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[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No.: FAA-2018-0653-; Notice No. 18-04]

RIN 2120–AK89

Yaw Maneuver Conditions—Rudder Reversals

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: The FAA proposes to add a new load condition to the design standards for transport category airplanes. The new load condition would require the airplane be designed to withstand the loads caused by rapid reversals of the rudder pedals and would apply to transport category airplanes that have a powered rudder control surface or surfaces. This rule is necessary because accident and incident data show that pilots sometimes make rudder reversals during flight, even though such reversals are unnecessary and discouraged by flightcrew training programs. The current design standards do not require the airplane structure to withstand the loads that may result from such reversals. If the airplane loads exceed those for which it is designed, the airplane structure may fail, resulting in catastrophic loss of control of the airplane. This proposal aims to prevent structural failure of the rudder and vertical stabilizer that may result from these rudder reversals.

DATES: Send comments on or before [INSERT DATE 90 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].

ADDRESSES: Send comments identified by docket number [Insert docket number from heading] using any of the following methods:

- Federal eRulemaking Portal: Go to http://www.regulations.gov and follow the online instructions for sending your comments electronically.
- Mail: Send comments to Docket Operations, M-30; U.S. Department of Transportation (DOT), 1200 New Jersey Avenue, SE., Room W12-140, West Building Ground Floor, Washington, DC 20590-0001.
- Hand Delivery or Courier: Take comments to Docket Operations in Room W12-140 of the West Building Ground Floor at 1200 New Jersey Avenue, SE., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.
- Fax: Fax comments to Docket Operations at 202-493-2251.

Privacy: In accordance with 5 USC 553(c), DOT solicits comments from the public to better inform its rulemaking process. DOT posts these comments, without edit, including any personal information the commenter provides, to www.regulations.gov, as described in the system of records notice (DOT/ALL-14 FDMS), which can be reviewed at www.dot.gov/privacy.

Docket: Background documents or comments received may be read at http://www.regulations.gov at any time. Follow the online instructions for accessing the docket or go to the Docket Operations in Room W12-140 of the West Building Ground Floor at 1200 New Jersey Avenue, SE., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

FOR FURTHER INFORMATION CONTACT:

For technical questions concerning this action, contact Robert C. Jones, Propulsion & Mechanical Systems Section, AIR-672, Transport Standards Branch, Policy and Innovation Division, Aircraft Certification Service, Federal Aviation Administration, 2200 South 216th Street, Des Moines, WA 98198; telephone and fax (206) 231-3182; e-mail Robert.C.Jones@faa.gov.

SUPPLEMENTARY INFORMATION:

Authority for this Rulemaking

The FAA's authority to issue rules on aviation safety is found in Title 49 of the United States Code. Subtitle I, Section 106 describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in Subtitle VII, Part A, Subpart III, Section 44701, "General Requirements." Under that section, the FAA is charged with promoting safe flight of civil aircraft in air commerce by prescribing regulations and minimum standards for the design and performance of aircraft that the Administrator finds necessary for safety in air commerce. This regulation is within the scope of that authority. It prescribes new safety standards for the design of transport category airplanes.

I. Overview of Proposed Rule

The FAA proposes to add a new load condition to the design standards in title 14, Code of Federal Regulations (14 CFR) part 25. The new load condition, to be located in new proposed § 25.353, would require that the airplane be designed to withstand the loads caused by rapid reversals of the rudder pedals. Specifically, applicants would have to show that their proposed airplane design can withstand an initial full rudder pedal input, followed by three rudder reversals at the maximum sideslip angle, followed by return of the rudder to neutral. Due to the rarity of such multiple reversals, the proposed rule would specify the new load condition is an ultimate load condition rather than a limit load condition. Consequently, the applicant would not have to apply an additional factor of safety to the calculated load levels.[1]

The proposed rule would affect manufacturers of transport category airplanes applying for a new type certificate after the effective date of the final rule. The proposed rule may also affect applicants applying for an amended or supplemental type certificate as determined under 14 CFR 21.101 after the effective date of the final rule. Proposed § 25.353 would apply to transport category airplanes that have a powered rudder control surface or surfaces, as explained in the "Discussion of the Proposal."

