Flight recorders are tested to withstand extreme conditions to ensure information survival

CIVIL AVIONICS DIRECTORY

Digitisation is doing for avionics what it is doing for all forms of data processing. It is making avionics faster, more accurate, compact, reliable and enabling tasks to be carried out which would have been impossible — or at least not practical — before its advent.

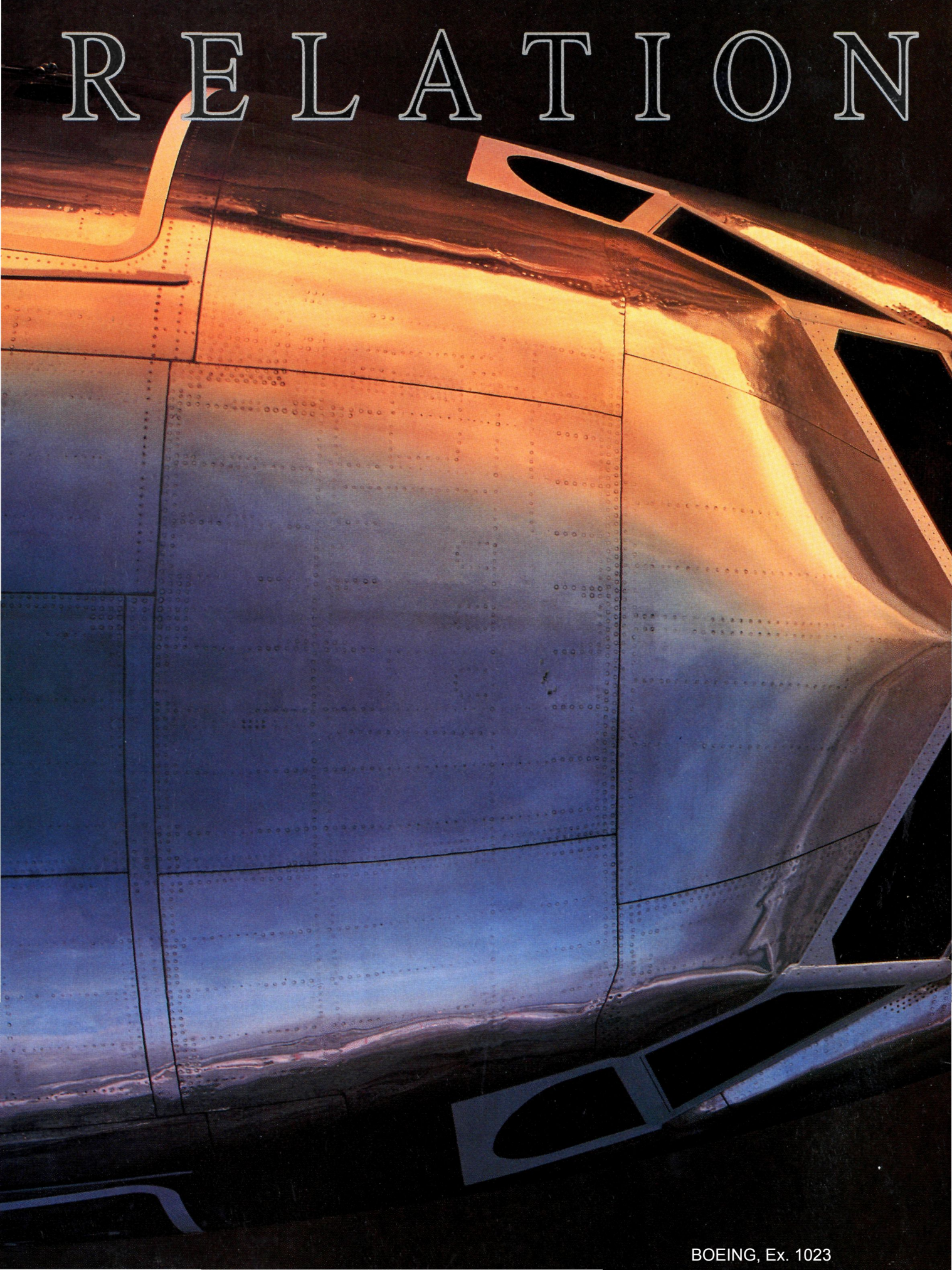
There is another development becoming progressively clearer in the avionics field: integration of the computing capacity for multiple tasks, and also progressive integration also of displayed information.

