



AEROSPACE RECOMMENDED PRACTICE

ARP6252™

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Integrated Rudder and Brake Pedal Unit, General Requirements for Fly-By Wire Transport and Business Aircraft

RATIONALE

There is a need for a document that provides general requirements for an integrated rudder and brake pedal unit based on a passive force-feel system that could be used interconnected with a similar unit for the adjacent pilot. This is because, increasingly, commercial fixed-wing transport and business aircraft are using fly-by wire flight control systems and the OEMs wish to control them with integrated rudder and brake pedal inceptor units, rather than the mechanism and sub-assemblies previously used.

This document satisfies this need.

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1. SCOPE

This Aerospace Recommended Practice (ARP) provides general requirements for a generic, integrated rudder and brake pedal unit, incorporating a passive force-feel system that could be used for fixed-wing fly-by wire transport and business aircraft.

This ARP addresses the following:

- The functions to be implemented
- The mechanical interconnection between captain and F/O station
- The geometric and mechanical characteristics
- The mechanical, electrical, and electronic interfaces
- The safety and certification requirements

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Telephone: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), <http://www.sae.org>

AIR5372	Information on Brake-By-Wire (BBW) Brake Control Systems
ARP4386	Terminology and Definitions for Aerospace, Fluid Power, Actuation, and Control Technologies
ARP4754	Guidelines for Development of Civil Aircraft and Systems
ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
ARP5724	Aerospace - Testing of Electromechanical Actuators, General Guidelines for
AS94900	Vehicle Management Systems - Flight Control Function, Design, Installation, and Test of Piloted Military Aircraft, General Specification for

2.1.2 EASA Publications

Available from European Aviation Safety Agency, Ottoplatz, 1, D-50679 Cologne, Germany, Tel: +49 221 8999 000, www.easa.europa.eu.

CS-23	Certification Specifications for Normal, Utility, Aerobatic, and Commuter Aeroplanes
CS-25	Certification Specifications for Large Aeroplanes

2.1.3 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

14 CFR Part 23 Code of Federal Regulations, Part 23 Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

14 CFR Part 25 Code of Federal Regulations, Part 25 Airworthiness Standards: Transport Category Airplanes

Advisory Circular AC 20-175 Controls for Flight Deck Systems

2.1.4 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA/DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

RTCA/DO-178 Software Considerations in Airborne Systems and Equipment Certification

RTCA/DO-254 Design Assurance Guidance for Airborne Electronic Hardware Considerations in Airborne Systems and Equipment Certification

2.1.5 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

MIL-STD-461 Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests

2.1.6 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 2669 Environmental Tests for Aircraft Equipment - Steady-State Acceleration

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS8584 Brake Systems, Wheel, Military Aircraft

2.2.2 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

DOD-HDBK-743	Anthropometry of U.S. Military Personnel
MIL-E-5400	Military Specification, Electronic Equipment, Airborne, General Specification
MIL-F-83300	Flying Qualities of Piloted V/STOL Aircraft
MIL-STD-883	Test Method Standard Microcircuits
MIL-STD-1797	Flying Qualities of Piloted Aircraft

2.3 Definitions

2.3.1 General terms

INCEPTOR: This is a device that is used to provide pilot control inputs and covers a variety of aircraft pilot controls including:

- The side sticks and center sticks
- The control columns, wheels, and yokes
- The pedals
- The throttles
- The rotorcraft cyclic and collective controls

PASSIVE INCEPTOR: This is a passive control inceptor system that primarily generates the artificial feel by passive mechanical elements like springs and dampers to achieve force profile gradients without active variation of feel forces.

NOTE: These passive elements could have some parameter changes regarding aircraft attitude and speed.

ZERO FORCE NULL BAND OR NULL BACKLASH: This is the range of inceptor displacement, with no applied force, over which the inceptor is statically stable.

NOTE: The zero force null band is typically determined by releasing the inceptor from deflected positions and determining where it comes to rest.

BREAKOUT FORCE: This is the force applied to the inceptor which creates a displacement captured by the inceptor sensors for a sensor output value specified by the customer.

