

# Ready for Take-Off



## THE LANGUAGE OF AERONAUTICS

C. DOUGLAS BILLET



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# Sky way

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## Foreword

*Ready for Take-Off* is an introduction to standard aeronautical English and is intended for use by students and adults involved or interested in aircraft and aircraft manufacturing. In preparing the book many hard choices had to be made as to which materials to include and which to exclude. For space considerations it was not possible to include every type of aircraft flown today. Nor was it imaginable to give attention to every aspect of aircraft manufacturing and assembly. *Ready for Take-Off* concerns itself with civil aircraft and, except for a few passages devoted to light aircraft and their systems, the large jet passenger airliners. Even these had to be narrowed down dramatically to the production of the two major players in today's aviation skies: America's Boeing and Europe's Airbus Industrie, although I have tried not to overlook other significant aircraft types such as Lockheed, McDonnell Douglas and Concorde.

*Ready for Take-off* is not meant to be a course in aeronautics or in aviation, but to present the vocabulary and language forms used in English when we need to talk about aircraft structures, components, their functions, and design. Students having learned the basic facts of wing structure and design as it exists, say, on an Airbus A320 should have little difficulty in talking about a wing on a Boeing or Tupolev. The terms *lift*, *thrust*, and *drag* apply to a B747 as well as to a Cessna or Beechcraft.

As its title suggests, *Ready for Take-Off* focuses on the manufacture, assembly, and preparation (including cabin layout and configuration) leading up to flight. For this reason little or no attention is paid to in-flight navigation including avionics, weather forecasting, and radio communications, areas which generally do not concern the engineers and technicians working in the earlier phases of aircraft construction and assembly.

*Ready for Take-Off* is the outgrowth of more than seven years of working with people from all areas of the aircraft industry in Toulouse, France. During these years much of the material contained in this book was used by hundreds of technicians, engineers, secretaries, assistants, maintenance managers and their staff, and even by people in commercial or contract departments. I was even lucky to design an entire training program for pilots, technicians and engineers preparing for the day when the "Super Guppy" transporter used to ferry aircraft parts around Europe was to be replaced by the now familiar "Beluga" transporter. This textbook is offered to everybody who, like all these people, are highly qualified in their individual fields, but for whom English is a hurdle which is often difficult to get over. It is also designed for students preparing for a career in any area linked to aeronautics.

### Level Considerations (students and teachers)

Students should have a basic working knowledge of English (pre-intermediate and intermediate levels) if they are to derive maximum benefit from using this book, although some sections, particularly the first two, can be used by elementary-level students if the objective is familiarization with basic terms and simple descriptions.

Teachers are expected to have a basic knowledge of aeronautics, as well as some of the physics involved in the various areas covered. A background in aeronautics is particularly desirable if they are to provide students with help in doing some of the practice exercises.

### Design of the book

The book is divided into 5 large sections starting with overall aircraft structure and including the principles of flight and ending with material related to problems, errors and accidents. As far as possible, I have made every attempt to involve the student as much as possible, even when working with expository passages which are often accompanied by practices asking the student to restate ideas using new words or expressions, to answer questions based on the passages, or to compare and contrast various facts or configurations.

Each section includes subsections with work focusing on particular topics. "**Vocabulary Checklists**" list important words with a clear examples. These are often followed by exercises to help students internalize the new vocabulary. Spaced throughout the book at appropriate locations are "**Grammar Checklists**" covering in table-format major grammatical structures. One of the most important *themes* is cause and effect and the different and varied ways of expressing it. Exercises dealing with this subject will be found from beginning to end. At regular intervals students will also find "**Training Exercises**", aimed at developing familiarity with language and grammar and "**Maintenance Checklists**", practices intended as review and recall opportunities. A few special sections called "**Going Further**" allow students to explore a given subject in greater detail.

# **Ready for Take-Off**

**Standart Aeronautical English**

**C. Douglas Billet**

Media Training Corporation





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Students and teachers will also find at regular intervals “**Special Presentations Sections**”. These give students an opportunity of training themselves in simple presentation skills. The first such section provides a model with typical introductions and transition phrases to use in giving a brief talk. Transparencies or slides can be made from the accompanying diagrams. Of course, each presentation section may also be used as the basis for a written exercise.

A word about “**Fluency Practices**”. These occur throughout the text. Students are presented with a model sentence, usually taken from a relevant passage, and asked to rephrase the idea in as many ways as they can. Prompts or “openers” are provided. The objective is to allow students to develop greater proficiency as they learn new expressions.

All the passages are based on authentic documents which have often been rewritten or otherwise “overhauled” to fit the designs of the topic, to provide a context for vocabulary, or to demonstrate grammatical patterns.

I have tried to ensure that the material contained in this text should be as up to date as possible. I have also made every effort to verify the facts and figures presented. Despite these efforts, some readers may find that newer developments have superseded those mentioned in this text, or may question certain data. I welcome any comments and corrections.

C. Douglas Billet  
Cannes, July 2000

### Special Acknowledgements

- [1] I would like to express my deep appreciation and gratitude to Airbus Industrie for its generous and gracious help in making available many outstanding photographs which appear in this book, as well as for granting permission to reproduce several authentic technical documents.
- [2] I also wish to thank Air France for making available several photographs appearing in the text, among which are the superb photograph of the 747 taking off and the Concorde in flight.
- [3] Special thanks are also reserved for Rolls-Royce and IAE for furnishing the outstanding illustrations of two Trent engines and allowing me to reproduce them.

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BACK COVER PHOTOGRAPHS ©Airbus Industrie; Illustration of the Rolls Royce Trent Engine ©Rolls Royce-IAE. All used with permission.

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# Ready for Take-Off



The captain has just extended flaps by 15°, extended lift spoilers, and has reduced engine ERT. Thanks to this and also certainly owing to the dihedral angle of the wing mount, we now have a resulting decrease in airspeed over the wing surfaces. The high pressure area over the aircraft, hitherto sustained so as to provide the lift we all needed, has been reduced, with a concomitant reduction in the lift. We are therefore in descent phase.

You don't say! But are you sure the dihedral angle has something to do with it?

I really needed a lift! Why spoil it?



section

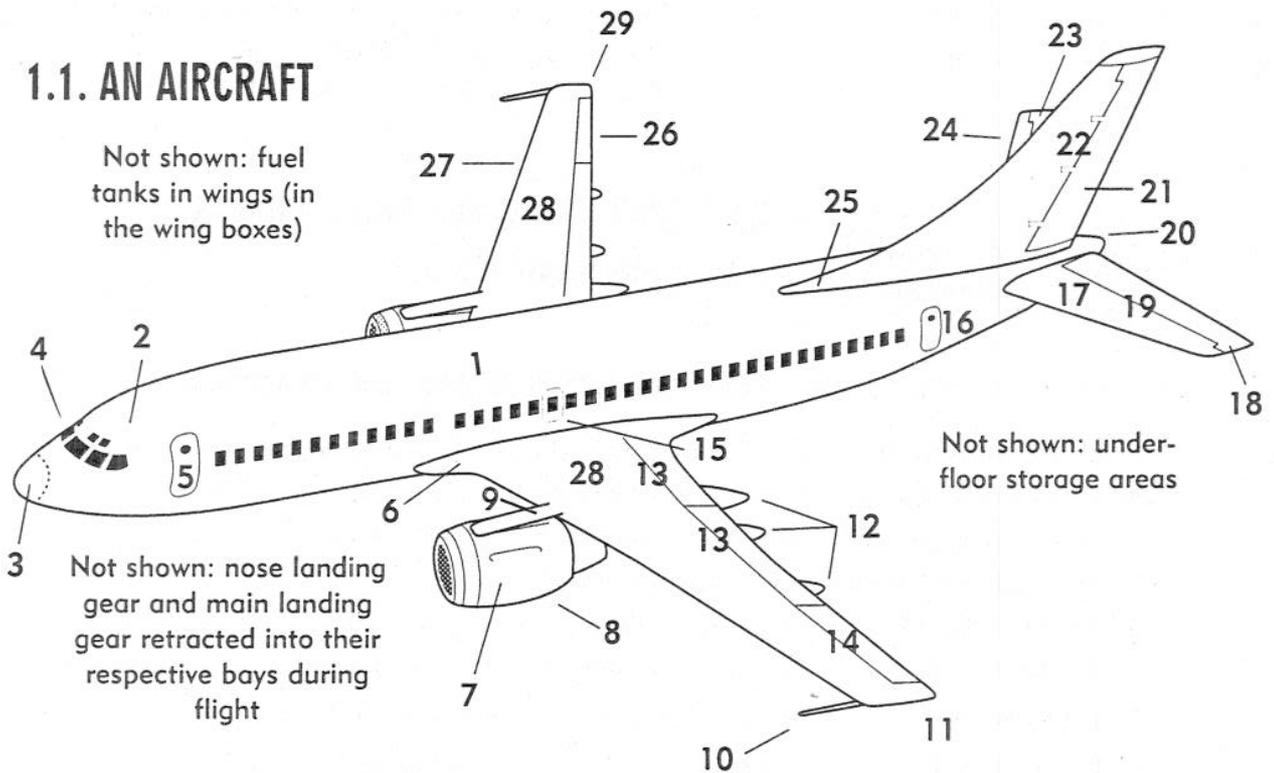
1

# Basic Aircraft Structure and the Principles of Flight

## PART 1: ON THE OUTSIDE

### Basic Aircraft Structures

### 1.1. AN AIRCRAFT



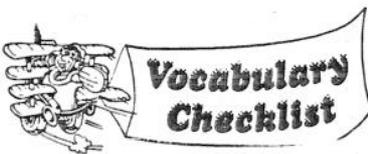
#### 1.1.1. IDENTIFY THE FOLLOWING PARTS. WRITE IN THE CORRESPONDING NUMBERS.

- |  |       |                                 |       |
|--|-------|---------------------------------|-------|
| a. fuselage  | ..... | o. port navigation light (red)  | ..... |
| b. cockpit   | ..... | p. flaps                        | ..... |
| c. radome  | ..... | q. aileron                      | ..... |
| d. wing  | ..... | r. flap track fairings          | ..... |
| e. leading edge (wing)                             | ..... | s. rear evacuation exit         | ..... |
| f. trailing edge (wing)                            | ..... | t. vertical stabilizer          | ..... |
| g. wing root fairing                               | ..... | u. horizontal stabilizer        | ..... |
| h. engine  | ..... | v. port trimming tailplane      | ..... |
| i. engine pod/nacelle                              | ..... | w. starboard trimming tailplane | ..... |
| j. pylon   | ..... | x. fin root fairing (fillet)    | ..... |
| k. passenger door                                  | ..... | y. rudder                       | ..... |
| l. emergency evacuation exit                       | ..... | z. tailcone                     | ..... |
| m. windscreen <sup>1</sup> (windshield) and wipers | ..... | aa. port elevator               | ..... |
| n. static dischargers                              | ..... | bb. starboard navigation light  | ..... |
|  |       | cc. starboard elevator          | ..... |

<sup>1</sup>windscreen is the British word for *windshield* used in the US.

### 1.1.2. MATCH EACH PART BELOW WITH WHAT IT DOES OR PROVIDES

- |                                |   |
|--------------------------------|---|
| 1. RADOME .....                | a. provides protection to tracks                                  |
| 2. ENGINE .....                | b. houses instruments   |
| 3. ENGINE POD/NACELLE .....    | c. provides thrust  |
| 4. PYLON .....                 | d. fastens the engine to the wing                                 |
| 5. WING .....                  | e. fastens stabilizer to fuselage                                 |
| 6. NAVIGATION LIGHTS .....     | f. houses the passenger cabins, cockpit and underfloor areas      |
| 7. FLAP TRACK FAIRINGS .....   | g. provides lift  |
| 8. VERTICAL STABILIZER .....   | h. identify the aircraft, make aircraft visible at night          |
| 9. HORIZONTAL STABILIZER ..... | i. with elevators, provides stability and balance in flight       |
| 10. FUSELAGE .....             | j. with fin and rudder, also contributes to stability and balance |
| 11. FIN ROOT FAIRING .....     | k. provides directional guidance in flight                        |
| 12. RUDDER .....               | l. surrounds and protects the engine                              |



### CHECK THAT YOU KNOW THESE WORDS Configuration and design

THESE EXPRESSIONS WILL BE USED THROUGHOUT THIS BOOK. BE SURE THAT YOU ARE FAMILIAR WITH THEM.

- to be fitted with/on** Aircraft are fitted with equipment. Wings are fitted with static dischargers.
- to be provided with** Wings are provided with static dischargers.
- to be furnished with** All equipment is furnished with specifications.
- to be equipped with** Aircraft are equipped with de-icers.
- to be designed for** This model of static discharger was designed for use on the B777.
- to be designed to** De-icers are designed to remove and prevent hazardous ice formation.
- to provide stg.** De-icers provide protection against ice formation.
- to be provided** Specifications are provided upon request.
- to furnish stg.** De-icers furnish protection against ice formation. Details will be furnished upon request.
- to supply stg.** The APU (auxiliary power unit) supplies power while the aircraft is grounded. The airline agreed to supply all airlines with updated service bulletins.

### Training Exercises!



### 1.1.3. GET INTO TRAINING. PRACTICE USING THE WORDS ABOVE.

1. Wings ..... flaps. Each wing is also ..... navigation lights.
2. Very sophisticated computer systems ..... the pilot ..... information during the entire flight.
3. The horizontal and vertical stabilizers are ..... stability in flight.
4. Each windshield (UK: windscreen) ..... to remove rain.
5. The engines ..... thrust for horizontal displacement of the aircraft.
6. Fuel tanks .....
7. All aircraft .....nose and main landing gear.

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## Vocabulary Checklist

### FOCUS ON ENABLING AND ALLOWING Vocabulary and Grammatical Patterns

○ **to allow somebody to do something**

The computer systems allow the pilot to monitor all flight parameters.

○ **to enable somebody to do something**

The newly designed display screens allow the pilot to see at a glance the engine pressure ratio.

○ **to make it possible for somebody to do something**

Today's widebodies make it possible for passengers to travel in maximum comfort.

○ **to allow something (to be done)**

Computer systems allow constant temperature control, allows the temperature to be controlled.

○ **to enable something (to be done)**

The computer systems enable pressurization and other parameters to be monitored at all times.

○ **to make it possible for something to be done**

Sophisticated warning systems make it possible for passengers to be transported in maximum safety conditions.

### Notice these models

1. Modern aircraft are equipped with sophisticated computer systems.
2. These systems are designed to allow the pilot to monitor all flight aspects.

#### **And combined into one sentence:**

3. Modern aircraft are equipped with sophisticated computer systems designed to allow the pilot to monitor all flight aspects.

### Training Exercises!



#### 1.1.4. GET INTO TRAINING.

MAKE COMPLETE STATEMENTS USING THE PROMPTS.

#### EXAMPLE:

Radar system/design/pilot/identification of obstacles or weather fronts

Aircraft are equipped with radar systems designed to allow pilots to identify obstacles and weather fronts.

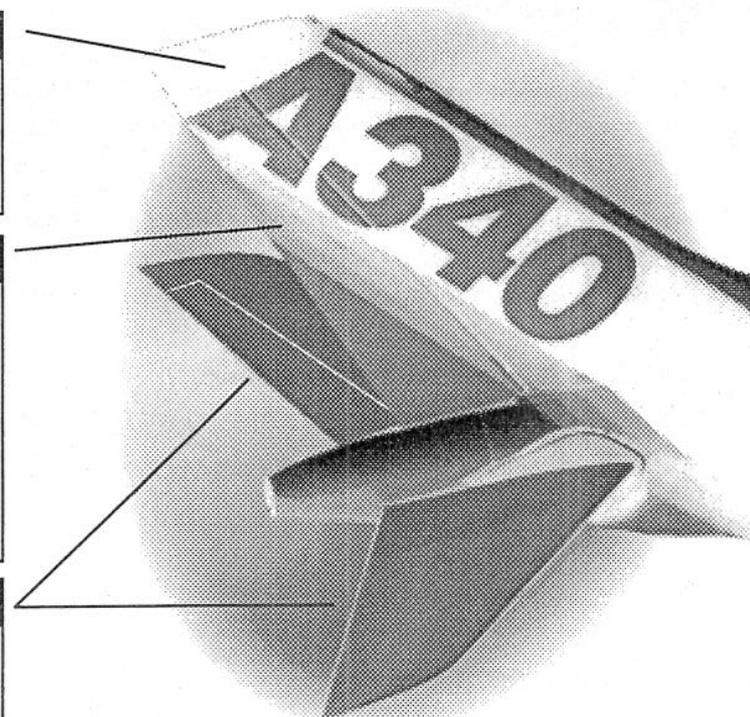
1. Wings/design/thrust
2. Navigation lights/aircraft/identified from a distance
3. Tailplane/flight stability
4. Cockpit windows/pilots/adequate angles of visibility
5. landing gear/taxi on the ground/ land
6. underfloor storage areas/passenger baggage/cargo/transport
7. fuel tanks in wings/engines/fuel
8. The APU (auxiliary power unit)/aircraft/electricity during on-ground operations.

## 1.2. SIMPLE DESCRIPTIONS

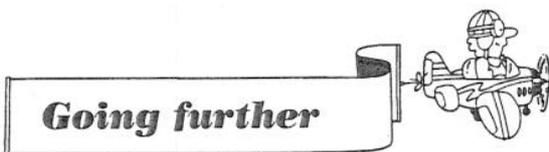
**THE VERTICAL STABILIZER**  
 The vertical stabilizer or tailplane is designed to provide stability when the aircraft pitches.

**THE RUDDER**  
 The rudder is the rearmost (or aftmost) part of the vertical stabilizer and provides directional guidance while the aircraft is on the runway, or corrects imbalance during flight (controlling the aircraft in the yaw axis).

**THE HORIZONTAL STABILIZER**  
 The purpose of the horizontal stabilizer is to provide the movement required for trimming to ensure balanced flight.



from an original photograph ©Airbus Industrie. Reproduced by permission.



**More detailed descriptions. Note the following description of the horizontal stabilizer.**

---

The horizontal stabilizer is one of the flight controls and is used to trim the aircraft in the pitch axis. It is actuated by two motors which are coupled differentially and which are driven by two different hydraulic systems. An elevator is located on each side of the horizontal stabilizer also driven by hydraulic actuators.

---

*For more information on pitch (and yaw) see the following pages.*

### 1.2.1. PRACTICE

**CAN YOU PROVIDE APPROPRIATE DESCRIPTIONS FOR THE OTHER AIRCRAFT STRUCTURES SHOWN IN THE DRAWING ON PAGE 2? FOR INSTANCE:**

- a. Emergency evacuation exits .....
- b. Starboard and port navigation lights: .....
- c. Cabin door: .....
- d. Flaps: .....
- e. Flap tracks: .....
- f. Windshield (UK: windscreens) : .....
- g. Windshield wipers: .....
- h. Wings: .....

*Structures such as wings, flaps, and slaps are treated in later sections.*

## 1.3. THE PRINCIPLE OF FLIGHT



The A-340-200 in flight. ©Airbus Industrie. Reproduced by permission.

What makes flight possible? The physics involves what is known as lift, thrust, drag and weight. The aircraft's wings provide the necessary lift. Air passes over and under the wings. Passing over the top surface of the wing, air must travel a greater distance and speeds up. The increase in speed creates an area of low pressure over the wings and over the aircraft in general, while a zone of higher pressure is created under the wings. It is the low pressure area which pulls the aircraft upward.

Drag is caused by friction as air passes over and around the aircraft structure.

Thrust is provided by the engines and propels the aircraft forward.

### 1.3.1. PRACTICE

FILL IN THE FOLLOWING INFORMATION ABOUT FLIGHT USING THE LANGUAGE CONTAINED IN THE ABOVE PASSAGE. SEE THE GRAMMATICAL PATTERN ON THE RIGHT.

1. What ..... possible?
2. Flight ..... by four factors called
  - A. ....
  - B. ....
  - C. ....
  - D. ....
3. It is ..... which causes lift.
4. It is ..... which causes drag.
5. Thrust .....by the aircraft's engines and is the force which .....

### WHAT MAKES IT HAPPEN?

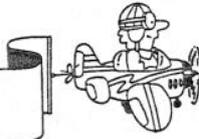
What is responsible for ... ?

What causes ... ?

What makes .... possible?

### 1.3.2.

#### Going further



### READ AND RESTATE

#### THE PRINCIPLES OF FLIGHT: BALANCED FORCES

The description on the right provides a simplified description of the forces involved in flight. Practice rephrasing the ideas using the language shown on the left.

#### LANGUAGE PRACTICE

is equated with  
Stated differently this means...  
Pressure is lowest where...

flow over the upper wing surface  
push up over  
pass under the wing  
air flowing beneath the wing  
flowing under the wing

#### EXPLAIN:

- 1) how a low-pressure area is created above the wing
- 2) how pressure is higher below the wing

#### COMPLETE:

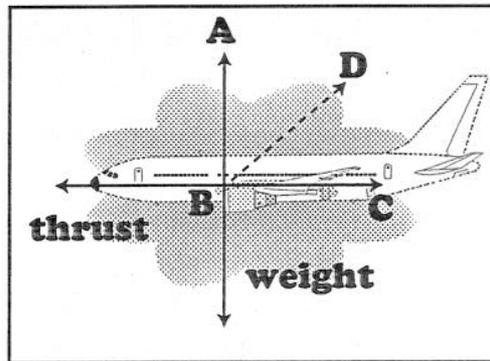
Opposing the forward thrust...  
The thrust is offset by...  
The forward thrust provided by the engines must...

See also: Cause and Effect:  
page 26.

#### BALANCED FORCES

High velocity means low pressure. This is equivalent to saying that pressure is least where velocity is highest, and that pressure will be greater where velocity is lower. This is the Bernoulli law.

When an aircraft is in flight at constant velocity, air streaming over the top of the wing must travel farther and faster than the air flowing along the underside of the wing. The air velocity above the wing surface is greater than that below it, resulting in an area of lower pressure.



In the figure above, the difference between the above-wing pressure and the below-wing pressure results in the force BD.

AB is the lift, equal to the weight of the aircraft and thus supports it. Vector BC is the component called *induced drag* which opposes the forward motion of the aircraft. *Profile drag* is related to surface characteristics (see page 12).

Engines must provide forward thrust equal to the drag for horizontal displacement to occur at constant speed. The aircraft moves even though all forces acting upon it are balanced, but at constant velocity.

Frictional drag results from resistance offered to airflow by the fuselage and other structures. One of the overriding concerns for aerodynamic engineers is how to reduce drag.

#### Training Exercises!



### 1.3.3. GET INTO TRAINING.

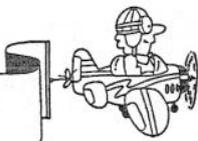
#### PRACTICE USING THE GRAMMATICAL PATTERN

#### DRAG IS LEAST/GREATEST

Pressure is (the) lowest where velocity is (the) highest.

#### REPHRASE THE FOLLOWING IDEAS USING THE PATTERNS ON THE LEFT.

1. Pressure increases steadily with decreasing velocity.
2. Maximum thrust results in maximum drag.
3. Drag decreases as altitude increases.



(1) **Airspeed over the wing surfaces:** referred to as the true airspeed of the aircraft (TAS). More lift is created at higher airspeeds.

(2) **Air density.** Lift is greater at higher densities.

(3) **The angle of attack.** This is the angle of the wing's inclination. Lift increases as the angle becomes larger.



(4) **The overall wing surface area.** A large wing provides more lift than a smaller wing.

Photograph ©Airbus Industrie. Reproduced by permission

### Training Exercises!



### 1.3.5. STATED DIFFERENTLY

PRACTICE THE PATTERN SHOWN IN THE MODEL IN MAKING STATEMENTS ABOUT THE 5 IDEAS WHICH FOLLOW.

#### Note this model:

The greater the airspeed the greater the lift.

1. air density / lift
2. angle of attack / lift
3. wing surface area / lift
4. drag at higher densities
5. drag and higher engine thrust

### 1.3.6. READ, UNDERSTAND AND ANSWER

*The angle of attack depends on the pitch of the aircraft, whether the nose is raised (nose up) or lowered (nose down). This is also referred to as the aircraft's attitude.*

1. How can the angle of attack be changed to increase lift?
2. How can the aircraft's attitude be changed?

**1.3.7. STATED DIFFERENTLY****READ AND RESTATE THE IDEAS.****Streamlining: a way to reduce drag**

Long thin objects slip through the air (and a liquid) more easily than wide ones.

An object so shaped that it slips through air or liquid easily is said to be streamlined. Maximum drag reduction occurs when an object is rounded in front, tapering in the rear (like the shape of a fish). For more information, see AERODYNAMICS on pages 12 and 13.

**■ USE THESE VERBS:**

- MOVE THROUGH
- PASS THROUGH
- FLOW AROUND
- GLIDE THROUGH
- SLIP THROUGH
- OFFER RESISTANCE TO

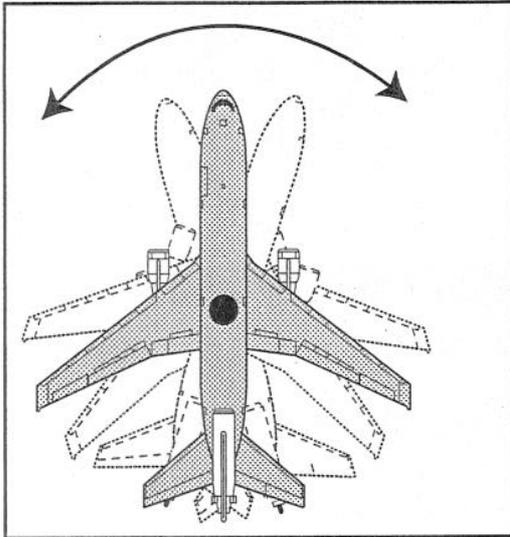
**■ IN TALKING ABOUT AIR FLOW AROUND THESE:**

- rounded objects
- thick blunt objects
- thin elongated objects
- flat objects
- rough-edged objects
- smooth-surfaced objects
- spherical objects

**Maintenance Check!****1.3.8. CHECK YOUR MEMORY!****CAN YOU USE ALL THESE WORDS IN A SIMPLE SENTENCE?**

- |  |   |                                  |   |                                |
|--|---|----------------------------------|---|--------------------------------|
| <input type="radio"/> nose landing gear  | <input type="radio"/> main landing gear     | <input type="radio"/> fuselage   | <input type="radio"/> radome            | <input type="radio"/> wing     |
| <input type="radio"/> leading edge       | <input type="radio"/> trailing edge         | <input type="radio"/> wing root  | <input type="radio"/> fairing           | <input type="radio"/> pylon    |
| <input type="radio"/> engine pod/nacelle | <input type="radio"/> evacuation exit       | <input type="radio"/> windshield | <input type="radio"/> static discharger | <input type="radio"/> port     |
| <input type="radio"/> starboard          | <input type="radio"/> flap                  | <input type="radio"/> aileron    | <input type="radio"/> flap track        | <input type="radio"/> vertical |
| <input type="radio"/> stabilizer         | <input type="radio"/> horizontal stabilizer | <input type="radio"/> tailplane  | <input type="radio"/> trimming          | <input type="radio"/> fin      |
| <input type="radio"/> fin root           | <input type="radio"/> rudder                | <input type="radio"/> tailcone   | <input type="radio"/> elevator          | <input type="radio"/> de-icer  |
| <input type="radio"/> fuel tank          | <input type="radio"/> APU                   | <input type="radio"/> lift       | <input type="radio"/> thrust            | <input type="radio"/> drag     |
| <input type="radio"/> weight             | <input type="radio"/> airflow               | <input type="radio"/> pressure   | <input type="radio"/> velocity          | <input type="radio"/> speed    |
| <input type="radio"/> underside          | <input type="radio"/> component             | <input type="radio"/> TAS        | <input type="radio"/> angle of attack   | <input type="radio"/> pitch    |
| <input type="radio"/> attitude           | <input type="radio"/> streamlining          | <input type="radio"/> shape      |   |                                |

## 1.4. STABILITY

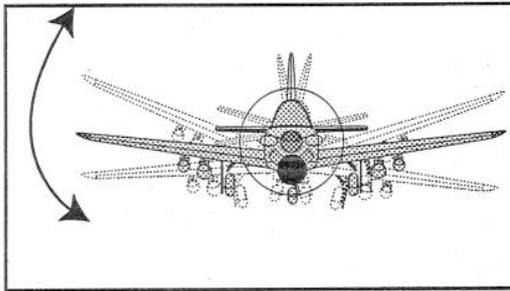


An aircraft is trimmed to ensure stability. During take-off and landing, trimming is a constant process, while in cruise it is usually performed automatically by computers. The horizontal stabilizer may be computer-controlled, with the appropriate setting determined by the computer in light of flight parameters.

Three important principles are involved in natural flight stability, all involving motion with respect to the aircraft's center of pressure (shown by a black dot in the drawings). These are:

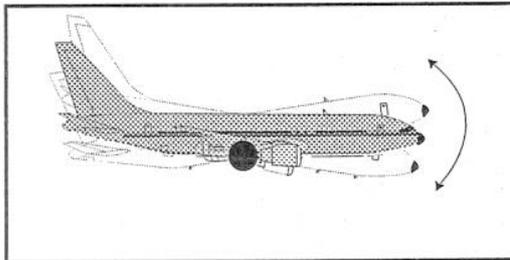
### YAWING

The tail fin is positioned to cause the aircraft to move about its vertical axis to correct the effects of wind which can yaw the aircraft to the left or right.



### ROLLING

Wind may roll the aircraft, causing it to slip to the side. When the aircraft sideslips, airflow hits the under surface of the lower wing, exerting an upward force. Due to the dihedral principle (the wing is mounted at an angle, for instance, 7°, to the horizontal), the wing on the opposite side of the aircraft body, tilted upward, is spared this sideways airflow, bringing the aircraft back to level position.



### PITCHING

Wind may pitch the nose of the aircraft up, thereby causing a simultaneous increase in the angle of attack of both wings and tailplane (horizontal stabilizer). Because it is far from the center of pressure, the accompanying increase in lift raises the tail, returning the aircraft to stable horizontal position.

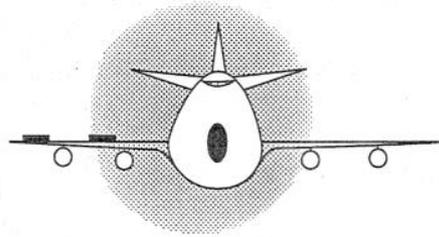


## CHECK THAT YOU KNOW THESE VERBS

All but two (SET/EXERT) describe movements

|  |   |
|--|---|
| <b>set</b>                               | The computers are set to control stability in light of flight parameters.                                       |
| <b>trim</b>                              | The pilot needs to trim the aircraft continuously during take-off.  |
| <b>sideslip</b>                          | A gust of wind can cause the aircraft to sideslip (slip to the side).   |
| <b>roll</b>                              | The aircraft rolls when one wing moves up and the opposite wing down.   |
| <b>yaw</b>                               | The aircraft yaws to the left or right around its vertical axis.  |
| <b>pitch</b>                             | The pilot can pitch the nose up or down. Wind can pitch the nose up or down.                                    |
| <b>exert</b>                             | We exert pressure on an object. We exert control over something.  |
| <b>bring back (return) to a position</b> | The pilot performs the proper actions to bring the aircraft back / to return the aircraft to stable conditions. |
| <b>move</b>                              | The aircraft moves laterally.   |
| <b>raise</b>                             | The pilot raises the horizontal elevator to force the tail down.  |
| <b>lower</b>                             | The pilot lowers the horizontal elevators to force the tail up.   |

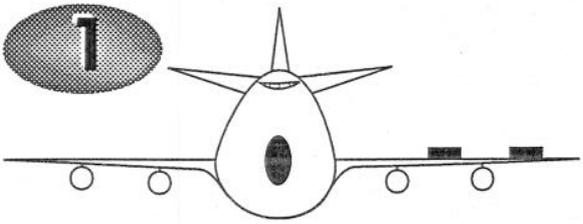
Ailerons are the flight control surfaces used in rolling (and turning) the aircraft. Shown here is the set of inboard and outboard ailerons in up position. Raising these ailerons causes reduced lift over the wing, pushing it down. The aircraft rolls or turns to the right. When the proper bank is reached, the ailerons are returned to their central position, and the aircraft continues to turn. By reversing aileron settings the pilot can return the aircraft to its previous straight horizontal position.



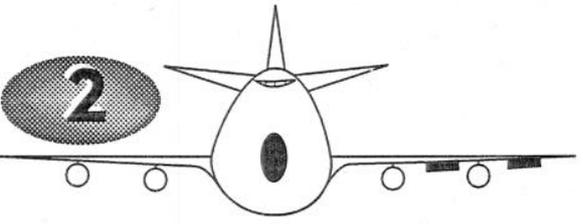
**Training Exercises!**

**1.4.1. PRACTICE DESCRIPTIONS.**  
Describing effects

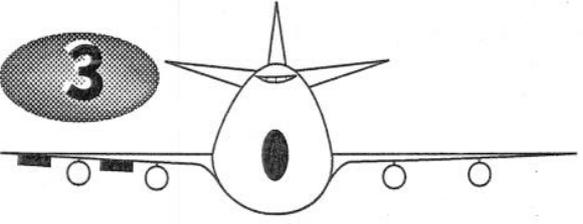
DESCRIBE THE EFFECT PRODUCED WHEN AILERONS ARE POSITIONED AS SHOWN IN EACH DRAWING.



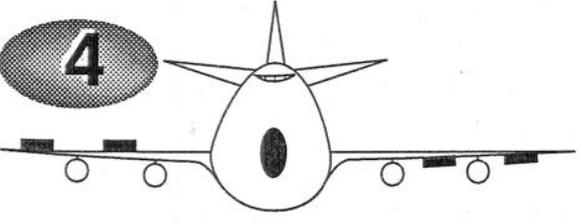
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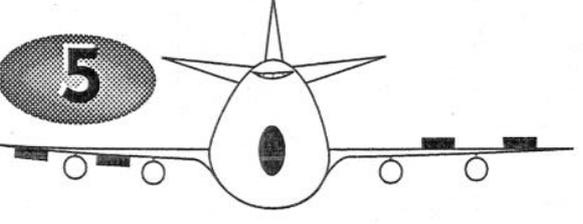
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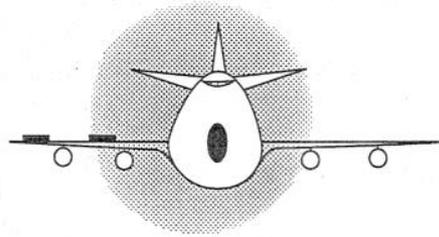


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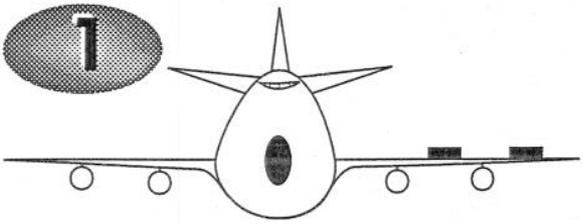
Ailerons are the flight control surfaces used in rolling (and turning) the aircraft. Shown here is the set of inboard and outboard ailerons in up position. Raising these ailerons causes reduced lift over the wing, pushing it down. The aircraft rolls or turns to the right. When the proper bank is reached, the ailerons are returned to their central position, and the aircraft continues to turn. By reversing aileron settings the pilot can return the aircraft to its previous straight horizontal position.



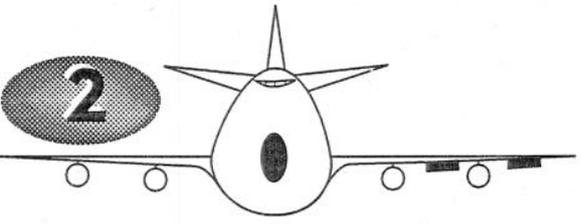
**Training Exercises!**

**1.4.1. PRACTICE DESCRIPTIONS.**  
Describing effects

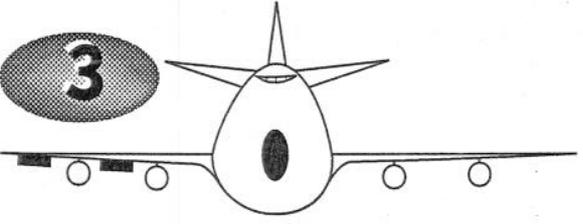
DESCRIBE THE EFFECT PRODUCED WHEN AILERONS ARE POSITIONED AS SHOWN IN EACH DRAWING.



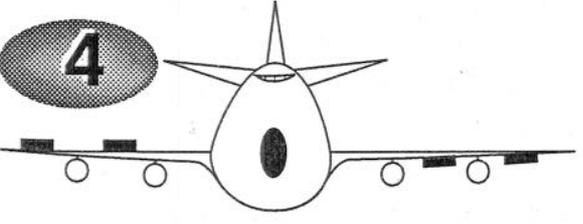
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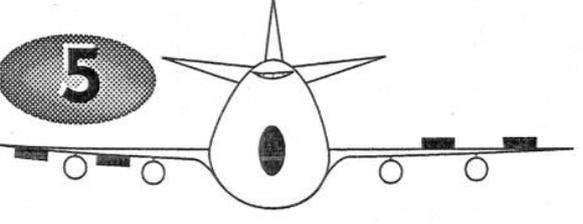
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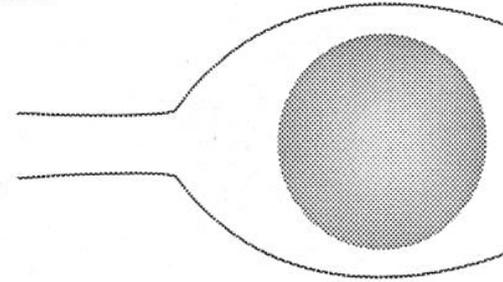
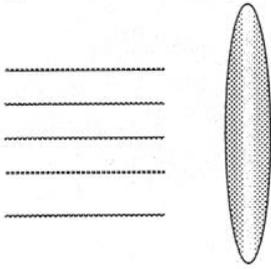


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## 1.5.

# Aerodynamics

Talking about the basic principles of aerodynamics



### Air behavior

The way air behaves as it flows over and around an object does not depend so much on the object's dimensions as it does on its shape. Air offers resistance to a moving object because this object must *occupy* the space that was previously *occupied* by air, thus *displacing* the air. The air is compressed in front of the moving object and flows along the contour of the object to occupy the free space left as the moving object *continues* on its way.

The greater the speed, the more compressed the air will be, and the greater the resistance will be. Resistance *thus* depends on velocity. This rule will *apply* whenever air meets a moving body.

### Resistance and airspeed

Resistance *thus* depends on airspeed and is proportional to the square of the speed. If speed increases by a factor of two, then resistance increases fourfold. Or stated differently: if an aircraft doubles its speed it will *meet* quadrupled resistance (profile drag). *As opposed to* induced drag which is caused by airflows resulting from lift, profile drag is directly *linked to* the shape and surface characteristics of the object.

This law *is valid* only for speeds lower than that of sound in air (330 meters per second). At supersonic speeds resistance increases more rapidly than the square of the velocity.

#### 1.5.1. PRACTICE: STATED DIFFERENTLY

Rephrase the ideas, replacing the words in *italics* in the passage on the left with the expressions below.

force out of the way / hold / move along path /  
proceed / take up / therefore

#### 1.5.2. FLUENCY PRACTICE

There are usually several ways to say the same thing. Restate the following idea using the expressions which follow and making any necessary changes:

The greater the speed, the more compressed will be the air, and the greater the resistance will be.

- When the speed increases, ....
- Compression becomes greater as ....
- As airflow speeds up, ...
- Compression increases when ....
- Resistance ....

#### 1.5.3 STATED DIFFERENTLY

Rephrase the ideas replacing the words in *italics* in the passage on the left with the expressions below.

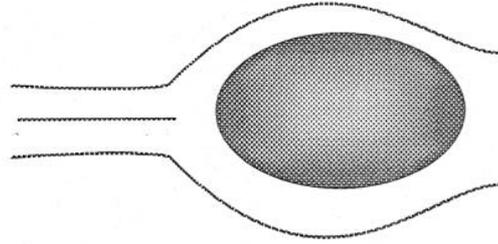
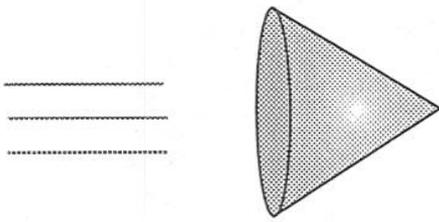
force out of the way / hold / path / proceed / take up /  
therefore / encounter / unlike

#### 1.5.4. FLUENCY PRACTICE

Now practice restating this idea using the sentence openers which follow:

As opposed to induced drag which is caused by airflows resulting from lift, profile drag is directly linked to the shape and surface characteristics of the object.

- Profile drag differs from... in that ....
- The shape and surface characteristics ....
- Changing an object's shape can result in ....
- Induced drag is directly linked to .... unlike .... which ....



## Shape

Resistance encountered by a sphere is half that experienced by the disc. Resistance encountered by the cone is  $\frac{2}{5}$  that of the disk. And resistance encountered by the egg-shaped object is only  $\frac{1}{20}$ . The latter favors air-flow toward the rear.

## Surface

A polished surface favors smooth air flow (laminar flow), whereas a rough surface leads to disrupted flow (turbulent flow).

## NOTE THESE DEFINITIONS

### LAMINAR FLOW

**Laminar flow is non turbulent motion of a fluid (or air) in which parallel layers have different relative velocities.**

### TURBULENT FLOW

**Turbulent flow is motion in a liquid (or air) whose speed at any point varies rapidly in an irregular manner.**

## 1.5.5. DEFINE AND DESCRIBE : CAN YOU DEFINE AND DESCRIBE THE FOLLOWING TERMS?

1. turbulence
2. smooth airflow
3. smooth surface
4. friction (or resistance)

## 1.5.6. FLUENCY PRACTICE

Rephrase the following idea using the expressions or structural patterns which follow:

A polished surface favors smooth air flow (laminar flow) whereas a rough surface leads to disrupted flow (turbulent flow).

1. Unlike polished surfaces which ...
2. Polished surfaces ... as opposed to ...

## Aerodynamics and lift

Aircraft wings are asymmetric in contour, which forces the airstream to follow a longer path along the topside than along the underside. Air must flow faster over the top to encounter air flowing along the underside at the rear edge of the wing. This fact accounts for lift which pulls the aircraft upward.

## 1.5.7. INTERPRET: COMPLETE EACH STATEMENT

1. Thanks to asymmetry in wing contour ....
2. Without this asymmetry ....
3. The faster airflow over the top surface of the wing results in .... (See preceding sections which deal with lift).

## 1.6. HOW BIG IS BIG?

The largest passenger aircraft to date is the B747, capable of transporting between 500 and 650 passengers (with the record maximum being 674) with a range of between 6,460 and 10,500 km. The 747 measures 77.66m in length and 11.8m in overall height. Wingspan is 59.64m (nearly 60m), almost 9m more than in the L-1011.

### NOTE THESE TYPICAL QUESTIONS:

How far is it from tail to nose? What is the overall length?

How far off the ground is the cockpit?

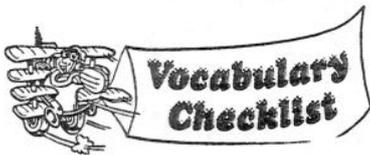
How large is the center fuel tank? What is its maximum capacity?

