FAST

AIRBUS TECHNICAL DIGEST

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AIRBUS INDUSTRIE

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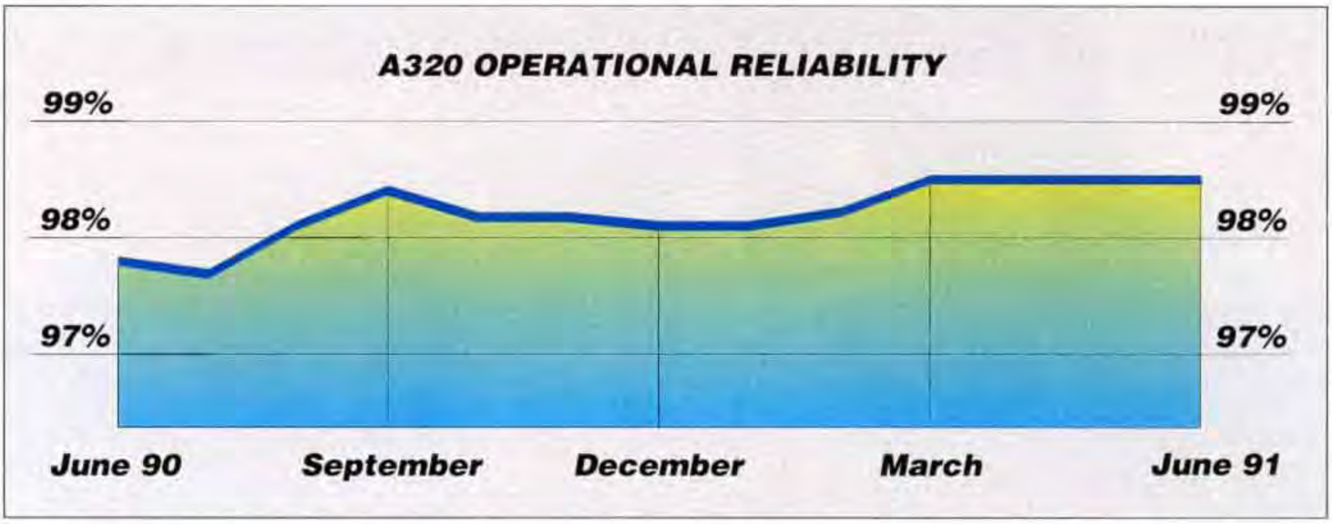


A320 Technical Symposium

"99% operational reliability is the goal"

Airbus Industrie held its second A320 Technical Symposium, in the Princesa Sofia Hotel, Barcelona in May. It was attended by almost two hundred representatives from nineteen customers, twenty-seven suppliers, Airbus Industrie, its partners and associate companies.

Iberia, the Spanish national airline, have recently started an ambitious A320 induction programme. It was therefore fitting for Mr Herrera, Iberia's Vice President Engineering, to welcome all participants in the A320 Technical Symposium to Barcelona, at the opening reception, on behalf of Mr Sternfeld, Senior Vice President Maintenance and Engineering, who joined the Conference later on.

Mr Bernard Catteeuw, Airbus Industrie's Senior Vice President Support, had opened the proceedings and also used the opportunity of the reception to present the annual award for A320 Operational Excellence to Air Inter. Only operators having twelve months continuous operation are considered. Other parameters taken into account when choosing the winner of this award include operational reliability and daily utilisation. Mr. Jehl, Vice President Maintenance, accepted the award for the staff of Air Inter and said that their consistently good performance with the A320 was due to three main factors: a good aircraft, good product support and very good cooperation between pilots and mechanics.

The conference was chaired by Roger Lecomte, Director Technical Support of Airbus Industrie, and covered three and a half days of intensive presentation and discussion of the A320's operation and maintainability. The fleet is steadily increasing in number. Twenty operators have taken delivery of nearly two hundred aircraft. Operational reliability of the A320 fleet is now consistently over 98.5%. Much progress has been made but 99% operational reliability is the goal, a task which will require the active participation of all A320 operators.

Always important at these symposiums are the informal breaks. They allow specialists from different groups to discuss subjects in great detail. It is also a unique opportunity for airline staff to get together to compare notes on the operation of their A320s. ■

Mr Catteeuw handing over the award for A320 Operational Excellence to Mr Jehl

The happy recipients with their award

General view of the busy atmosphere within the A320 Technical Symposium conference room

As the Airbus fleet expands so does the programme of Technical Symposiums and Conferences. The current programme is as follows:

Technical Symposiums

- *A300/A310, Spring 1992*
- *A320, Spring 1993*

Conferences

- *Suppliers and Airlines, Spring 1992*
- *Materials, Autumn 1992.*

Suppliers Conference

"Our mutual target is to be Number One"

All Airbus Industrie's Suppliers were invited to a conference in Paris on 19 June, 1991. Over two hundred persons representing 137 equipment manufacturers attended this meeting, together with representatives from Airbus Industrie and its partners.

Three guest speakers opened the proceedings: Mr Stuart Iddles, Airbus Industrie Senior Vice President Commercial, gave a general review of the Airbus market position and emphasised that improvements were required from Suppliers on spare parts support. He was then followed by Mr Jean-Claude Gendronneau, Vice President Maintenance and Engineering from Air France, who stressed his Airline's priorities: provide passengers with a safe, reliable, economic and comfortable aircraft. The third guest speaker, Mr Robin Wohnsigl, Director of Airbus Base Operations at Northwest Airlines, described three weeks in the busy life of one A320, showing the impact of each unscheduled component removal on the aircraft dispatch reliability and on airline costs. This description clearly brought home to everyone how unreliability of components affects the operation of an aircraft.

The last three years of A320 operation were reviewed and the quality of Supplier's documentation and Product Support was studied.

With the first flight of the A340 being imminent, it was opportune to remind the Suppliers of the importance of having their Product Support ready to meet the challenge of A340 entry into service. This new aircraft is also bringing in new procedures such as ATA Specification 2000. The use of Spec. 2000 for initial provisioning of spare parts is obligatory for Suppliers to the A330/A340 programme. An open session allowed discussion of the requirements.

Mr Catteeuw conveyed the following messages:

- Airbus Industrie's current objective is to capture more than 30% of the total civil aircraft market and this requires achievement of outstanding Product Support performance.
- The Suppliers are therefore requested to improve on the following attitudes and topics:
  - listen first, then act, discuss later,
  - decrease the time to fix problems,
  - improve spare parts delivery performance and repair turn times,
  - do things right the first time and stick to your commitments,
  - measure your own performance and share the performance indicators with Airbus Industrie and the Operators,
  - be prepared to match Airbus Industrie's growth,
- The A340 has to be more mature than any other aircraft at entry into service, demanding a closer relationship between Suppliers' Product Support and Engineering organisations.
- Our mutual target is to be Number One in Product Support; this will be measured by our common customers giving Airbus full recognition of the achieved standard.

Following this conference, six meetings with smaller groups of Suppliers are scheduled during autumn of this year in Toulouse to offer the Suppliers' Product Support Management the opportunity to see the A340 production and to have working sessions dedicated to maintainability and common targets such as turnaround times. ■

by Michel Ensuque
Airbus Industrie Product Support
Supervisor Maintenance Resources & Planning

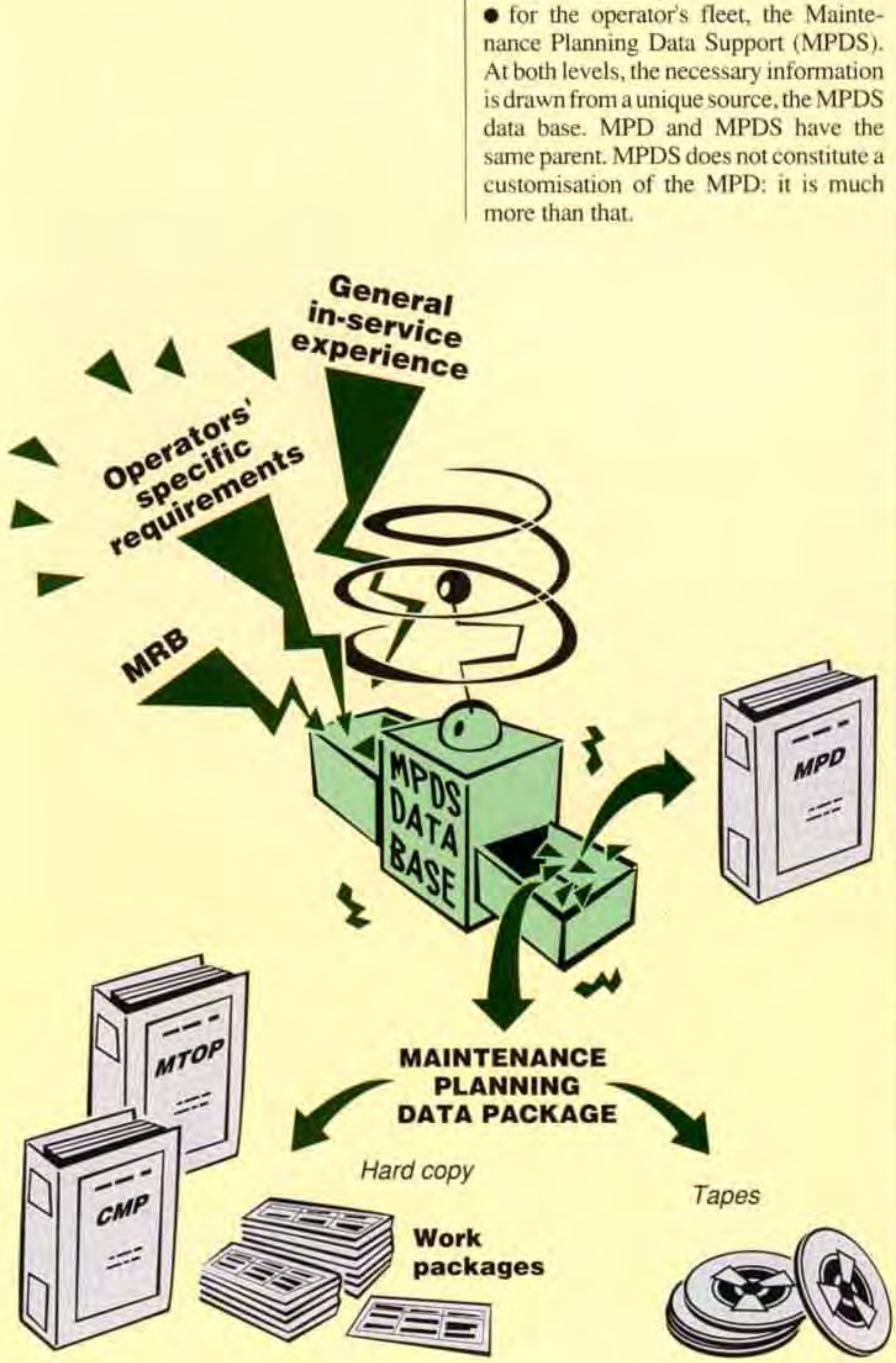
MAINTENANCE PLANNING DATA SUPPORT

In issue number 10 of FAST, we described how the Maintenance Review Board document is developed as the initial maintenance programme for a newly designed aircraft. In this article we show how Airbus Industrie takes benefit from the Maintenance Review Board Document to provide an additional service, Maintenance Planning Data Support, in preparation for and performance of scheduled maintenance events.

In all countries, operational regulations require that transport aircraft are maintained in accordance with an approved maintenance programme, the content and lay-out of which are defined by the regulations. Responsibility for such a programme is assigned to the operator of the aircraft. In order to help Airbus operators to fulfil their responsibility and to go further in preparation of maintenance work, Airbus Industrie has developed, since the very first A300, a two-level maintenance support system :

- for the aircraft type, for example the A320 family, a Maintenance Planning Document (MPD),
- for the operator's fleet, the Maintenance Planning Data Support (MPDS).

At both levels, the necessary information is drawn from a unique source, the MPDS data base. MPD and MPDS have the same parent. MPDS does not constitute a customisation of the MPD: it is much more than that.



THE MPDS DATA BASE

For every scheduled maintenance task on an aircraft model, the MPDS data base mainly contains a series of data related to the definition of the task itself (e.g. cross reference with the detailed description of the work, access panels to open, main zone affected, origin of the task, threshold and interval..) plus information on the resources needed to perform the work (special tools, man-hours, skill, consumables, expendables, systematic spares...).

Other more general data may be included in the MPDS data base such as the man-hours required for opening/closing each access panel. With successive improvements and additions, the A330/A340 and future MPDS data bases should have more than twenty fields of information per task.

Of course, the results of the Maintenance Review Board (MRB) process constitute the prime source of data to fill in the MPDS data base. But in-service experience and aircraft individual definition changes are permanently considered to keep the MPDS data base up to date.

THE MAINTENANCE PLANNING DOCUMENT

The MPDS data base is first used to establish the Maintenance Planning Document. This hard copy document lists, in its volume 1, all the scheduled maintenance tasks with a selection of related data. Threshold and interval of the task are expressed as in the MRB document, i.e. using letter codes A and C (and their multiples) or usage parameters such as flight hours, flights, APU hours, engine cycles, calendar time. Effectivity of the task is considered at the level of the aircraft model fleet and is expressed most of the time by using the Airbus modification status of the aircraft.

MPD volume 2 contains additional information such as illustrations, significant structural items, photographs, component storage data, special GSE/tools required for scheduled maintenance, aircraft zoning and access panels description.

The MPD is revised as necessary: two or three times per year when the model is recent; once per year, when the model family is mature. Temporary revisions are issued to cover urgent changes.

Although not requested by the ATA 100 specification for technical publications, the MPD and its revisions are provided to every Airbus customer.

The necessary further step in customisation, leading to a real Customer

Maintenance Programme and fully customised maintenance data is proposed by Airbus Industrie through the MPDS.

Volume 1 of the MPDS represents the Airbus Industrie recommended Maintenance Programme. But since it considers a whole model family (e.g. the A310 MPD addresses all the A310 models and configurations) and an average operational environment, it may not constitute, as is, the most appropriate programme or workable planning tool for an individual operator: it requires customisation, to be actually used as a tool, for an individual operator. It is also used as a basis for the establishment of individual Airline Maintenance Programmes. That "reference document" aspect is enforced by the fact that every Airbus MPD is officially approved by the French Authority (DGAC).

MPDS : A MADE TO MEASURE SERVICE

MPDS comprises two kinds of material: the Planning Data and the Supporting Data. This service covers all the scheduled maintenance activities for a given period of time. For example, an MPDS covering four years would be delivered in four yearly packages to take advantage of the latest status of the technical documentation.

Planning data

The MPDS service starts with a customisation analysis, jointly performed by Airbus Industrie and the Customer. The aim is to record all data specific to the customer fleet where maintenance tasks are affected by the local environment : many task intervals have a certain level of freedom for change based on operator experience; other task intervals have to be adapted in accordance with local regulations; others offer alternative possibilities, for which a decision has to be taken.

Furthermore it may appear useful to create some tasks to address items not traditionally covered by the MRB document like cabin refurbishing or items affecting only commercial equipment of the aircraft.

All these customised data will be recorded in the MPDS data. This first step of customisation completes the data needed for a customised maintenance programme. The second step is the definition of the Maintenance Task Operating Plan (MTOP).

A maintenance programme is mainly a list of maintenance tasks, each with its threshold for compliance and subsequent intervals resulting from different methods of analysis. These thresholds and intervals may be expressed in different units such as calendar time, flying hours, flight cycles, etc. In addition, it is not always practicable to perform tasks at the precise time they are due since this could lead to too many interruptions of the operation. Tasks are therefore grouped into packages to suit operational requirements, maintenance resources and deadlines for task performance. Each task due during the planning period considered is allocated to a maintenance event in compliance with customer requirements (some exceptions do exist). By anticipating the first performance of some tasks, the content of these maintenance events may be adapted - up to a certain limit - to available manpower resources. One of the most frequent demands is to equalise the amount of work between several maintenance checks. When performing this task allocation, it is necessary to know the aircraft's operational activities.

These Planning Data are offered on two media, at the customer choice :

● **On magnetic tape.** The data extracted from the MPDS data base completed by task allocation and customisation is available on magnetic tape. If the operator has the necessary electronic data processing equipment and programmes, he can print his own Maintenance Programme, Maintenance Task Operating Plan and planning documentation.