TRIM: In this ARP, the rudder pedal trim function is used when the trim actuator is moving the anchor point of the rudder pedal artificial feel.

For other general terms, refer to ARP4386.

2.3.2 Specific Terms for Rudder and Brake Pedal Unit

The definitions of the angular positions and displacements of rudder and brake pedal units are provided in Figures 1 and 2.

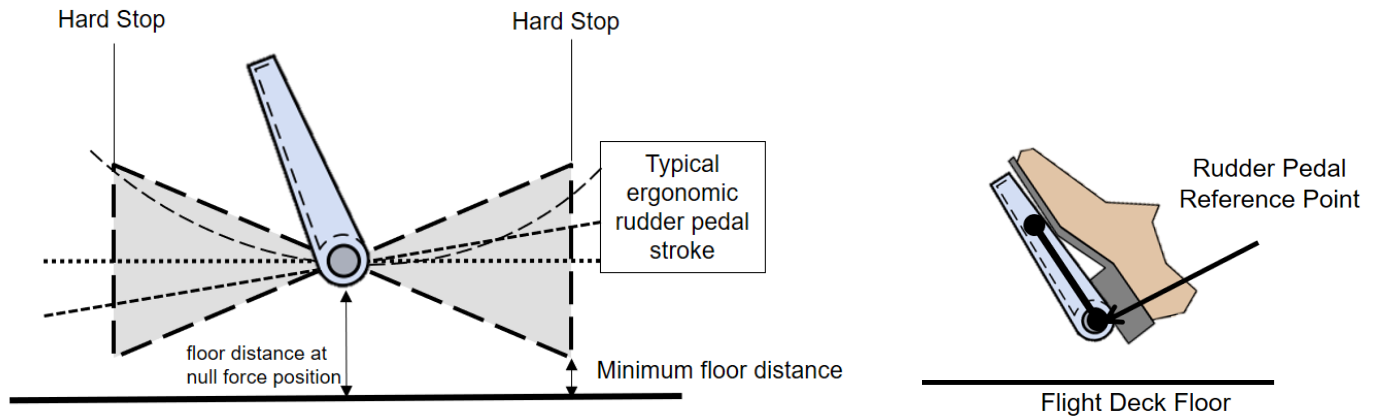


Figure 1 - Typical geometry definitions at null force position for rudder pedals

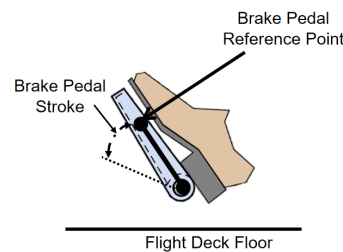


Figure 2 - Typical geometry definitions at null force for the brake pedal

PEDAL INTERFACE POINT: This is the point on the pedal from which applied force and pedal displacement are defined when moving the rudder pedal.

BRAKE PEDAL INTERFACE POINT: This is the point on the pedal from which applied force and pedal displacement are defined when moving the brake pedal.

RUDDER PEDAL ARM: This is the distance between the rotation axis for the rudder pedal motion and the pedal interface point for rudder pedals motion.

RUDDER PEDAL DISPLACEMENT: This is the travel of the rudder pedal when activated by the pilot. It could be defined as a distance (circular stroke; linear distance along an arc) or as an angular displacement.

RUDDER PEDAL FULL STROKE: This is the travel of the rudder pedal when activated by the pilot from one stop to the other stop.

BRAKE PEDAL STROKE OR DISPLACEMENT: This is the angular displacement for the brake command.

NOTE: AIR5372 provides some information about brake pedal displacement.

2.4 Abbreviations

FC: Flight Cycles

FDAL: Function Design Assurance Level

FH: Flight Hours

F/O: First Officer

LVDT: Linear Variable Differential Transformer

MTBF: Mean Time Between Failure

MTBUR: Mean Time Between Unscheduled Removal

OEM: Original Equipment Manufacturer

RVDT: Rotary Variable Differential Transformer

PIO: Pilot-Induced Oscillation

3. FUNCTIONS AND GENERAL DESCRIPTION

The rudder and brake pedal unit described in this document includes the following functions which might be included in the customer specification, depending on the cockpit architecture and other factors.

a. A captain station with two pedals (left and right).