How far is it from one emergency evacuation exit to the next?

How many gallons (liters) of fuel does the center fuel tank hold?

How much engine thrust is required for take-off with full passenger load?

Photograph ©Air France. Reproduced by permission.



## DIMENSIONS, WEIGHTS, CAPACITY

Note the questions and the answers.

- |                           |                                  |
|---------------------------|----------------------------------|
| ○ What is its width?      | It's 3m wide.                    |
| ○ How wide is it?         | It's 3m in width.                |
| ○ What is its length?     | It's 33m in length.              |
| ○ How long is it?         | It's 33m long.                   |
| ○ What is its height?     | It's 10m high.                   |
| ○ How high is it?         | It's 10m in height.              |
| ○ What is its weight?     | } It weighs 150 (metric) tonnes. |
| ○ How much does it weigh? |                                  |
| ○ What's its capacity?    | It has a capacity of 30,000 l.   |
| ○ How much can it hold?   | It can hold 30,000 liters.       |

### HOW + ADJECTIVE?

*This is a very common pattern in conversation.*

- How useful is it?
- How important is the change?
- How thin is the air at 35,000ft?
- How bad (extensive) was the damage?
- How strong was the wind?



## 1.6.1. QUESTIONS AND ANSWERS

Talking about dimensions

WORKING WITH A PARTNER IF POSSIBLE, PRACTICE ASKING AND ANSWERING QUESTIONS ABOUT THE B747 (100/200/300 SERIES). SEE ALSO THE GRAMMAR FILE ON PAGE 16.



100-200-300 series

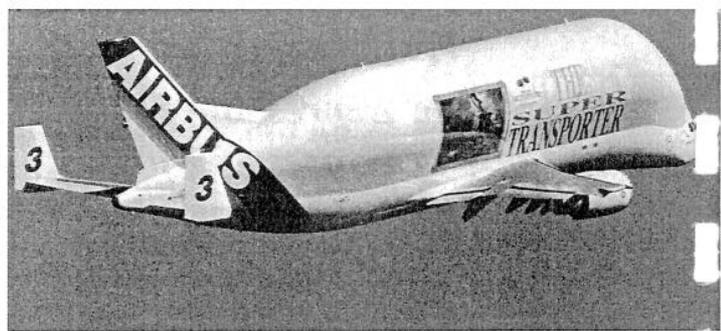
|                         |   |
|-------------------------|---|
| passenger load:         | 500 (100 series)/550 (200 series)/660(300 series) |
| range (full load):      | 6,460km (100) /10,900km (200) / 10,500km (300)    |
| overall length:         | 70.66m (231.76ft)                                 |
| overall height:         | 11.8m (63.40ft)                                   |
| wingspan:               | 59.64m (195.62 ft)                                |
| mtow (tonnes)*:         | 332.9 (100) / 371.9(200) / 377.8 (300)            |
| fuel capacity (liters)  | 183,570(100) / 198,380 (200) / 198,380 (300)      |
| (US gallons)            | 48,650 (100) / 52,580 (200) / 52,580 (300)        |
| normal cruise altitude: | 28,000ft to 39,000ft                              |

\* MAXIMUM TAKE-OFF WEIGHT

## 1.7. VERY BIG

**The Super Transporter, dubbed BELUGA, offers some surprises when it comes to size and cargo capabilities.**

Photograph ©Airbus Industrie Reproduced by permission.



The super transporter, derived from the A300-600R airframe, was designed for more efficient transport of aircraft structures of the Airbus production range from manufacturers across Europe to their final assembly sites in France and Germany. As such, it was intended to replace the 4 former "Super Guppy" aircraft converted from the Boeing 377 whose maintenance costs were beginning to exceed allowable limits. The "Beluga" also offers improved turnaround time of 45 minutes, down from the 1-3 hours for the Super Guppy, entailing a dramatic reduction in transport lead times as components are shuttled around Europe. According to some estimates, the time required to bring together structures can be cut in two. This means, for instance, 4 days instead of the 8 days normally required to gather components for A320 final assembly.

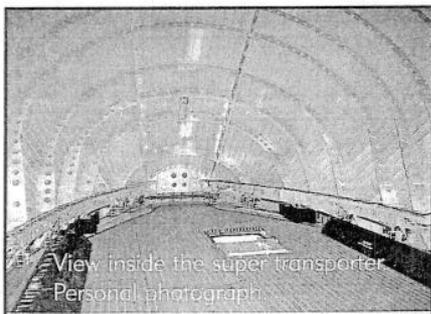
With tightened transport loops among the Airbus partners and subcontractors cost-savings will be substantial. The Super Guppy was to be phased out of operations as of 1999.

### 1.7.1. ANSWER THE QUESTIONS, USING THE SUGGESTED VOCABULARY GIVEN IN PARENTHESES.

- What purpose do the transporters — the Super Guppy and the Beluga — serve? (*to shuttle*)
- How are transport lead times improved? (*to halve or to cut in two, to bring down from...to*)
- What effects does this have on final assembly? (*instead of*)
- How do transport specialists ensure the most efficient lead times? (*transport loops*)
- What transition from Super Guppy to Beluga is planned? (*scheduled/phase out*)

### 1.7.2. READ AND PRACTICE

#### *Inside the super transporter*

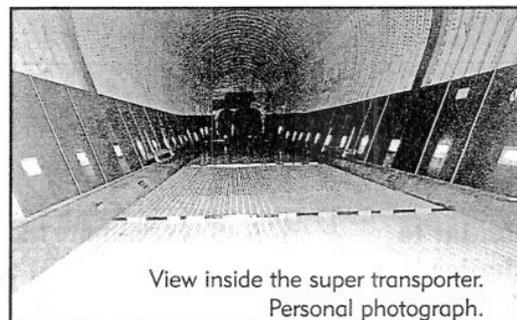


A radical departure from conventional design is the underfloor cockpit and one-piece loading door opening vertically. This configuration offers 2 advantages. First, it eliminates the need to disconnect aircraft systems during loading, thereby ensuring greater safety. Second, loading and unloading times are reduced.

Providing for an underfloor cockpit required substantial modifications to the original A300-600R flight deck which had to be moved forward 1.5m, placing the cockpit below the original level. Only two areas are pressurized: the cockpit and a rear compartment reserved for transporting equipment certificated for use exclusively in pressurized aircraft.

#### **BELUGA IN FIGURES:**

cockpit and upper fuselage extended to 7.7m in diameter.  
main hold height: 7.4m (2 times height of original cabin)  
hold width: 7.26m  
increase in height of reinforced main fin: +1.2m  
cargo door (largest ever manufactured) weight: 2t  
payload: 45.5t  
range with full payload: 1700 km  
Pair of center-mounted hinges, with two jacks on each side allow door to open to height of 17m



1. What does the underfloor cockpit make it possible to do? What does it do away with?
2. What modifications needed to be made?
3. Practice making complete descriptions based on the information provided in the second half of the box: BELUGA IN FIGURES.



**Expressing Comparisons**  
**Expressing Identity or Equivalence**  
**Expressing Similarities and Differences**

☛ **Comparisons**

|  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. The 747 is <b>less noisy than</b> the 737 on take-off.</li> <li>2. The 737 is <b>(much) noisier than</b> the 777.</li> <li>3. The A330 is <b>wider than</b> the A320.</li> <li>4. The A320 is <b>narrower than</b> the A330.</li> <li>5. The RR Trent 800 is <b>more powerful than</b> the PW 4000.</li> <li>6. The PW 4000 is <b>less powerful than</b> the RR engine.</li> <li>7. The RR Trent provides <b>greater/more thrust than</b> (does) the PW 400.</li> <li>8. The engine burns fuel <b>more efficiently than</b> the other. (adverb)</li> </ol> | <p><i>General rule: adjectives with 1 or 2 syllables add -ER for the comparative. Longer adjectives form their comparatives with <b>MORE or LESS</b> (examples 5, 6, &amp; 8)</i></p> |
| <ol style="list-style-type: none"> <li>9. The B747 is <b>longer than</b> the B767 (<b>is</b>).</li> <li>10. The B747 has a far <b>greater wingspan than</b> the B767 (<b>has or does</b>).</li> <li>11. The RR Trent provides <b>greater thrust than</b> the PW 4000 (<b>does</b>).</li> <li>12. The RR Trent provides <b>greater thrust than does</b> the PW 4000.<br/> <i>(Note the position of the auxiliary in the last sentence.)</i></li> </ol>  | <p><i>The corresponding auxiliary is often used, but it is omitted just as often.</i></p>   |
| <ol style="list-style-type: none"> <li>13. A is <b>twice as large as</b> B (is). A is <b>double the size of</b> B.</li> <li>14. A is <b>four times heavier than</b> C (is). A weighs <b>four times as much as</b> C (does).</li> </ol>   | <p><i>Other common and useful patterns to note</i></p>  |

☛ **Identity or Equivalence**

|  |  |
|--|--|
| <p>A <b>is the same as</b> B.<br/>         The PW 4000 <b>has the same thrust rating as</b> the second engine (<b>has or does</b>).<br/>         The thrust of the PW 4000 <b>is equivalent to</b> that of the CFM.<br/>         The thrust <b>is equal to</b> that of the CFM.<br/>         20 inches <b>is equivalent to/is equal to</b> 50.8 centimeters.</p> | <p><i>Again, the corresponding auxiliary may or may not be used.</i></p> |
| <p>A is { <b>approximately</b><br/><b>nearly</b><br/><b>almost</b> } the same as B, but it isn't quite as long.</p>  | <p><i>When two items are not quite identical</i></p>                     |

☛ **Similarity and Differences**

|   |   |
|---|---|
| <p><b>similar to</b><br/> <b>similar in</b><br/> <b>different from</b><br/> <b>different in</b><br/> <b>to differ in/from</b><br/> <b>like</b><br/> <b>to be alike</b><br/> <b>unlike</b></p> | <p>A is (very, quite) similar to B.<br/>         A is similar (to B) in overall height.<br/>         But B is different from A in its thickness.<br/>         It is different (from A) in skin thickness.<br/>         B also differs (from A) in its use of composite materials.<br/>         A is like B in many ways, but differs from B in one respect.<br/>         A and B are very much alike, but differ in one minor respect.<br/>         Unlike A, B requires longer to reach rotation, or take-off speed.</p> |
|---|---|



## 1.8. PRACTICE COMPARING AND CONTRASTING

### 1.8.1. COMPARING ONE TO ANOTHER.

LOOK AT THE INFORMATION ON THREE WELL-KNOWN WIDEBODIES. THEN PRACTICE MAKING COMPARISONS.

| aircraft       | AIRBUS A300<br><br>B4-100 | BOEING 747<br><br>100-200-300 series | LOCKHEED L1011<br> |
|----------------|--|--|---|
| parameters     |  |  |   |
| PASSENGER LOAD | 251  | 500-650  | 330   |
| RANGE          | 3,890 km   | 6,460-10,500 km  | 8,520 km  |
| OVERALL LENGTH | 53.6 m   | 70.66 m  | 50.04 m   |
| OVERALL HEIGHT | 16.5 m   | 19.33 m  | 18.86 m   |
| WINGSPAN       | 44.8 m   | 59.64 m  | 50.9 m  |
| MTOW (TONNES)* | 150  | 332-377  | 225   |

MTOW = maximum take-off weight

*And the MD-10?  
How does it  
compare with  
the others?*

PASSENGER LOAD: 380  
range: 9670 km (6200 m)  
OVERALL LENGTH: 55.30 m (181.38ft)  
OVERALL HEIGHT: 17.68 m (58ft)  
WINGSPAN: 49.17 m (165.28 ft)  
MTOW (TONNES) 251.7



### 1.8.2. PRACTICE

For each pair below, state the apparent difference, then a comparison which explains the difference.

**EXAMPLE:**

*MD-10/L-1011: passenger load  
The L-1011 cannot transport as many passengers as the MD-10. In fact, the MD-10 can carry 50 more passengers (than the L-1011 can).*

- MD-10/L-1011: overall height
- MD-10/L-1011: wingspan
- A300/L-1011: overall length
- A300/MD-10: range with full passenger load
- B747/L-1011: passenger load and range (see page 14 for information relating to the B747 series)
- A300/B747: mtow

### 1.8.3. PRACTICE

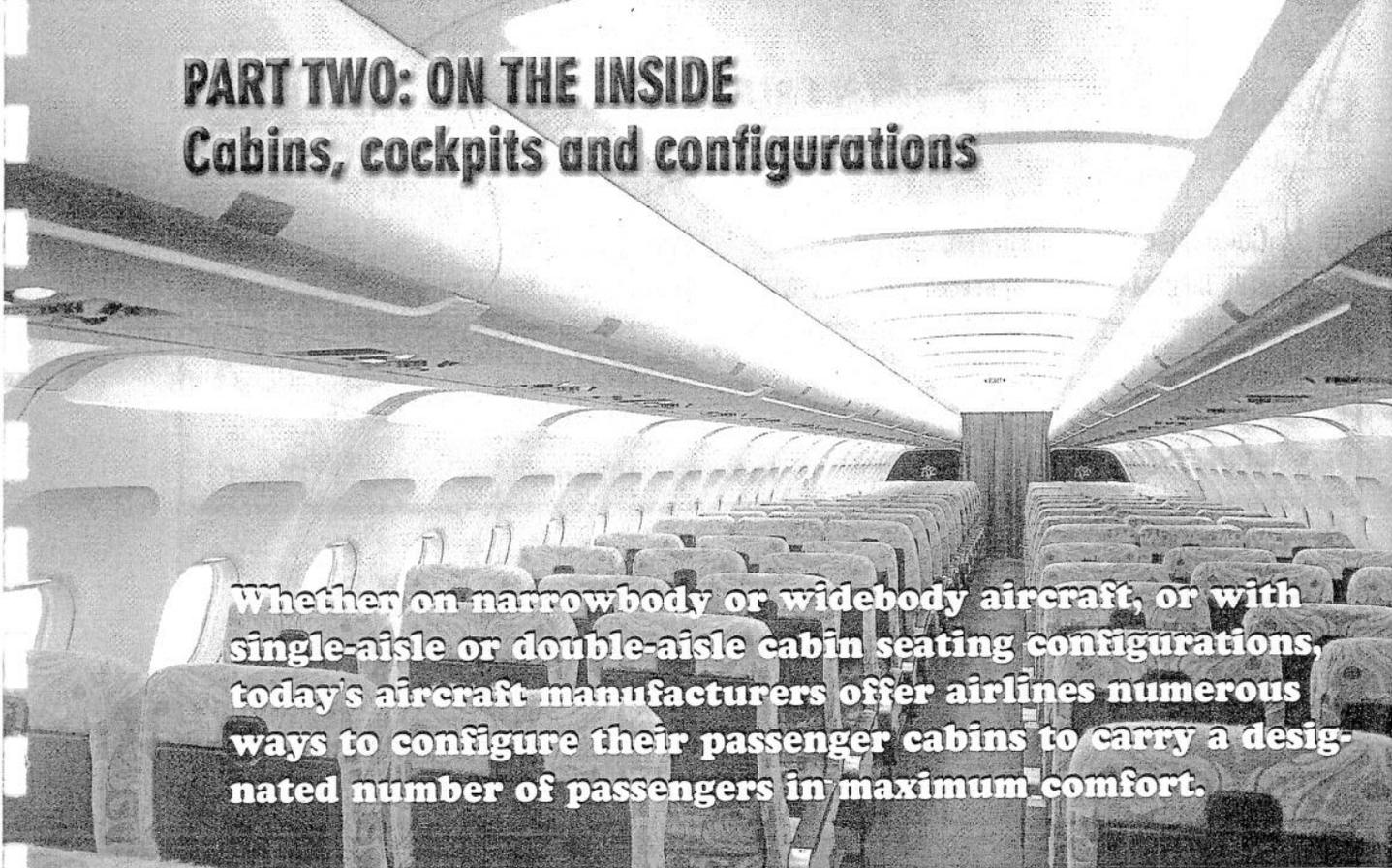
If there is a difference, how great is the difference? Below you will see data for 4 randomly selected engines. How many statements of similarities and differences can you make?

|          | thrust (kN) | length (m) | fan diameter(m) |
|----------|-------------|------------|-----------------|
| CFM56-2B | 106.8       | 2.43       | 1.73            |
| CFM56-5A | 117.9       | 2.42       | 1.75            |
| PW4084   | 373.8       | 4.86       | 3.04            |
| JT1505*  | 14.19       | 1.53       | 0.52            |

(\*This engine powers smaller aircraft such as the Cessna).

# PART TWO: ON THE INSIDE

## Cabins, cockpits and configurations



Whether on narrowbody or widebody aircraft, or with single-aisle or double-aisle cabin seating configurations, today's aircraft manufacturers offer airlines numerous ways to configure their passenger cabins to carry a designated number of passengers in maximum comfort.

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### 1.9. Cabin Configuration

#### Passenger compartment

The cabin layout and seating arrangements can be configured in keeping with specific airline requests as long as these arrangements comply with airworthiness directives.

Shown above: six-abreast seating broken by a center aisle. The A320, like the B737 features single-aisle configuration.

#### Passenger seats

The A300 (B2 and B4) offered 261 seats, 8-abreast at a seat pitch of 864mm with 483mm aisles. In today's seats, lighter weight composite materials are replacing traditional metal frames.

In 1995 BE Aerospace introduced new business-class seats featuring adjustable leg rests, headrests, dynamic lumbar support, and full IFE (in-flight entertainment) integration.

Sleeper seats are now common on long-haul flights, some converting into a complete bed. British Airways has introduced seat-beds in individual private passenger cabin spaces.

Then there are the convertible seats (CVS) allowing a bank of standard economy-class seats to be converted into business-class seats and vice versa in minutes.

In addition to seats, passenger cabins are also configured with attendant seats, galleys and lavatories.

The A300 B2 and B4 had a galley and 2 toilets aft of the cockpit, and 4 additional lavatories at the rear at designated locations. Passenger seats aft of partitions, galleys or exit cross-aisles are provided with in-armrest tables.

Airlines generally specify color schemes from the possible ranges on offer.

#### Additional considerations

Each cabin is fitted with a row of overhead storage bins along each sidewall of the passenger cabin. Storage compartments are provided with two doors each fitted with adjustable slam locks.

In the A340, each overhead compartment may hold a maximum of 50 kg (110 lbs) and extends over a 2.12 m (83.5 in) pitch.

Cabins must also provide for Passenger Service Units, comprising loudspeakers, attendant call buttons, reading lights, emergency oxygen, and seat and seat row numbering.

Cabin floors are carpeted in keeping with airline requests.

#### Curtains and partitions

Cabins are usually fitted with curtains to divide compartments. This item is BFE (a piece of Buyer Furnished Equipment) as opposed to what is termed SFE (Seller Furnished Equipment).



# Vocabulary Checklist

## DO YOU KNOW ALL THESE WORDS?

### Types of aircraft and cabin configuration

- narrowbody
- single-aisle
- seating arrangement
- three-abreast
- lavatory
- storage bin
- partition
- widebody
- twin-aisle
- airworthy
- pitch
- in-armrest
- slam lock
- BFE
- to configure
- seat
- airworthiness
- galley
- color scheme
- a carpet/carpeted
- SFE
- aisle
- seating
- two-abreast
- attendant
- stowage (storage)
- curtains
- convertible seats

### OF SPECIAL IMPORTANCE

- IN KEEPING WITH:** New designs have been introduced in keeping with passengers' wishes.
- TO COMPLY WITH:** Airline manufacturers must comply with airworthiness directives.
- IN COMPLIANCE WITH:** All steps were performed in compliance with airworthiness directives.

## 1.9.1.

### Vocabulary practice



### TEST YOURSELF

#### COMPLETE OR ANSWER:

- a. Customers (airlines) may request a configuration but ...
- b. A bank of 4 seats, one next to the other, would be called ...
- c. Unlike traditional seat frames, ...
- d. BE Aerospace designed three features offering passengers more comfort. These are:
 

....., ....., and .....
- e. A flight from New York to Tokyo is referred to as a ..... flight.  
Typically used for this type of flight is a ..... aircraft.  
A flight from London to Paris is referred to as a ..... flight.  
Typically used for this type of flight is a ..... aircraft.
- f. British Airways introduced a unique feature in its first class cabin configuration:
 

.....
- g. Describe the difference between the vast majority of passenger seats and ones found directly behind a galley partition:
- h. .... is designed to prevent overhead stowage bins from opening during flight.
- i. Describe the difference between a standard item of equipment and one designated BFE.
- j. Inspection revealed that the configuration did not ..... standard safety regulations.
- k. Passenger safety units must be provided ..... safety regulations.
- l. Airlines offer different types of meals ..... cultural considerations of their passengers.

## 1.9.2. Model description

### Cabin accommodations. The example of the A300B2-B4

The widebody layout called for 261 seats in 8 abreast seating (2-2+2-2) with a seat pitch of 34 inches (864 mm), and 19-inch (483-mm) aisles. The standard baseline seat width measured 40.4 inches (1.03 m). An available option included a double row of overhead storage bins running down the center of the cabin. A general feature on widebody seating has each row of seats broken in two locations to yield 2 parallel aisles extending the entire length of the cabin.

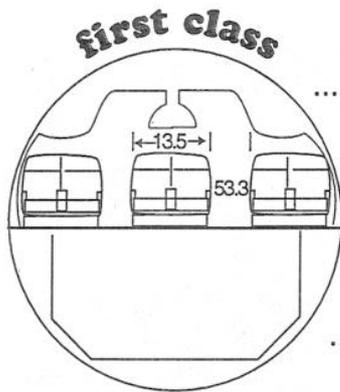


## 1.9.3. DESCRIBING CONFIGURATIONS

DESCRIBE THE CABIN CONFIGURATIONS BELOW.

### WORDS TO USE IN YOUR DESCRIPTIONS

- |   |   |   |
|---|---|---|
| <input type="radio"/> narrowbody                  | <input type="radio"/> widebody                  | <input type="radio"/> cabin layout                  |
| <input type="radio"/> short-haul<br>(short-range) | <input type="radio"/> long-haul<br>(long-range) | <input type="radio"/> medium-haul<br>(medium-range) |
| <input type="radio"/> twin-aisle                  | <input type="radio"/> single-aisle              | <input type="radio"/> aisle width                   |
| <input type="radio"/> baseline seat (width)       | <input type="radio"/> single-seat width         | <input type="radio"/> legroom                       |



.....

.....

.....

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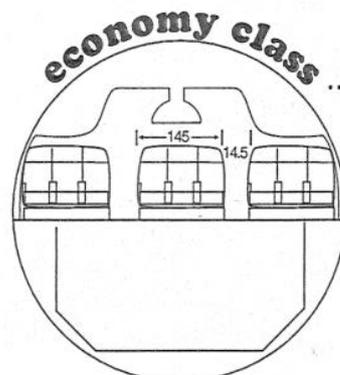


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## 1.9.4. DESCRIBING CONFIGURATIONS

Describe the three cabin configurations of the A340 shown below. What does each configuration provide or feature that is not found in the other compartments? What advantage does each offer (number of passengers, for instance)? See the model description on the previous page.

### The A340 first class cabin

- bank of two seats (baseline): 53 inches (134.6cm)
- individual seat: 26.5 inches (67.3 cm)
- legroom, reclining seats
- arrangement (seats/aisles)
- partition
- curtain
- carpet
- aisle width



Photograph ©Airbus Industrie. Reproduced by permission.

### The A340 business class

- general cabin configuration
- bank of two seats (baseline): 48 inches (121.9cm)
- individual seat: 24 inches (60.96 cm)
- arrangement here
- overhead storage compartments
- passenger service units
- lighting
- aisles and aisle width



Photograph ©Airbus Industrie. Reproduced by permission.

### The A340 economy class

- general cabin configuration
- bank of two seats (baseline): 40.4 inches (102.6cm)
- individual seat: 20.2 inches (51.3 cm)
- arrangement here
- overhead storage bins
- passenger service units
- lighting
- aisles and aisle width



Photograph ©Airbus Industrie. Reproduced by permission.



## 1.9.5. **Special Presentation Section**

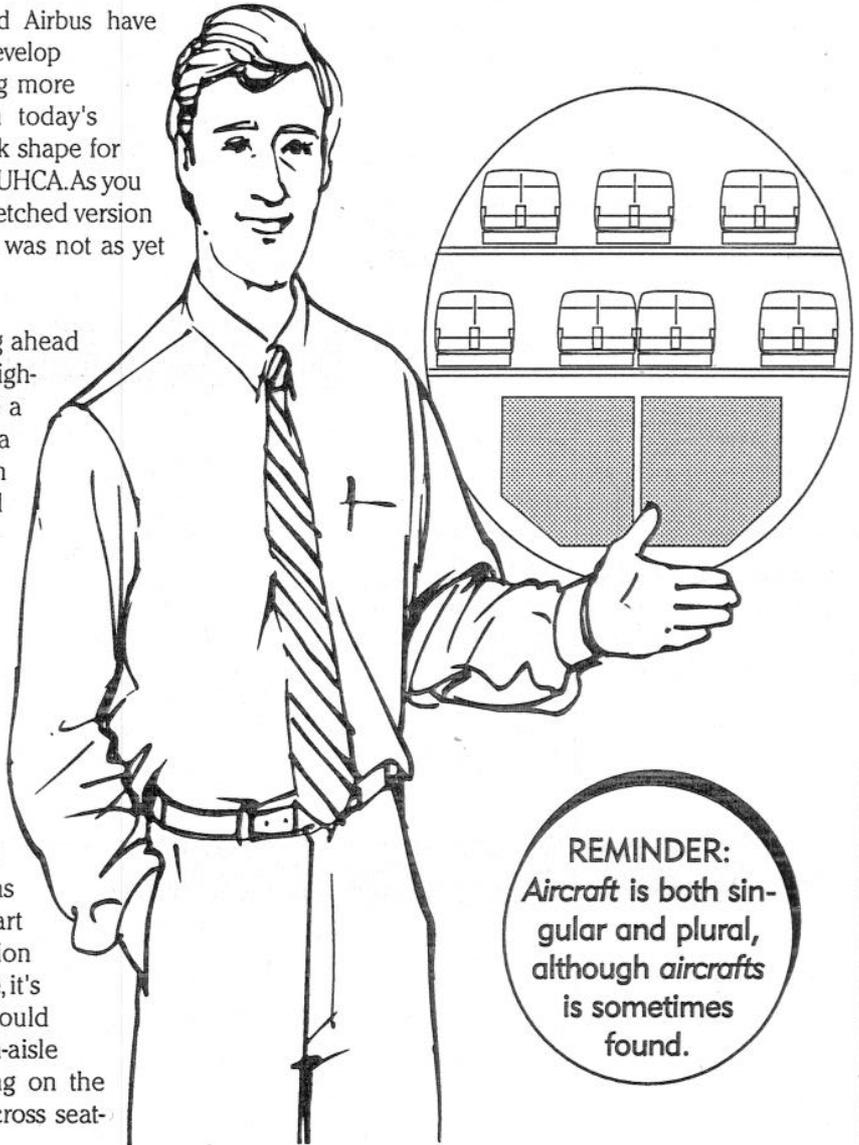
This section is designed to allow you to practice making brief presentations, but you may also prepare a written description.

**Below, the introduction to a presentation on cabin configurations suggested a decade ago for the UHCA (ultra high-capacity aircraft), and the description of the most typical model put forward at that time.**

Good afternoon. Both Boeing and Airbus have been confronted with the need to develop an aircraft capable of transporting more passengers than is possible on today's 747s. In the early 1990s plans took shape for the Ultra High-Capacity Aircraft, or UHCA. As you know, Boeing decided to offer a stretched version of its 747, judging that the market was not as yet ready for a new design.

Airbus, on the other hand, is going ahead with the development of a new high-capacity aircraft which should be a 600-800 seater. The idea is not a totally new one. In fact, it's been around for quite some time. And that's the subject of my presentation today: not the present or the future, but a quick reminder of the past visions of the aircraft that would transport perhaps up to 800 or 1000 people.

In the early 1990s there were many suggested configurations for such a large transporter. In the next 20 minutes or so, I intend to describe briefly the various plans as they stood at that time. Let's start with the simple circular cross-section design shown here. As you can see, it's a twin-deck configuration that would allow 6-abreast seating on the twin-aisle upper deck, with 8-abreast seating on the twin-aisle lower deck, with four-across seating in the mid-section.



**REMINDER:**  
Aircraft is both singular and plural, although *aircrafts* is sometimes found.

### **STATING YOUR SUBJECT**

In the next twenty minutes

- I intend to describe/to explain/to show/to present...
- I will explain/show/describe, etc.
- I am going to reveal/show/etc.
- You will discover/learn/find out etc.

### **OTHER USEFUL EXPRESSIONS**

- As you can see (from the picture)...
- A look at the picture will show...
- Let's begin by looking at...
- Let's start with/ Let's begin with ...
- Now that we've seen ... let's go on to...



## 1.9.6. DESCRIBING CONFIGURATIONS

Suggested configurations for the UHCA

THE TALK CONTINUES. HERE ARE THREE OTHER CONFIGURATIONS TO DESCRIBE.

### VOID CONFIGURATION

.....

.....

.....

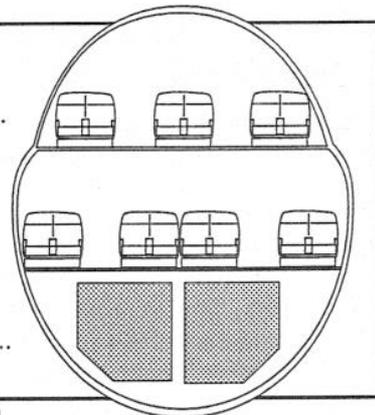
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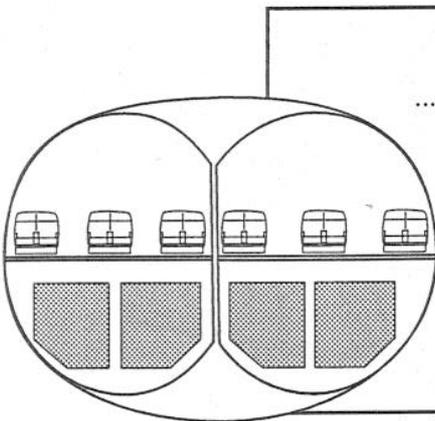
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USEFUL LANGUAGE: an arrangement configured so as to allow/so as to have a twin-deck configuration/ spacious underfloor cargo space

### DOUBLE-BUBBLE CONFIGURATION (HORIZONTAL)



.....

.....

.....

.....

.....

.....

calls for twin circular cabins/ side by side/ one next to the other

### THE SO-CALLED "CLOVERLEAF" CONFIGURATION

.....

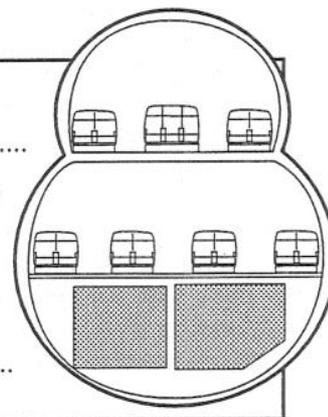
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### LATER DATE A3XX SPECIFICATION (with allowances for possible derivatives)

|                                     |   |
|-------------------------------------|---|
| Overall length:                     | 70.8-77.4 m                                   |
| Wingspan                            | 79.0-79.9 m                                   |
| Height:                             | 24.3 m  |
| full-length twin-deck configuration |   |
| MTOW                                | 540-583 t                                     |
| Accommodations:                     | 555-656 pax in 3 classes                      |
|                                     | eventually nearly 1,000 on stretched versions |
| Range with 3 classes                | 14,150 — 16,190 km                            |

As of late 1997, Airbus Industrie had defined these specifications.

## 1.9.7. A BRIEF LOOK AT OTHER EQUIPMENT AND FURNISHINGS

### Galleys



Standard outfittings on galleys include water supply via main water lines in the underside of the fuselage which also supply lavatory sinks, and drainage system. Each galley sink is equipped with a manually operated shutoff valve providing water at a given pressure (1.70 bar) during flight. Each galley also receives a constant supply of electricity (90VA, 115/200V, 400Hz, 3 phase AC power). A push-button switch for galley electrical power is found on the overhead panel in the cockpit, with all other electrical power supply switches running galley equipment controls located in galley structures. On-ground electrical supply is ensured via the APU (auxiliary power unit) located in the tailcone. In the past dry ovens were the rule; today modern steam ovens can heat up to 32 meals.

Additional equipment includes coffee makers and refrigeration equipment.



An integral part of in-flight catering: trolleys which flight attendants wheel up and down the aisle serving passengers meals and beverages.

A typical trolley is the ATLAS-type which measures 12 inches (30.5 cm) in width and stands 32 inches (81.28 cm) high. Trolleys are designed to fit under counter areas in galleys when not in use.

#### MAKE SURE YOU UNDERSTAND

|                    |                |
|--------------------|----------------|
| OUTFITTING         | OVEN           |
| WATER SUPPLY       | CATERING       |
| POWER SUPPLY       | MEALS          |
| SINKS, BASINS      | BEVERAGES      |
| DRAINAGE SYSTEM    | TO STAND       |
| SHUTOFF VALVE      | TO FIT         |
| PUSH-BUTTON SWITCH | COUNTER AREA   |
| TO RUN EQUIPMENT   | OVERHEAD PANEL |

Phonographs ©Airbus Industrie. Reproduced by permission.

#### 1.9.7.A. PRACTICE: TRUE OR FALSE?

find justification for your answer in the above descriptions.

1. Galleys are supplied with direct current.
2. The water supply system to galleys is separate from that supplying lavatories.
3. Both lavatory and galley basins receive water at the same pressure.
4. In the event of an emergency, the captain can cut electrical supply to the galleys.
5. Each galley has its own switching devices for its various equipment.
6. Only dry ovens may be used to heat food.
7. Trolleys are fitted on rollers.
8. Without trolleys catering would be difficult, if not impossible.

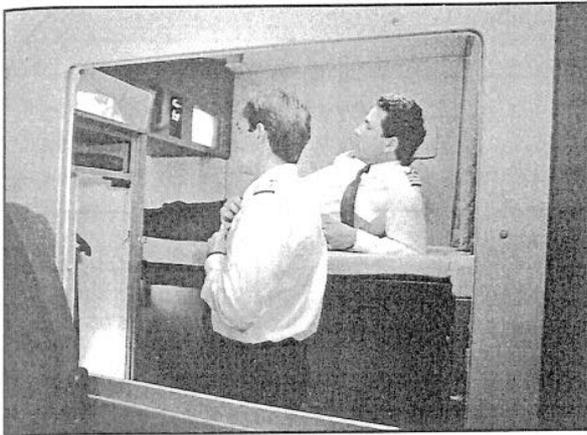
#### 1.9.7.B. PRACTICE: COMPLETE EACH STATEMENT.

Use language from the descriptions above.

1. On all aircraft, water and electrical supply are considered ....
2. Water is removed via ....
3. To receive or catch water, galleys and lavatories are equipped with ....
4. The opposite of a flip switch is ....
5. Electrical needs during ground operations ...
6. Electrical galley equipment is powered ...
7. Besides heavy galley structures such as sinks, ...
8. Trolleys allow ...
9. When not in use, trolleys ...

**1.9.7.c. PRACTICE. FILL IN THE BLANKS WITH THE WORDS GIVEN ABOVE EACH PASSAGE.**

**Special crew accommodations**

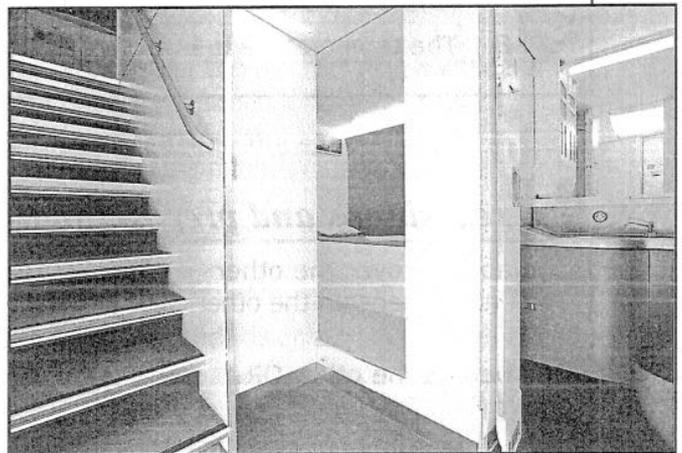


**to monitor / to outfit with / long-haul layout / displays**

The A340 ..... rest areas for crew members. Rest areas ..... relaxing and spacious accommodations for crew members during ..... flights. Shown here is a special ..... equipped with ..... which allow crew members to ..... flight information.

**well-lit / accommodations / separate lead up to / equipped with / lower fresh air supply / adjacent to / facility**

Shown here on the A340, are spacious ..... on the ..... level. The stairs ..... the main level. .... crew rest area is located a ..... lavatory ..... The area is ..... via ceiling and recessed lights and ..... is ensured via the aircraft's air conditioning system.



Photographs ©Airbus Industrie. Reproduced by permission.

**1.9.7.d. PRACTICE. WRITE A COMPLETE DESCRIPTION OF AN AIRCRAFT LAVATORY**

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- Aircraft lavatories: standard equipment**
- outward opening door
    - lock with *OCCUPIED/VACANT* indicator
    - openable from outside
  - interior design and configuration
    - toilet unit (seat + cover)
    - wash basin (sink) with hot and cold water
    - resistant to corrosion
  - waste bin, self-closing lid
  - wall-mounted mirror
  - coat-hook (lavatory-side of door)
  - toilet paper dispenser (accommodating rolls only)
  - paper towel dispenser
  - *NO SMOKING* and *RETURN TO SEAT* signs



**Verbal Constructions: Simple present: Active and Passive**  
**Prepositions**  
**Summary of Cause and Effect**

**Verb tense: Simple present tense**

|                |  |   |
|----------------|--|---|
| <b>ACTIVE</b>  | <ol style="list-style-type: none"> <li>1. Flight controls <b>provide</b> stability during flight.</li> <li>2. The pilot <b>determines</b> the flight parameters prior to take off.</li> <li>3. Mechanics <b>use</b> rivets for many fastening needs.</li> <li>4. We <b>indicate</b> temperature in degrees Celsius.</li> </ol>                   | <p><i>Most technical descriptions involve primarily the use of the simple present tense because this is the tense which describes habitual or repetitive occurrences. Remember the -s in the third person singular. NOTE: technical descriptions make extensive use of the passive voice.</i></p> |
| <b>PASSIVE</b> | <ol style="list-style-type: none"> <li>5. Stability during flight <b>is provided</b> by the flight controls.</li> <li>6. The flight parameters <b>are determined</b> by the pilot prior to take off.</li> <li>7. Rivets <b>are used</b> for many fastening needs.</li> <li>8. The temperature <b>is indicated</b> in degrees Celsius.</li> </ol> |   |

**Prepositions and prepositional phrases: locations**

|   |  |   |  |
|---|--|---|--|
| One above / over the other                              |  | B is adjacent to A.   |  |
| One under / beneath the other                           |  | B is next to A. A and B are next to each other.   |  |
| One behind the other OR: one in front of the other      |  | A is (10mm) to the left of B. B is (10mm) to the right of A. A and B are separated (from each other) by a distance of 10mm. |  |
| side-by-side  |  |   |  |
| one beside the other/the next OR: one next to the other |  |   |  |

**Cause and Effect**

|   |  |
|---|--|
| <p><b>to cause</b><br/> <b>to be caused by</b><br/> <b>to result in</b><br/> <b>to result from</b><br/> <b>to arise from</b><br/> <b>to lead to</b><br/> <b>to be due to</b><br/> <b>be responsible for</b></p> | <p>Turbulence causes many problems.<br/>                 Stalling is caused by excessive angle of attack and slow speed.<br/>                 Bird ingestion can result in engine failure.<br/>                 Many accidents result from stalling.<br/>                 Accidents may also arise from pilot error.<br/>                 Chafed wires may lead to sparks which can cause an explosion.<br/>                 The accident was due to a combination of factors.<br/>                 Nobody has yet determined what was responsible for the incident.</p> |
| <p><b>Common questions used in asking about causes and effects</b></p>  | <p>What causes an aircraft to stall?<br/>                 What makes an aircraft stall?<br/>                 What does stalling result from?<br/>                 What does it result in?<br/>                 What did that lead to?<br/>                 What is it responsible for?</p>   |



# Maintenance Check!

## 1.10. PRACTICE AND REVIEW PRINCIPLES OF FLIGHT + CAUSE AND EFFECT

**1.10. A.** This is a review exercise which will also allow you to practice expressing cause and effect as shown on the preceding page. You should try to use all the patterns shown, and it would also be a good idea to practice asking questions.

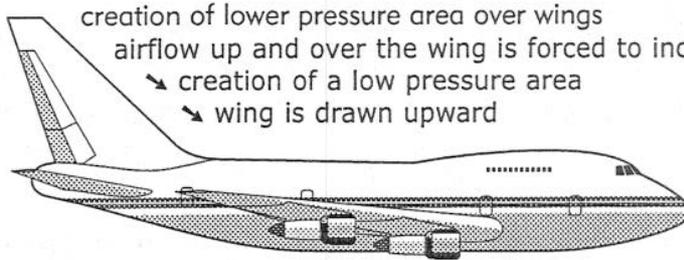
Prepare a complete description of the three phenomena, lift, profile drag, and induced drag. Each arrow indicates a direct result or effect.

For the principles of flight and aerodynamics, see pages 6-13.

### ■ Note

This practice is an excellent opportunity for working on your presentation skills.

### LIFT:



- creation of lower pressure area over wings
- airflow up and over the wing is forced to increase in speed
- ↘ creation of a low pressure area
- ↘ wing is drawn upward

### PROFILE DRAG:

- air is diverted around the form of the aircraft
- streamlining the aircraft structure
- ↘ drag reduction

A second cause: friction between the aircraft skin surface and airflow (skin friction)

- Speed an important factor: doubling the speed
- ↘ quadrupling profile drag

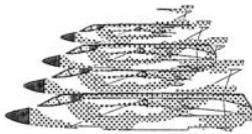
### INDUCED DRAG:

- a direct result of lift
- cause: the mixing of the upper and lower airflows at the trailing edge of the wings

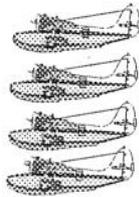
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### 1.10.B. DESCRIBE THE TWO FORMATIONS

formation A



formation B




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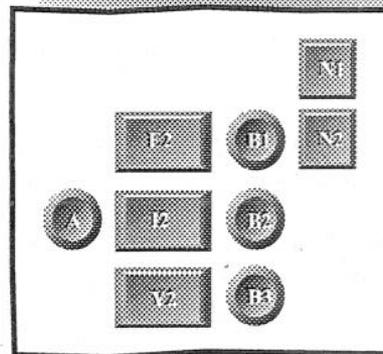
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### 1.10.C. HOW ARE THE BUTTONS ARRANGED?