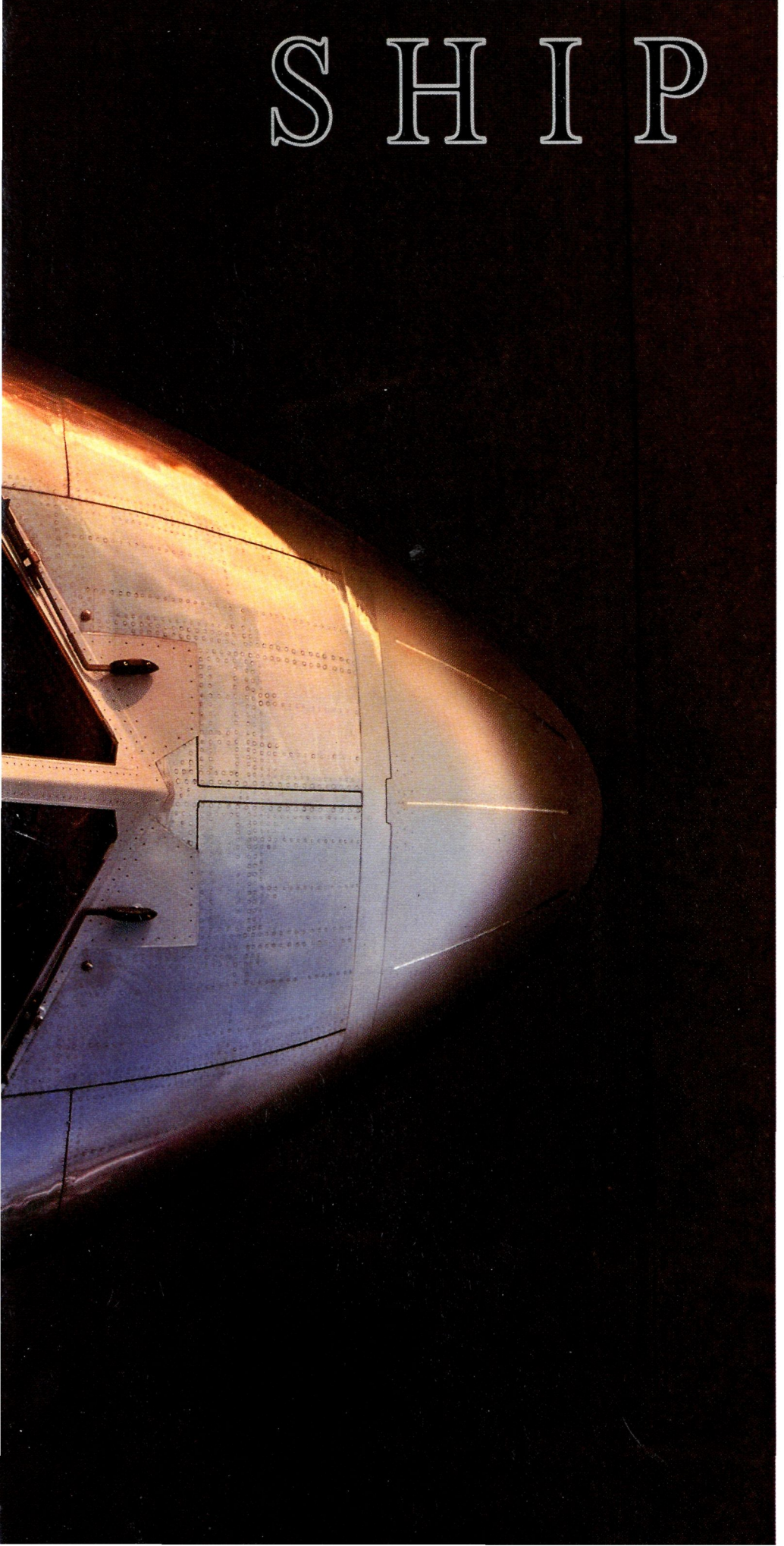
COMPILED BY MICHAEL PAYNE

Obviously sensors will remain independent with specific designated roles as suppliers of the base data on which the computers work, but a single high-capacity computer could now receive all sensor-supplied data, sort it, address it, and send it to cockpit display or control unit destination.

Stand-alone avionic units are still widely available, but indications are that the future airliner will have a multiple-channel computing system with high redundancy which will manage all the aircraft's flight control and management needs.

In the following tables the size of some avionics-rack equipment is presented in manufacturers' standard unit terms. As digitisation makes units smaller, the ARINC "form-fitter" MCU (modular concept unit) is superceding the ATR (air transport radio) rating. 1 MCU corresponds approximately to 1/8 ATR.





Today, solid business relations are built on trust and respect. And at Collins Avionics, we've built relations that have launched some of the most advanced ships in history.

From the beginning, we reach a little higher in the design, development and integration of avionics. Like the systems we created for the Fokker 100, which made a fully coupled autolanding possible on its maiden flight. And where our avionics go we follow with unsurpassed customer support.

When you work with Collins Avionics, the results are a long-term relation. And a technically advanced ship.

Collins Air Transport Division, Rockwell International, 400 Collins Rd. N.E., Cedar Rapids, Iowa 52498.

Rockwell International

...where science gets down to business

COLLINS AVIONICS

Aircraft courtesy of USAir.

WEATHER RADAR

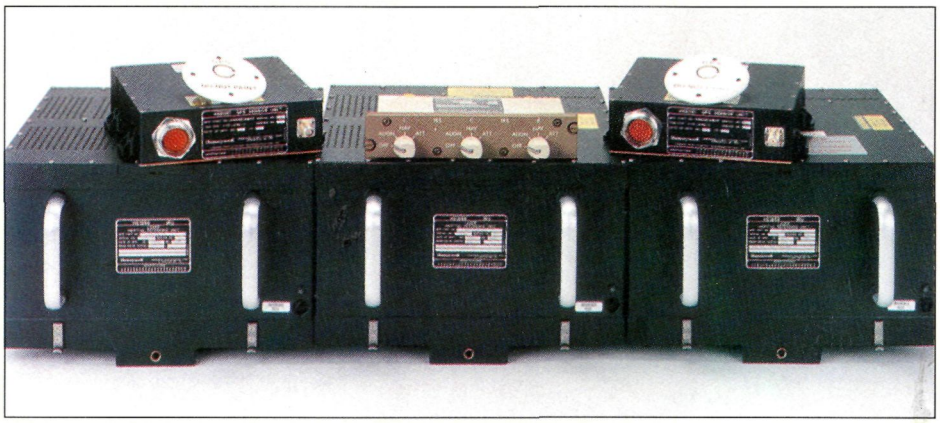
Commercial weather radar has benefited enormously from the technical advance of military airborne radar funded by defence budgets. Intense precipitation, which indicates turbulence, can be detected at considerable distances, so that pilots can plan deviations. Digital signal-processing — including doppler processing for detecting turbulence — and multi-colour displays provide civil aircrew with facilities as effective for their purpose as those combat crews have.

