

DOWTY AEROSPACE  
LANDING GEAR

DOWTY

## THE DOWTY MISSION STATEMENT

"Our aim is to become the preferred partner of our customers and associates worldwide by providing competitive advantage to them through the quality of our products, performance and service."

DOWTY IS AN INTERNATIONAL GROUP of engineering companies creating innovative systems and products developed from the latest electronic, hydromechanical and polymer technologies. Its customers are in aerospace, maritime, industrial, automotive and the advanced electronic and information technology industries.

SINCE ITS FOUNDATION in Cheltenham, England in 1931, Dowty has expanded its operations to include well over 50 operating units structured into 4 divisions and sub-divided into various strategic business units based in 17 countries with approximately 60% of sales for the European market and 30% for the North American market.

PEOPLE ARE THE GROUP'S MOST IMPORTANT ASSET. They deliver the quality and service that make Dowty companies such effective partners to their customers.

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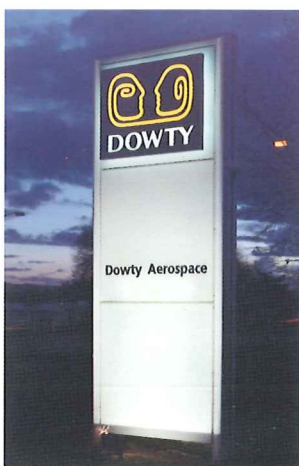
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## DOWTY AEROSPACE DIVISION

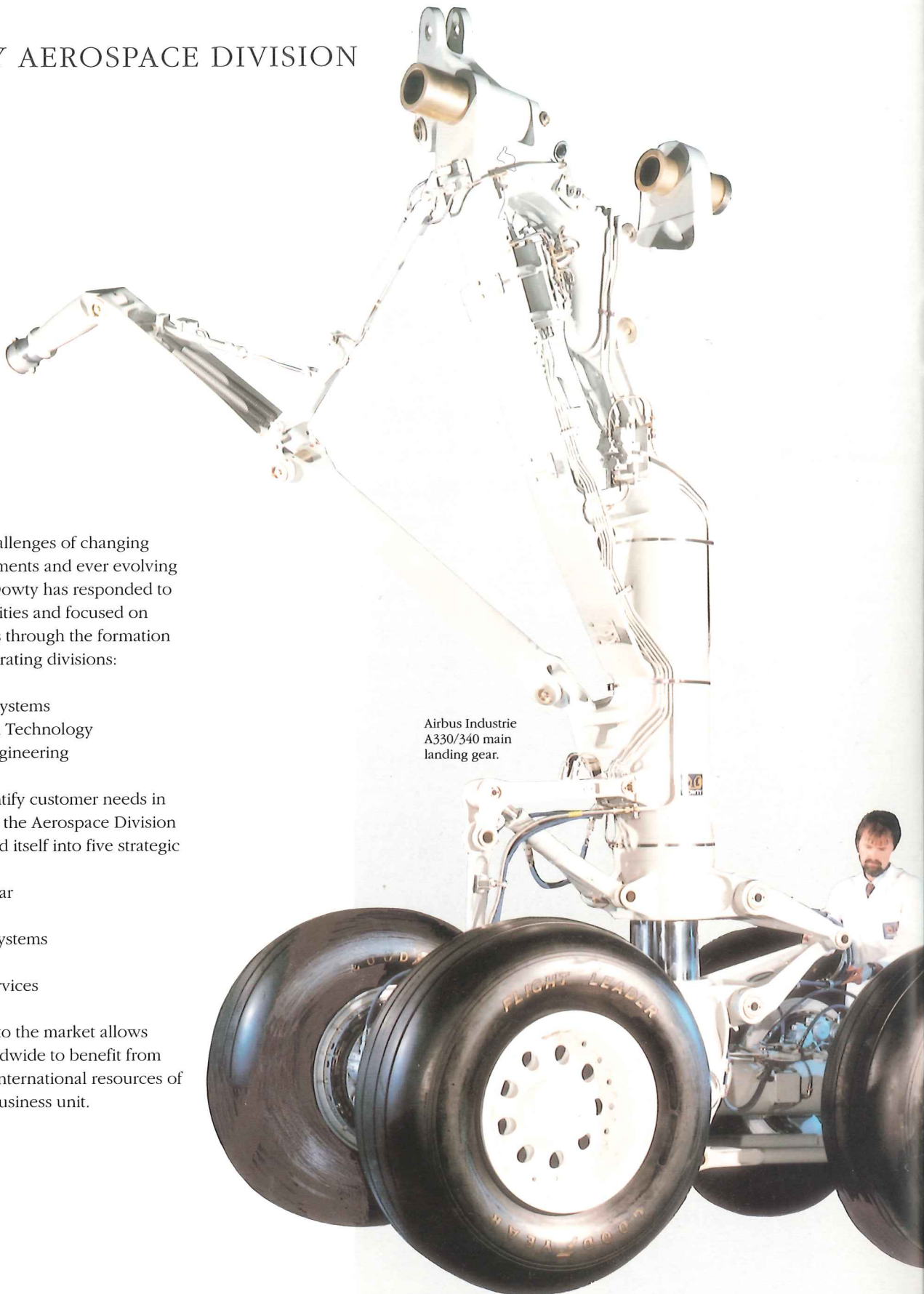
To meet the challenges of changing market requirements and ever evolving technologies, Dowty has responded to these opportunities and focused on growth markets through the formation of four key operating divisions:

- Aerospace
- Electronic Systems
- Information Technology
- Polymer Engineering

In order to identify customer needs in global markets, the Aerospace Division has repositioned itself into five strategic business units:

- Landing Gear
- Hydraulics
- Actuation Systems
- Propellers
- Aviation Services

This approach to the market allows customers worldwide to benefit from the combined international resources of the particular business unit.