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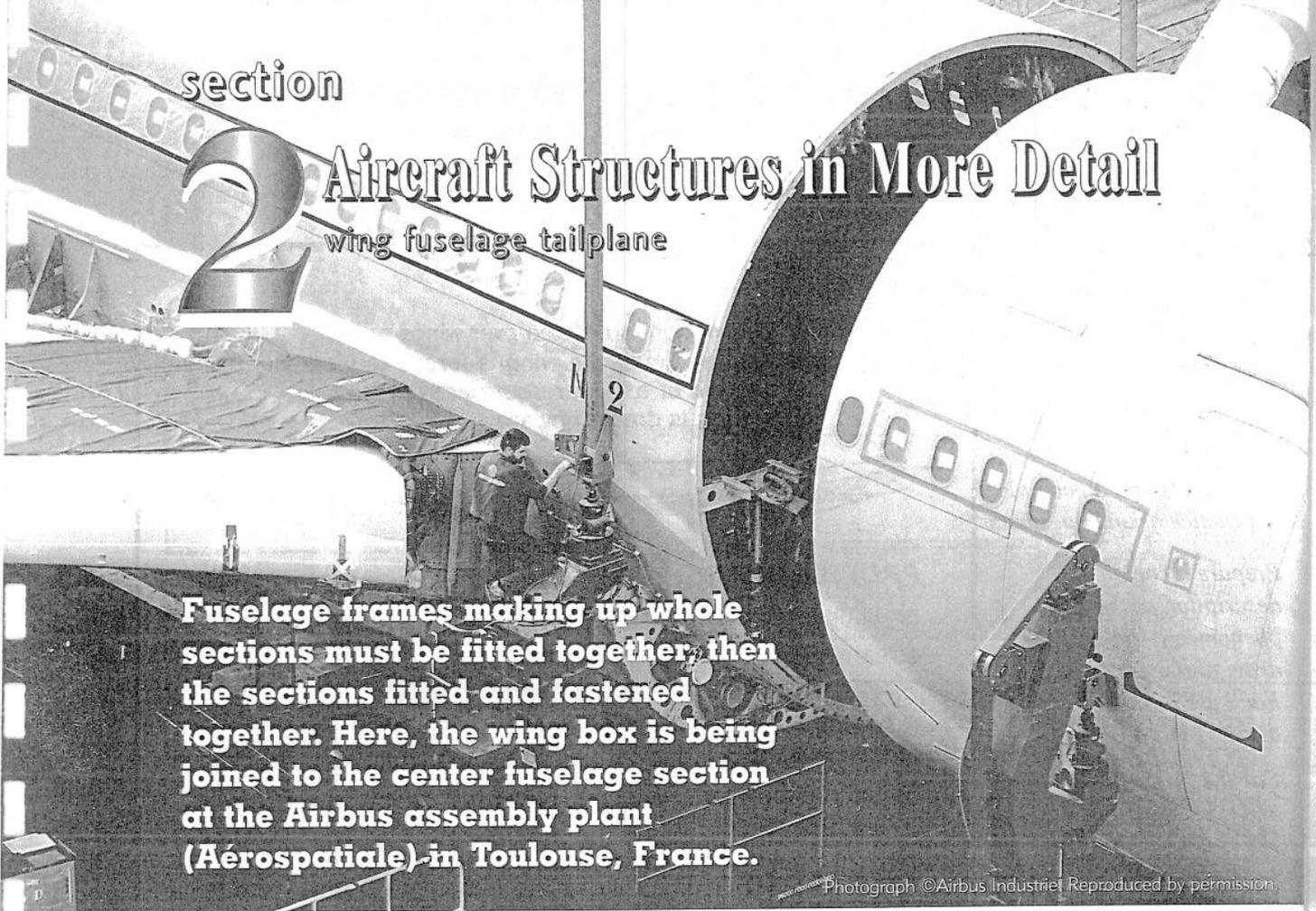
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section

# 2 Aircraft Structures in More Detail

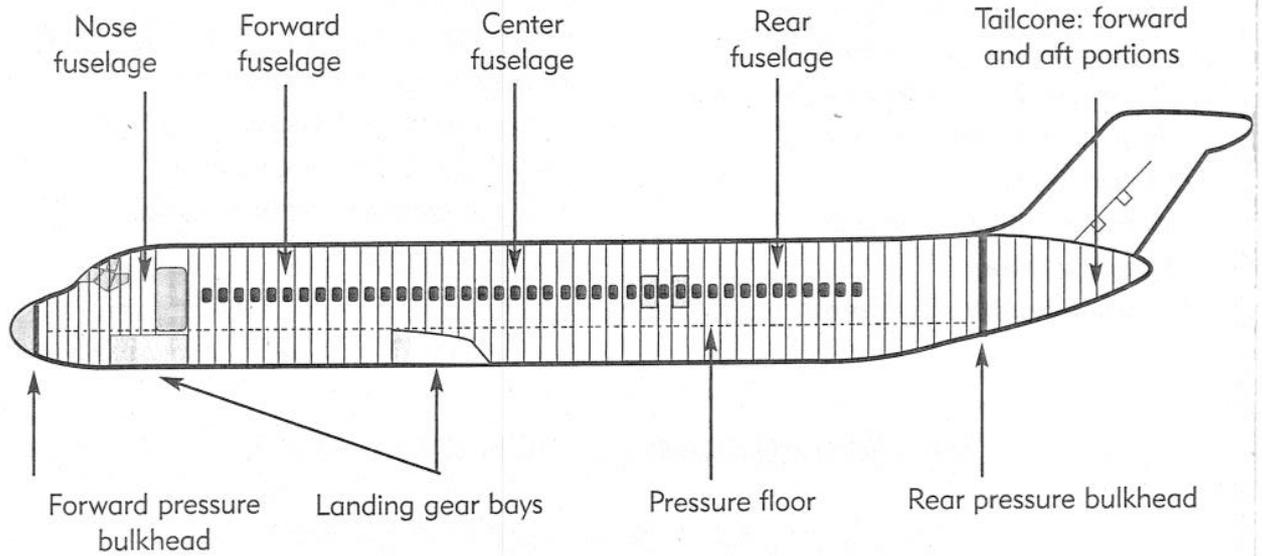
wing fuselage tailplane



**Fuselage frames making up whole sections must be fitted together, then the sections fitted and fastened together. Here, the wing box is being joined to the center fuselage section at the Airbus assembly plant (Aérospatiale) in Toulouse, France.**

Photograph ©Airbus Industries. Reproduced by permission.

## 2.1. THE FUSELAGE



The aircraft fuselage is made up of 3 main sections: the forward fuselage, the center fuselage and the rear fuselage. Each section is composed of individual frames, fitted together to make up the total section.

Most passenger aircraft feature a circular-section fuselage measuring from 3.5m to 5.6 or 6m in diameter. The underfloor area, beneath the pressure floor, usually has at least 2 large holds reserved for containerized loads (ULDs or *unit load devices*), and in some instances, pallets. The most recent aircraft feature compartments which are arranged at a convenient height enabling easy access for maintenance personnel. In the under-floor area are also found avionics, electric, air-conditioning, fuel and hydraulic systems.

The fuselage sections also contain the nose and main landing gear bays.

**2.1.1. PRACTICE: MASTERING THE TERMS**  
**COMPLETE EACH SENTENCE.**

- a. Three main sections .....
- b. Individual components called frames ...
- c. The passenger compartments and the storage compartments are separated by...
- d. The area beneath the passenger cabin...
- e. A matter of great importance for baggage handlers and ground maintenance crews is ...
- f. Landing gear is located ...
- g. Aft of the rear pressure bulkhead ...

**2.1.2. PRACTICE: EXPRESSING PURPOSE**  
**STATE THE PURPOSE OF:**

- a. forward pressure bulkhead
- b. rear pressure bulkhead
- c. pressure floor
- d. landing gear bays
- e. cargo holds
- f. ULDs (unit load devices)



**DO YOU KNOW THESE EXPRESSIONS?**

**Describing location, composition and structure**

**LOCATION**

- towards the front / fore of
- towards the rear / aft of
- is found in/under/fore of
- is located in/under/aft of
- is located between ... and ...
- extends from... to...
- inner/outer
- innermost/outermost
- upper/lower
- uppermost/bottommost

**COMPOSITION AND STRUCTURE**

- is made of (+ material)
- is made up of (+ components)
- is composed of (material or components)
- consists of (+ parts, elements)
- comprises (+ the components)
- is divided into (parts, sections)
- is separated into (parts, sections)

**DESCRIBING COMPOSITION OR MAKE-UP**

*The vertical stabilizer is made up of two parts: the fin and the rudder.*

*Two parts make up the horizontal stabilizer: the fin, foremost and the rudder, rearmost (or aftmost).*

*Two parts make up the horizontal stabilizer: the fin, the foremost component, and the rudder, the aftmost.*

*The system comprises 3 independent units.*

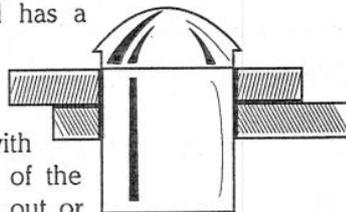
PROVIDE A COMPLETE DESCRIPTION OF THE FOLLOWING, STATING, IF POSSIBLE, THE LOCATION AND PURPOSE OF EACH.

- a. The APU (Auxiliary Power Unit)
- b. The landing gear
- c. The radar
- d. The rear pressure bulkhead
- e. The center fuselage extends...
- f. The fuselage (structural description)
- g. The cockpit

for more detailed coverage of the components please refer to corresponding sections.

**2.1.4. HOW ARE THEY FASTENED?**

A rivet is a short metal pin used to fasten two or more pieces together. It is cylindrical in shape and has a rounded or flat head at one end. The rivet is passed through two holes aligned with each other. The end of the cylindrical pin sticks out or protrudes from one of the pieces, here the bottommost.



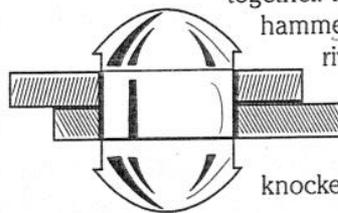
The pin can be made of steel and may be put into place under heat. Other materials may also be used including copper, aluminum and brass. These are softer metal. The pin may be hollow or solid.

**FITS AND FASTENINGS**

Two parts are

|          |   |          |
|----------|---|----------|
| held     | } | together |
| fastened |   |          |
| fitted   |   |          |
| riveted  |   |          |
| bonded   |   |          |
| welded   |   |          |

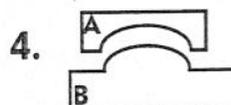
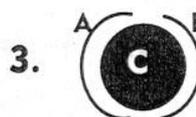
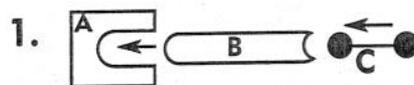
The rivet is inserted through the pieces to be held together. The end of the cylindrical pin is hammered into a head. The heads of the rivet is not flush with either surface. To remove the rivet, one of the heads is cut off using a tool such as a chisel. The rivet is then knocked out using a special tool.



**2.1.4.A. PRACTICE. COMPLETE:**

1. First, the holes in the two pieces ..... and then the rivet can be .....
2. .... holds the rivet against the surface of the top piece in the illustrations.
3. The rivet pin can be made of ....., ....., ....., or ..... and can be either ..... or .....
4. To hold the two pieces securely together, the opposite end of the rivet pin .....
5. It's impossible to remove a rivet unless .....

**2.1.4.B. PRACTICE. DESCRIBE THE FITS**



fit onto  
fit into  
fit together  
(dovetail)  
fit around  
fit over  
fit on over



**A. MAKE A COMPLETE DESCRIPTION USING THE NOTES BELOW.**

**FUSELAGE — THREE PARTS:**

- forward fuselage
- center fuselage
- rear fuselage
- each part : frames

main material: aluminum alloy, with high-strength steels and titanium at highest stress points

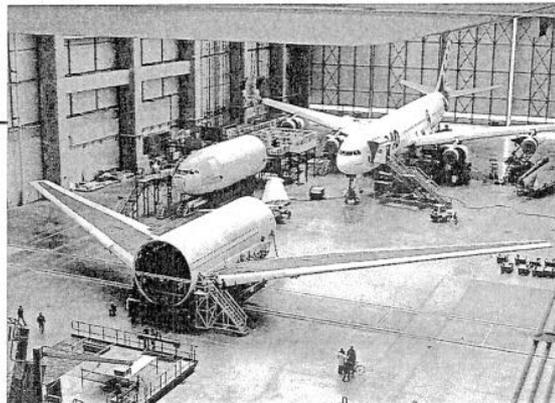
construction: skin/stringer/frame type

means of fastening and assembly: bolting, bonding, riveting, and welding

Where corrosion is a factor or risk, and on all fuselage skin joints: use of interfaying sealant  
composition:

**PRESSURIZED AND UNPRESSURIZED AREAS:**

- (1) pressurized area: cockpit, avionics compartment, lower deck compartment, passenger cabin
- (2) unpressurized area: nose, main landing gear wells, center wing box and areas beneath, tail section aft



Forward and center fuselage sections appear in this photo. Note that wings have already been attached. Photo ©Airbus Industrie. Reproduced by permission.

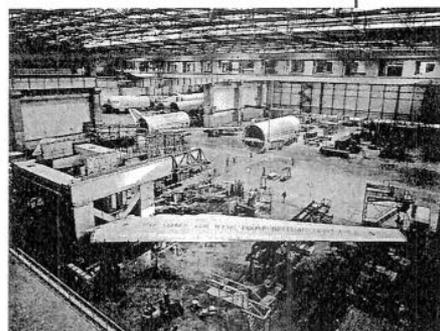
*TO FAY:* to fit or join closely or tightly

*STRINGER:* longitudinal member in the fuselage used for reinforcement

*SEALANT:* any product used to seal an opening, here at the fuselage skin joints.

**B. BELOW IN NOTE FORM YOU SEE DIMENSIONS RELATING TO THE FUSELAGE AND WINGBOX. CAN YOU MAKE COMPLETE STATEMENTS USING THE VOCABULARY SEEN IN PREVIOUS SECTIONS?**

- fuselage cross section: 5.64 m
- circular
- floor: slightly below mid-position
- cabin interior: height: 2.54 m
- underfloor hold: height 1.76 m
- An example: the A320
  - fuselage width: 3.95m
  - cabin width: 3.69m
- Wing box in foreground in preparation for junction to center fuselage section



In the foreground: wingbox arriving from BAe (British Aerospace) Photo ©Airbus Industrie. Reproduced by permission.



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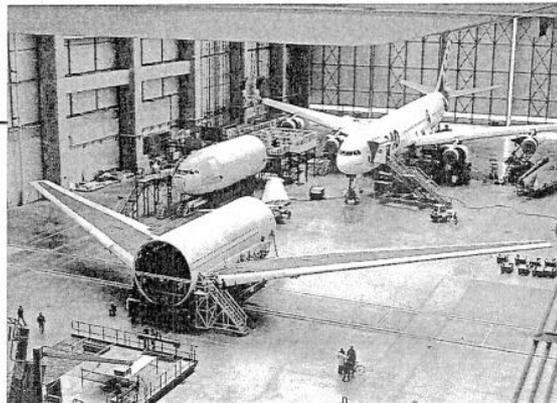
construction: skin/stringer/frame type

means of fastening and assembly: bolting, bonding, riveting, and welding

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Forward and center fuselage sections appear in this photo. Note that wings have already been attached. Photo ©Airbus Industrie. Reproduced by permission.

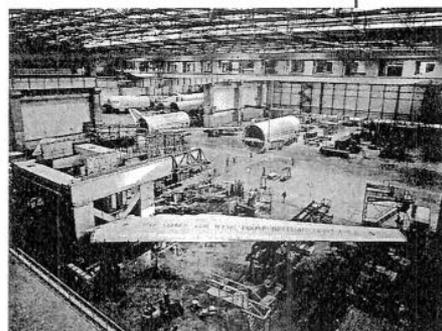
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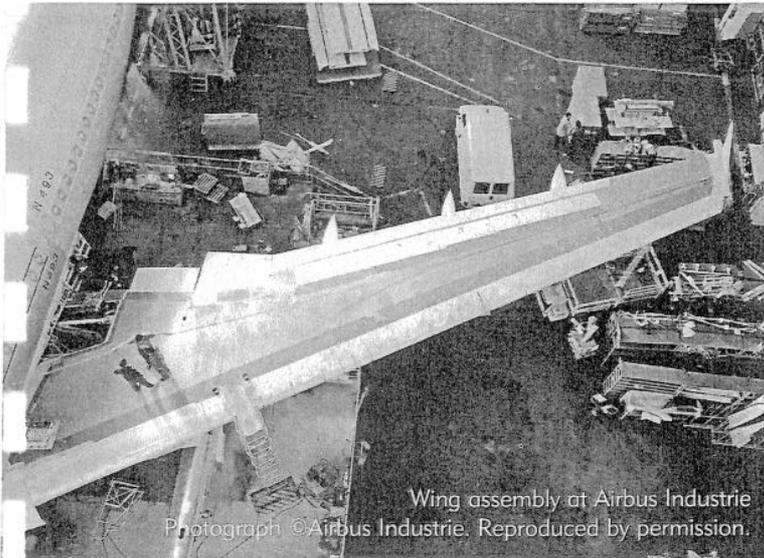
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In the foreground: wingbox arriving from BAe (British Aerospace)  
Photo ©Airbus Industrie. Reproduced by permission.

## 2.2.DESCRIBING WING STRUCTURE



An aircraft's wings are designed to provide the necessary lift. On a Boeing 747 wingspan measures nearly 60m. To ensure proper aerodynamic functioning, wings are swept back at an angle, for instance 37° on the 747. Flaps, slats (also called *leading edge flaps*) and spoilers (air brakes) are used to modify lift. At take-off, when maximum lift is required, the flaps are fully extended, resulting in an increase in wing area of 20% and an increase in lift of 80%. On some Airbus models, fully extended flaps prolong chord (straight line between leading and trailing edges) by 25%. On landing, flaps are fully extended down, with spoilers also fully raised.

Wings are mounted at an angle (for instance, 7° on the large Boeing 747) to the horizontal for improved aerodynamic features. This is the dihedral angle.

The number of slats and flaps and their configuration vary depending on the aircraft. Flaps on the trailing edge ride on tracks and are deployed in take off phase to improve lift. Spoilers are raised to disrupt airflow on the upper wing surfaces and when deployed on landing result in lift spoilage (they are also called *lift dumpers* because of this). When used in flight their deployment results in a rapid decrease of speed and increased rate of descent (hence spoilers are also referred to as *speed brakes*).

Ailerons are used in roll. An upward movement causes reduced lift; a downward movement provides increased lift.

Besides their importance in generating lift, wings also house the aircraft's fuel tanks located within the wingboxes.

### WHAT IS THE WORD OR EXPRESSION?

1. The straight line joining leading edge and trailing edge: .....
2. The angle wings make to the horizontal: .....
3. Allow and guide the extension and retraction of flaps: .....
4. Used in flight to reduce speed: .....
5. Used upon landing to reduce lift: .....

### 2.2.1. READ, UNDERSTAND AND NOTE: WINGBOXES AND WINGSKINS

Left and right (port and starboard) wing boxes are joined to the center section integral with the fuselage. Each wing box also includes a front and rear spar, a center spar running to the engine pylon rib, and inter-spar ribs to lend structural support. Each wing is covered with machined wing skins, 2 or 3 on the top surface and 2 or 3 on the underside.

SPAR: longitudinal member of the wing carrying the ribs.

Airbus wing skins are manufactured using a special process called saturation shot-peening. The surface is pelted with tiny hard steel balls at high speed. The impacts cause omnidirectional stretch indentations outward from the skin surface which are invisible to the naked eye. Both sides may be shot peened to improve curvature and fitting characteristics.

#### LIST ALL THE COMPONENTS OF A WING MENTIONED IN THE ABOVE DESCRIPTION

.....

.....

.....

.....

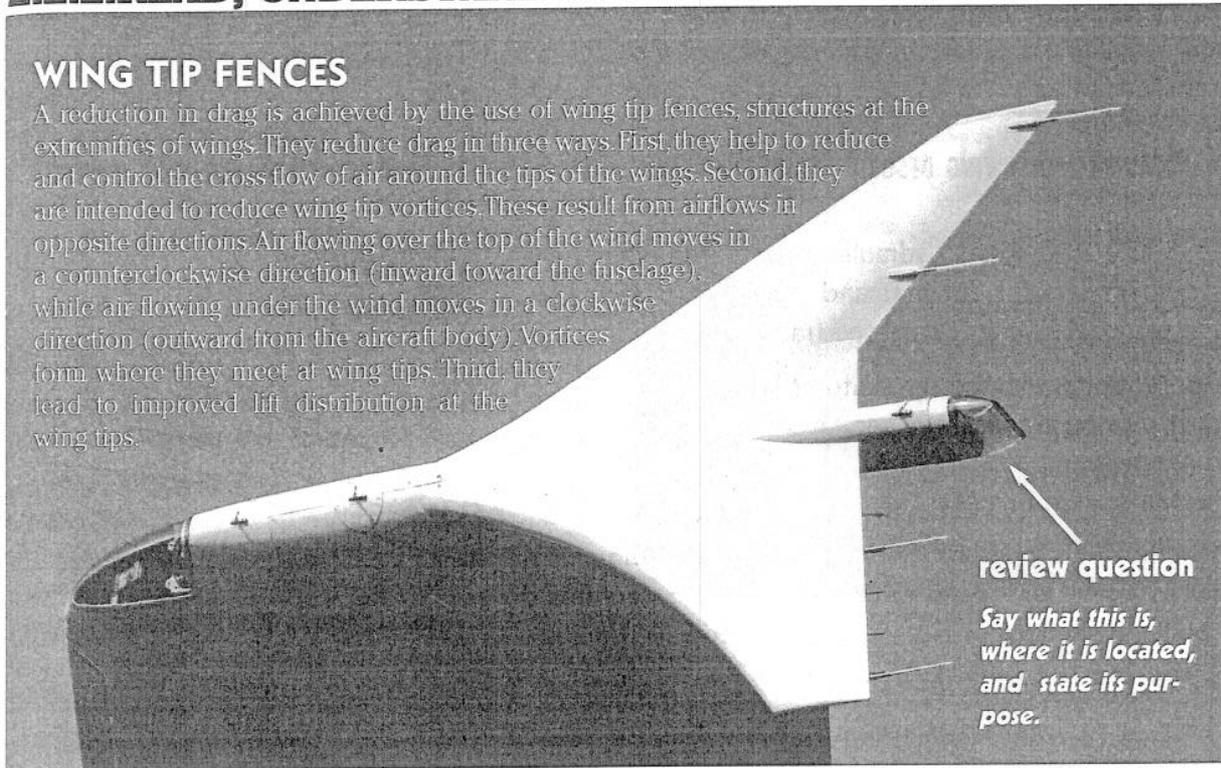
#### FIND THE SYNONYMS

- a. to strike, hit, or bombard
- b. very small
- c. in all directions
- d. pull apart or lengthen using force

## 2.2.2.READ, UNDERSTAND AND NOTE

### WING TIP FENCES

A reduction in drag is achieved by the use of wing tip fences, structures at the extremities of wings. They reduce drag in three ways. First, they help to reduce and control the cross flow of air around the tips of the wings. Second, they are intended to reduce wing tip vortices. These result from airflows in opposite directions. Air flowing over the top of the wing moves in a counterclockwise direction (inward toward the fuselage), while air flowing under the wing moves in a clockwise direction (outward from the aircraft body). Vortices form where they meet at wing tips. Third, they lead to improved lift distribution at the wing tips.



Photograph ©Airbus Industrie. Reproduced by permission.

### 2.2.3. PRACTICE: FILL IN THIS BRIEF OUTLINE WITH INFORMATION FROM THE PASSAGE ABOVE

I. Location and general purpose

.....  
.....

II. 3 ways that drag is reduced

1. ....
2. ....
3. ....

### 2.2.4. VOCABULARY: DESCRIPTION

Use each of the following verbs in an original sentence in reference to the wing shown on the preceding page and the brief passage on wing tip fences above.

1. to feature
2. to disrupt
3. to weaken
4. to slow down
5. to result in

### 2.2.5. ANSWER THESE QUESTIONS:

1. What do the wing tip fences do away with?
2. What do the wing tip fences provide?
3. What is the difference between an aircraft with and one without wing tip fences?
4. What does an upward movement of the aileron result in?
5. What happens when spoilers are deployed?
6. What part do spoilers play in landing phase?



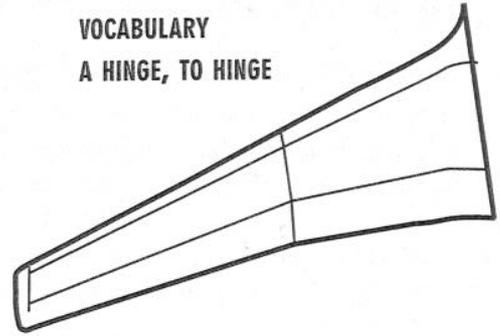
**A. READ THE FOLLOWING DESCRIPTION OF THE A300B WING AND DRAW IN THE COMPONENTS MENTIONED.**

The A300B features hydraulically-actuated hinged surfaces (spoilers, lift dumpers and airbrakes) located along the top of the wing toward the trailing edge.

Conventional wing design features one outboard aileron with, moving inboard, two sections of spoiler followed by three sections of airbrake, the aileron, and finally two sections of lift dumpers.

Modifications made to the A300 B2 and B4 wing introduces a new low-speed outboard aileron, 3 sections of spoiler, 2 sections of airbrake, an all-speed aileron and 2 inboard sections of airbrake.

**VOCABULARY**  
A HINGE, TO HINGE



**THE MODIFIED A300 B2 AND B4 WING**

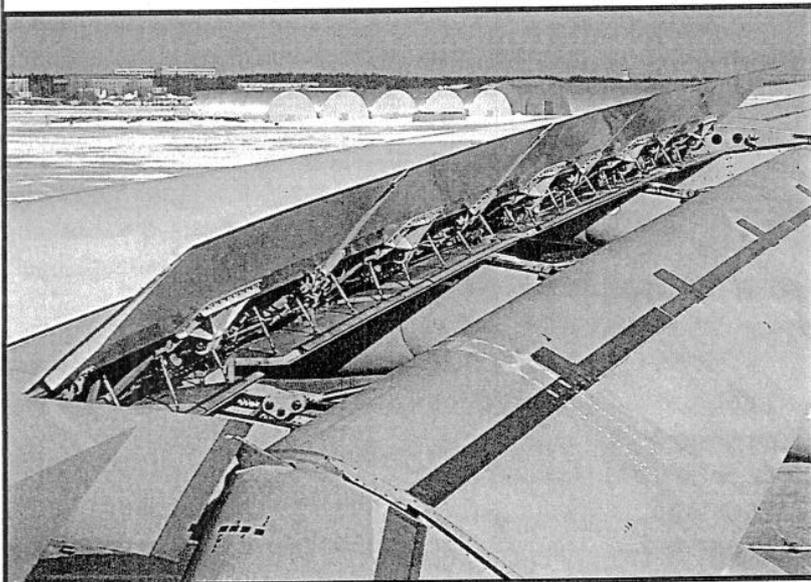
**B. PREPARE A COMPLETE DESCRIPTION OF THE INFORMATION SHOWN HERE.**

**FLAPS**

- ☛ tracked slotted type
- ☛ run without break past the rear of the engines
- ☛ 2 sections
- ☛ composite materials (all CFRP)
- ☛ each rides aft and downward on 2 tracks
- ☛ 3 outboard tracks housed in CFRP fairings

**SLATS**

- ☛ the only wing movables
- ☛ aluminum alloy
- ☛ broken by the pylon strut
- ☛ one section inboard
- ☛ 4 sections outboard



Photograph ©Airbus Industrie. Reproduced by permission.

*Describe the position of the various components shown here in the photograph. What part of the wing is most visible?*

*How are spoilers, airbrakes, flaps, and slats positioned?*

**STRUT:**  
*structural piece designed to withstand pressure in the direction of its length.*

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to b  
to f  
to a  
to r  
to y  
to b

C. READ THE FOLLOWING DESCRIPTION OF MODIFICATIONS MADE TO THE B737 WING, THEN FILL IN THE CHART BELOW WITH THE CORRECT FIGURES.

## NEW WING FOR NEW GENERATION OF BOEING 737

### New design for 737-600-700-800 series

The new 737 launched in the late 1990s offered the first derivatives to benefit from extensive wing redesign. The new slender wing, with a wingspan of 34.4m, featured an increase in area of 25% leading to a 30% increase in fuel capacity. This makes it possible for the aircraft to achieve greater payload capacity, higher service ceiling, and a longer range.

Thanks to the new wing the aircraft has a more economical cruise speed of Mach 0.79 at a ceiling of 41,000ft (12,500m) as opposed to the 37,000 ft and Mach 0.74 for prior versions.

An important addition is a low-drag wing tip for faster speed. The wing area now is 125m<sup>2</sup> (1345 ft<sup>2</sup>) made possible via an increased span of 5.4m and all-new wingbox. Improved fuel capacity results from the movement of the rear spar aft. Increased wing dimensions also allowed the redesign of fuel and surge tanks, bringing fuel capacity for each wing up to 4,900 liters, which together with the 16,230 center-fuel tank, yields a total fuel capacity of 23,036 liters, enabling the a/c to add 1,600 km to its range.

|                                | WINGSPAN | CRUISE SPEED | CEILING |
|--------------------------------|----------|--------------|---------|
| Specifications prior to change |          |              |         |
| Modification undertaken        |          |              |         |
| New specification              |          |              |         |

#### COMPLETE THE FOLLOWING STATEMENTS:

- The wingspan was stretched so as to \_\_\_\_\_
- The rear spar was moved aft so as to \_\_\_\_\_
- Wing was redesigned so as to \_\_\_\_\_
- The modified dimensions enabled \_\_\_\_\_
- The increase in length also made it possible to \_\_\_\_\_



#### DO YOU KNOW ALL THE FORMS?

BELOW ARE WORDS (NOUNS AND VERBS). FILL IN THEIR CORRESPONDING FORMS. WHEN NONE EXISTS, PUT AN X IN THE BLANK.

| VERBS      | NOUNS | VERBS       | NOUNS | NOUNS       | VERBS |
|------------|-------|-------------|-------|-------------|-------|
| to offer   | ..... | to stretch  | ..... | a redesign  | ..... |
| to benefit | ..... | to enlarge  | ..... | an increase | ..... |
| to feature | ..... | to extend   | ..... | an addition | ..... |
| to achieve | ..... | to expand   | ..... |             |       |
| to result  | ..... | to improve  | ..... |             |       |
| to yield   | ..... | to move     | ..... |             |       |
| to bring   | ..... | to lengthen | ..... |             |       |

## 2.2.7. BOEING PROPOSES DERIVATIVES OF THE B777

2 new growth derivatives of the B777 were proposed by Boeing in response to airline interest. The -200X (read: *Dash two hundred X*) was intended to be the longest-range airliner available to date — 15,900 km (8,600 nm) — offering a maximum passenger load of 298 in a three-class cabin configuration. The -300X has a maximum range of 12,200 km accommodating 355 passengers in a three-class cabin arrangement.

Structurally speaking, the two stretched versions are alike, the only difference being that the -300X will feature *two* plugs added: 5.34 m fore and 4.80 m aft of the wing on the -300X.

Plans also call for lengthening the wing by 1.37 m and extending fuel tanks into the outer wings. To provide additional increased fuel capacity the new -200X derivative offers optional auxiliary fuel tanks

in the rear cargo compartment. Boeing decided against installing auxiliary fuel tanks in the horizontal stabilizer as the gain was deemed insignificant.

A host of other modifications need to be achieved if the new variant is to comply with specifications. Engine thrust must be upgraded to 454kN as opposed to the 343kN-thrust engines powering the 777-200 and the 400kN-thrust required on the 777-300. Leading engine manufacturers have proposed derivatives of existing engines without making substantial modifications. Changes are also scheduled to be made to landing gear to be fitted with new wheels and tires to deal with the higher take-off and landing weights.

Stretch plans also require strengthening landing gear, horizontal stabilizer and fuselage as well as new wingtips.

### 2.2.7.A. PRACTICE: DESCRIBING PLANNED CHANGES

For each feature below, state the planned change, which derivative is involved, and how it is to be achieved.

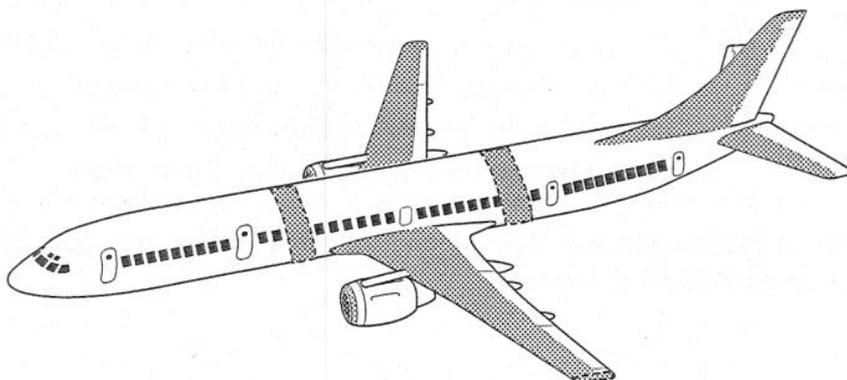
- stretched wing
- increased passenger loads
- increased fuel capacity
- cabin configurations
- fuselage stretch
- rear cargo hold

### TRY TO USE THESE EXPRESSIONS:

- Like...
- Unlike...
- Similar to...
- As opposed to...
- Compared with...
- With respect to...
- Regarding...

### 2.2.7.B. PRACTICE: LABELING THE ILLUSTRATION

The following illustration is not intended to be an exact replica of the B777, nor are the modifications to scale or necessarily accurate in any other way. Label all changes (the shaded areas) described in the passage above. Certain equipment such as fuel tanks and landing gear are not shown. You should draw arrows to their approximate locations.



## Gerunds and Gerund Phrases

### Participial Phrases

### Changes

#### Gerunds and gerund phrases

|  |  |
|--|--|
| <ol style="list-style-type: none"> <li>1. <b>Increasing take-off and landing weight</b> required <b>strengthening the landing gear</b>.</li> <li>2. Longer ranges required <b>increasing fuel capacity</b>.</li> <li>3. Enlarging fuel tanks meant <b>having to extend wingspan</b>.</li> <li>4. These changes involved <b>redesigning the entire wing</b>.</li> </ol> | <p><i>Gerund phrases can be subjects and direct objects of certain verbs such as</i><br/><b>REQUIRE, MEAN, NECESSITATE, INVOLVE.</b></p> |
| <ol style="list-style-type: none"> <li>5. Boeing was interested <b>in offering</b> airlines several variants.</li> <li>6. Fuel tank capacity was increased <b>by enlarging</b> wings.</li> <li>7. Engineers were not <b>against adopting</b> the proposals.</li> <li>8. They were afraid <b>of losing</b> time.</li> </ol>   | <p><i>Gerunds must be used after prepositions.</i></p>   |

#### Participial phrases

|   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. <b>With all changes (being) approved</b>, the next step was simple.</li> <li>2. <b>The changes (having been) accepted</b>, the team went to work.</li> <li>3. <b>Working overtime</b> the team managed to complete the first draft.</li> <li>4. Plans are similar, <b>the only difference being that the -300X will carry 355 passengers</b>.</li> <li>5. Gains are substantial, <b>the most significant being fuel economy</b>.</li> <li>6. Many reasons were cited, <b>the most important being the need to increase passenger load</b>.</li> </ol> | <p><i>Present participles end in —ING and resemble gerunds. Unlike gerunds which function as nouns, participles are verbal forms. Note that past participles can also be used in participial phrases (1 and 2).</i></p> |
|---|---|

#### Changes

|   |  |
|---|--|
| <p>to increase by<br/>an increase in<br/>an increase of<br/>make a change to<br/>make a change in</p> | <ol style="list-style-type: none"> <li>1. We <b>increased</b> the temperature <b>by</b> 4°C.</li> <li>2. We noted <b>the increase in performance, in</b> temperature.</li> <li>3. We noted <b>an increase of</b> 4° in the temperature.</li> <li>4. We need to <b>make several changes to (also IN)</b> the leading edge.</li> <li>5. We <b>made a change in</b> our design, <b>in</b> our plans.</li> </ol> |
|---|--|

**NOTE:** The verbs **decrease, rise, fall, decline**, and their noun forms (the same as their verb form) follow the same pattern as **increase**.

## 2.2.8. PRACTICE:

The illustration below shows proposed modifications to the B737-800 to offer a new derivative, the 900X. Prepare a full description of the changes suggested in the illustration. This is an excellent opportunity to practice presentation skills.

### DEVELOPMENT OF B737-900X STRETCH FROM THE B737-800

**FUSELAGE EXTENSION**

- similar to -600 stretch
- 2 plugs

**SEATING CAPACITY**

- 3 additional rows (6-abreast)
- 180 passengers (2 classes)
- 207 (higher density arrangement)



**LANDING GEAR**

- current landing gear unable to cope with increased take-off weight and landing speeds

**ENGINES**

- probable requirement: 127kN (28,000 lbs) of thrust



### DO YOU KNOW THESE WORDS?

Describing modifications and changes. Note that verbs are often formed by adding **-EN** to the adjective. But this is not an absolute rule.

|   |  |
|---|--|
| <b>to lengthen</b> ≠ <b>to shorten</b>  | We are lengthening the wing.                           |
| <b>to strengthen</b>                    | We are strengthening the landing gear.                 |
| <b>to weaken</b> (≠ <b>strengthen</b> ) | The structure was weakened through constant friction.  |
| <b>to upgrade</b>                       | Engine manufacturers are upgrading engine performance. |
| <b>to enhance</b>                       | This will enhance the overall design (improve)         |
| <b>to widen</b> ≠ <b>to narrow</b>      | The cabin will be widened by 1.2m.                     |
| <b>to boost</b> (= <b>to increase</b> ) | They boosted the fuel tank capacity.                   |
| <b>to stretch</b>                       | The wing was stretched 1.4 m.                          |

For more practice see the exercise on the next page.

### 2.2.9. PRACTICE: DESCRIBING MODIFICATIONS

State the changes that have been made in light of the situation described on the left. (note: in some cases it may be possible to use more than one verb.) See the grammar file on the next page for important notes on the present perfect and past tenses (and passive constructions).

- a. It was too heavy. ....
- b. It was not strong enough. ....
- c. It was too narrow. ....
- d. It was too high. ....
- e. It was too low (temperature). ....
- f. It was too thick. ....
- g. It was too long. ....
- h. It was too thin. ....
- i. It was too short. ....
- j. It was too complicated. ....
- k. It was too small. ....
- l. There were too many parts. ....
- m. Thrust was insufficient. ....
- n. The surface was rough. ....
- o. It was too soft. ....
- p. It was too tight. ....
- q. It was too fragile or delicate. ....
- r. It was too loose. ....
- s. The pressure was too high. ....
- t. It was too hard. ....

### 2.2.10. PRACTICE:

In each case you see what has been changed. Explain the former situation or state of affairs (Eg: it was too narrow; it wasn't wide enough). See the grammar file covering the present perfect and past tenses on the next page if you are not sure about the differences between these two tenses.

- 1. The wing has been strengthened. ....
- 2. The fuselage has been stretched. ....
- 3. An additional circuit has been added. ....
- 4. The wing has been made thinner. ....
- 5. The angle of sweep has been increased. ....
- 6. New lighter materials have been used to redesign the rudder. ....
- 7. Cockpit windows have been widened. ....
- 8. The bearings have all been replaced. ....
- 9. The software has been upgraded to take into account newer technology. ....
- 10. A second backup system has been provided. ....



**Present Perfect**  
**Present Continuous, Passive form**  
**Pure Future with WILL**

**Present perfect and passive forms used together**

|   |  |
|---|--|
| <p>1. The new designs <b>haven't been finished</b> yet.<br/>         Some last-minute changes <b>are being made</b> to the wing design.</p> <p>2. No decision <b>has been reached</b> yet.<br/>         Several new ideas <b>are being evaluated</b>.</p> <p>3. We <b>have not finished</b> final preparations.<br/>         The aircraft <b>is being painted</b>.</p>  | <p><i>The present perfect describes a state of events up to the present time. The passive form of the present continuous is used here to explain or qualify the first statement.</i></p> |
| <p>4. <b>Have the designs been finished?</b><br/>         What kind of changes <b>are being made</b> to it?</p> <p>5. <b>Has a decision been made yet? Why hasn't one been made yet?</b><br/> <b>Which ideas are being considered?</b></p> <p>6. <b>Have all the preparations been finished?</b><br/> <b>Where is the painting being done?</b></p> <p>7. <b>Why hasn't it been done before? Why is it being done now?</b></p> | <p><i>Note the interrogative forms, and remember that "negative questions" (examples 5 and 7) are very common in English.</i></p>  |
| <p>8. <b>The technicians are being shown</b> how the part should be replaced.</p> <p>9. <b>Several engineers are being asked</b> to study this question.</p> <p>10. <b>The technicians are being told</b> which step to complete next.</p> <p>11. <b>They are being given</b> a full set of instructions to refer to.</p>   | <p><i>Note also the passive constructions involving show, tell, ask, and give.</i></p>   |

**Present perfect or simple past tense?**

|  |  |
|--|--|
| <p>Have you received the revised plans?<br/>         Has the project been finished?<br/>         Has the surface been tested?</p> <p>The data<sup>1</sup> have been analyzed, but nothing has been detected.</p> <p>Three engineers have been sent to conduct tests.</p> <p>Five fissures have been detected to date.</p> <p><sup>1</sup> Data is plural (of datum).</p> | <p>Did you receive the plans last week?<br/>         Was the project finished in time yesterday?<br/>         Was the surface tested before it was installed?</p> <p>Following the incident, the data were analyzed, but nothing was detected. Three engineers were sent, but they haven't returned yet.</p> <p>Five fissures were detected during the inspection before they destroyed the piece.</p> |
|--|--|

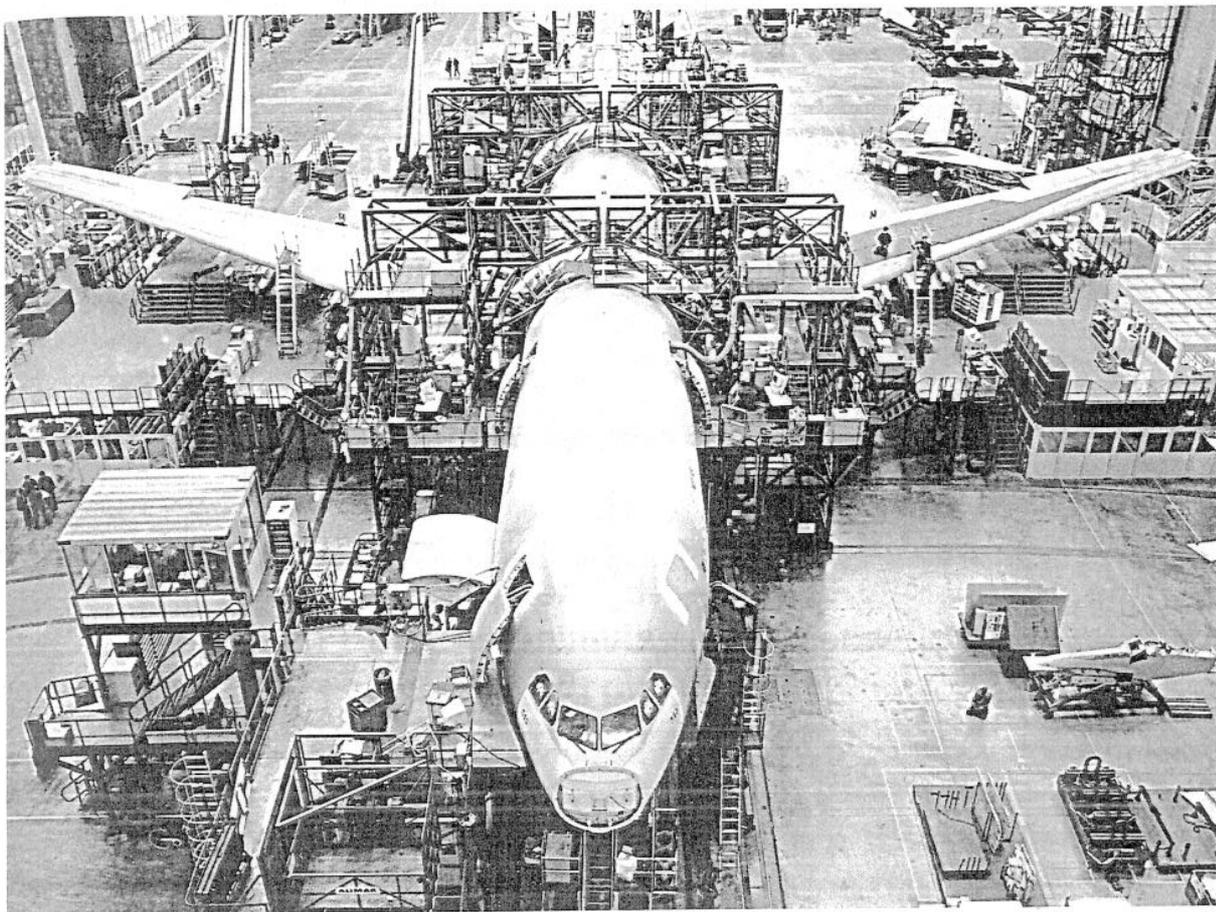
*The present perfect is never used with any expression of past time because it describes a state of affairs, a series of events or actions relating to a present situation. The simple past tense is used when past time is stated or clearly understood.*

*Of particular interest is the last example. The present perfect **Five fissures have been detected to date** allows us to think that more may be found. The simple past **Five fissures were detected during the inspection** tells us that five, and only five, were found and no more can ever be found during the inspection (completed last week). Note that the past time is implied: **during the inspection** (at a past time known to both speaker and listener).*

2.  
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3.  
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6.  
7.  
8.