Manufacturer	Designation	Function	Weight (kg)	Size
Bendix/King	RDR-4A	Power 125W at X-band, three antenna sizes. Five-colour display 8.5cm x 10.9cm. Display can show radar picture, TCAS picture or both together.	transmitter/ receiver 11.8 76cm antenna 13 61cm antenna 5.8 46cm antenna not stated	8 MCU
Honeywell	708A	Power 150W at X-band, several antenna sizes. Seven-colour display 10 x 10cm. Output will interface to EFIS display.	Transmitter/ receiver 11.4 61cm antenna 10.5	8 MCU
Rockwell Collins	TWR-850	Power 24W at X-band from solid state transmitter integral with antenna and narrow-bandwidth coherent receiver. Three antenna sizes. Uses EFIS display.	Transmitter/ receiver 46cm antenna 8.5; 29.5cm deep 36cm antenna 8; 22cm deep 30cm antenna 7.8; 22cm deep	
Westinghouse	MR-3000 MR-2000	Two new radars benefiting from coherent pulse-doppler technology developed for F-16 fighter radar. The larger (MR-3000) is said to have exceptional turbulence and windshear detection capability.	Electronics only MR3000 16 MR2000 9	

Weather radar can be combined with TCAS in a single display

INERTIAL-BASED POSITION REFERENCE SYSTEMS

Not so long ago, the mechanical gyro and accelerometer stood alone as the basis of precision navigation out of radio range. New systems based on strapdown laser gyros and microprocessors are steadily taking over; only the accelerometer remains as a mechanical input to the computer. Further, the computer can simultaneously process air data inputs so that a complete range of attitude, heading, motion and position information is available from a single unit. For even more precision, GPS satnav inputs can be integrated to update the inertial reference from time to time.



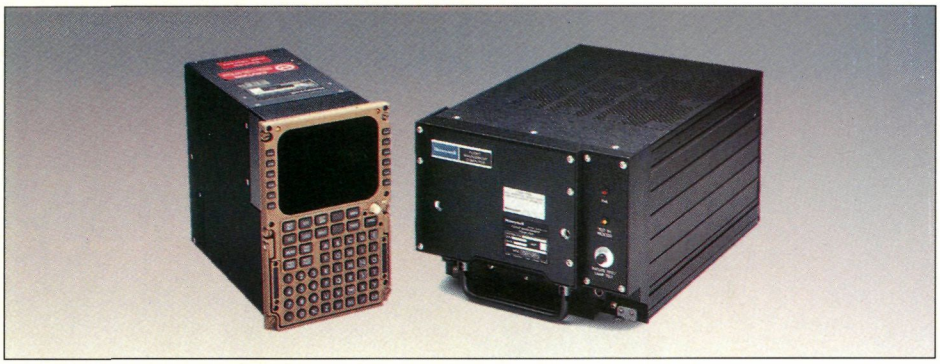
(Right) *Inertial systems are often triplicated*

Manufacturer	Designation	Function	Weight (kg)	Size
Honeywell	HG 1050 series	Laser gyro-based inertial reference system offered alone or integrated with air data computer or GPS receiver. Boxes size 10 MCU are being superseded by 4 MCU boxes based on smaller gyro.	20	10 MCU box
		Normal triple installation provides 2nm/h accuracy without GPS or 100 metres with. Standard fit in 737, 747-400, 757, 767, A320, MD-11.	12.3	4 MCU box
Litton	72R, 72RL	Platform uses two 2-axis, unfloated, dry-bearing gyros. Provision for VOR/DME updates. Model 72RL has better display and facilities.	28.6	1 ATR
	92	Laser gyro based INS especially suitable as retrofit. Extensive interfaces including Omega/VLF and GPS.	26	1 ATR
	90-100, 91	Laser gyro IRS. Former has only digital outputs, latter adds analogue outputs. GPS enhancement.	18.6	10 MCU
	101	Laser gyro IRS with integral air data computer and interface to GPS sensor.	11.6	4 MCU
	81-01, 81-02	Attitude and heading reference units incorporating twin two-degrees-of-freedom gyros and taking inputs from compass, VOR/DME and air data. Latter all-digital, former adds analogue outputs.	11 - 13	8 MCU
Sextant Avionique	Cirus	A military AHRS also offered for civil aircraft.		
Smiths Industries		A range of AHRS units.		