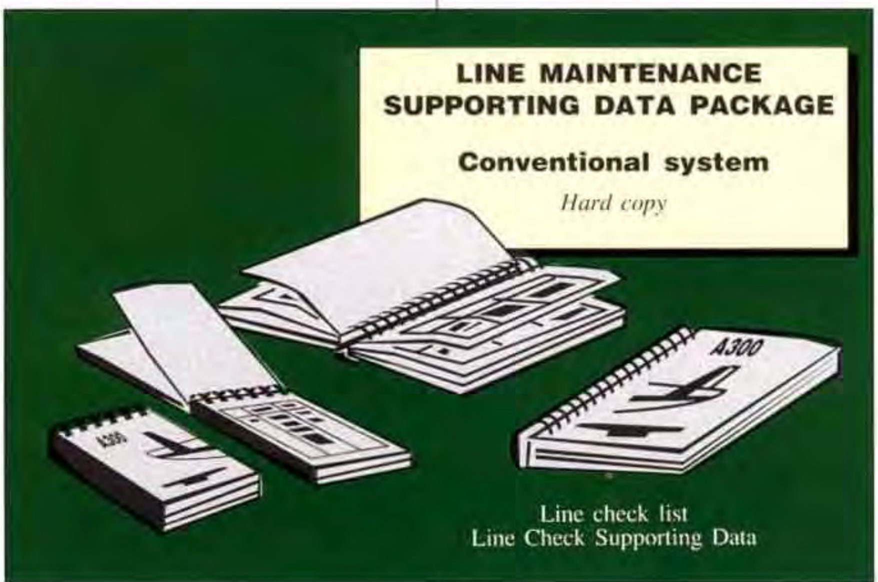
● **On hard copy.** Customer Maintenance Programme, Maintenance Task Operating Plan and Work Packages are provided on paper. For every maintenance event of the planning period considered, a separate work package is established, which provides a stack of ready-to-use forms:

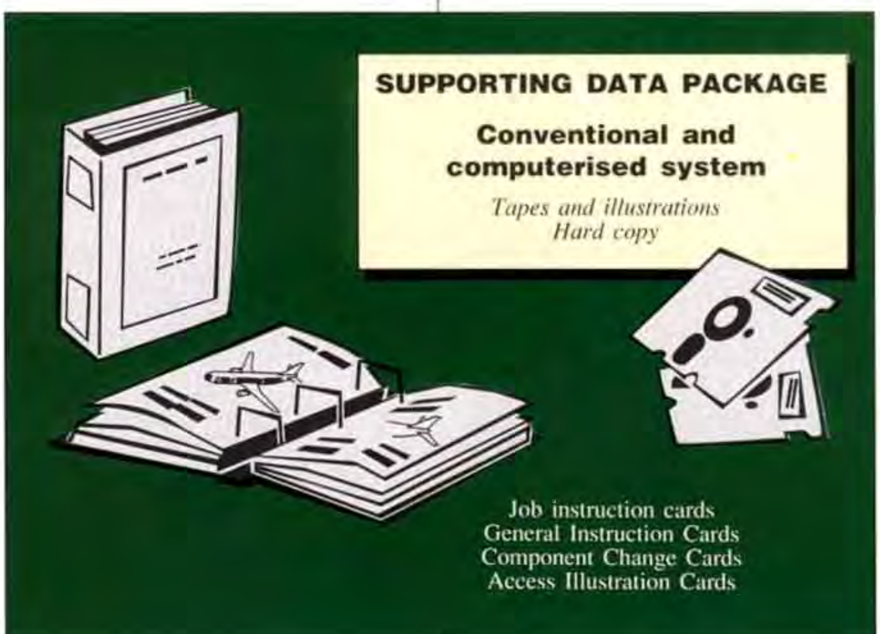
○ *Work preparation data* (list of tasks, zones affected, access panels to be opened, Job Instruction Cards required, expendables and consumables, spare parts, GSE/tools, manpower),

❍ *Access cards,*
❍ *Access summary/record cards*
❍ *Maintenance task cards* give a brief description of the task plus additional planning information.
❍ *Maintenance Task summary/ record cards*
❍ *Defect/Rectification cards*

Supporting data

The above documents are intended mainly for planners, while supporting data provide the necessary detailed information to conduct the task through the following documents:
❍ *Line Check Lists* (LCL) which are available in the form of booklets for preflight, daily and weekly tasks only. Customers often request to have these tasks listed apart from other MPDS documents, since their planning is generally not subject to change.





❍ *Line Check Supporting Data* (LCSD) provide complementary information relative to the Line Check Lists. A kind of mini Aircraft Maintenance Manual addressing systems affected by these tasks.
❍ *Job Instruction Cards* (JIC) detail how the scheduled maintenance tasks should be performed.
❍ *General Instructions Cards* (GIC) contain more general procedures and maintenance practices (normally referred to in the JIC) for such tasks as aircraft jacking, pressurization of hydraulic systems...
❍ Component Change Cards (CCC) contain instructions for removal/installation of selected components (including tests after installation).
❍ Access Illustration Cards (AIC)contain access information as a complement to the Access Cards.

All the cards are available on hard copy and, partially, on floppy disk (illustrations are still on hard copy). They are based on current aircraft manuals, mainly the Aircraft Maintenance Manual. Customisation of these cards is possible and would be part of the customisation analysis.

CONCLUSION

Maintenance Planning data are obvious candidates for electronic data processing by the maintenance information system, which is actually a maintenance management system. The Airbus Planning Data Package magnetic tape is primarily intended to ease the initialisation of such computerised systems.

The Production Management Data Base (PMDB), as defined by ATA 100 specification, should contain - among other things - similar planning data. It is hoped that data for the scheduled maintenance task will become almost identical for Airbus Maintenance Planning Data Support and ATA PMDB.

Advantages of the magnetic support compared to the hard copy option are obvious: greater independence for the operator, easier updating, the ability to simulate several maintenance plans based on different operational assumptions.

Since 1975, more than forty operators have been supplied with the Airbus MPDS service. Initially the aim was mainly to ease aircraft entry into service, and the planning period considered mainly covered the first two years, whereas today the MPDS is also used to prepare heavy maintenance events due after eight or nine years of aircraft operation.

This large number of users and the great variety of usage confirms the usefulness of this service which is kept well adapted to market requirements. ❑

ADVANTAGES OF CONTAINERISATION ON A320 AND A321

by Denis Dempster, FAST Editor

The standard build for the A320/A321 features a bulk system for the carriage of freight. The containerised system is an option, the reason being that its advantages on a standard-body aircraft and return on investment therefrom are not as obvious as on a wide-body aircraft. The total investment will vary for each airline and will need to be justified.

Both loading systems have been developed with the active participation of a group of airlines who are significant operators in the freight market. Their experience led to the design of an optimised product: the A320/A321 lower deck compartments and freight doors are sized to allow for the base plate of an LD3 container - which is the most commonly used by the world's airlines - and high enough to carry a version of it - the LD3-46 (46 inches high) or NAS 2K2C, IATA contour G. This container can be carried on all current and proposed wide-body aircraft (having base plate restraint) with a certain loss of volume but no loss of maximum density capacity. Further variants of the LD3-46 are the LD3-46W (IATA contour AKH)* and a pallet with extenders and net, NAS 2K3P to the same IATA contour, which minimises logistical problems.

The choice of the LD3-46 family allows:

- maximum utilisation of available freight capacity with minimum technical turnround times (25 minutes) with one lower deck loader;
- at nearly all airports, use of the ground support equipment with minimum platform height of 75 inches, which is already available for wide-body aircraft. (A320 minimum sill height is 78 inches);
- maximum use of the air freight infrastructure in existence worldwide;
- straightforward freight marketing;
- benefits to be gained from the concept of containerisation;
- all the advantages linked to shorter loading and turnround times.

Carriage of cargo will be the sole source of profit on some routes and the only means to break even on others and as one airline says *"If containerisation allows an airline to increase its carriage of revenue cargo, even slightly, or effectively to improve aircraft utilisation, there is no question that containerisation becomes highly beneficial."* The containerised version of the A320 already enjoys high acceptance in the air cargo world.

* *See glossary of terms page 14*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The decision to choose bulk or containerised freight loading systems requires the study of many factors, all of which have a bearing on the ultimate decision. In this chapter these factors have been grouped into four sections :

- Company policy covering business objectives;
- Network data covering the status of all the potential route stations;
- Practical operation, in which relevant data are studied;
- Economics in which all potential costs and revenues are studied.

Company policy

The team chosen by the airline to evaluate the bulk or containerised loading options must be aware of the potential benefits offered by the container option as well as their company's policies and views on:

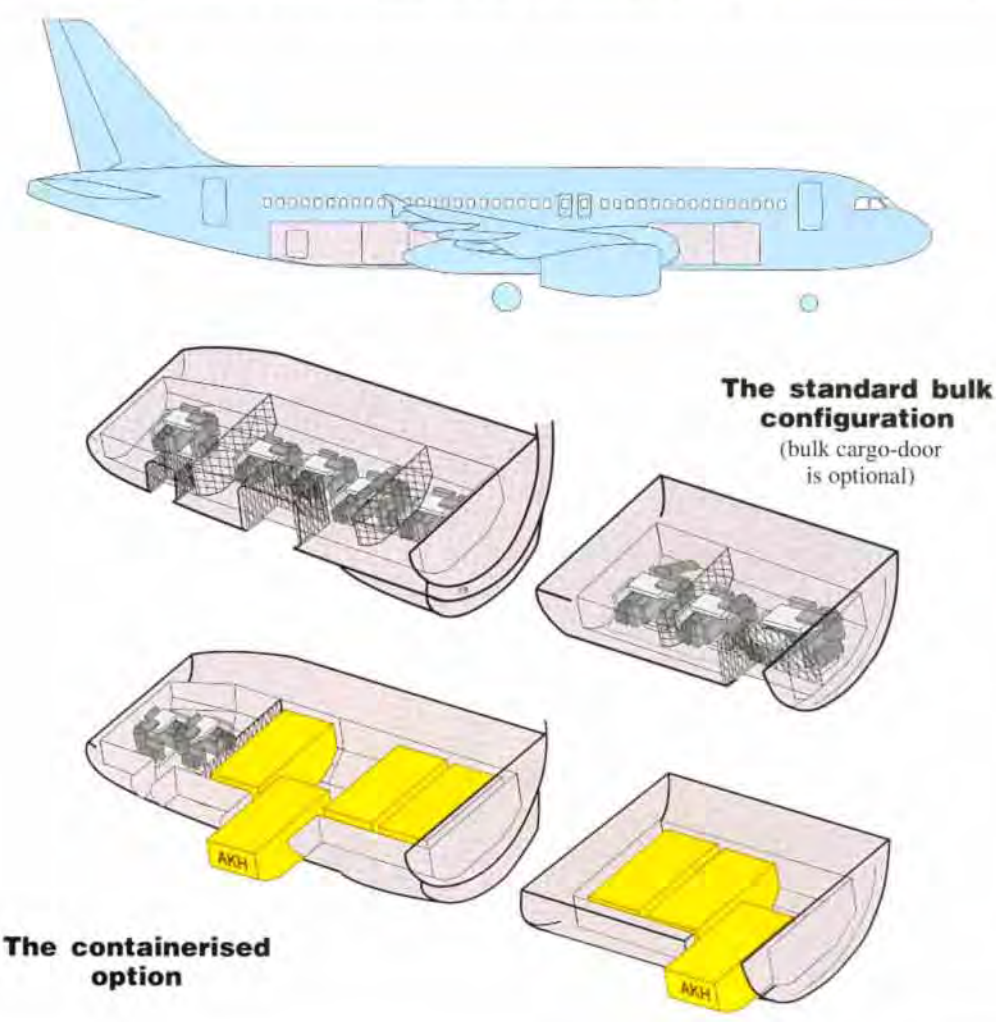
- seating layout and baggage/cargo volumes;
- desire to enter or develop the cargo market;
- marketing the volume which is available for cargo;
- possibility of transfer and interlining of loads; *The possibility to transfer baggage in containers between standard and wide-body aircraft is now being increasingly appreciated.*
- use of the 20 to 30 minute turnround capability (i.e. scheduling short turnrounds or retaining the potential to catch up on a delayed schedule. *Two container loaders would be necessary for a 20 minute turnround. For a 25 minute turnround only one container loader is necessary, with a crew of two. A crew of three may also be necessary to load the bulk hold, giving a total of five persons. In an all-bulk configuration nine persons are necessary (three per hold).*
- renegotiation of airport handling charges due to short turnrounds; *Airlines using the containerised version of the A320 have been able to negotiate reduced handling charges.*
- exploitation of fast baggage delivery, reduction of pilferage and weather damage;
- reduction in injuries to bulk loading staff;
- better customer service;
- flexibility to operate certain flights in bulk loading mode.

Practical operation

Having everything available at the right time in good working order is essential for the efficient turnround of an aircraft. The type of ground operation chosen will have a serious effect on the operating economics. One must therefore study:

- loading/unloading times (bags/kg per minute);
- manpower required (and their training);
- loading procedures;
- location and availability of Ground Support Equipment (GSE);
- positioning, storage and maintenance of new GSE;
- ULD control;
- individual ULD restraint allowing better aircraft Center of Gravity control;
- increased utilisation of gates and aircraft;
- better use of GSE and labour resources;
- ability to unload and load maximum allowable containerised volumes and weights even during 20 minute turnround times;
- fast loading, which is a requirement for the successful carriage of live animals and perishable goods;

A320 - THE LOWER-DECK COMPARTMENTS



❍ ability to load packages which take up the maximum available volume or maximum permitted weight, which would otherwise not be possible. When carried in wide-body aircraft the LD3-46 can carry the same maximum weight as the LD3;
❍ possibility of remote loading of ULDs, in an environment better adapted to work conditions, thus with less handling and less damage;
❍ occasional bulk loading stations.

Network data

In order to develop an adequate background for investment, routes must be planned and each station studied to define its needs. For example:

For the whole network:
❍ fleet size;
❍ flight schedules;
❍ additional flights due to short turnround times;
❍ aircraft annual utilisation;

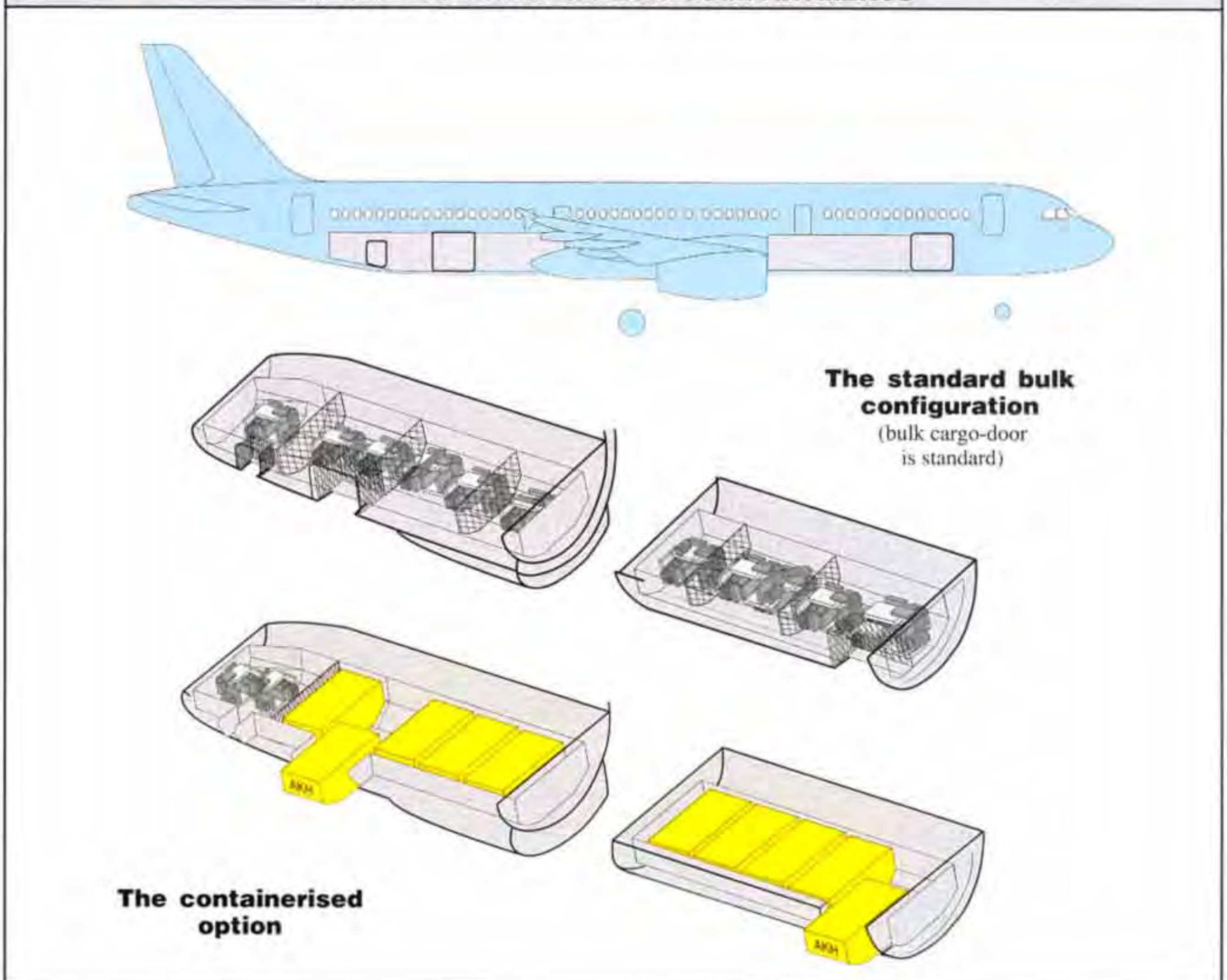
At each station:
❍ number of passengers;
❍ baggage weight and volume;
❍ quantity of baggage containers needed;
❍ possible quantity of freight containers;
❍ quantity of ULDs;
❍ number of aircraft on the ground simultaneously (including other types using same GSE);
❍ any GSE already available on station? Would its availability suit the proposed schedule? If not, what additional GSE would be necessary?
❍ self or contract handling;

For each aircraft:
❍ quantity of ULDs (per ULD position in the aircraft).