II. Background

A. Statement of the Problem

Accident and incident data from the events described in section II.B.1 show pilots sometimes make multiple and unnecessary rudder reversals during flight. In addition, FAA-sponsored research[2] indicates that pilots use the rudder more often than previously

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[1] The terms "limit," "ultimate," and "factor of safety" are specified in § 25.301, "Loads," § 25.303, "Factor of safety," and § 25.305, "Strength and deformation." To summarize, design loads are typically expressed in terms of limit loads, which are then multiplied by a factor of safety, usually 1.5, to determine ultimate loads. In this proposal, the design loads would be expressed as ultimate loads, and no additional safety factor would be applied.

[2] Report No. DOT/FAA/AM-10/14, "An International Survey of Transport Airplane Pilots' Experiences and Perspectives of Lateral/Directional Control Events and Rudder Issues in Transport Airplanes (Rudder Survey)," dated October 2010, is available in the Docket and on the Internet at http://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/media/201014.pdf.

thought and often in ways not recommended by manufacturers. Section 25.1583(a)(3)(ii) requires manufacturers to provide documentation that warns pilots against making large and rapid control reversals as they may result in structural failures at any speed, including below the design maneuvering speed (V_A). Despite the requirement, and though such rudder reversals are unnecessary and discouraged by flightcrew training programs, these events continue to occur (see section II.B.1, "History – Accidents and Incidents" below).

Section 25.351, the standard for protecting the airplane's vertical stabilizer from pilot-commanded maneuver loads, only addresses single, full rudder inputs at airspeeds up to the design diving speed (V_D)[3]. This design standard does not protect the airplane from the loads imposed by repeated inputs in opposing directions, or rudder reversals.[4] If the loads on the vertical stabilizer exceed those for which it is designed, the vertical stabilizer may fail, resulting in the catastrophic loss of airplane control.

Incidents and accidents related to rudder reversals have occurred in the past, and the FAA believes that another such event could occur, resulting in injuries to occupants or a structural failure that jeopardizes continued safe flight and landing of the airplane.

B. History

1. Accidents and Incidents

Rudder reversals have caused a number of accidents and incidents. On November 12, 2001, American Airlines Flight 587 (AA587), an Airbus Model A300-600 series airplane, crashed at Belle Harbor, New York, resulting in 265 deaths and the loss

[3] V_D is the design diving speed: the maximum speed at which the airplane is certified to fly. See 14 CFR 1.2. Advisory Circular 25-7C provides additional information related to V_D.
[4] A rudder reversal is a continuous, pilot-commanded pedal movement starting from pedal displacement in one direction followed by pedal displacement in the opposite direction.

of the airplane. The National Transportation Safety Board (NTSB) found that the probable cause of this accident was the in-flight separation of the vertical stabilizer as a result of the loads beyond ultimate design that were created by the first officer's unnecessary and excessive rudder pedal inputs. The NTSB also noted that contributing to these rudder pedal inputs were characteristics of the Airbus A300-600 rudder system design and elements of the American Airlines Advanced Aircraft Maneuvering Program.[5]

In two additional events—commonly known as the Interflug incident[6] and Miami Flight 903 accident (AA903)[7]—the vertical stabilizer of each airplane experienced loads above the ultimate load level due to pedal reversals commanded by the pilot after the airplane stalled.[8] While none of the passengers and crew were injured in the Interflug incident, a passenger was seriously injured and a crewmember sustained minor injuries in the AA903 accident. The AA903 airplane also sustained sheared fasteners, deformed nacelles, and engine component damage, but landed safely. A catastrophe similar to AA587 was averted in each of these events because the vertical stabilizer was stronger than required by the design standards.[9]

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[5] Aircraft Accident Report NTSB/AAR-04/04, "In-flight Separation of Vertical Stabilizer, American Airlines Flight 587, Airbus Industrie A300-605R, N14053, Belle Harbor, New York, November 12, 2001," dated October 26, 2004, is available in the Docket and on the Internet at https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR0404.pdf.

[6] On February 11, 1991, an Airbus Model A310 series airplane experienced in-flight loss of control over Moscow, Russia.