(Below) *GPS constantly updates the inertial reference*

FLIGHT MANAGEMENT SYSTEMS

The flight management system is a computer. Before take-off the pilot feeds in the flight plan — which includes route, destination and distance, and data including fuel load, passenger load, aircraft weight and weather. The computer works out the optimum flight path to meet the requirements and constraints. During flight, it will send instructions to autopilot and autothrottle to deliver demanded performance with optimum efficiency. It sees that relevant information is displayed on flight deck screens. It is the key to accurate, economical flight.



(Right) *Extensive interface for the flight management computer*

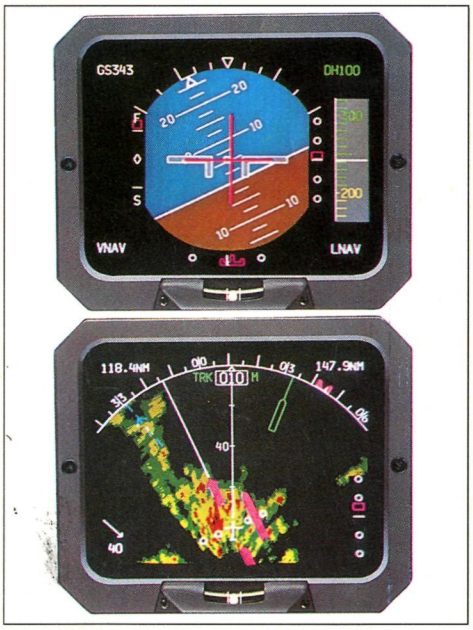
Maunfacturer	Designation	Function	Weight (kg)	Size
Global Wulfsberg Systems	GNS-X	Navigation management plus fuel and comms frequency management. Gives best computed position from VOR, DME, Loran C, GPS, VLF/Omega and inertial inputs. Installed on BAe 146 and Jetstream.	nav unit 4	1/4ATR short
Honeywell	Advanced flight management computer system	Development of Sperry FMS used in 757/767 and A300-600 and A310. Nav database 500K words, bulk store 1,000K words. All inputs including MLS and upcoming ATC datalinks. Full ACARS capability. Appears capable of near-total flight management. Specified for numerous aircraft.	Computer unit 12.7	8MCU
Racal Avionics	RNS 5000	Navigation management system accepting up to four sensors. Steers by DME/DME whenever possible. Includes fuel management.	Nav unit 5.5	4 MCU
Sextant Avionique	Flight management and guidance computer	Management functions include automatic landing. Used on A320.		
	Flight management guidance and safe envelope computer.	Adds responsibility for maintaining flight within safe envelope. Specified for A330 and A340.		
Smiths Industries	Enhanced flight management computer system	Development of established system with nav database enlarged to 1,000K words. Specified for A300-600 and A310.		
Universal Navigation	UNS 1A compact	Navigation management from five sensors, plus fuel management. Includes 3D approach procedures.	Nav unit 3.5	2MCU
	UNS 1B	Adds full SID/STAR terminal procedures.	3.5	2MCU