## 2.2.11. PRACTICE: PASSIVE VOICE AND VERB TENSES

Look at the photograph carefully. In the background on the left you will see what appear to be the vertical stabilizer and rudder. In the background center-right you will see the horizontal stabilizer. Write complete sentences or questions below.



### 2.2.11. A. USE THE PRESENT CONTINUOUS PASSIVE FORM FOR EACH VERB GIVEN.

1. What ..... in this picture? (DO)
2. The wings ..... to the center section integral with the fuselage. (JOIN) In this picture the wings ..... into place (MOVE).
3. At the same time, the wing skins of the right hand wing ..... (VISUALLY INSPECT) for signs of defects or other anomalies.
4. Inside, electric cables ..... in the underfloor areas. (INSTALL)
5. In addition, fuselage junctions ..... (INSPECT or CHECK)
6. Hinges ..... (TEST) for performance and reliability.
7. Several engineers ..... (CONSULT) for their opinion.
8. Four or five technicians ..... (GIVE) final details concerning wing mounts.

### 2.2.11. B. MAKE COMPLETE STATEMENTS BASED ON THE INFORMATION GIVEN. ASK A QUESTION IF NO ANSWER IS GIVEN (THE ANSWER SHOULD BE CLEAR FROM THE PHOTOGRAPH.)

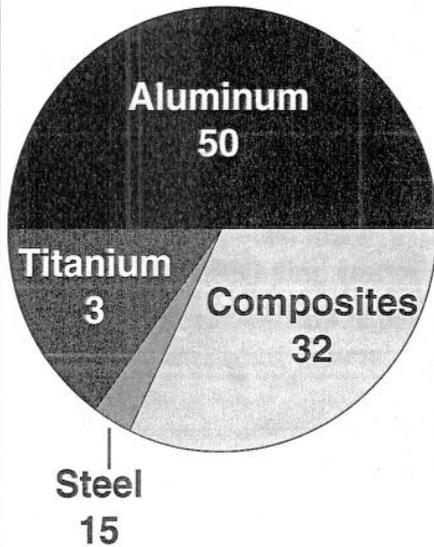
1. Horizontal stabilizer joined?  YES  NO
2. Vertical stabilizer joined?  YES  NO
3. Starboard service door and other doors mounted?  YES  NO
4. Radome mounted?  YES  NO
5. Aircraft painted?  YES  NO
6. Seats installed?  YES  NO
7. Cabin windows installed?  YES  NO
8. Fuselage sections joined?  YES  NO
9. Cabin layout completed?  YES  NO
10. Cockpit layout completed?  YES  NO
11. Cockpit windows mounted?  YES  NO
12. Hydraulic lines in place in wings?  yes  no



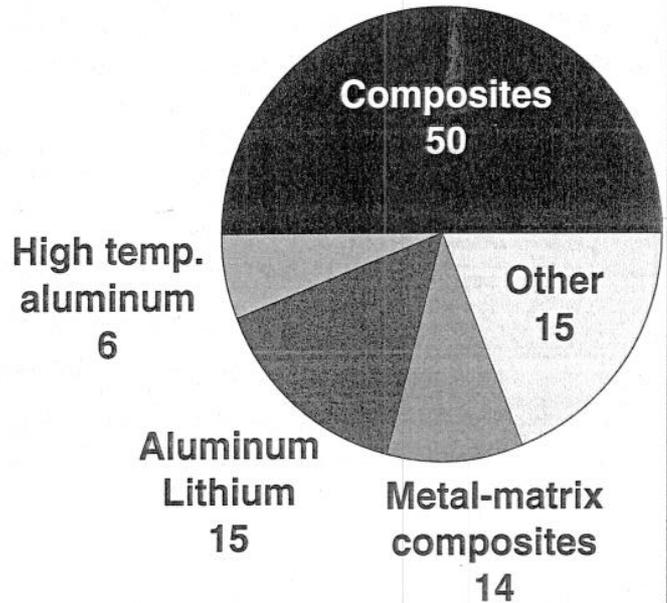
**A. COMPOSITION**

# Materials used in aircraft construction

## SUBSONIC AIRCRAFT



## SUPERSONIC AIRCRAFT



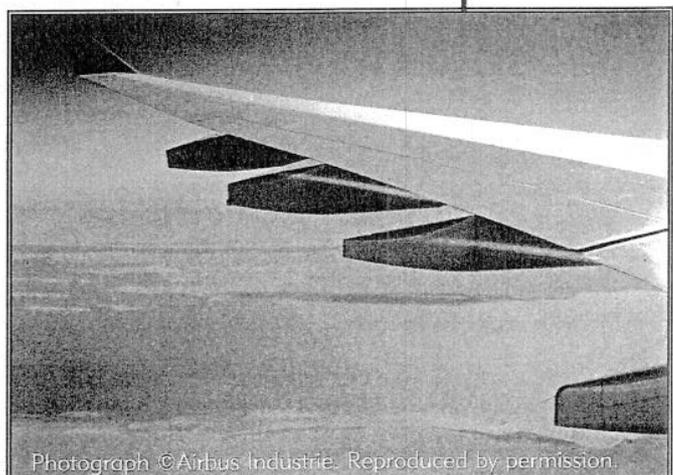
*Figures represent percentage of materials used in overall aircraft construction.*

The illustration reveals the general material composition of subsonic and supersonic aircraft. Can you make complete statements using the expressions seen in previous sections?

## B. WINGS

Look at the photograph of the Airbus wing.

1. Which part of the wing is visible? Which wing is shown?
2. On the left, near the center, you see a "gap" or separation. Explain this. What are the components on each side of this gap?
3. Describe the visible components of the aerofoil, their functions, and how and under what conditions they are brought into operation.



Photograph ©Airbus Industrie. Reproduced by permission.

The  
stru  
the

- a.
- b.
- c.
- d.
- e.
- f.
- g.
- h.

This  
both  
desc



15.3



max



com



\*C<sub>L</sub>



## Maintenance Check!

### 2.2.13. FINAL PRACTICE AND RECALL Technical description and/or presentation

The illustration below is a drawing made from a photograph of the A320 wing (dotted lines show structures which are not visible on the surface of the wing). Can you locate all the components on the drawing? Write the letter on or next to the corresponding component.

a. flap track fairings

b. static dischargers

c. wing skin paneling

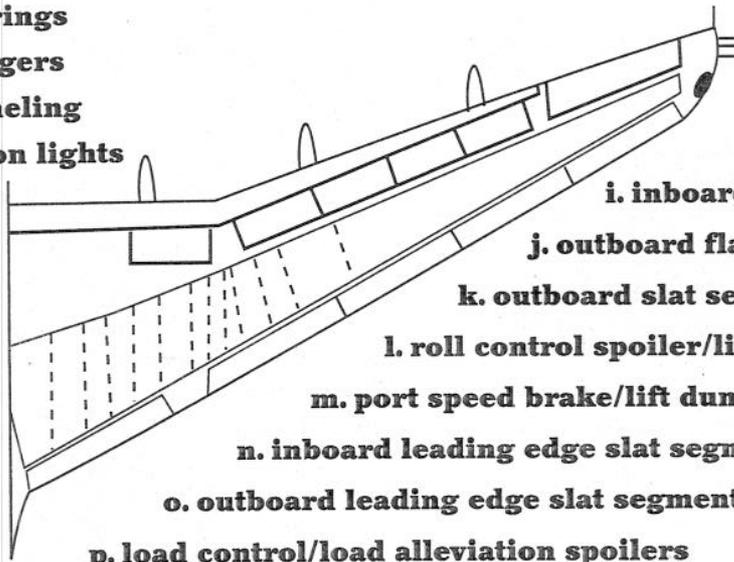
d. port navigation lights

e. ribs

f. spars

g. port aileron

h. port wing tip



i. inboard flap segment

j. outboard flap segment

k. outboard slat segments

l. roll control spoiler/lift dumper

m. port speed brake/lift dumper

n. inboard leading edge slat segment

o. outboard leading edge slat segments

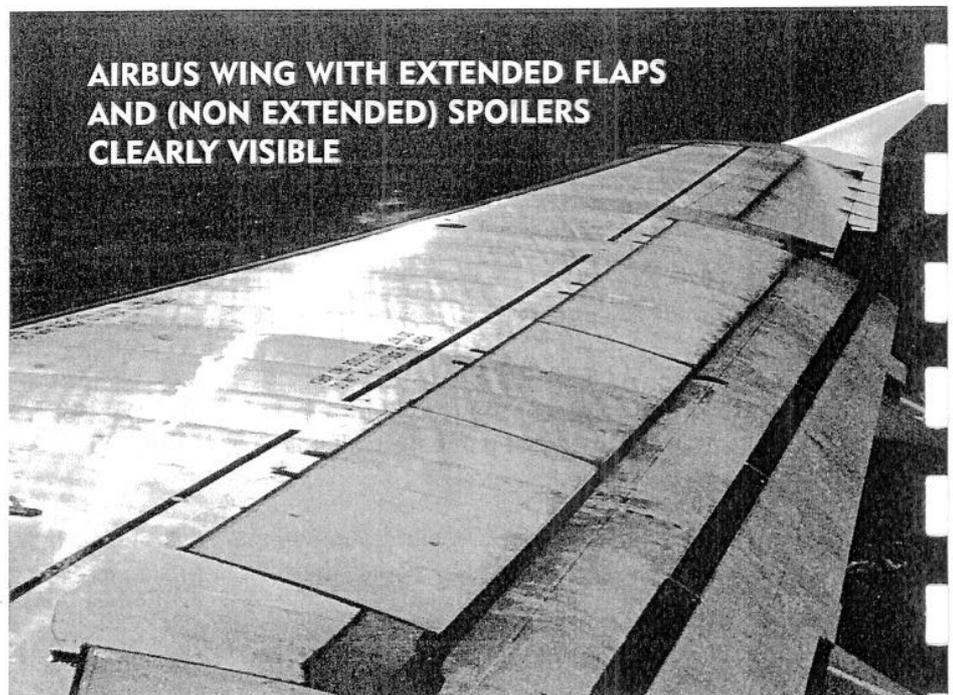
p. load control/load alleviation spoilers

This is an opportunity to practice writing a technical description or making a brief presentation. Or both. Look at the general features outlined below and work the information into a complete description using appropriate vocabulary (features, designs, fittings, functions).

## GENERAL FEATURES

- ➊ maximum thickness far aft
- ➋ root thickness/chord ratio 15.3% tapering to 10.8% at the tip
- ➌ high-lift system reaching  $C_L^*$  maximum of 3.2
- ➍ more structurally efficient wing
- ➎ wing tip fences
- ➏ flaps, ailerons and spoilers in composite materials
- ➐ aspect ratio of 9.4
- ➑ aerodynamic improvements

\* $C_L$  = coefficient of lift



Photograph ©Airbus Industrie. Reproduced by permission.

## 2.3. OIL SYSTEMS: AN EXAMPLE FROM LIGHT AIRCRAFT



### Description of a simple oil system in light aircraft

■ **the engine-driven oil pump** supplies oil from the sump or tank through oil lines, passages and galleries to the moving parts of the engine to keep them lubricated and thereby avoid damage. The pump is the primary component of the system because it keeps the oil circulating throughout the engine.

■ **the pressure relief valve** is a spring-loaded device which opens to relieve pressure if the pressure set on the valve is exceeded. The valve enables oil to return to the pump inlet.

■ **oil filters** are provided on all systems. Their purpose is to remove foreign particles, impurities, carbon particles and dust and dirt from the circulating oil. Oil picks up such impurities as it travels through the engine. Oil filters are inspected regularly and replaced at prescribed intervals.

■ **the oil filter bypass valve**

is located within the oil filter housing. The purpose of this valve is to allow oil to bypass the filter if the filter becomes clogged. It thus prevents the flow of oil from being impeded or stopped.

■ **the sump**

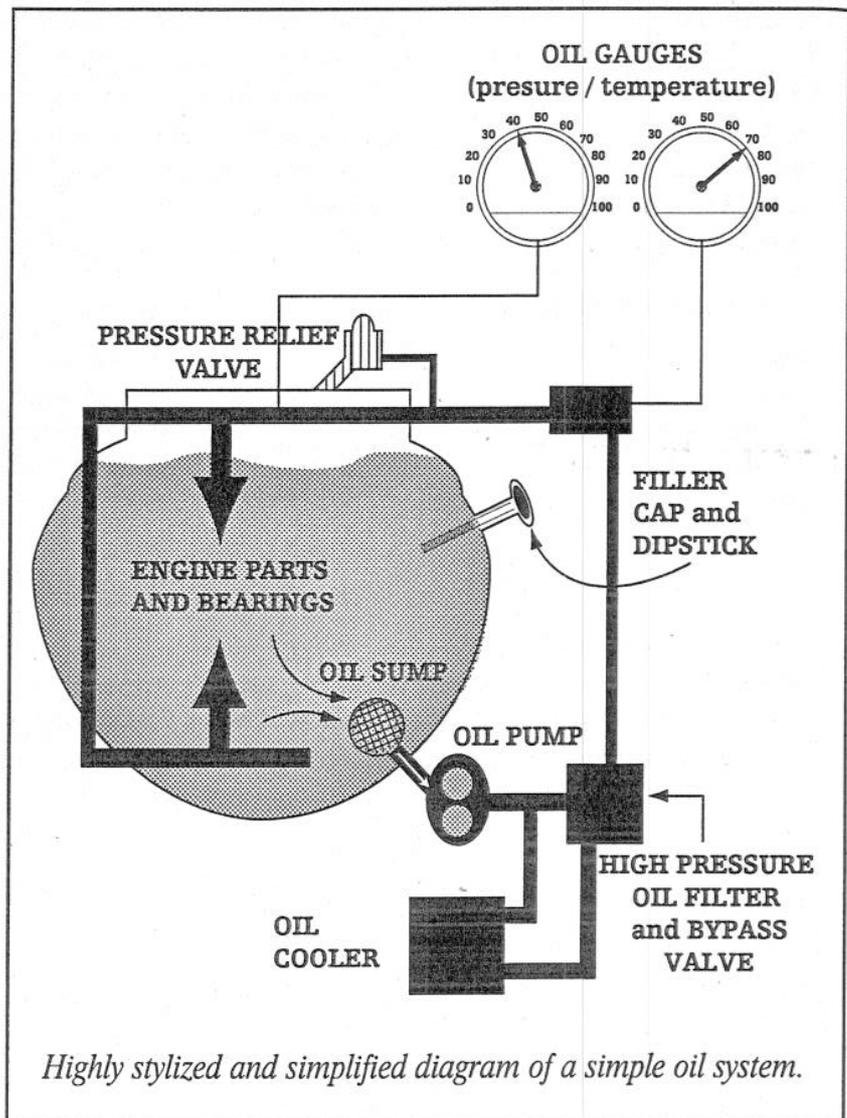
is a reservoir fastened to the lower part of the engine casing.

■ **scavenge pumps**

are found in dry sump engines. They remove (scavenge) the oil from the sump attached to the lower part of the engine casing and pump it back into the oil tank which is separated from the engine.

■ **the oil cooler**

receives the oil pumped from the sump through the oil filter. If the oil is already cool, a thermally-operated valve allows it to bypass the cooler. If the oil has become excessively heated, this valve enables it to flow through the cooler. If the valve is clogged, a pressure bypass valve allows the oil to bypass the cooler.





## Vocabulary Checklist

### DO YOU KNOW THESE WORDS?

#### Oil flow, filters and pressure valves

to relieve  
 relief-valve  
 to exceed  
 to pick up  
 an inlet  $\neq$  an outlet  
 to bypass  
 to impede  
 housing  
 to clog

Excess pressure must be relieved.  
 This is accomplished using a relief valve.  
 Pressure must not exceed a certain level.  
 Oil picks up impurities as it travels through the system.  
 Oil enters via an inlet and leaves via an outlet.  
 Oil does not travel through this filter, it bypasses it completely.  
 Impurities can impede the smooth flow of oil.  
 The housing protects the valve.  
 Filters eventually become clogged (with impurities).

Oil picks up **impurities** such as:

dust  
 dirt  
 foreign bodies  
 foreign particles  
 grit

The oil filter **removes** impurities. It

**draws out**  
**filters out**  
**eliminates**  
**gets rid of** } these impurities.

#### 2.3.1. LANGUAGE PRACTICE

Refer to the diagram. In complete sentences, say as much as you can about the following components or mechanisms, and describe their purpose. Can you state what would happen if something were to go wrong with each? Or if a particular item were not removed or replaced when defective?

- oil pump
- pressure relief valve
- oil sump
- oil cooler
- oil filter
- oil filter bypass valve
- scavenge pump
- dipstick
- cap (filler cap on oil tank)

#### 2.3.2. PRACTICE.

Complete the following ideas in your own words.

- If the pressure exceeds a given level, ...
- If impurities get into the oil and are not removed, ...
- If oil filters are not inspected regularly, ...
- Because oil filters become clogged and inefficient, ...
- If an oil filter becomes clogged, ...
- Oil is circulated by means of ...
- The sump serves to ...

## 2.4. AN EXAMPLE OF A TYPICAL COOLING SYSTEM



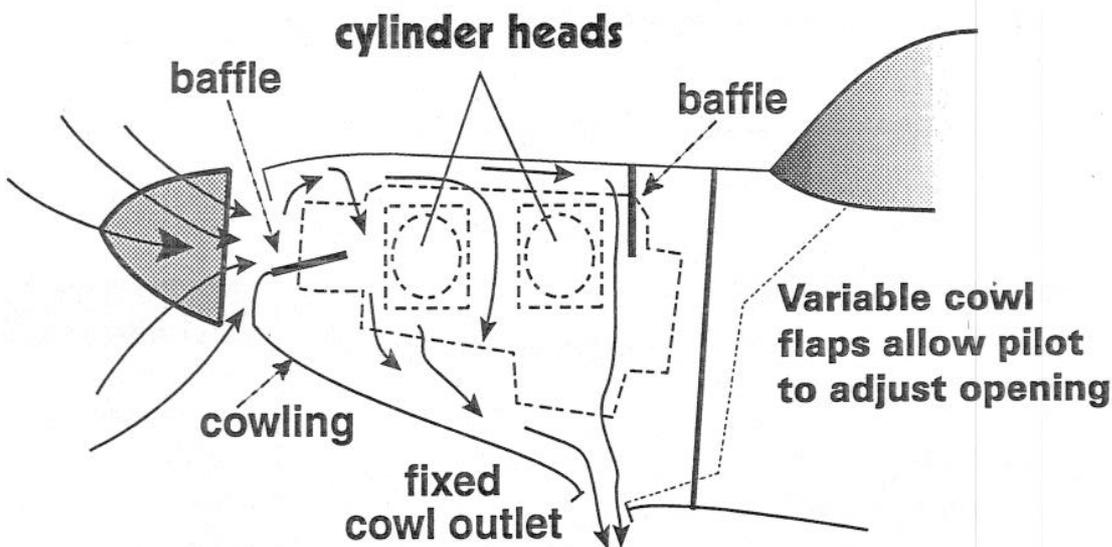
### 2.4.1. FILL IN THE BLANKS USING VERBS ON THE RIGHT TO OBTAIN A COMPLETE DESCRIPTION.

The piston engine (1) \_\_\_\_\_ the propeller and thus (2) \_\_\_\_\_ chemical energy of the fuel into heat and pressure energy through combustion with air. Heat and pressure energy are (3) \_\_\_\_\_ into mechanical energy needed to (4) \_\_\_\_\_ the propeller. But the engine (5) \_\_\_\_\_, leading to high engine temperatures. In some engines, it is airflow which (6) \_\_\_\_\_ the engine. Cylinders are fitted with cooling fins which increase the exposed surface area, allowing better cooling. Uneven cooling sometimes (7) \_\_\_\_\_. To (8) \_\_\_\_\_ this from (9) \_\_\_\_\_, certain key features are (10) \_\_\_\_\_.

#### VERBS

prevent  
happen  
occur  
cool  
provide  
drive  
heat up  
transform  
convert

### 2.4.2. READ THEN MATCH THE VARIOUS PARTS BELOW AND THEIR FUNCTIONS, OR DEFINITIONS.



Cylinder heads require constant cooling. A gauge enables the pilot to monitor closely cylinder head temperature (CHT). Not pictured are *cooling fins* which are mounted on cylinder heads to increase their surface area. *Cowling* surrounds the engine, covering it and increasing airflow. *Cowling ducts* are openings aft of the propeller allowing air to enter the engine cavity and circulate. Air escapes via *cowling outlets* which are both fixed and variable. The latter variety are also referred to as *faired cowl flaps* and can be set by the pilot to control engine cooling. In addition to *cowl flaps*, engine *baffles* distribute the air evenly around the cylinders. Cooling has a price: the open flaps cause an increase in drag called *cooling drag*.



- |                       |      |  |
|-----------------------|------|--|
| 1. COOLING FINS       | .... | a. enables air to escape                             |
| 2. COWLING DUCTS      | .... | b. increases exposed surface area                    |
| 3. BAFFLES            | .... | c. covers engine and increases air                   |
| 4. COWL OUTLET        | .... | d. invariable air outlet                             |
| 5. COWLING            | .... | e. indicates the temperature of the cylinder head    |
| 6. COOLING COWL FLAPS | .... | f. captures air behind the propeller                 |
| 7. FAIRED COWL FLAPS  | .... | g. distributes air evenly around cylinders           |
| 8. FIXED COWL OPENING | .... | h. parasite drag increasing with open flaps          |
| 9. COOLING DRAG       | .... | i. enable the pilot to control engine cooling        |
| 10. CHT GAUGE         | .... | j. allow more air to escape from engine compartment. |
- (CHT = cylinder head temperature)

**2.4.3. PRACTICE: FOR EACH DEFINITION GIVE THE CORRESPONDING TERM.**

- |  |       |
|--|-------|
| a. It's a streamlined metal covering.                | _____ |
| b. It's an opening, or duct, allowing air to enter.  | _____ |
| c. It's an opening, or duct, allowing air to escape. | _____ |
| d. It's a partition or plate that guides airflow.    | _____ |
| e. It's a measuring device indicating temperature.   | _____ |

**2.4.4. LANGUAGE PRACTICE: INSTRUCTIONS**

*This practice involves giving instructions. use the expressions on the right.  
(See also vocabulary checklist, page 86.)*

**ENGINE TEMPERATURE**

- \_\_\_ that oil temperature gauge during flight.
- \_\_\_ that cylinder head temperature is normal.
- \_\_\_ high temperatures.
- \_\_\_ running engine on the ground for long periods.
- \_\_\_ that cowl flaps are open for maximum cooling.
- \_\_\_ engine instruments to confirm existence of a possible problem (for instance, oil pressure and oil temperature gauge.)
- \_\_\_ to manual for instructions.

**VERBS**

**monitor**

**guard against**

**avoid**

**prevent**

**check**

**cross-check**

**use**

**refer to**

**ensure**

**make sure**

**be sure**

**check to see if**

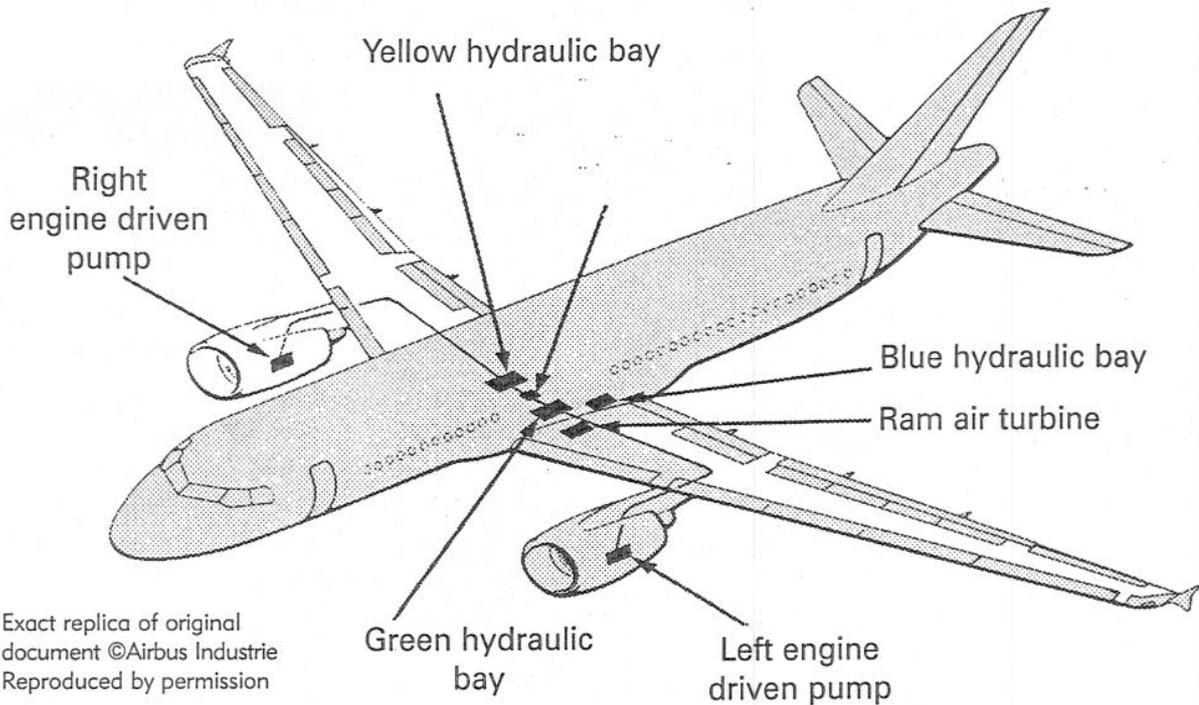
**check to see that**

em-  
heir  
ven-  
out-  
can  
ven-  
'rag.

## 2.5. HYDRAULIC SYSTEMS



Hydraulic bays are adjacent to the MLG wheel bays and, at about 2 m from the ground, are easily accessible for maintenance.



Hydraulic power is used to operate high power demand devices : flight controls, landing gear systems and cargo compartment doors. Hydraulically-driven actuators also drive leading-edge slats and trailing-edge flaps.

The A320 system features three independent 300psi (206 bars) hydraulic systems referred to as the blue, green, and yellow systems powered in the following manner:

- Yellow & Green systems are equipped with engine-driven pumps operating at 140 liters per minute
- Yellow & Blue systems are equipped with electric pumps with maximum outflow rated at 25 l/m.
- Yellow & Green systems feature an interconnecting two-way power transfer unit
- Blue system is provided with a drop-out ram air turbine in case of emergency
- Yellow system is equipped with a hand pump as a second way to open cargo doors

### DRIVING SLATS AND FLAPS

Duplex hydraulic motors are found in the fuselage. Their purpose is to drive low-friction torque shafts running along the wing and carrying angle boxes at frequent intervals. These angle boxes drive the ball screwjacks attached to the moving surfaces.

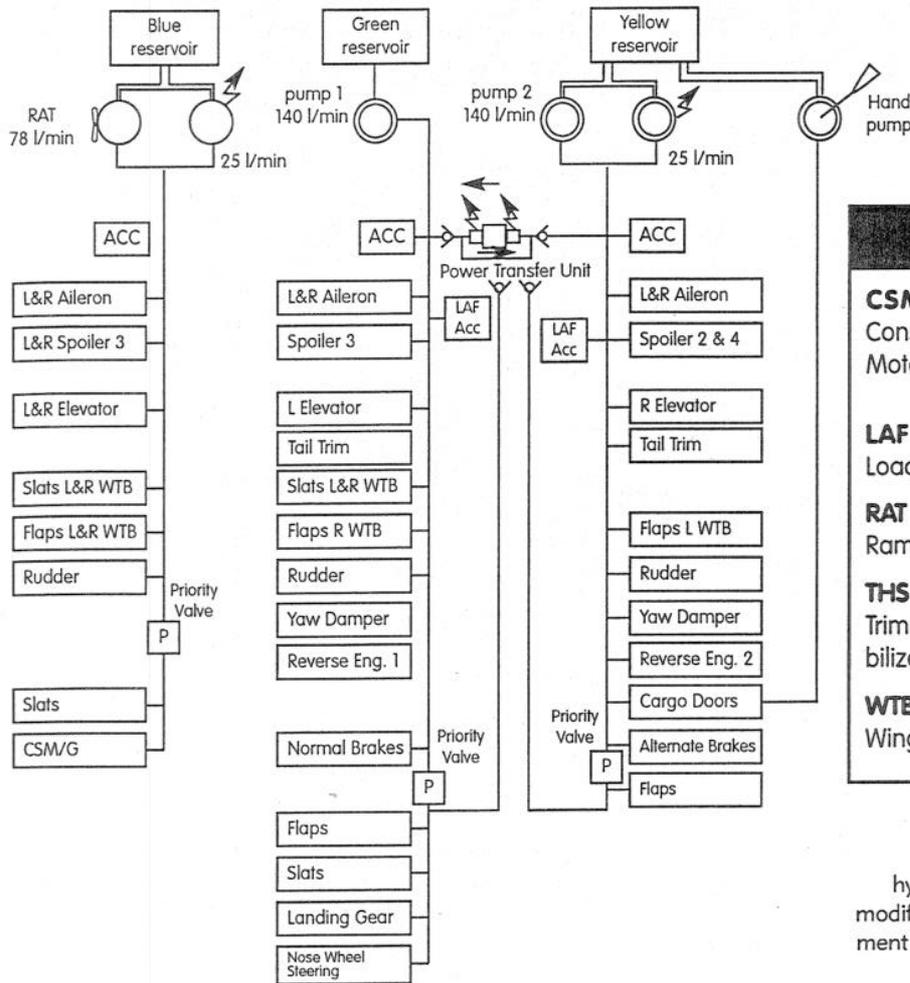
Slat drive tracks are housed in sealed cans inside the front of the integral wing tanks. In recent aircraft these cans are made using superplastic-formed/diffusion bonding titanium.

Failure on one hydraulic system to one slat or flap motor leaves the second driving at half speed.

### 2.5.1. COMPLETE

- a. Flaps and slats are moved by ....
- b. These in turn are driven by .....
- c. Extending the entire length of the wing are ...
- d. Sealed cans, located ....., encase (or house) ...
- e. In the event that one hydraulic system driving slats or flap motors fails...

# A320 hydraulic system



| LEGEND       |                                 |
|--------------|---------------------------------|
| <b>CSM/G</b> | Constant Speed Motor/Generator  |
| <b>LAF</b>   | Load Alleviation Function       |
| <b>RAT</b>   | Ram air turbine                 |
| <b>THS</b>   | Trimmable Horizontal Stabilizer |
| <b>WTB</b>   | Wing tip brake                  |

Exact replica of A320 hydraulic system with slight modifications to format. Document ©Airbus Industrie, reproduced by permission.

## 2.5.2. YOUR TURN TO DESCRIBE AND COMMENT

Above you see a schematic drawing of the hydraulic system on the A320. Without referring back to the article on the preceding page, present a clear description of the system. How are the various components (brakes, landing gear, cargo doors, and so on) actuated? Can you explain the advantage of having a hand pump? What purpose does it serve?

## 2.5.3. COMPARE AND CONTRAST. HOW DOES THIS SYSTEM DIFFER FROM THE ONE ABOVE? (THE A300 WAS THE FIRST AIRBUS AIRCRAFT.)

### A300B

#### ■ BLUE HYDRAULIC CIRCUIT

- 1 PUMP - NUMBER 1 ENGINE
- 1 PUMP - DRIVEN BY EMERGENCY DROP-OUT RAT (RAM AIR TURBINE)
- Drives all flight control surfaces and number 1 flap motor

#### ■ GREEN HYDRAULIC SYSTEM

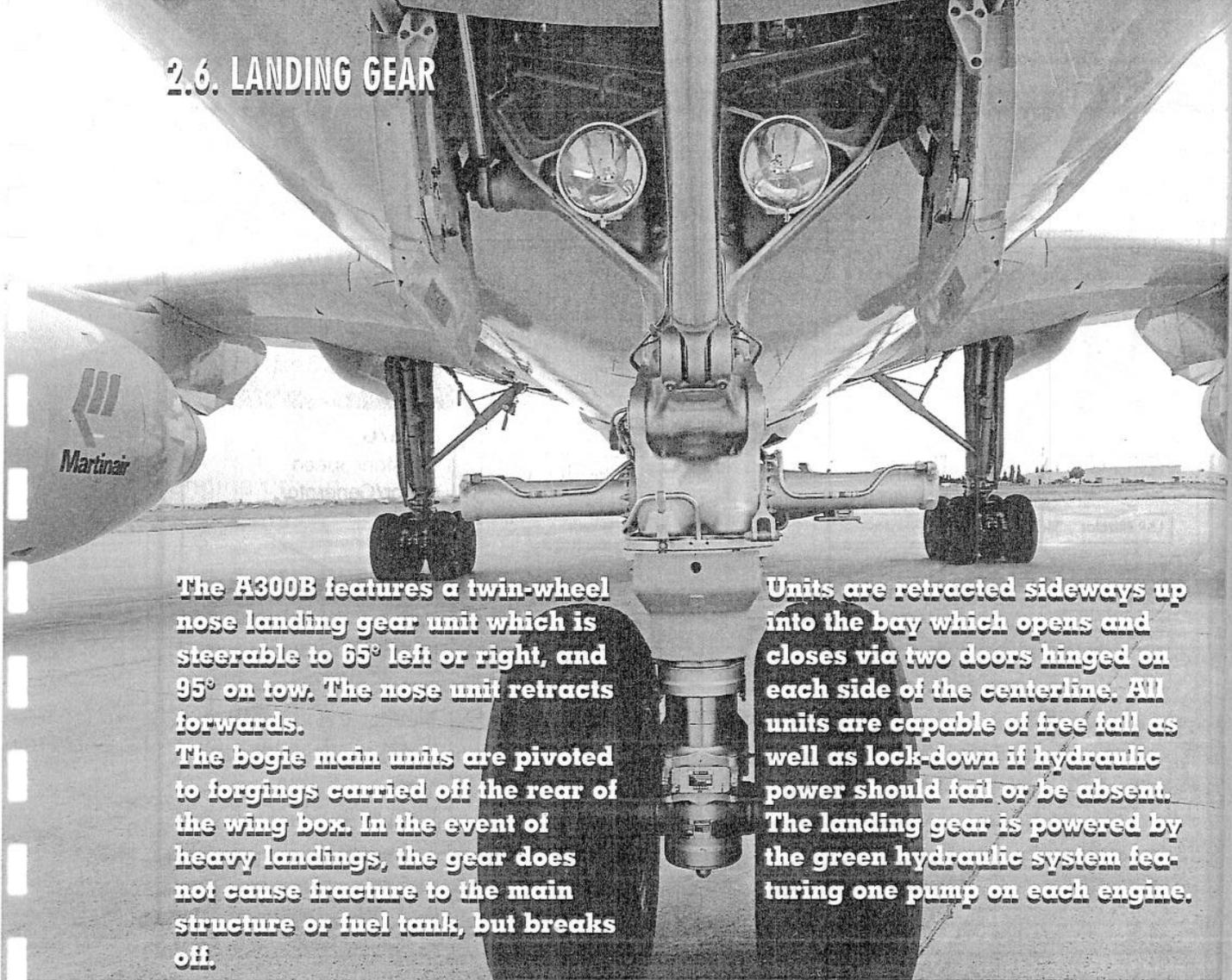
- 1 PUMP - EACH ENGINE
- All flight control surfaces, slats, airbrakes, landing gear, steering and wheelbrakes

#### ■ YELLOW HYDRAULIC SYSTEM

**PUMPS: 1- NUMBER 2 ENGINE AND 1 ON RAT. DRIVES**

- All flight control surfaces
- Number 2 slat motor
- Number 2 flap motor
- Disk- and wheelbrakes
- Steering / landing gear emergency release

## 2.6. LANDING GEAR



The A300B features a twin-wheel nose landing gear unit which is steerable to 65° left or right, and 95° on tow. The nose unit retracts forwards.

The bogie main units are pivoted to forgings carried off the rear of the wing box. In the event of heavy landings, the gear does not cause fracture to the main structure or fuel tank, but breaks off.

Units are retracted sideways up into the bay which opens and closes via two doors hinged on each side of the centerline. All units are capable of free fall as well as lock-down if hydraulic power should fail or be absent. The landing gear is powered by the green hydraulic system featuring one pump on each engine.

**2.6.1. REFER TO THESE NOTES ON TWO OTHER AIRBUS VARIANTS AND MAKE COMPLETE STATEMENTS. (WHAT CONTRASTS AND SIMILARITIES CAN YOU EXPRESS?)**

### THE A310

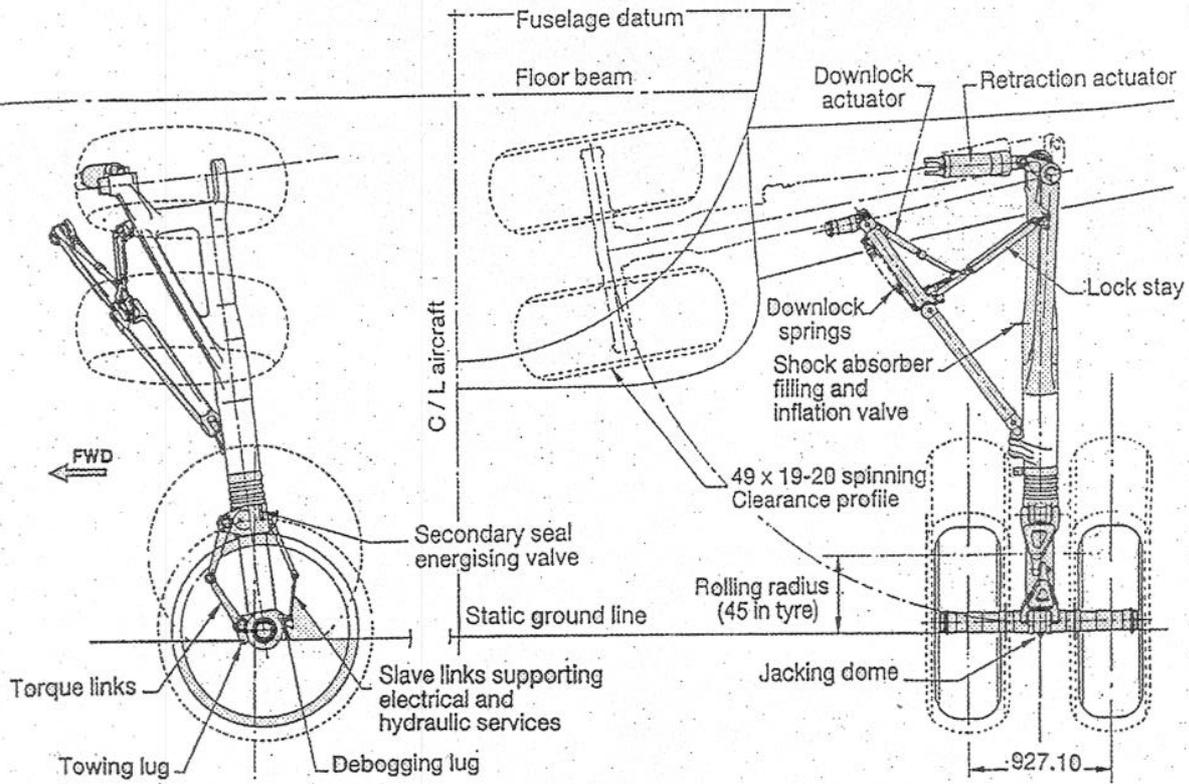
- all new optimized design
- smaller tires than on A300
- customer option: use of A300 tires at inflation pressure reduced to 8.9 bars
- nose gear: of the A300 type, tires at 9.0 bars
- standard brakes: Messier-Hispano-Bugatti, then later, and now standard, carbon brakes & radial tires → massive reduction in weight (544 kg)

### THE A320

- Landing gear driven by the green hydraulic system: one pump on each engine
- In the event of failure: the yellow system is taken over and supplies power via the transfer unit, if green hydraulic system fluid is not lost
- the yellow hydraulic system drives the wheelbrakes, steering and landing gear emergency release

See also section 2.5. The hydraulic systems.

# A320 main gear - standard configuration



|            |                      |                    |
|------------|----------------------|--------------------|
| Tyre sizes | Basic (radial)       | 45 x 16 - R20      |
|            | Option 1 (radial)    | 46 x 17 - R20      |
|            | Option 2 (cross-ply) | 49 x 19 - Type VII |

Note : A wider selection of tyre sizes may be offered when available.

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## 2.6.2. PRACTICE: LOCATE THE FOLLOWING COMPONENTS AND STATE THE EXACT LOCATION OF EACH.