Airbus Industrie  
A330/340 main  
landing gear.

Landing Gear customers include:

Airbus Industrie, Boeing, British Aerospace, Canadair, CASA, Deutsche Airbus, Dornier-Deutsche Aerospace, Eurofighter, Fokker, Gulfstream, de Havilland, Kaman Aerospace, McDonnell Douglas, MBB-Deutsche Aerospace, Panavia, Piaggio and Shorts.

# DOWTY AEROSPACE LANDING GEAR

Dowty Aerospace Landing Gear is the only company in the world with an established infrastructure to completely design, develop, manufacture and support total landing gear systems on both North American and European continents, with additional support capability in Asia.

The aim is to be the 'preferred partner' of all our customers. Commitment to the concept of service is fundamental to the response of Dowty Aerospace Landing Gear to the market. It means listening to its customers, understanding their requirements and responding urgently and intelligently with solutions matching their needs.

Every individual within the company is committed to ensure that customer satisfaction is achieved through the provision of a high standard of service:

- Responsive and supportive
- On time delivery
- Engineering excellence
- Product performance
- Cost effective manufacture
- Quality
- Product support



Dowty Aerospace Landing Gear is comprised of the following facilities:

**Dowty Aerospace Landing Gear (Gloucester)** is the largest of the landing gear operations and employs approximately 1600 people in a 475,000 sq ft (44,127 sq m) facility. It is located at Gloucester in South West England.

**Dowty Aerospace Landing Gear (Toronto)** is located in Ajax just East of Toronto and employs approximately 400 people in a 200,000 sq ft (18,580 sq m) facility.

Both facilities maintain extensive design, development, manufacture and support capabilities, for all types and sizes of landing gear systems on both commercial and military aircraft.

**Dowty Aerospace Landing Gear (Montreal)**, located close to the Mirabel International Airport, is the newest of the landing gear manufacturing and test operations.

This is the latest example of the major investments being made to ensure that Dowty maintains a leading position within the landing gear industry.

The facility was developed exclusively for the complete fabrication of large four and six wheeled bogie landing gears, initially to produce the main landing gears for the Airbus A330/340 airliner. The first phase of the facility, completed in 1991, occupies an area of 160,000 sq ft (14,864 sq m) and is equipped with select state of the art manufacturing, heat treatment and processing equipment.



Eurofighter landing gear system.

The initial phase of the Montreal project makes it the most modern large landing gear production facility in the world and planned expansions will make it the largest in the world.

**Dowty Aerospace Landing Gear (Peterborough)** is also included within Dowty Aerospace Landing Gear. This electronics company specialises in custom designed digital and analog microprocessor based system controllers and monitors for landing gear and ground steering systems. The company is located East of Toronto.

Dowty Aerospace Landing Gear is backed by the Aerospace Division's worldwide network of repair facilities and customer support centres. The total landing gear system capability is further complemented by the related hydraulics, electronics and polymer technologies found elsewhere within the Dowty Group.

These combined capabilities provide Dowty customers worldwide with the most comprehensive landing gear service.

# LANDING GEAR CAPABILITY

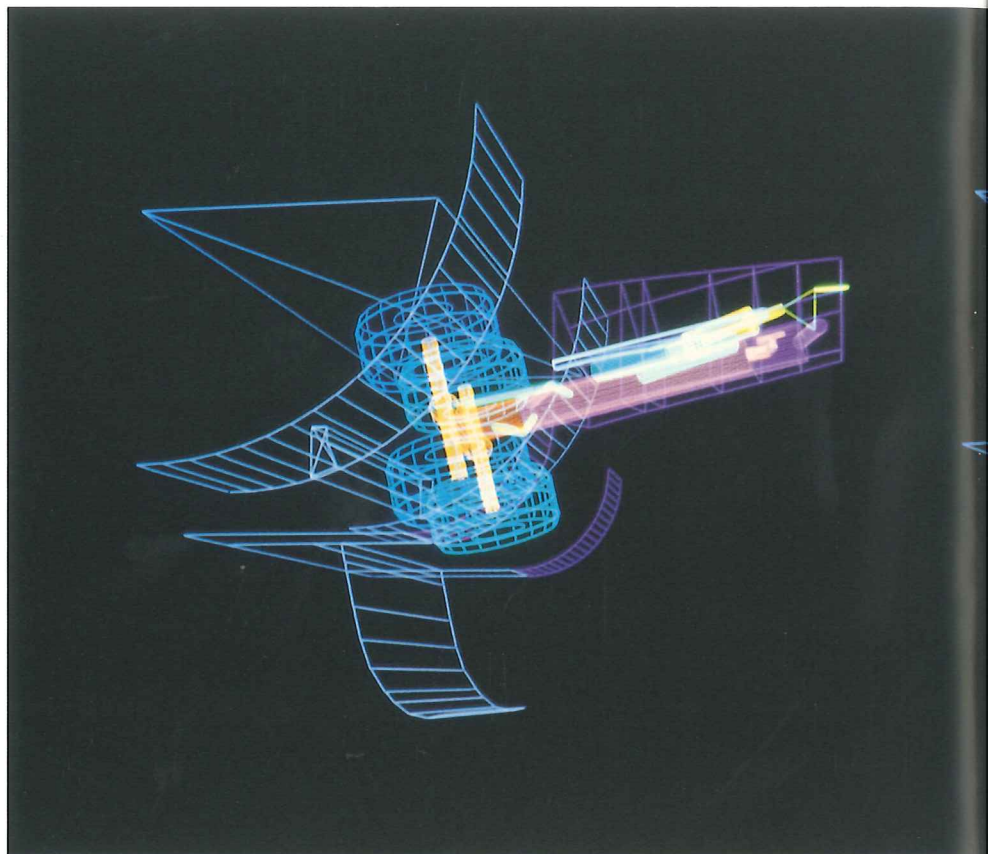
The resources of Dowty Aerospace Landing Gear provide the infrastructure to produce completely qualified landing gear systems for any fixed wing, rotary wing, military and commercial customer specification.