(Below) *FMS data is easily readable*

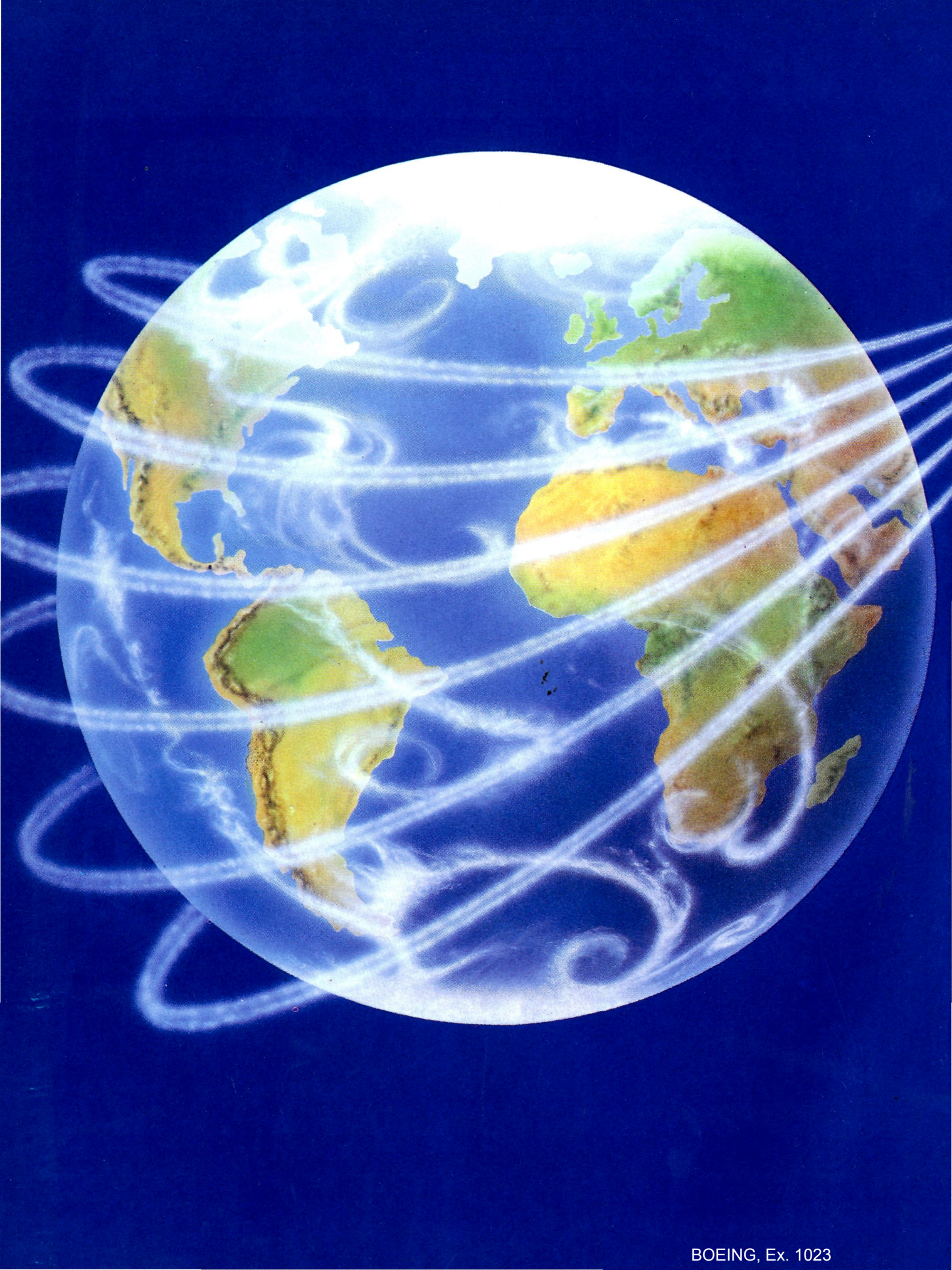
ELECTRONIC FLIGHT INSTRUMENTATION SYSTEMS

All major Western aircraft makers use high-brightness, high-resolution, full-colour Cathode Ray Tubes (CRTs) to display the main information on flight decks. The information is clear and easy to read; display formats far more informative than is possible with conventional instruments and improvements can be devised, developed and implemented relatively easily; and as far as is necessary, any format available on a flight deck can be called up on any screen. Disadvantages are the considerable bulk of a CRT and its heat output, which requires fan cooling. Both snags should be absent in the next-generation displays, which will be based on matrixes of pin-point, coloured, liquid crystal elements.

Manufacturer	Designation	Function	Weight (kg)	Size (cm)
Honeywell Sperry	Flight instrument systems	Full colour Cathode Ray Tubes 20.3cm square for MD-11 class aircraft, normally six per flight deck, two primary info, two nav info, one engine, one systems info. Three display generators.	15	20.3 x 20.3 x 35.5
		Similar tubes 15.2 cm wide x 12.7 high used in MD-80 installation. Separate EADI and EHSI.	4.8	15.3 x 12.7 x 26.7
Bendix/King	EFS 10 system	Full colour Cathode Ray Tubes 12.7cm square, 15.2cm square or 15.2 x 12.7cm.		
Rockwell Collins	EFIS 85A(1)/86A(1)	Full colour Cathode Ray Tubes 12.7cm square or 15.2 x 12.7cm.	Five-tube (small) 40 (large) 41.8	12.7 x 12.7 x 24.9 15.2 x 12.7 x 25.9
		Two EADI, two EHSI, one multi-function normal complement, but reductions available.		
Sextant Avionique	Electronic instrument system	Electronic navigation display system.		
Smiths Industries	Electronic instrument system	Full colour multi-purpose displays.		



Electronic altitude director (top) *and horizontal situation indicator*



THINKING IN FORMATION

WITH THE BOEING 777

for ELMS
Electrical Load Management System
for FQIS
Fuel Quantity Indicating System
and ASM
Auto Throttle 'Smart' Actuator

"The best in the air" generates and assures a long history for both product and operator.

Smiths Industries expertise in designing systems, for both commercial and defence, reflects the strong links the company continues to have with its customers. Close collaboration in the development of today's flight systems, displays and controls maintains leadership.

Teamwork, delivering on-time and with innovative solutions has meant that Smiths Industries is consistently being chosen to support key projects, both commercial and defence.

By anticipating and meeting market demands, the company has successfully doubled its resources and market share, securing long term product support – worldwide.

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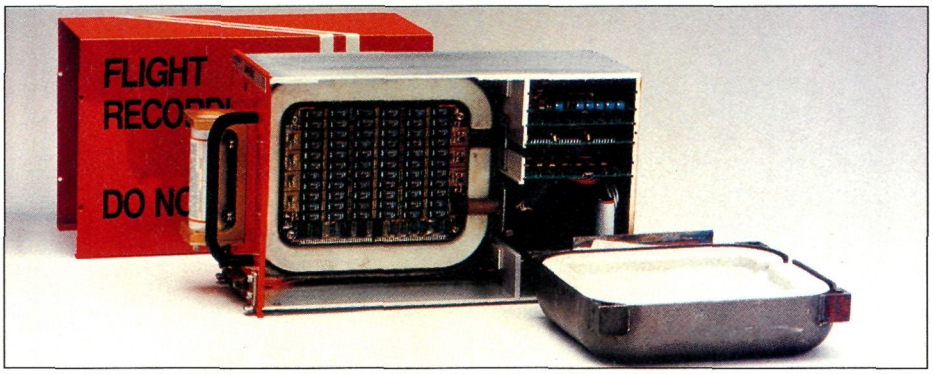
SMITHS INDUSTRIES
Aerospace & Defence Systems

Smiths Industries Aerospace and Defence Systems,
765 Finchley Road, Childs Hill, London NW11 8DS.
Tel: 081-458 3232. Fax: 081-209 0526. Telex: 928761.