1. retraction actuator
2. downlock actuator
3. downlock springs
4. lock stay
5. shock absorber filling and inflation valve
6. jacking dome
7. towing lug
8. debogging lug
9. torque links
10. slave links
11. secondary seal energising<sup>1</sup> valve

<sup>1</sup> American spelling: energizing

## 2.6.3. PRACTICE: DIMENSIONS SOME ARE GIVEN, OTHERS MUST BE INFERRED

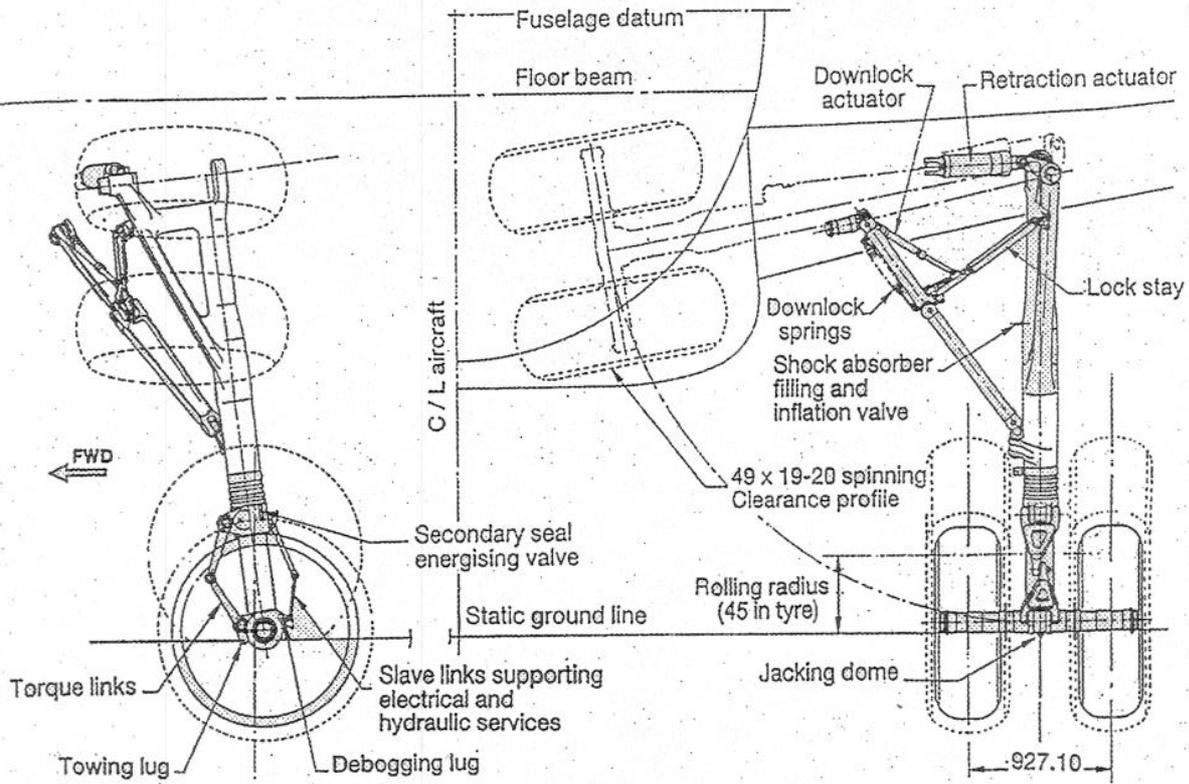
1. torque link
2. retraction actuator
3. downlock actuator
4. basic radial tire<sup>2</sup>
5. cross-ply tire
6. lock stay
7. span between tires
8. rolling radius
9. from floor beam to ground

<sup>2</sup> American spelling: tire

## 2.6.4. PRACTICE: FITTINGS AND FASTENINGS

- Can you describe how the various components shown in the illustration above fit together (or are fitted together) and/or connected?
- Describe the movements when the gear is extended and retracted.

# A320 main gear - standard configuration



|            |                      |                    |
|------------|----------------------|--------------------|
| Tyre sizes | Basic (radial)       | 45 x 16 - R20      |
|            | Option 1 (radial)    | 46 x 17 - R20      |
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## 2.6.4. PRACTICE: FITTINGS AND FASTENINGS

- Can you describe how the various components shown in the illustration above fit together (or are fitted together) and/or connected?
- Describe the movements when the gear is extended and retracted.

## 2.6.5. FOCUS ON NOSE LANDING GEAR

Aircraft are fitted with landing gear made mostly of high tensile steel forgings. The nose gear features some high-strength aluminum alloy components.

The nose gear retracts forwards into the fuselage. Hydraulic actuation of a steering rack mounted on the gear leg provides steering to  $\pm 75^\circ$ . This also provides a maximum towing angle of  $\pm 95^\circ$ .

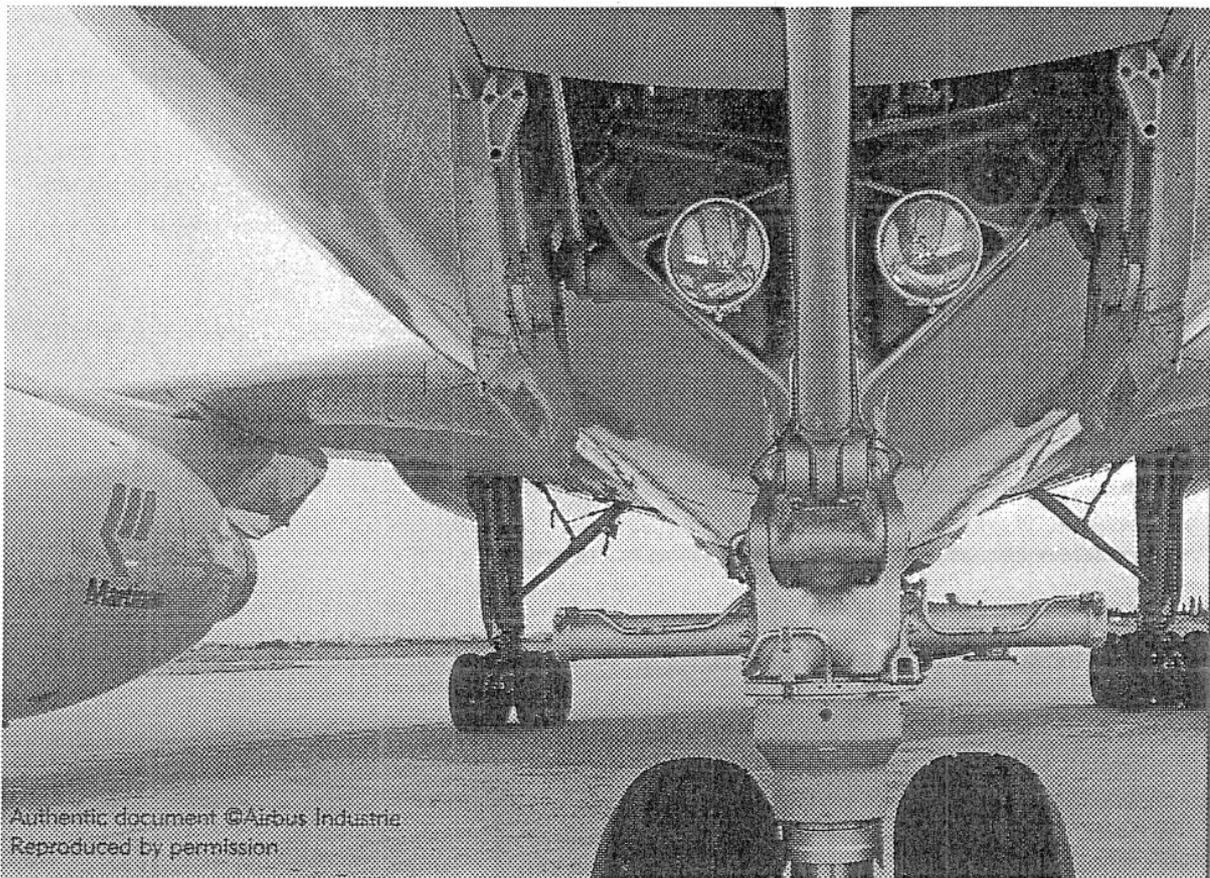
The aircraft comes with main landing gear designed to retract sideways into the fuselage.

A four-wheel bogie landing gear is available as an option.

The landing gear is supplied with a single shock absorber which is supported fore and aft by a fixed drag strut and laterally by a folding strut.

An hydraulic system is provided to actuate the gear and some gear doors. The system is equipped with proximity detectors and associated logic controls designed to achieve the proper sequencing.

## A320 Nose landing gear



### 2.6.6. COMPLETE THE STATEMENTS.

1. .... are used in the construction of landing gear.
2. .... are used in the nose gear.
3. The nose gear retracts .....; and extends .....; the main gear retracts .....
4. A fixed drag strut is used to .....
5. A folding strut is used to .....
6. Proper sequencing is ensured .....

The  
from  
wic  
air  
sec  
A p  
coc  
from  
eng  
or  
of t  
pac  
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Du  
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## 2.7. CABIN PRESSURIZATION AND AIR-CONDITIONING

The air conditioning system depends on compressed air from the engines, the APU or any ground supply unit. On widebody jets, a typical system is made up of two separate air conditioning bypass packs located in the fuselage center section.

A pneumatic system controller together with bleed air pre-coolers ensure proper supply to packs of compressed air from the engines via a pneumatic duct. Air bled from engines is too hot and compressed to be used to pressurize or cool the cabin, although it is suitable for other uses. Part of the bled air is tapped and sent to the air conditioning packs which supply air to the cabin at required pressure and temperature.

During cruise phase, both fresh air and recycled cabin air deliver about 7200 ft<sup>3</sup> per minute (3400 liters per second).

In the passenger cabins air circulates by being drawn in at floor level and expelled overhead at storage compartment level.

During on-ground and in-flight periods, the passenger compartment can be heated to 20-21°C. Similarly, the air conditioning system is designed to cool the passenger cabin to 25-27°C with maximum humidity ranging between 65% and 60% when the outside temperature exceeds 30°C.

Separate temperature controls are located in the cockpit and the passenger compartments.

The cockpit receives a continual flow of fresh air. Cockpit crew members also have individual air outlets available at their seats. The cockpit is also equipped with adjustable outlets allowing for windshield defogging.

### 2.7.1. READ THE BRIEF DESCRIPTION AND ANSWER THESE QUESTIONS.

1. List the sources of compressed air  
.....  
.....  
.....
2. Explain "bleed air."
3. Define and explain the role of packs (or bypass packs).
4. How are packs supplied with compressed air?
5. Explain typical temperature settings and how these are controlled.
6. What special provisions are made for the cockpit? Why?

## 2.8. WATER SUPPLY AND DRAINAGE

Pressurized water systems supply potable water to galleys and lavatories via main water lines located in the under-floor area. Water lines must be made of non corrosive materials, usually stainless steel.

A typical system in use on widebodies has two tanks installed in the pressurized section of the fuselage providing a maximum of roughly 185-190 US gallons (or roughly 700 liters) of water.

Hot water is supplied via an electrical heater with thermostat controls found under wash basins in lavatories.

### Toilets and waste removal

Waste is stored in special storage tanks located in under-floor pressurized areas. Each is provided with a service panel for draining and cleaning. Lavatory wash basins and galley sinks are provided with overflow ducts and a normally open plug with an air stop device, and are drained overboard by means of heated masts.

### 2.8.1. READ THE BRIEF DESCRIPTION AND ANSWER THESE QUESTIONS.

1. What is the capacity of each water storage tank?
2. Explain how hot and cold water are supplied to a lavatory basin or galley sink.
3. How are toilets and lavatory sinks drained? Is one drainage system used?
4. A mast is a (vertical) pole usually rising from a ship's deck. How would you understand the word as it is used here?

## 2.9. SUPPLEMENTARY SECTION: DESIGN PARAMETERS



# THE DESIGN OF THE FIRST BOEING 737-300

The Boeing 737-300 was designed to be more fuel efficient. From the outset, however, engineers were faced with numerous drawbacks. For one thing, the design of the new aircraft required the use of new and bigger engines. And it was here that the Boeing engineers ran into their first great difficulty, for such an engine couldn't be attached to existing struts under the wing. Fitting them in the normal position would have caused problems of ground clearance: the landing gear would have had to be lengthened so as to ensure

proper clearance. This solution was obviously impractical for three reasons. Increasing landing gear length would have entailed:

- 1) increased weight
- 2) extensive structural modifications
- 3) increased cost.

By using the super computer, engineers were able to come up with a new design for the upper part of the nacelle, allowing front engine mounting with no drag.

### 2.9.1. PRACTICE.

Find words or expressions in the above passage which mean:

- a. cause, result in
- b. to find, discover
- c. from the beginning
- d. evidently
- e. to install, to mount
- f. to meet or encounter
- g. disadvantage, inconvenience
- h. to be confronted with
- i. many
- j. the top part
- k. wide-ranging, great, far-reaching
- l. to make possible (2)

### 2.9.2. FLUENCY PRACTICE

Practice rephrasing the following ideas using the prompts given.

1. The 737-300 was designed to be more fuel efficient.

Fuel efficiency was what ...  
The overriding concern...  
Engineers were faced with the task of ...  
The design of the Dash 300 ...

2. By using the super computer, engineers were able to come up with a new design.

The new design was made possible...  
Only by using a super computer ...  
Engineers devised ...  
The design of the new upper part of the nacelle...

## GERUNDS

The gerund is used after certain verbs such as *require, mean, necessitate*.

*It required redesigning certain components.*

*It will mean having to work late.*

Notice how we use gerund phrases. There are two gerund phrases in the following example, one the subject and the other the object of the verb require.

*Finding a new engine mount design required using a super computer.*

## CONDITIONAL PATTERN

The conditional pattern here is used when we are referring to events having taken place in the past.

If the engineers *had fitted* the engines in the normal position, this *would have resulted* in problems of ground clearance.

Without the changes, the new design *would not have brought* the fuel economies which Boeing wanted.

See also grammar file #3, page 37.

### 2.9.3. PRACTICE USING GERUND PHRASES

- Building a more fuel efficient aircraft meant ...
- Using new and bigger engines ...
- Having proper ground clearance with the bigger engines in regular position would have required ...
- Lengthening the landing gear would have meant ...
- Increasing the weight would ...
- Making extensive structural modifications ...
- Increasing the cost of the aircraft ...
- Mounting the engines in front ...
- But having the engines mounted in front also meant ...
- Engineers were finally able to come up with a new design by ...
- Redesigning the nacelle ...

### 2.9.4. PRACTICE USING THE CONDITIONAL PATTERN

It would have meant having to...

- Increased sales → design of a more fuel efficient aircraft
- Increased fuel efficiency → newer and bigger engines
- The use of such an engine → modifications in mounting
- Normal mounting → increased landing gear length
- New (front-mounted) engine design → redesign of the upper nacelle part

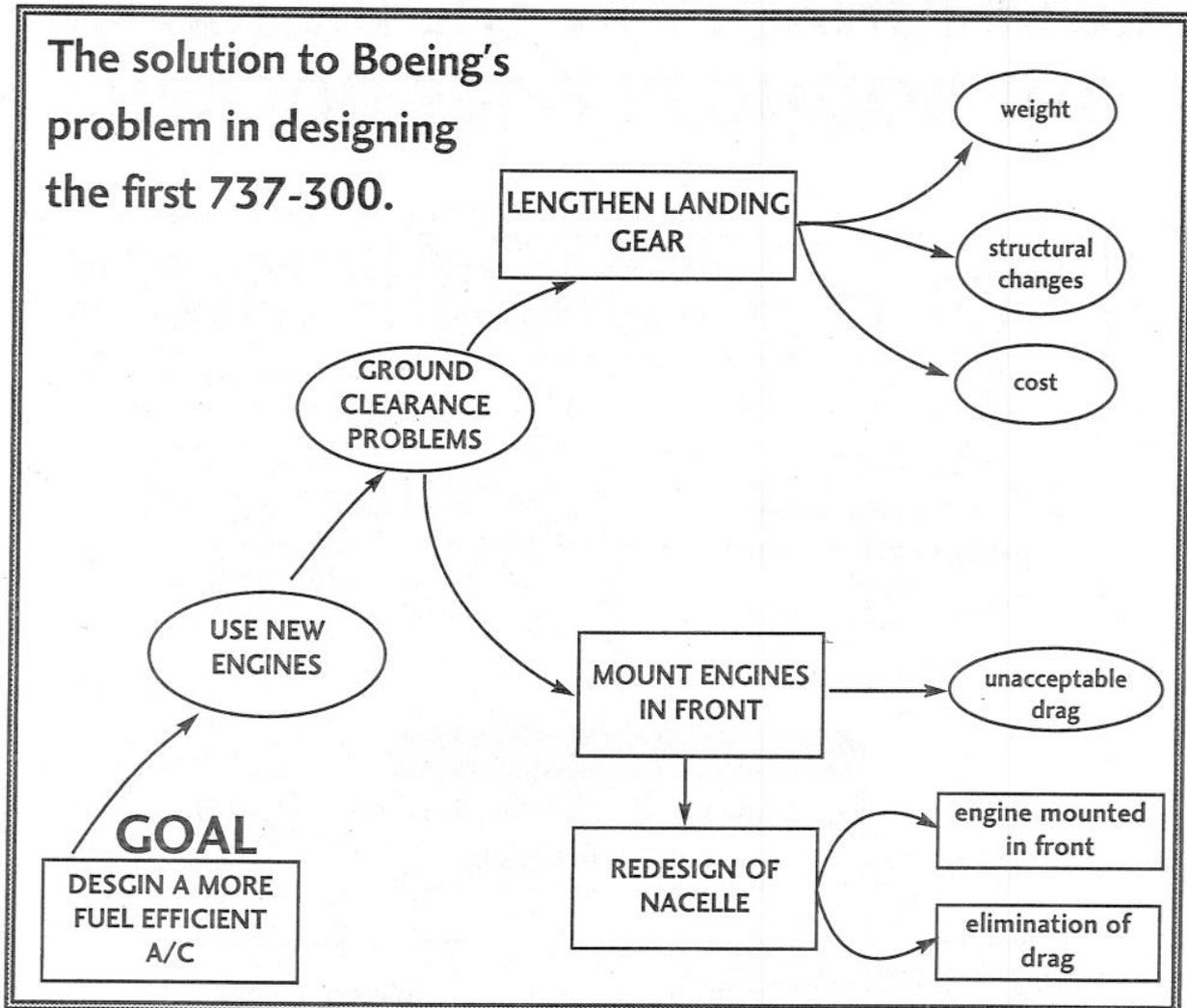


## Special Presentation Section

2.10.

An opportunity to practice your presentation skills or to work on your fluency.

The following diagram is based on the passage in section 2.9. (the design of the first Boeing 737-300. Prepare a brief presentation of the subject shown below or a description of the problem and its solution. For additional practice, answer the questions at the bottom of the page. You should use gerund constructions wherever possible as well as expressions of cause and effect.



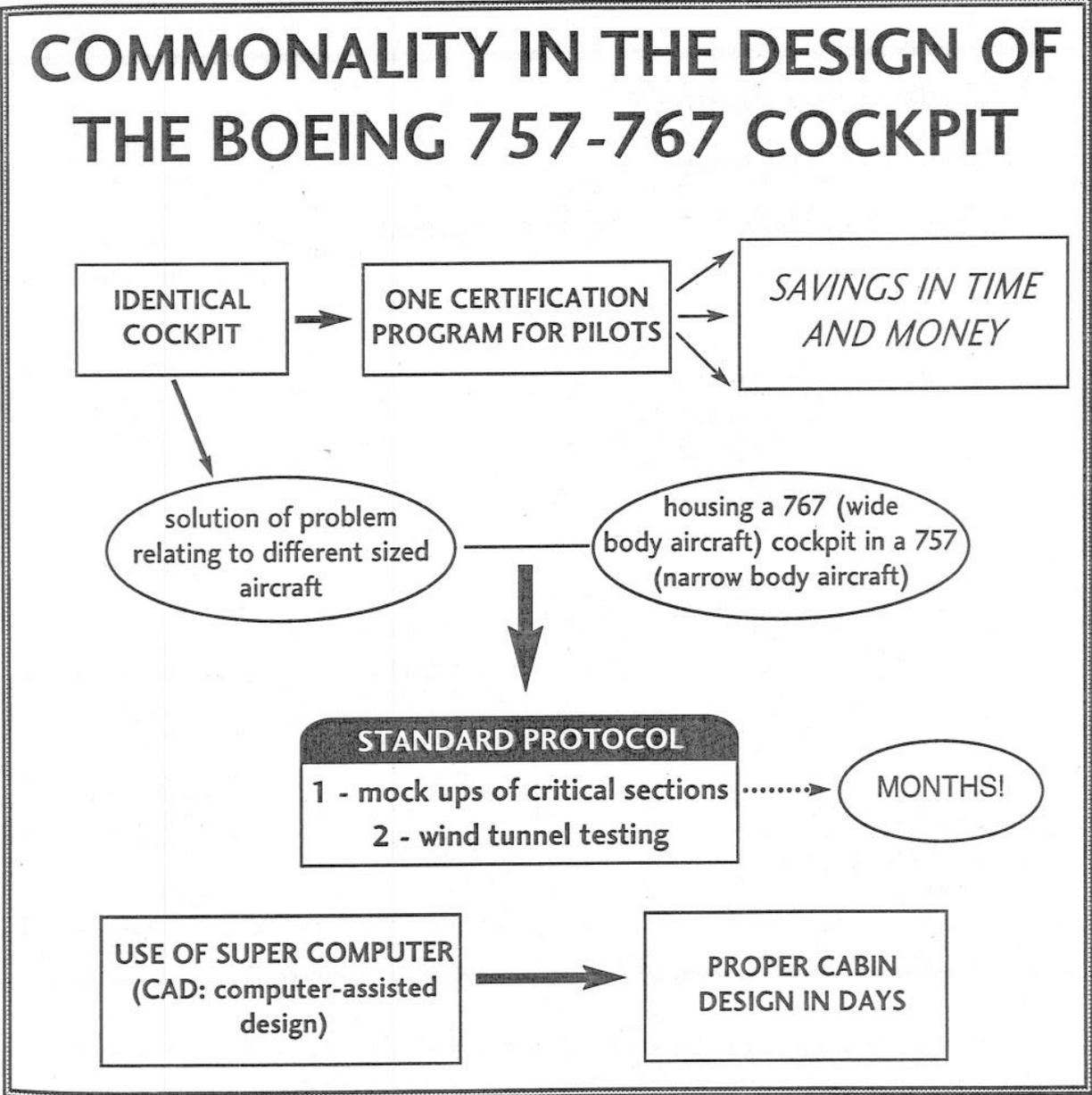
1. What impact would the results of lengthened landing gear have had on the new aircraft?
2. What would have been the implications of front-mounted engines?
3. How did the Boeing engineers finally come up with a design for front-mounted engines without the drag penalty?
4. Why did the engineers find the drag "unacceptable." That is, why weren't they willing to accept the drag penalty?



**Special  
Presentation  
Section**

**2.11.**  
An opportunity to practice your presentation skills or to work on your fluency.

The resolution of the problem shown below has not been covered in any preceding section. The diagram explains simply how Boeing came up with one (common) cockpit design for two aircraft of different sizes. Some useful language is provided below.



**GIVING BACKGROUND INFORMATION**

There was every reason to design ...  
 Pilots would no longer need ...  
 It would no longer be necessary to require pilots ...  
 The only problem/obstacle was that ...  
 The Boeing engineers had to...  
 Resorting to standard protocol at that time...

**CONFRONTED WITH/ FACED WITH**

to face / to be faced with  
 to be confronted with  
 to deal with  
 to come to grips with  
 to find a way to  
 to find a solution to



**■ SUGGESTED FINAL REVIEW AND RECALL ACTIVITIES**

**🕒 Presentation practice**

Make a brief presentation of the A320 shown above, describing its basic features and general structure.

**🕒 Basic aircraft structures**

Identify as many structures as you can in the photograph. Mention those not shown such as:

- the APU (auxiliary power unit)
- fuel tanks
- underfloor area
- cabins

Can you briefly describe how wings and fuselage are made and assembled?

**🕒 The principles of flight**

Referring to the photograph, explain how areas of high and low pressure are created, and how even though all forces are balanced the aircraft is propelled forward at constant velocity.

**CONFIGURATION**

equipped with  
provided with/supplied with  
fitted with  
outfitted with  
furnished with  
mounted/installed/fitted in(to)  
designed  
purpose

**LOCATION**

forward fuselage  
center fuselage  
rear fuselage  
tailcone...  
tailplane...  
located in...  
situated in...  
found...  
aft of / behind  
ahead of / fore of  
on each side of

**ENABLING**

enable  
allow  
make it possible for/to

fusel  
forw  
cent  
rear  
pres  
land  
pres  
unde  
carg  
stres  
fusel  
fusel  
strin  
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a var  
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fuel  
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to up  
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cowl  
cowl  
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to ci  
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faire  
vent  
filter  
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## A WEALTH OF WORDS

A list of major terms used in section 2

### FUSELAGE

fuselage frames  
forward fuselage  
center fuselage  
rear fuselage  
pressure bulkhead  
landing gear bays  
pressure floor  
underfloor area  
cargo hold (compartment)  
stress point  
fuselage skin  
fuselage skin joints  
stringer  
lower / upper decks  
growth derivative  
to stretch  
a stretched version  
a variant  
a (stretch) plug  
fuel capacity  
engine thrust  
to upgrade / an upgrade  
take-off/landing weight

### LIGHT A/C: COOLING AND OIL SYSTEMS

cylinder head  
cylinder head temperature  
cooling fin  
cowling  
cowling flap  
baffle  
cavity  
to circulate  
cooling drag  
faired cowl flap  
vents  
filter/screen  
spark plug  
fouling  
sump  
scavenge pump  
pressure relief valve  
inlet/outlet  
impurities  
to clog  
to pick up  
to remove/filter out  
to drain  
bypass valve  
engine casing

### WINGS

wing box  
wing skin  
wingspan  
to sweep back  
the sweep  
the angle of sweep  
spoilers  
lift spoilage  
airbrakes  
lift dumpers  
to extend / extension  
to retract / retraction  
the chord  
dihedral angle  
slat  
flap  
aileron  
to deploy / deployment  
to disrupt / disruption  
spar  
rib  
saturation shot peening  
wing tip fence  
crossflow (air)  
wing tip vortex (*pl*: vortices)  
clockwise movement  
counterclockwise movement  
to hinge / a hinge  
to actuate / actuated  
actuator  
outboard / inboard  
tracks / tracked

### PRESSURIZATION / WATER SYSTEMS

bypass pack  
bleed air  
precooler  
to tap (air, water)  
to heat / to cool  
to draw in / to expel  
defogging  
heater  
waste removal  
waste storage  
overflow duct  
to drain  
overboard

### HYDRAULIC SYSTEM

hydraulic bay  
outflow  
duplex hydraulic motors  
low-friction  
torque shaft  
angle box  
screwjack  
flap/slat motor  
steering  
to drive  
to power

### LANDING GEAR

retract inward  
sideways  
bogie  
twin-wheel  
forgings  
torque links  
rolling radius  
jacking dome  
towing lug  
strut  
debogging lug  
slave links  
lock stay  
shock absorber  
floor beam  
tire (*British*: tyre)  
spring

### MISCELLANEOUS

to fit  
to fasten  
to bond  
to weld  
to rivet  
to position  
to place  
to lodge  
to fay  
interfaying  
pin  
junction  
alloy  
composite material



# 3

## Powerplants for the aircraft

from propellers to jets

How does a propeller provide thrust?



### 3.1. READ AND NOTE THE HIGHLIGHTED WORDS

A piston engine needs a **propeller** which **converts** the power output from the engine into thrust.

A piston engine **develops** power and **transmits** it to the propeller by means of a **shaft**; the piston engine transmits this power to the propeller as **engine torque** or **turning effect**. The torque **rotates** the propeller and the propeller **transforms** this turning effect into a push or pull force called **thrust**. The propeller **generates** forces due to its motion through the air.

The propeller creates a **horizontal lift force** and **pulls** the aircraft **through** the air.

When a propeller rotates, the static pressure ahead of the blade is lower than the pressure behind the blade. The result is **forward thrust**.

transform  
create  
convey  
generate  
turn  
require  
send  
provide  
push  
pull through

#### 3.1.1. PRACTICE: DEFINE THE FOLLOWING TERMS

- turning effect
- engine torque
- horizontal lift force
- propeller
- forward thrust

#### 3.1.2. PRACTICE: REVIEW AND RECALL

How many aircraft structures can you identify in the drawing of the airplane?

3.  
Fill  
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thi  
Th  
thr  
Wl  
the  
3.  
Fil  
A  
(3)  
Th  
pe  
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wh  
Th  
(1:  
W  
(1:  
3.  
☺



### 3.1.3. PRACTICE: RECALL ACTIVITY: FOCUS ON VERBS

Fill in the blanks with an appropriate verb.

A piston engine (1) \_\_\_\_\_ a propeller which (2) \_\_\_\_\_ the power output from the engine into thrust.

A piston engine (3) \_\_\_\_\_ power and (4) \_\_\_\_\_ it to the propeller by means of a shaft. The piston engine (5) \_\_\_\_\_ this power to the propeller as engine torque or turning effect. The torque (6) \_\_\_\_\_ the propeller and the propeller (7) \_\_\_\_\_ this turning effect into a push or pull force, the thrust.

The propeller (8) \_\_\_\_\_ a horizontal lift force and (9) \_\_\_\_\_ the aircraft through the air.

When the propeller (10) \_\_\_\_\_ the static pressure ahead of the blade is lower than the pressure behind the blade. The result is forward thrust.

### 3.1.4. PRACTICE: RECALL ACTIVITY: FOCUS ON ALL RELEVANT VOCABULARY

Fill in the blanks with appropriate words.

A (1) \_\_\_\_\_ engine requires a propeller which (2) \_\_\_\_\_ the (3) \_\_\_\_\_ from the engine into \_\_\_\_\_.

This type of engine develops (4) \_\_\_\_\_ and (5) \_\_\_\_\_ it to the propeller by means of (6) \_\_\_\_\_. The piston engine transmits this power to the propeller as (7) \_\_\_\_\_ or (8) \_\_\_\_\_. The (9) \_\_\_\_\_ rotates the propeller which (10) \_\_\_\_\_, the thrust.

The propeller is also responsible for a (11) \_\_\_\_\_ and pulls the aircraft (12) \_\_\_\_\_.

When the propeller (13) \_\_\_\_\_ the static pressure (14) \_\_\_\_\_ is (15) \_\_\_\_\_ than the pressure (16) \_\_\_\_\_. The result is (17) \_\_\_\_\_.



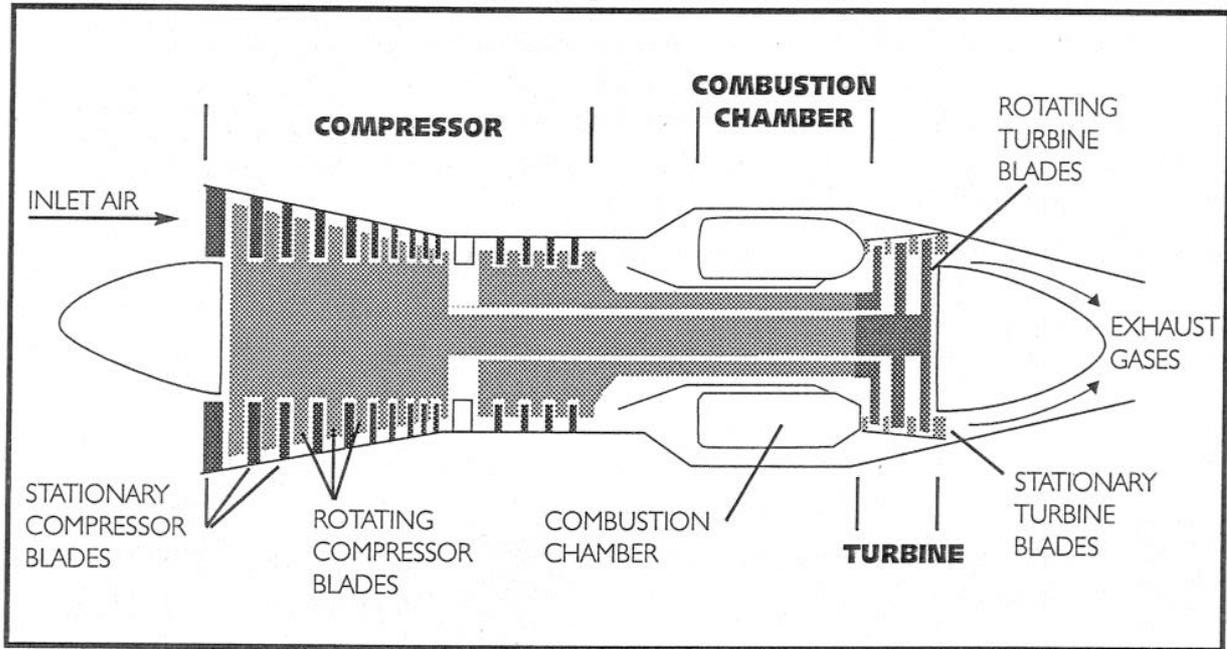
## Special Presentation Section

**3.1.5.** Both light and jet aircraft depend on lift. But lift is not achieved in the same manner.

In section 1, principles of flight, the phenomenon of lift was described as being due to a difference in pressure between two areas. With a propeller engine there are also two areas of differing pressure. Explain and contrast the two cases.



## 3.2. How does a jet engine provide thrust?



*aircraft turbojet engine*

### The compressor

The compressor is made up of a series of rotating disks, each of which is a set of fanlike blades.

These rotary disks alternate with rings of stationary blades fastened to the engine casing. These blades are sometimes referred to as stators or vanes. The structure is intended to redirect airflow from one set of rotary blades to the next. The purpose of the compressor is to draw in air, heat it to the appropriate temperature, and then force this heated air into the combustion chamber.

### The turbine

With alternating sets of rotary and stationary blades, the turbine is similar to the compressor in structure.

The turbine spins exhaust gases, forcing them out through the exhaust nozzle at high speed. This is what provides the thrust necessary to propel the aircraft forward.

Shafts also connect the turbine to the compressor, and this draws in more air.

### The combustion chamber

It is in the combustion chamber that high-pressure air is mixed with a fine spray of fuel. This mixture is subsequently ignited, giving rise to extremely hot exhaust gases which expand rapidly as they are directed at high speed into the turbine.

#### 3.2.1. ANSWER

1. The compressor can be described as a two-part structure, one mobile and one immobile. Explain.
2. The compressor compresses air. Where does the air come from and how is it compressed?
3. What is the purpose of the *nozzles*?
4. How are turbine and compressor connected? How can the turbine be said to drive the compressor?

# Structural requirements and problems

## THE COMPRESSOR

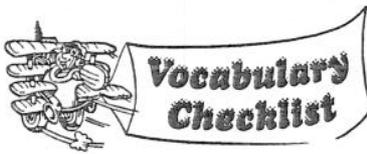
- blades and vanes are subject to aerodynamic load resistance
- centrifugal force causes rotary blades to stretch or become elongated in time, a deformation called *creep*
- disks housing the blades must stand up to high load-bearing capacity (holding blades against centrifugal force).

## THE COMBUSTION CHAMBER

- Thermal fatigue occurs. This means constant and repeated constrained expansion and contraction with alternating extremes of temperatures.
- Corrosion and distortion at high temperatures (1,100°C).
- Components need to be formable and weldable.

## THE TURBINE

- Same requirements as for compressors
- The turbine must be able to resist corrosive gases and higher temperatures.



DO YOU KNOW THE WORDS?

Look back at the drawing and see whether you can identify these parts and describe their functions.

|                |               |
|----------------|---------------|
| <b>blade</b>   | <b>nozzle</b> |
| <b>stator</b>  | <b>vanes</b>  |
| <b>exhaust</b> | <b>shafts</b> |

### 3.2.2. LANGUAGE PRACTICE

Use each of the following expressions in at least one statement based on jet engine operation

**alternate with**  
**fastened to**  
**referred to as / known as**  
**mixed with**

### 3.2.3. PRACTICE: DEFINITIONS.

Provide a clear definition of the following terms:

**creep**  
**stators**  
**compressor**  
**corrosion**  
**exhaust**



DO YOU KNOW THE WORDS?

### Verbs and nouns

#### VERBS

**connect**  
**contract**  
**corrode**  
**distort**  
**expand**  
**ignite**  
**mix**  
**propel**  
**resist**

#### NOUNS

**connection**  
**contraction**  
**corrosion**  
**distortion**  
**expansion**  
**ignition**  
**mixture**  
**propulsion**  
**resistance**

### RESISTANCE

The combustion chamber must be able to:

- **withstand**
- **stand up to**
- **resist**

corrosion and distortion at high temperatures.

### SERIES/SET

Note that *series* in English is singular.

- **A series of changes is planned.**

Also singular: *a set*:

- **A set of instruments was ordered.**

# STARTING THE JET ENGINE

Tenses in main and subordinate clauses and special verbal constructions

|               |   |
|---------------|---|
| <b>STEP 1</b> | A pneumatic starter motor is used to start the engine turning so as to provide required airflow through the compressor.                           |
| <b>STEP 2</b> | Pressurized fuel is sprayed into the combustion chamber. Ignition takes place by means of electric igniters which are switched on.                |
| <b>STEP 3</b> | As the fuel continues to burn the engine gradually speeds up until the number of revolutions per minute enables the engine to be self-sustaining. |
| <b>STEP 4</b> | Once the self-sustaining phase has been reached, the starter and igniters are switched off.   |
| <b>STEP 5</b> | The pilot continues to accelerate the engine until it reaches what is referred to as idle rpm.  |
| <b>STEP 6</b> | Exceeding idle rpm requires pushing forward the thrust lever located on the flight deck.  |

## ⊕ Tenses in main and subordinate clauses and clauses with BEFORE/AFTER/UNTIL and NOT UNTIL/NOT BEFORE

|   |  |
|---|--|
| <ol style="list-style-type: none"> <li>The engine must be at minimum speed before the fuel <b>is injected</b>.</li> <li><b>When the engine reaches/has reached</b> minimum speed, the fuel <b>is injected</b>.</li> <li><b>Once the engine reaches/has reached</b> minimum speed, the fuel <b>is injected/will be injected</b>.</li> <li><b>After the engine has reached minimum speed</b>, the fuel <b>is injected/will be injected</b>.</li> </ol>  | <p><i>The future (will) can be used only in the main clause, never in the subordinate clause where the present or present perfect tenses must be used.</i></p>   |
| <p>SENTENCES WITH <i>UNTIL</i>, <i>UNLESS</i>, and <i>NOT UNTIL</i>, <i>NOT BEFORE</i></p> <ol style="list-style-type: none"> <li>The fuel <b>will not be injected until</b> the engine has reached a minimum speed.</li> <li>The fuel <b>will not be injected unless</b> the engine has reached a minimum speed.</li> <li><b>Not until</b> a minimum engine speed has been reached, <b>will the fuel be injected</b> (can the fuel be injected).</li> <li><b>Not before</b> the engine has reached this speed <b>can/will the fuel be injected</b>.</li> </ol> | <p><i>(not) until is often used with the present perfect tense.</i></p> <p><i>Note that the future again can be used only in the main clause.</i></p> <p><i>Notice the inverted structure in examples 7 and 8!</i></p> |

## ☉ Gerunds: reminder, review and recall

1. Turning the engine at speed requires **using a pneumatic starter**.
2. **Providing sufficient airflow through the compressor** can be achieved by **using a pneumatic starter**.
3. **Injecting fuel into the compressor** must be postponed until the engine has reached a minimum speed.

The gerund phrase is highlighted in bold-face type. Note that manner is expressed using **BY + Gerund** (example #2).

See also Grammar File #3 on page 37 for more information on gerunds.



**OVER TO YOU TO PRACTICE**  
The practices below will help you to master these grammatical patterns.

### PRACTICE 1: BEFORE • UNTIL • UNLESS AND VERB TENSES. COMPLETE EACH STATEMENT.

- a. Sufficient flow through the compressor is not achieved ...
- b. Fuel is not sprayed ...
- c. The fuel does not ignite ...
- d. The engine does not become self-sustaining ...
- e. The starter is not switched off ...
- f. Idle rpm is not reached ...
- g. Accelerating beyond idle rpm ...

### PRACTICE 2: NOT UNTIL • NOT BEFORE • ONLY WHEN. MAKE COMPLETE STATEMENTS USING THE PROMPTS

- a. starter motor — sufficient airflow
- b. sufficient airflow — fuel injection
- c. given rpm — self-sustaining engine
- d. self-sustaining engine — disengagement of starters, extinction of igniters
- e. idle rpm reached — acceleration ceases

### PRACTICE 3: GERUND PHRASES. COMPLETE THE FOLLOWING, USING THE VERBS HERE.

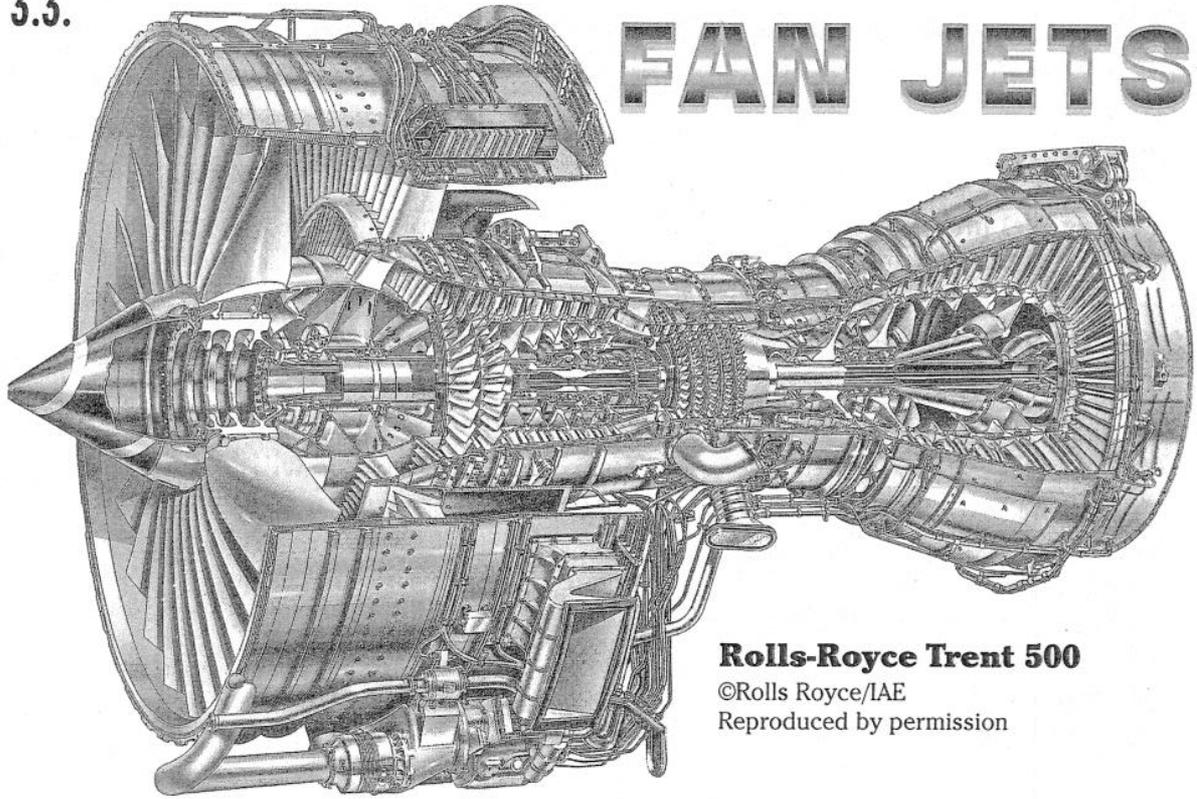
**It means • It requires • It involves**

- a. Starting the engine...
- b. Attaining sufficient airflow...
- c. Igniting the fuel...
- d. Achieving idle rpm ...
- e. Accelerating beyond idle rpm...