[7] On May 12, 1997, an Airbus Model A300-600 series airplane experienced in-flight loss of control near West Palm Beach, Florida, after the flightcrew failed to recognize that the airplane had entered a stall.

[8] The Interflug and Miami Flight 903 events are discussed in NTSB Aircraft Accident Report NTSB/AAR-04/04, pp. 103-110. See footnote 5 on p. 6.

[9] FCHWG Recommendation Report, "Rudder Pedal Sensitivity/Rudder Reversal," dated November 7, 2013, is available in the Docket and on the Internet at https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/TAEfch-rpsrr-3282011.pdf. See p. 5 of the report.

Other rudder reversal events have occurred more recently. On January 10, 2008, an Airbus Model 319-114 series airplane, operated as Air Canada Flight 190 (AC190), encountered a wake vortex while at cruise altitude over Washington State.[10] The pilot responded with inputs that included six rudder reversals. The flightcrew eventually stabilized the airplane and diverted to an airport capable of handling the injured passengers.

The Transportation Safety Board of Canada (TSB) investigated this event, along with NTSB accredited representatives, and classified it as an accident. Analysis by the TSB showed that the pilot's actions resulted in a load on the vertical stabilizer that exceeded its limit load by approximately 29 percent. The TSB found that the flightcrew was startled by wake turbulence at that altitude, erroneously believed that the airplane had malfunctioned, and therefore responded with erroneous actions. The pilot had received training to avoid rudder reversals.

On May 27, 2005, a Bombardier DHC-8-100 series airplane, operated by Provincial Airlines Limited for passenger service, experienced a stall and uncontrolled descent over Canada.[11] During climb-out, the indicated airspeed gradually decreased, due to the flightcrew's inadvertent selection of an incorrect autopilot mode. The airplane stalled at an unexpectedly high airspeed, likely due to the formation of ice. The flightcrew's failure to recognize the stall resulted in incorrect control inputs and the loss of 4,200 feet of altitude in approximately 40 seconds before recovery. There were no

[10] TSB Aviation Investigation Report A08W0007, "Encounter with Wake Turbulence," is available in the Docket and on the Internet at http://tsb.gc.ca/eng/rapports-reports/aviation/2008/a08w0007/a08w0007.pdf.
[11] TSB Aviation Investigation Report A05A0059. See footnote 10 on p. 7.

injuries and the airplane was not damaged. During this event, the pilot commanded a rudder reversal.

2. New Transport Airplane Programs

Since the AA587 accident, the FAA has responded to the risk posed by rudder reversals, in part, by requesting that applicants for new type certificates show that their designs are capable of continued safe flight and landing after experiencing repeated rudder reversals. Applicants have been able to show this capability through rudder control laws in flight control systems. Applicants have incorporated these control laws through software and, therefore, added no weight or maintenance cost to the airplanes.

In 2016, the European Aviation Safety Agency (EASA) began applying special conditions to new airplane certification programs. EASA mandated these special conditions to address the exact risk of rudder reversals explained in this NPRM. The requirements in the EASA special conditions are identical to the requirements proposed in this NPRM.

3. FAA Survey of Pilots' Rudder Use

In 2006, the FAA sponsored a survey[12] to better comprehend transport category pilots' understanding and use of the rudder. This survey included transport pilots from all over the world. The FAA's analysis of the survey data found that—

- Pilots use the rudder more than previously thought and often in ways not recommended by manufacturers.
- Pilots make erroneous rudder pedal inputs, and some erroneous rudder pedal inputs include rudder reversals.

[12] Report No. DOT/FAA/AM-10/14 (see footnote 2 on p. 5), OMB Control No. 2120-0712.

- Even after specific training, many pilots are not aware that they should not make rudder reversals, even below V_A. Over the last several years, training and changes to the airplane flight manual (AFM) have directed the pilot to avoid making cyclic control inputs. The rudder reversals that caused the AC190 incident in 2008, and the Provincial Airlines Limited incident in 2005, occurred despite this effort.
- The survey indicated that pilots in airplane upset situations (e.g., wake vortex encounters) may revert to prior training and make sequential rudder reversals.