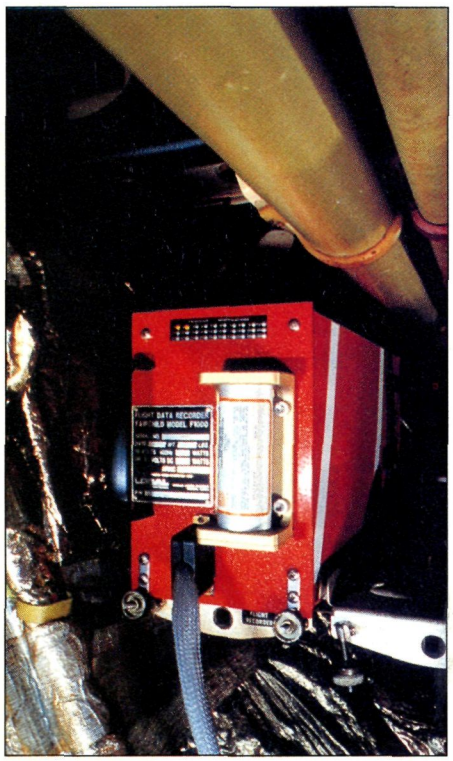
DATA ACQUISITION AND RECORDING UNITS

No commercial aircraft can fly now without recorders noting every significant change of state in its vital systems (which includes the human system on the flight deck). The information is used to improve the way aircraft are built, used and maintained; at the extreme, after a crash, recorded data may be the only clue to what went wrong. Recording data is a considerable data management task. Acquisition units have to digitise, sort, label and assemble data from diverse sources before the recording task can begin.



Manufacturer	Designation	Function	Weight (kg)	Size (cm)
GEC-Plessey Avionics	PV 1954	Acquisition unit meeting all requirements for 32 parameter data recording. Wide diversity of analogue, digital and discrete input facilities. Output 64 12-bit data words/sec.	5	1/2 ATR short
	PV 3810	As above but lower minimum operating temperature and smaller package.	4	3/8 ATR short
	PV 1591	For manual data entry into recorders	0.9	8.6 x 14.6 x 11.7
	PV 1584	Combined acquisition unit/crash protected recorder with 25h capacity.	11.5	1/2ATR long
GEC Avionics	Crash survivable memory	Uses semiconductor storage with 5Mbytes capacity. Will survive 3,000g shock, 1,100°C fire and 24h immersion.	4.5	25.4 x 15.2 x 15.2
	Engine health monitoring recorder	Removable 1Mbyte cartridge. Links to existing sensors.	35.5	14.6 x 29.2 x 24.1
Loral Data Systems	Fairchild F-1000	Solid state unit. Will survive 3,400g shock, 1,100°C fire and immersion to 20,000ft. Storage capacity 25h.	13.5	1/2 ATR long
	Fairchild A100A	Cockpit voice recorder. Endless tape loop of 30min minimum duration. Four channels. Crash protected.	11	1/2 ATR short
	Fairchild GA100	Variant of above for commuter aircraft.	10.5	1/2 ATR short
Nord-Micro	Flight data interface unit	Acquisition unit for A320. Includes "plausibility" check on incoming data.		
	Flight data management unit	Recording and data preparation unit for A320. Collects and evaluates data for over 2,000 parameters, and records significant events. Drives cockpit printer.		
Sundstrand	Flight data management unit	Collects, processes, sorts, analyses, formats for distribution and distributes data on 747-400 and MD-11. Interfaces to numerous on-board readouts and recorders.	11.5	6 MCU
	DFDAU	Digital acquisition unit. Accommodates all mandatory parameters. Wide diversity of inputs. Any one unit is programmed for interchange between any three aircraft types.	11	6 MCU

The latest recorders use semiconductor memory. They are built and installed to survive a crash.



GLOBAL POSITIONING SYSTEMS

Increasingly, navigation kits include a radio receiver fixing position by reference to signals emitted by the US military's Navstar satellites — the global positioning system (GPS). GPS is more accurate than any alternative and — most important — in due course will be effective worldwide, providing a common reference everywhere, as well as introducing a reference to places devoid of radio aids.

Manufacturer	designation	Function	Weight (kg)	Size (cm)
Global Wulfsberg	GPS unit	Five channel system. Sensor blending algorithm. Can be integrated into manufacturer's flight management systems.	3.2	1/4 ATR short
Litton	2001	Eight continuously tracking channels. Available configured for installations in or away from avionics bay. Can be part of manufacturer's nav reference systems.	3.6	2 MCU
Racal Avionics	GPS unit	Two-channel system which can be part of manufacturer's flight management system.		
Sextant Avionique	NSS 100S	Five-channel system which can be part of manufacturer's Omega/VLF/GPS radio nav system.		
Universal Navigation	UNS 764-1	Two-channel system which can be part of manufacturer's Omega/VLF/GPS radio nav system.	3.4	2 MCU

GPS should be accurate to 100m almost worldwide

DIGITAL AIR DATA COMPUTERS

An air data computer accepts continuous digitised measurements of the air environment around the aircraft and computes factors for display and transfer to other aircraft systems. Inputs are dynamic and static air pressures and temperatures, barometric corrections and angles of attack. Displayed outputs include airspeed, Mach number, altitude and rates of climb and descent. Data may pass to a dozen or more aircraft systems.

