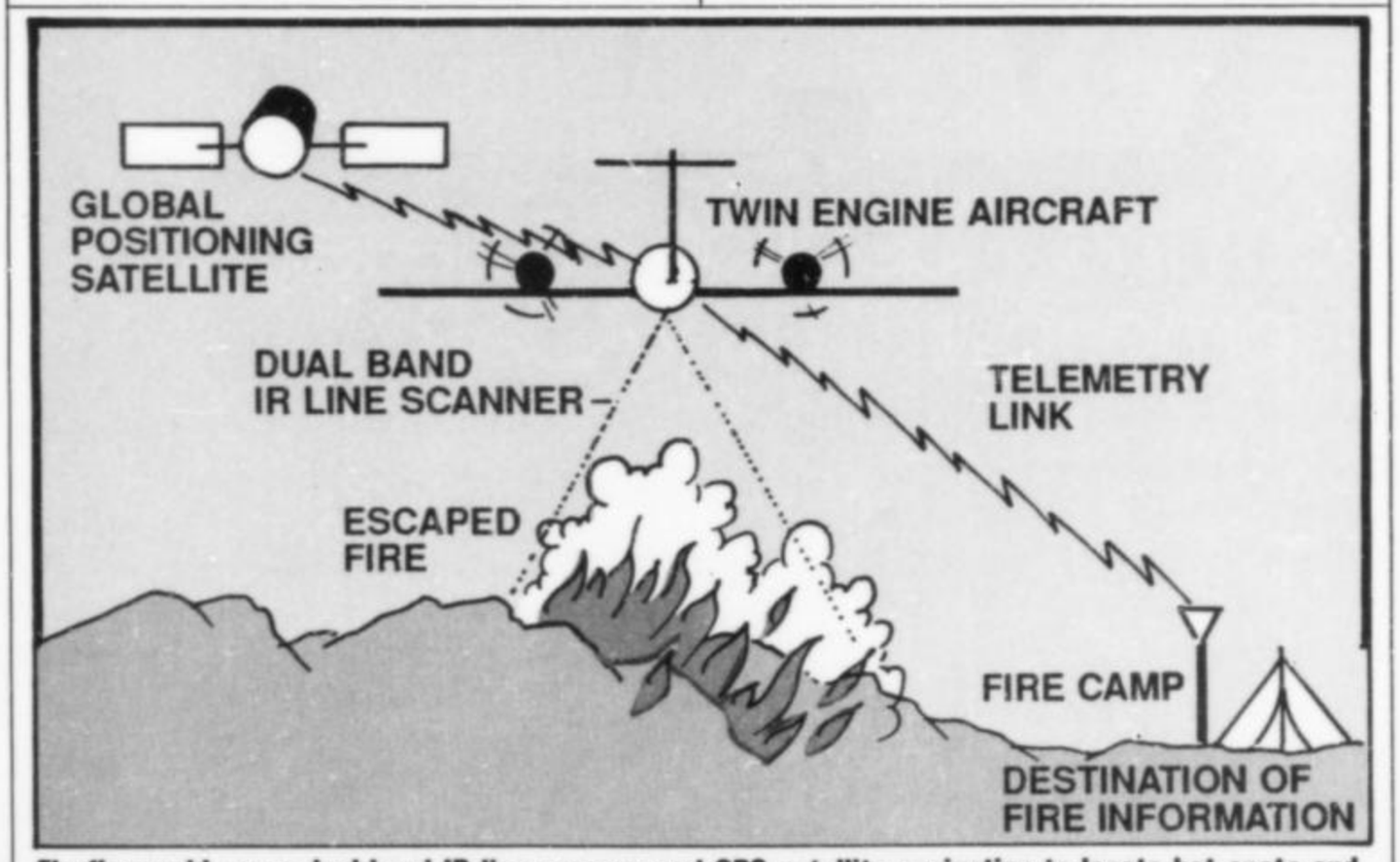
Fire missions are flown at a variety of altitudes and airspeeds. Low-altitude mapping missions can be as low as 2,000 ft. above ground level and as slow as 120 kt. This defines the low-altitude portion of the sensor requirements, since the IR scanner is to provide 50% overlap on successive scans. The overlap gives double detection of small fires, but rejects false alarms from single detections. The Firefly aircraft would use the Global Positioning System for navigation when the GPS constellation of satellites is complete. Until then, the aircraft would use Loran.

Knowing the aircraft position, heading and altitude accurately is fundamental to being able to correlate aircraft images of the ground with locations on a map. The digital elevation data base of the U. S. Geological Survey (USGS) would supply another element of this process. The survey is dividing the continental U. S. into 100-meter squares and providing an average terrain elevation for each square. Half of the National Forest land is covered now, and the Forest Service expects USGS to finish the task by 1992, McCleese said.

GPS will reduce uncertainty in aircraft position, in three dimensions, to 25-100 meters. Aircraft gyros will provide aircraft heading and attitude. Errors in those gyros are typically 0.1-2 deg., according to JPL. They translate directly into uncertainty in the viewing angle from the aircraft, and therefore into position error. Increasing airspeed and altitude also can decrease accuracy. The final Firefly, however, will have a position accuracy of ±500 ft., Nichols said.

The navigation system would be integrated using a 16-bit microprocessor, which would sample navigation signals at 10-millisec. intervals. The microprocessor allows the entire process to be integrated using off-the-shelf computer hardware, according to Nichols. This should minimize maintenance and make it easy for the Forest Service if it decides to reproduce the system in the future.

The first upgrade would add the new data acquisition system to the existing IR scanner. The signal processing subsystem would consist of a specialized microprocessor, video processing electronics, a vid-



Firefly would use a dual-band IR line scanner and GPS satellite navigation to locate hot spots and fire perimeters, and data-link the locations to the U. S. Forest Service fire center on the ground.

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eo monitor and a video recorder. The subsystem would digitize the sensor data from both IR bands. It would combine the data mathematically and quantify the levels of thermal brightness. The design also would combine dual-band data in a way that would minimize the possibility of false alarms caused by objects at less than 600C and by solar reflection.

JPL designed the system to use digital video processors that can accept either digital or analog sensor outputs. A pipeline architecture should allow parallel processing of the sensor data at a rate of 10 megapixels/sec.

The terrain images would be displayed to the airborne operator in monochrome, overlayed by fire areas in red that intensify with the temperature of the fire. The operator would be able to select either IR band or a combination. He would select an image and freeze the frame to prepare for transmission. The operator also could add notes and highlight landmarks that are visible in the images, using the operator terminal.

Low-altitude mapping missions can be as low as 2,000 ft. above ground level and as slow as 120 kt.

The data link would not transmit images, however. The system would automatically identify the latitude and longitude of hot spots and fire boundaries. These coordinates, along with the operator's annotation, would be transmitted to the ground station.

After the image gathering has been completed, the aircraft would fly toward the fire camp to establish line-of-sight communications. The ground station would receive the information over a VHF data link that will use existing Forest Service frequencies. At the fire camp's ground station a plotter would receive the information from a ground computer and draw the fire map on a mylar sheet that will overlay standard Forest Service topographic maps. That information would be available at the fire camp within 30 min. of the time it was recorded, an improvement over the hours it currently takes, according to the Forest Service.

Firefly is expected to weigh about 200 lb. and require less volume than the current 16-cu.-ft., 300-lb. system. It would have either an improved cryogenic or a mechanical cooler for the IR detectors. Firefly also is expected to be more reliable and maintainable than existing systems. The Forest Service requires that the system operate for the entire fire season—about 10 months—without a failure. □

FILTER CENTER

THE U. S. AIR FORCE has created an organization at Edwards AFB, Calif., dedicated to ground and flight testing airborne electronic warfare systems. The engineering unit was formed during a major reorganization of the Air Force Flight Test Center earlier this year. It is charged with developing uniform EW system testing criteria, techniques and facilities that parallel those governing airframe evaluations.

THE U. S. ARMY'S CENTER FOR NIGHT VISION and Electro-optics will evaluate a Thomson CSF radar installed in a modified AH-1 Cobra helicopter equipped with AH-64 Apache subsystems. The Romeo millimeter-wave radar will be tested for its ability to detect obstacles to low-flying helicopters such as power lines, trees and high terrain. The radar presents a color-coded alert on a screen to indicate the proximity of danger (AW&ST July 6, 1987, p. 103).

RAYTHEON HAS SELECTED Harris Corp.'s Night Hawk 3800 computer for the FAA's Terminal Doppler Weather Radar system. The radar system is designed to detect microbursts and wind shear in the vicinity of major U. S. airports. The award from Raytheon, the prime contractor, is for 47 of the multiprocessing computer systems with an option for an additional 55 computers. The contract has a potential value of $18.5 million, according to Harris.

THE WESTINGHOUSE ELECTRONIC SYSTEMS GROUP has delivered its first three VHSIC processors to Boeing Military Airplanes for integration in the mission equipment package being developed for the LHX helicopter. The package is intended to automate the functions of a number of major subsystems, including the target acquisition system, aircraft survivability equipment, displays and weapon controls. Boeing is developing Ada software for the mission equipment package for demonstrations during the ongoing demonstration/validation phase.

GEC SENSORS LTD. will supply forward-looking infrared systems for the U. S. Marine Corps AV-8B aircraft. The U. K. and U. S. governments jointly evaluated the Flir, which also is manufactured for the RAF Tornado GR1 and Harrier GR5.The Flir will be mounted inside the fuselage. The image will be presented on the head-up display.

THE X-RAY INSPECTION SYSTEM made by Bechtel and American Science and Engineering for the U. S. Technical On-Site Inspection project is being installed at Votkinsk, 600 mi. east of Moscow. The effort is managed by the U. S. Air Force's Electronic Systems Div. The Cargoscan system will be used to image portions of missiles—contained in canisters inside rail cars—as they leave a missile factory in Votkinsk. In this way the U. S. inspection team can verify that there are no banned SS-20 missiles in the railroad cars without opening the cars or the canisters. Cargoscan uses American Science's Model 7000 imaging subsystem, which produces digitized X-ray images that can be processed, enhanced and manipulated by the operator. The X-rays can penetrate several inches of steel (AW&ST May 22, p. 95).

LOCKHEED AIR SERVICES has selected Smiths Industries to provide the flight management system for the new P-7A aircraft, formerly called LRAACA, for the U. S. Navy. Smiths will provide two flight management computers and two control display units per aircraft. The $8.2-million, full-scale engineering effort will modify existing systems and will add a 1553-data bus.

RACAL AVIONICS will supply navigation systems for Belgian Sea King helicopters made by Westland. The suite includes the Racal Doppler 71 velocity sensors and tactical airborne navigation system (TANS), which has a single light-weight central processor. Belgium intends to use the system for land and sea search and rescue missions.

THE GODDARD SPACE FLIGHT CENTER plans to issue a request for proposal to the Physical Science Laboratory of New Mexico State University to support the upgrade of the ultraviolet imaging telescope. This is one of three telescopes making up the Marshall Space Flight Center-managed astronomical observatory. The effort is to support the modification and subsequent flights of the telescope on board the space shuttle.

Eastern Unions Losing Bid to Unseat Lorenzo

JAMES T. MCKENNA/NEW YORK

Trump Shuttle officials revealed the airline's livery last week after they won the Bankruptcy Court's approval to buy Eastern's Northeast shuttle and 21 727s for $365 million. They hope to have some aircraft painted in these colors by the time they take over the shuttle in about two weeks.

Eastern Airlines' striking unions are running out of options to force Frank Lorenzo to surrender control of the Miami-based carrier, industry and union officials said.

The unions' efforts were set back further last week when the U. S. Bankruptcy Court here approved the sale of Eastern's Northeast shuttle to Donald Trump for $365 million. The unions have been fighting a shuttle sale for more than a year.

In addition, Eastern and its committee of creditors plan to begin negotiations this week on the final form of the airline's plan to reorganize under Chapter 11 of the bankruptcy code. The creditors are focusing on Eastern's plan to resume operations because it "is the only option on the table besides liquidation," one key official involved with the committee of Eastern's creditors said last week, "and liquidation no longer appears viable."

"Things are moving inexorably into Lorenzo's court," this official said. Lorenzo is chairman of Texas Air Corp., owner of Eastern and Continental Airlines. Eastern this week will announce a summer flight schedule that includes expanded service from its Atlanta hub and from Miami to Northeast markets, Eastern President Phil Bakes told AVIATION WEEK & SPACE TECHNOLOGY.

Eastern was forced into bankruptcy court Mar. 9 by a walkout of its pilots, flight attendants and mechanics. The strikers refuse to return to work until Eastern is free of Lorenzo's control. But all efforts to find a buyer for the airline have failed, leaving the unions just two prospects for defeating Lorenzo, neither of which is under their control. Lorenzo could lose if a trustee takes control of Eastern, or if an FAA probe uncovers endemic illegal maintenance practices at Eastern. Neither is likely, industry and FAA officials said.