C. Aviation Rulemaking Advisory Committee (ARAC) Activity

In 2011, the FAA tasked ARAC to consider the need to add a new flight maneuver load condition to part 25, subpart C, that would ensure airplane structural capability in the presence of rudder reversals and increasing sideslip angles (yaw angles) at airspeeds up to V_D. The FAA also tasked ARAC to consider if other airworthiness standards would more appropriately address this concern, such as pedal characteristics that would discourage pilots from making rudder reversals.[13] ARAC delegated this task to the Transport Airplane and Engine subcommittee, which assigned it to the Flight Controls Harmonization Working Group (FCHWG).

The FCHWG was tasked to examine several options to protect the airplane from pilot-commanded rudder reversals. These options included developing new standards for—

- Loads,
- Maneuverability,
- System design,

[13] This notice of ARAC tasking was published in the Federal Register on March 28, 2011 (76 FR 17183).

- Control sensitivity,
- Alerting, and
- Pilot training.

The FCHWG completed its report in November 2013.[14] ARAC and the FAA accepted the report. The report's findings and recommendations guided the formation of this proposal.

While multiple rudder reversals are a very low probability event, they have occurred in service and cannot be ruled out in the future. The FCHWG found that a load condition was the optimal way to protect the airplane from the excessive loads that can result from multiple rudder reversals. The FCHWG recommended a load condition over the other options because it would be a performance-based requirement. The FCHWG noted that this would provide applicants for design approval with the flexibility to determine the best way to meet a load condition.

D. NTSB Safety Recommendation

Following the AA587 accident described in section II.B.1 of this NPRM, the NTSB provided safety recommendations to the FAA. The NTSB stated, "For airplanes with variable stop rudder travel limiter systems, protection from dangerous structural loads resulting from sustained alternating large rudder pedal inputs can be achieved by reducing the sensitivity of the rudder control system (for example, by increasing the pedal forces), which would make it harder for pilots to quickly perform alternating full rudder

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[14] FCHWG Recommendation Report, "Rudder Pedal Sensitivity/Rudder Reversal," dated November 7, 2013, is available in the Docket and on the Internet at https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/TAEfch-rpsrr-3282011.pdf. See footnote 9 on p. 7.

inputs." In Safety Recommendation A-04-056[15], the NTSB recommended that the FAA modify part 25 to include a certification standard that will ensure safe handling qualities in the yaw axis throughout the flight envelope, including limits for rudder pedal sensitivity.

This proposed rule would address this recommendation and, if incorporated on new airplane designs, would reduce the risk of an event similar to AA587. The proposed rule would also respond to the NTSB's concern about rudder pedal sensitivity.

E. Other Regulatory Actions

1. 2010 Revisions to § 25.1583

During its investigation of the AA587 accident, the NTSB found that many pilots of transport category airplanes mistakenly believed that, as long as the airplane's speed is below V_A, they can make any control input they desire without risking structural damage to the airplane. AA587 exposed the fact that this assumption is incorrect. As a result, the NTSB recommended that the FAA amend its regulations to clarify that operating at or below V_A does not provide structural protection against multiple, full control inputs in one axis, or full control inputs in more than one axis at the same time.[16] After making its own assessment, the FAA agreed, and revised § 25.1583(a)(3) at Amendment 25-130, effective October 15, 2010.

Section 25.1583(a)(3) was revised to change the information that applicants must furnish in the AFM explaining the use of V_A to pilots. The amendment clarified that,

[15] NTSB Safety Recommendation A-04-056 is available in the Docket and on the Internet at http://www.ntsb.gov/safety/safety-recs/RecLetters/A04_56_62.pdf.
[16] NTSB Safety Recommendation A-04-60 is available in the Docket and on the Internet at http://www.ntsb.gov/safety/safety-recs/recletters/A04_56_62.pdf.

depending on the particular airplane design, flying at or below V_A does not allow a pilot to make multiple large control inputs in one airplane axis or full control inputs in more than one airplane axis at a time without endangering the airplane's structure. However, the AC190 accident shows that even a properly trained pilot might make rudder reversals when startled or responding to a perceived failure.