Economics

All the potential costs, investments and revenues must be calculated for both systems:
❍ additional system and ULD weight ;
❍ additional fuel consumption from greater MWE and OWE;
❍ baseplate restraint allowing lower MWE.
❍ cost of manpower,
❍ cost of maintenance of GSE and ULDs;
❍ cost of controlling the movement of ULDs;
❍ cost of ground handling contracts;
❍ investment in aircraft systems and in GSE, ULDs, warehouse and storage equipment; *Less storage space required for ULDs compared with baggage trolleys.*
❍ improved revenue from freight;
❍ savings from reduced pilferage;
❍ savings from fewer injuries to loading staff; *One large North American airline has calculated that the savings to be realised from reduced pilferage, reduced damage to baggage and cargo (handling is reduced by 50%) and reduced industrial injury, amounts to over US$ 50,000 per aircraft per year!*
❍ *savings from lower turnover of staff; Several European airlines are now finding difficulty either in employing staff to bulk load aircraft, or in keeping them in that job. As early as possible the loaders get themselves transferred to other jobs, usually because of frequent industrial injuries;*
❍ savings due to reduced labour costs;
❍ revenue from greater aircraft utilisation;
❍ rate of return on investment. *The rate of return on investment in the aircraft is potentially enhanced due to its containerised cargo carrying capacity and ability to pick up full loads during short turnrounds, thus maximising its utilisation.*

A321 - THE LOWER-DECK COMPARTMENTS



Notes

1) Only the cost of handling freight during a turnround is considered. Whilst the cost of handling the baggage may increase due to the hire of, or investment in, GSE, it is believed that this additional cost is more than offset by better service to the passengers - faster baggage arrrival and less damage, and shorter turnrounds allowing lower handling charges and higher utilisation of the aircraft.
2) Tow tractors for baggage or container trains have not been included in the investment calculations since it is assumed that the same quantity would be required for either system.
3) Manpower and belt loader for the bulk hold have not been included since they are required for both versions.
4) Belt loaders and baggage trolleys may exist at some stations, but they still have to be paid for so their repayments should be included in the bulk loaded version.

1.1 - OPERATING COSTS - CONTAINERISED VERSION

Aircraft type A321 Fleet size 10

Annual utilisation: 2080 flt cycles 920 km sector length 2600 flt hours

Average pax load 125 (67%) ULD ratio for baggage / freight 4 / 6 **[A]**

ADDITIONAL FUEL CONSUMPTION due to extra MWE/OWE (Baggage containers only. See note 5)

EXAMPLE

/ IATA cont. G at / kg tare weight = ...

4 IATA cont. H at 79 kg tare weight = 316

6 Pallets at 60 kg tare weight = 360

Cargo systems at 92 kg = 92 (64kg per A320, 92kg per A321 increase in MWE)

Total increase in MWE/OWE = 768 kg

With fuel burn at 0.029 kg per block hour per kg of installed weight therefore: (See note 11)

768 kg of installed weight x 0.029 kg of fuel x 2600 flight hours per year x 28 cents per kg of fuel

Annual cost of additional fuel consumption per aircraft = $ 12,435

Annual cost of additional fuel consumption per aircraft using ULD ratio in line A (See notes 1 & 6) = $ 7461 **[B]**

MANPOWER FOR LOADING/UNLOADING BAGGAGE AND FREIGHT

2 men x .5 hours x 470 flights per year x $ 40 per m/h = $ 18,800
2 men x .75 hours x 1100 flights per year x $ 40 per m/h = $ 66,000
2 men x 1.0 hours x 250 flights per year x $ 40 per m/h = $ 20,800
= $ 104,800

Therefore annual manpower requirement per aircraft using ULD ratio in line A (See notes 1 & 6) = $ 62,880 **[C]**

MAINTENANCE COSTS FOR ULDS AND GSE (See note 9)

Assume 15 % of the investment per year for the fleet (line I) = $ 353,370

Therefore annual maintenance costs per aircraft = $ 35,337 **[D]**

GROUND HANDLING CONTRACTS

250 turnrounds at $ 900 each = $ 225,000
.... turnrounds at $ .... each = $ ....
.... turnrounds at $ .... each = $ ....
= $ 225,000

Annual ground handling costs per aircraft using ULD ratio in line A (See notes 1 & 6) = $ 135,000 **[E]**

ADDITIONAL ULD CONTROLLERS

2 men at $ 80,000 per year including overheads = $ 160,000

Therefore annual cost of controllers per aircraft using ULD ratio in line A (See notes 1 & 6) = $ 9,600 **[F]**

TOTAL ANNUAL OPERATING COSTS PER A/C (B+C+D+E+F) = $ 250,278 **[G]**

5) The weights of pallets and containers used for the carriage of freight have not been included in the OWE because they are normally included in the weight of the freight. However this may vary depending on operator practice.

6) Only two men are required to offload/load containers and pallets from the forward and aft compartments in 25 minutes but six men are required to unload/load bulk from the same compartments. For turnrounds of 20 minutes two container loaders would be required, each with two men.

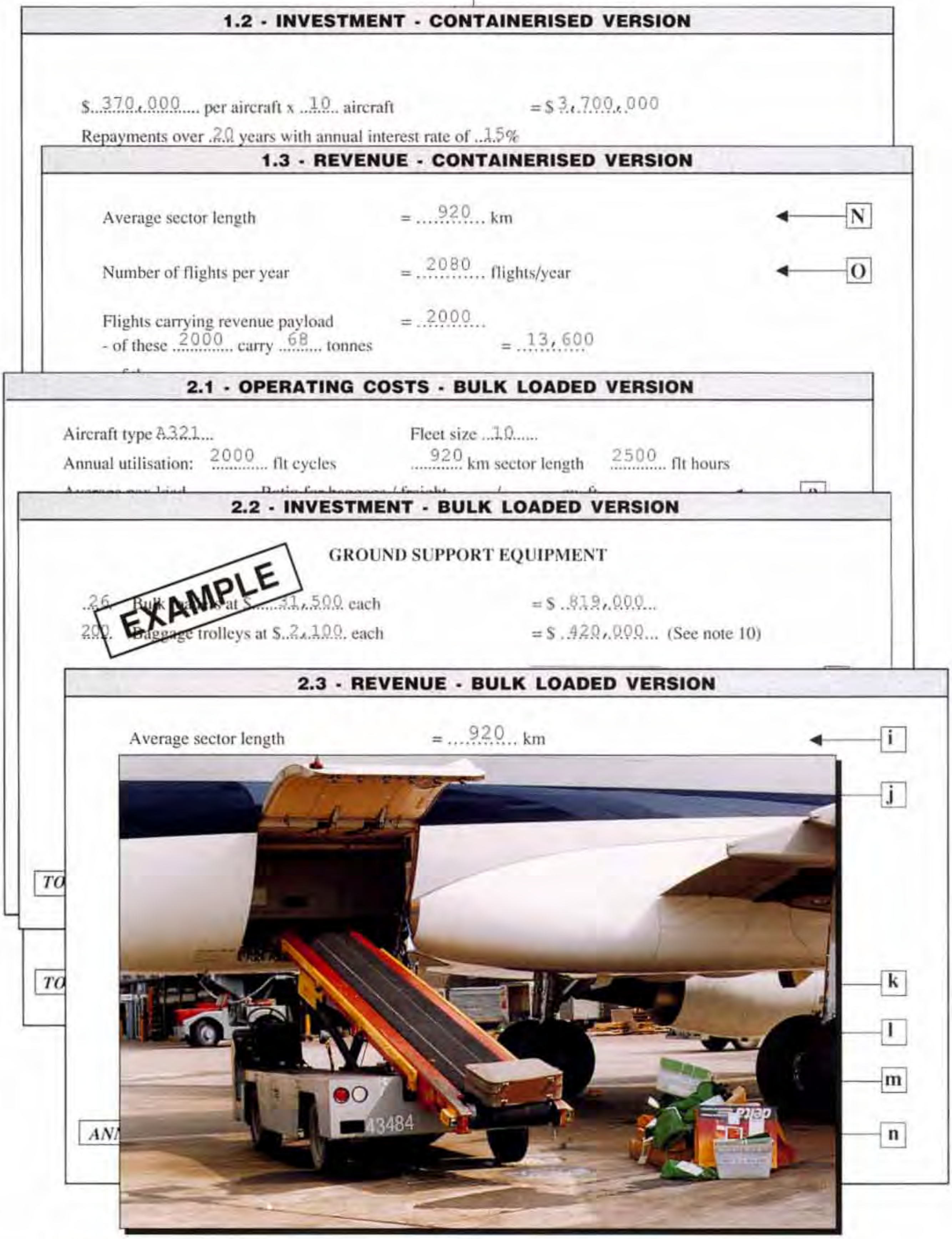
7) Aircraft utilisation may be slightly increased for the containerised version due to its potential for allowing shorter turnrounds and therefore more time in the air.

8) The number of ULDs required per aircraft will vary due to the route network and type of operation and typically can range between 3 - 7 per aircraft position for baggage and 5 - 12 for freight.

9) Percentage for maintenance and period for depreciation will vary depending on usage.

10) At airports where storage space is limited, the ability to stack containers may be of considerable value. They could take up much less space than baggage trolleys.

11) Fuel burn varies with aircraft weight and sector length. A typical figure for the A320 on a 500nm sector would be 0.023kg of additional fuel burnt per block hour per extra kilo of installed weight. For the A321 the figure would be 0.029kg.



3.1 - CONTAINERISED VS BULK LOADING SUMMARY OF ANNUAL PROFITS PER AIRCRAFT

EXAMPLE

	CONTAINERISED	BULK	
Additional fuel cost (line B)	= $ 7,461		
Ground handling charges (lines C+E)	= $ 197,880	(b+d) 357,000	
Cost and control of GSE (lines D+F+L)	= $ 111,115	(c+g) 34,849	
Total costs	= $ 316,456	391,849	← o
Revenue from freight (line R)	= $ 3,753,600	(m) 2,001,000	
Savings due to:			
Reduced pilferage	= $ 20,000		
Fewer industrial injuries	= $ 50,000		
Increased aircraft utilisation	= $ 100,000		
Increased GSE utilisation	= $ /		
Increased gate utilisation	= $ /		
Total income	= $ 3,923,600	2,001,000	← p
Annual profit (loss) per aircraft (p - o)	= $ 3,607,144	1,609,151	

DIFFERENCE = $ 1,997,993

CONCLUSION

The containerisation of freight loads in aircraft is the main ingredient in the success of today's worldwide air freight industry. This is because it serves the customer well whether the customer is a passenger whose baggage arrives more quickly, undamaged and not pilfered, or an exporter who can pack his own goods and know that they will be delivered safely and quickly.

The ability to carry containers and pallets in wide-body aircraft became accepted practice twenty years ago. Successfully implemented, it is now so widely accepted that it requires an effort to recall all its advantages. Moreover, containers and pallets have become the key element in making the air freight industry the success it is.

When extending the unitisation of freight loads to standard-body aircraft it is of paramount importance to design the aircraft system so that it is as close as possible to the standards which already exist worldwide, including carriage of the most successful Unit Load Devices. This reasoning was the background to the decision to offer an LD 3-based containerised cargo system as an option in the A320. This option already enjoys high acceptance in the airfreight world, and will be available in the A321.

There are some very distinct gains to be made from using the container loading system. The major one is the ability to carry full loads of freight even on 20 minute turnrounds. Some others may be difficult to quantify in money terms, but they contribute directly to improving the reputation of the airline, and include:

- better customer service, faster baggage delivery, less damage to baggage due to handling and weather:
- reduced turnover of staff due to improved working conditions;
- improved labour relations. ❑

Copies of a brochure "Advantages of containerisation on A320 and A321" may be obtained from Denis Dempster, Editor, FAST Airbus Technical Digest - Tel: +33 (61) 93 39 29 Fax: +33 (61) 93 31 01

Glossary of terms

GSE	Ground Support Equipment
IATA	International Air Transport Association
LD	Loading Device (i.e. container)
MWE	Manufacturer's Weight Empty
NAS	National Aerospace Standard
nm	Nautical mile
OWE	Operating Weight Empty
ULD	Unit Loading Device

Airbus Service Company Inc., Spares Center

21780 Filigree Court
Ashburn, Virginia 22011-6205
USA

Airbus Industrie of North America and its product support subsidiary Airbus Service Company, officially opened a new 65,000 sq.ft aircraft spare parts and distribution center at the above address on June 4th. Located in Loudoun County, Virginia near Washington DC's Dulles International Airport, it is the first facility in the United States wholly-owned by an affiliate of Airbus Industrie.

The warehouse was purposely designed to enable Airbus Service Company (ASCO) to meet the needs of its customers and it can quickly and economically be expanded to 105,000 sq. ft. when the need arises.

In the past seven years the Airbus customer base in this region has grown from one airline operating thirty-four A300s to twelve airlines and leasing companies with more than five hundred A300s, A310s, A320s, A330s and A340s in operation or on order. Airbus Industrie is forecasting a worldwide need for 11,500 new aircraft in the period ending in 2009. As North America accounts for almost half the world market it can expect substantial growth. Airbus support facilities must therefore also grow to meet that demand.

The Spares Center not only supports Airbus aircraft operating in the United States and Canada, but also those of companies based outside North America operating into the area. It could also be called upon to expedite replacement parts to other continents.

The current Airbus aircraft spare parts inventory in the United States is valued at about $US 125 million. The Spares Center employs forty-five people and has an initial spares stock of about $US 80 million. It signifies Airbus Industrie's commitment to support its growing number of airline customers in the United States and Canada.

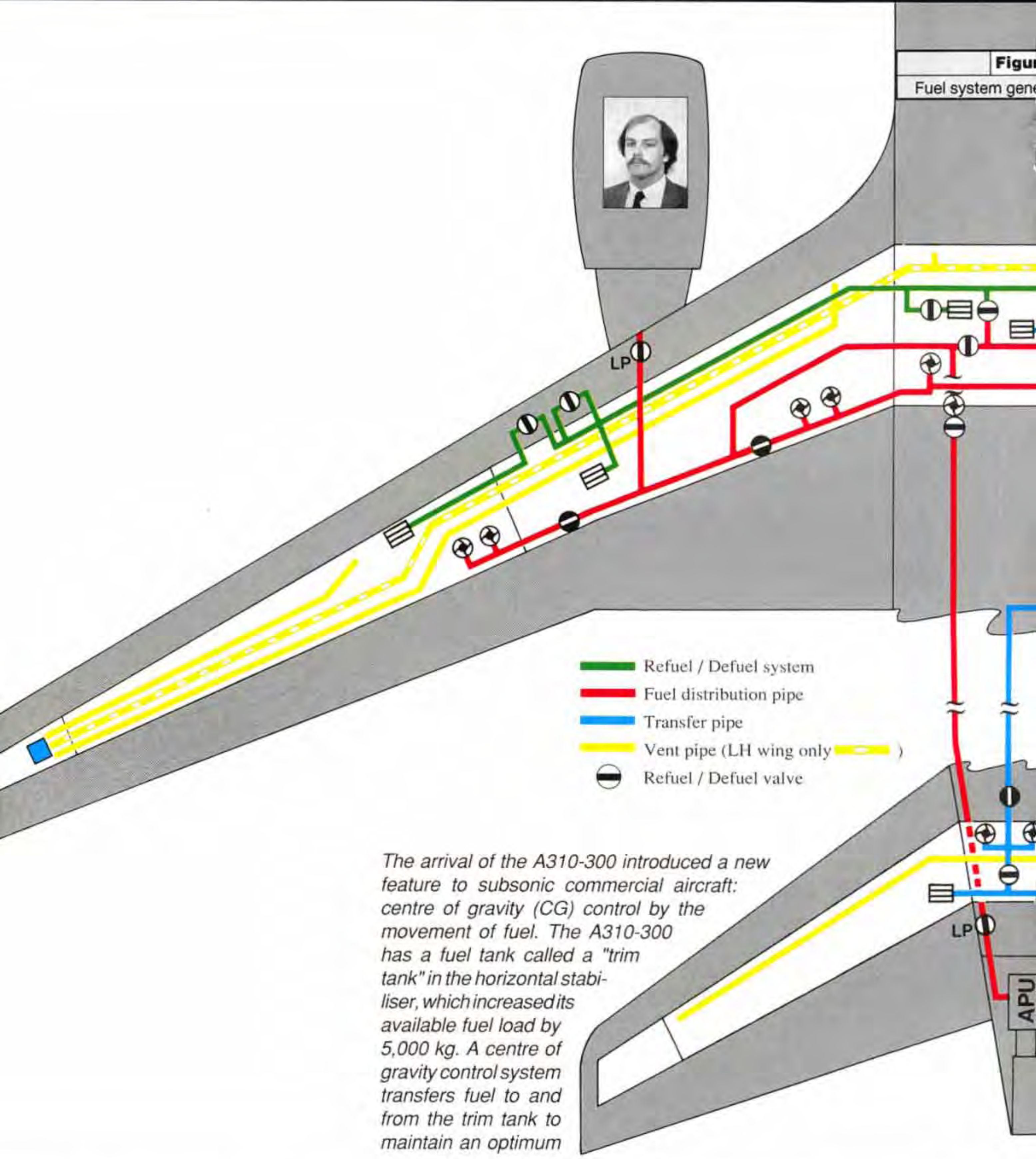
The stock is composed of proprietary parts, including "insurance spares", covering about 40,000 part numbers, for delivery under AOG or Critical conditions. Each part and each shelf location is bar coded. The stock is managed with the help of ASCO's own computerised stock control system, called ASCO Material Management System (AMMS). It is linked to the computer in Airspares, the Airbus Spares Center in Hamburg, Germany, and it can reply to operator queries automatically in accordance with the requirements of ATA Spec. 2000. An AOG (aircraft on ground) service is in operation 24 hours a day.