"It's a war of attrition now," Kit Darby, president of the Future Aviation Professionals of America, said. The unions want Bankruptcy Judge Burton R. Lifland to appoint a trustee on the grounds that Lorenzo's management of Eastern has been inept or fraudulent. Lifland is scheduled to hear arguments on the call for a trustee this week.

Eastern's plan 'is the only option on the table besides liquidation, and liquidation no longer appears viable'

However, appointing a trustee might defeat Lifland's oft-stated goal of getting Eastern flying again quickly, since Texas Air Corp. officials have vowed they will appeal. "Appointing a trustee would stop the process dead," one key official in Eastern headquarters said. "The appeals process could take months."

Nevertheless, some pilots union officials see the appointment of a trustee as their best hope. "If he is not replaced with a trustee, or if he appeals and gets a stay of the appointment, Lorenzo just wins, that's all," one key adviser to the pilots union said. "We're out of short-term options."

The pilots continue to press for some party to buy Eastern, and won support last week when the governor of Florida and the AFL-CIO said they each would consider lending $50 million in pension funds to aid a buyout. Former Piedmont Airlines Chairman William Howard and Chicago investor Joseph Ritchie have submitted bids, but Eastern, its creditors and the court have not taken those bids seriously. "Howard and Ritchie made presentations to the creditors committee two weeks ago," one official said. "But they had nothing to say."

The unions' other hope is that the FAA probe of Eastern maintenance bases inspired in part by their complaints bears fruit (AW&ST May 22, p. 102). Three unsigned depositions taken by the FAA from striking Eastern mechanics in New York that were made available to Aviation Week indicate that that probe is focusing on three general areas:

- That threats from upper management allegedly prompted foremen to clear aircraft for return to service that had not been maintained or inspected properly. One mechanic cited the case of a L-1011 engine with substantial damage to its Stage 7 blades that allegedly was signed off by a maintenance supervisor.
- That to speed an aircraft's return to service, maintenance managers and foremen at the Kennedy Airport maintenance base allegedly signed off work that was never done.
- That maintenance managers and foremen allegedly inspected repairs that they

'If he is not replaced with a trustee, Lorenzo just wins, that's all. We're out of short-term options'

performed themselves, thus eliminating the preferred safety check of having a second set of eyes look at the repair.

Eastern officials said the alleged violations are the result of union sabotage. At the FAA's request, Eastern has removed all aircraft from its Kennedy base and has removed the facility from its operating specifications.

FAA officials are auditing maintenance records from the airline's other bases. "To date, there is no evidence to indicate that similar problems exist anywhere else," Anthony Broderick, FAA associate administrator for regulation and certification, said. However, FAA investigators have contacted mechanics at Eastern's Boston and Atlanta bases, and have begun taking depositions from mechanics in Miami.

Bakes said the maintenance probe would have little effect on the revived Eastern Airlines. "The events being investigated are all prestrike events that occurred under prestrike conditions, and the inquiry will find that whatever occurred at Kennedy was isolated," Bakes said. "The FAA find us very responsive to whatever recommendations they may make as a result of the probe."

Eastern was fined $9.5 million in 1986 by the FAA for maintenance discrepancies (AW&ST May 19, 1986, p. 34).

Eastern won a crucial victory when Lifland ruled that Trump's $365-million bid for the Air-Shuttle operation and 21 Boeing 727 aircraft was the best offer Eastern had. Phoenix, Ariz.-based America West Airlines withdrew its $415-million bid for the shuttle May 24 after it failed to obtain financing.

Trump Shuttle officials plan to take over the Washington-New York-Boston shuttle within two weeks. They have maintained the currency of 42 newly hired pilots, and late last week were running some of the 168 striking Eastern pilots they have hired through recurrency training. The training uses a Trans World Airlines Phase 2 727 simulator at Kennedy.

After settlement costs for the shuttle sale, Eastern will net about $300 million, which will underwrite its flight operations as it integrates 22 replacement pilots who graduated last week into its flight schedule. Furthermore, when Trump takes over the shuttle, about 80 managerial pilots who are flying the shuttle for Eastern now will be freed to resume training and other duties for the struggling Miami-based carrier. It has 452 pilots in training.

The sale also will enable Lorenzo and Bakes to press their argument to Eastern's creditors that their plan to resume operations is the most viable option for bringing the carrier out of bankruptcy proceedings.

The creditors will begin talks this week with Eastern to refine its revival plan and get more debts paid off, but that is the only plan before them. The talks are essentially not over whether Lorenzo and Bakes will be permitted to revive Eastern, but how. That is bad news for the unions, one official said.

"He'd like a couple of hundred pilots to cross the lines," this official said. "In fact, he needs those pilots if he is going to meet his projected summer flight schedule. But that's it. He doesn't want any more pilots back, because when the airline is flying again, he does not want to have to deal with a union vote." □

Pan Am Will Proceed With Bid For Northwest Airlines Parent

NEW YORK

Pan Am Corp. will be among many bidders for Northwest Airlines' parent company when final bids come due this week.

Thomas G. Plaskett, chairman of Pan Am Corp., which owns Pan American World Airways, said the company will proceed with a bid for NWA, Inc., by the May 30 deadline.

Plaskett spent much of last week searching for financiers to provide a bridge loan for Pan Am's bid. Prudential-Bache Securities and an investor group called Airlie Group have agreed to provide up to $400 million for Pan Am's effort (AW&ST May 15, p. 70).

Pan Am has many competitors.

Investor Marvin Davis has extended his $90-a-share tender for NWA stock to 6 p. m. EST, May 31. Los Angeles investor Alfred Checchi also is weighing a bid for NWA, as is the leveraged buyout firm of Kohlberg Kravis Roberts, and officials of the Minneapolis/St. Paul-based company said they have as many as six other bidders that they have not identified.

Northwest's unions have met with several potential bidders to discuss how those bidders' business plans would affect union members' job security and the airline's aircraft acquisition plan. Northwest has 25 firm orders for Airbus Industrie A320s and may order up to 75 more. It has firm orders for 10 A330s and is still negotiating options for 20 A340s. Northwest also has 12 Boeing 747-400s on order, three of which have been delivered.

Northwest unveiled its new aircraft livery last week as it prepared to accept buyout bids.

Members of the Air Line Pilots Assn. at Northwest remain the critical players in any takeover attempt. They have been without a contract for about three years. Although mediated talks with the company have intensified in recent weeks, the union has a standing authorization to strike.

That threat of a strike probably would scare off significant financial backing for any of the bidders, industry officials said. To mount a successful takeover, therefore, a bidder would have to gain the support of the pilots. □

AMR Eagle Boosts Saab-Scania With Firm Order for 50 SF340Bs

CHRISTOPHER P. FOTOS/WASHINGTON

Saab SF340s ordered by AMR Eagle will be powered by General Electric CT7-9B turboprop engines. The commuter affiliate of American Airlines placed 50 orders and 50 options for the 34-passenger aircraft. The company also took options on 50 Saab 2000 transports.

AMR Eagle has placed an order that could be worth more than $300 million for 50 Saab-Scania SF340Bs, boosting the Swedish aircraft's prominence in the U. S. while supporting expansion of the carrier's commuter line.

AMR Eagle, the commuter sister of American Airlines, placed options for another 50 of the 34-passenger aircraft. Excluding de Havilland, the Canadian aircraft company now owned by Boeing, no U. S. manufacturer offers commercial passenger aircraft in this category.

The firm orders alone will nearly double the number of SF340s operating in the U. S. Regional Airline Assn. figures show that 70 of the aircraft were flying in the country at the end of 1988. The order makes AMR Eagle, AMR's commuter division, the largest customer for SF340Bs.

The company also took options on 50 Saab 2000 transports. The 50-passenger transport, a derivative of the SF340, was launched last December on the strength of a letter of agreement from Switzerland's Crossair, which plans to buy 25 Saab 2000s and holds options for another 25.

AMR Eagle and Saab declined to release the cost of the firm order. Officials at Avmark, an aviation consulting and services firm based in Arlington, Va., estimated the cost of SF340Bs at about $7.5 million each. For the AMR transaction, this translates into a potential worth of $375 million for the 50 firm orders. But an Avmark official said a discount, possibly as much as 20%, for this high-volume order was likely. A Saab official said the combined value of the orders and options was about $1.4 billion.

The first 15 SF340Bs are scheduled for delivery in January, 1990, to Nashville Eagle hubs at Nashville and Raleigh/Durham. Saab plans to deliver 24 more in 1991 and 11 in 1992. If options are converted to orders, 24 more would be delivered in 1992-93. The Saab 2000s would be delivered between 1994 and 1997, if converted to firm orders.

TREND TOWARD BIGGER AIRCRAFT

Including Nashville Eagle, AMR owns four commuter carriers. None now operates SF340s, although Dallas-based Metroflight, an American Eagle code-sharing partner, does.

The Saab 2000's delivery schedule is so far in the future that AMR Eagle has yet to make concrete plans regarding its deployment. But the SF340B will be used for both replacement and expansion, according to an American Airlines official. Steve Horner, an Avmark analyst specializing in commuter and regional airlines, thinks the company's purchase of the 34-seat turboprop points toward greatly expanded use of larger commuter aircraft by U. S. regionals.

Many analysts believe airport congestion and traffic growth will lead to the use of larger aircraft by major carriers. Horner and others see this trend also affecting the regional and commuter airlines as 30-seat aircraft replace 19-seaters as the primary commuter transports. At the same time, the use of 50-seat aircraft is projected to grow as well.

"It's pretty evident most of these aircraft will be replacing the aircraft AMR Eagle currently owns, to provide 'seamless service,' " Horner said. This refers to the attempt by some airlines to provide major-carrier-grade service on all legs of a trip, regardless of whether a given segment is flown by a commuter or its major code-sharing partner.

In a marketing sense, American is far ahead of some of its competitors, according to Horner. "They want to provide a consistent product on every segment, whether it's turboprop or jet," he said.

Adding to the importance of the purchase, in Horner's view, is that in past years, "American has tended to do something like this and revolutionize the industry." USAir was setting up code-sharing agreements in the 1960s, when it was Allegheny Airlines. "But, until American started doing it in 1983 and 1984, it didn't really catch on," he said. The same could be said for frequent flier programs, according to Horner.

Not everyone agrees that American's approach will be followed by other carriers. Some majors do own some of their commuters. But others, such as Delta Air Lines, have contented themselves with

buying minority equity in their code-sharing commuters, according to John Fredericksen, executive vice president of the Regional Airline Assn.

"American took a big step when it bought the commuters, but it doesn't look like all the others are in a rush to follow," he said. "There are lots of ways to skin a cat. Northwest operates a leasing company. They buy airplanes, then lease them to the [Northwest] Airlinks"—that carrier's designation for its code-sharing partners.

"Continental owns three [commuters], and it does tend to buy aircraft," Fredericksen acknowledged. But United Airlines "has nothing to do" with acquiring aircraft for its code-sharing partners.

In winning the contract from AMR Eagle, Saab beat out competitors such as Boeing de Havilland's Dash 8-100, which seats 36-40, and the Embraer Brasilia, which seats 30.

Horner believes Saab was the only manufacturer willing to reduce its price low enough for the block order. Nevertheless, "I think this was a coup for them. They've solidified their market share position for the next several years." Aircraft in the Saab 2000's category include the ATR42, the Dash 8-300 and the Fokker 50, as well as the Canadair Regional Jet, "to a smaller extent." □

WestAir Acquires Jetstreams To Boost Commonality of Fleets

LOS ANGELES

WestAir Holding, Inc., is acquiring British Aerospace Jetstream 31 and Super 31 aircraft to increase the uniformity, speed and passenger comfort of the fleets used by its two regional airlines.

The lease of the 15 Jetstream 31 and 22 Jetstream Super 31s will reduce the number of aircraft types operated by WestAir/United Express and NPA/United Express from five to three.

Timothy P. Flynn, WestAir Holding's chairman, said the operation of only three types of aircraft is intended to increase the efficiency of the airlines' crew training, aircraft maintenance amd spare parts operations. The commonality also will provide for easier movement of aircraft from one market to another.

The new aircraft are being sold by British Aerospace PLC to British Aerospace, Inc., and in turn leased by Jet Acceptance Corp. to WestAir Holding through a third-party financing arrangement. Jet Acceptance Corp. and British Aerospace, Inc., are subsidiaries of British Aerospace Holdings, Inc.

Nearly all of WestAir Holding's present 78 aircraft are leased to provide the company with increased fleet flexibility and to avoid having capital tied up in aircraft purchases.

The few Embraer Bandeirantes owned by the holding company will be sold as new Jetstreams are delivered.