The extensive capabilities offered include:

- Experience over a wide spectrum of aircraft
  - from executive to commuter aircraft
  - from regional turboprops to wide body long range aircraft
  - from military trainers to the latest generation strike and interceptor aircraft
  - from naval deck landing aircraft to vertical take off and lift aircraft and helicopters.
- The most modern landing gear production facilities in North America and Europe.
- Extensive landing gear engineering experience derived from a wide range of proprietary designs.
- Ability to produce landing gear
  - either as complete systems fully dressed, including associated hydraulics for immediate installation on the aircraft build line
  - or as make to print contract manufacturing.

The key benefits we offer include:

- High reliability and safety.
- Optimised design/minimum parts.
- Minimum space/minimum weight.
- High performance/ground ride standards.
- Low life cycle costs.
- Ease of maintenance.
- Worldwide product support.

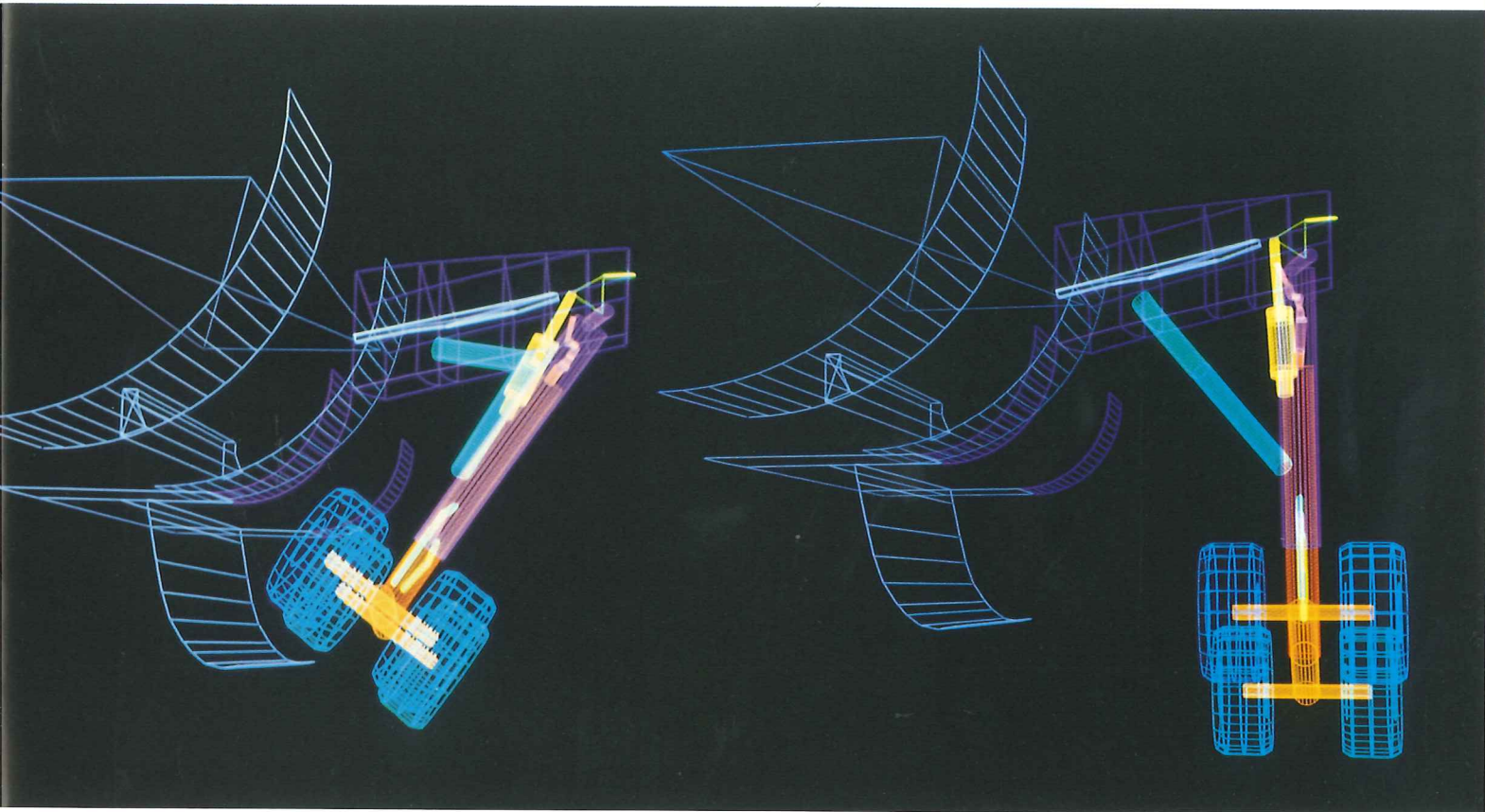


Computer aided mechanism analysis of landing gear retraction path.

## DESIGN CONSIDERATIONS

Landing gear design is dictated by the type and size of aircraft, its configuration and operational role.

The integration of the landing gear with the aircraft is a complex relationship between the many conflicting parameters of shock absorption, ground ride, minimum stow area, complexity, weight and cost. This necessitates extensive trade studies and concurrent engineering prior to reaching an optimised design concept.



Aircraft characteristics influencing the landing gear design include:

- Airframe load carrying parameters.
- Structural attachment points.
- Landing gear weight allowance.
- Stowage space restrictions which may greatly increase the complexity of the gear and can dictate the geometry of the equipment.
- Acceptable aircraft ground clearance at all attitudes.

- Other factors such as engine and fuel tank location, air intake geometry, position of external stores internal equipment.