The ASCO Spares Center close to Washington Dulles airport complements the main spares center in Hamburg and the distribution center, primarily of parts available for lease, in Hong Kong. ■

ASCO Spares Center can be contacted at:
Telephone: +1 (703) 729 4300
Telefax: +1 (703) 729 4343
and the AOG operations room at:
AOG telephone: +1 (703) 729 9000
AOG telefax: +1 (729) 4373

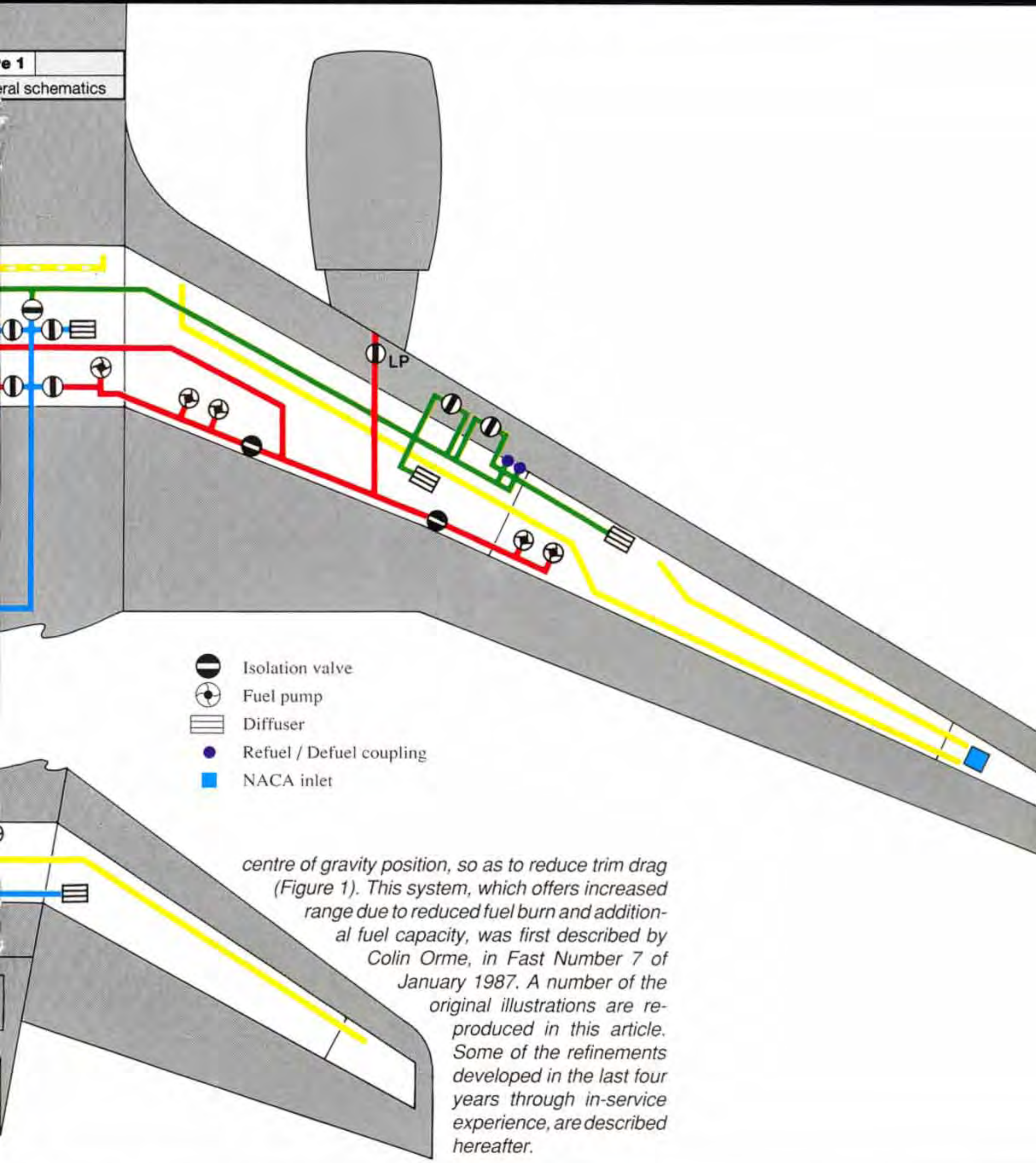
REFINEMENT OF THE CENTRE OF GRA

by Nigel Hitchman
Airbus Product Support / Technical Support
Senior Engineer Fuel System



The arrival of the A310-300 introduced a new feature to subsonic commercial aircraft: centre of gravity (CG) control by the movement of fuel. The A310-300 has a fuel tank called a "trim tank" in the horizontal stabiliser, which increased its available fuel load by 5,000 kg. A centre of gravity control system transfers fuel to and from the trim tank to maintain an optimum

VITY CONTROL SYSTEM ON A310-300



centre of gravity position, so as to reduce trim drag (Figure 1). This system, which offers increased range due to reduced fuel burn and additional fuel capacity, was first described by Colin Orme, in Fast Number 7 of January 1987. A number of the original illustrations are reproduced in this article. Some of the refinements developed in the last four years through in-service experience, are described hereafter.

The centre of gravity is controlled by the Centre of Gravity Control Computer (CGCC). It is active when trim tank mode is selected to Auto and at least one of the two trim tank pumps is switched on (Figure 2).

The CGCC has two functions, one of which is command and the other monitor. It computes the actual centre of gravity position according to:

- fuel quantity in each tank;
- fuel tank moment data (CG of each individual tank corrected for aircraft pitch attitude by the Inertial Reference System);
- Zero fuel weight (ZFW) and zero fuel centre of gravity (ZFCG) position which are entered into the CGCC by the crew through the control and display unit of the flight management system (FMS);
- other miscellaneous inputs. The CGCC determines a target centre of gravity position, which moves as aircraft altitude and weight change, and by transferring the fuel forward and aft, keeps the aircraft at the target position.

OPERATION

At the refuelling stage the trim tank would only have fuel put in it if more fuel is required than can be held in the other tanks. The trim isolation valve is closed automatically during take-off and opens when the slats are fully retracted (Figure 3a). An indication is given if it does not open. In climb, up to Flight Level 205 (approximately 20,500 feet), the centre of gravity target is used only to transfer fuel forward in the event of the CG position having moved too far aft. No aft transfer is possible below FL205. Above FL205 the CGCC transfers fuel forward and aft (Figures 3b and 3c) as necessary to keep the aircraft at its optimum CG position. On descent, crossing FL200, all fuel in the trim tank is transferred forward provided the forward CG position limit is not exceeded and the centre tank has the available capacity. The CGCC is programmed to take into account the many variations in flight profile which an airline can expect, from short flights when the aircraft never reaches FL205 to very long flights which use up most of the fuel.

MONITORING AND FAILURE DETECTION

When the CG control was added to the A310, the CGCC was enhanced by including the capability to monitos the FQI values. For example:

- Check of the FQI value at a particular point during refuelling, done when the calibration sensor becomes wet, which is at around the 1,000 kg point in all tanks, except the outers.
- Check of the increase in fuel weight for a given period during refuel to ensure no sudden changes.

Figure 2

Fuel system control panel

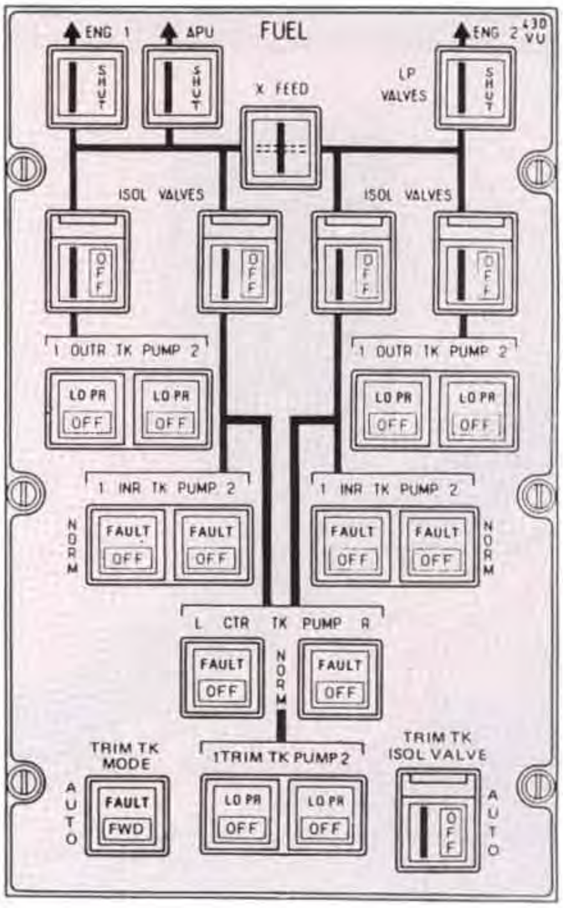
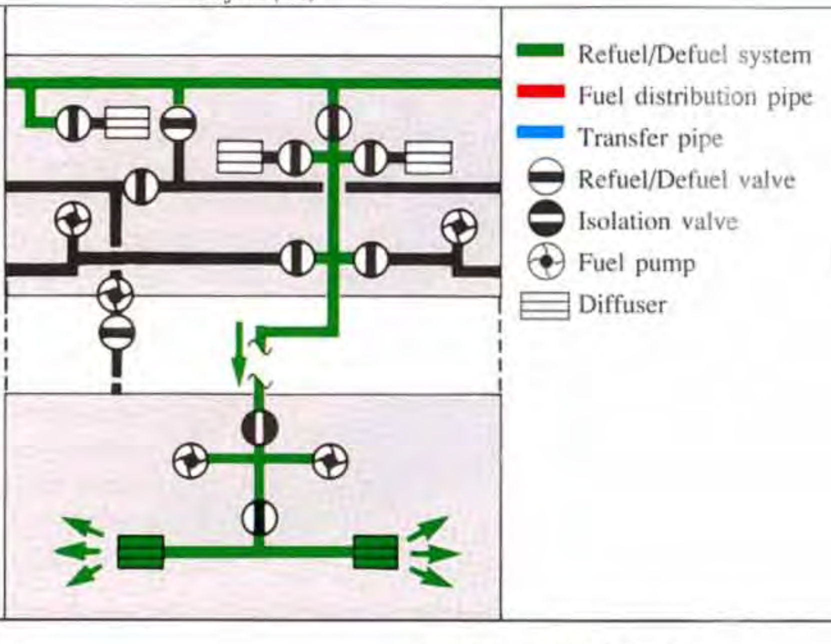


Figure 3

System layout and operation

Refuel (3a)



● Check of the FQI for each tank during flight based on the quantity at take-off, corrected for engine burn, from the fuel flow meters and transfers based on the valve positions and known transfer rates.
● Check of the status of ARINC and discrete inputs from Fuel Quantity Indicator Computer (FQIC), level sense amplifier, fuel flow meters, FMS, Inertial Reference System and Digital Air Data System.
● Check of the status and correct operation of all transfer valve and fuel pumps.

If no faults are detected, the CGCC continues in normal mode. Depending on the types of failures detected the CGCC can enter into two other modes:
● **Alternate mode**, signified by ECAM message "AFT XFR NOT AVAIL". Full CGCC control is maintained and no crew action is required. It happens when a discrepancy between the FQI data and the CGCC monitor channels or certain peripheral failures occur. In alternate mode the CGCC transfers fuel forward only, ensures the CG is maintained within safe limits and prevents the centre tank from overfilling.
● **Fault mode**, signified by ECAM message "TRIM TK SYSTEM FAULT". The CGCC either cannot maintain CG control (due, for instance, to a failed valve), or it cannot calculate the CG correctly (due, for instance, to failed FQI signals). Now the CGCC gives up control and the crew is instructed to manually transfer all fuel forward, monitoring the centre tank quantity to ensure it is not overfilled.

An independent monitor of the CG is maintained using the horizontal stabiliser position monitor. Here the aircraft CG can be exactly measured by knowing the amount of stabiliser trim required for the present flight conditions, thus inferring the CG. This unit will provide for the A310-300 an aft CG warning at 41% and excess aft CG warning at 43%. If these warnings occur, the crew are advised on ECAM to manually transfer fuel forward to ensure the aircraft aft CG limit is not exceeded.

To our knowledge, Airbus has never had an aft CG warning due to a CGCC system failure, but warnings have been seen due to incorrect cargo loading, leading to wrong ZFW and ZFCG figures being entered in the FMS.

IMPROVEMENT PROGRAMME

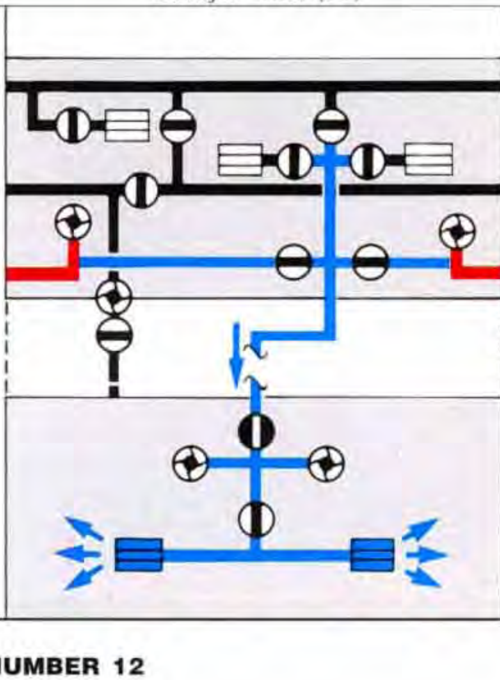
During the early days of trim tank system operation, a number of CGCC alternate and fault modes were seen due to the FQI monitor being tripped. These were found not to be due to FQI errors as was expected, but to components of the fuel system failing, causing the monitor values to be incorrect. Thus, although the FQI values were correct and the calculated CG and its control correct, the CGCC thought it detected an error.