2. Airworthiness Directives

In 2012, the FAA adopted an airworthiness directive (AD) applicable to all Airbus Model A300-600 and Model A310 series airplanes.[17] The AD was prompted by the excessive rudder pedal inputs and consequent high loads on the vertical stabilizer in the events described previously, including AA587. The AD required operators to either incorporate a design change to the rudder control system or other systems, or install a modification that alerts the pilot to stop making rudder inputs.

In 2015, the FAA adopted an AD applicable to all Airbus Model A318, A319, A320, and A321 series airplanes.[18] That AD was prompted by a determination that, in specific flight conditions, the allowable load limits on the vertical stabilizer could be reached and possibly exceeded. Exceeding allowable load could result in detachment of the vertical stabilizer. The AD also required a modification that alerts the pilot to stop making rudder inputs.

[17] AD 2012-21-15 was published in the Federal Register on November 9, 2012 (77 FR 67526). For more information, see Docket No. FAA-2011-0518 on the Internet at http://www.regulations.gov.
[18] AD 2015-23-13 was published in the Federal Register on December 29, 2015 (77 FR 67526). For more information, see Docket No. FAA-2011-0518 on the Internet at http://www.regulations.gov.

F. Advisory Material

The FAA has developed proposed Advisory Circular (AC) 25.353-X, "Design Load Conditions for Rudder Control Reversal," to be published concurrently with this NPRM. This proposed AC would provide guidance material on acceptable means, but not the only means, of showing compliance with proposed § 25.353. The FAA will post the proposed AC on the "Aviation Safety Draft Documents Open for Comment" Web page at http://www.faa.gov/aircraft/draft_docs/.[19] The FAA requests that you submit comments on the proposed AC through that Web page.

III. Discussion of the Proposal

The FAA proposes to revise 14 CFR by adding new § 25.353 to add a design load condition. It would apply to transport category airplanes that have a powered rudder control surface or surfaces, as explained later in this section. The load condition would require that the airplane be able to withstand three full reversals of the rudder pedals at the most critical points in the flight envelope. From a neutral position, the pedal input would be sudden and to one side and held; then, as the maximum sideslip angle is reached, the pedals would be suddenly displaced in the opposite direction and held until the opposite angle is reached; then again to the first side; then again to the second side; then suddenly moved back to the neutral position.

The reason for this proposal is that pilots make inadvertent and erroneous rudder pedal inputs, and the accident and incident data show that the loads caused by rudder reversals can surpass the airplane's structural limit load and sometimes its ultimate load.

[19] The proposed AC is also available in the Docket. To ensure the FAA receives your comments on the proposed AC, please submit them via the instructions found on the "Aviation Safety Draft Documents Open for Comment" Web page.

Compliance with the proposed rule would require a showing that the airplane's vertical stabilizer and other airplane structure are strong enough to withstand the rudder reversals.

Ten of the eleven members of the FCHWG recommended proposing some form of a new load condition to protect the airplane against rudder reversals. During discussions, five members of the FCHWG[20] recommended requiring a load condition that would protect the airplane from three, sequential, full rudder reversals. This notice puts forth those proposals.

Five members of the FCHWG[21] recommended a similar load condition, which would only protect against a single reversal of the rudder pedals. The FAA is not proposing this alternative because a new rule that only includes a single rudder reversal, with a safety factor of 1.0, would not materially increase the design load level from current design loads criteria and would not be effective in preventing accidents such as the AA587 accident.

One member, The Boeing Company (Boeing), took the position that no new rulemaking or design standards are required, and that the risk from rudder reversals should be addressed by flightcrew training. Boeing stated that rudder reversals are always inappropriate and that pilots should never make such commands. Boeing argued it is inappropriate to issue an airworthiness standard to mitigate a situation caused by actions that pilots should avoid. The FAA rejects this alternative because, while multiple rudder reversals are a very low probability event, they have been seen in service, despite training, and cannot be ruled out in the future.

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[20] The Air Line Pilots Association, International (ALPA), EASA, National Civil Aviation Agency – Brazil (ANAC), and Transport Canada Civil Aviation (TCCA), and FAA representatives.
[21] Airbus, Bombardier, Cessna, Dassault Aviation, and Embraer.