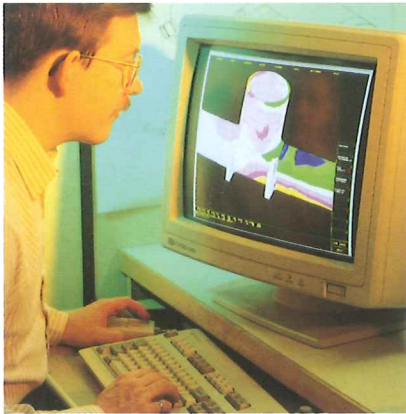
Besides these aircraft influences, landing gear design involves suspension options, shock absorption techniques, materials technology, steering controls, retraction mechanisms, associated hydraulics and landing gear control computers.

# DESIGN AND TECHNOLOGY

The range of landing gear systems, although varying in size and complexity, encompass similar technologies. Illustrated are some of the design capabilities, technologies and facilities that make up Dowty Aerospace Landing Gear.

## Design

The landing gear design engineering staff are instrumental in the introduction of innovative designs, new technologies, materials and processing methods.



Computer Aided Design systems are used extensively, including CATIA, GRAFTEK and ICEM (plus) for 2-D, 3-D and solid modelling techniques, to study design alternatives and provide fast accurate detailed design solutions.

The Computer Aided Engineering aspects of the design activity include the benefits of ADAMS mechanism analysis and LUSAS and PATRAN finite element analysis.

## Reliability and Maintainability

Reliability and maintainability are major considerations during the design and development process and are constantly reviewed throughout the manufacturing programme. Intelligence gathered from in-service reports is made available to both product support services and design engineering. This policy has resulted in Dowty landing gear systems providing high reliability, requiring the minimum of maintenance, resulting in low cost of ownership.



Computer Aided Design and Engineering techniques.

## Materials

Dowty landing gear designers have developed significant expertise in the utilisation of ultra high strength tensile steels and aluminium alloys. Titanium and corrosion resistant steels are used also for special applications.



Electron beam microscope to aid materials investigations.

Due to the ever increasing demands for higher strength, lower weight landing gears with improved corrosion and wear characteristics, Dowty continues to evaluate new materials including composites, and maintains a design and manufacturing development program to determine which aspects will be of value in the design of tomorrow's landing gears.



### Landing Gear Suspension Research

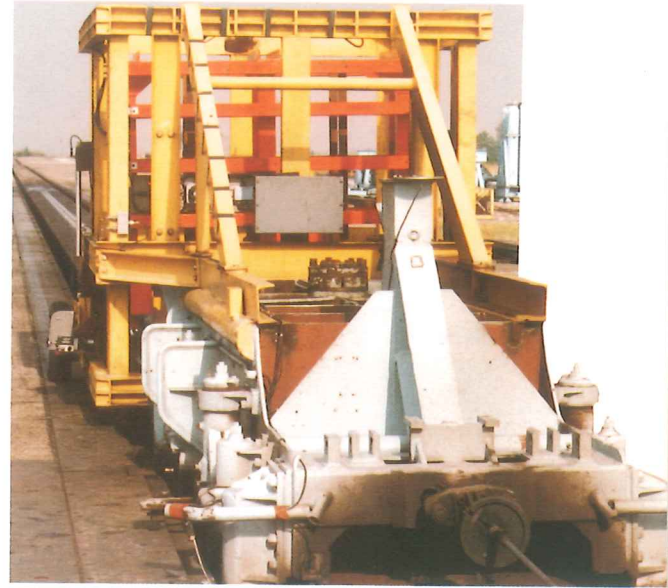
A long tradition of technical innovation has resulted in today's advanced landing gear systems produced by Dowty. These include such technologies as rough ground performance, kneeling mechanisms, shortening mechanisms, controlled articulation and crash attenuation systems for vertical lift aircraft.

The on-going suspension research will allow Dowty to respond to the severe requirements future landing gear will encounter when aircraft operate from secondary standard, semi-prepared and unprepared runways. Systems under investigation include:

- Passive:** Utilising optimised self-adaptive damping devices.
- Semi-Active:** Where damping forces are controlled in response to the aircraft motion.
- Active:** When the full suspension force is subject to control.



Advanced landing gear suspension research.



Landing gear rough runway trials.

### Hydraulic Sub Systems

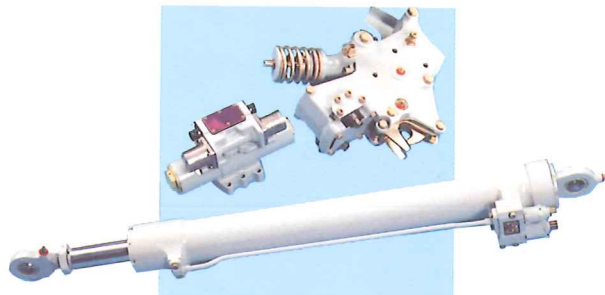
Dowty Aerospace Landing Gear has the infrastructure to produce complete landing gear systems with design responsibility for all associated hydraulic equipment.

This includes such sub systems as:

- Actuation Mechanisms
- Folding Stays/Braces
- Direction Linkages
- Selector Valves
- Up/Down Locks
- Door Locks
- Hydromechanical Steering Mechanisms

Through our close relationships across the Division and Group, the landing gear system capability is complemented by the hydraulic expertise of Dowty Aerospace Hydraulics.

Landing gear hydraulic products.



Landing gear sealing products.



### Landing Gear Sealing Products

The Polymer Division of Dowty also supports Dowty Aerospace Landing Gear. Polymer companies produce a wide range of fluid sealing products which are approved for use in the aerospace industry.

**Landing Gear Electronics**

Dowty Aerospace Landing Gear benefits from having a dedicated North American based electronics company within the business unit.

This provides a meaningful advantage to the landing gear design capability allowing Dowty to offer landing gear and ground steering systems that are controlled by Dowty electronics.