### PRACTICE 4: VERBS AND NOUNS. YOU SEE THE VERB FORM. FILL IN THE CORRESPONDING NOUN FORM.

| VERBS         | NOUNS |
|---------------|-------|
| a. accelerate | ..... |
| b. achieve    | ..... |
| c. attain     | ..... |
| d. disengage  | ..... |
| e. engage     | ..... |
| f. require    | ..... |

# FAN JETS



**Rolls-Royce Trent 500**

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## A simple description of the performance of turbofan jets

Air is sucked in at the intake by a compressor which is a two-stage device, the two parts of which are

- **rotors** (large rotating blades)
- **stators** (stationary blades)

The rotors propel the air through the stators, causing an increase in pressure. A number of stages will be necessary to raise the pressure to sufficient levels.

Performance is enhanced in large jet engines by dividing the compressor into distinct sections referred to as *spools* (usually 2 or 3). Each spool is powered by its own turbine and connecting shaft. The letter N is used to designate compressors; spools are identified as follows:

- **N1** (low pressure spool, or LP)
- **N2** (high pressure spool, or HP)
- **N3** (also high pressure spool, or HP)
- N2 (or N3) is located just fore of the combustion chamber.

Propulsion is also enhanced via another design: the bypass, a channel or duct allowing some of the N1 air to exhaust directly without entering the main engine, ie, it bypasses the engine core.

In today's huge bypass engines, N1 has taken on the design of an enormous fan — a single ring of blades which when rotating rapidly bypass 5 times the volume of air sent to the main engine, providing up to 75% of the engine's total thrust.

Air driven through N2 and N3 undergoes tremendous compression before it is propelled into the combustion chamber where only one-third will now mix with burning fuel at 2000°C. The remaining two-thirds air volume provides cooling.

From the combustion chamber the air is now propelled through the guide vanes. These force the air onto turbine blades, causing them to rotate. Each turbine drives a compressor via its connecting shaft.

Leaving the turbine, the air continues to expand rapidly, as it exhausts via the jet pipe, cutting the air and producing the noise associated with modern jet aircraft.

The noise is measured in perceived noise decibels (PNdB). A 747 generates 107 PNdB upon take-off, and most airports have limited acceptable noise to 110 PNdB).

The term "fan jet" is derived from the modern design of the N1 compressor which is a huge disk composed of rotating blades acting like a fan.

### 3.3.1 PRACTICE: PROVIDE CLEAR AND COMPLETE DEFINITIONS OF THE FOLLOWING.

- a. fan jet engine
- b. bypass engine
- c. spool
- d. compressor
- e. engine pipe
- f. guide vanes

### 3.3.2. PRACTICE: DESCRIBING OPERATIONS AND SEQUENCING

Complete the following openers (see also page 62).

The first step involves..

Then, this air is propelled through...

Before the air enters the combustion chamber ...

Some N1 air bypasses the main engine by means of...

The bypassed air..

The role of the N2 and N3 compressors is...

In the combustion chamber...

The next stage involves...

The air which is driven onto the turbine blades...

### PRATT & WHITNEY solves recurring problems

In 1997, P&W undertook to solve certain reliability problems affecting the PW4000 which were increasing the removal and in-flight shutdown rate of all 4000-versions. Reported among the incidents were:

- surges
- HP compressor blade and dovetail cracking
- HP turbine blade-root cracking
- fan-blade fractures
- angle gearbox bearing failures

Thanks to findings made possible by computational fluid-dynamics analysis, P&W came up with a new blade design which solved the problem of cracking on the fifth high pressure compressor stage.

A new fan-blade leading edge design offering a thicker radius was meant to provide heightened resistance to foreign-body impacts which was found to produce cracking in leading edges.

P&W announced plans to come to grips with binding, wear, failure and leakage problems occurring at the bleed valve located between high and low pressure compressors, and to replace the low-pressure turbine (LPT) stage-five vanes from some engines powering the 777.



### 3.3.3. PRACTICE: ANSWER THESE QUESTIONS

1. What problems were reported between high and low pressure compressors?
2. What additional measures were taken?
3. Describe the new fan-blade leading edge designed by P&W. What had been causing damage to blade leading edges?
4. What incidents were sometimes reported occurring during flight?

### 3.3.4. PRACTICE: THE FOLLOW-UP

The modifications made by P&W were successful. Describe the state of affairs following the engine manufacturer's changes. Try to use these expressions:

**(no longer) occur**  
**sustain damage**  
**fail**  
**crack**  
**fewer incidents of ...**

### 3.4. How is engine power measured?

#### One means: the EPR

A ratio called the *engine pressure ratio* (EPR) is commonly used to measure engine power. This is the ratio of turbine discharge (exhaust) pressure to the compressor inlet pressure. Boeing 747 PW engines, for instance, under normal conditions have full power take-off EPR of 1.44. When powered by the Rolls Royce RB211-524 the ratio is 1.63.

Compressor speeds (20,000 revolutions per minute, or rpm) are expressed as percentages of maximum speed. In cruise phase, the N1 speed is roughly 90%. However, maximum take-off N1 speed can be 103%. As a general rule, on take-off and climb, pilots aim for a setting as low as possible when conditions allow.

In descent, thrust levels are closed resulting in idle power. On approach and landing the EPR is set depending on the speed required, usually varying between 1.05 and 1.10 on final approach.

When landing has to be aborted and go-around engaged, the aircraft must climb rapidly to clear the runway or immediate airport vicinity to attempt a second landing, full EPR requirement is set.

At altitudes of 40,000ft, where the air becomes thin, engine performance is directly linked to the density of intake air. Engine performance decreases with decreasing air density. But because drag also decreases at higher altitudes, the aircraft's speed will actually increase regardless of lower engine performance.

#### 3.4.1. PRACTICE: FILL IN THIS BRIEF OUTLINE

Find the relevant information from the article on the left.

##### 1. TAKE-OFF

requires: .....

EPR: .....

N1 .....

##### 2. CRUISE

N1 .....

##### 3. DESCENT

EPR and N1 .....

##### 4. APPROACH AND LANDING

EPR .....

##### 5. IN GO-AROUND

EPR .....

#### 3.4.2. PRACTICE: DESCRIPTIONS

Practice making clear descriptions using the following information.

#### B777 FLIGHT PARAMETERS

|                 | EGT   | EPR   | N1    | N2  | FUEL FLOW |
|-----------------|-------|-------|-------|-----|-----------|
| <b>IDLING</b>   | 385°C | 1.03  | 20%   | 56% | 775       |
| <b>TAKE-OFF</b> | 450°C | 1.20  | 85%   |     | 6-8,000   |
| <b>CLIMB</b>    | 490°C | 1.40  | 92.5% |     | 8,600     |
| <b>CRUISE</b>   | 370°C | 1.125 | 82%   |     | 3,300     |

## Ready for Take-off!

To what EPR setting are power levers set at rotation?  
What is N1 speed?



Photograph © Air France. Reproduced by permission.

**Vocabulary practice**

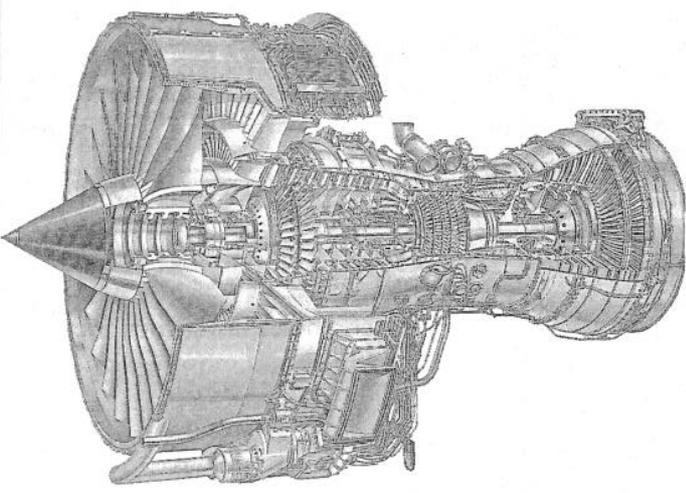


**3.4.3. TERMS YOU SHOULD KNOW**  
**FILL IN THE BLANKS WITH APPROPRIATE WORDS OR EXPRESSIONS.**

1. Another term used to designate exhaust is ..... (two words)
2. A mathematical term relating two variables is .....
3. Pilots ..... the lowest possible settings on take-off.
4. When we speak of an engine's capabilities and functioning we rate its .....
5. When preparing for take-off, pilots ..... flaps at 20°.
6. When an aircraft lands, it usually must ..... the runway as rapidly as possible so as not to be an obstacle for other aircraft.
7. Following take-off, the aircraft ..... to a given altitude where it next ..... (two words). It is now in ..... phrase. When nearing its destination airport, the pilot is instructed to begin ..... The last two phases are ....., as the aircraft draws nearer to the runway, and finally .....
8. If, for some reason, at the last minute the pilot decides that he cannot touch down, he ..... landing and enters ..... phase, pulling the aircraft up.
9. A device or place allowing air or a fluid to enter a cavity is called a(n) .....

**3.4.4.PRACTICE: REVIEW AND RECALL. PROVIDE A COMPLETE DESCRIPTION OF THE RR TRENT 772.**

BELOW AN ILLUSTRATION WITH BASIC INFORMATION.



**BASIC DATA: TRENT 772**

*Take-off performance*

|                         |             |
|-------------------------|-------------|
| Thrust                  | 71,100lb    |
| Overall pressure ratio: | 35.5        |
| Bypass ratio:           | 5.0         |
| Inlet mass flow:        | 2027 lb/sec |

*Cruise performance*

|                            |               |
|----------------------------|---------------|
| Thrust:                    | 12,000lb      |
| Specific fuel consumption: | 0.584lb/hr/lb |

*Dimensions*

|              |        |
|--------------|--------|
| Fan diameter | 97.4in |
| Length:      | 154in. |

Illustration ©Rolls-Royce/IAE. Reproduced with permission.

**Note:**

Engine thrust is usually indicated in pounds (lbs), kilograms (kg) or more commonly in kilo-Newtons (kN). The Newton is the SI unit of force.

### 3.5. Engine manufacturers take steps to remedy deficiencies

In 1996 numerous reports of engine rundown ..... on flights with the B757 and led Boeing to ..... warnings to operators.

The incidents ..... at the top of descent when thrust was reduced to low idle using autothrottle command and in acceleration from low idle. Other incidents were reported subsequent to engaging engine anti-ice in early descent stages in ..... weather conditions. Although incidents ..... one engine, the remaining engine revealed core-compressor stall in several instances.

The suggested remedy implied modifications to the bleed valve-control unit and fuel-flow governor, two measures which would result in an increase in compressor stall margins.

#### 3.5.1. READ AND PRACTICE

First complete the report using words given below (you may need to use other forms of the verbs listed), then complete the statements which follow.

**issue occur experience encounter**  
**alert somebody to the danger or possibility of**  
**poor bad involve concern**  
**unsatisfactory visibility reduced to 200m**

1. Weather conditions seemed to have a direct bearing on engine anomalies because ...
2. Incidents of engine rundown were also linked to changes in thrust ...
3. To solve this problem, it was decided to raise ...
4. To achieve this, two other changes needed to be made, namely ...

It was back in 1991. Cathay Airlines was evaluating the forthcoming B777 and future growth variants. Boeing had designated the RR Trent 800 providing a thrust ratio of 396kN (89,000 lbs) for the new aircraft. Cathay wanted an engine with maximum thrust of 567.5kN. As it stood, the Trent 800, equipped with a 2.42m fan, could not provide more than 409.413kN.

Rolls Royce determined that increasing fan size to 2.53m would require an additional turbine stage entailing a weight penalty on the order of several hundreds of pounds and defeating any gains in power. According to RR engineers, the Trent 800 was fully capable of delivering the 423kN of thrust with the existing fan. Given that the future 777 was deemed to have a maximum gross take-off weight of 277,270 kg, no more than 396kN thrust would be needed.

#### 3.5.2. PRACTICE: RELATIVE CLAUSES WITH WHICH

1. It was Cathay Airlines which...
2. The engine which Boeing...
3. The RR Trent 800, which...
4. The engine which... had to provide a max thrust of
5. The max thrust ..... was 409.413kN.
6. RR engineers envisioned increasing fan size, a move which...

#### 3.5.3. PRACTICE: FILL IN THE BLANKS WITH THE RELEVANT INFORMATION AND/OR COMPLETE THE STATEMENTS.

- a. Boeing's estimate of regular thrust for the 777 .....
- b. Trent 800's existing maximum thrust: .....
- c. Cathay's estimated thrust requirement: .....
- d. RR's max thrust rating for the engine: .....
- e. Boeing's estimate of 777 maximum take-off weight (mtow): .....
- f. The redesign of the Trent 800 to yield more thrust would have entailed ....
- g. Increasing the fan diameter to 2.53m ....
- h. The weight penalty....
- i. In conclusion: the only problem with increasing fan size was that ....

## ■ What gets the most wear and tear in jet engines?

Engine manufacturers and repair agents are unanimous in their answer: the hot sections including turbine, shroud, blades and nozzles. Vanes and stators also sustain heavy wear and tear. The GE/Snecma CFM56 has, for instance, 76 blades and 23 nozzles which need to be monitored for corrosion and damage over the engine's operating life.

### 3.6. Dealing with older, noisier aircraft

In the wake of popular protest and concern over noise pollution, a number of municipalities have taken steps, some more severe than others, to cope with levels of noise generated by aircraft — particularly older aircraft — in the vicinity of airports.



#### **HUSH! PLEASE MAKE LESS NOISE!**

To comply with increasingly stricter legislation limiting airport noise, or to avoid landing fee surcharges ranging from \$175,000 to \$500,000 per aircraft per year, operators of older airliners (707 cargos, DCs, 737s, and so on) emitting excessive noise have been hushkitting their aircraft. Hushkits come in various designs depending on the manufacturer. The design of one kit features an inner acoustic ring fitted inside the engine intake made of a carbon-reinforced plastic honeycomb that has been acoustically treated. Additional noise-reducing modifications involve the use of a fan-exhaust ejector shroud, a thrust reverser translating sleeve, and an inlet diaphragm.

#### **3.6.1. THE EFFECTS OF INSTALLING HUSHKITS: 3.6.2. DESCRIBE A TYPICAL HUSHKIT**

- |   |  |
|---|--|
| <ul style="list-style-type: none"><li>a. noise levels ↘</li><li>b. thrust ↘</li><li>c. weight ↗</li><li>d. fuel consumption ↗</li></ul> | <ul style="list-style-type: none"><li>a. ... come in ...</li><li>b. ... is designed to lower noise after an aircraft lands.</li><li>c. ... fits inside the engine intake and consists of ...</li><li>d. ... placed within... to limit noise on exhaust</li></ul> |
|---|--|

#### **3.6.3. PRACTICE: COMPLETE EACH STATEMENT.**

- a. Many aircraft operators have decided to hushkit their older aircraft ....
- b. Unlike newer aircraft engines ...
- c. Hushkits are designed to...
- d. Without hushkitting, ...

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#### **3.6.1. THE EFFECTS OF INSTALLING HUSHKITS:** | **3.6.2. DESCRIBE A TYPICAL HUSHKIT**

- |   |  |
|---|--|
| <ul style="list-style-type: none"><li>a. noise levels ↘</li><li>b. thrust ↘</li><li>c. weight ↗</li><li>d. fuel consumption ↗</li></ul> | <ul style="list-style-type: none"><li>a. ... come in ...</li><li>b. ... is designed to lower noise after an aircraft lands.</li><li>c. ... fits inside the engine intake and consists of ...</li><li>d. ... placed within... to limit noise on exhaust</li></ul> |
|---|--|

#### **3.6.3. PRACTICE: COMPLETE EACH STATEMENT.**

- a. Many aircraft operators have decided to hushkit their older aircraft ....
- b. Unlike newer aircraft engines ...
- c. Hushkits are designed to...
- d. Without hushkitting, ...

## 3.7. The Concorde: sole supersonic passenger transporter



### NOSE

To ensure maximum visibility on take-off and landing, nose tilts downward at 12°, moving up to 5° and 0° at supersonic speed.

**Powerplant:**  
4-engine Rolls Royce/Snecma Olympus 593 deliver 17,260 kg thrust to propel aircraft at 596 m/sec.

Photograph ©Air France. Reproduced by permission.

### 3.7.1. PROVIDE A DESCRIPTION OF THE CONCORDE USING THE FOLLOWING SPECIFICATIONS

#### Fuselage and structure:

aluminum alloy  
skin temperature: 120°C at 18,000 m  
(outside air temperature: -55°C)  
During flight: entire fuselage undergoes  
20cm lengthening

#### Fuel tank capacity:

90 (metric) tonnes

#### Dimensions:

Length: 62.10 m  
Wingspan: 25.56 m  
Ceiling: 18,300 m

Dry operating weight + fuel: 185,000 kg

Fuselage diameter: 2.87m

Passenger load: 100

### 3.7.2. SUPERSONIC ENGINES: ONE MAJOR DIFFERENCE IS THE INTAKE DESIGN

The intake shown in figure 1 (for subsonic flights) could not be used on aircraft flying at supersonic speeds. The intake would generate a shock wave ahead of the intake opening. At Mach 2.0 in the stratosphere compression efficiency would be 80% or less as opposed to 95% efficiency or higher on intakes designed for oblique shocks on supersonic aircraft.

Figure 2 shows the type of intake used on Concorde. This intake, if not of variable geometry, is suitable at one given speed, making variable geometry indispensable.

Figure 3 shows another arrangement designed to deal with the shock compression, breaking it down into stages of oblique (conical) shocks that terminate in weakened normal shock.

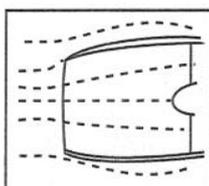


FIGURE 1

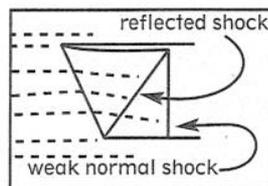


FIGURE 2

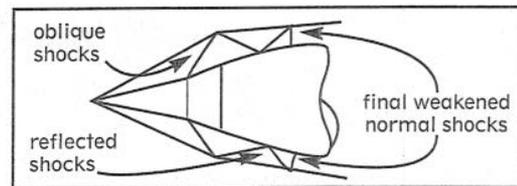


FIGURE 3

## Concorde suffers its first fatal crash

On Tuesday, July 25, 2000, a chartered Air France Concorde flight from Paris to New York crashed hardly 2 minutes following take-off from Charles de Gaulle Airport north of Paris, killing all 100 passengers and 8 crew members in addition to 6 people on the ground. It was the first major incident to befall Concorde since it began commercial operations in 1976. The aircraft's main landing gear apparently broke apart just before take-off, damaging the fuel tanks and engines which burst into flames, but the exact cause of the disaster has yet to be determined.



### Maintenance Check!

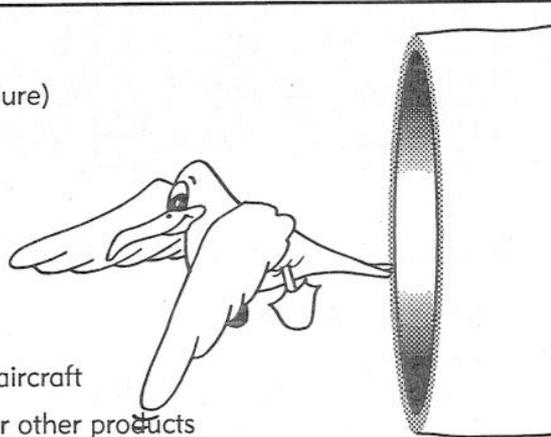
## 3.8. CAUSE AND EFFECT

SEE ALSO GRAMMAR FILE #2, PAGE 26.

### A. MAKE CAUSE AND EFFECT STATEMENTS EXPLAINING POSSIBLE CAUSES OF ENGINE FAILURE

#### WHAT CAUSES ENGINE FAILURE?

- mechanical failure (for instance, turbine blade failure)
- birds get sucked into the engine ("ingestion")
- fuel starvation
  - inadequate fuel supply
  - mishandling of fuel tank selection
  - ice formation
  - ice formation in the carburetor of light aircraft
  - contaminants in fuel, especially water or other products
- electrical failure in magneto system
- computer failure
- pilot error



### B. MAKE MORE CAUSE AND EFFECT STATEMENTS ABOUT THE EFFECTS OF SOLAR ACTIVITY ON AIRCRAFT RADIO EQUIPMENT

#### WHAT MAY CAUSE RADIO EQUIPMENT TO FAIL?

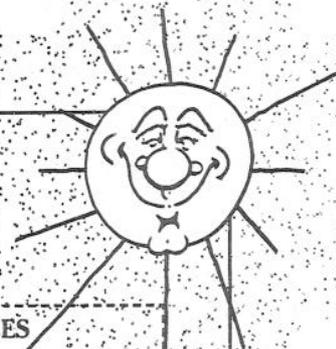
##### INTENSE SOLAR ACTIVITY

- disturbances in aircraft radio equipment used for:
  - communications
  - navigation
  - radar
- HF: particularly affected
- VHF: also possible signal loss

##### SERIOUS CONSEQUENCES

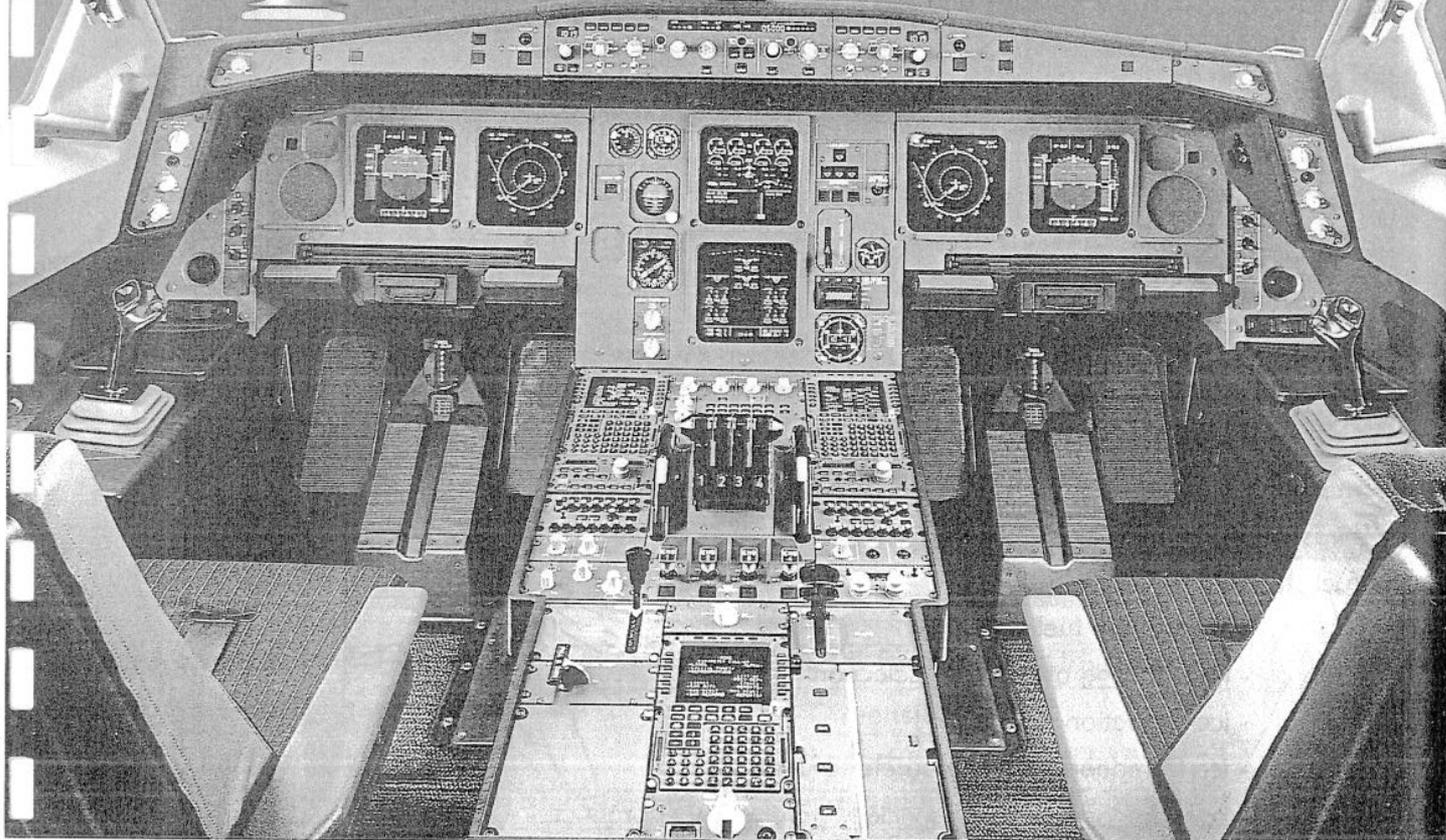
##### 11-YEAR SUNSPOT ACTIVITY CYCLE CHARACTERIZED BY:

- sudden eruption of solar flare
- burst of X-ray and UV rays
- stream of high-energy particles known as the solar wind



# 4 Inside the cockpit

The most recent configurations from Boeing and Airbus



The cockpit of the A340, nearly identical to that of the A320.. Photograph ©Airbus Industrie. Reproduced by permission.

## 4.1. HISTORICAL PERSPECTIVES

### Cockpit design in the A300 B2-B4/A310

The original design called for two pilots facing forward with a console between each. Furthermore, a CM3 seat (Crew-member 3) was initially to be provided behind on the right for the flight engineer with his panels on the right.

A fourth seat for an observer was also fitted. As such this configuration was called SFCC (side-facing crew cockpit).

In the A310, this was later modified to do away with the CM3 and the FFCC (Forward-facing cockpit crew) was born.

### Airbus A320 Cockpit and displays

Digital avionics with FBW (Fly-By-Wire) flight controls integrated an all-new technology.

Each pilot enjoys an uninterrupted view of 2-color display panels largest then available: (184 sq. mm).

Radio management panels (RMPs) to side of the throttles on the control console. Purpose: to control a mass of communications and navigation avionics (HFs, VHF<sup>1</sup> VORs<sup>2</sup>). small SSC (sidestick controller): ahead of his outboard armrest.

1 Very high frequency (HF = high frequency)  
2 Very high frequency omnidirectional range

1. Explain the difference between SFCC and the FFCC.
2. If CM3 designated "Crew-member 3", whom do CM1 and CM2 designate? (Hint: who is the "number 1" person in the cockpit?)
3. Can you locate the components mentioned in the description of the A320 cockpit in the photograph of the A340 cockpit (remember that both are nearly the same).



Photograph ©Air France. Reproduced by permission.

## 4.2. THE BOEING 777 COCKPIT: A BRIEF DESCRIPTION

The 777 cockpit features electrically-powered seats and large windows with wide-angle view, and in the opinion of many pilots and test pilots, offers the most spacious cockpit cabin of any to date, with the most advanced FBW found on any Boeing aircraft. The square display screens measure 200 mm on a side, making them also among the largest of any display screens on commercial jets. LCDs (liquid crystal displays) brighten in bright or strong light

PDF (primary flight display) and ND (navigation display) are next to each other directly in front of the pilot.

EICAS (Engine-Indication and Crew Alerting Systems) and MFD (Multi-function display) are positioned vertically one above the other in the center. The EICAS screen is primarily reserved for main engine instrument readings. Also provided to the right and beneath the EICAS screen are blocks reserved for memos, warnings and data from supplementary systems.

The MFD selector panel is located to the right of the glare shield autopilot mode control panel (MCP).

3 flight-management control and display units are found in the central console between pilot seats, as well as integrated-navigation/communication-frequency selector panels. Directly behind the console is a printer and accompanying bin for storing paper.

The overhead-system panel is within easy reach of cockpit crew members.

### MAKE SURE YOU KNOW:

**PDF**  
**NC**  
**LCD**  
**EICAS**  
**MFD**  
**MCP**

- The description mentions several items and display units. Can you locate them in the photograph?
  - PDF ● ND ● EICAS ● MFD ● MFD selector panel
  - overhead panel ● glare shield ● special-purpose blocks
  - MCP ● flight-management control and display units
  - navigation/communication-frequency selector panels
  - central console ● printer
- What differences can you describe between the A340/A320 and B777 cockpits as presented on these two pages?

### 4.3. BOEING AIMS HIGH!

The Aircraft Information Management System (AIMS) found on the B777 features the very latest innovations in state-of-the-art technology. Comprising two separate cabinets housing all input and output hardware, AIMS deals with

- all aspects of flight management
- display control
- central maintenance
- aircraft conditions management
- flight deck data acquisition
- engine performance data
- data conversion

#### 4.3.1. COMPLETE OR ANSWER:

1. AIMS represents ...
2. The basic AIMS system is composed of ...
3. What do the following acronyms (invented for this practice) stand for?

DC .....  
FL .....  
FDDA .....  
ACM .....  
EPD .....

#### 4.3.2. COMPLETE:

1. Robust partitioning enables the same computer ...
2. ASIC offers a distinct technological advance in that ...
3. Another noteworthy advantage of robust partitioning is that ...

AIMS is the "central nervous system" of the 777 fly-by-wire, with all other operations closely linked to it. To perfect such a system, Honeywell implemented two of the most recent innovations in avionics: robust partitioning, making it possible for the same computer to run and use different software applications, and ASIC, a new technology which integrates an increased number of system functions in one processor channel.

Thanks to robust partitioning, software dedicated to flight-critical functions is kept distinctly separate from non flight-critical functions within each computer module.

Other systems interact with AIMS, such as EFIS and FMS

In one other way, Boeing took a giant step forward with the introduction of active-matrix liquid-crystal flat-panel display screens, a noteworthy improvement over traditional CRT or hybrid CRT displays.

#### 4.3.3. FIND REFERENCES TO THESE:

- application-specific integrated circuits
- flight management system
- electronic flight instrument system
- cathode ray tube

#### 4.3.4. FLUENCY PRACTICE: RESTATE THE SAME IDEA USING THE NEW GIVEN SENTENCE OPENERS:

Thanks to robust partitioning, software dedicated to flight-critical functions is kept distinctly separate from non flight-critical functions within each computer module.

- a. Robust partitioning enables...
- b. It is now possible to...

#### 4.3.5. MAKE SURE YOU UNDERSTAND THE ACRONYMS: WRITE THEM OUT.

1. AIMS \_\_\_\_\_
2. EFIS \_\_\_\_\_
3. FMS \_\_\_\_\_
4. CRT \_\_\_\_\_

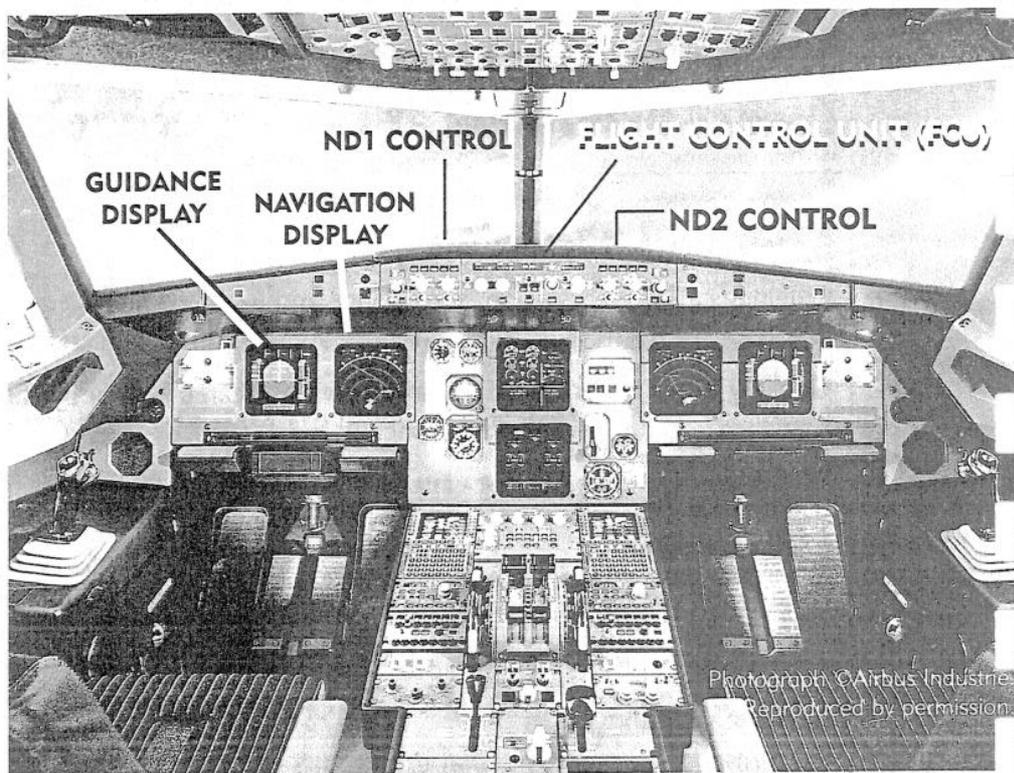
## 4.4.FLIGHT DECK CONFIGURATION: A320

*NOTE: This section also focuses on compound nouns. You should find the equivalent of each acronym in the list in the bottom right-hand corner of this page, paying special attention to the formation of the compound nouns.*

The FMGS is made up of:

- 2 FMGCs
- 2 FACs in avionics bay
- 2 MCDUs
- FCU center of glare shield
- 2 thrust levers

*For more information and practice, see the exercises below.*



### LOCATE THESE ITEMS IN THE PHOTOGRAPH

**2 MULTIFUNCTION CONTROL AND DISPLAY UNITS (MCDUs)**  
One is located in the top left-hand corner, the other in the top right-hand corner of the central console (or on the right and left sides of the forward pedestal).

#### THRUST LEVERS

In the central part of the console, one for the pilot, the second for the co-pilot, transmit output to the FMGCs and the FADECs

#### SCRATCH PAD WITH KEYBOARD

For the pilot, to the left of his thrust lever; for the co-pilot, directly to the right of his thrust lever.

#### SIDESTICK CONTROLLER

Situated ahead of the outboard armrests.

### MORE ABOUT FMGC AND EFIS.

FMGC System sends roll and pitch commands to the EFCS which comprises two computers: the ELAC and the SEC. Furthermore, the FMGS sends thrust commands to the FADEC in association with the movement of the thrust levers. The system is also designed to transmit flight plan, map and position data to the EFIS<sup>1</sup> via the DMC so as to display to the pilot aircraft position with respect to the flight plan.

### REFERENCES

system engagement status  
 system related messages  
 display management computer  
 flight management guidance system  
 flight augmentation computer  
 flight control unit  
 flight display  
 instrument landing system  
 full authority digital engine control  
 elevator aileron computer  
 spoiler elevator computer  
 electronic flight instrument system  
 electronic flight control system  
 flight management guidance computer  
 true air speed

### <sup>1</sup>What's in each of the 2 EFISs? A PFD and an ND.

#### PFD

- FMGS guidance target (FD commands, speeds, altitudes, headings)
- SES
- SRM
- navigation information (ILS)

#### ND

- flight plan displayed
- position and flight path
- navigation features (air-fields, waypoints)
- computed current speed (TAS, ground speed, wind)

## 4.5. AVIONICS

### AVIONICS

## A very brief look at recent technological advances

### CNS/ATM SYSTEMS

Communications, navigation, surveillance and air-traffic management is undergoing considerable development. Here's just a partial list of some of the recent technology.

**GPS: global positioning system**, advocated heavily by the United States, is a satellite-based system. Rockwell-Collins launched in 1996-1997 a new GPS-based FMS system.

**MMR (multi-mode receiver)** is another system favored by Europe, and which integrates:

- GPS
- ILS (instrument landing system)
- MLS (microwave landing system)

As of 1995, the United States government has been pushing FMS/GPS. American Airlines moved ahead for fleet-wide installation of FMS/GPS.

In Europe the consensus is that existing ILS units, having experienced several incidents, need to be replaced with systems protected from interference from high-powered FM radio stations. MMR would seem the best suited for these requirements.

Lockheed-Martin (1996-1997) came out with **ILS/GPS MMR** capable of being upgraded to integrate its Autonomous Precision Approach and Landing System (APALS) which featured an airborne radar that scans the ground below the approach path and guides the aircraft as it touches down.

**GPWS (ground proximity warning systems)** was developed by AlliedSignal, and later enhanced — EGPWS (enhanced ground proximity warning systems) — to provide display of terrain around the airport

### WHICH SYSTEM DOES WHAT?

Refer to the passage above and fill in the name of the system together with its acronym.

1. capable of detecting possible hazards when aircraft is landing  
\_\_\_\_\_
2. traditional system guiding aircraft landing onto runway  
\_\_\_\_\_
3. an integrated system featuring both satellite-based and microwave-based positioning-landing systems  
\_\_\_\_\_
4. protects against FM interference  
\_\_\_\_\_
5. scans and displays vicinity around airfield  
\_\_\_\_\_

# Compound nouns

## Complex adjective formation



### Compound nouns

|  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. OUTPUT <b>SIGNALS</b></li> <li>2. FLIGHT AUGMENTATION <b>COMPUTER</b></li> <li>3. FLIGHT AUGMENTATION COMPUTER OUTPUT <b>SIGNALS</b></li> <li>4. FLIGHT AUGMENTATION COMPUTER <b>COMMANDS</b></li> </ol> | <p><i>Extremely common in English, compound noun constructions put the main word (noun) last (here shown in boldface type). The other nouns function like adjectives.</i></p> |
| <ol style="list-style-type: none"> <li>5. DATA DETECTION PROCESSING AND MEMORIZATION SYSTEMS</li> <li>6. COMMUNICATION, NAVIGATION, SURVEILLANCE AND AIR-TRAFFIC MANAGEMENT <b>IMPROVEMENTS AND SYSTEMS</b></li> </ol>                             | <p><i>In theory there is no limit to the number of nouns. In practice, we limit the number to 5 or 6.</i></p>   |

### Complex adjective formation

|   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. <b>time-consuming</b> procedures</li> <li>2. <b>distance-measuring</b> devices</li> <li>3. <b>signal-emitting</b> equipment</li> </ol>  | <p><i>Noun + present participle (-ing)</i></p>                          |
| <ol style="list-style-type: none"> <li>4. <b>airport-approach</b> preparations</li> <li>5. <b>surveillance-broadcast</b> networks</li> <li>6. <b>approach-determination</b> parameters</li> </ol>   | <p><i>Noun—noun (usually hyphenated)</i></p>                            |
| <ol style="list-style-type: none"> <li>7. <b>high-frequency</b> radio transmission</li> <li>8. <b>low-power</b> output</li> <li>9. <b>high-ratio</b> engine bypass</li> </ol>   | <p><i>Adjective—noun (usually hyphenated)</i></p>                       |
| <ol style="list-style-type: none"> <li>10. <b>engine-supplied</b> power</li> <li>11. <b>FAA-approved</b> device</li> <li>12. <b>buyer-furnished</b> equipment</li> <li>13. the entire procedure is <b>computer controlled</b>.</li> </ol>   | <p><i>Noun—past participle (often hyphenated)</i></p>                   |
| <ol style="list-style-type: none"> <li>14. a <b>well-known</b> and <b>thoroughly-tested</b> device</li> <li>15. an <b>often-used</b> procedure</li> <li>16. a <b>poorly-understood</b> and <b>highly-feared</b> meteorological occurrence</li> <li>17. The phenomenon is <b>well known</b> to most experienced pilots.</li> </ol> | <p><i>Adverb—past participle (hyphenated when preceding a noun)</i></p> |



Thanks to a fast-thinking pilot and a quickly-made decision, the high-powered, hand-controlled, high-speed, push-button operated but lever-maneuverable, thoroughly-tested and unconditionally-guaranteed automatic eject chair hurled the captain out of the cockpit just in time for him to realize that he had neither a self-opening nor manually-commanded parachute with him...



A. MATCH THE ACRONYM WITH ITS CORRESPONDING DESCRIPTION. IN SOME CASES THERE WILL BE MORE THAN ONE DESCRIPTION.

- |           |       |  |
|-----------|-------|--|
| 1. STDMA  | _____ | a. air traffic management  |
| 2. ADS-B  | _____ | b. self-organized time-division multiple datalink                    |
| 3. NEAN   | _____ | c. very high frequency   |
| 4. VHF    | _____ | d. distance-measuring equipment                                      |
| 5. INS    | _____ | e. velocity hazard frequency   |
| 6. DME    | _____ | f. data measuring equipment  |
| 7. ATM    | _____ | g. size temperature and distance measure analysis                    |
| 8. CNS    | _____ | h. communication-navigation-surveillance                             |
| 9. HUD    | _____ | i. international navigation security                                 |
| 10. RVSM  | _____ | j. automatic dependent surveillance-broadcast                        |
| 11. CNSE  | _____ | k. inertial navigation system  |
| 12. STDMD | _____ | l. aircraft information data systems                                 |
| 13. CFD   | _____ | m. communication-navigation-surveillance equipment                   |
| 14. CFDS  | _____ | n. centralized fault display system                                  |
| 15. AIDS  | _____ | o. aircraft data and instrument recording system                     |
| 16. ADIRS | _____ | p. North European automatic dependent surveillance-broadcast network |
|           |       | q. reduced vertical-separation minima                                |
|           |       | r. computer fault display  |
|           |       | s. air data and inertial reference system                            |
|           |       | t. head-up display   |
|           |       | u. instrument navigation system                                      |
|           |       | v. aircraft temperature maintenance                                  |
|           |       | w. air information and data services                                 |

B. PRACTICE MAKING MEANINGFUL COMPOUND NOUNS.

The words in boxes can be used with most of the words in ovals. And you can also meaningfully combine many of the words in ovals. Try to make as many meaningful combinations as you can. In each case you should be able to explain the term or idea.

