ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL TWO

INSTRUCTIONAL GUIDE

SECTION 5

EO M231.05 – DESCRIBE AIRCRAFT CONTROL SURFACES

Total Time: 60 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-802/PG-001, Chapter 4. Specific uses for said resources are identified throughout the Instructional Guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Create presentation slides or handouts of Figures A-1, B-1, C-1 and D-1.

Create handouts of Figure E-1.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for TP1 to TP4 and TP6 to TP10 to introduce aircraft control surfaces and give an overview of them.

An in-class activity was chosen for TP5 and TP11 as it is an interactive way to provoke thought and stimulate an interest among the cadets.

INTRODUCTION

REVIEW

Review EO M231.01 (Identify the Four Forces That Act Upon an Aircraft) and EO M231.04 (Describe the Axial Movements of an Aircraft), to include:

- Weight,
- Drag,
- Thrust,
- Lift,
- Yaw,
- Pitch, and

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- Roll.

OBJECTIVES

By the end of this lesson the cadet shall be expected to identify and describe the locations, operations, methods and purposes of aircraft control surfaces.

IMPORTANCE

It is important for cadets to learn about aircraft control surfaces so they can understand subsequent and related principles of flight.

Teaching point 1 **Identify Control Surface of the Empennage**

Time: 5 min Method: Interactive Lecture

An aircraft's empennage is very often called the tail section. Its most obvious parts are the vertical and horizontal stabilizers, each of which has other names as well. The vertical stabilizer is sometimes referred to as the fin and the horizontal stabilizer is sometimes referred to as the tailplane.



Use a model of a light fixed-wing aircraft with control surface detail to demonstrate the location of the empennage and associated control surfaces.

The rudder is hinged to the back of the vertical stabilizer or fin. It is used to steer (yaw) the aircraft around the vertical axis.



Show the cadets a slide or handout of the aircraft control surfaces located at Annex A.

The elevator is hinged to the back of the horizontal stabilizer or tailplane. It is used to climb or descend by changing pitch around the lateral axis.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. What two stabilizers are found on the empennage?

Q2. Which two moveable control surfaces are located in the empennage?

Q3. What axial movements do the elevator and the rudder produce?

ANTICIPATED ANSWERS

A1. The vertical stabilizer, or fin, and the horizontal stabilizer, or tailplane, are on the empennage.

A2. The rudder and the elevator are found in the empennage.

A3. The rudder changes yaw around the vertical axis and the elevator changes pitch around the lateral axis.

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Teaching point 2 **Explain How Stabilizers Reduce Unwanted Axial Movement**

Time: 5 min Method: Interactive Lecture

The horizontal and vertical stabilizers reduce unwanted pitch and yaw. The control surfaces are held straight by the passing wind. This is because the air moving past the flat surfaces of the stabilizers tends to resist a change of direction as predicted by Newton's second law (a force must be applied to alter the motion of the air).



Use a model of a light fixed-wing aircraft with control surface detail to demonstrate the location of the vertical and horizontal stabilizers.

The vertical stabilizer, or fin, provides the aircraft with directional stability. Air moving past the fin resists any unwanted yaw around the vertical axis.

The horizontal stabilizer, or tailplane, provides the aircraft with longitudinal stability. That is, air moving past the tailplane resists unwanted roll around the longitudinal axis and unwanted pitch around the lateral axis.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS

Q1. What axial movement does the vertical stabilizer or fin reduce?

Q2. What axial movement does the horizontal stabilizer or tailplane reduce?

Q3. How do stabilizers reduce unwanted axial movements?

ANTICIPATED ANSWERS

A1. The vertical stabilizer reduces unwanted roll and unwanted yaw.

A2. The horizontal stabilizer reduces unwanted roll and unwanted pitch.

A3. Air moving past the flat stabilizer surfaces tends to resist any change of motion.

Teaching point 3 **Explain How the Rudder Produces Yaw**

Time: 5 min Method: Interactive Lecture

The rudder is located at the very back of the aircraft, hinged to the trailing edge of the vertical stabilizer, or fin. The rudder can be turned left and right to give the pilot directional control. The rudder rotates the aircraft about its vertical (yaw) axis by pushing the tail to the left or to the right.



The rudder operated by itself causes the aircraft to yaw around its vertical axis.

When the rudder is turned to the right side of the fin, the moving air will push the empennage to the left, causing the aircraft to yaw to the right around its vertical axis.

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When the rudder is turned to the left side of the fin, the moving air will push the empennage to the right, causing the aircraft to yaw to the left around its vertical axis.