Advances in digital and analog micro-processor based controls have provided the technology necessary to interface with the aircraft's avionics, another requirement of modern aircraft design.

Other landing gear related equipment such as computers, switches and harnesses can be supplied by Dowty Electronic Systems Division companies.

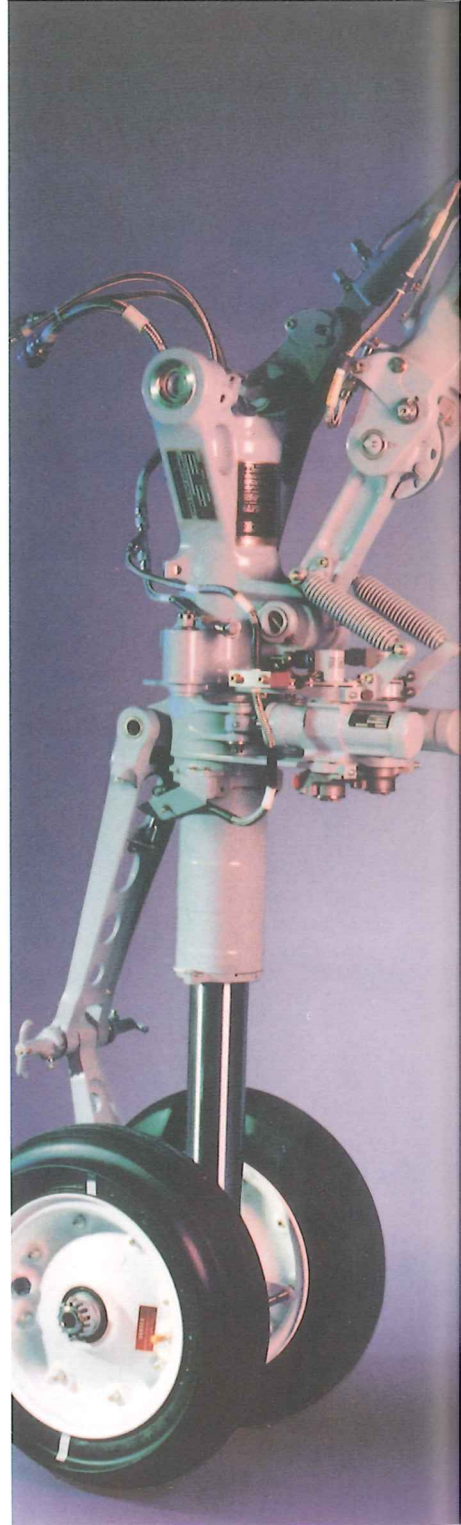
**Steer by Wire Systems**

Dowty introduced the first electronically controlled Nosewheel Ground Steering System to the executive aircraft market.

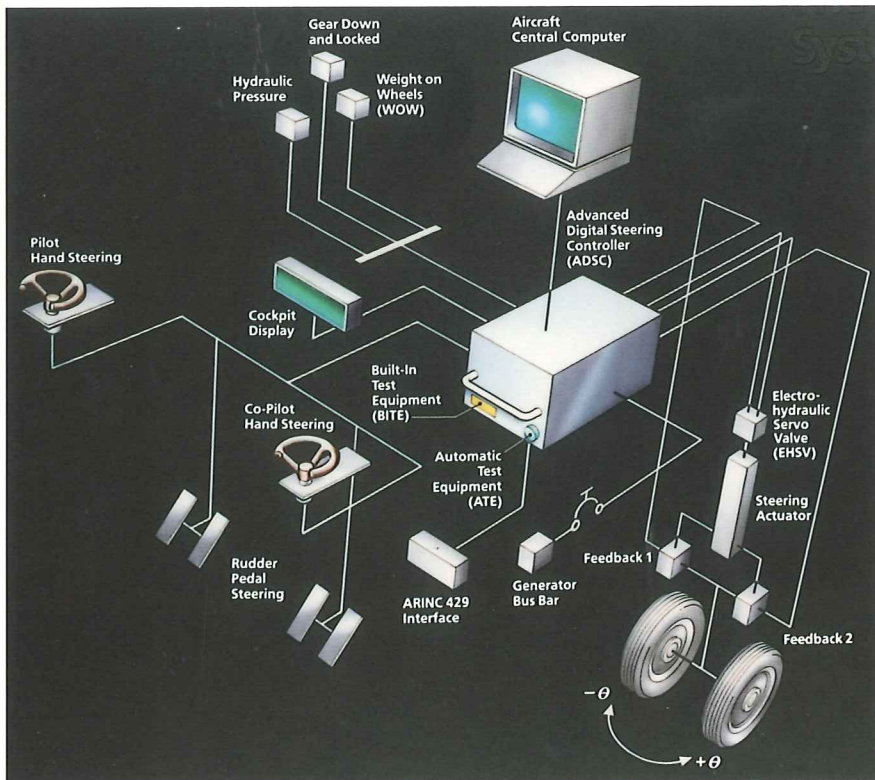
Today, Dowty has developed Steer by Wire systems to enhance the ground handling capabilities of both commercial and military aircraft around the world. Retrofit systems have been supplied also to replace existing non Dowty hydromechanical steering equipment.

Dowty's Steer by Wire systems comprise a micro-processor based electronic control unit which integrates signal inputs from transducers, mounted on the rudder pedals and/or pilot's handwheel to control the electro-hydraulically steered nosewheel.

Ongoing development programs include multi wheel steering technology and other interface options.



Canadair Regional Jet nose landing gear.



Advanced steering control system.



### Landing Gear Control Computers

Various electronic landing gear computers have been developed for commercial and military aircraft.

The landing gear computer is designed to provide an electronic control and interface system to control the retraction and lowering of the landing gear and the landing gear doors, interfacing with various proximity switches within the landing gear system.