The following Service Bulletins were issued:
● **Increase the monitor tolerance margins on the CGCC**
→ *Airbus Industrie SB A310-31-2044.*
● **Change the fuel pump diaphragms** Failed diaphragms, although maintaining a good supply of fuel for the engines and aft transfer, were not giving a transfer at the expected rate and so the monitor failed.
→ *Intertechnique SB 205-28-05/06*
● **Improve the fuel pump canister non return valve** - Leaks from one tank to another through sticking non-return valves made the CGCC think the FQI was incorrect, thus causing the monitor to fail.
→ *Intertechnique SB 205-28-01*
● **Modify the fuel feed pipes in the centre tank** - Cracked pipes, as well as affecting the fuel distribution, also caused the CGCC to go into alternate mode.
→ *Airbus Industrie SB A310-28-2043*
● **Trim tank pump control** - Change required due to operators mistakenly leaving the pumps running on ground during fuel transfer. Control was added to automatically turn off the pumps five minutes after the low level sensor was dry, on ground as well as in flight.
→ *Airbus Industrie SB A310-28-2036*

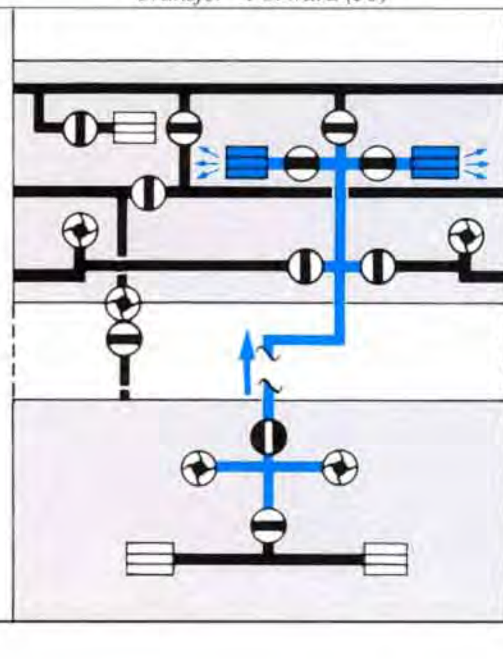
Subsequently, some more causes of alternate and fault modes have been seen and are resolved as follows :
● It was found that water in the trim tank, if not sufficiently drained was adversely affecting the FQI. An improved drainage procedure has been added in the Aircraft Maintenance Manual, where a suction pump can be used. During aft transfer, water around the probe no. 8 would be pushed up into the probe and cause a large over-read, thus leading the CGCC to detect a fault and go to alternate mode. In addition, at the end of a long flight, when the trim tank was emptying, frozen water would collect on the probe and cause an over-read of up to 800 kg, with the consequence that the pumps continued to run with the tank empty, and therefore a trim tank system fault and ECAM warnings would appear to turn the pumps off.

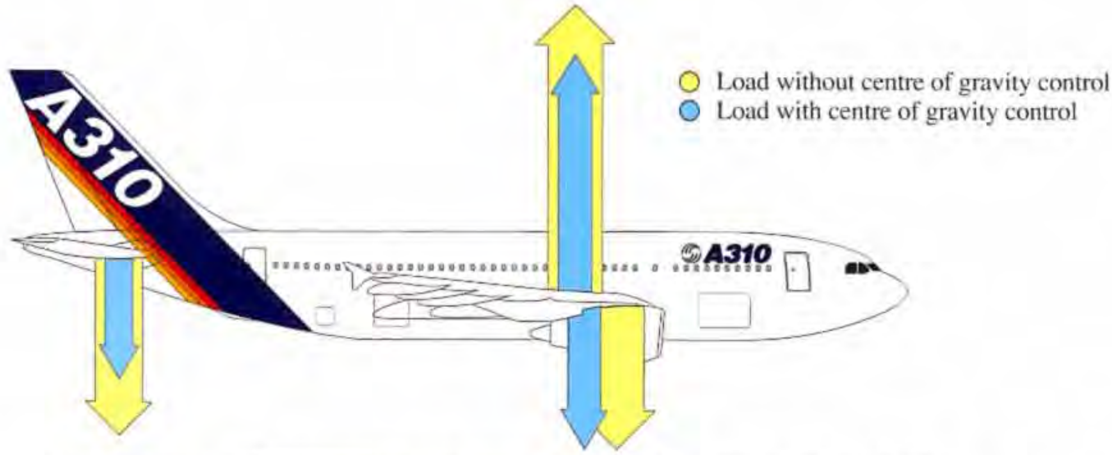
A modification introduces a shortened probe no. 8 to increase clearance to approximately 25 mm from the bottom of the tank. Additionally, the water drain pick-up point is relocated to a more optimum position and the design improved.
→ *Airbus Industrie SB A310-28-2045, and A300-28-6025.*
● On the A300-600R only, there were occurrences of CGCC alternate mode during refuelling due to the FQI rate of change monitor being exceeded. It was

Transfer - Rear (3b)



Transfer - Forward (3c)





found that the monitor rate was very close to the actual refuel rate and had a much narrower tolerance than required, therefore that tolerance has been widened.

- On aircraft flying very long flights, of approximately five to twelve hours duration, it was found that on some flights the FQI monitor based on fuel transfers and engine burn was failing, but with no failure of the FQI or the monitoring system. Analysis showed that it was probable that during all the auto feed changeovers and transfer start and stops, the monitor values used were changing frequently and could introduce integration errors which, together with other differences within individual tolerances, could in fact fail the monitor. To prevent this failure, it was decided to take advantage of the calibration sensor check of FQI during refuel and carry out this check in flight when the sensor dries. If the check is successful, then the other monitors will be reset to the defined FQI value at the calibration sensor level, rather than the previously integrated value. This is provided by a modification to the CGCC.
- The CGCC has been found susceptible to power interrupts causing it to go into alternate or fault mode during power transfer on ground. Additionally, this was also found to be corrupting the bite memory causing it to become unreadable. An improvement has been made to the power interrupt handling of the CGCC.

Whereas previously a different standard of computer was required for each version, the CGCC family is now rationalised to include only two versions of the computer able to be fitted on aircraft with up to two additional centre tanks by use of pin programming:

→ for A310-300, the B473ACM2, *SB A310-31-2050*,

→ for A300-600R, the B473ABM2, *SB A300-31-6036*.

RECOMMENDATIONS

Water drainage

Operators are recommended to ensure that regular water drainage is carried out according to the recommendations in the Maintenance Planning Document, and using procedures contained in the Aircraft Maintenance Manual. Operators report a considerable improvement of the trim tank system if water drainage from the trim tank is done at least once a week. An optional water scavenge system is being developed which will automatically remove water and reduce the importance of the water drainage task.

Trouble shooting

When a trim tank system fault occurs, it can be due to a variety of failures of a number of systems monitored by the CGCC. Prior to starting trouble-shooting, it is essential to correctly read the bite for the CGCC and the FQI, analyse the crew reports and to follow advice in the Trouble- Shooting Manual or the "Trim Tank Trouble-shooting Guidelines" booklet issued by Airbus Industrie Product Support Technical Department (ref. ST22/948.1341/90 - November 1990).

Due to the dynamic nature of the trim tank system and its monitoring, the system can often appear to have no fault on ground and be reset, only to fail again the next flight. Only by reading the bite and proper trouble-shooting, can failure be identified and rectified.

ECAM warnings and crew action

Two main ECAM messages are associated with the trim tank system to tell the crew the status, and, in one case, to request action (they are not guidelines how to trouble-shoot the aircraft, this is provided from the bite).

- "TRIM TANK AFT XFR NOT AVAIL" notifies an *alternate mode* where the CGCC still retains full control of the system and no crew action is required.
- "TRIM TANK SYSTEM FAULT" notifies a *Fault mode* where the CGCC no longer controls the system and the crew is instructed to manually transfer the fuel forward.

Manual control

Manual forward transfer is carried out with both trim tank pumps selected on and the forward mode push-button selected to forward. This opens both the forward and auxiliary transfer valves and the pumps will run until switched off by the crew. It is therefore essential that when carrying out a manual forward transfer, the crew monitor the trim tank quantity to ensure the pumps are turned off once the tank is empty and sufficient space in the centre tank is provided to ensure it is not overfilled. Five minutes after low level, an ECAM warning will occur to tell the crew to turn off the trim tank pumps, if they have been left running. This must be followed and the forward mode push-button put back to the auto (released) position.

Load sheet

It is essential that the load sheet is accurate in order to fully benefit from fuel saving due to optimum CG control. The CGCC can only operate based on ZFW and ZFCG input to the FMS. If these figures are wrong, then although the CGCC may think it is maintaining an optimum CG, the real CG may be completely different. The independent stabiliser position monitor will ensure that a warning will occur if the CG gets too far aft, but there is nothing to check if the CG is really optimum.

CONCLUSION

The trim tank system has been in service for over five years with improving reliability, providing reduced fuel consumption and increased range for a large number of operators. The system is a complex one but, when maintained and serviced in the correct way, can generate many savings for Airbus operators. Emphasis should be put on water drainage, embodiment of all modifications and proper trouble-shooting of any faults. ■

TCAS II

By Peter Potocki de Montalk Department Manager Cockpit/Avionics Engineering Directorate

By now, most people in the aviation industry have heard of TCAS II (*) and many of them are involved in this programme. There are many descriptions of TCAS, but perhaps the most appropriate one is «civil aviation's biggest-ever avionics programme».

The purpose of this article is to describe what TCAS II is, how it got to be that way, who needs it, how it works, and how we build it into the aircraft that Airbus Industrie makes, both new and already in service.

TCAS II (pronounced Teekass Two) is the acronym for Traffic Alert and Collision Avoidance System. It is a system designed to alert the crew to the presence of other traffic in their immediate area which could cause a collision risk, and provide them with advisories that enable them to achieve safe separation, by climbing or descending.

TCAS is designed to be an added aid to safety - it is certainly not a substitute for Air Traffic Control or for seeing-and-avoiding other traffic. It is designed to operate in such a way as to avoid needless disturbance to the Air Traffic Control System. Extensive studies have been performed (by the FAA and other civil aviation authorities worldwide) to estimate the safety improvements TCAS II can bring. These show that although TCAS II cannot handle all situations, it is expected to resolve nearly all of the critical airmisses involving airline aircraft.

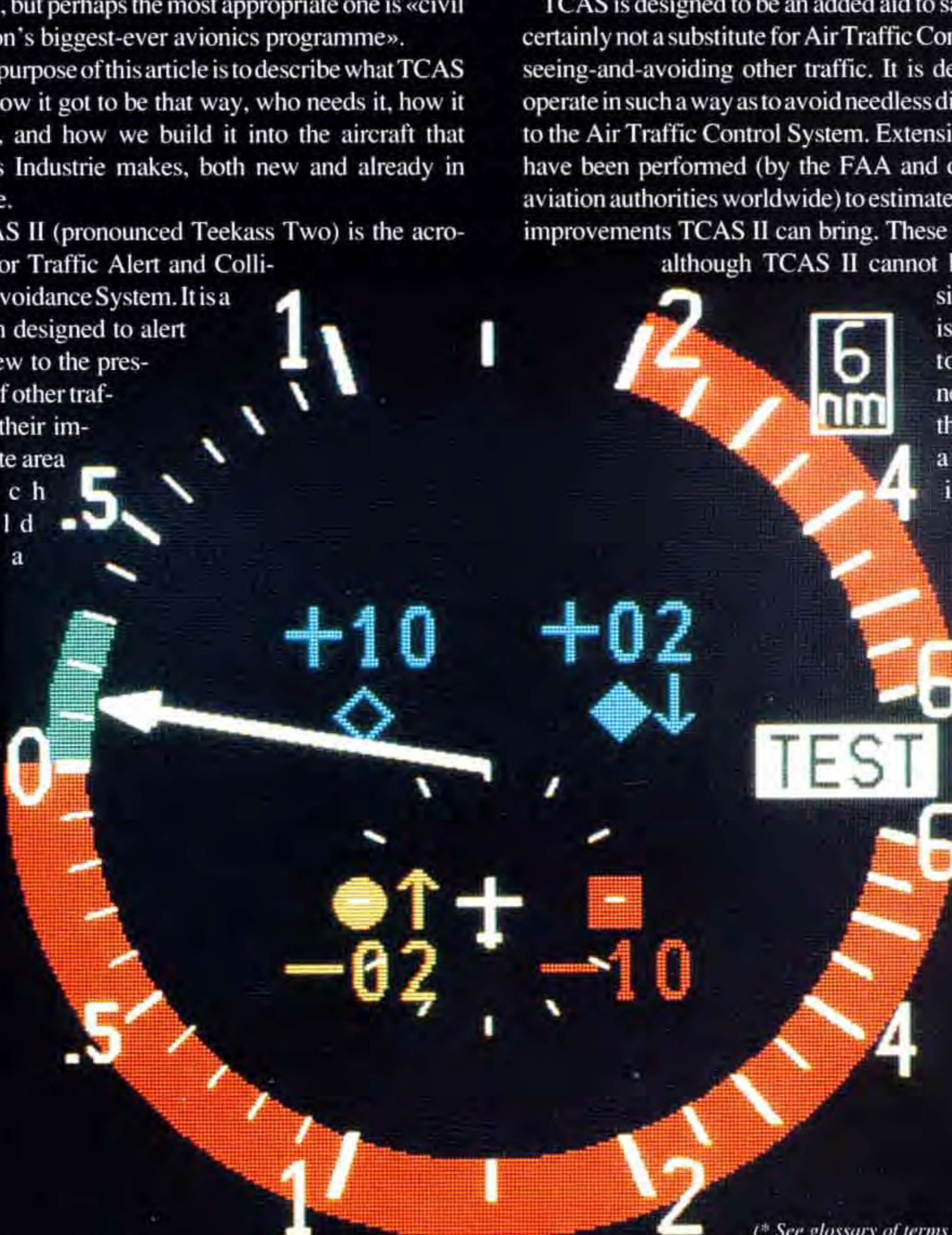


Photo: JC Berthomieu (Aerospatiale)

(* See glossary of terms on page 29)

The FAA has defined three types of TCAS. TCAS I is for smaller aircraft than Airbus Industrie makes, and TCAS III is at present in the experimental stage (it issues "fly-left" and "fly-right" advisories in addition to the vertical axis advisories of TCAS II). TCAS III is not expected to be ready for airline service for a number of years.

This article discusses TCAS II - the system which we are installing.

HISTORY

The development of an effective anti-collision system has been a goal of many people in the aviation community for decades and particularly in the United States. TCAS has its roots in studies of collision avoidance concepts initiated by ATA in 1955/56, and some of its fundamental physical concepts were laid down by Dr John S. Morrell of Bendix in 1956. During the late '50s and early '60s, studies on passive and non-cooperating systems showed them to be impractical, and studies in the late '60s by many manufacturers concentrated on transponder and time/frequency techniques. However, these needed similar equipment on all aircraft in the area. In the mid '70s, studies concentrated on BCAS (Beacon Collision Avoidance System) which relied on aircraft being equipped with Air Traffic Control Transponders (or Beacons).

In 1981, the FAA made the decision to develop this concept further for use in all traffic areas envisioned for the next 20 years. The FAA also decided that the system should be independent of the ground system. The result is TCAS.

The US Congress has required that TCAS II be carried by all turbine powered aircraft with more than 30 seats by a given set of dates (US and non-US airlines have different dates) when operating in US airspace. The widespread carriage of transponders by non-airline aircraft has also been made mandatory in much of US airspace.

The aviation authorities of many countries (including the FAA) are working through ICAO towards an international standard for a collision avoidance system, called ACAS (Airborne Collision Avoidance System). The work on TCAS and ACAS is proceeding together, with the aim of ensuring inter-operability between all the countries' requirements and equipment. This means that the industry should be able to use the same equipment worldwide, as is now the case for VOR, ILS and all other ICAO navigation and communication systems. This work is expected to continue for a number of years.

The airlines started installing TCAS in 1990, by retrofitting it in accordance with Supplementary Type Certificates, the first of which was for a Bendix TCAS on a US Air B737. By December 31, 1990 over 500 aircraft equipped with TCAS were in service. As of April 1991, more than 1500 TCAS systems had been delivered for installation, and 750 000 TCAS flight hours had been accumulated. The major airframe manufacturers are certifying TCAS on their current-production aircraft during 1991.