Show the cadets a slide or handout of the rudder control system located at Annex B.

The rudder is operated by the rudder bar or pedals in the cockpit. The pedals work together. When the bar or pedals are level the rudder is straight. Pressure applied to the right pedal moves the left pedal upwards and vice versa.

Pressure on the left rudder pedal displaces the rudder to the left into the airflow. This increases pressure on the left side and forces the tail to move to the right. This moves the nose of the aircraft to the left. Conversely, pressure applied to the right pedal moves the rudder to the right. The tail moves to the left and the aircraft yaws to the right.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS

Q1. Where is the rudder located?

Q2. What is the rudder used for?

Q3. What controls the rudder?

ANTICIPATED ANSWERS

A1. The rudder is hinged to the trailing edge of the vertical stabilizer of fin.

A2. To produce controlled yaw by rotating the aircraft about its vertical (yaw) axis.

A3. A set of pedals in the cockpit.

Teaching point 4 **Explain How the Elevator Controls Pitch**

Time: 5 min Method: Interactive Lecture

Both the left and right portions of the horizontal stabilizer, or tailplane, have a moveable control surface known as an elevator.



The elevator rotates the aircraft about its lateral (pitch) axis by pushing the empennage, or tail-section, up or down.

The elevator, of which there is normally a left and a right section, is located on the trailing edge of the horizontal stabilizer. It is used to give the pilot lateral control. Raising the elevator into the moving air above the tailplane will push the empennage down, thus raising the aircraft's nose. Alternately, lowering the elevator down into the air moving below the tailplane will push the empennage up, thus lowering the aircraft's nose. These pitch movements take place around the lateral axis.

The pilot controls the elevator by pushing or pulling on the control column.

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Pushing the control column forward lowers the elevator into the wind passing under the tailplane, pushing the empennage up. This causes the aircraft's nose to drop and the aircraft will descend.

Pulling the control column back raises the elevator into the wind passing over the tailplane, pushing the empennage down. This causes the aircrafts nose to rise and the aircraft will climb.



Show the cadets a slide or handout of the elevator control system located at Annex C.

CONFIRMATION OF TEACHING POINT 4

QUESTIONS

Q1. Where is the elevator control surface located?

Q2. What axial movement does the elevator control?

Q3. How does the pilot operate the elevator?

ANTICIPATED ANSWERS

A1. The elevator control surface is located on the trailing edge of the horizontal stabilizer.

A2. The elevator controls pitch around the aircraft's lateral axis.

A3. The pilot pushes on the control column to descend and pulls back to climb.

Teaching point 5 **Enact Control Surface Movements Controlled by a Pilot**

Time: 5 min Method: In-Class Activity



Review the cockpit controls that move the associated empennage control surfaces. Have the cadets enact control movements with a "pilot" calling out pedal and stick movements to the remainder of the class, who then act as pitch and yaw control surfaces.

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets learn what cockpit control causes which control surface to move.

RESOURCES

N/A.

ACTIVITY LAYOUT

Form the cadets into a circle. Have the cadet who is the pilot seated where the other cadets can see the pilot's movements.

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ACTIVITY INSTRUCTIONS

One cadet is designated the pilot and is seated in the clear view of the standing cadets. The seated cadet, who is the pilot, will pretend to move pedals and pretend to move a control column, but only one at a time.

Divide the remainder of the class into “rudders” and “elevators”. The standing cadets must mimic the correct moving control surface with their right arm (elevator: up and down) or left arm (rudder: left and right). After a minute of imaginary flight, ask the cadets to perform both elevator and rudder movements with both right and left hands simultaneously.

SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 5

The cadets’ participation in the activity will serve as the confirmation of this TP.

Teaching point 6 **Identify the Wing Control Surfaces**

Time: 5 min Method: Interactive Lecture



Show the cadets a slide or handout of the aircraft control surfaces located at Annex A.

AILERONS

The surfaces that control roll are located near the ends of the wings on the trailing edge. They are called ailerons.



Ailerons operate simultaneously, but in opposite directions. When the right aileron rises to push the right wing down, the left aileron lowers to push the left wing up.

The down-going aileron increases the wing’s lift and the up-going aileron decreases the wing’s lift. Therefore, the left wing’s lift increases and the right wing’s lift decreases. The left wing lifts and the right wing descends, so the aircraft rolls to the right and keeps rolling until the ailerons are retracted.

To recover from the roll, the ailerons must be applied in the opposite direction until the aircraft is level and the ailerons are then again neutralized for level flight.



Show the cadets a slide or handout of the aileron control surface located at Annex D.