Such systems are able to fulfill the modern requirements of high reliability, ease of maintenance and on board fault monitoring. In addition, the system provides status signals, built-in test equipment and interfaces with the maintenance recording system.



Airbus A320 and A330/340 Landing Gear Computers.

### Landing Gear Switches

Custom designed landing gear selector switches give pilots an indication of the system under control by tactile knob shapes or a 'visual attention getter'.

High integrity limit switches provide reliable operation in locations such as landing gear selection and indication.

### Landing Gear Harnesses

Dowty Electronic Systems companies have developed complete electrical harness assemblies to meet the critical standards of the landing gear system.



Bell/Boeing V-22 landing gear control unit.



Fitting landing gear harness.



The Canadair Regional Jet is equipped with Dowty designed landing gear and an electronically controlled steering system.

# DEVELOPMENT AND TEST



Photo-elastic testing, used by Dowty to verify stress analysis programs during the development of a landing gear.



Retraction testing of A340 main landing gear in Europe.



Drop testing the A340 centreline landing gear in North America.

Comprehensive test facilities are available in both Europe and North America allowing development and complete qualification of landing gear to be undertaken in either continent.

These extensive test facilities are fully equipped to perform landing gear qualification to Federal (FAR) and European Joint Airworthiness Regulations (JAR). These test requirements include:

- Drop testing
- Strength testing
- Fatigue testing
- Functional testing
- Vibration testing
- Environmental testing
- Experimental stress management
- Photoelastic testing

Development engineers, aided by test management and data acquisition systems, study every aspect of operation during the duty life cycle to ensure complete verification of unit performance.

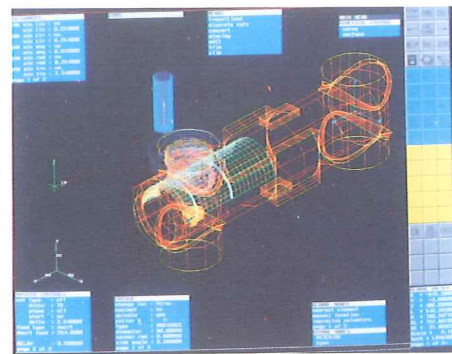
Computerised test management.



Drop testing the A320 main landing gear in Europe.

# PRODUCTION

GNC computer aided manufacturing system.



CAMAND computer aided manufacturing system.

Highly skilled manufacturing engineers ensure that the advanced technology equipment and systems selected meet the specific needs of the customers' current and future programmes.



Distributed numerical control manufacturing system.

The advanced capability of mirror image machining on multi spindle machines provides a cost-effective "just-in-time" service to the customer.

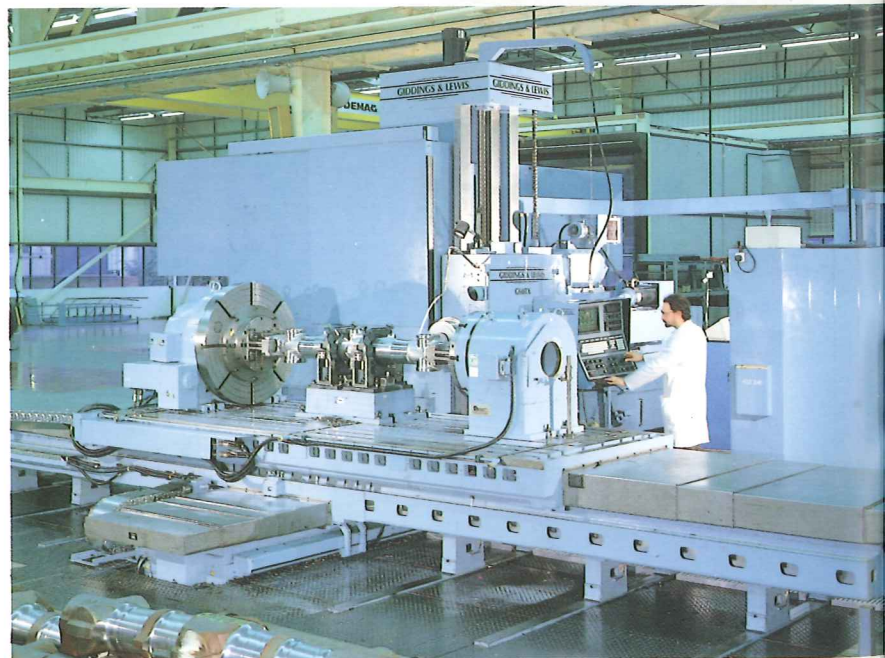
To ensure customer satisfaction, Dowty Aerospace Landing Gear, through its continued investment in the modernisation and expansion of its facilities, has developed the most modern landing gear production capability in the world.

Each manufacturing operation has been developed to produce a range of landing gear of specific sizes. Large size landing gears are produced in Montreal and Gloucester and medium sized landing gears in Toronto and Gloucester.



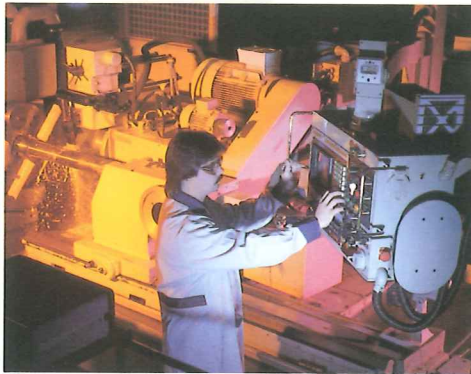
To facilitate the most efficient and cost effective manufacturing practices the company's resources are continually enhanced through investment in advanced machine tools, new facilities and manufacturing and engineering systems.