The left and right pedals are connected by mechanical devices to provide the opposite displacement.

b. An F/O station with two pedals (left and right).

The left and right pedals are connected by mechanical devices to have the opposite displacement.

c. Position sensors for the rudder command, which provide increasing and decreasing position signals relative to the pedal's rudder null stroke to the flight control computers; the number and type required depend on the system architecture.

One or more sensors might be connected to a flight data recorder.

d. Position sensors for brake command, which provide increasing and decreasing position signals relative to the brake pedal's null stroke to control computers; the number and type required depend on the system architecture.

One or more sensors might be connected to flight data recorder. The sensors output should be phased in such a way that increasing electrical output is achieved for forward motion of the right pedal of each station.

e. Rudder and brake artificial feel and centering devices.

f. Rudder pedal damping device (if needed).

g. A connecting mechanical system between the two stations for rudder command (typical).

h. A connecting mechanical system between the two stations for brake command (if needed).

i. A redundant structure depending on the safety assessment and design.

j. Segregated electrical harnesses including aircraft interface connectors.

- k. Protection devices to prevent foreign object ingress.
 - l. Mechanical stops for rudder and brake pedal movement.
 - m. Access for a standard rigging pin to hold the pedals in neutral position and allow interconnection adjustment (if needed).
 - n. Trim function (if needed) or an attachment point for trim function.
 - o. Back drive function (if needed) or an attachment point for back drive function.
 - p. Position sensors for steering command (if needed).
 - q. A disconnection device system allowing single pilot displacement in event of jam (if needed).
 - r. A mechanical or electromechanical device to adjust the station null position to accommodate different pilot heights.
4. INFORMATION TRANSMISSION FOR DIGITAL FLIGHT DATA RECORDERS FOR TRANSPORT CATEGORY AIRPLANES ACCORDING TO CFR PART 121.344/CS 121.344 INTEGRATION IN THE COCKPIT

4.1 Location in Typical Two-Crew Cockpit

Figure 3 shows a typical flight deck installation.



Figure 3 - Typical installation

The captain and the F/O stations are typically connected mechanically to synchronize the pedal positions between their stations.

Each station may have its own set of functions, depending the safety assessment and system architecture.

4.2 Envelope and General Geometry

Figures 4 and 5 show the typical envelope for a rudder and brake pedal unit.

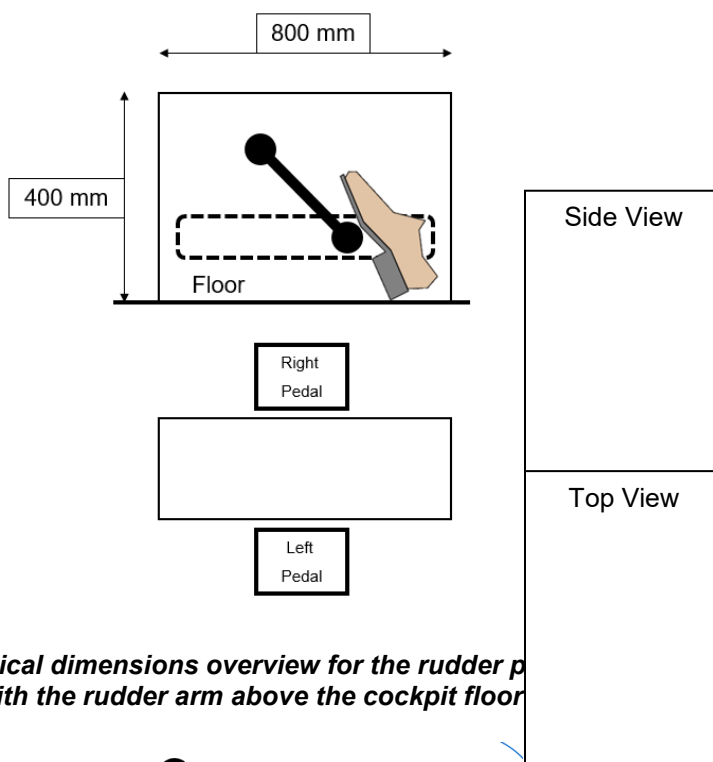


Figure 4 - Typical dimensions overview for the rudder pedal with the rudder arm above the cockpit floor