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WING FLAPS



Show the cadets a slide or handout of the aircraft control surfaces located at Annex A.

Flaps are located nearer the fuselage on the trailing edge of the wing.

Both flaps operate together. They are raised together and they are lowered together with one control mechanism.

Flaps are lowered to create lift and to slow the aircraft. When they are lowered into the air moving past the under-surface of the wing, they slow the air and the air pushes them up, creating lift while simultaneously slowing the aircraft by creating both form drag and induced drag. When fully lowered, the drag created exceeds the lift generated.



Flaps allow for shorter landings.

CONFIRMATION OF TEACHING POINT 6

QUESTIONS

Q1. Which two wing control surfaces always move in opposite directions?

Q2. What axial movement do ailerons control?

Q3. How do flaps help with landings?

ANTICIPATED ANSWERS

A1. The left aileron and the right aileron.

A2. Ailerons control roll around the longitudinal axis.

A3. Flaps slow the aircraft allowing shorter landings.

Teaching point 7 **Explain the Operation of Ailerons**

Time: 5 min Method: Interactive Lecture

Ailerons lift one wing and lower the opposite wing simultaneously as a single cockpit control is operated to produce roll.



Ailerons move in opposite directions to each other and are controlled by operating the control column from side to side.

When the control column is moved to the right, the left aileron moves down and the right aileron moves up so the aircraft rolls to the right into a banked position.

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When the control column is moved to the left, the left aileron goes up and the right one moves down so the aircraft rolls to the left into a banked position.

When the pilot wants to stop the roll and stay in a banked position, the control column is returned to centre and the ailerons retract. To recover from the roll into a level position, the ailerons must be extended into the opposite directions. They are then retracted for level flight.

CONFIRMATION OF TEACHING POINT 7

QUESTIONS

Q1. How do ailerons produce roll around the longitudinal axis?

Q2. How does the pilot control the ailerons?

Q3. How does the pilot stop the roll and stay in the banked position?

ANTICIPATED ANSWERS

A1. As one aileron is raised the other is lowered so they push up on one wing and down on the other simultaneously.

A2. The pilot moves the control column to the left to roll to the left and to the right to roll to the right.

A3. To stop the roll and stay in a bank, the pilot returns the control column to centre.

Teaching point 8 **Explain the Operation of Flaps**

Time: 5 min Method: Interactive Lecture

The aircraft's flaps are also located on the trailing edge of the wing, as are ailerons, but the flaps are placed nearer to the fuselage.

Flaps are used to generate lift at the expense of airspeed and both left and right flaps operate simultaneously.



Show the cadets a slide or handout of the aircraft control surfaces located at Annex A.

Both flaps operate together. They are raised together and lowered together.

Flaps are lowered to create lift and to slow the aircraft. When they are lowered into the air moving past the under-surface of the wing, they slow the air and the air pushes them up, creating lift while simultaneously slowing the aircraft by creating both form drag and induced drag. When fully lowered, the drag created exceeds the lift generated.



Flaps allow for shorter and safer landings.

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CONFIRMATION OF TEACHING POINT 8

QUESTIONS

Q1. Where are an aircraft's flaps located?

Q2. What are flaps used for?

Q3. How do flaps affect an aircraft's landing performance?

ANTICIPATED ANSWERS

A1. An aircraft's flaps are located on the trailing edge of the wings, close to the fuselage.

A2. Flaps are used to slow the aircraft and simultaneously generate lift.

A3. By slowing the aircraft, flaps allow shorter and safer landings.

Teaching point 9 **Explain the Use of Trim Tabs**

Time: 5 min Method: Interactive Lecture

Trim tabs were developed to hold control surfaces in position without constant control pressure from the pilot.

A pilot has to do a lot of work to hold control surfaces in position. When the pilot has set a course in a crosswind, the control surfaces often have to stay in a working position for long periods of time.

To save the pilot from having to do this, trim tabs were invented. A trim tab is a small, adjustable control surface that can be extended from the trailing edge of an aircraft's control surface. So, it is a control surface that is hinged onto a larger control surface. The wind, pushing on the trim tab when it is extended, provides the force necessary to hold the aircraft's main control surface in position.



Trim tabs are often found on the trailing edge of the rudder, the elevators and on the ailerons.

CONFIRMATION OF TEACHING POINT 9

QUESTIONS

Q1. What are trim tabs for?

Q2. Where are trim tabs located?

Q3. How does a trim tab work?

ANTICIPATED ANSWERS

A1. Trim tabs hold control surfaces in position without constant control pressure being applied by the pilot.