These investments include Computer Aided Design and Manufacture (CAD/CAM), proprietary manufacturing software (CAMAND), Distributed Numerical Control (DNC), Manufacturing Resource Planning (MRP II) and Computer Aided Process Planning (CAPP), progressing to a fully computer integrated design, manufacturing and quality system.



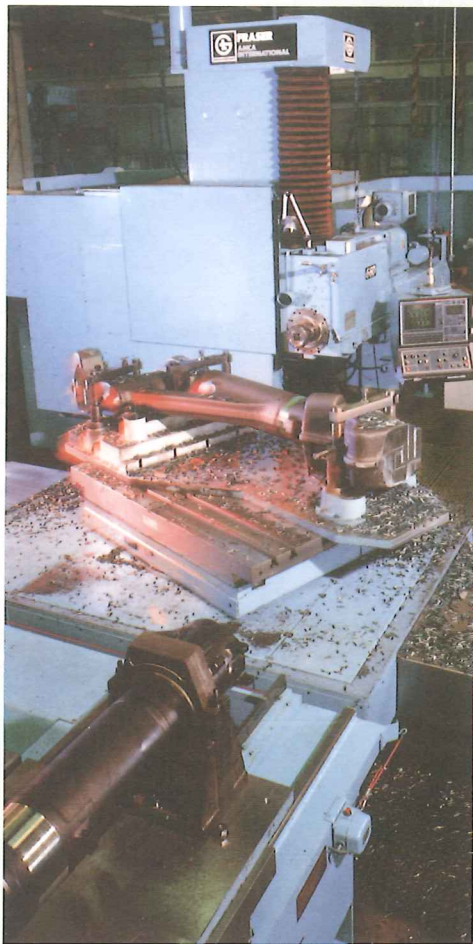


The manufacturing operation is thus strategically placed to provide the best possible service for both North American and European markets.



The Dowty production facilities are equipped with state-of-the-art machine tools which are operated by highly trained operatives.

The two and three shift operations ensure that Dowty can accommodate quickly and efficiently varying production rates which may result from fluctuations in the aircraft market.



At Dowty every effort is made to ensure that the customers' delivery requirements are met, on time, in a cost effective manner.

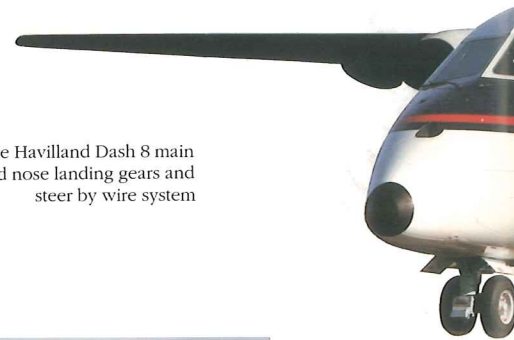
# COMMERCIAL CUSTOMERS



Airbus A320 main landing gear.



Airbus A330/340 main landing gear and A340 centerline gear.



de Havilland Dash 8 main and nose landing gears and steer by wire system



Fokker 50 main and nose landing gears.



Canadair CL-601 Business Jet main and nose landing gear and steer by wire system.





British Aerospace 146 main and nose landing gears.



Shorts 360 main and nose landing gears.



Fokker 100 main and nose landing gears.



Piaggio P180 main and nose landing gears.



British Aerospace ATP main and nose landing gears.

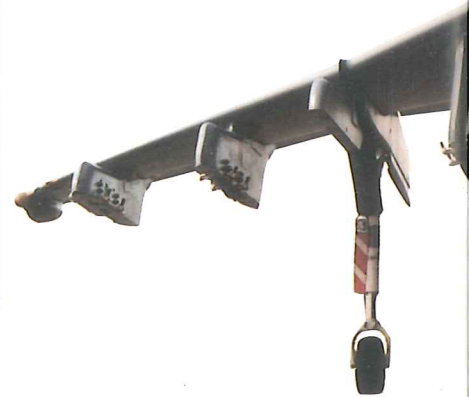


Canadair Regional Jet main and nose landing gears and steer by wire system.



# MILITARY CUSTOMERS

Eurofighter, the new European fighter aircraft. Dowty is the lead partner in the design and development of the complete landing gear system.



Panavia Tornado main and nose landing gears.



Bell/Boeing V-22 Osprey main landing gear and landing gear control unit.





Sepecat Jaguar main and nose landing gears.



Casa C-101 main and nose landing gears.



Kaman Aerospace SH-2F main landing gear.



British Aerospace Harrier II and McDonnell Douglas AV-8B main, nose and wing gears.



British Aerospace EAP main and nose landing gears. The EAP was the development aircraft and forerunner to the Eurofighter.



# CUSTOMER SUPPORT

It is the objective of Dowty Aerospace Landing Gear to maintain the most responsive after sales support service in the world.

To ensure minimum downtime throughout the operational life of a landing gear, reliability, maintainability and integrated logistic support are prime considerations from the initial design phase and then continuously based on the feed-back of in-service data.

The Dowty commitment to support extends to a wide range of commercial and military aircraft of all sizes operating worldwide. To meet this commitment Dowty has developed a landing gear support infrastructure that is second to none.

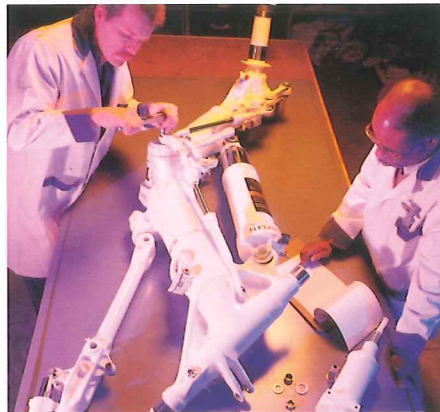
## Repair and Overhaul

Dowty has amalgamated its many repair and overhaul facilities into one strategic business unit – Dowty Aerospace Aviation Services.