Twenty-one of the new 19-passenger aircraft are scheduled to be delivered by the end of the year, with the remainder set for delivery in 1991 and 1992. The lease agreement is subject to the approval of the WestAir Holding board of directors.

By 1992, WestAir Holding's two carriers are scheduled to be equipped with an all-pressurized fleet that would include 53 Jetstream 31/Super 31s—not including the 15 option aircraft—42 Brasilias and the six British Aerospace 146s. The numbers include 26 additional Brasilias that are scheduled to be delivered by the end of 1992. Bandeirante and Short Brothers 360 aircraft are being eliminated from the fleets. □

British Aerospace Decides to Proceed With Jetstream 41 Development Program

LONDON

British Aerospace will proceed with development of the 29-seat Jetstream 41 turboprop commuter aircraft, company officials said last week as they received a $200-million order from WestAir Holding, Inc., of the U. S., for up to 52 of the company's Jetstream 31 and Super 31 aircraft.

All three aircraft types are to be manufactured on a common production line at the British Aerospace factory in Prestwick, Scotland.

The WestAir Holding order is for 15 Jetstream 31 aircraft and 22 Super 31s, an uprated version of the basic 19-seat transport. In addition, options on an additional 15 Super 31s were taken.

The holding company plans to place the aircraft with a subsidiary commuter, WestAir Airlines of Fresno, Calif. The Super 31s will be delivered to another subsidiary commuter carrier, NPA, Inc., of Pasco, Wash. Both commuter carriers are part of the United Express network, serving United Airlines hubs at Los Angeles, San Francisco, Sacramento and Fresno, Calif.; Portland, Ore., and Seattle, Wash.

WestAir Airlines serves a total of 46 cities in the western U. S. and also operates six British Aerospace 146-200 four-jet short-haul transport aircraft.

The Jetstream 41 development program, which British Aerospace officials said would involve an investment of more than $205 million, will be undertaken with two risk-sharing partners, Field Aircraft of Derby, England, and Pilatus Aircraft Ltd. of Stans, Switzerland. Some component suppliers also are expected to become risk-sharing partners.

British Aerospace will provide about half of the capital needed for the Jetstream 41 development program, with the balance coming from risk-sharing partners and other financing facilities.

FIRST FLIGHT IN 1991

The Jetstream 41 program was unveiled initially and a mockup of the fuselage displayed at the Regional Airline Assn. meeting in Denver, Colo., in November, 1988 (AW&ST Nov. 21, 1988, p. 29). The aircraft will be powered by two Garrett TPE331-14 turboprops, flat rated at 1,500 shp. The 22,377-lb. aircraft will be manufactured on a common production line with the Jetstream Super 31. The original Jetstream 31 will be phased out of production after the WestAir order is completed.

First flight of the Jetstream 41 is planned for summer, 1991, with deliveries to begin in the third quarter of 1992. The aircraft will be certificated in the U. S. to FAR 25 standards and in Europe to JAR 25 requirements. It will be operated under FAR Part 135 regulation requirements.

Production is planned to reach its maximum rate in the mid-1990s, with 35 Jetstream 41s and 20 Jetstream Super 31s being produced annually.

British Aerospace market research foresees that during the decade of the 1990s, some 2,300 aircraft will be required in the 15-40 seat size category. The company claims that the Jetstream 31 and Super 31 already have captured more than 45% of the world market for pressurized 19-seat commuter aircraft.

Officials said that some 100 letters of intent and other expressions of interest had been received for the Jetstream 41.

British Aerospace officials said that the two aircraft would be designed to have a high degree of commonality to reduce support and maintenance costs. The company also anticipates that a common type rating for pilots who fly both aircraft will be achieved. The two designs have a common fuselage cross section and both are powered by the same basic engine, the Garrett TPE331, although in different versions. The Super 31 is powered by the TPE331-12; the Jetstream 41 will have the TPE331-14. □

Need for International Standards On Aircraft Maintenance Is Cited

JAMES T. MCKENNA/NEW YORK

The world's airlines must develop international standards for maintaining leased aircraft and reduce the possibility that flaws in a mechanic's skills or work environment will threaten safety, industry and U.S. government officials said.

Current maintenance standards will become inadequate as leasing companies play a larger role in supplying airlines with aircraft, these officials said. Furthermore, maintenance practices may have to be revamped as airlines strive to ensure the safe operation of aging aircraft.

"The process of having a mechanic in a hangar at two o'clock in the morning, wearing 10-power scopes and looking at his 1,100th rivet needs some scrutiny," Robert L. Goodrich, director of flight standards for the U.S. Federal Aviation Administration, said.

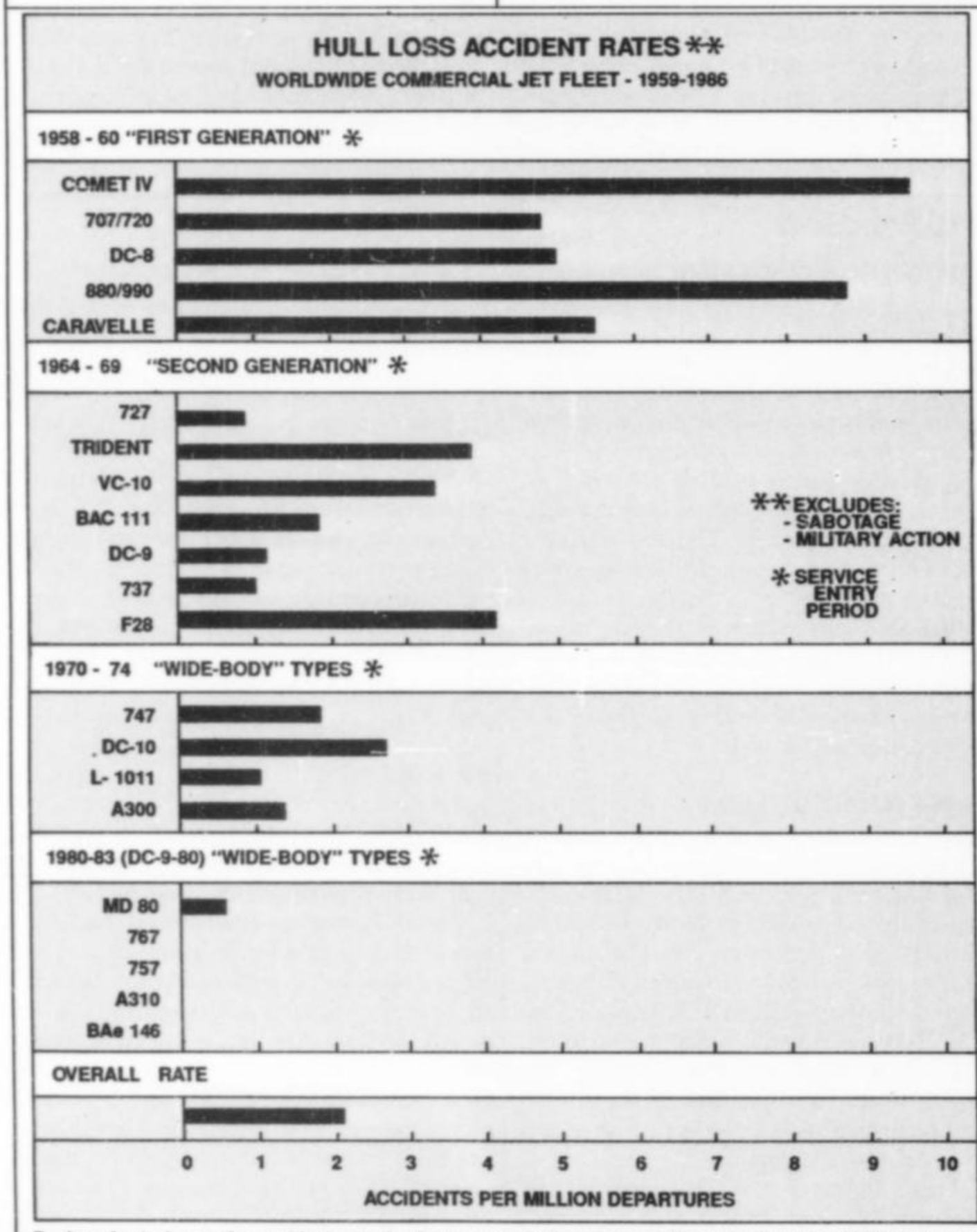
Leasing companies will assume a larger role in supplying aircraft as the demand for air travel outstrips the ability of Boeing, Douglas and Airbus Industrie to produce transports (AW&ST Apr. 24, p. 24). "Even if you take a conservative growth rate, the big three [commercial airframe manufacturers] can't handle it all," Thomas J. Bohman, Douglas Aircraft Co.'s program manager for MD-80 lease aircraft, recently told AVIATION WEEK & SPACE TECHNOLOGY. "By the end of the century, virtually no one will own their own aircraft. The trend is to preserve capital by leasing."

Three leasing companies—Ireland's GPA Group, the U.S.'s International Lease Finance Corp. and Australia's Ansett Worldwide—have 1,300 commercial aircraft on order or option. GPA intends to become the premier aircraft owner in the world.

Robin H. H. Wilson, GPA's chief technical officer, questioned whether a greater dependence on leased aircraft will require new maintenance standards.

"We are reasonably well aware of what the challenges are" and are "involved in various steps to address these problems," Wilson said. He did agree that the situation will "call for a different kind of discipline" than was used before in maintaining aircraft, and that the responsibility for performing critical maintenance "needs to be very precisely defined."

Leasing aircraft provides several advantages. Airlines can respond quickly and inexpensively by leasing transports when traffic increases and returning them when traffic dips. A manufacturer's customer base can be broadened when lease companies introduce its aircraft to operators who could not afford to purchase the aircraft outright. Furthermore, the lessors can shift aircraft from one country to another to match changes in demand.



Boeing chart shows the accident rate for jet transports has dropped dramatically since 1958. Industry officials are focusing increasingly on the effects maintenance can have on safe operations.

INTERNATIONAL AIRCRAFT

But moving aircraft across international borders can confound efforts to ensure safe airline operations, these officials said. First, since maintenance standards are drafted by individual nations, the approved maintenance program of an airline in one country may be different from that of a carrier in another country.

"If we have an aircraft in Nigeria that's sold to an operator in Lima, Peru, but it's owned by a company in a third country, who's going to be the policeman" for ensuring proper maintenance, Thomas E. McSweeny, acting deputy director of the FAA's Aircraft Certification Service, said. "It's not just a problem in the U.S. It's all over the world."

Second, an operator may not perform heavy maintenance on a leased aircraft if that maintenance can be deferred until the aircraft is returned to its owner or the next lessee.

"The economic need to move the aircraft is obvious, but it focuses our attention back to what basic maintenance programs, documentation and standards we can agree on," Goodrich said. "A $10-million lease transaction doesn't make much sense if we have to ask the

lessee for $3 million worth of documentation to demonstrate that the aircraft has been maintained properly."

"We want to assure ourselves that regular inspections are being performed," Ben A. Cosgrove, the vice president and general manager of Boeing Commercial Airplanes' Engineering Div., said.

Goodrich, McSweeny and Cosgrove were among the industry officials who spoke at the Institute for International Research's recent conference here on maintaining and financing aging aircraft. Their proposals are an attempt to anticipate and solve maintenance problems before they threaten safety. That attempt is a direct result of the fatal fuselage failure of an Aloha Airlines 737-200 last year (AW&ST May 9, 1988, p. 92).

"I don't think we were out in front on those problems," Goodrich said. "We're better focused because of Aloha."

Clyde R. Kizer, the U.S. Air Transport Assn.'s vice president of engineering and maintenance, said the significance of the Aloha accident was that its causes were not specific to that airline. "Something in the system failed," he said. "That structural failure represented a common threat that we had to address collectively."

That resulted in the formation of the Airworthiness Assurance Task Force, which issued recommendations for revamping maintenance and inspection procedures for Boeing aircraft in March (AW&ST Mar. 6, p. 64). The FAA has converted some of those recommendations to airworthiness directives (AW&ST May 22, p. 34). Another task force should issue its recommendation for Douglas aircraft soon. Recommendations for Airbus, Lockheed and other aircraft should follow.

When the task force completes its review of maintenance and inspection procedures, it will review corrosion prevention and control programs and recommend methods of improving them. The task force then will focus on adapting nondestructive inspection techniques from other industries for use in commercial aviation and developing new NDI technology. But Cosgrove, Goodrich and other officials said research must go beyond hardware.