WHO NEEDS TCAS II

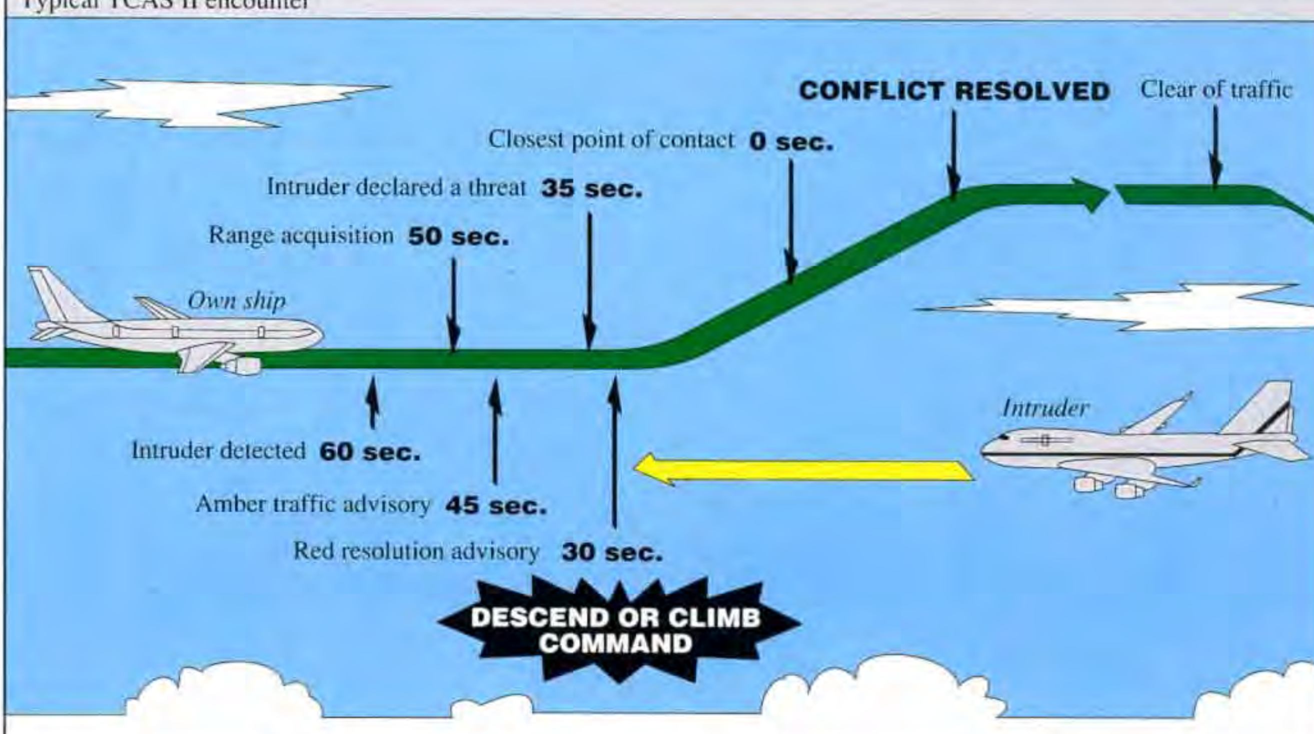
The only country which requires TCAS to be used in its airspace is the United States. No other country has declared an intention to require use of a collision-avoidance system, although officials in a number of countries have said that they intend to require an Airborne Collision Avoidance System (ACAS) in due course. We would expect this to happen only after the ICAO ACAS standards are issued in a few years' time, and in accordance with the usual ICAO implementation schedules.

The FAA requirement for TCAS II applies to all turbine-powered aircraft with more than 30 seats which enter US airspace. It applies equally to aircraft operated by US and non-US airlines, but with different time-scales for compliance. TCAS II is not required for freighter aircraft.

The compliance timescales are contained in the FAA Final Rule dated April 9, 1990, which the interested reader may obtain from his own airline's regulatory department. But to put it briefly, airlines must install TCAS II by December 30, 1993 in order to continue their operations (FAR 121.358 (a), 139.18 (c) and 125.224 (a) refer). US operators must also comply with the provisions of FAR 121.358 (a) which require phased compliance. They were required to have 20% of their total fleet equipped by the end of 1990 if they have more than 30 aircraft, and they must have 50 % of their total fleet equipped by the end of 1991 regardless of fleet size. Each carrier may choose its most convenient mix of aircraft to satisfy these requirements. The same dates apply to windshear protection features which have been installed in Airbus aircraft since 1974, and

Figure 1

Typical TCAS II encounter



updates are now available to comply with current regulatory requirements.

HOW TCAS WORKS

In order to make a collision-avoidance system work, we need to detect all the traffic around our own aircraft (we will call it *own ship*), determine whether each aircraft (or *intruder*) that we detect is likely to be a *threat* to safe separation, and then issue an *advisory* to *own ship*'s crew so that they can manoeuvre to avoid the threat (Figure 1). If the *threat* is also equipped with TCAS II it is also likely to start manoeuvring to avoid *own ship*, so we will need to communicate with it in order to coordinate the manoeuvres of both aircraft.

As an illustration, if a *intruder* is a few miles behind *own ship*, and flying on the same track and flight level at the same speed, it does not constitute a *threat*. If instead it is flying on a collision course towards *own ship* it definitely does become a *threat*, and one aircraft should climb (and the other should stay level or descend) in order to obtain safe separation. Once they have passed, both aircraft should resume their originally-intended flight paths, so as to avoid disturbance to other traffic. So we need to detect, to track, to compute, to coordinate and to display.

TCAS detects other aircraft by interrogating the *intruder's* ATC transponder, and by listening to the squitter transmissions from Mode S transponders, much like the Secondary Surveillance Radar (SSR) used by Air Traffic Control. In many ways, TCAS is an airborne SSR, with some special characteristics to enable it to perform its task. The TCAS computer contains the transmitter and receiver circuitry needed to drive the upper and the lower antennas - we need a lower antenna because the *threat* may be climbing towards *own ship*. As with an SSR, TCAS detects the range and azimuth of the *intruder*, and uses the *intruder's* Mode C reply to know its altitude.

The TCAS II computer also houses the processor, which maintains a track file on each of the *intruders*, using the range, azimuth and altitude information on the *intruder* , supplemented by data on *own ship*'s own movements from the air data and inertial or gyro systems. The *intruders* are displayed to the crew on Traffic Advisory Displays. The processor examines the tracks and determines whether any of them will result in insufficient horizontal or vertical separation from *own ship*. It also determines the time remaining to closest-point-of-approach. We call this time Tau (τ), the letter of the Greek alphabet which is a common mathematical notation for time-related parameters. When Tau is less than about 40 seconds, the processor triggers an aural and visual Traffic Advisory (TA) to alert the crew to the approaching *intruder*. The crew should not start manoeuvring in response to a TA. If Tau becomes less than about 25 seconds the processor triggers an aural and visual Resolution Advisory (RA). Preventive RAs advise the crew not to manoeuvre in a sense which would result in insufficient separation. Corrective RAs command a vertical speed sufficient to achieve safe separation as comfortably as possible. Should the *threat* manoeuvre in such a way as to counter the effect of the RA, the processor will continue computing in order to reinforce or otherwise change the RA so as to achieve safe separation in the new circumstances.

When both *own ship* and the *intruder* are TCAS II equipped, the manoeuvres need to be coordinated. To do this, information is exchanged between both aircraft using the data link capabilities of the Mode S ATC transponder which is part of the TCAS installation (during retrofits, existing transponders need to be replaced or updated to TCAS standard). This information is then used by the processor in the TCAS. The Mode S datalink RA information is also available to ATC, enabling them to determine that an aircraft is manoeuvring in response to an RA. In passing, the Mode S transponder installations that are at present in use will need to be updated again, once the operational Mode S ground stations are put into service by the aviation authorities worldwide, so as to comply with the ATC organisations' own data link needs. There is no holding back progress !

The need for minimal disturbance of the airspace and for proper coordination between TCAS II users has led to a need for even tighter control than usual of some of the system characteristics. On behalf of the FAA, Mitre Corp. supplies the necessary software pseudocode to all TCAS II manufacturers (Bendix, Collins and Honeywell) for them to incorporate into their equipment. Similarly, all three manufacturers use the same industry standard vocabulary for the synthetic voice audio alerts.

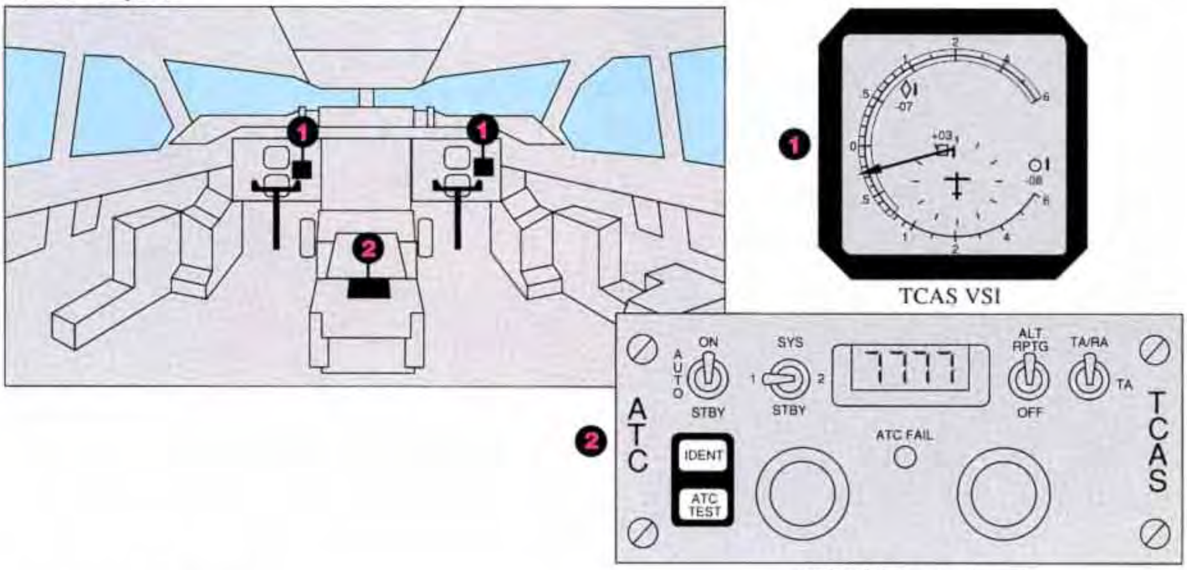
TCAS II uses a number of interlocks from the aircraft's other systems to ensure that the manoeuvres needed are within the normal performance capability of the aircraft, and that RAs and other warnings (such as GPWS) do not conflict with each other. The TCAS II procedures ensure proper operation. These include an addition to the engine-out procedure to operate TCAS in TA-only mode, so as to avoid RAs which could exceed the aircraft's engine-out climb capability.

In addition to the synthetic voice aurals, the RAs are displayed to the crew

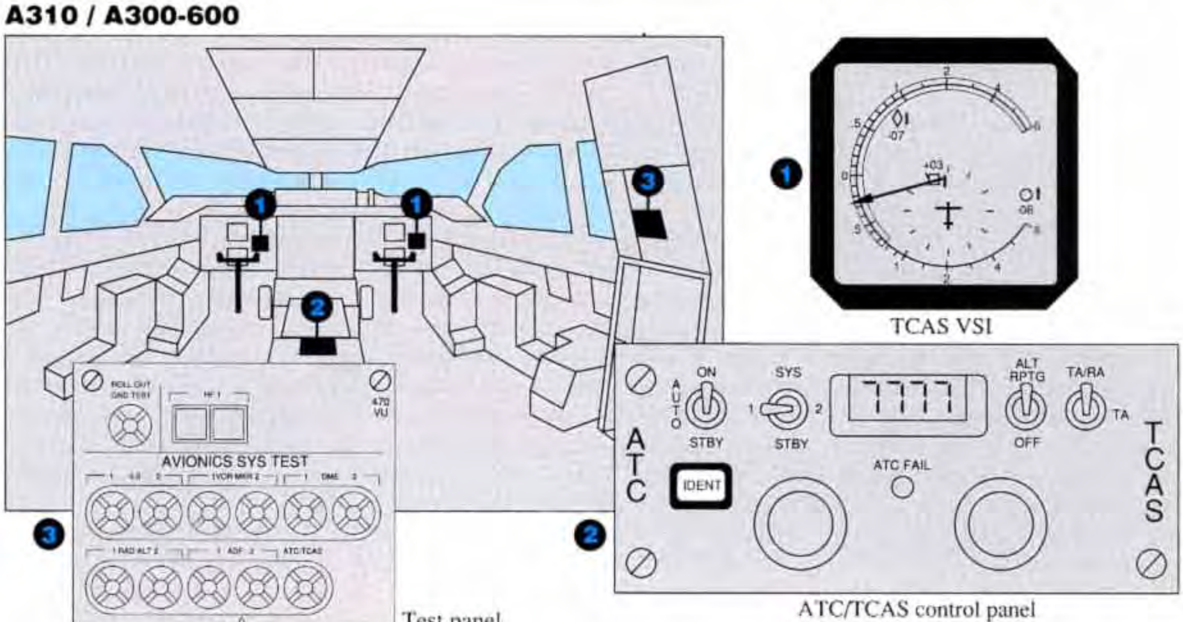
Figure 2

TCAS II cockpit typical installation

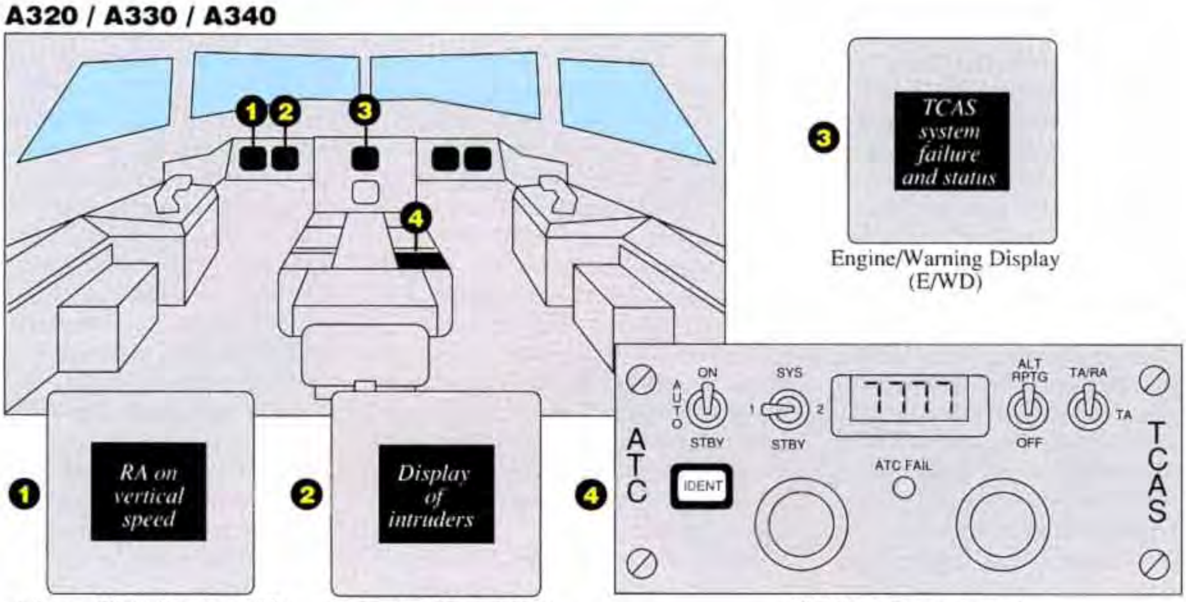
A300 B2/B4



A310 / A300-600



A320 / A330 / A340



on the VSI or PFD, depending on aircraft type (Figure 2).

Traffic advisory displays usually use the VSI or ND (depending on aircraft type), although the weather radar display unit and separate TA displays have been used in some TCAS II implementations. TCAS II tracks up to thirty-one *intruders* simultaneously, but contains logic which limits the displayed *intruders* to a number that the crew can assimilate.

The FAA is issuing AC 20-131A, showing an acceptable means of compliance when carrying out airworthiness certification of TCAS II, as well as AC 120-TCAS which addresses the way TCAS II should be used.

AIRBUS INDUSTRIE AND TCAS II

Early on in the TCAS II programme, Airbus Industrie set up a structured approach to TCAS II (Figure 3) intended to allow timely rule compliance for the operators while at the same time designing the system, so that all the changes could be incorporated in any customer's aircraft while affecting a minimum number of LRUs.

This approach was discussed with those operators who anticipated that they would be affected by TCAS rules. A step-by-step approach was agreed where the TCAS standard options would be made available first of all, and any associated changes desired by a particular airline would be developed separately to their own time-scales, as an add-on to the standard option. The TCAS standard options were themselves designed by Aerospatiale, the Airbus partner responsible for the system, so that aircraft would be delivered early with the structural, wiring and rack changes installed, so as to avoid long down-times as far as possible, and the TCAS II equipment could then be installed during overnight stops, at the operator's convenience. Airbus Industrie selected Bendix as the TCAS vendor best placed to allow timely certification of the TCAS II standard options. The Service Bulletins for retrofit of TCAS II into aircraft built with no TCAS provisions are similarly structured, so as to allow airlines to plan their TCAS provision retrofits to coincide, as far as possible, with the maintenance down-time scheduled for each aircraft.