A2. Trim tabs are often located on the trailing edge of control surfaces.

A3. Air pushes on the trim tab when it is extended and provides force to hold the aircraft control surface in position.

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Teaching point 10 **Explain the Use of Dynamically Balanced Control Surfaces**

Time: 5 min Method: Interactive Lecture

Dynamically balanced control surfaces were developed to make pilots' work easier. These surfaces use air pressure to help move the controls by having a portion of the control surface in front of its own hinge to catch the passing air. This takes the load off the pilot's control mechanism. That way, the wind itself helps push the control surface into the position that the pilot has selected, making the controls feel lighter.

CONFIRMATION OF TEACHING POINT 10

QUESTIONS

Q1. Why are control surfaces dynamically balanced?

Q2. What do dynamically balanced controls use to help the pilot?

Q3. How does dynamic balance get the wind to help move the control surfaces?

ANTICIPATED ANSWERS

A1. Control surfaces are dynamically balanced to make them easier to operate.

A2. Dynamically balanced controls use the force of the wind to help operate the control surfaces.

A3. The moving air helps operate the control surface because part of the control surface is designed to project out into the wind in front of its own hinge to catch the passing air.

Teaching point 11 **Colour and Label the Control Surfaces in a Drawing of an Aircraft**

Time: 5 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets label the control surfaces shown on a scale drawing.

RESOURCES

Coloured pencils.

ACTIVITY LAYOUT

N/A.

ACTIVITY INSTRUCTIONS

Give each cadet a copy of the aircraft drawing located at Annex E and access to a variety of coloured pencils. Have each cadet colour the control surfaces and label them.

Supervise and answer questions during this activity to ensure that the colouring and labelling is done accurately.

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SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 11

The cadets' participation in the activity will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. What is one moveable aircraft control surface and what is it used for?

Q2. What is a second moveable aircraft control surface and what is it used for?

Q3. What is a third moveable aircraft control surface and what is it used for?

Q4. What is a fourth moveable aircraft control surface and what is it used for?

Q5. What is a fifth moveable aircraft control surface and what is it used for?

ANTICIPATED ANSWERS

A1. Elevators are used to produce controlled pitch of the aircraft.

A2. Rudders are used to produce controlled yaw of the aircraft.

A3. Ailerons are used to produce controlled roll of the aircraft.

A4. Flaps are used to create lift and slow the aircraft simultaneously.

A5. Trim tabs are used to hold the control surfaces where the pilot wants them.

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

N/A.

CLOSING STATEMENT

Control surfaces are important parts of an aircraft, which control movement around the aircraft's three axes. Knowing about them is important for understanding the principles of flight.

INSTRUCTOR NOTES/REMARKS

N/A.

REFERENCES

C3-116 A-CR-CCP-263/PT-001/(ISBN 0-9680390-5-7) MacDonald, A. F. and Peppler, I. L. (2000). *From the Ground Up: Millennium Edition.* Ottawa, ON: Aviation Publishers Co. Limited.

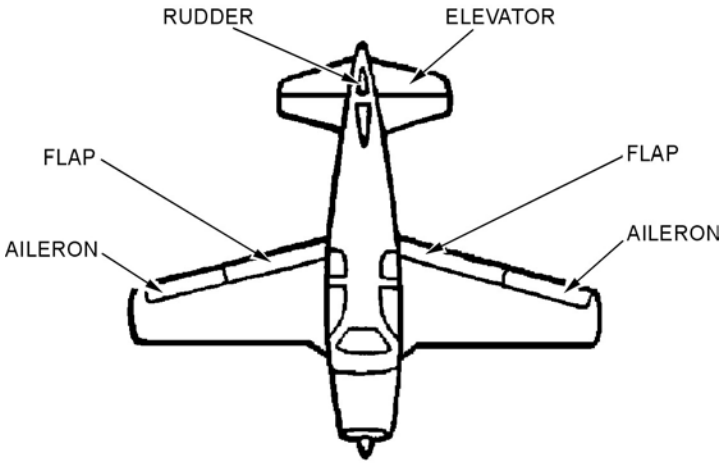
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AIRCRAFT CONTROL SURFACES

CONTROL SURFACES



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Figure A-1 The Control Surfaces of an Aircraft