As indicated previously, yaw maneuver loads are currently specified in § 25.351, "Yaw maneuver conditions." The FAA used this requirement as a template to develop the proposed new rudder reversal design load condition. Therefore, the proposed load condition would be similar to the load condition required by § 25.351, except as follows:

- Section 25.351 specifies a single, full-pedal command followed by a sudden pedal release after the airplane has reached the steady-state sideslip angle. Proposed § 25.353 would specify a single, full-pedal command followed by three rudder reversals, and return to neutral.
- In the proposed rule, the rudder reversals must be performed at the maximum sideslip angle, which is referred to as the "overswing sideslip angle." This term is also used in § 25.351 and would have the same meaning. The overswing sideslip angle is the maximum sideslip angle that occurs following full rudder pedal input and includes the additional sideslip that may occur beyond the steady-state sideslip angle.
- The § 25.353 load requirement would be an ultimate design load condition, instead of a limit load condition as in § 25.351. This means that applicants would apply a safety factor of 1.0, rather than 1.5. The proposed rudder reversal maneuver would cover the worst-case rudder maneuver expected to occur in service. Because service history has shown that three full rudder reversals are unusual, the FAA proposes that a safety factor of 1.0 is appropriate.
- The proposed § 25.353 condition would require only that the applicant account for the rudder reversals at speeds up to the design cruising speed (V_C). In contrast, § 25.351 requires applicants to account for speeds up to V_D. The reason for this

difference is that V_C represents the majority of the flight envelope, and compliance to V_D is not necessary due to the infrequency of exposure to such speeds and the low probability that a rudder reversal will occur at speeds above V_C.

- Section 25.351 requires a pilot force of up to 300 pounds, depending on the airplane's speed. In contrast, the pilot force specified in § 25.353 would be limited to 200 pounds because it would be difficult, and therefore very unlikely, for a pilot to maintain 300 pounds of force while performing rapid alternating inputs.
- The proposed § 25.353 condition would be evaluated only with the landing gear retracted and speed brakes (and spoilers when used as speed brakes) retracted. This is because flight loads would be more severe with the gear and speed brakes retracted.

A. Expected Methods of Compliance.

The proposed rule is performance-based. For example, an applicant could choose to comply with the proposed standard by using control system architecture and control laws to limit the airplane response to rudder reversals, and thereby reduce structural loads on the airplane. An applicant could also choose to comply by increasing the capability of the airplane to withstand the maximum expected structural loads that could result from the proposed load condition.

B. Proposed Applicability.

After examining all the data and considering stakeholder opinions, the FAA has determined that the proposed rule should apply to new type certification programs of transport category airplane designs and to amended or supplemental type certificate programs as determined under § 21.101. The proposed rule would affect manufacturers of transport category airplanes. In the future, applicants who want to certify new airplanes under part 25 would have to comply with proposed § 25.353.

As noted previously, this proposed rule would apply only to airplanes that use powered rudder control surfaces. In this proposed rule, a powered rudder control surface is one in which the force required to deflect the surface against the airstream is generated or augmented by hydraulic or electric systems. An unpowered rudder control surface is one for which the force required to deflect the surface against the airstream is transmitted from the pilot's rudder pedal directly through mechanical means, without any augmentation from hydraulic or electrical systems. Powered rudder control systems include fly-by-wire (FBW) and hydro-mechanical systems. Unpowered rudder control systems are also referred to as mechanical systems. Incorporation of a powered yaw damper into an otherwise unpowered rudder control system does not constitute a powered rudder control surface, for the purpose of this proposed rule. The reasons that the FAA proposes to exclude airplanes with unpowered (mechanical) rudder control surfaces are as follows, and the FAA seeks comment on these reasons:

1. The only U.S. transport category airplane models, currently in production, that use unpowered rudder control surfaces are small business jets. Small airplanes typically have a minimal delay between pilot yaw control inputs and airplane response. The pilots of these airplanes receive more immediate feedback of airplane response to their yaw control inputs and, therefore, are less likely to execute inappropriate pedal movements resulting in rudder reversals.