'We have to see if we can use new technologies to help mechanics work harder with less risk of human failure'

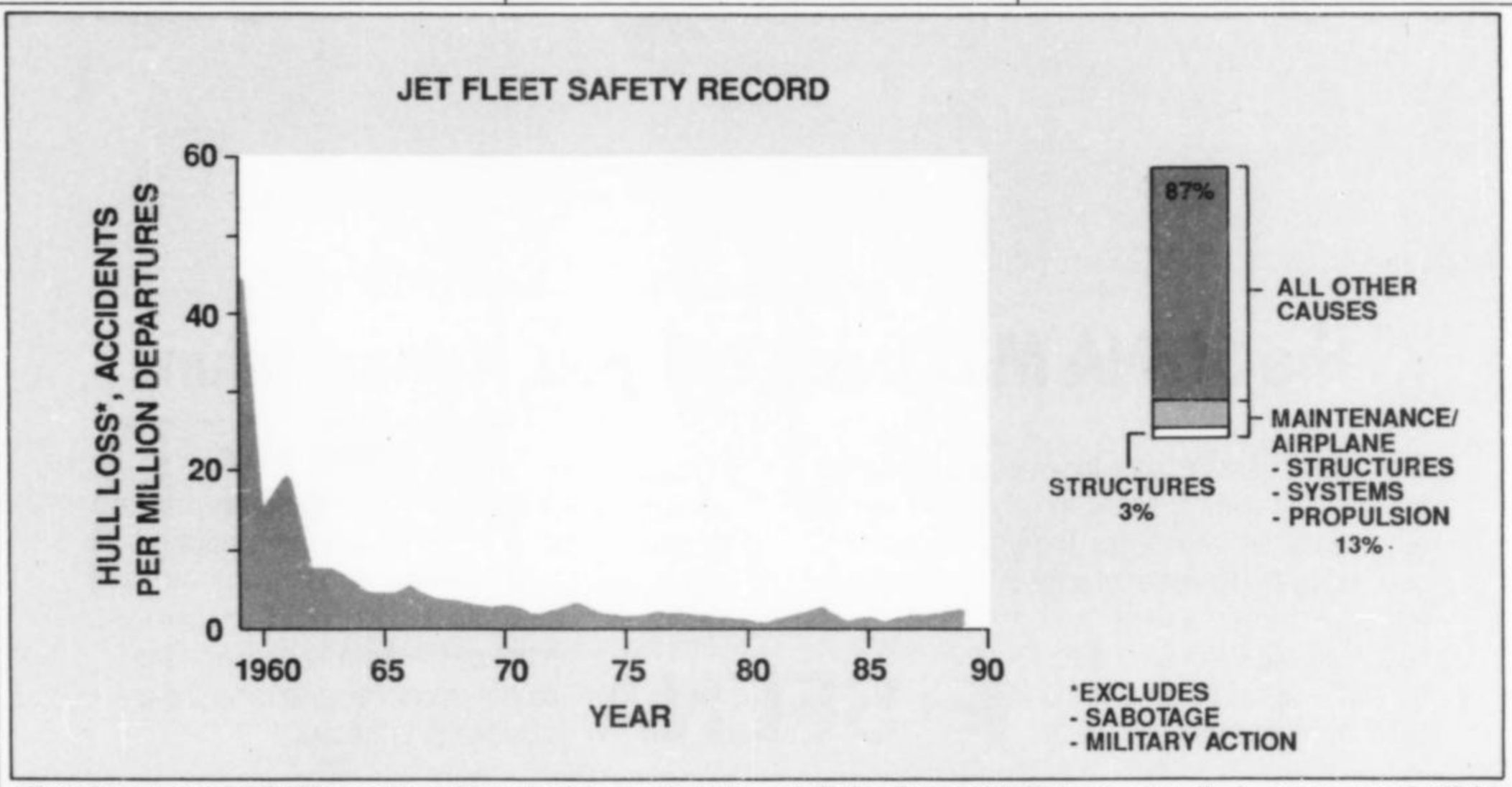
"For the near future, we will continue to rely on a knowledgeable, trained mechanic inspecting these aircraft," Cosgrove said. About 80% of new structural problems are found "just by trained mechanics being around the airplane." The industry must find methods of improving the mechanic's ability to find those problems, he said.

Goodrich said robotics and artificial intelligence hold promise for complementing a mechanic's ability to detect minute cracks and flaws in aircraft. "We have to see if we can use modern new technologies to help mechanics work harder with less risk of human failure. We've talked about human factors for years," he said. "It's time we did something about it."

The industry also must review who is maintaining its aircraft, the officials said.

"We have to sit back and ask ourselves some questions," the FAA's McSweeny said. "What kind of people are the carriers hiring? Are the schools developing the right kind of engineers and mechanics to maintain aircraft? It's not simple, but we have to ask ourselves if times have changed."

Goodrich urged industry officials to develop new international standards quickly. "I don't think we have the leisure to work on these problems over the next few years," he said. "We need to work them out in the next few months." □



"If we have to spend $10 billion on the problem of aging aircraft, don't spend it all on structures, which is 3% of the problem," Ben A. Cosgrove of Boeing Commercial Airplanes, says. He is among several officials calling for greater scrutiny of maintenance standards and practices.

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FAA and NASA Design Program To Improve Human Performance

NEW YORK

The FAA and NASA are forging a program to enhance aviation safety by refining how human beings work in the U. S. air transportation system.

Officials from the agencies hope to gain formal approval by August for agreements covering development of a national plan, H. Clayton Foushee, a NASA Ames human factors researcher on assignment to the FAA, told AVIATION WEEK & SPACE TECHNOLOGY. On June 4, Foushee will become the FAA's chief scientific and technical adviser for human factors.

The program would seek to measure how elements such as automation, communications, training, tradition and physiological and psychological traits can hinder a pilot's or air traffic controller's ability to operate safely.

It also will go beyond flight deck and ATC studies—typical subjects of human factors research—to examine how those same elements affect a mechanic's ability to ensure the safe inspection and repair of aircraft.

A NEW EMPHASIS

"I can't remember a single serious meeting occurring on human factors in maintenance before Aloha," Foushee said, referring to the fuselage failure of an Aloha Airlines 737-200 (AW&ST May 9, 1988, p. 92). He added that results of the research would be applied to all aspects of the aviation industry, not just flight deck, ATC and maintenance operations.

Human factors is a multidisciplinary field that researches human physical and mental limits, then uses that knowledge to develop and improve the procedures and tools with which humans work and the environment in which they work.

The drive for a national human factors program was spurred by passage of the Aviation Safety Research Act of 1988, which instructed the FAA to use 15% of its research budget for long-term projects (AW&ST Oct. 31, 1988, p. 91). The agency is working with NASA because the space agency has "probably the majority of civil aviation and advanced research capabilities," Foushee said, but "Congress is holding the FAA responsible" for developing the program.

The FAA has adopted in principle the research categories identified in a report issued last month by an Air Transport Assn. task force. It will modify them to cover a range of FAA roles and missions. The eight general tasks of the proposed program are:

- Determine the safest mix of automation and manual operations.
- Expand and improve the Aviation Safety Reporting System, which is intended to identify the root causes of human errors in aviation.
- Improve understanding of human performance factors, negative as well as positive, in accidents and incidents.
- Develop better methods of measuring and improving human capabilities.
- Improve communications among critical personnel in aviation operations.
- Improve the display, control and integration of data generated by advanced-technology monitors.
- Develop improved techniques and strategies for selecting, training and evaluating aviation personnel.
- Develop standards and procedures for certifying and validating human engineering aspects of equipment designs.

The ATA task force said such a program is "capable of reducing by 50% the rate of incidents and accidents caused by human error" and providing "a basis for preventing such events."

If the program is approved, Foushee said, the FAA would appoint groups of private, academic and government researchers to identify specific areas to be examined.

Those specific tasks would be assigned to academic or private institutions and major government laboratories, which would perform the research.

"The FAA will serve in a program management role," he said, "pulling broad and somewhat diverse efforts together and avoiding the duplication of research capabilities that already exist."

The agency also wants to tap the extensive data base on aviation operations and maintenance that exists in the U. S. military and among the U. S. airlines "to pick the best parts of all those programs and discard the worst," another FAA official said. □

Funding, Procurement Reform Called Top Priorities for FAA Reorganization

MICHAEL MECHAM/WASHINGTON

A cross section of the commercial aviation community has concluded that making the Federal Aviation Administration an independent agency will not solve its problems unless Congress enacts procurement and personnel reforms and increases the FAA's funding.

Congress also has been advised against changing the FAA's structure until a reorganization ordered last year by former FAA Administrator Allan T. McArtor has had a chance to bear fruit.

These judgments, by leading aviation groups, congressional technical advisers and regional government leaders, are intended to frame the debate that will begin in Congress this summer over whether to remove the 31-year-old agency from the jurisdiction of the Transportation Dept.

Calls for FAA independence began in the final years of the Reagan Administration, when successive Transportation secretaries dominated the FAA's agenda with what critics contend were political considerations to further the concept of deregulation and to suppress federal spending. But unprecedented air traffic congestion, public concern about air safety, declining air service to rural America and fears of international terrorism are driving a counter trend to make the FAA its own bureaucratic master.

"In seeking a long-term, professional, nonpolitical leadership of the FAA, we are willing to risk the decisions and actions of a tough commander operating on technical merits rather than those of inexperienced political appointees," former FAA administrator and Pan American World Airways chairman Najeeb E. Halaby said.

Halaby represented organizations as diverse as the Aerospace Industries Assn., Airline Pilots Assn., Air Transport Assn., National Assn. of State Aviation Officials, National Business Aircraft Assn. and the Regional Airline Assn. in a recent appearance before the House Transportation subcommittee on aviation. Halaby led the FAA as an independent agency during the Kennedy-Johnson administrations.

Subcommittee Chairman James L. Oberstar (D.-Minn.) intends to begin hearings next month on a bill to make the FAA independent. His counterpart in the Senate, Wendell H. Ford (D.-Ky.), sponsored similar hearings in the last Congress and has informed Transportation Secretary Samuel K. Skinner that he, too, intends to pursue his goal of making the FAA independent (AW&ST Feb. 13, p. 99).

Skinner has vowed to rejuvenate the FAA within the Transportation Dept. in an effort to dissuade Congress from making it independent. He has won wide praise in Congress for his grasp of aviation issues.

Halaby said FAA's administrator should be given "clear and direct authority along with the responsibility" to manage the agency. Politics has weakened the administrator's authority over procurement, funding and personnel management over the past five years, he said.

"Nowadays, if you've got a problem with the FAA, you don't go to the FAA, you go to the secretary of Transportation," Halaby said.

The FAA leadership vacuum has been exacerbated by the time it has taken to nominate Navy Adm. James B. Busey, 4th, as administrator. The process was delayed while the Navy found his replacement as commander of allied forces in southern Europe. That hurdle now has been cleared and Busey's Senate nomination hearings are expected in June.

'We are willing to risk the decisions of a tough commander operating on technical merits . . .'

Oberstar envisions an FAA that would be essentially immune from many of Washington's political and economic influences:

- It would be given a separate budget that would neither be subject to reductions by the White House Office of Management and Budget nor be included in sequestration orders under the Gramm-Rudman antideficit law. Last year Ford dropped a similar approach because of opposition from congressional budget committees.
- Its employees would be given special civil service status to allow hiring on a pay-for-performance basis as a way to attract talented technical personnel. The need to improve FAA pay scales is seen as the only way to attract air traffic controllers to work in 11 FAA facilities in New York, Chicago, Los Angeles and Oakland. The Office of Personnel Management and the FAA have proposed offering 20% bonuses to meet critical staffing shortages there, but the plan has met opposition for budgetary reasons.
- It would have acquisition authority designed to meet its special technical needs in a more timely manner than government regulations allow now.
- Its administrator would fulfill a fixed term of long duration. Ford has proposed a seven-year term.

This last point is a priority for the Conference of the Federal Managers Assn. as well. Chairman Maurice F. Connor said that new administrators have a tendency to want to reorganize the agency, which affects its leadership, stability and programs. "During the past year, Administrator McArtor initiated a reorganization of FAA's top management," he said. "Soon after its implementation, Administrator McArtor departed."