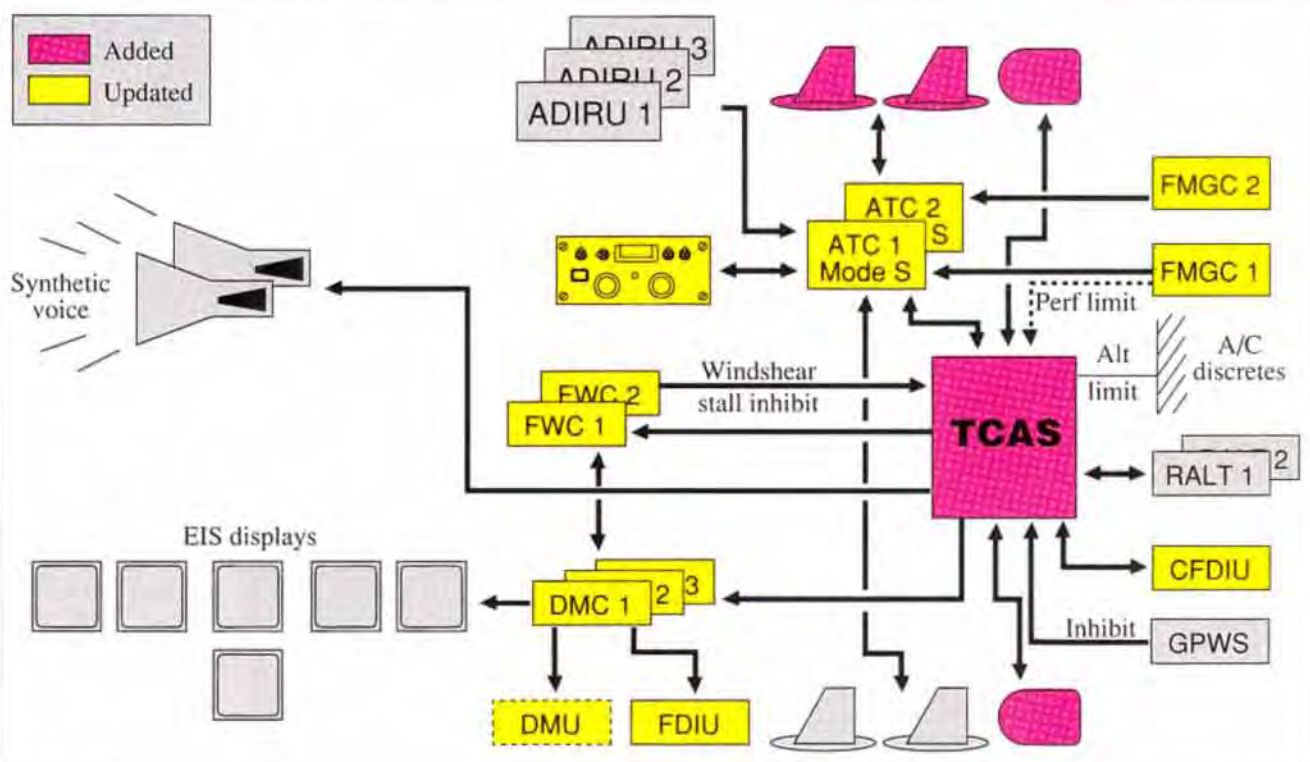
A new kind of option has been developed to cater for airlines who have elected to buy the equipment from Collins or Honeywell or are undecided whether their aircraft will operate in airspace where TCAS is required. These are the TCAS Complete Provision options. They include all the equipment certificated for use with Bendix TCAS, but do not include the TCAS Computer and TCAS antennas. The Complete Provision options are the same as a Full Provision would be, except that the TCAS computer and antennas have not been installed, tested and then removed from each individual aircraft with the option. The Complete Provisions have been designed so as to support TCAS II operation with Collins or Honeywell equipment, but these configurations have not yet been certificated.

The Airbus Industrie TCAS II installation ensures maximum commonality of the design between operators and across the product lines, with as much common equipment used as possible. The Standard Option TCAS II computer and antennas, and the Mode S ATC transponder and antennas can be used on any Airbus Industrie aircraft and are also used on many other manufacturers' aircraft types. Different approaches were adopted for the A300/A310/A300-600 and A320/A321/A330/A340 product families.

A300/A310/A300-600

These aircraft were not originally designed with TCAS in mind, and there is no space available in the main avionics racks to install TCAS in a standard place for all versions. Racks have therefore been added (in the forward part of the electronic compartment for A300, and in the aft part for A310/A300-600) to install the TCAS computer and the associated Mode S transponders. The upper TCAS antenna is installed on the centre line of a complex-curvature part of the fuselage, aft of and above the VHF1 antenna, thus avoiding significant blockage. The range required for TCAS II is 14 miles, and the upper antenna achieves a range of 30 miles. The lower antenna is mounted on the fuselage centre-line (below the top antenna) on A300 and A300-600, and is a little to one side on A310 (the centre-line was already occupied). The A310 lower TCAS antenna is installed on a wedge-shaped

Figure 3
A320 TCAS II (including Mode S)



adapter to restore its performance.

The *intruders*, RA vertical speed commands and flags are displayed on the TCAS/VSI, which is a new (Sextant) liquid crystal display flat-screen instrument. It is the same size as, and replaces, the existing electromechanical Sextant/Thomson/Jaeger (or for most A300s, Honeywell/Sperry) VSI.

The A310/A300-600 synthetic voice audio uses existing inputs on the loudspeaker electronics. These were used on early production aircraft with the L-type Flight Warning Computer for radio altitude call-outs. Many A310 operators are already replacing the L-type FWC with the S-type per SB 31-2051 and this change is required when installing TCAS II so as to free the input for the synthetic voice audio.

On A300s, the audio warning box has to be reworked to install the piece-parts on the existing provisions for an additional input, which is then used for the TCAS II synthetic voice audio.

The upper Mode S antennas are installed on the structural provisions, and early-model ATC transponder antennas on the lower fuselage need to be replaced with the same model as the upper antennas, so as to handle the higher power output of the Mode S transponder.

The existing Mode A and C ATC transponder control panel is replaced with a combined (Sextant) ATC/TCAS panel.

On A310s and A300-600s the digital flight data acquisition unit may need to be updated (along with its wiring) to comply with any operational regulatory requirements that the airline may have. We are not aware of any such requirement affecting A300B2/B4.

At the time of writing, all the Standard Option TCAS II development, test and certification work has been completed on the A310 and A300-600. Formal certification awaits FAA issue of the TSO for the current version of the Bendix TCAS computer. This should have taken place by the time this article appears.

The certification programme for A300B2/B4s depends on availability of an airline test aircraft, and is scheduled for June 30, 1992. The equipment used is the same as for A310s and A300-600s but is wired differently to suit the electronics of the A300.

A320/A321/A330/A340

These aircraft were designed somewhat later and the definition of TCAS was firm enough at the time for space provision to be made in the main avionics racks. In addition, Mode S transponders were part of the initial design. The A320/A321 upper TCAS antenna is installed on the fuselage centre line, well aft of the VHF1 antenna, with the lower TCAS antenna directly below it. The A330/A340 upper TCAS antenna is installed on the forward fuselage upper centre line, with the lower antenna under it. The VHF1 antenna on A330/A340 is located 3 frames behind - the fuselage of the A330/A340 is long enough to avoid dropping below industry standards on mutual interference between VHF1 and VHF3.

The *intruders* are displayed on the Navigation Display (Figure 4), and the RA vertical speed commands are displayed on an extended VSI scale on the PFD (Figure 5). Flags (TCAS fault) are displayed on ECAM (Figure 6), and TCAS is connected to the CFDS/CMC.

The A320/A321 synthetic voice audio shares the existing CVR test audio input on the cockpit amplifier loudspeaker, and the A330/A340 audio goes via the AMU (which contains the loudspeaker amplifier).

The upper Mode S antennas are installed on the existing provisions.

The Mode S transponders, FWCs, DMCs, CFDIU and ATC control panel on the A320/A321 need to be updated to work with TCAS. The FMGCs may be updated at the same time to output flight numbers in the right format for use by the Mode S transponder, and the FDIU may need to be updated to comply with any operational regulatory requirements

Figure 4

A320/A330/A340 Navigation Display with Traffic Advisories

Selected range: 20 nm

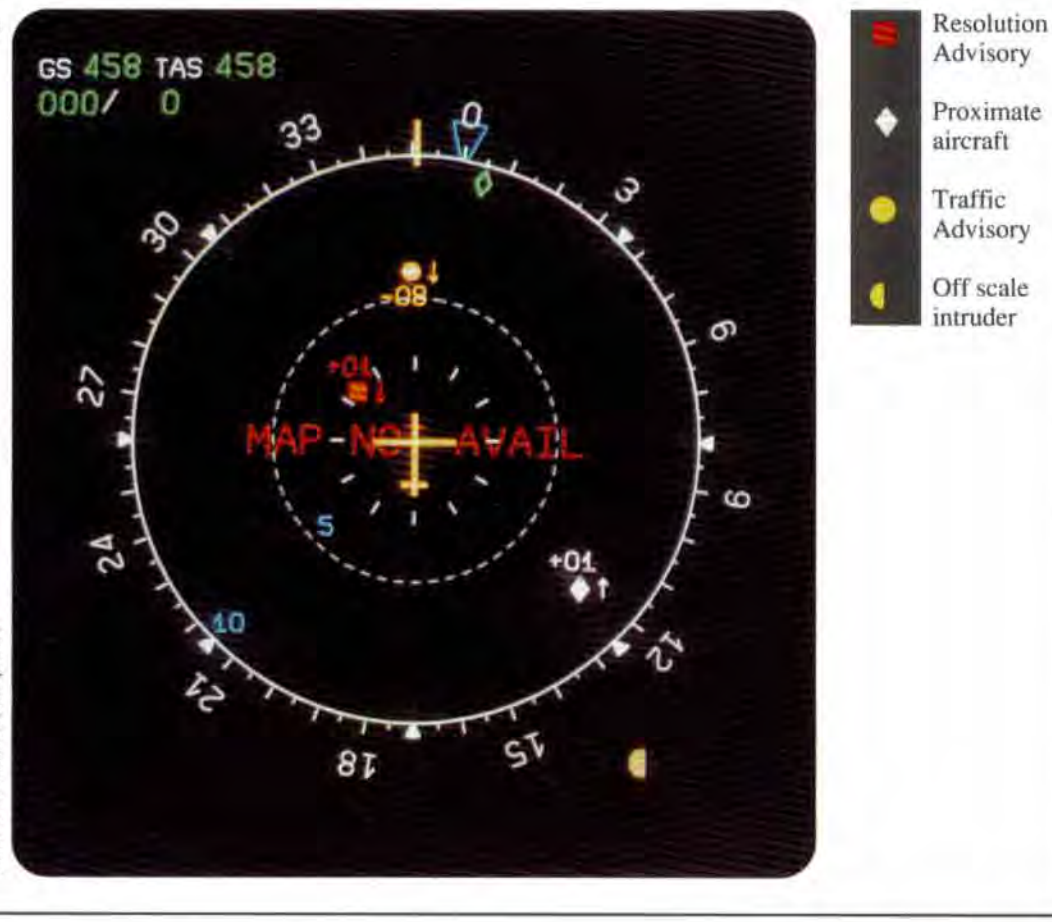


Photo: JC Berthoumieu (Aerospatiale)

Figure 5

A320/A330/A340 Primary Flight Display with Preventive Resolution Advisories

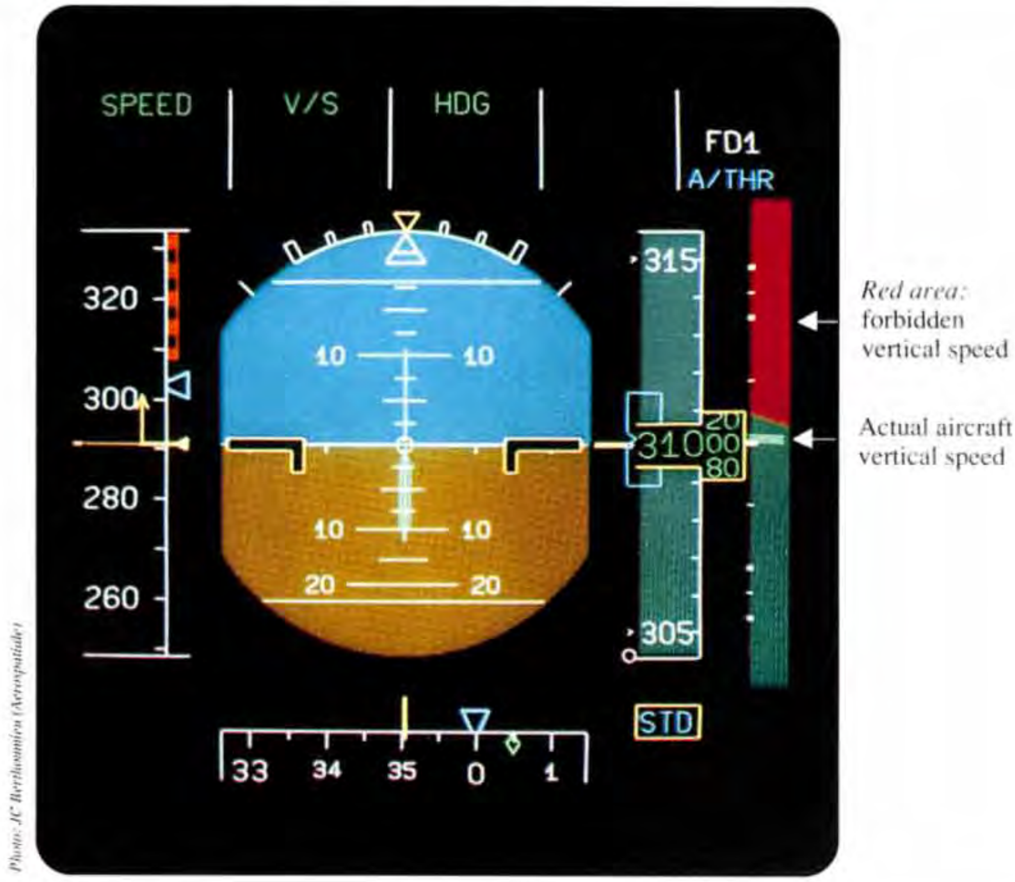


Figure 6

A320/A330/A340 ECAM with TCAS fault displayed

TCAS INSTALLATION - MODIFICATIONS / SERVICE BULLETINS

A300B2/B4			
M08473	TCAS - Structural provisions: Blanking plates for ATC Mode S and TCAS antennas	SB 34-116	07/91
M08474	TCAS - System provisions: Shelf installation (500 VU) / Wiring	SB 34-117	07/91
M09341	ATC Mode S installation Bendix: VSI-ATC S/TCAS control panel installation TCAS antennas / computer installation ATC Mode S transponder / control panel / antennas	SB 34-903 (experimental)	03/92

A310			
M07758	ATC - Structural provision for ATC Mode S top antennas: Blanking plates	SB 34-2049	07/91
M07759	ATC - Mini provision for TCAS and ATC Mode S: Attachment points		
M07890	TCAS II - Antennas structural provisions : Blanking plates		
M07763	ATC Bendix Mode S transponder: ATC Mode S antennas / Shelf installation (500VU) ATC Mode S control panel / ATC Mode S / Selective calling	SB 34-2050	07/91
M08165	ATC - Flight number report wiring: Information coming from FMS		
M07761	TCAS II - System provisions: Wiring		
M08601	ATC - TCAS II complete provision: VSI, ATC/TCAS control panel install.	SB 34-2057	09/91
M08616	TCAS II - Installation BENDIX: TCAS antennas / computer installation	SB 34-2056	09/91

A300-600			
M07758	ATC - Structural provision for ATC Mode S top antennas: Blanking plates	SB 34-6025	07/91
M07760	ATC - Mini provision for TCAS and ATC Mode S: Attachment points		
M07891	TCAS II - Antennas structural provisions : Blanking plates		
M07764	ATC Bendix Mode S transponder: ATC Mode S antennas / Shelf installation (500VU) ATC Mode S CTL PNL / ATC Mode S / Selective calling	SB 34-6026	07/91
M08165	ATC - Flight number report wiring: Information coming from FMS		
M07762	TCAS II - System provisions: Wiring		
M08601	ATC - TCAS II Complete provision: VSI, ATC/TCAS control panel instal.	SB 34-6032	09/91
M08765	TCAS II - Installation BENDIX: TCAS antennas/computer installation	SB 34-6033	09/91

A320			
M22031	ATC - Bendix Mode S transponder (capable of TCAS) Selective calling (M21109 basic)	Not applicable	-
M20354	ATC - Antenna diversity: Upper Mode S antennas installation	SB 34-1015	05/90
M21665	TCAS II - Antennas structural provisions: Blanking plates / coaxial cables brackets	SB 34-1011	03/91
M21125	ATC flight number report: Information coming from FMGS, FMGS associated mod (M21038)	SB 34-1016	06/91
M21693	TCAS II - System provision (Kit A07 D149.180 diode missing) Wiring installation / CVR wiring associated mod (M21974)	SB 34-1017	04/91
M22311	TCAS II - complete provisions (transponder Bendix): TCAS / ATC Mode S control panel installation DMC / FWC / CFDIU / FDIU with TCAS capability	SB 34-1027	12/91
M22536	TCAS II - Installation Bendix: TCAS antennas and computer installation	SB 34-1028	12/91

that the airline may have.

If the airline elects to change the Mode S transponder manufacturer when installing TCAS, the old transponder may be returned to inventory in accordance with the airline's procedures. TCAS II certification for A320 is planned for the beginning of September 1991, with deliveries and availability of retrofit equipment starting in October and November respectively.