Digital air data computers feed information to many other aircraft systems

Manufacturer	Designation	Function	Weight (kg)	Size
Honeywell	HG 480-E1	Development of Sperry ARINC 706 DADC for 737-300, -400 and -500.		1/2 ATR long
Nord-Micro	N-M DADC	Developed for Airbus A310. Said to exceed ARINC 706.		
Rockwell Collins	ADS 82	Compatible with APS 85/95 flight guidance systems.	3	1/2 ATR short-low
	ADS 85	Compatible with APS 65/85 flight guidance systems.	2.7	1/2 ATR short-low
Sextant Avionique	CAe 120	ARINC 706 compatible development of a combat aircraft DADC.		
Smiths Industries		Designed for 737-300.		

GROUND PROXIMITY WARNING SYSTEMS AND WINDSHEAR WARNERS

GPWS were invented about 15 years ago, after several aircraft had crashed because pilots did not know that they were too close to the ground. A unit takes radar altimeter and air data inputs and gives voice warnings if the rate of descent or closure to the ground is excessive, if the absolute ground clearance is too little, and if height is lost after take-off. Some units are integral with windshear warners. Windshear is a sudden change in windspeed or direction which tends first to increase and then suddenly to reduce airspeed to a dangerous level. It can be fatal if an aircraft is near the ground unless the pilot recognises the nature of the situation and takes appropriate action. Warners detect windshear effects on an aircraft, sound a warning and direct recovery action.

Manufacturer	Designation	Function	weight (kg)	Size (cm)
Honeywell Sperry	Sperry Windshear system	Sensor and computer providing "caution" and "warning" displays and recovery guidance. Stand-alone or integration into flight management or performance management systems.	stand-alone 5.5	stand-alone 3/8 ATR short
Rosemount	Angle-of-attack systems	Windshear detector-transmitters and recovery indication instruments.	sensors less than 1.4	
Safe Flight Instruments	6501	Computerised windshear warner incorporating accelerometers and using existing air data and angle of attack sensors. Visible and audible indication.	2.7	1/4 ATR short
	6508	As above plus recovery guidance.		
	6509	Windshear/stall warning system. As above plus stall warning. Integral recorder.	2.3	22.9 x 10.2 x 10.2
	1501	Angle-of-attack computer and indicator	1.4	19.4 x 8.4 x 8.1
	1703	Angle-of-attack vane sensor.		11.8 dia x 6.5
Sextant Avionique	Windshear guidance display	Part of Sextant flight control computer system. Provides recovery guidance imagery on A300-600 and A310.		
Sundstrand	Mark VII GPWS	Provides all possible ground proximity warnings. Extendable to include altitude call-outs and bank angle alerts, and windshear warning and recovery guidance. Very widely used.	2.6	1/4 ATR short

FUEL MEASUREMENT SYSTEMS

Safety and economics demand accurate measurement of the amount of fuel in the tanks at all times. Aircraft attitude and motion, along with the odd shapes of many tanks, make measurement technically complex. Tanks have numerous probes rising from the bottom surface, the fuel level around each is detected and the results integrated. Conventionally, a probe's changing electrical capacitance with changing fuel level is the detection principle.

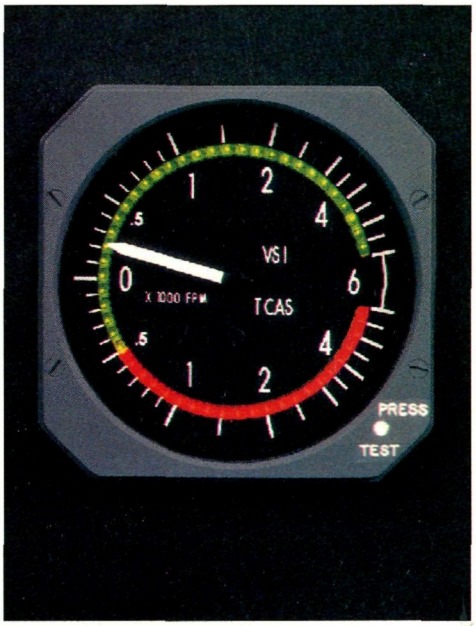
Manufacturer	Designation	Function	Weight	Size
Smiths Industries	FQIS	New technique measures fuel height within perforated probe by timing ultrasonic pulse from transducer in base to surface and return of reflection. Said to be accurate to 1%. Specified for Boeing 777.		

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEMS AND MODE S TRANSPONDERS

TCAS are intended to minimise the risk of a mid-air collision in increasingly crowded skies. The unit interrogates the SSR transponders in nearby aircraft, notes their absolute and changing altitudes and indicates their bearings. It indicates the required evasive manoeuvre if a collision with a nearby aircraft appears imminent. Wholly effective use presumes universal fit of Mode S transponders, which have a data link enabling closing aircraft to communicate to reconcile their manoeuvres.