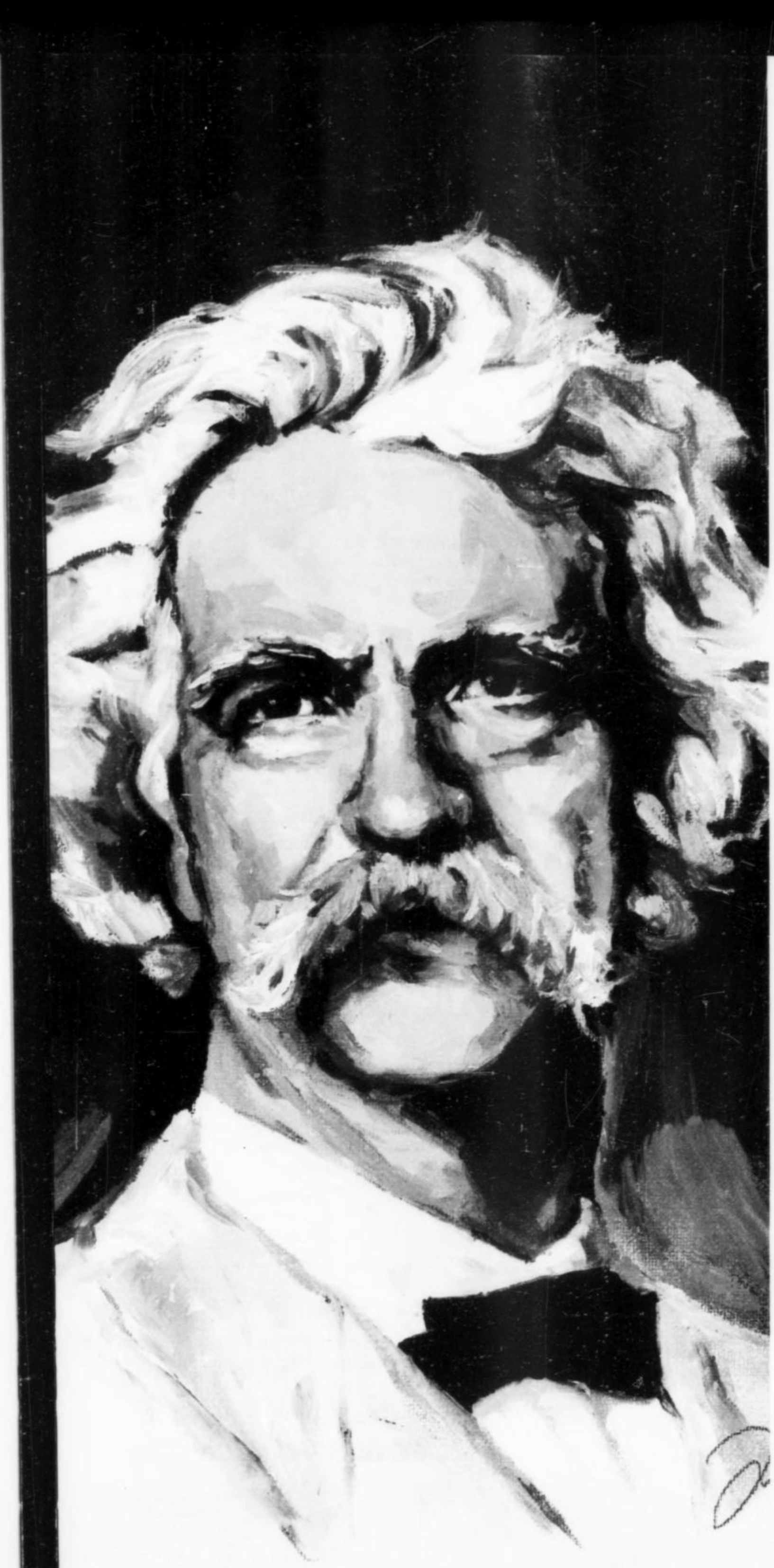
But Acting FAA Administrator Robert E. Whittington said McArtor's changes may be beneficial, although he cautioned that it will take "a longer-range view to confirm that is the case."

McArtor's reorganization was intended to centralize authority in Washington. "We heard repeatedly from the aviation community that the FAA's approach to issues varied too much from one region of the country to another, that there was not one FAA but many separate FAAs," Whittington said. McArtor wanted "straight-line" reporting from the field to Washington in major disciplines, such as air traffic control or flight standards, rather than through regional directors.

Although it lacks a permanent administrator, the FAA has hired more air traffic controllers, developed better analytic tools for managing airport and airspace demand, upgraded training and improved human factors analysis, according to a study by Edith B. Page of the congressional Office of Technology Assessment.

The 17 organizations represented by Halaby concluded that reorganization cannot overcome the FAA's most pressing and complex need—funding. At current levels, they said, the FAA cannot fund such ambitious programs as the $25-billion National Airspace System Plan or an eight-year airport improvement program valued at $24 billion.

The General Accounting Office has criticized the FAA's procurement practices. It cited such failings as starting production on the $1.1-billion Microwave Landing System before validating the number of sites it will need or testing a system prototype. GAO Transportation Director Kenneth M. Mead cautioned Congress, however, that making the FAA independent could frustrate the national transportation master plan that Skinner has announced as his goal. □



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Mark Twain
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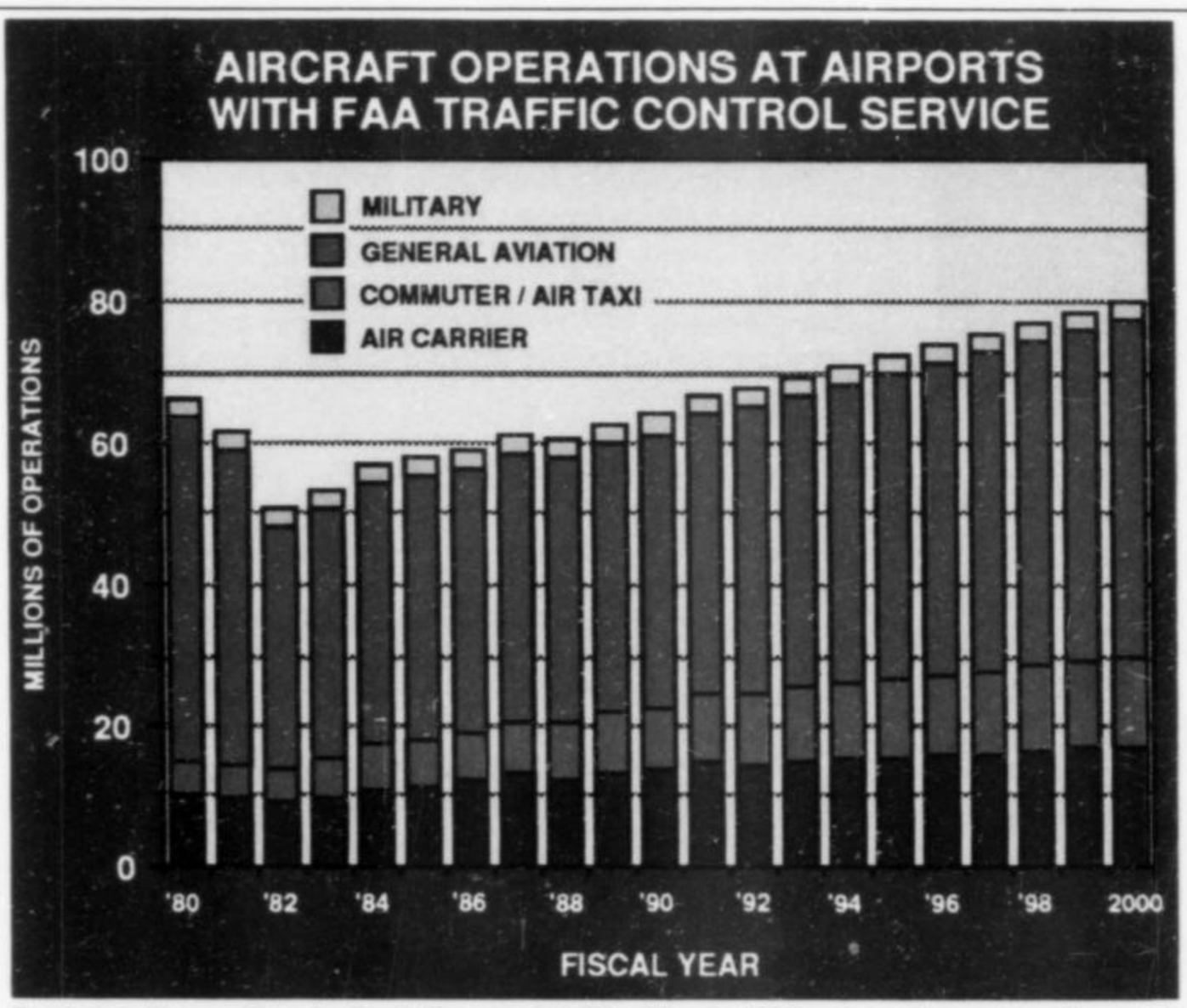
FAA Task Force Will Study Solutions to Capacity Crisis

JAMES OTT/WASHINGTON



Total aircraft operations in the U. S. exceeded 60 million in 1987 and are forecast to rise to 80 million at FAA-control tower airports by the turn of the century.

A task force has been formed within the FAA to evaluate proposals such as wayports that look to the future and offer solutions to the growing problem of airport congestion.

A briefing paper presented to the 15 committee members questioned the practicality of wayports as a near-term solution. The wayport concept envisions airport facilities built in remote areas with ample airspace and dedicated to siphoning off the hub-and-spoke airline operations and critical cargo and mail from congested airports (AW&ST Jan. 9, p.64).

Wayport advocates would face probable difficulties in obtaining financing and cooperation of airlines, according to the briefing paper, written by James V. Mottley, the agency's manager, national planning division for airports. He favored the creation of new hub airports from among existing and underused commercial service facilities. His claim is that these airports would accommodate much of the airline connecting complexes and passenger transfer traffic that are clogging some large airports.

James Sheppard, the agency's district airport manager, Orlando, Fla., an advocate of wayports, serves on the committee. Since Sheppard first gained national attention with the wayport concept in January, the concept has won support from dozens of airport officials and local governments, largely in the southeastern U. S. A House bill proposes a study of the idea and a site selection process.

The task force is charged with developing "a national strategy that will enable us to deal with the predicted demand in the system," according to Paul L. Galis, director, office of airport planning and programing. Its findings will be submitted to the airlines and airports this summer. Galis believes the task force's conclusions will be folded into the national transportation policy promised by Transportation Secretary Samuel K. Skinner by the end of the year.

FAA briefing paper acknowledges public concern over potential gridlock in the system

The briefing paper observed:

■ "Federal inaction might better be attributed to lack of consensus among the officials involved.

■ "Public concern has become so great that a remedy must be found, or a national policy developed for dealing with airport congestion. The public is alarmed by the prospect . . . that current air traffic delays eventually will deteriorate into gridlock unless more airports are built.

■ "The situation is seen as life-threatening by some air travelers, who infer that increased congestion must be accompanied by reduced safety."

PROMISING SHIFT

In the briefing paper, Mottley called the shift of connecting traffic to underused airports "one of the most promising innovations now under discussion." An example of recent years was the development by American Airlines of hubs at Raleigh/Durham, N. C., and Nashville, Tenn.

The agency has identified about two dozen underused U. S. airports located more than 100 mi. from congested airports. These could serve as hubs for connecting traffic, relieving the congested hubs and allowing them to focus on origin and destination traffic. The underused facilities offer adequate runways and dual IFR approaches.

U. S. airlines serve 280 primary airports in the U. S., the core of the air transportation system. The 100 busiest of these airports accommodate more than 95% of the passengers, the top 25 nearly 67%, according to a 1988 study of the Transportation Research Board of the National Research Council.

The research board recommended improving and enhancing capacity, especially at points of congestion; adding new airports in metropolitan areas with the highest traffic volumes, and developing a new type of airport, such as a wayport, devoted to providing transfer points for passengers.

A prime suggestion was to move quickly on obtaining sites for new passenger transfer facilities, according to Larry L. Jenney, aviation specialist, with the Transportation Research Board.

Jenney said the issues facing the government and industry in solving the airport capacity crisis are fundamental, not technical. "The questions here deal with relations between governments and the concerns of institutions, such as the airlines. The issues are: who does the planning, who are the sponsors and who are the operators?

"The gut issue is—Is the system going to be centrally planned or the result of

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independent local initiatives, as is happening in Denver? What we have in U. S. airports is not a system. It's a connection of what exists. It is not planned with a system concept in mind. The network of air traffic control is a system, but airports are certainly not."

In his briefing paper, Mottley said the belief of the 1970s that improved technology for air traffic control would increase runway capacity has proven untrue. "The most severe airport problems, and the most intractable, have involved runway capacity," Mottley said.

Although new runways are warranted at many airports, they have not been built "for political, institutional and environmental reasons. Aircraft noise is a volatile issue," he added, "and few politicians have been willing to support new runways that would add to noise problems."

THREE APPROACHES

Mottley said three approaches to solving airport congestion have emerged among industry and government officials. There are adherents to each view, which leads to the lack of consensus. In each case, the level of airport congestion and forecasts are interpreted, and there are differences over the role of the government.

First, there is a view that existing airports are adequate to meet priority needs and sustain growth safely and reliably. What is needed is a mechanism to allocate capacity. Supporting this view is the philosophy that the provision of ample airport capacity at low cost is unsound economically. Supporters advocate the use of a pricing mechanism to allocate capacity, with high prices being charged during peak hours.

Advocates of this position claim that congestion at hub airports was induced by airline scheduling practices, and that congestion could be relieved by unbunching airline departures. Thus, the Transportation Dept. cracked down on airline scheduling practices and required the airlines to report on-time performance.