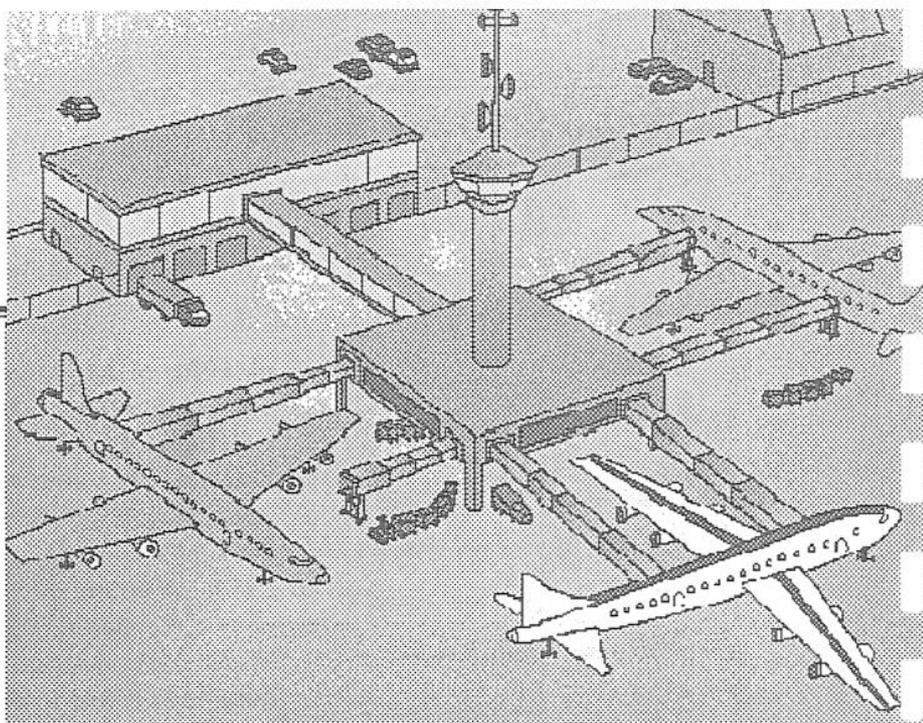
|             |                 |           |
|-------------|-----------------|-----------|
| preparation | NAVIGATION      | software  |
| equipment   | ASSEMBLY        | procedure |
| feature(s)  | FLIGHT          | step      |
| route       | modification(s) | design    |
| difficulty  | requirement(s)  | problem   |

**C: FIND AS MANY COMPOUND NOUNS AS YOU CAN INVOLVING AN**

# AIRPORT

*Think of all the things which involve airports:*

- PASSENGERS, EMPLOYEES
- MAINTENANCE
- TERMINALS
- RUNWAYS
- FACILITIES



## D: THERE IS A DIFFERENCE.

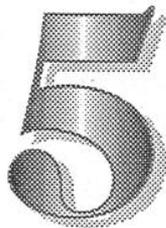
*Consider the following pairs of compound words carefully. Can you explain the difference?*

- |                     |                  |                       |                    |
|---------------------|------------------|-----------------------|--------------------|
| 1. screen display   | display screen   | 6. display size       | size display       |
| 2. computer control | control computer | 7. aircraft model     | model aircraft     |
| 3. flight detection | detection flight | 8. color presentation | presentation color |
| 4. anomaly display  | display anomaly  | 9. system measurement | measurement system |
| 5. flight problem   | problem flight   | 10. computer network  | network computer   |

## E: WRITING TERMS WITH COMPLEX ADJECTIVES AND COMPOUND NOUNS.

*Re-phrase the following terms using complex adjectives wherever possible and compound nouns.*

- |  |  |
|--|--|
| 1. aircraft flying at low altitudes<br>_____                                   | 6. a system dependent on datalinks<br>_____  |
| 2. factors which limit time<br>_____   | 7. a method of communication based on the use of satellites<br>_____                                       |
| 3. surveillance based on (the use of) transponders<br>_____                    | 8. a radar device which scans the ground<br>_____  |
| 4. a system which can be operated by hand<br>_____                             | 9. the system was subjected to extensive testing and modified before implementation<br>_____               |
| 5. a system of communication which has been tested over time<br>_____<br>_____ | 10. it's a device which uses high power but emits at low frequency and has many purposes<br>_____<br>_____ |



# Errors, Misjudgments, Failures and Technical Problems

## PART 1: DELAYS IN ASSEMBLY AND OTHER PROBLEMS

Written and/or telephone communication practice

### MODEL-PRACTICE 5.1. AN E-MAIL MESSAGE

TO: — (aircraft manufacturer home office)  
 FROM: T.H. (assembly plant)  
 SUBJECT: STORED A/C STATUS

A/C initial storage operations were somewhat delayed during the preceding months due to the absolute priority given to working parties on the first -400 a/c to be delivered to the airlines. These operations may now resume normally.

Regards,  
 TH.

#### 1. USE THE PASSIVE VOICE IN THE SIMPLE PAST TENSE (SEE GRAMMAR FILE #4, PAGE 40)

- A/c initial storage operations...
- Priority ...
- Working parties ...
- The first -400 a/c ...

#### 2. EXPRESS THE CAUSE AND EFFECT RELATIONSHIP.

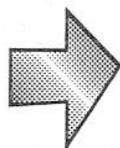
- Storage operations were delayed ...
- The delay in operations ...
- Priority given to the delivery of ...

#### SUGGESTED CAUSE-EFFECT VOCABULARY:

cause bring about result from result in lead to because of on account of

#### RELATED COMMUNICATION ACTIVITY (E-MAIL OR PHONE)

Write an e-mail message or make a telephone call based on the information in the following notes.



- assembly of -400 delayed 10 days ago.
- reasons
  - lack of manpower
  - emergency situation
  - delivery problem involving tools
- assembly now OK (in go-ahead phase)

### MODEL-PRACTICE 5.2. AN E-MAIL MESSAGE FROM THE ASSEMBLY DIVISION

SUBJECT: -400 assembly halt

The a/c is to be handed over to flight test department tomorrow but is not ready.

Main landing gear actuating cylinders enabling us to perform functional tests of undercarriage and obtain customer acceptance have not been delivered by subcontractor who promises delivery for the end of the week.

Scuff plates have yet to be installed on the rear pax<sup>1</sup> doors, but should be finished by tomorrow.

Handover must therefore be postponed until next week.

#### Note these patterns:

The a/c *is to be*, *was to be handed over*...

Delivery is *promised for* the end of the week.

One step *has yet to be finished*.

It must be / will be *postponed* until ...

<sup>1</sup> PAX: common abbreviation for passenger(s)

■ RELATED COMMUNICATION ACTIVITY  
(E-MAIL OR PHONE)

Write an e-mail message or make a telephone call based on the information in the following notes.



- handover to flight tests: end of the week
- impossible to apply electrical power to a/c because 2 subcontractors have not delivered:
  - transformer-rectifiers (delivery on Fri.)
  - static inverter (delivery early next week)
  - 35 electrical panels (end of next week)
- action: delay/postpone handover (at least two weeks)

**MODEL-PRACTICE 5.3. AN E-MAIL REQUESTING REPLACEMENT PART**

TO: — (aircraft manufacturer parts supply service)  
FROM: MM (Field Representative in Hong Kong)  
SUBJECT: FUSELAGE DAMAGE ON A/C 006

13 February. Fuselage damage on West Airways a/c 006 unloading at Hong Kong Airport.

Severe damage occurred to aft passenger door arising from improper maneuver of baggage conveyor belt by Hong Kong airport ground service.

A 6-cm dent was made in the door, making tight locking of the door impossible. Consequently, passenger cabin could not be assured of adequate pressurized air.

To make the a/c operational, a new aft passenger door must be installed. Please send immediately P/N 63927536 \* (AFT PASSENGER DOOR) to Hong Kong airport maintenance facility by 16 February.

Please confirm.

**RE-WRITE THE MESSAGE USING THESE EXPRESSIONS:**

to sustain damage  
to suffer damage

to result from

owing to a 6-cm dent in the door

... so as to make the a/c operational

Before the a/c can be made operational...

an urgent request  
to request something urgently

Please make sure P/N reaches Hong Kong ...

no later than

\* Note: P/N = part number

■ RELATED COMMUNICATION ACTIVITY (E-MAIL OR PHONE)

1. You are in the parts supply department. You will have no difficulty in meeting the field representative's request. Write the confirmation.
2. You are in the parts supply department. It will be impossible to get the P/N to Hong Kong Airport in time. Explain this simply and clearly and suggest an alternate date.
3. You are the field representative at Hong Kong Airport. The P/N has not arrived despite the confirmation message (in 1 above). Write the appropriate e-mail message, or make the appropriate telephone call.

**Key vocabulary to remember and use**

to cause something to happen

to be caused by

to lead to something

to result from something

to result in something

As a result (of) ...

Owing to / due to

to request something

to ensure that something is done

to make sure that something is done

by + date or time (deadline)

at the latest

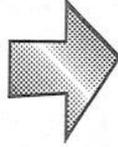
within + duration (period of time)

to be scheduled for + date/time

## MODEL-PRACTICE: 5.4.

### ■ RELATED COMMUNICATION ACTIVITY (E-MAIL OR PHONE)

Write an e-mail message or make a telephone call (or both!) based on the information in the following notes. Arrows (→) indicate result, or cause-effect relationship. You should use complete sentences.



#### VERBS

vibrate  
shake  
land  
rupture  
deform  
sustain damage  
suffer damage  
be damaged

TO: — (product support at manufacturer's)  
FROM: MM (Field representative in Jakarta)  
SUBJECT: FLAP ATTACHMENT DAMAGE ON -300

(date) Sunshine Airways -300 a/c number 107; landing approach / conditions of strong crosswind and turbulence: Jakarta airport

A/C 107 shaken — flap vibrations with 15cm amplitude  
→ safe landing only after 4 runway touch contacts (and considerable bouncing of a/c).

Vibrations during landing approach coupled with touch-down impacts

- rupture of attachment of RH Flap Number 1
- deformation of RH flap number 1
- damage to RH flap number 2

Request: flap attachment P/N 56739114  
RH flap P/N 32/75940  
flap attachment P/N 7634032

TO: SSA maintenance dep't. at Jakarta Airport. Next flight operation for a/c 107: normally (date 7 days from today's date). Latest possible delivery : (day before this date).

### ■ RELATED COMMUNICATION ACTIVITIES(E-MAIL OR PHONE)

1. Because of the importance of your message, you decide to call product support later. Your message was sent during the middle of the night their time. So you call to make sure your e-mail was received.
2. You are at product support. You call your field rep in Jakarta to explain that it will not be possible to perform the requested actions in the time requested. You will need at least 10 days (the P/Ns must be supplied by a subcontractor, but you will ask for rush delivery).

*Useful expressions  
for both parties  
involved* →

Hello, did you get my e-mail about...

What do you think?

We really need those parts by...

Can you get those parts to us by...

Do you think you'll be able to...

Do you think you can manage to...

Right-hand flap number 1 is unusable

I'd appreciate it if you could try to...

We're not going to be able to get them to you by...

There's no way we can get them to you by...

The problem is that...

We'll do everything we can, but I doubt we can get the parts to you by...

We'll do our best...

## MODEL-PRACTICE 5.5. A REQUEST SENT TO THE AIRCRAFT MANUFACTURER FROM MAINTENANCE

**SUBJECT: -300 - RUDDER ARTIFICIAL FEEL UNIT**

A rudder artificial feel unit (P/N 18374739200400) was removed from aircraft D-AIK (MSN 526) and P/N -00002, which is an older version, was installed in its place. According to Mr. Sanothu, of product support, the interchangeability code for this unit is 01, indicating one-way, ie, only the substitution of the new P/N for the old one is allowed!

I contacted our materials department for information and was told that the fail safe fork end of the unit 18374739200400 was weakened. He argued that this was caused by corrosion which led to cracking. As a precautionary measure, the units were modified (Mod 6924).

Unaware of any corrosion problems and respective service bulletin, I contacted Mr. Dunnaman at the design office. He is responsible for the design of this unit.

He informed me that from a technical point of view there is no need for a one-way interchangeability because fit, form and function are not involved. Owing to problems in the structure area, more corrosion-resistant aluminum plates were adopted. Such plates are also used for the fork ends.

If you continue to require only one-way interchangeability (and this is not in our interest seeing that no corrosion problems were reported) then we request a service bulletin providing information as to how the older versions of the component is to be modified.

Best regards,

JJ

### ANSWER THE QUESTIONS:

1. What does the problem involve?
2. What was the view of the product support department?
3. What did the cracking reportedly result from
4. What did the corrosion reportedly result in?

### COMPLETE THE IDEAS:

5. The former version may be replaced by an updated one, but ....., and apparently, .....
6. More corrosion-resistant aluminum was selected since .....



### DO YOU KNOW THESE WORDS?

#### Interchanging, substituting and replacing

- |  |   |
|--|---|
| <input type="radio"/> <b>interchangeable</b> | The two parts are interchangeable.                        |
| <input type="radio"/> <b>substitute</b>      | You can substitute A <u>for</u> B.                        |
| <input type="radio"/> <b>replace</b>         | You can replace A <u>with</u> B. A is replaceable with B. |
| <input type="radio"/> <b>change</b>          | We decided to change A <u>for</u> B.                      |
| <input type="radio"/> <b>exchange</b>        | We decided to exchange A <u>for</u> B.                    |
| <input type="radio"/> <b>in place of</b>     | We installed A in place of B.                             |
| <input type="radio"/> <b>in its place</b>    | We removed A and installed B in its place.                |

## 5.6. DEALING WITH PROBLEMS: COMMUNICATION APPLICATIONS

### 5.6.1. RESERVOIR PROBLEM

#### BURSTING OF -300 RESERVOIR DURING LANDING GEAR EXTENSION

Below, the notes of the engineer who was sent to look into the situation.

## NOTES

**Occurrence:** -300 reservoir (green system) burst during landing gear extension

**Probable cause:**

Ordinarily, reservoir fluid contents are increased by approximately 3 liters during landing gear extension (due to different ext/ret jack areas).



Probable accidental overfilling of the reservoir during maintenance.

Consequently, the existing air pressure relief valve was unable to cope with the high fluid flow. Result: reservoir overpressurization.

**Solution:**

- 1- replacement of valve and
- 2- caution during maintenance!

#### PRACTICE: CAUSE AND EFFECT (ARROWS INDICATE RESULTING STATE OR ACT)

1. The different ext/ret jack areas → an increase in reservoir contents
2. Overfilling resulted in...
3. Overpressurization resulted from ...
4. Overpressurization → bursting
5. Bursting → landing gear extension difficulties

#### PRACTICE: THE PASSIVE VOICE

1. Reservoir contents .... when landing gear .....
2. Here the reservoir burst while the landing gear ...
3. During maintenance, the reservoir ...
4. Did damage occur to the pressure relief valve? — It ...
5. During maintenance, caution ...

#### RELATED COMMUNICATION ACTIVITY (E-MAIL OR PHONE)

Write an e-mail message or make a telephone call based on the information in the notes above.



### CHECK THAT YOU KNOW THESE WORDS

Giving instructions: checking, ensuring, making certain...

- |  |  |
|--|--|
| <input type="radio"/> to advise                    | We advise you to change it. You are advised to change it.        |
| <input type="radio"/> to recommend                 | We recommend that you change it periodically.                    |
| <input type="radio"/> to recommend —ing            | We recommend inspecting it periodically for corrosion.           |
| <input type="radio"/> Care should be taken to...   | Care should be taken to separate the two components.             |
| <input type="radio"/> Care should be taken that... | Care should be taken that the two are separated.                 |
| <input type="radio"/> Be careful to...             | Be careful to separate the two.                                  |
| <input type="radio"/> Be careful that...           | Be careful that the parts are grounded/ that they do not touch.  |
| <input type="radio"/> Be careful when              | Be careful when removing the panel.                              |
| <input type="radio"/> Exercise caution             | Exercise caution when removing the panel.                        |
| <input type="radio"/> Be sure to                   | Be sure to remove the parts first.                               |
| <input type="radio"/> Be sure that                 | Be sure that all parts are grounded.                             |
| <input type="radio"/> Be certain to                | Be certain to remove the panel first.                            |
| <input type="radio"/> Be certain that              | Be certain that the panel has been removed.                      |
| <input type="radio"/> Make sure/certain to         | Make sure to use proper sealant. Otherwise leaks can occur.      |
| <input type="radio"/> Make sure/certain that       | Make sure that the proper sealant has been used.                 |
| <input type="radio"/> Check                        | Check the panel for corrosion. Also check for signs of weakness. |

## 5.6.2. FLAP PROBLEMS REQUIRE ASSISTANCE AND INSTRUCTIONS

### KRUEGER FLAP INCIDENTS

On the right, the notes of the engineer who was sent to look into the situation.

#### ■ PRACTICE 1: THE REPORT

Write out the complete e-mail message or brief report on the incidents. You are writing to the engineer who later looked into these problems.

#### ■ PRACTICE 2: WRITE THE REPLY.

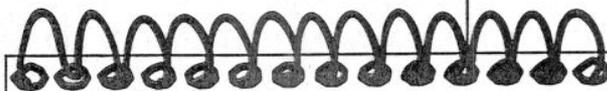
You are the engineer from product support. Indicate:

- what you think are (may be) the causes
- your recommendations

See the excerpt from the maintenance manual below.

#### ■ TELEPHONE COMMUNICATIONS

Work with a partner. One of you is the airline technician or engineer reporting the incidents, the other is from product support (at the aircraft manufacturer's). After simulating the first call, you may want to change roles when you act out the second call.



#### Krueger Flap Incidents

##### Incident 1 - last Monday

Failure of Krueger flap structures on aircraft during routine ground maintenance

Cause: 2 possible factors

- 1- insufficient tolerances between pylon and flap
- 2- bonding failures between composite surfaces and honeycomb structures

##### Incident 2 - last Friday

Krueger flap found to have been cracked after part of one of the flaps had separated on flight from Sydney to Singapore

##### Solution

Replace flaps and institute inspection procedures to prevent recurrence

#### **Procedure (Ref. Fig. 401)**

- Job set-up
- (1) Extend Krueger flaps
  - (2) Display warning notices
  - (3) Depressurize hydraulic system
  - (4) Open, safety and tag the circuit breakers A3, A7, A8.
  - (5) Position access platform.
  - (6) Install rigging pin through both rib 2B and outboard bracket (Krueger flap fully extended)
  - (7) Remove fillet fairing strips, HL, JL and KL. Open panels 513(613)PL
  - (8) Remove 9 nuts, spacers and screws along rear edge of top panel, and 30 screws around remaining 3 sides of panel. Collect spacers. Ease panel forward to disengage rear edge.

#### **WARNING! READ!**

##### KRUEGER FLAP AND BOX-STRUCTURE REMOVAL/INSTALLATION

**LANDING GEAR:** make certain ground safeties and chocks are in position.

**FLIGHT CONTROL SURFACES:** make certain travel range is clear

**HYDRAULICS:** Before pressurizing make certain controls match surface position

**BEFORE POWER IS SUPPLIED TO AIRCRAFT** make certain that electrical circuits upon which work is in progress are properly isolated!

#### ■ PRACTICE 1: TELEPHONE CONTACT BETWEEN PRODUCT SUPPORT AND GROUND MAINTENANCE

The person from product support should ask questions and give instructions:

Have you...?

Now that you have... you should...

#### ■ PRACTICE 2: EXPRESSING PROPER SEQUENCES AND WARNINGS

The person from product support should use patterns such as:

Have you checked to see...?

You mustn't ... until/before you have ...



## Imperatives and instructions

### Modal auxiliaries **MUST** and **SHOULD** **PREVENT/STOP/AVOID**

Reminder: Sequences in subordinate clauses

#### ⊕ Imperatives and Consequences

|   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. <b>Check</b> to see that A and B are connected.</li> <li>2. <b>Check</b> A to see if (whether) it's connected to B.</li> <li>3. <b>Always be sure</b> to connect A and B before continuing.</li> <li>4. <b>Don't proceed</b> before checking to see that A and B are connected.</li> <li>5. <b>Never continue</b> before checking to see that they are connected.</li> <li>6. <b>Avoid touching</b> the surfaces with fingers.</li> </ol> | <p>Note negative imperative form with <b>DONT</b> and <b>NEVER</b>. <b>AVOID</b> must be followed by the gerund.</p> |
| <ol style="list-style-type: none"> <li>7. <b>Unless it is removed, damage may/can occur</b> to the other parts.</li> <li>8. Be sure to remove it. <b>Otherwise damage may/can occur</b> to the parts.</li> </ol>  | <p>Express consequences using <b>UNLESS</b> or <b>OTHERWISE</b>.</p>   |

#### ⊕ Modal auxiliaries **MUST** and **SHOULD**

|   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. The part <b>mustn't be</b> removed.</li> <li>2. You <b>mustn't use</b> abrasive chemicals.</li> <li>3. Any anomalies <b>must be reported</b> to product support at once.</li> <li>4. This part <b>needn't be covered</b> (but you may cover it if you wish).</li> <li>5. You <b>don't have to / needn't report</b> this (but you may if you wish).</li> </ol> | <p><b>MUST</b> expresses obligation. In the negative it expresses prohibition. For absence of obligation use <b>DONT HAVE TO</b> or <b>NEEDNT</b>.</p> |
| <ol style="list-style-type: none"> <li>6. The two components <b>shouldn't be</b> too close to each other.</li> <li>7. When <b>should we schedule</b> the next servicing?</li> </ol>   | <p><b>SHOULD</b> expresses advice or what is a good idea.</p>  |

#### ⊕ Prevent, Avoid, Stop

|   |   |
|---|---|
| <p>prevent stg./sb. from —ing<br/>         avoid —ing<br/>         stop —ing<br/>         stop stg. / sb. from —ing</p> | <ol style="list-style-type: none"> <li>1. This will <b>prevent incidents</b> like this <b>from happening</b> again.</li> <li>2. We must <b>avoid doing</b> that again.</li> <li>3. The computer <b>stopped transmitting</b> data during flight.</li> <li>4. This will <b>stop rust from forming</b>.</li> </ol> |
|---|---|

#### ⊕ Tense sequences: main clause and subordinate clauses\*

|  |  |
|--|--|
| <ol style="list-style-type: none"> <li>1. Don't remove the panel <b>until you have checked...</b></li> <li>2. Don't proceed <b>unless you have removed</b> the panel.</li> <li>3. Remove the panel <b>only when you have checked/after you have checked.</b></li> <li>4. <b>Only when/Not until you have checked,</b> should you proceed to ...</li> </ol> | <p>Use the Present or Future tense in the main clause, the present or present perfect in the subordinate clause.</p> |
|--|--|

\* See grammar file #5, page 64 for more information on tenses.

### 5.6.3. PRACTICE: GRAMMATICAL PATTERNS AND VOCABULARY RELATING TO INSTRUCTIONS AND WARNINGS

The following excerpt from a maintenance manual indicates the procedure to follow when repairs to plastic surfaces become necessary.



MEMO

#### **REPAIRS TO PLASTIC SURFACE**

1. **VISUAL INSPECTION OF WINDOWS AND WINDSHIELD**
  - ✓ Cracks or other signs of surface damage?
2. **DETECTION OF NON-DEEP SURFACE ABRASION**
  - ✓ Remove using typical Micro-Mesh abrasion removal process (EXTREME CAUTION!)
3. **DETECTION OF SOME CRAZING?**
  - ✓ evaluation: structural weakening in plastic?
  - ✓ evaluation: interference with pilot's vision?If yes to either, proceed with repair
4. **SURFACE PATCH PROCEDURE**
  - ✓ stop-drill crack
  - ✓ cut patch to extend beyond edge of the crack at least 3/4 inch (1.91cm)
  - ✓ form patch so as to lie fully on the surface contour
  - ✓ taper patch edge (1-inch bevel)
  - ✓ spread patch with adhesive
  - ✓ position patch on surface of panel under repair
  - ✓ apply pressure to patch for several hours
  - ✓ 24 hours later: polish patch to achieve clear edges

#### ■ SUGGESTED ACTIVITIES: ORAL AND WRITTEN

1. Describe the procedure outlines above using the passive voice as if explaining the procedure to somebody or preparing a full written description. This can be done as an e-mail message to a technician.
2. Give detailed instructions using the patterns shown on the preceding page and vocabulary related to instructions. Imagine that you are giving these instructions over the telephone to a technician responsible for ground maintenance at some distant airport.
3. Write a brief report relating the repairs which were made during a visit you made last week.

## 5.6.4. FLAP JAMMING: COMMUNICATIONS APPLICATIONS

You are in the product support division of the aircraft manufacturer and one of your colleagues has sent this e-mail message to an airline ground maintenance technician at a distant airport. Apparently there is still a problem, because you receive a message (by e-mail or by telephone) requesting urgent help. Perhaps this message was never received. Use the information it contains in trying to help the maintenance technician who now contacts you.

### -300 A/C MSN 311 FLAP JAMMING

Impossible to reset manually the flap screwjack for 3 lockout indicator. This screwjack could be the cause of the repeated experienced system lockout.

Product support confirms that this equipment should be replaced.

Based on our in-service experience, one flap jamming involving the activation of S/J 3 and 4 was once caused by a WTB solenoid internal leakage.

Product support recommends replacing first the flap screwjack 3 and then if trouble persists, replacing the 2 RH WTB solenoids.

If continuing flap jammings are experienced, we recommend the following:

In the event of jam, perform landing without trying to reset, rising control lever.

On ground, with the hydraulic power still on and slat/flap control lever still in the same position, check for the presence of trapped torque in the transmission shafts of jammed wing to isolate the jammed station.

On this station, check again the carriage rollers. If they are found to be in good condition, replace the jack and check the complete wing rigging.

Problem will be solved following jack 3 replacement.

### ■ SUGGESTED ACTIVITIES

1. Ask appropriate questions (using the present perfect tense as in the examples here:)

*Have you had this failure before... When was the last time it occurred?*

*How many times...?*

*Have you checked....? Have you checked for ...? Have you checked to see ...?*

*Has the ... been checked?*

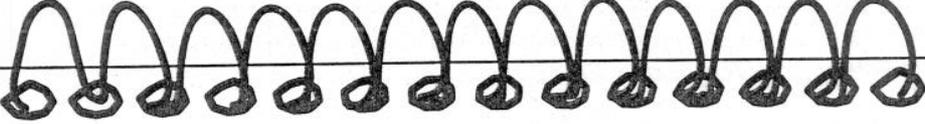
2. Give clear instructions, being careful of verb tenses:

*Once you have replaced the ... you should...*

*Once the x has been replaced, you should ...*

## 5.6.5. AIR DUCT FAILURE: COMMUNICATIONS APPLICATIONS

Here are your notes on a recent problem concerning air ducts.



|  |  |
|--|--|
| <p><i>Air duct failure → 1m x 70cm hole in the aircraft.</i></p> <p><i>Duct failure blew off an external panel located beneath the port wing.</i></p> <p><i>Occurrence during aircraft's ascent through 16,000ft (5,000m).</i></p> <p><i>→ sudden drop in pneumatic duct pressure to about 1/6 of normal level</i></p> <p><i>→ no cabin depressurization</i></p> <p><i>→ no injuries</i></p> <p><i>Delivery date of a/c: June 1983</i></p> <p><i>hours accumulated: 38,786</i></p> <p><i>cycles accumulated: 3,376</i></p> <p><u><i>solution:</i></u><br/><i>replacement of duct with a new one 40% thicker.</i></p> | <p>lead to/result in/<br/>cause/ be responsible for<br/>bring about<br/>result from/be caused by</p> <p>climb</p> <p>bring about<br/>cause<br/>result in<br/>result from<br/>lead to</p> <p>past perfect</p> <p>past perfect</p> <p>past perfect</p> <p>recommend / advise /<br/>suggest</p> |
|--|--|

### PRACTICE: VERBS AND TENSES

1. A hole measuring 1m x 70cm ...
2. An external panel located beneath the port wing...
3. The failure occurred while ...
4. The aircraft was climbing ...
5. Pneumatic duct pressure ...
6. Cabin depressurization...
7. No injuries ...
8. No passengers...
9. The aircraft ... in June of 1983.
10. The aircraft ... 38,786 hours when this incident ...

### PRACTICE: CAUSE AND EFFECT

Prepare a complete description of the event using the expressions above on the right.

## 5.6.5. AIR DUCT FAILURE: COMMUNICATIONS APPLICATIONS

Here are your notes on a recent problem concerning air ducts.



|  |  |
|--|--|
| <p><i>Air duct failure → 1m x 70cm hole in the aircraft.</i></p> <p><i>Duct failure blew off an external panel located beneath the port wing.</i></p> <p><i>Occurrence during aircraft's ascent through 16,000ft (5,000m).</i></p> <p><i>→ sudden drop in pneumatic duct pressure to about 1/6 of normal level</i></p> <p><i>→ no cabin depressurization</i></p> <p><i>→ no injuries</i></p> <p><i>Delivery date of a/c: June 1983</i></p> <p><i>hours accumulated: 38,786</i></p> <p><i>cycles accumulated: 3,376</i></p> <p><u><i>solution:</i></u><br/><i>replacement of duct with a new one 40% thicker.</i></p> | <p>lead to/result in/<br/>cause/ be responsible for<br/>bring about<br/>result from/be caused by</p> <p>climb</p> <p>bring about<br/>cause<br/>result in<br/>result from<br/>lead to</p> <p>past perfect</p> <p>past perfect</p> <p>past perfect</p> <p>recommend / advise /<br/>suggest</p> |
|--|--|

### PRACTICE: VERBS AND TENSES

1. A hole measuring 1m x 70cm ...
2. An external panel located beneath the port wing...
3. The failure occurred while ...
4. The aircraft was climbing ...
5. Pneumatic duct pressure ...
6. Cabin depressurization...
7. No injuries ...
8. No passengers...
9. The aircraft ... in June of 1983.
10. The aircraft ... 38,786 hours when this incident ...

### PRACTICE: CAUSE AND EFFECT

Prepare a complete description of the event using the expressions above on the right.

## PART 2: MORE SERIOUS INCIDENTS AND ACCIDENTS

The problems in this section involve serious damage to aircraft, personal injury and fatalities linked to aircraft accidents.

### 5.7. READ AND NOTE THE HIGHLIGHTED WORDS. SAYING IT DIFFERENTLY.

Read the short passage on the left. Note the highlighted expressions. The expressions shown on the right can be used to rephrase these ideas. Try rephrasing the ideas in as many different ways as you can.

The co-pilot engaged go-around mode but **did not check with** the pilot. The autopilot complied. The pilot attempted to override, rather than correctly disengage the mode. In addition, the pilot delayed in acting. The aircraft stalled, but the pilot **could not stabilize it**. Minutes later the aircraft crashed near the runway and burst into flames. The ground personnel arrived promptly on the scene but **could not rescue** the crew members or passengers.

**FAILED TO CHECK WITH  
NEGLECTED TO CHECK WITH  
WAS UNABLE TO  
WAS NOT ABLE TO  
TRIED UNSUCCESSFULLY TO  
DID NOT MANAGE TO  
WAS NOT SUCCESSFUL IN  
DIDN'T SUCCEED IN**

#### 5.7.1. PRACTICE: ENLARGING VOCABULARY

Rephrase the following ideas (not necessarily related to the incident in 5.6.) using the the same vocabulary in the passage and above on the right .

1. The pilot did not request clarification.
2. The aircraft manufacturer did not inform the airlines that software modifications were available.
3. The co-pilot did not check with the pilot on the procedure.
4. The co-pilot did not disengage the mode.
5. The pilot waited too long before acting.
6. The pilot did not contact the control tower in time.
7. The control tower did not inform the pilot of the conditions.
8. The flight control system computer did not react.
9. The pilot couldn't bring the aircraft out of stall.
10. Despite his efforts, the co-pilot couldn't help.
11. The aircraft couldn't be stabilized.
12. They waited before requesting emergency landing authorization.
13. The control tower did not respond immediately.
14. The ground personnel couldn't arrive on the scene in time.
15. The fire couldn't be contained.
16. Why couldn't they contain the fire?
17. Why did they wait before intervening?
18. They made several attempts to rescue the people but couldn't do it.



☉ Failures

|                 |   |  |
|-----------------|---|--|
| FAIL TO FAILURE | 1. The pilot <b>failed to use</b> the proper procedure.<br>The pilot's <b>failure</b> to use it caused the accident.  | Fail and neglect can also imply fault. <b>Mistakenly</b> suggests that error is involved.              |
| NEGLECT TO      | 2. He <b>neglected to use</b> the proper procedure.<br>He <b>neglected to use</b> the procedure correctly.  |  |
| MAKE USE OF     | 3. He didn't <b>make (proper) use of</b> the procedure.   |  |
| MISTAKENLY      | 4. He <b>made improper use of</b> it.   |  |
|                 | 5. He <b>mistakenly used</b> the wrong procedure.   |  |
| FAIL            | 6. The mechanism <b>failed to respond</b> .<br>7. The safety device <b>failed to function</b> .<br>8. The landing gear <b>failed to deploy</b> .<br>9. His attempts to stabilize the aircraft <b>failed</b> . | All these expressions describe an outcome, action or state which deviates from the normal or expected. |
| GO WRONG        | 10. Something <b>went wrong with</b> the device.  |  |
| BE WRONG        | 11. Something <b>was wrong with</b> it. What <b>was wrong</b> with it?  |  |

☉ Inability

|               |   |  |
|---------------|---|--|
| UNABLE        | 1. We were <b>unable to avert</b> the accident.   | Note: <b>could</b> is not ordinarily used in the affirmative when there is the idea of the successful accomplishment of an action. |
| MANAGE TO     | 2. We <b>didn't manage to engage</b> it in time.  |  |
| SUCCEED IN    | 3. We <b>didn't succeed in finding</b> the cause. |  |
| SUCCESSFUL IN | We <b>were not successful in finding</b> it.      |  |
| COULD (NOT)   | 4. We <b>couldn't find</b> the cause.             |  |

☉ Blame and Responsibility

|                      |  |
|----------------------|--|
| BLAME SB.FOR         | 1. The pilot <b>was blamed for the error</b> .   |
| BLAME STG. ON        | 2. The incident <b>was blamed on poor visibility</b> .<br>The incident <b>was blamed on computer failure</b> . |
| HOLD RESPONSIBLE FOR | 3. The pilot <b>was held responsible for the accident</b> .  |

☉ Should + perfect infinitive

He **shouldn't have delayed** in acting.  
He **shouldn't have engaged** the go-around mode without first checking with the pilot.  
He **should have checked** with the pilot.

☉ Might + perfect infinitive

He **might have averted** the accident.  
The accident **might have been averted**.  
He **might have been able** to regain stability.

You will have the opportunity to practice using all these grammatical patterns and expressions in the pages which follow.

# Pilot Error Responsible for Crash?

## NTSM Report Contested by ALPA

On September 19 1989 US Air flight 5050 failed to take off from runway 13 at New York's La Guardia Airport. The Boeing 737-400 plunged into Bowary Bay, killing 2 and injuring 21.

According to a report issued by the National Transportation Safety Board (NTSB), the crash was due solely to pilot error, a finding contested by the US Airline Pilots Association (ALPA).

The report incriminates the pilot, claiming that he had failed either to reject the take off which had been initiated with a mistrimmed rudder, a condition that the captain had failed to detect prior to take off.

Crew members who were on board reported that the captain had attempted to correct the drifting movement of the aircraft by using nose-

wheel steering just before his unsuccessful attempt to abort.

The rudder had been set *in the full left position* causing a 16° deflection.<sup>1</sup>

The report goes on to note that the captain had failed to make use of the autobrake during the roll resulting in delayed effective braking. The first officer had inadvertently disarmed the autothrottle, causing ground roll to be lengthened.

The report concludes that the captain made improper use of nosewheel steering, while his use of differential braking led to attainment of maximum braking being delayed. Airspeed was not being monitored by either pilot. The pilot apparently *rejected take-off 5kt above the computed take-off commit ( $V_2$ ) speed.*<sup>1</sup> ■

### 5.8.1. PRACTICE STATING UNSUCCESSFUL EVENTS.

The following failures, errors or unsuccessful attempts are taken from the above article. Practice using the vocabulary on the preceding pages and make complete statements.

- take off from La Guardia
- pilot did not reject the take-off in time
- pilot did not take the necessary control to continue take off
- the rudder had not been correctly trimmed
- the pilot did not notice this error in rudder trimming
- the aircraft did not respond correctly, but drifted
- the rudder had not been set correctly, causing a 16° deflection
- the captain did not use the autobrake correctly
- the first officer committed an error in disarming the autothrottle
- the captain did not use the nosewheel steering correctly
- the captain did not use the differential braking to full advantage
- neither pilot was monitoring the airspeed

### 5.8.2. PRACTICE: REVIEW AND RECALL: CAUSE AND EFFECT (SEE PAGE 26). ARROWS INDICATE RESULTS.

- failure to take off → crash in Bowary Bay → 2 deaths and 21 injuries
- mistrimmed rudder → 16° deflection → instability
- incorrect use of autobrake → delayed effective braking
- use of differential braking → delay in reaching maximum braking
- airspeed was not monitored → captain rejected take-off 5kt above the computer take-off commit speed

### 5.8.3. PRACTICE: CONDITIONALS

EXAMPLE:

The pilot rejected take-off

*If the pilot hadn't rejected take-off, the crash wouldn't have (might not have) occurred.*

- a. monitoring of airspeed
- b. delay in reaching maximum braking
- c. (improper) use of nosewheel steering
- d. use of the autobrake
- e. (inadvertent) disarming of the autothrottle
- f. rudder setting
- g. attempt to abort (was unsuccessful, but ...)
- h. the crash was due solely to pilot error

### 5.8.4. PRACTICE: MODALS SHOULD AND MIGHT + PERFECT INFINITIVE: SHOULD HAVE/ SHOULD NOT HAVE ...

- a. captain did not reject the take off in time
- b. captain did not react quickly enough
- c. rudder had been mistrimmed and this went unnoticed
- d. captain's use of nosewheel steering to correct drifting movement
- e. captain apparently waited too long before attempting to abort
- f. no use was made of the autobrake during the roll
- g. first officer's disarming of the autothrottle
- h. neither pilot was monitoring the airspeed



## THE PREFIX MIS-

Do you know these words?

- to misuse** They misused the safety mechanism.
- misuse (of)** It happened due to the misuse of the safety mechanism.
- to miscalculate** He miscalculated the distance.
- a miscalculation** A miscalculation of the distance was responsible.
- to misunderstand** The air traffic controller misunderstood the pilot.
- a misunderstanding** It happened because of a misunderstanding between pilot and control tower.
- to misjudge** He misjudged the ground wind speeds.
- a misjudgment** It happened because of a misjudgment of ground wind speeds.

Other common verbs made with the prefix MIS-. Can you use them? Do you know their noun forms?

|                   |                    |                    |                    |                    |                    |
|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| <b>misact</b>     | <b>misadvise</b>   | <b>misalign</b>    | <b>misapply</b>    | <b>misassemble</b> | <b>misclassify</b> |
| <b>misconnect</b> | <b>miscopy</b>     | <b>misdate</b>     | <b>misdescribe</b> | <b>misdevelop</b>  | <b>misdraw</b>     |
| <b>misemploy</b>  | <b>misestimate</b> | <b>misfunction</b> | <b>misgauge</b>    | <b>misidentify</b> | <b>misinform</b>   |
| <b>mislabel</b>   | <b>mislocate</b>   | <b>mismatch</b>    | <b>misposition</b> | <b>misprint</b>    | <b>misroute</b>    |
| <b>misshape</b>   |                    |                    |                    |                    |                    |



## WARNINGS

Do you know these words and expressions?

- warn sb. about (of) stg.** They warned him about (of) the danger.
- be warned about (of)** He was warned about (of) the danger.
- alert sb. to stg..** They alerted him to the dangers.
- be alerted to stg.** He had been alerted to the dangers.
- make sb. aware of** They made him aware of the dangers.
- issue a warning** They had issued a warning.
- to receive warning** He had received early (or: prior) warning about the danger.
- to be given warning** He had been given early warning.
- heed a warning** He decided to heed the warning and turn back.
- disregard a warning** He disregarded the warning and decided to go ahead.



## DEVELOP YOUR WORD POWER.

### 5.8.5. READ AND RESTATE.

#### CRASH IN CANADA

An Air Georgian Cessna 208B crashed at Barrie-Orillia, Ontario, Canada. The pilot had been alerted to the danger of icing due to cold weather and later reported losing control of the aircraft during instrument approach to the runway. The Cessna crash-landed short of the runway. Icing was found on the wing.

1. The pilot had been warned...
2. Canadian air traffic control ...
3. A warning...
4. The pilot had been given early warning ...
5. Apparently the pilot failed to ...
6. The cause of the accident was attributed to...

### 5.8.6. PRACTICE: OVER TO YOU TO MAKE THE REPORT.

#### DH-4A Caribou crashes in Alaska

The incident occurred in January during a night approach.  
Propeller overspeed → right engine shutdown.

Pilot given information about difficult landing conditions.

Diversion of crew to Sparrevohn Strip, Alaska.

Severe turbulence/reduced visibility/poor landing conditions

→ aircraft's attempts to make night approach nearly impossible

→ crash into slope

#### USE THESE WORDS:

CAUSE

RESULT IN

LEAD TO

ALERT/WARNED

HEED WARNING

MAINTAIN COURSE

# Past, Past Continuous and Past Perfect tenses

## Active and passive constructions



### Use of these tenses

|  |  |
|--|--|
| <p><b>EXAMPLE #1</b></p> <p>On December 29, 1991, a China Airlines 747-200 <b>collided</b> with high ground in a cloud near Taipei, Taiwan, in its airfield approach phase. The aircraft <b>had experienced</b> engine failure during ascent and <b>had been cleared</b> to return to land. The collision <b>occurred</b> while the aircraft <b>was descending</b>. 5 people <b>were killed</b>.</p> | <p><i>past tense describes the event which is always associated with a known date or time</i></p> <p><i>past perfect: events happening before the event above</i></p> <p><i>past continuous explains the circumstances; the passive form of the simple past here explains the consequences</i></p> |
| <p><b>EXAMPLE #2</b></p> <p>On December 29, 1991, a China Airlines 747-200 <b>collided</b> with high ground in a cloud near Taipei, Taiwan, <b>while it was making</b> airfield approach near Taipei, Taiwan.</p>  | <p><i>Notice that <b>while</b> is followed by the past continuous and explains the circumstances surrounding the event (expressed in the simple past tense).</i></p>   |
| <p><b>EXAMPLE #3</b></p> <p>On December 29, 1991, a China Airlines 747-200 <b>was approaching</b> the airfield near Taipei, Taiwan, <b>when it collided</b> with high ground in a cloud.</p>   | <p><i>a description of the circumstances (the past continuous) at the time of the incident expressed by <b>when + simple past</b></i></p>  |

### Active and Passive forms

|  |  |   |
|--|--|---|
| <p><b>ACTIVE VOICE</b></p> <p>They <b>repaired</b> it (last week).</p> <p>They <b>were repairing</b> it when our team arrived.</p> <p>They <b>had repaired</b> it before we arrived.</p> | <p><i>The passive voice is always formed with the appropriate tense of the verb <b>BE</b> (here the simple past and past perfect) and the past participle of the verb.</i></p> | <p><b>PASSIVE VOICE</b></p> <p>It <b>was repaired</b> (last week).</p> <p>It <b>was being repaired</b> when our team arrived.</p> <p>It <b>had been repaired</b> before we arrived.</p> |
|--|--|---|

| <b>AIRLINE ACCIDENTS</b> |                   |                 |                                |                   |                  |  |
|--------------------------|-------------------|-----------------|--------------------------------|-------------------|------------------|--|
| <b>Date</b>              | <b>Carrier</b>    | <b>Aircraft</b> | <b>Location</b>                | <b>Fatalities</b> | <b>Occupants</b> | <b>Circumstances</b>   |
| Jan.20, 1997             | Air China         | B747-200        | JFK Airport New York           | 0                 | unavailable      | in landing phase: end of landing roll veered off runway, heavy damage to nose landing gear and forward fuselage  |
| May 23, 1991             | Aeroflot          | Tu-154          | St Petersburg, Russia          | 0 crew, 12 pax    | 4 crew, 166 pax  | engine failure: crashed on landing, aircraft broke in two  |
| Oct. 16, 1991            | American Airlines | MD-80           | New York, USA                  | 0 crew, 0 pax     | 6 crew, 109 pax  | collision with 737: both a/c on ground and taxiing in. 20 injuries during evacuation phase   |
| March 5, 1997            | American Airlines | MD83            | Cleveland, Ohio, Airport (USA) | 0 crew, 0 pax     | 6 crew, 103 pax  | landing phase: night, very poor weather conditions prevailing on runway, thin wet snow (prior treatment with de-icing chemicals) aircraft slid left off runway |
| March 5, 1997            | United Airlines   | DC-10           | Las Vegas, USA                 | 0 crew, 0 pax     | 10 crew, 165 pax | pressure bulkhead blowout on climb   |

**RECOMMENDED ACTIVITIES AND PRACTICES: EXPLAINING THE CIRCUMSTANCES**

- The incident/accident **happened** (occurred) ...
- It happened **while...**  
The aircraft **was —ing, when ...**
- The accident **involved** (a certain number of people)  
A certain number of people **were involved** in the accident.