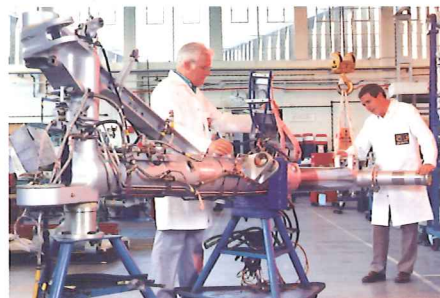


Spares support – 24 hour, 365 days a year AOG support.

The specially equipped and approved Repair and Overhaul facilities are staffed by Dowty trained engineers, technicians and inspectors. They offer exchange and lease schemes, turnaround times to meet operator needs and rework schemes developed by the original landing gear designers. Repair facilities are located at Gloucester, England; Sterling, Virginia, USA; Toronto, Canada and Singapore. Singapore provides one of the few large landing gear repair facilities outside Europe and North America.



Overhaul of Canadian Forces CF-18 main landing gear at Toronto.



Gloucester, UK.



Worldwide service support.

## Customer Support Centres

A structure of dedicated Customer Support Centres is located at strategic locations around the world to provide a single point of contact for operators providing a locally available specialist support service.

The responsibilities of the Customer Support Centres located at Sterling, Gloucester and Singapore include:

- Dedicated computerised spares management
- Integrated logistics support management
- Training
- Service
- Scheduled meetings with operators
- Technical liaison with engineering

The essence of Dowty's Customer Support Service is to achieve product differentiation and customer advantage through quality of service.

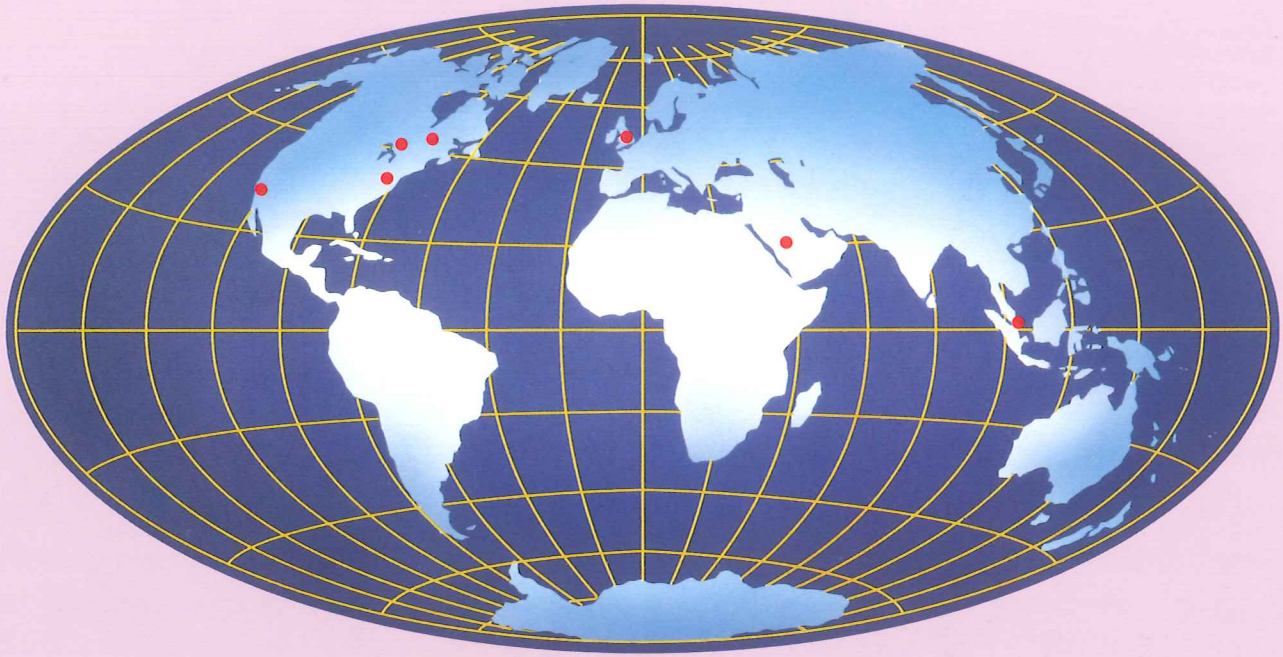
Singapore.



Customer Support Centres and Repair and Overhaul bases.



Sterling, USA.



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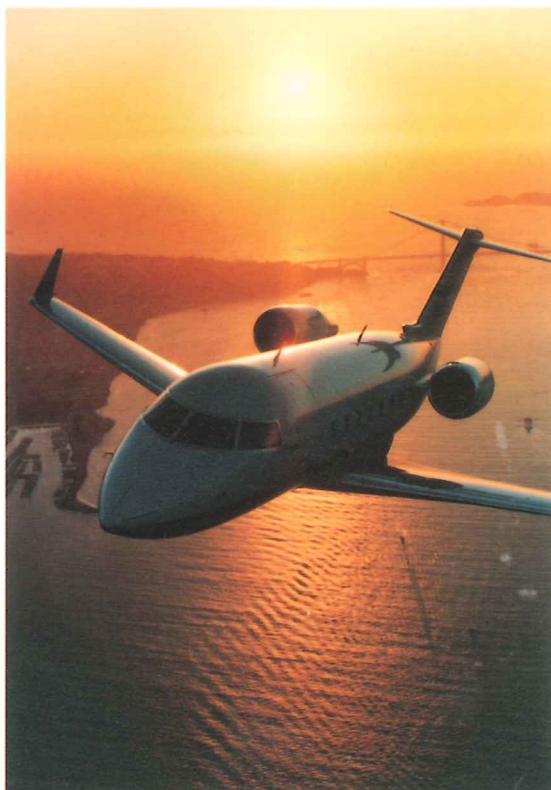
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