A second group believes that more capacity is needed, but that the lack of capacity is no crisis. The position is supported by moderates who assume that congestion will be alleviated gradually by new construction. This would take place at cities where "service levels are unsatisfactory or airline employment and economic development are desired."

Those holding this view believe that sites are available in most urban areas to expand existing airports and develop new ones. Political and environmental issues, along with a lack of commitment by airlines, are roadblocks, however.

"Airlines tend to defer development as long as possible and then accomplish it in modest increments in order to minimize their costs and discourage competition

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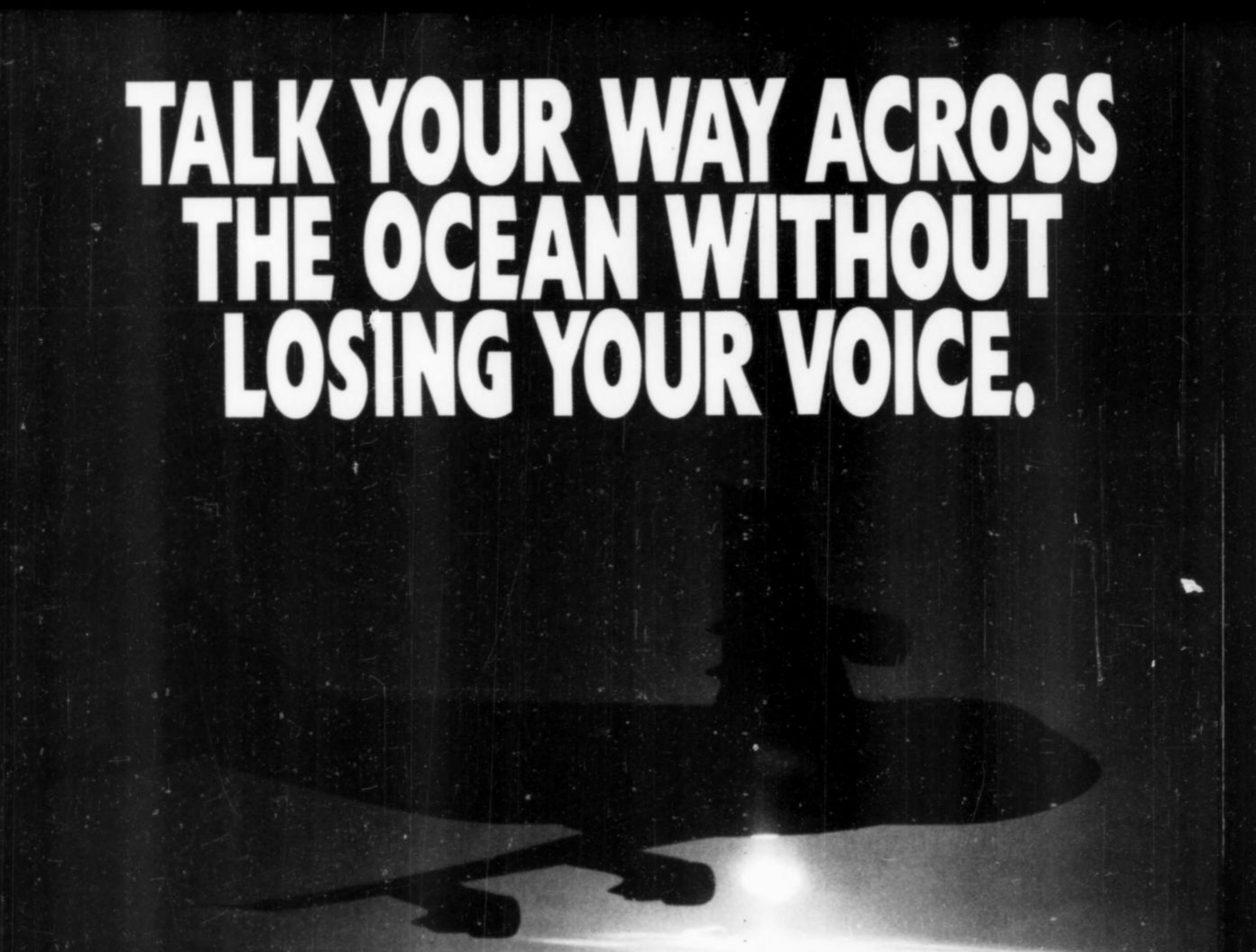

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from other airlines," the briefing paper said.

The moderates also are skeptical about how the anticipated doubling of traffic growth by the turn of the century will affect airports. U. S. airlines would absorb much of the traffic growth by carrying more people in aircraft and using larger aircraft, according to this view.

The moderates' analysis of FAA forecasts indicates that delays would increase, but would remain tolerable. A worst case is for a doubling of traffic delays by the year 2000. No airport would experience delays any worse than those already experienced by New York's LaGuardia Airport.

The third view is that airport capacity is critically inadequate, that delays are increasing and that these will cause gridlock unless bold new measures are taken. Those who hold this view are supported by the widespread belief that federal and local officials are unwilling or are unable to act. Proponents cite the surplus in the Airport and Airway Trust Fund and the difficulties of local governments, such as Denver, in planning a new facility.

MAJOR ROADBLOCKS

The view that a crisis is at hand is supported by the observation that airline delays start to rise as a runway approaches its capacity. The congestion at some airports is so severe that a 25% increase in operations would lead to runway gridlock.

The increase in near midair collisions in recent years has increased travelers' concerns and added a safety element to the debate.

Supporters also hold that traditional approaches to airport development are failing and that new proposals are required.

Major roadblocks, according to the briefing paper, are political developments of recent years that have prevented the U. S. government from providing leadership.

Historically, the federal government has relied on state and local governments to handle their own transportation problems. Lately, the trend toward private enterprise solutions has discouraged an assertive role by the federal government.

Furthermore, airport congestion is severe at fewer than 25 metropolitan areas and "probably is not a critical issue for most governors, senators and representatives," the FAA paper said. "It is unlikely that the Congress would enact legislation that would focus tens of billions of dollars in aid on a relative handful of major cities."

Even if such legislation were passed, the Office of Management and Budget would recommend a presidential veto, given the severe budget deficit and national debt, the paper added.

Sheppard's wayport concept is the most widely accepted of the various proposals.

Sir Colin Marshall, chief executive of British Airways, endorsed the concept in his Patterson Lecture Apr. 27 at Northwestern University, Chicago. Citing traffic growth, he said, "there simply is no room left, and nothing truly meaningful on the horizon, to relieve the traffic on the ground or in the air corridors surmounting that ground."

"It is my belief," he added, "that the airline industry will have to move towards things like this even if it means we must deal with the competitive shifts which would result from reallocating the flow of hub traffic and with who gets the new slots and how."

The concept also has won support of the Reason Foundation, Santa Monica, Calif., which advocates privatization of U. S. airports as a means toward efficiencies and solving the congestion and delay issues. Wayports provide an ideal opportunity to test the idea of airports as for-profit enterprises, according to Robert W. Poole, Jr., president of the foundation.

Wayports are now the subject of the Wayport Development Act introduced to the House by Rep. J. Roy Rowland (D.-Ga.).

The bill would set up a commission of 15 members who, within a year, would study the idea and propose sites. Financing largely would come from a revolving loan fund using the $6-billion surplus in the Aviation Trust Fund.

Wayports are being studied by the FAA task force along with other concepts such as superports, superhubs, new ports of entry and the like, according to the FAA's Galis. "There are a lot of concepts out there that we don't really have a handle on—at least to the extent that we're comfortable with them." □

Airport Improvement Program

FISCAL 1989 FUNDING*

ENTITLEMENTS	
Primary Airports	$597.6
Cargo	42.0
States	168.0
Alaska Supplemental	10.3
Subtotal	**817.9**
DISCRETIONARY	
Noise	$140.0
Reliever	140.0
Commercial Service	35.0
System Planning	7.0
Carryover Entitlements	135.2
Capacity, Safety, Noise	93.7
Remaining	31.2
Subtotal	**582.1**
Appropriation	**$1,400.0**

For Fiscal 1990, the Bush Administration is asking for an increase in discretionary money for airport capacity, safety and noise projects.

*In millions of dollars. Source: FAA

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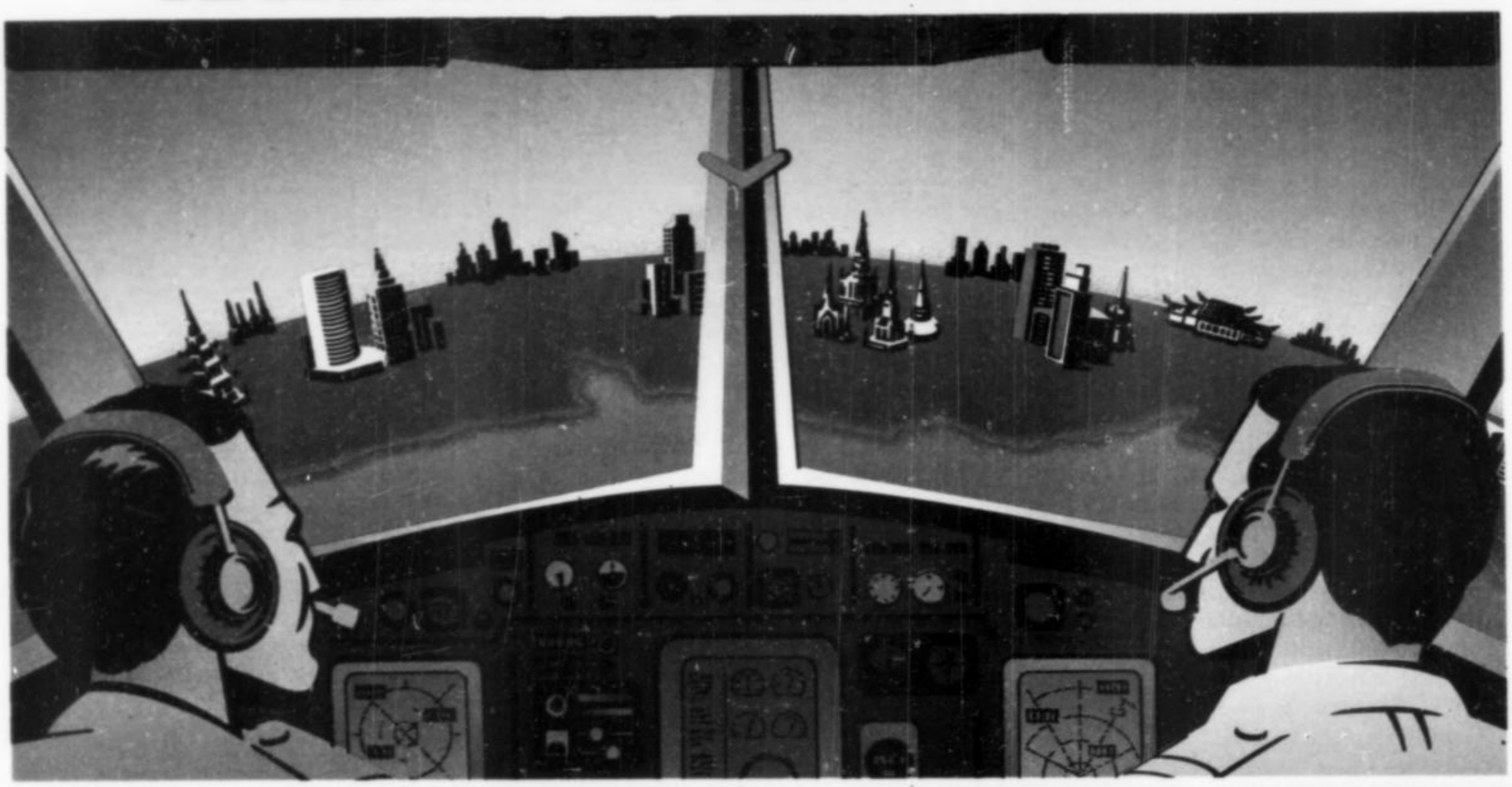

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British Airways Profits Set New Company Record

LONDON

British Airways last week reported record profits for the second consecutive year and awarded its employees with a week's extra pay in recognition of their efforts.

Employees already were entitled to a bonus of $2^1/_2$ weeks extra pay under the existing profit sharing plan, instituted when the airline was privatized in 1984.

Lord King, chairman of the British carrier, said the company had pre-tax profits during the year ending Mar. 31, 1989, of approximately $453 million, an increase of about $24 million over the pre-tax profit reported for the previous year.

The increase was significant because it represented the results of the first full year of operation by British Airways after it acquired British Caledonian. In last year's financial report, which came only three months after British Caledonian had been acquired, the company reported a loss in the latter airline's operation of approximately $60 million.