Manufacturer	Designation	Function	weight (kg)	Size (cm)
Bendix/King	TPA 81A	TCAS interrogator/processor	9	11,700cm^3
	ANT 81A	TCAS directional antenna	0.9	950cm^3 exposed
	ITA 81A	TCAS dedicated traffic display	3.9	12.7 x 11.4 x 25.4
	IVA 81A	TCAS traffic/vertical speed display	2	3 ATI x 19
	IVA 81B	TCAS resolution/vertical speed display	2	3 ATI x 19
	TRA 67A	Mode S transponder	6.4	7,540cm^3
Honeywell	TCAS system	TACS interrogator/computer	12.3	6 MCU
		TCAS directional antenna	0.5	23cm wide small projection
		TCAS all-purpose flat-panel LCD display	1.8	3 ATI x 18.4
		Mode S transponder	6.6	4 MCU
		TCAS transponder controller	1.1	14.6 x 5.7 x 12.7
Kollsman	47174	Resolution/vertical speed display	1.4	8.25 x 8.25 x 21
Rockwell Collins	TTR 920	TCAS interrogator/processor	8.9	6 MCU
	TRE 920	TCAS directional antenna	0.7	15.2 x 28 x 2.5
	TTC 920	TCAS transponder controller	0.9	5.7 x 14.6 x 18.4
	TVI 920	TCAS flat-pannel LCD vertical speed display	2	3 ATI x 19
	WXI 711	Combined TCAS/weather radar display	5.9	Mark II
	TPR 720	Mode S transponder, 115v AC	5.5	4 MCU
	TDR 94D	Mode S transponder, 28v DC	3.9	8.4 x 12.5 x 31.8
Sextant Avionique		TCAS vertical speed indicator		
Smiths Industries	2074	TCAS low-cost vertical speed indicator		
	2871	TCAS flat-panel LCD vertical speed indicator		

(Above) Many items come together to make a TCAS installation. (Below)A universal TCAS instrument is the vertical speed indicator



Manufacturers' addresses

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GEC Avionics, Airport Works, Rochester, Kent ME1 2XX, UK. Tel: +44 (634) 844 400, Fax: +44 (634) 832 664.

GEC-Plessey Avionics, Martin Road, West Leigh, Havant, Hampshire PO9 5DH, UK. Tel: +44 (705) 492 249; Fax: +44 (705) 493 385.

Global Wulfsberg Systems, 2144 Michelson Drive, Irvine, California 92715, USA. Tel: +1 (714) 851 0119; Fax: +1 (714) 752 0604.

Honeywell Sperry, Air Transport Systems Division, PO Box 21111, Phoenix, Arizona 85036-1111, USA. Tel: +1 (602) 436 2311; Fax: +1 (602) 436 2252.

Kollsman, 220 Daniel Webster Highway, Merrimack, New Hampshire 03054-4809, USA. Tel: +1 (603) 889 2500; Fax: +1 (603) 889 7966.

Litton Aero Products, 6101 Condor Drive, Moorpark, California 93021-2699, USA. Tel: +1 (805) 378 2000; Fax: +1 (805) 378 2255.

Loral Data Systems, Fairchild Aviation Recorders Division, PO Box 3041, Sarasota, Florida 34230, USA. Tel: +1 (813) 371 0811; Fax: +1 (813) 371 6996.

Nord-Micro Elektronik-Feinmechanik AG, Victor-Slotosch-Strasse 20, D-6000 Frankfurt 60, Germany. Tel: +49 (6109) 303 223; Fax: +49 (6109) 303 233.

Racal Avionics, 88 Bushey Road, London SW20 0JH, UK. Tel: +44 (81) 946 8011; Fax: +44 (81) 946 7530.

Rockwell Collins, Air Transport Division, 400 Collins Road NE, Cedar Rapids, Iowa 52498, USA. Tel: +1 (319) 395 5772; Fax: +1 (319) 395 4333.

Rosemount Ltd, Heath Place, Bognor Regis, West Sussex PO22 9SH, UK. Tel: +44 (243) 863121; Fax: +44 (243) 867554.

Safe Flight Instruments, New King Street, PO Box 550, White Plains, NY 10602-0550, USA. Tel: +1 (914) 946 9500; Fax: +1 (914) 946 7882.

Sextant Avionique, 5-7 rue Jeanne Braconnier, Parc Tertiaire, 92366 Meudon-la-Foret, France. Tel: +33 (1) 46 29 88 00; Fax: +33 (1) 40 94 02 51.

Smiths Industries, Aerospace and Defence Systems, Bishops Cleeve, Cheltenham, Gloucestershire GL52 4SF, UK. Tel: +44 (242) 663333; Fax: +44 (242) 661795.

Sundstrand Data Control, 15001 NE 36th Street, PO Box 97001, Redmond, Washington 98073-9701, USA. Tel: +1 (206) 885 3711; Fax: +1 (206) 885 8211.

Universal Navigation, 3260 E. Lerdo Road, Tucson, Arizona 85706-5021, USA. Tel: +1 (602) 741 2300; Fax: +1 (602) 741 0103.

Westinghouse Modular Radar, PO Box 1693 MS 1112, Baltimore, Maryland 21203, USA. Tel: +1 (301) 765 4396; Fax: +1 (301) 765 9976.