TCAS II CERTIFICATION

The FAA has a set of rules for TCAS II certification, published in draft AC 20-131A. Initial Certification of equipment sets which include a TCAS II computer, the TCAS antennas, and the associated Mode S transponder are obtained by the TCAS equipment manufacturer, using a suitable aircraft of his choice.

In addition to ensuring that the units of the TCAS II equipment set operate properly together, the process ensures that the equipment set will work and co-ordinate properly with other vendors' equipment sets installed on other proximate aircraft.

When this equipment set is installed in another type of aircraft, the follow-on certification procedure is used, thus eliminating unnecessary duplication of work. Follow-on certification usually requires airframe manufacturer involvement, to a greater or lesser extent.

At the time of writing, each TCAS II equipment manufacturer (Bendix, Collins and Honeywell) has initially certificated its own TCAS II computer together with its own TCAS antennas and Mode S transponder. In addition, Honeywell have certificated their own TCAS II computer and antennas in association with the Collins Mode S transponder. In all cases, specific part numbers of equipment are involved, and some manufacturers have elected to use different part numbers for different makes of aircraft.

When ordering BFE TCAS II equipment, the airline should ensure that the TCAS II manufacturer has certificated (or is planning to certificate) the equipment set that is to be ordered, and that the part numbers on order are intended for use on the various makes of aircraft which the airline plans to equip with TCAS.

THE FUTURE

TCAS II is a huge programme which is only just beginning and it is only wise to plan ahead for some yet-to-be-decided product improvements. The TCAS II equipment which is presently being certificated by Airbus Industrie is already an improved version of the existing equipment in service, and more improvements are bound to follow in the next few years. After that, we may be able to look forward to TCAS III, when it comes out of the experimental stage.

Airbus Industrie has now started work on some of the associated changes which airlines require in addition to the Standard Options, such as different makes of control panel etc. (See Table of Modification/Service Bulletins). Added display feature changes are being held, pending airline operational feedback on the standard options.

Discussions are now under way with both Collins and Honeywell to achieve follow-on certification of their equipment, so as to best serve customers who prefer their equipment to the standard option Bendix installation. Honeywell were the first to start this process, and we plan to have an initial agreement by the time you read this. Collins started TCAS II discussions several months later, and we aim to obtain follow-on certification for their TCAS prior to the 30 December, 1993 rule compliance date, subject to agreement with Collins.

Airlines which prefer to wait for Collins or Honeywell TCAS rather than Bendix would do well to consider requesting TCAS II Complete Provision for each Airbus aircraft concerned, so as to be able to start early on most of the retrofit work and to reduce avoidable retrofit work on new-build aircraft. ■

Airlines may obtain further information on TCAS installations in Airbus aircraft from the following sources:

New Aircraft: Contractual

North America:
AVSA/Customer Changes Manager, Sita: TLSSTCR, Telex: 520055F, Fax: +33 (61) 304011

All other regions:
Airbus Industrie/Customer Changes Manager (AI/CC-CT), Sita: TLSBC7X, Telex: 530526F, Fax: +33 (61) 934981

Technical
Customer Engineering Manager (AI/EM-C) Sita: TLSBI7X, Telex: 530526F, Fax: +33 (61) 934316

In-service aircraft:
Local Airbus Industrie Field Service Representative, or Airbus Customer Support Manager (AI/SX), Sita: TLSBM7X, Fax: +33 (61) 934610

Glossary of terms

AC	Advisory Circular	FWC	Flight Warning Computer
ACAS	Airborne Collision Avoidance System	GPWS	Ground Proximity Warning System
ADIRU	Air Data/Inertial Reference Unit	ICAO	International Civil Aviation Organisation
AMU	Audio Management Unit	ILS	Instrument Landing System
ATA	Air Transport Association	LBA	Luftfahrt Bundesamt
ATC	Air Traffic Control	LCD	Liquid Crystal Display
AWB	AudioWarning Box	LRU	Line Replaceable Unit
BCAS	Beacon Collision Avoidance System	ND	Navigation Display
BFE	Buyer Furnished Equipment	PFD	Primary Flight Display
CFDIU	Centralised Fault Display Interface Unit	RA	Resolution Advisory
CFDS	Centralised Fault Display System	RALT	Radio Altimeter
CMC	Central Maintenance Computer	SRS	Speed Reference System
CPA	Closest Point of Approach	SSR	Secondary Surveillance Radar
CVR	Cockpit Voice Recorder	TA	Traffic Advisory
DFDAU	Digital Flight Data Acquisition Unit	Tau (τ)	Time remaining to closest point of approach
DGAC	Direction Générale de l'Aviation Civile	TCAS	Traffic Alert and Collision Avoidance System
DMC	Display Management Computer	TSO	Technical Standard Order
FAA	Federal Aviation Administration	US	United States
FAR	Federal Aviation Regulations	VOR	VHF Omni-directional Radio Range
FDIU	Flight Data Interface Unit	VHF	Very High Frequency (communication radio)
FMGC	Flight Management and Guidance Computer	VSI	Vertical Speed Indicator

OPERATION IN AREAS CONTAMINATED BY CRUDE OIL SMOKE

Middle East airspace is currently seriously contaminated by crude oil smoke. Airbus Industrie has released an FCOM Bulletin, the context of which is reproduced here, to assist aircrew who may encounter this pollution.

REASON FOR ISSUE AND SCOPE

The purpose of this FCOM Bulletin is to provide flight crews with background information and operational recommendations for operation in areas contaminated with crude oil smoke.

BACKGROUND INFORMATION

Although no detailed and direct information is available concerning the particulars of the crude oil smoke contamination, information provided by French meteorological and petroleum institutes estimate the oil smoke clouds to be composed of :

- 90 % heavy particles which would not reach over 5 000 ft,
- 10 % lighter particles likely to culminate up to, approximately, 25 000 ft.

Crude oil smoke is understood to be mainly composed of greasy/oil particles and non-abrasive soot. The associated gases are understood to have a high sulphur content. In the event of a crude oil smoke cloud encounter, the immediate operation of engines and aircraft systems is not anticipated to be adversely affected. However extended or repeated exposure is anticipated to result in contamination of engines and airframe/systems. Separate information is planned to be released for maintenance personnel awareness.

OPERATIONAL RECOMMENDATIONS

Although forecasting the horizontal and vertical extension of the contaminated areas (using usual meteorological forecasting models) appears to be largely impeded by the particular nature of the smoke emission as well as by factors such as convection or turbulence, records should be established and kept up-dated with available information regarding the extension or variations of the contaminated area.

Flight into areas of known crude oil smoke contamination should be avoided, mainly during night time or day time Instrument Meteorological Conditions (IMC), as crude oil smoke may not be visible.

Crude oil smoke being composed of small particles, the weather radar should not be relied upon for detection as no weather radar return is to be expected.

Should a cloud of crude oil smoke be encountered, the flight crew should be alert to consider the following procedure steps, as required by particular conditions:

CREW OXYGEN MASKS/
SMOKE GOGGLES .... AS REQUIRED

As smoke/fumes may be present in the cockpit and result in breathing discomfort and/or eyes irritation.

PASSENGER OXYGEN .... AS REQUIRED

No breathing difficulties are anticipated except, depending on contamination, for passengers with known breathing deficiency.

ENGINE PARAMETERS................... MONITOR

Although limited exposure is not anticipated to affect the engine inlet sensors and consequently the compressor stability and fuel control functions, any parameter shift should be reported in the log book for maintenance awareness and action.

- Flight crew should also be aware of the following possible conditions and alert to react, as required:

- one or several triggering of smoke warnings as a result of contamination within the air conditioning system. Do not apply the published AIR COND or other SMOKE procedures,
- unreliable airspeed indication, due to pitot/static system contamination,
- reduced VHF communication range and/or VHF interference caused by incorrect static discharge due to accumulation of greasy particles on the aircraft skin,
- reduced visibility due to oily deposits and carbon particles collecting on the windshields.

- When operating in areas contaminated with crude oil smoke, particular attention should be paid during the normal aircraft walkaround inspection, for any evidence of oily deposits and/or carbon particles contamination on the following areas:

- radome,
- windshields,
- airframe probes and sensors,
- engine fan blade and inlet probes and sensors.

- In case of findings or doubts, maintenance determination/confirmation should be called for, and maintenance action taken, as required.

FOLLOW-UP

The above background and recommendations are provided on the basis of preliminary information being available regarding crude oil smoke and its potential effects on aircraft operation. This FCOM Bulletin will be complemented and/or revised, as dictated by in-service experience. ❑

FIELD SERVICE REPRESENTATIVES

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AMSTERDAM	31 (20) 6484175	31 (20) 6485005	SPLTSKL
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ATHENS	30 (1) 9832479	30 (1) 9818581	ATHEYOA
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BOMBAY - IAC	91 (22) 6124328	91 (22) 6124328	BOMYCIC
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MALTA	356 773984	356 993013	MLAEZKM
MANILA	63 (2) 8315444	63 (2) 8315444	-
MELBOURNE	61 (3) 3380281	61 (3) 3382038	MELLZAN
MIAMI	1 (305) 8712322	1 (305) 8711441	-
MINNEAPOLIS	1 (612) 7260414	1 (612) 7260431	-
MONTREAL	1 (514) 4226310	1 (514) 4226340	YULEEAC
NAIROBI	254 (2) 822763	254 (2) 822763	-
NEW YORK (JFK)	1 (718) 6568635	1 (718) 6322225	-
PARIS (CDG) - AFR	33 (1) 48642548	33 (1) 48642235	PARBI7X
PARIS (ORY) - ITF	33 (1) 49780185	33 (1) 49780288	ORYASAF
PARIS (ORY) - LIB	33 (1) 46750943	33 (1) 46750949	ORYAIVD
PHOENIX	1 (602) 6937444	1 (602) 6937445	-
PRAGUE	42 (2) 3164275	42 (2) 3164727	PRGMMOI
PUSAN	82 (51) 9714106	82 (51) 9714106	PUSXSKE
ROME	39 (6) 6529077	39 (6) 6011564	FCOYSAZ
SAN JOSE	506 412228	506 417223	-
SAO PAULO	55 (11) 5437375	55 (11) 5437375	SAOPZVP
SEOUL	82 (2) 6643219	82 (2) 6654417	SELXSKE
SHANGHAI	86 (21) 2556671	86 (21) 2556671	-
SINGAPORE	65 (5) 425380	65 (5) 455027	-
TAIPEI	886 (3) 3834718	886 (3) 3834410	-
TEHERAN	-	98 (21) 9112773	THRMBIR
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TOKYO - JAS	81 (3) 37476174	81 (3) 37476004	-
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TULSA	1 (918) 2922581	1 (918) 2923227	HDQMRAA
TUNIS	216 (1) 750855	216 (1) 750639	TUNTITU
VANCOUVER	1 (604) 2763548	1 (604) 2763776	YVRBI7X
VIENNA	43 (222) 711103235	43 (222) 711103688	-
ZURICH	41 (1) 8102383	41 (1) 8127727	ZRHZESR

Longitudinal trimming made easy

Trimming aircraft by moving weight fore and aft is not a new idea. Moving fuel about is one solution. However some airlines are looking for something a little less sophisticated and one may even have solved the passenger entertainment problem at the same time.

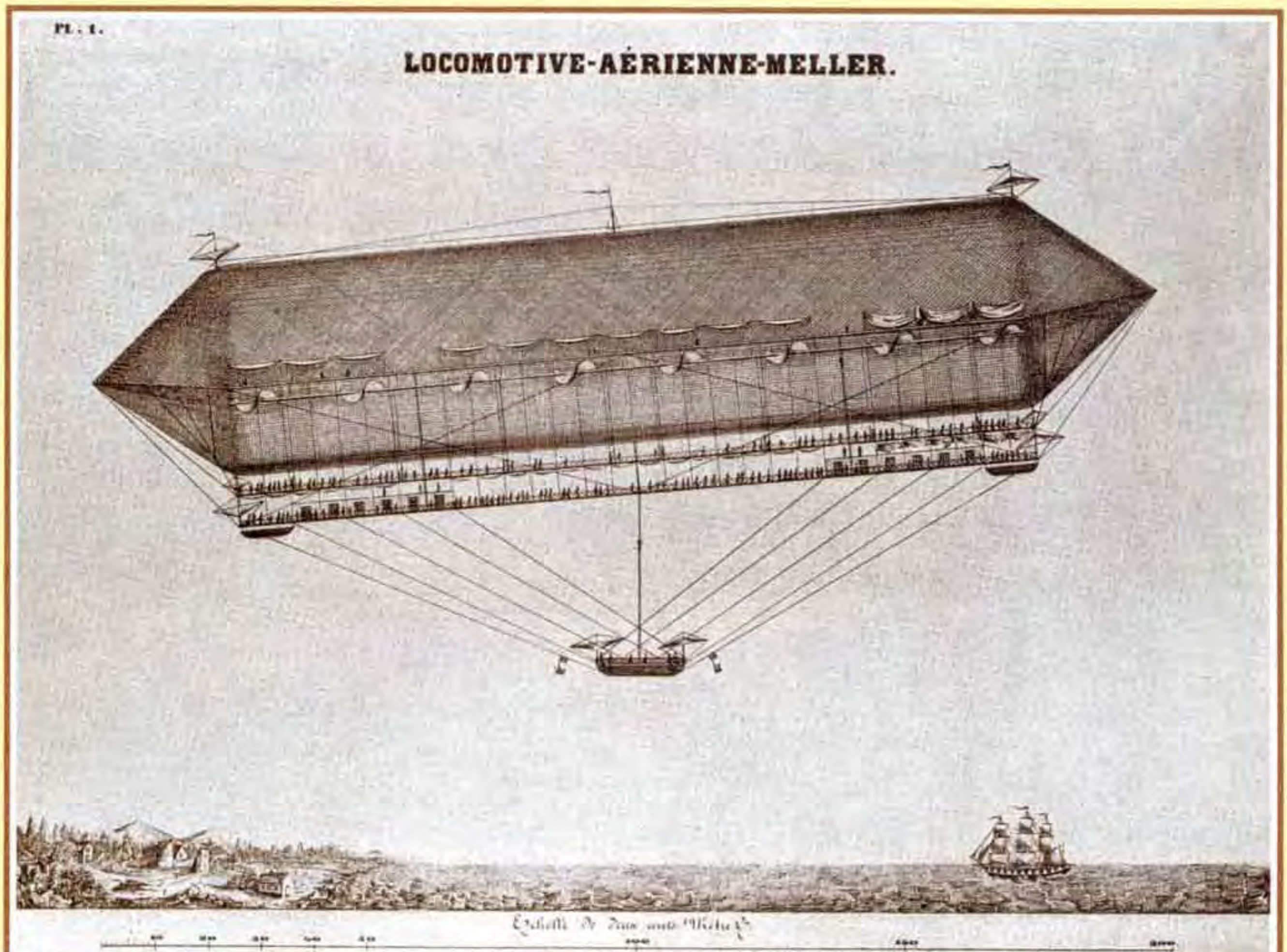
A recent poll of passengers waiting to board a flight on which there was no entertainment system and not even coffee was served, discovered that the majority would be only too happy to move around the cabin, since this would give them something to do and the view would change from time to time.

* *Simply Indescribable Distribution System*

The S. I. D. S.* system shown below, which dates back to 1851, has obvious merits:

- simple, low weight, fail safe centre of gravity control system,
- elementary environmental control system,
- full fare paying First Class passengers can spend the complete voyage in the comfort of their cabins on the lower deck,
- full fare paying Economy Class passengers are free to move about the centre area of the lower deck
- cheap fare passengers occupy the upper deck and are required to move fore and aft as the Captain orders, to achieve the optimum centre of gravity position.

This system, having stood the test of time, is being looked at again, particularly by some low cost operators!



WHAT WE HAVE IN COMMON IS UNIQUE.

In a competitive environment where efficiency counts, aircraft commonality has become an important issue.

Airbus fly-by-wire technology applied to the A320/A321, A330 and A340 provides all these aircraft with identical handling characteristics. Flight decks are virtually identical in layout and instrumentation; systems are designed using exactly the same philosophy.

The unique result is Cross Crew qualification across this 150 to 350 seat new generation family. Only Airbus Industrie can offer this.

The benefits, derived from a Cross Crew qualification between such differently sized aircraft, are enormous:

Difference Training courses lasting days, replace Full Type Rating courses lasting weeks.

Unprecedented aircrew mobility between aircraft types.

Stand-by and other non-productive time substantially reduced.

All this increases aircrew productivity while easing scheduling and reducing overheads.

The bottom line is a saving per aircraft of $250,000 to $400,000 every year. The same as you would achieve by further reducing the fuel burn of these already fuel-efficient aircraft by a massive 10%.

This is just one of the ways Airbus Industrie reduces airline costs by employing advanced technology to simplify complex tasks.

AIRBUS INDUSTRIE