SALES GROW

Overall sales for the combined airline increased by about $845 million to $7.19 billion and the number of passengers carried on scheduled services increased about 12% to 22.6 million. Sales included such activities as package vacations and other non-flying services the airline performs.

Lord King said traffic passenger yields improved sharply, largely as a result of increases in club class traffic. During the past year, traffic using the airline's Club World service has increased 31% and by 12% on the carrier's Club Europe services.

British Airways' operating profits for the year just ended were due to sharply improved results in the Americas and the Middle and Far East, while traffic within Europe was characterized by Lord King as "disappointing."

The airline's operating surplus generated by routes to the Western Hemisphere increased from approximately $246 million during the previous fiscal year to more than $305 million in the year just ended, while the operating surplus on routes to the Middle East, Far East and Australasia jumped from approximately $60 million to more than $152 million.

Operating surplus on routes to Africa increased from nearly $70 million a year ago to more than $82 million in the year being reported.

By contrast, the airline's operating surplus on routes within Europe declined to about $27 million from the nearly $68 million reported a year ago.

Lord King said this was due to a combination of factors including increased competition on some routes within Europe, loss of some British Caledonian routes, and the cost of amalgamating the rest into the British Airways route system and the cost of developing regional hubs at Manchester and Birmingham, England.

The Americas succeeded Continental Europe as British Airways' prime sales area, with sales in the region totaling $2.32 billion. Sales in Continental Europe totaled nearly $1.98 billion. British domestic sales totaled approximately $765 million. Sales in all geographic areas except Continental Europe were up.

Air traffic control problems continued to hamper British Airways during the 1988-89 year, with the airline's on-time record—departures within 15 min. of the scheduled time—decreasing to 72% in the year just ended from 80% in the previous year. Cost of these delays was put at about $25 million.

The British airline ended its fiscal year with a fleet totaling 211 aircraft, including seven Anglo-French supersonic Concordes and 40 Boeing 747-100/200s.

On order were 19 Boeing 747-400s, 17 767-300s and 24 737-300/400/500 aircraft. Three Boeing 757-200s, from a total order of 38, remained to be delivered, and six of 10 Airbus A320s originally ordered by British Caledonian also had not been delivered.

The airline's short-haul routes were being operated by a fleet of 15 turboprop aircraft, with four British Aerospace Advanced Technology turboprops still to be delivered. The carrier also was operating 34 British Aerospace 111-500s and 45 Boeing 737-200s.

The trijet fleet consisted of 17 Lockheed L-1011-1/50/200s and eight McDonnell Douglas DC-10-30s acquired from British Caledonian.

A total of 58 aircraft, including 12 Boeing 747-400s, 17 Boeing 767-300s and 11 Boeing 737s, were on option. □

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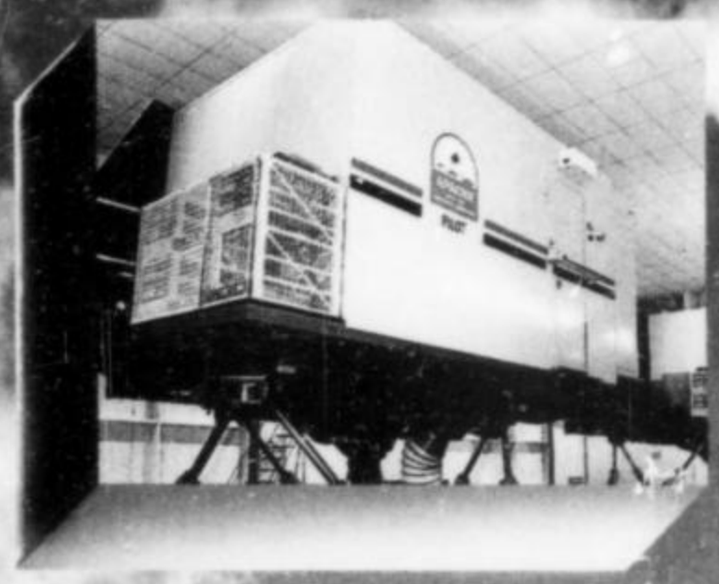

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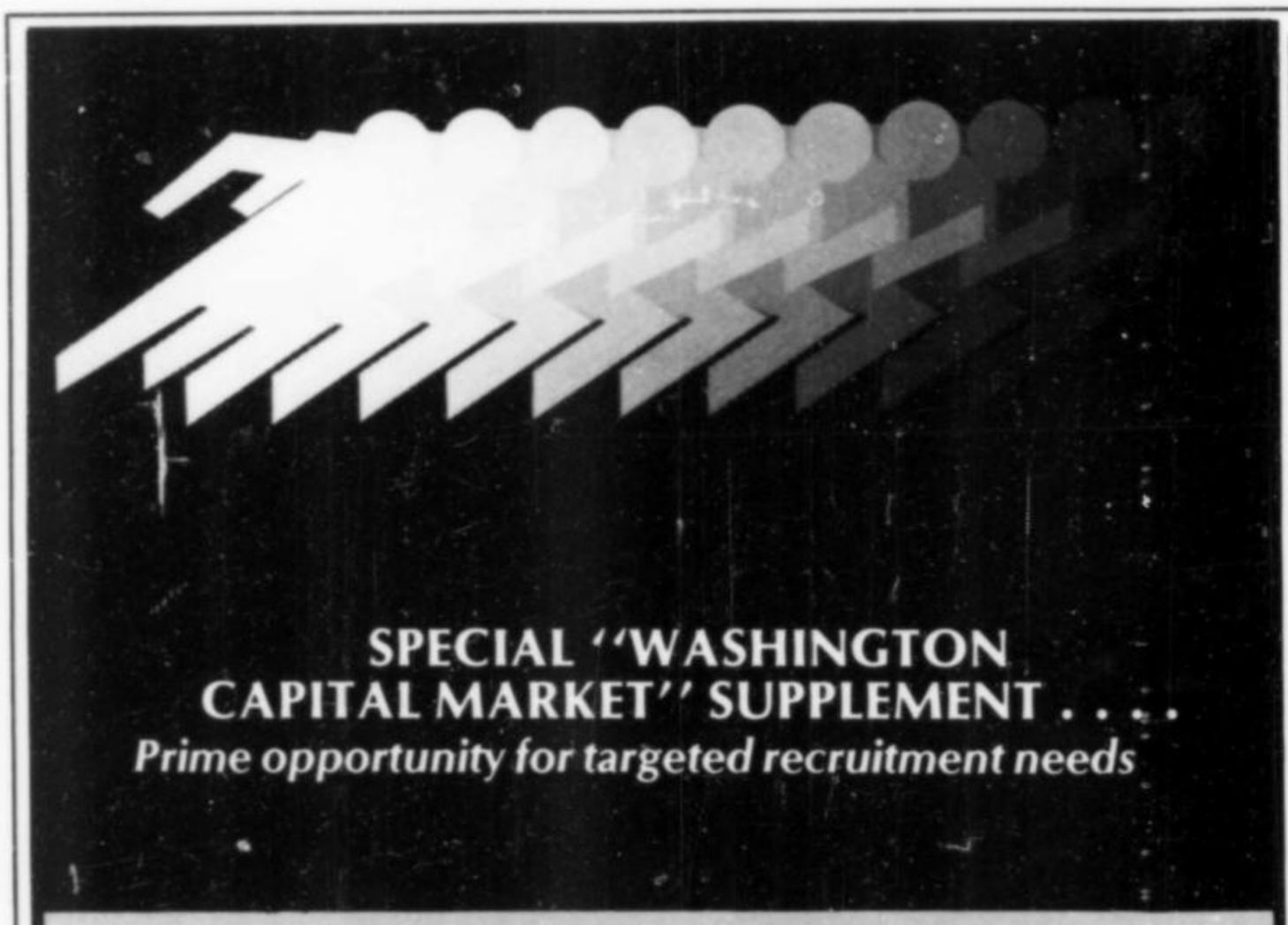

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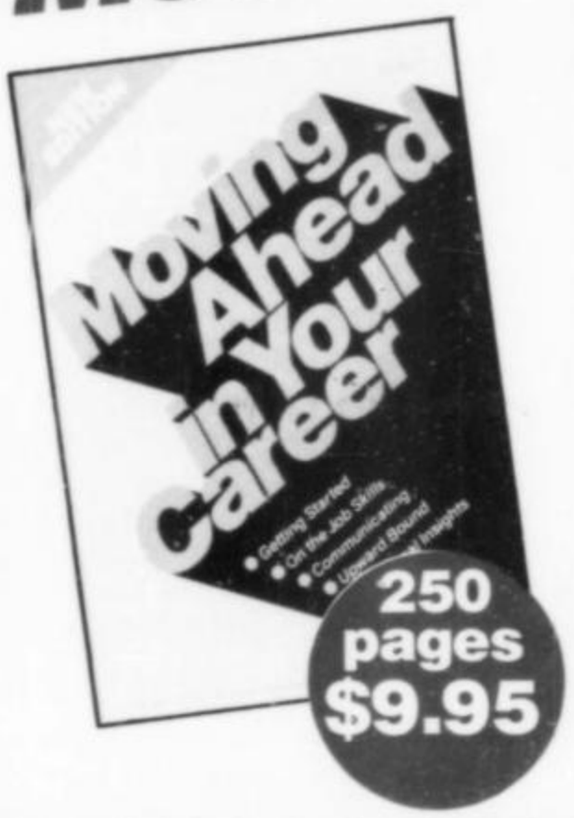

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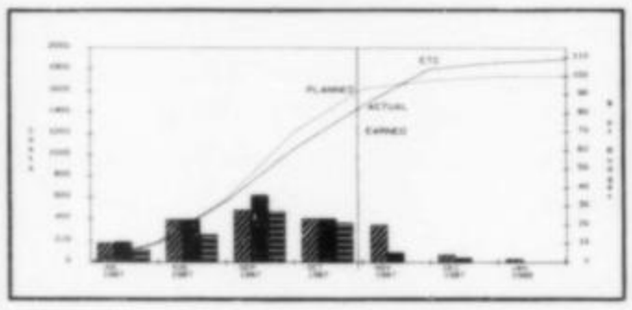

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AEROSPACE CALENDAR

June 5-7—1989 Intersociety Advanced Marine Vehicles Conference and Exhibit. Hyatt Regency Hotel, Washington, D. C. Contact Joseph Sladky, Jr., (206) 392-7267.

June 5-8—1989 ASME Turbo Expo-Land, Sea & Air. 34th ASME International Gas Turbine & Aeroengine Congress and Exposition. Metro Toronto Convention Center, Toronto, Ont., Canada. Call (404) 847-0072. Telex: 707340 IGTC ATL.

June 6—Total Quality Management Workshop. Marriott Hotel, Baltimore-Washington International Airport. Contact Helen Schreider (817) 776-3550.

June 6—CanExpo '89. Techmart, Santa Clara, Calif. Contact Brian Casey (408) 988-8355, Fax (408) 988-6315.

June 6-7—Commercial Aviation and Aerospace—Toward the Year 2000. Inter-Continental Hotel, Paris, France. Contact Financial Times, Ltd. Telex: 27347 FTCONF G. Telephone: 01-925-2323.

June 6-8—Tactical Warfare Symposium. NAS Whidbey Island, Oak Harbor, Wash. Contact Lt. Cdr. Steve Ewell, (206) 257-2093.

June 6-9—Pathfinder: Technology in the 21st Century. NASA Langley, Hampton, Va. Contact Lisa Savedge, (202) 646-7529.

June 8-18—Paris air show, Le Bourget, France. Contact French Trade Shows. Tel: (212) 869-1720.

June 10-11—AIAA Seminar on Applied Numerical Grid Generation. Hyatt Regency Hotel, Buffalo, N. Y. Contact Lisa Savedge, (202) 646-7529.

June 11-14—International Conference on Communications—World Prosperity Through Communications. Sheraton Boston Hotel, Boston, Mass. Call Nancy B. Janus, (617) 924-3585.

June 11-15—174th Meeting of the American Astronautical Society, Ann Arbor, Mich. Contact Pam Hawkins, (202) 328-2010.

June 12-13—Foreign Military Sales. Sheraton National Hotel, Arlington, Va. Call (202) 337-7000.

June 12-16—The Human Element in the Aviation Industry. Montreal, Canada. Sponsored by Richardson Management Associates, 2060 Sherbrooke St. West, Suite 102, Montreal, Que. H3H 1G5. Tel.: (514) 935-2593.

June 13-15—4th Annual Ada software Engineering Symposium. J. W. Marriott Hotel, Houston, Tex. Contact Cathy McDonald (703) 824-5531.

June 13-15—1989 Tri-Service Combat Identification Systems Conference (CISC-89). Monterey, Calif. Contact Joseph Mignogna, (215) 672-6250.

June 14—Europe 1992 Single Market and U. S.-Canada Free Trade Agreement, Seminar. Swiss Grand Hotel, Chicago, Ill. Contact Judy Pierson, (312) 938-5031.