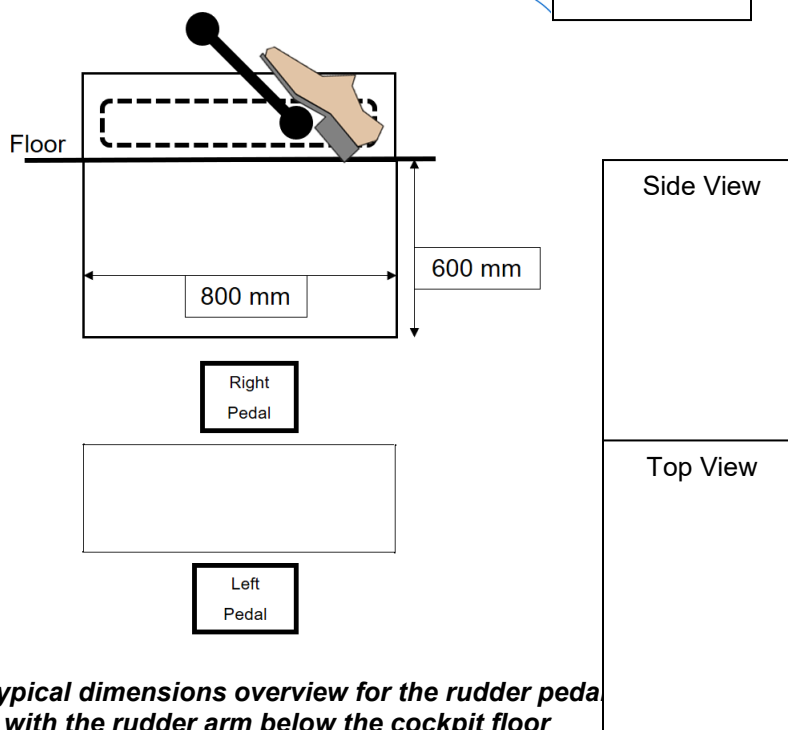


Figure 5 - Typical dimensions overview for the rudder pedal with the rudder arm below the cockpit floor

Typically, the rudder and brake pedal unit is attached to either to structure below or above the floor, or to the forward bulkhead or control console structure.

All information detailed below should be included in the source control drawing and/or the specification.

- The rudder pedal full stroke
- The rudder pedal arm length (if needed)
- The brake pedal full stroke

- d. Distance between the right and left pedals, and distance from the floor
- e. Pedal orientation through the stroke
- f. Pedal's rise and fall relative to the aircraft structure
- g. Envelope
- h. Station position in cockpit, access for maintenance
- i. Weight and center of gravity location
- j. Mounting features and method of mounting to aircraft structure

4.3 Pilot Validation

The pilot evaluation of the rudder and brake pedal unit is an important part of validating the specification requirements. A specific pilot validation activity should be planned between the aircraft manufacturer, the specification owner, and the supplier.

5. DESIGN REQUIREMENTS

This section defines generic design requirements in addition to the certification requirements detailed in 5.1.

NOTE: Where the requirement is a generic recommendation, but the final value depends of the customer specification, a typical value is proposed.

5.1 Applicable Airworthiness Requirements

5.1.1 Normal, Utility, Acrobatic, and Commuter Category Airplanes

The following paragraphs from 14 CFR Part 23/CS 23 Airworthiness Standards are applicable to rudder and brake pedal unit.

23.143	General
23.303	Factor of Safety
23.397	Limit Control Forces and Torques
23.399	Dual Control System
23.405	Secondary Control System
23.671	Control Systems - General
23.672	Stability Augmentation and Automatic- and Power-Operated Systems
23.673	Primary Flight Controls
23.677	Trim Systems
23.679	Control Systems Locks
23.683	Operating Test
23.685	Control System Details
23.693	Joints