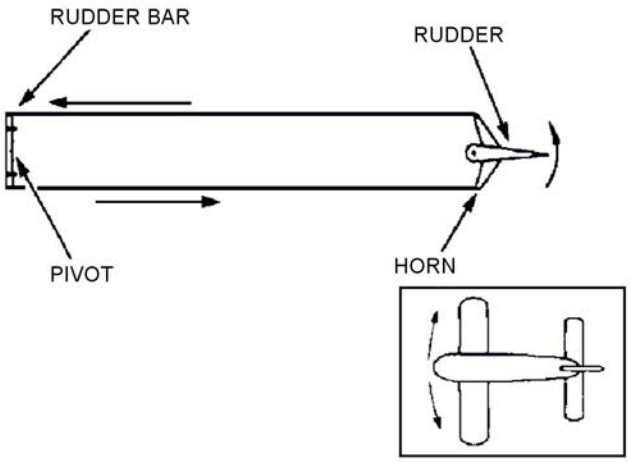
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RUDDER CONTROL SYSTEM

THE RUDDER



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Figure B-1 Operation of a Rudder

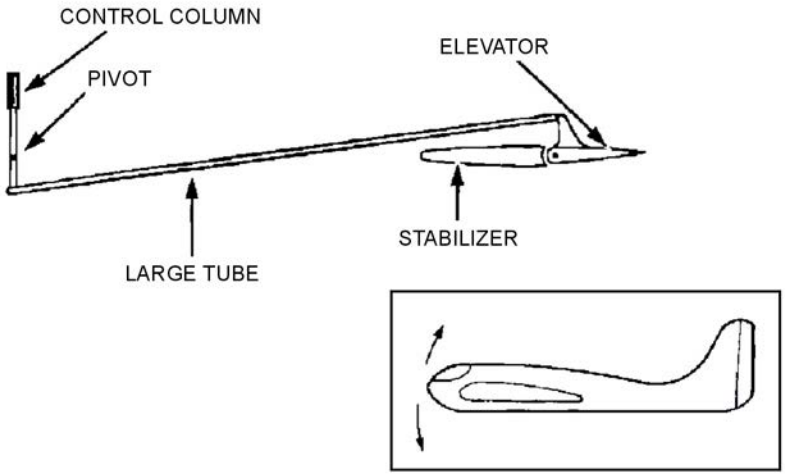
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ELEVATOR CONTROL SYSTEM

THE ELEVATOR



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Figure C-1 Operation of an Elevator

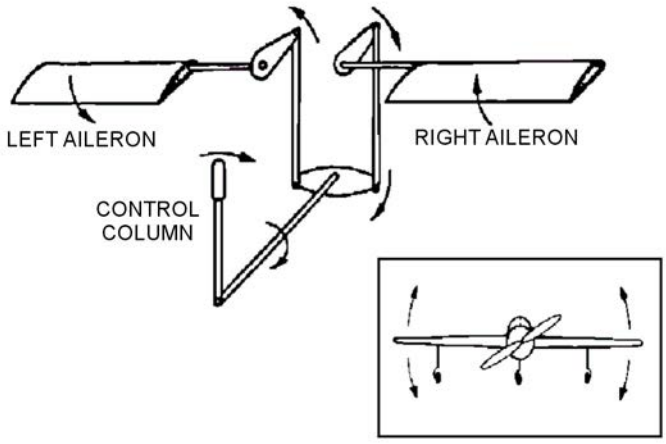
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AILERON CONTROL SYSTEM

THE AILERONS



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Figure D-1 Operation of Ailerons

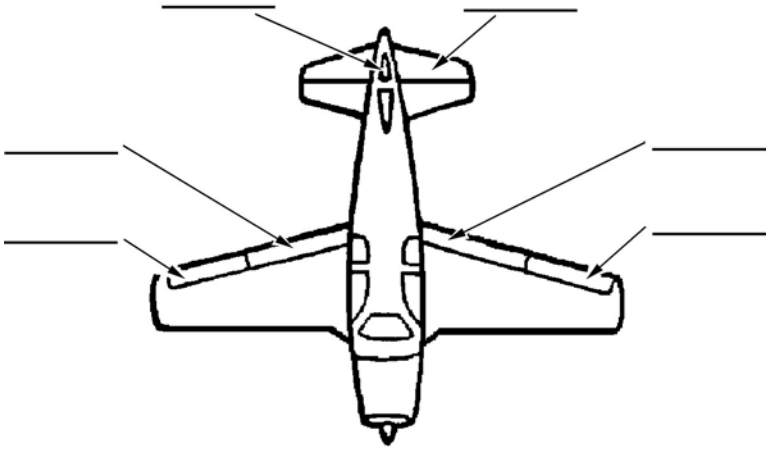
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IDENTIFYING THE CONTROL SURFACES

CONTROL SURFACES



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Figure E-1 Identifying the Control Surfaces of an Aircraft

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