June 14-16—IEEE's International Microwave Symposium & Workshops. Hyatt Regency Hotel, Long Beach, Calif. Call (212) 705-7900.

June 18-20—International Committee on Aeronautical Fatigue (ICAF) 1989. Van Leer Jerusalem Institute, Israel. Contact Prof. Avraham Berkovits, telex: 46406 TECON IL. Fax: 972-4-231848.

June 19-21—SAMPE's Third International Electronics Materials & Processes Conference. Sheraton Plaza La Reina Hotel, Los Angeles, Calif. Contact Marge Smith, (818) 331-0616.

June 19-23—International Materials Handling Equipment Exhibition. Sydney, Australia. Contact National Materials Handling Bureau, 105 Delhi Rd., North Rydne 2113, Australia. Telex 25386.

June 20-22—2nd Annual National CASEcon. Jacob K. Javits Convention Center, New York. Contact Annie Zdinak or Mark Haviland, (800) 444-EXPO.

June 20-22—3rd Electronics Materials & Process Conference. Sheraton La Reina Hotel, Los Angeles, Calif. Contact Holly Barnett or Shay Stockdill, (714) 474-9111.

June 21—"Transitions from Development to Production." Willard Hotel, Washington, D. C. Call (202) 628-9100.

June 21-23—VHDL and Modeling in the Defense Dept. Procurement Process. To be held at the Ramada Renaissance Hotel, Washington, D. C. Contact Paul Hunter, (202) 767-3264, or Dr. Edward Tsou, (213) 814-1844.

June 22—Armed Forces Communications and Electronics Assn., international convention, "1992 and You." Convention Center, Washington, D. C. Contact Richard Keating, (703) 486-0780.

June 22-23—"Meeting The Challenge of EDI." Boston Park Plaza Hotel & Towers, Boston, Mass. Contact K. Eric Wolfe, (703) 525-1191. Fax: (703) 276-8196.

June 22-23—Western Regional Transportation and International Data Forum. Holiday Inn, San Francisco, Calif. Contact K. Eric Wolfe, (703) 525-1191. Fax: (703) 276-8196.

June 26-27—Fourth Annual Conference on European Aviation. Amsterdam, the Netherlands, Amstel Intercontinental Hotel. Contact Trisha Mulhall, (01) 821-6788.

June 27-29—Professional Aviation Maintenance Assn., 18th Annual Conference. Philadelphia, Pa. Contact Theresa Hamlin, (314) 739-2580. □

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LETTERS

STEALTH FIGHTER

Your May 1 issue has a cover caption that says, "Unveiling the Stealth Fighter." I was hoping for some great close-up views of the F-117A as the cover led me to believe, but alas not so.

Is it possible that the AVIATION WEEK & SPACE TECHNOLOGY staff missed NBC Nightly News on Dec. 15 last year? The program showed crystal clear video of a daylight overhead pass of the F-117A just outside its home base at Tonopah, Nev.

The video clip, which runs for only 5 sec. or so, is much more revealing than the photo you published. It also conflicts with the statement made by William B. Scott when he said, "Handling quality deficiencies apparently were resolved as the aircraft matured," referring to its nickname "Wobblin' Goblin" (AW&ST May 1, p. 24). The video clearly shows the instability of the aircraft on a low-level pass.

LEE ROBERT CALDWELL
TORONTO, ONT., CANADA

STEALTH COMPROMISED

It appears that Aviation Week has compromised another "black" weapon system and provided our potential adversaries with the key to defeating our latest low observable technology. I refer to the article entitled: "USAF Expands Use of F-117A, Adds More Daytime Flights" (AW&ST May 1, p. 24)

In addition to the revealing photographs, you quoted observers as saying, "This sound was entirely different . . . it even set the dogs off before we could hear it."

I'm sure that at this very moment, somewhere in the USSR, plans are being drawn up for an early warning system using canines.

In the 1950s, American ingenuity and know-how developed the Distant Early Warning (DEW) Line to protect the U. S. Now we are faced with the Soviets responding in kind with their own DEW (Dog Early Warning) Line.

I hope you are proud of the destabilizing effect your article has had on the balance of power between the U. S. and the USSR.

ALAN K. ALBRECHT
INDIANAPOLIS, IND.

F-117A MISSION

I have to take to task your story on the F-117A in your May 1 issue. I don't believe the Air Force would risk launching the Lockheed F-117A in a multiaircraft formation for any reason. The Air Force had a hard time launching a dozen F-111Fs to bomb Libya.

The F-117A is to be used to take out hardened targets and would fulfill that mission in a single aircraft formation. To put on the line a $220 million surgical strike aircraft for the scenario outlined in your coverage would not be wise. Besides, the only organization capable of launching up to 20 aircraft at one time and keeping them in the air is the Air National Guard.

JAMES C. GOODALL
133RD TACTICAL AIRLIFT
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IUS PROBLEMS

Craig Covault got slightly carried away with his facts in his article about the Magellan shuttle mission (AW&ST Apr. 24, p. 42). It was the IUS rocket stage for the TDRS-D payload of the March, 1989, STS-29 flight that suffered a broken nozzle from the clumsy technician, not Magellan's IUS stage as stated by Covault.

Aviation Week's revelations abou the F-117A stealth fighter were very exciting, but were you aware that a very clear view of the aircraft at low altitude appeared on the NBC-TV evening news in December, 1988 (AW&ST May 1, p. 24)? While it does not reveal the underside silhouette as does your photograph, the clip clearly highlights the unusual shape of the airframe.

JOEL W. POWELL
CALGARY, ALBERTA, CANADA

(Reader Powell is correct concerning the IUS—Ed.)

REBUFFED PILOT

How ironic it is that the U. S. Navy is short of pilots when many people like myself disenrolled from Navy ROTC in 1980 and 1981 because of Adm. Hyman G. Rickover's "nuclear draft" (AW&ST May 1, p. 54).

I have been a pilot since 1979 and passed Navy and Marine Corps flight physicals but was not offered a pilot billet. I would have been an eight-year Navy pilot now and have no interest in the airlines. I have been flying for almost 10 years and none of it with the airlines.

People who really want to fly are not deterred by an eight-year commitment; they are turned away by not flying in the Nuclear Navy.

DOUGLAS G. DOBBIN
HOUSTON, TEX.

NORTHWEST CRASH

Your story on Douglas Aircraft Co.'s request to the National Transportation Safety Board to reopen the investigation of the Northwest Airlines Flight 255 crash contained a serious mischaracterization of our position (AW&ST May 1, p. 106).

The article stated that the Air Line Pilots Assn. accepts the NTSB's finding that the pilots failed to set the flaps.

It is not, nor has it ever been, ALPA's position that the pilots failed to set the flaps. We have not ruled out the possibility that the crew set the flaps but that they did not deploy.

ALPA does, however, accept the part of the NTSB finding that states the takeoff warning system failed due to "unknown reasons," as was found in the initial investigation. Although the circuit breaker in question was damaged beyond the ability to be tested, the subsequent discovery of a previously unknown failure mode in a circuit breaker on another Northwest aircraft shows it is possible for a breaker to fail (to a shorted condition) yet look perfectly normal on visual inspection. This explains how power to the warning system could have been interrupted without the crew's knowledge.

There is no evidence to indicate that the Flight 255 circuit breaker had been intentionally pulled by the pilots. Furthermore, a pilot riding jumpseat with the Flight 255 crew two legs prior to the accident noted that the warning system was functional, because it went off during taxiing while he was in the cockpit.

I hope this clarifies ALPA's position on this matter.

HENRY A. DUFFY,
PRESIDENT
AIR LINE PILOTS ASSN.
WASHINGTON, D. C.

(The misstatement of ALPA's position resulted from a misunderstanding between an ALPA spokesman and Aviation Week—Ed.)

AVIATION WEEK & SPACE TECHNOLOGY welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, AVIATION WEEK & SPACE TECHNOLOGY, 1221 Avenue of the Americas, New York, N.Y. 10020. Letters must be under 200 words and you must give a genuine identification. We will not print anonymous letters, but names will be withheld. We reserve the right to edit letters.

A14 WAK 169 E

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The Company's activities are comprehensive: development, testing, quantity production, supply of spares, training, maintenance and repair.

Radars designed in compliance with a uniform system concept offer merits for procurement, in operation and in logistics. Therefore the right decision: C-band radars from AEG for air defence. Modern equipments and systems for anti-aircraft and air defence systems are only one example for the activities and innovations of AEG. Principal areas in defence technology are reconnaissance and monitoring, command and communication, electronic warfare, fire power and fire control, airborne and ground-based equipment, training, system management, logistics, servicing and quality assurance.

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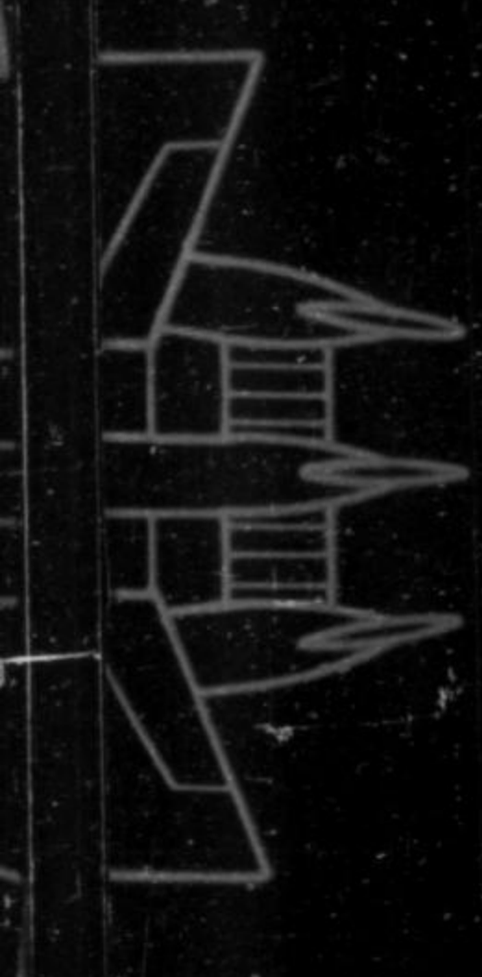

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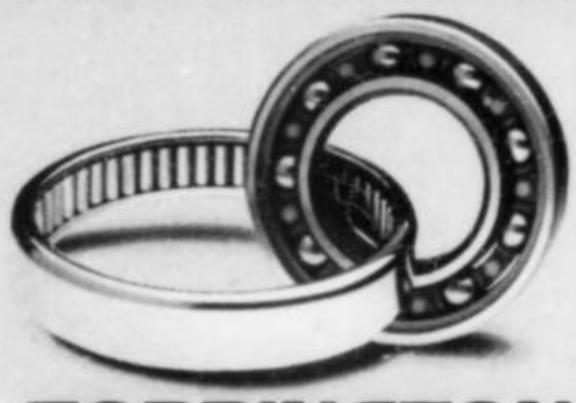

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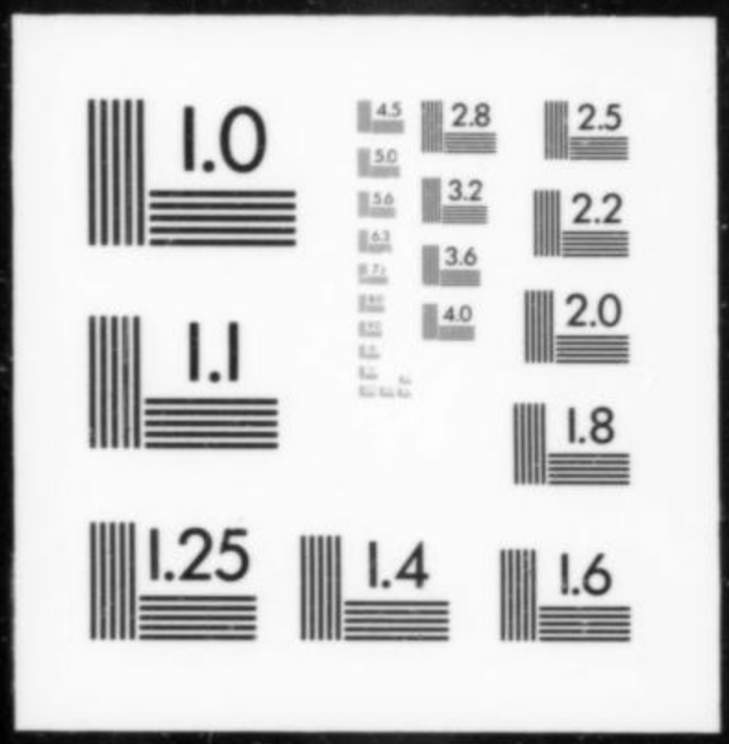
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