**SPECIAL FOCUS: RELATIVE CLAUSES**

- 6 people were injured/killed in an accident **which...**  
The aircraft, **which had just ...**, was bound for..
- Engine failure is blamed for the accident/crash **in which...**



**5.8.8. USING THE TENSES**

**PREPARE COMPLETE ACCOUNTS OF THE INCIDENTS**

# AIRLINE ACCIDENTS

| Date           | Carrier            | Aircraft          | Location                                  | Fatalities     | Occupants       | Circumstances   |
|----------------|--------------------|-------------------|---|----------------|-----------------|---|
| Feb.2, 1991    | Labrador Airways   | Cessna 208        | Goose Bay Labrador                        | 1              | 1               | In En route phase; crashed into a bog   |
| March 10, 1997 | Gulf Air           | A320              | Abu Dhabi Airport, UAE                    | 1 (Crew)       | 8 Crew, 107 pax | take-off aborted at near V1 speed aircraft veered off runway, struck embarkment, sever damage to aircraft: nosegear thrust up into cockpit, captain badly injured |
| Aug. 15, 1991  | Air Bissau         | F27-100           | Dori, Burkina Faso                        | 3              | 3               | En Route phase, aircraft lost, hit trees during attempted forced landing in a field   |
| Sept.17, 1991  | Ethiopian Airlines | Hercules (Et-AJL) | Mt. Arey, Djibouti                        | 4              | 4               | airfield approach phase; aircraft crashed into mountain after beginning descent   |
| Feb. 1, 1997   | Air Senegal        | BAe 748-21        | Tambacounda Airport, Tambacounda, Senegal | 3 crew, 20 pax | 4 crew, 48 pax  | take-off, climb to 1000 ft after take-off, sudden veer to left and loss of altitude, collision with ground beside runway. Cause: left engine failure              |
| Feb.14, 1997   | Varig              | B737-200          | Carajas Airport, Carajas, Brazil          | 1 (crew)       | 6 crew, 46 pax. | landing phase: violent storms, visibility very poor;hard landing aircraft veered right, stopped by trees, main landing gear collapsed                             |

**RECOMMENDED ACTIVITIES AND PRACTICES**

- [1] Oral practice: explain the events and the surrounding circumstances as they are suggested in the notes above . Use the past and the past continuous tenses, and the past perfect if you need to mention noteworthy events or circumstances which occurred prior to the main event.
- [2] Oral practice: imagine that you have been given one or more of the above accidents to investigate. What questions can you ask? What additional information do you need? For instance, Why didn't the pilot heed the warning issued by...? What caused the aircraft to veer...?
- [3] Written practice: write a complete report for at least one of the above accidents. Imagine any additional details. If you have done [2] above, you may include the questions in your report.
- [4] If you are working in a group, imagine that you are on a panel reporting to the NTSB, for instance, or perhaps participating in a television broadcast devoted to air traffic mishaps. Each participant should prepare one complete, but succinct, report.

## 5.9. THE EXPLOSION OF TWA FLIGHT 800

This section is made up of 3 passages relating to the disaster of the TWA 747 which exploded minutes after take-off from New York in 1996. Each passage adds new information.

### PASSAGE #1: 1 WEEK FOLLOWING THE DISASTER

# Disaster hits TWA 747 after take-off from New York

The causes of the explosion of the TWA B747-100 on July 17, 1996 in which all 210 passengers and crew members died will not be known until the cockpit voice recorder (CVR) and flight-data recorder (FDR) have been recovered and analyzed. The aircraft, which exploded only 20 minutes following take-off from JFK in New York, was bound for Paris and was to fly on to Rome.

**TAKE OVER FROM  
HERE AND USE  
THESE NOTES TO  
ADD THIS INFOR-  
MATION TO THE  
REPORT**

arrival from Athens: 3 hours before  
scheduled departure for Paris

Take-off: 20.19 from JFK (1 hour  
late)

sudden disappearance from radar  
screens: 20.48

13,000ft (4 000 m) altitude

fall to sea at point 15km off Long  
Island, about 110 miles (160 km)  
from New York City

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A Coast Guard ship cruising in the vicinity reports having picked up a Mayday distress signal. Whether it had emanated from the 747 is not known.

Both FBI and NTSB are looking into the explosion to determine whether a criminal act — a terrorist bomb — had been involved. As of July 18 no evidence had been uncovered to support this hypothesis. Nor does any evidence exist suggesting that a ground-to-missile impact, or collision with another aircraft. At this stage, a mechanical failure cannot be ruled out. Attempts are underway to recover the wreckage of the 747.

#### WHETHER (OR NOT)

Whether the signal came from the 747 (or not) is not known.

We do not know whether the signal came from the 747 or not.

#### DETERMINE WHETHER...

We are trying to determine whether the pilot sent the distress signal.

#### NOR + AUXILIARY + SUBJECT

We have no proof of a criminal act. **Nor does any evidence exist** to support the hypothesis of a missile impact.

He didn't say when he was leaving. **Nor did he say** when he would be coming back.

The committee will not accept the testimony. **Nor will it admit** this evidence.



### 5.9.1. GRAMMAR PRACTICE

REPHRASE THE QUESTIONS USING THE PATTERNS INVOLVING **WHETHER** ON THE PREVIOUS PAGE.

1. Had something gone wrong during the flight from Athens? Had somebody placed an explosive on board before the 747 left for New York?
2. Was there a Navy ship in the area? If so, was anything unusual observed?
3. Will more pieces of the wreckage be recovered? Will these reveal conclusive evidence?

REPHRASE USING **NOR**.

1. Nobody reported anything unusual in Athens. Nothing unusual was reported in New York.
2. The FBI and the NTSB haven't made any comment yet.
3. The pilot reported no anomalies. The control tower wasn't alerted to any unusual incidents or circumstances.

### PASSAGE #2: SEVERAL WEEKS FOLLOWING THE DISASTER. READ AND PARTICIPATE.

Fill in the blanks (refer to passage #1 for language and facts). Some useful expressions are also provided on the right.

Analysis of \_\_\_\_\_ (CVR) of TWA flight 800 which \_\_\_\_\_ reveals a brief sound a split-second before the explosion, 11.5 minutes into the flight.

The \_\_\_\_\_ (FDR) has been successfully retrieved. Both CVR and FDR \_\_\_\_\_ damage from impact, but \_\_\_\_\_ no signs of fire damage.

Investigators are still attempting to determine \_\_\_\_\_, or \_\_\_\_\_.

So far, investigators have not been able to find any conclusive evidence of an explosion from the few pieces of wreckage recovered from the area 19 km off Long Island where the aircraft fell.

#### USEFUL EXPRESSIONS

- failed to detect
- have been unable to detect
- failed to uncover
- failed to reveal
- no trace
- no sign
- no evidence
- no indication

### 5.9.2. PRACTICE: COMPARE THE VERSIONS

Compare passages #1 and #2. How do they complement each other? What additional or new information is given in #2 that clarifies or modifies the information initially provided in the passage written one week after the disaster?

Passage #3 follows on the next page.



## 5.10. A true story

### A Narrowly-Averted Disaster?

The following is a true incident of a rather unusual (for the pilot!) flight on a 747.

Prior to take off the weight distribution was calculated and the results were as follows:

|                      |          |
|----------------------|----------|
| dry operating weight | 165 tons |
| payload              | 35 tons  |
| fuel                 | 110 tons |

Everything seemed normal until the aircraft was ready for take-off. The pilot noticed that acceleration was slower than what he expected it to be. Indeed, liftoff required more effort from the pilot than would otherwise have been needed.

En route climb was very poor, a fact which many passengers later reported that they had noticed, but had dismissed as being inconsequential.

Cruise at 35,000 feet needed a boost in engine power in order to maintain a lower than normal air-speed.

However, descent and landing were normal and went smoothly.

What could have accounted for these anomalies?

#### 5.10.1 PRACTICE WITH CONDITIONALS : IF...

If the indicated weight calculations **had been** correct, the aircraft **wouldn't have experienced** the anomalies.

Now indicate what would have been the case for each of the following:

**acceleration      lift off      climb      engine power in cruise      descent**

#### 5.10.2. PRACTICE WITH MODAL AUXILIARIES

There **must have been** more weight on board than the figures showed.

What **might have been** responsible for the weight discrepancy?

Discuss the following using: **must/may-might/could**

- **passengers**
- **aircraft weight**
- **fuel**
- **baggage**
- **weather factors**
- **mistake in calculations**

THE CAUSE OF THE PROBLEM:  
The discrepancy is due to excess weight in the passengers' carry-on baggage! At check-in the actual weight of the payload is accurately determined by assessing total passenger weight and weighing passengers' luggage. Carry-on baggage was not, at the time, weighed. On the flight in question, almost all the passengers were COIN COLLECTORS going to a national convention. Each was carrying several kilograms in metal coins.

- (b) The captain should have been alert to many of the anomalies.
- (c) The rudder should not have been mistrimmed, and the captain should have noticed this.
- (d) Many believe that the captain should not have tried to correct the drift by using nosewheel steering.
- (e) He should not have waited so long before aborting. Had he reacted more quickly he might have averted the crash.
- (f) The autobrake should have been used. This might have prevented the accident.
- (g) The first officer should not have disarmed the autothrottle.
- (h) Somebody should have been monitoring the airspeed.

5.9.1. (Page 101)

- (1) Officials wondered (the question was asked) whether something had gone wrong during the flight from Athens, or whether somebody had placed an explosive on board before the plane left New York.
- (2) Investigators were curious about (as to) whether a Navy ship was in the are, and if so, whether anything unusual had been observed.
- (3) It is too early to know (say/tell) whether more pieces of the wreckage will be recovered, or whether these pieces will reveal conclusive evidence.

NOR

- (1) Nothing unusual was reported in Athens. Nor was anything unusual reported in New York.
- (2) The FBI hasn't made any comment. Nor has the NTSB (come out with a statement).
- (3) The pilot reported no anomalies. Nor was the control tower alerted to any unusual incidents or circumstances.

PASSAGE #2 (Page 101)

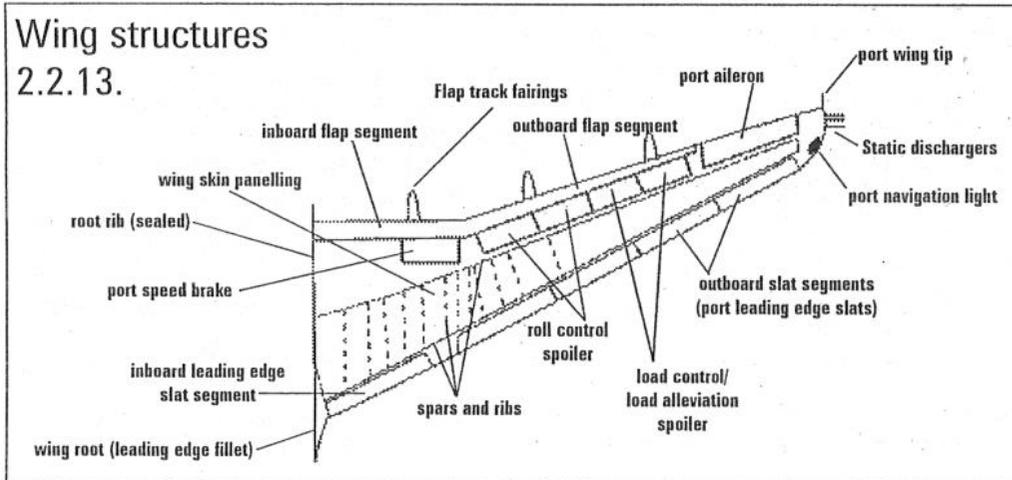
Analysis of the cockpit voice recorder of TWA flight 800 which exploded only 20 minutes following take-off from JFK in New York reveals a brief sound a split-second before the explosion, 11.5 minutes into the flight.

The flight-data recorder has been successfully retrieved. Both CVR and FDR sustained damage from impact but shows (exhibits/displays) no signs (trace) of fire damage.

Investigators are still attempting to determine whether a criminal act, missile impact, or mechanical failure caused the explosion.

Wing structures

2.2.13.



Ready for Take-Off

Answers to selected practice exercises

SECTION 1

1.1.1. (a) 1 (b) 2 (c) 3 (d) 28 (e) 27 (f) 26 (g) 6 (h) 8 (i) 7 (j) 9 (k) 5 (l) 15 (m) 4 (n) 10 (o) 29 (p) 13 (q) 14 (r) 12 (s) 16 (t) 22 (u) 17 (v) 19 (w) 24 (x) 25 (y) 21 (z) 20 (aa) 23 (bb) 29 (cc) 26

1.1.2. (1) b (2) c (3) l (4) d (5) g (6) h (7) a (8) j (9) i (10) f (11) e (12) k

1.1.3. EXAMPLES. (1) Wings are fitted with flaps. Each wing is also equipped with navigation lights; (2) Very sophisticated systems provide the pilot with information... (3) The horizontal and vertical stabilizers are designed to provide stability in flight. (4) Each windshield is provided with wipers to remove rain. (5) The engines furnish/provide thrust... (6) Fuel tanks are designed to hold a certain quantity of fuel during flight. (7) All aircraft are equipped/supplied with nose and landing gear.

1.1.4. EXAMPLES. (1) Wings are designed to provide the required thrust. (2) navigation lights allow the aircraft to be identified from a distance. (3) The tailplane is designed to provide stability. (4) Cockpit windows enable the pilots to have adequate angles of visibility. (5) Landing gear makes it possible (for the aircraft) to taxi on the ground and to land. (6) Underfloor storage areas allow passenger baggage and cargo to be transported. (7) The fuel tanks fitted in the wings allow (the required amount of) fuel to be stored during flight. (8) The APU is designed to provide the aircraft with electricity during on-ground operations.

1.2.1. EXAMPLES. (a) Emergency evacuation exits enable passengers to leave the aircraft quickly in the event of an emergency. (b) All aircraft must be equipped with starboard and port navigation lights that enable the aircraft to be identified during flight and on the ground, especially at night. (c) The cabin door enables passengers to board and deplane. (d) Flaps make it possible to enlarge the wing surface area and are thus required in landing phase. (e) Flap tracks allow the flaps to travel up and down from inside to outside the wing, as required. (f) The windshield make it possible for the cockpit crew to have adequate angles of visibility. (g) Windshield wipers are provided to remove rain. (h) Wings are designed to provide the required lift.

1.3.1. (1) What makes flight possible? (2) Flight is made possible by four factors called (A) lift, (B) drag (C) thrust (D) weight. (3) It is the wing which causes lift. (4) It is friction (air resistance) which causes drag. (5) Thrust is provided by the aircraft's engines and is the force which propels the aircraft forward (ensures horizontal movement forward).

1.3.5. (1) The higher the air density, the greater the lift. (2) The larger the angle of attack, the greater the lift will be. (3) The larger the wing surface area, the greater the lift will be. (4) The higher the density of the air, the more drag will be experienced. (5) The higher the engine thrust (is), the greater amount of drag will result.

1.3.6. (1 and 2) The aircraft's pitch can be changed (the nose can be pitched up or down).

1.8.2. (a) The MD-10 is not as high as the L1011 which is about 1 meter higher. (b) Both aircraft have nearly the same wingspan; the L1011 is a little more than 1 meter longer than the MD-10. (c) The L1011 is not as long as the A300. The A300 is 3 meters longer than the Lockheed. (d) The range of the A300 is less than that of the MD-10. The range of the MD-10 is nearly 6 thousand km greater than

the range of the A300. (e) The Lockheed does not transport as many passengers as the B747, which, on average, can carry 200 to 300 more passengers than the L1011. With respect to range, the L1011 has a greater range than the B757-100. However, both the B747-200 and 300 have greater ranges: the 200's being 10,900 km and the 300's being 10,500 km: two thousand km more than for the L1011. (f) The maximum take-off weight for the A300 is less than that of the B747 which has double the mtow of the Airbus.

#### 1.9.1. VOCABULARY PRACTICE (page 19)

(a) it must comply with airworthiness directives. (b) 4-abreast seating (c) today's frames make use of lighter composite materials. (d) adjustable leg rests, headrests, and dynamic lumbar support. (e) A flight from New York to Tokyo is referred to as a long-haul flight. Typically used for this type of flight is a widebody aircraft. A flight from London to Paris is a short-haul flight. Typically used for this type of flight is a narrowbody aircraft.

(f) seat-beds in individual private passenger cabin spaces (g) passenger seats found directly behind or aft of galleys have no table as there are no seats in front of them. For this reason seats in these areas are fitted with in-armrest tables.

(h) A door fitted with adjustable slam locks (i) Standard items of equipment will be found on all aircraft, and are Seller Furnished Equipment, whereas customers may request optional items which are called Buyer Furnished Equipment, or BFE.

(j) comply with (k) in keeping with/in compliance with/in accordance with  
(l) in keeping with/in accordance with

#### 1.9.3. CONFIGURATION DESCRIPTIONS (EXAMPLES) page 20

The first-class compartment features 6-abreast seating separated by two aisles, each 53.5 cm in width. Each 2-seat bank is 135 cm wide. The business class offers 8-abreast seating: a central 4-seat bank, and a 2-seat bank on either side. Individual seats are about 46 cm in width. In economy class we have 9-abreast seating separated by 2 aisles measuring only 14.5 cm in width. The 3-seat bank is 145 cm in length, meaning that each seat is about 48 cm wide (2 cm wider, apparently, than in business class!)

#### 1.9.7.A. PRACTICE (page 24) TRUE OR FALSE?

(1) FALSE. Each galley receives 3-phase AC power. (2) FALSE: "water supply via main water lines in the underside of the fuselage which also supply lavatory sinks and drainage systems."

(3) TRUE: 1.70 bar (4) TRUE: "A push-button switch for galley electrical power is found on the overhead panel in the cockpit."

(5) TRUE. "with all other electrical supply switches running galley equipment controls located in the galley structures."

(6) FALSE: "today modern steam ovens can heat up to 32 meals." (7) TRUE: "flight attendants wheel [them] up and down the aisle" (8) TRUE. Catering means to provide food and beverages to passengers. Trolleys make it possible to serve passengers in their seats.

#### 1.9.7.B. PRACTICE (page 24)

(1) standard outfitings (standard equipment) (2) a drainage system (3) sinks (4) a push-button switch (5) are ensured by the auxiliary power system, or APU (6) by a constant supply of electricity (7) galleys also feature refrigeration equipment and coffee makers (8) flight attendants to serve passengers food and beverages in their seats during flight (9) are stored under counter areas.

#### 1.9.7.C. PRACTICE (page 25)

The A340 is outfitted with rest areas for crew members. Rest areas provide relaxing and spacious accommodations for crew members during long-haul flights? Shown here is a special layout equipped with computer screens which allow crew members to monitor flight information.

#### 5.6.5. AIR DUCT FAILURE — VERBS AND TENSES (Page 91)

- (1) A hole measuring 1m x 70 cm was caused by the air duct failure.
- (2) An external panel located beneath the port wing was blown off.
- (3) The failure occurred while the aircraft was ascending through 16,000 ft.
- (4) The aircraft was climbing when the incident occurred/happened.
- (5) Pneumatic duct pressure suddenly dropped/fell to about 1/6 of its normal level.
- (6) Cabin depressurization did not occur.
- (7) No injuries were reported/ no injuries occurred.
- (8) No passengers were injured.
- (9) The aircraft had accumulated 38,786 hours in June of 1983.
- (10) The aircraft had already accumulated 38,786 hours when this incident occurred.

#### 5.7.1. ENLARGING VOCABULARY (Page 92)

- (1) The pilot failed to request clarification/neglected to request clarification.
- (2) The manufacturer failed to/neglected to notify the airlines that software modifications were available.
- (3) The co-pilot failed to check/neglected to check with the pilot on this procedure.
- (4) The co-pilot failed to/neglected to disengage the mode.
- (5) The pilot failed to act on time.
- (6) The pilot failed to contact the control tower in time. (did not manage to contact)
- (7) The control tower neglected to (failed to) inform the pilot of the conditions.
- (8) The flight control system failed to react.
- (9) The pilot was unable to/did not manage to/failed to/failed to bring it out of stall (did not succeed in/was not successful in bringing it out of stall)
- (10) The co-pilot tried unsuccessfully to help.
- (11) They did not manage to / were unable to stabilize the aircraft.
- (12) They neglected to request emergency landing authorization.
- (13) The control tower failed to respond immediately.
- (14) The ground personnel did not manage to arrive on the scene in time.
- (15) They were not successful in/didn't succeed in containing the fire.
- (16) Why didn't they manage to/ were they unable to contain the fire?
- (17) Why did they fail to intervene? Why were they unable to intervene?
- (18) They tried unsuccessfully to rescue the people.

#### 5.8.3. PRACTICE: CONDITIONALS (Page 95) POSSIBLE STATEMENTS

- (a) If the pilot had been monitoring the airspeed, he would have been able to react in time.
- (b) If maximum braking had not been delayed, the crash might have been averted.
- (c) If the nosewheel steering had been used properly, the incident might have been avoided.
- (d) If the captain had made use of the autobrake, he might have been able to prevent the crash.
- (e) If the first officer hadn't inadvertently disarmed the autothrottle, ground roll would not have been lengthened.
- (f) If the rudder had not been set in the full left position, there would not have been a severe deflection.
- (g) If the captain had succeeded in aborting take-off the crash would not have occurred and 2 people would not have been killed.
- (h) If the captain and first officer had not made the errors which they made this incident would not have occurred.

#### 5.8.4. MODALS SHOULD AND MIGHT + PERFECT INFINITIVE (Page 95)

- (a) The captain should have reacted in time so as to reject the take-off.

Monitor the oil temperature gauge during flight (*that* should not be used here).

Check/check to see that cylinder head temperature is normal.

Avoid/guard against high temperatures.

Avoid running engine on the ground for long periods.

Be sure that cowl flaps are open for maximum cooling.

Check/monitor engine instruments to confirm existence of a possible problem.

Refer to manual for instructions.

2.5.1. (Page 48)

(a) hydraulically-driven actuators (b) hydraulic (pump-driven) systems, or pumps (c) torque shafts

(d) inside the front of the integral wing tanks... house the slat drive tracks (e) the second will be driven at half speed

2.6.6. (Page 52)

(1) High tensile steel forgings (2) high-strength aluminum alloy components (3) it retracts forwards, extends downward. The main gear retracts sideways. (4) support fore and aft the shock absorber (5) support the shock absorber laterally (6) by means of (via) proximity detectors and associated logic controls

2.7.1. (Page 53)

(1) 3 sources of compressed air: the engine, the APU (auxiliary power unit), or ground supply source

(2) Bleed air is air drawn off ("tapped") from engines. (3) Packs are air-conditioning units which reduce the pressure of bleed air (and cool it at the same time). Packs are like large refrigerating units.

(4) via a pneumatic duct (5) On the ground and during flight, cabin temperature is maintained at about 20°C, or air conditioned to temperatures ranging between 25° to 27°C at 65% humidity when the outside temperature rises above 30°C. Controls are found in the cockpit and passenger cabins.

(5) The cockpit is supplied with fresh air continually and there are special provisions for windshield defogging, the purpose being in the first case to ensure proper ventilation for the crew alertness and in the second to ensure adequate visibility.

2.8.1. (Page 53)

(1) 86-90 US gallons (or about 340 l). (2) Water is supplied via water lines in the underfloor area; hot water is supplied via an electrical thermostatically-controlled heater located under lavatory wash basins.

(3) Drainage is achieved using open plug with and air stop device, with overflow ducts to keep basins from overflowing. (4) As used in official specifications, *mast* is a draining conduit.

2.9.1. (Page 54)

(a) to entail (b) to come up with (c) from the outset (d) obviously (e) to fit (f) to run into (g) drawback (h) to be faced with (i) numerous (j) upper part (k) extensive (l) to allow / to ensure

3.1.1. (Page 60)

(a) Turning effect is the power transmitted to the propeller from the engine.

(b) Torque is a force which produces rotation, here equivalent to turning effect.

(c) Horizontal lift force is the force generated by the propeller and which results in the aircraft's being "pulled" horizontally through the air.

(d) A propeller is a device, usually made of metal or of composites, which is designed to spin so as to create the horizontal lift force.

(e) Forward thrust is the force imparted to the aircraft resulting from the creation of a zone of lower pressure in front of the rotating propeller blades.

3.1.3. PRACTICE: RECALL ACTIVITY. (Page 61)

(1) needs/requires (2) converts/transforms (3) creates/generates (4) conveys/sends (5) transmits/conveys (6) rotates (7) transforms/converts (8) creates/generates (9) pulls/draws (10) rotates

3.1.4. PRACTICE: RECALL ACTIVITY (Page 61)

(1) piston (2) converts/transforms (3) power from the engine into thrust (4) power (5) conveys (6) shaft (7) turning effect (8) torque (9) torque (10) transforms the turning effect into a push or pull force called (11) horizontal lift force (12) through the air (13) rotates (14) ahead of the blade (15) lower (16) behind the blade (17) forward thrust

3.2.1. ANSWER (Page 62)

(1) The mobile components are the rotary disks; the immobile components are the rings of stationary blades called vanes or stators.

(2) The air is drawn into the compressor from outside through the air inlets. This is the inlet air.

Compression results from the forced movement of the airflow through the stators.

(3) Nozzles allow air to exit from the engine in a highly directed flow.

(4) Via shafts that draw in more air to be compressed.

3.2.3. PRACTICE: DEFINITIONS (Page 63)

Creep is defined as a deformation occurring in blades caused by the forces to which they are exposed and which causes the blades to become elongated.

Stators, also known as vanes, are rings of stationary blades fastened to the engine casing.

The compressor is one part of a jet engine which is composed of a series of rotating blades in rings of stators. The compressor draws in air from outside, and redirects airflow through the stators into the combustion chamber.

Corrosion is an alteration (usually) of metallic surfaces caused by the interaction of some gas or fluid and the material composing the surface.

Exhaust is the airflow exiting through nozzles at high speed.

GRAMMAR CHECKLIST #5

PRACTICE 1 (Page 65) POSSIBLE COMPLETIONS

(a) ...unless a pneumatic starter motor is used to start the engine turning

(b) ...until airflow through the compressor is sufficient

(c) ... unless electric igniters are used

(d) ... until a certain engine speed has been reached

(e) ...until the engine has become self-sustaining

(f) ... until the engine has been accelerated to a given speed

(g) ... cannot be achieved unless the thrust lever has been pushed forward/is pushed forward

PRACTICE 2 (Page 65) POSSIBLE STATEMENTS

(a) Only when a starter motor is used can sufficient airflow be achieved.

(b) Only when sufficient airflow has been achieved will/can fuel be injected.

(c) Not until a given rpm has been reached is the engine self-sustaining (will the engine be —)

(d) Not before the engine has become self-sustaining are the starters disengaged and the igniters switched off.

(e) Only when idle rpm has been reached does acceleration cease.

PRACTICE 3 (Page 65) POSSIBLE STATEMENTS

(a) Starting the engine requires first using a starter motor.

- (b) Attaining sufficient airflow requires using a starter motor.
- (c) Igniting the fuel involves using electric igniters.
- (d) Achieving idle rpm means accelerating the engine beyond the self-sustaining phase.
- (e) Accelerating beyond idle rpm requires pushing forward the thrust lever.

## PRACTICE 4. (Page 65)

(a) acceleration (b) achievement (c) attainment (d) disengagement (e) engagement (f) requirement

## 3.3.1. (Page 67)

- (a) Fan jet engines feature a fan operating in a duct to draw in additional air which is compressed through two or three spools and later expelled, providing extra thrust.
- (b) A bypass engine features a duct or channel (the bypass) which allows some of the N1 air to exhaust directly, thereby bypassing (not entering) the main engine.
- (c) A spool is one of several, usually three, sections of a large jet engine, powered by an individual turbine and connecting shaft.
- (d) A compressor is composed of two parts, one mobile, the rotors, which are large rotating blades, and the other immobile, the stators, which are stationary blades through which air is propelled by the rotors. Compressors compress air which is then directed into the combustion chamber.
- (e) The engine pipe, or jet pipe, is the exhaust duct from which the compressed and heated air exits from the turbine, undergoing rapid expansion as it does so.
- (f) Guide vanes are structures designed to direct or force air from the combustion chamber onto the turbine blades, causing their rotation.

## 3.3.2. PRACTICE (Page 67)

The first step involves drawing air into the compressor.

Then, this air is propelled through the stators to raise the pressure to required levels.

Before the air enters the combustion chamber it is propelled through a series of spools.

Some N1 air bypasses the main engine by means of a specially designed bypass channel or duct.

The bypassed air exhausts directly without entering the engine core.

The role of the N2 and N3 compressors is to compress the air even more.

In the combustion chamber about one third of the compressed air is mixed with injected fuel which burns at very high temperatures.

The next stage involves propelling the air through guide vanes onto turbine blades.

The air which is driven onto the turbine blades exits directly from the combustion chamber and causes the blades to rotate or spin.

## 3.3.3. ANSWER THESE QUESTIONS (Page 67)

- (1) The bleed valve located between these compressors had been exhibiting various problems such as binding, wear, failure and leakage.
- (2) P&W replaced the low-pressure turbine stage-five vanes from some engines.
- (3) The new fan-blade leading edge features a thicker radius designed to offer heightened resistance to foreign-body impacts. This new design was responsible for the cracking in leading edges. NOTE: *The sentence reads: offering a thicker radius was meant to provide heightened resistance to foreign-body impacts which was found to produce cracking in leading edges. The relative pronoun which must have as its antecedent a thicker radius and NOT foreign-body impacts because of the singular verb was. It is true that this possible confusion might have been avoided by rewording the sentence. But this compact (or compressed?) style is common in many articles of this nature.*
- (4) In-flight shutdowns were increasing in frequency, as is explained in the first paragraph.

## 2.2.10. PRACTICE (page 39)

- (1) It presented weak areas, it was less rigid, less strong.
- (2) It was shorter
- (3) There were not enough circuits, there were too few circuits.
- (4) It was thicker.
- (5) The angle was smaller.
- (6) It was heavier (heavier materials were used previously); its weight was greater.
- (7) They were narrower.
- (8) They were older, less efficient, worn, etc.
- (9) It was older, less sophisticated, was slower, etc.
- (10) Previously there was only one backup system.

## 2.2.11. A.PRACTICE: PASSIVE VOICE AND VERB TENSES (page 41) :

- (1) What is being done in this picture? (2) The wings are being joined. They are being moved into place. (3) The wing skins are being inspected visually. (4) Electric cables are being installed. (5) Fuselage junctions are being inspected (checked). (6) Hinges are being tested. (7) Several engineers are being consulted. (8) 4 or 5 technicians are being given final details concerning wing mounts.

## 2.2.11.B. (page 41)

- (1) The horizontal stabilizers haven't been joined. (2) The vertical stabilizer hasn't been joined. (3) Have the starboard service door and other doors been mounted (yet)? (4) The radome has (already) been mounted. (5) Has the aircraft been painted (yet)? (6) The seats haven't been installed (yet). (7) Have the cabin windows been installed (yet)? (8) Have the fuselage sections been joined (yet)? (9) The cabin layout hasn't been completed (yet). (It is in the process of being completed). (10) The cockpit layout hasn't been completed (yet). It is being done right now. (11) Have the cockpit windows been mounted (yet)? The picture shows us that they have (already been mounted). (12) Hydraulic lines haven't been placed in the wings (yet).

## 2.3.2. PRACTICE; (page 45)

- (a) If the pressure exceeds a given level damage to the engine or to its components can occur. High pressure can also cause valves to malfunction or lines to burst. Leakage can also result from excessively high oil pressure.
- (b) If impurities get into the oil and are not removed clogging may occur (pipes and/or valves may become clogged).
- (c) If oil filters are not inspected regularly, operators may overlook clogged filters and fail to replace them.
- (d) Because oil filters become clogged and inefficient they must be inspected and replaced regularly.
- (e) If an oil filter becomes clogged it lead to impurities in the oil/ it must be replaced immediately.
- (f) Oil is circulated by means of an oil pump.
- (g) The sump serves to siphon off, or to collect oil.

## 2.4.1 (page 46)

- (1) drives (2) converts (3) transformed (4) drive (5) heats up (6) cools (7) occurs (8) prevent (9) happening (10) provided

## 2.4.2. (Page 47)

- (1) b (2) f (3) g (4) a (5) c (6) i (7) d (8) j (9) h (10) e

## 2.4.3. (Page 47)

- (a) cowling (b) cowling duct (c) cowl(ing) outlet (d) baffle (e) CHT gauge

- (b) Attaining sufficient airflow requires using a starter motor.
- (c) Igniting the fuel involves using electric igniters.
- (d) Achieving idle rpm means accelerating the engine beyond the self-sustaining phase.
- (e) Accelerating beyond idle rpm requires pushing forward the thrust lever.

## PRACTICE 4. (Page 65)

(a) acceleration (b) achievement (c) attainment (d) disengagement (e) engagement (f) requirement  
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- (2) P&W replaced the low-pressure turbine stage-five vanes from some engines.
- (3) The new fan-blade leading edge features a thicker radius designed to offer heightened resistance to foreign-body impacts. This new design was responsible for the cracking in leading edges. NOTE: *The sentence reads:* offering a thicker radius was meant to provide heightened resistance to foreign-body impacts which was found to produce cracking in leading edges. *The relative pronoun which must have as its antecedent a thicker radius and NOT foreign-body impacts because of the singular verb was. It is true that this possible confusion might have been avoided by rewording the sentence. But this compact (or compressed?) style is common in many articles of this nature.*
- (4) In-flight shutdowns were increasing in frequency, as is explained in the first paragraph.

Shown here on the A340 are spacious accommodations on the lower level. The stairs lead up to the main level. A separate crew rest area is located adjacent to the lavatory facility. The area is well-lit via ceiling and recessed lights and a fresh air supply is ensured via the aircraft's air conditioning system.

## 1.10.B. (page 27)

Formation A: Four-abreast; the aircraft are side-by-side, one beside the other (one beside the next), one next to the other. Formation B: the aircraft are one over/above the other (one over/above the next).

## 1.10.C. (page 27)

Buttons F2, I2 and Y2 are arranged in a vertical row, one above the other. Button A is to the left of this row, next to I2. Buttons B1, B2 and B3 are also arranged in a vertical row, one above the next, to the right of F2, I2 and Y2. N1 and N2 are in the upper right-hand corner. N2 is to the right of B1, and N1 is directly above N2.

## SECTION 2.

## 2.1.1. PRACTICE (page 29)

(a) make up/comprise the fuselage. (b) ...make up/compose each section. (c) bulkheads (d) is divided/separated into areas called holds for passenger baggage and cargo, including containerized loads referred to as ULDs. (e) easy access for ground personnel at convenient heights (f) in the landing gear bays (g) is located the tailcone.

## 2.1.2. PRACTICE (page 29)

- (a) The forward pressure bulkhead serves to separate the cabin and crew fuselage areas from the radome.
- (b) The rear pressure bulkhead is the separation between the passenger cabin and the tailcone.
- (c) The pressure floor separates the passenger cabin from the underfloor areas used for transporting baggage and cargo.
- (d) Landing gear bays are areas in which the landing gear is folded and stored during flight.
- (e) Cargo holds are underfloor areas reserved for unit load devices (ULDs), cargo, or pallets.
- (f) ULDs are special containers in which individual items can be placed and transported.

## 2.1.4.A. PRACTICE (page 30)

(1) First the holes in the two pieces are aligned with each other and then the rivet can be passed through them. (2) The rounded head holds the rivet against the surface of the top piece in the illustrations. (3) The rivet pin can be made of steel, copper, aluminum or brass and can be either hollow or solid. (4) To hold the two pieces securely together, the opposite end of the rivet pin is hammered into a head. (5) It is impossible to remove a rivet unless one of the heads is cut off.

## 2.1.4.B. PRACTICE (page 30)

- (1) C fits onto the end of B. B fits into A.
- (2) A and B fit together (perfectly). The protruding end of B fits into the recessed part of A. The two dovetail.
- (3) A and B fit around C.
- (4) A fits (snugly) over B. A fits on over B.

## 2.2. WHAT IS THE WORD OR EXPRESSION (page 32)

(1) chord (2) dihedral angle (3) tracks (4) speed brakes (5) spoilers

## 2.2.1. READ, UNDERSTAND AND NOTE (page 32)

wingbox, front and rear spar, center spar, inter-spar ribs

Find the synonyms: (a) to pelt (b) tiny (c) omnidirectional (d) to stretch

2.2.13. WING STRUCTURES: See the figure on the last page.

## 2.2.3. READ, UNDERSTAND AND NOTE: WING TIP FENCES PRACTICE page 33)

I. Location: at the extremity, at the end of each wing. Purpose: to reduce drag

II. Three ways that drag is reduced. (1) reduction and control of the cross flow of air around the tips or extremities of the wings; (2) reduction, or sometimes elimination of vortices; (3) result in enhanced lift distribution

## 2.2.5. ANSWER THESE QUESTIONS (page 33)

- (1) They help to do away with wing tip vortices
- (2) They provide enhanced lift distribution, better control of the cross flow of air around the tips.
- (3) An aircraft without wing tip fences may experience more drag (and this results in greater fuel consumption).
- (4) It results in reduced lift, and the aircraft descends.
- (5) When spoilers are deployed lift is reduced, speed is decreased and the aircraft descends.
- (6) They reduce lift on landing because they disrupt airflow on wing surfaces.

## 2.2.6. C. NEW WING FOR NEW GENERATION OF BOEING 737 (page 35)

- (1) The wingspan was stretched so as to
- (2) The rear spar was moved aft so as to improve fuel capacity.
- (3) The wing was redesigned so as to lead to a more fuel-efficient aircraft.
- (4) The modified dimensions enabled the aircraft to achieve a more economical fuel speed/
- (5) The increase in length also made it possible to redesign fuel and surge tanks/boost or increase fuel capacity.

## DO YOU KNOW ALL THE FORMS? (page 35)

| VERBS      | NOUNS       | VERBS       | NOUNS            | NOUNS       | VERBS       |
|------------|-------------|-------------|------------------|-------------|-------------|
| to offer   | offer       | to stretch  | stretch          | a redesign  | to redesign |
| to benefit | benefit     | to enlarge  | enlargement      | an increase | to increase |
| to feature | feature     | to extend   | extent/extension | an addition | to add      |
| to achieve | achievement | to expand   | expansion        |             |             |
| to result  | result      | to improve  | improvement      |             |             |
| to yield   | yield       | to move     | movement/motion  |             |             |
| to bring   | X           | to lengthen | lengthening      |             |             |

## 2.2.9. PRACTICE. DESCRIBING MODIFICATIONS (page 39)

- (a) We have lightened it/reduced its weight/made a reduction in its weight.
- (b) We have strengthened it/reinforced it.
- (c) We have widened it/ increased its width.
- (d) We have lowered it/reduced its height. (e) We have raised it/increased it.
- (f) We have thinned it/reduced its thickness (g) We have shortened it/reduced its length.
- (h) We have thickened it/made it thicker/increased its thickness
- (i) We have lengthened it/increased its length/made it longer
- (j) We have simplified it/made it less complicated
- (k) We have enlarged it/made it larger/increased its size
- (l) We have reduced the number of parts/done away with (eliminated) some of the parts.
- (m) We have increased it (n) We have smoothed it/made it smoother/eliminated the roughness.
- (o) We have made it harder (p) We have loosened it
- (q) We have strengthened/fortified/reinforced it. (r) We have tightened it.
- (s) We have lowered it/reduced it.
- (t) We have softened it (material) / made it easier, less difficult (subject)

## 3.4.3. TERMS YOU SHOULD KNOW (Page 69)

(1) turbine discharge (2) ratio (3) set (4) performance (5) set (6) clear (7) climbs... levels off ... cruise ... descent...approach...landing (8) aborts...go-around (9) inlet

## 3.5.1. READ AND PRACTICE (page 70)

In 1996 numerous reports of engine rundown were experienced/encountered on flights with the B757 and led Boeing to issue warnings to operators. The incidents occurred at the top of descent when thrust was reduced to low idle using autothrottle command and in acceleration from low idle. Other incidents were reported subsequent to engaging engine anti-ice in early descent stages in poor weather conditions. Although incidents involved/concerned one engine, the remaining engine revealed core-compressor stall in several instances.

- (1) Weather conditions seemed to have a direct bearing on engine anomalies because the incidents were reported in connection with anti-icing.
- (2) Incidents of engine rundown were also linked to changes in thrust since incidents occurred when thrust was reduced to low idle and in accelerating from low idle.
- (3) To solve this problem, it was decided to raise compressor stall margins.
- (4) To achieve this, two other changes needed to be made, namely modifications to the bleed valve-control unit and also to the fuel-flow governor.

## 3.5.2. WHICH... (Page 70)

- (1) It was Cathay Airlines which wanted an engine with a maximum thrust of 567.5 kN.
- (2) The engine which Boeing had designated was the RR Trent 800 / The engine which Boeing had designated did not provide the thrust required by Cathay Airlines.
- (3) The RR Trent 800, which had been designated by Boeing, provided a thrust ratio of 396 kN.
- (4) The engine which Cathay Airlines wanted/requested had to provide a maximum thrust of 567.5 kN.
- (5) The maximum thrust which the RR Trent 800 could provide was 409.413 kN.
- (6) RR engineers envisioned increasing fan size, a move which would result in more thrust, but which would also entail a weight penalty.

## 3.5.3. PRACTICE (Page 70)

(a) 396 kN (b) 409.413 kN (c) 567.5 kN (d) 423 kN (e) 277,270 kg (f) a weight penalty on the order of several hundreds of pounds (g) would require an additional turbine stage (h) would defeat any gains in power (i) any appreciable gains in power would be offset by a weight penalty.

## 3.6.3. PRACTICE: COMPLETE EACH STATEMENT (page 71)

- (a) ... to comply with legislation/ to avoid landing fee surcharges (and/or fines or legal action brought by the authorities)
- (b) ... older engines are noisier/generate or produce more noise
- (c) ... reduce the noise level
- (d) ... the noise levels of older aircraft are excessive and therefore do not comply with current legislation.

4.1. (1) The side-facing crew cockpit was the conventional arrangement that featured 3 or 4 seats; the forward-facing crew cockpit design pioneered by Airbus on the A310 did away with the third (and fourth) seats, not without loud protests from some.

(2) CMI designates the pilot and CM2 the co-pilot.

## 4.3.1. COMPLETE OR ANSWER (Page 76)

- (1) Aircraft Information Management System
- (2) two separate cabinets that contain all input and output hardware