2. The only U.S. transport category airplane models, currently in production, that use an unpowered rudder control surface are also equipped with a yaw damper. The FAA has assessed the design of this yaw damper and determined its normal operation would be adequate to reduce yaw overshoot loads resulting from rudder reversals to acceptable levels. However, the yaw damper system on these airplanes is not required to be operational on any given flight. The yaw damper is included in these airplanes primarily to improve ride quality for passenger comfort (as opposed to providing adequate stability about the yaw axis to ensure airplane safety). Since the yaw damper may not be available on a given flight, the manufacturer of these airplanes has stated it might need to add structure or an improved yaw damper to any new type certificated airplanes to comply with the proposed rule.[22] This would significantly increase design, production, and operation costs. The FAA considers that, for these airplanes, the cost to comply with the proposed, new load condition through structural modification is not justified by the relatively low risk these airplanes face from rudder reversals. Further, the FAA considers it unlikely that many of these airplanes would fly for extended periods without an operable yaw damper that provides acceptable ride quality. Therefore, most of these airplanes have protection against yaw overshoot loads, even if they are not required to demonstrate this protection during certification.
3. The use of unpowered rudder control surfaces is diminishing in the transport category airplane fleet. The FAA expects that most, if not all, new type certificate

[22] A record of this conversation between the FAA and airplane manufacturer is available in the Docket.

applications to which this proposed rule would apply will employ powered rudder control surfaces.

4. The FAA has reviewed the accident and incident records and has found no events in which pilots commanded inappropriate rudder reversals on airplanes with unpowered rudder control surfaces. This alone does not mean such systems cannot be affected by pilot-commanded inappropriate rudder reversals. However, the absence of any previous incidents indicates that excluding these designs would not appreciably increase the future risk of such events above acceptable levels.

C. Summary.

The proposed design criteria would provide a practical, relatively low-cost solution that would be achievable on future designs without the requirement to significantly strengthen the vertical stabilizer, or make significant changes to system design. In fact, some current airplanes would be able to meet the proposed criteria with no changes whatsoever. This proposal should require a minimal increment of applicant resources to show compliance. While an applicant might choose to comply with this performance-based standard by strengthening the airplane structure, the FAA believes that most applicants would use control laws to comply with this proposed rule. These control laws are a part of the flight control computer, and they adjust control surface deflections based on pilot input and other factors like airspeed. Since control laws are typically implemented through systems and software, there would be little to no incremental cost in the form of weight, equipment, maintenance, or training.

IV. Regulatory Notices and Analyses

Changes to Federal regulations must undergo several economic analyses. First, Executive Orders 12866 and 13563 direct that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 (Pub. L. 96-354), as codified in 5 U.S.C. 603 *et seq*., requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act of 1979 (Pub. L. 96-39), 19 U.S.C. Chapter 13, prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, the Trade Agreements Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104-4), as codified in 2 U.S.C. Chapter 25, requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation with base year of 1995). This portion of the preamble summarizes the FAA’s analysis of the economic impacts of this proposed rule.

In conducting these analyses, FAA has determined that this proposed rule has benefits that justify its costs and is not a “significant regulatory action” as defined in section 3(f) of Executive Order 12866. The rule is also not “significant” as defined in DOT's Regulatory Policies and Procedures. The proposed rule will not have a significant economic impact on a substantial number of small entities, will not create unnecessary obstacles to the foreign commerce of the United States, and will not impose an unfunded mandate on State, local, or tribal governments, or on the private sector by exceeding the threshold identified previously.

A. Regulatory Evaluation

Department of Transportation Order 2100.5 prescribes policies and procedures for simplification, analysis, and review of regulations. If the expected cost impact is so minimal that a proposed or final rule does not warrant a full evaluation, this order permits a statement to that effect and the basis for it to be included in the preamble if a full regulatory evaluation of the costs and benefits is not prepared. Such a determination has been made for this proposed rule. The reasoning for this determination follows.

1. Background

The genesis of this proposed rule is the crash of American Airlines Flight 587 (AA587), near Queens, New York, on November 12, 2001, resulting in the death of all 260 passengers and crew aboard, and the death of five persons on the ground. The airplane was destroyed by impact forces and a post-crash fire.

The National Transportation Safety Board (NTSB) found that the probable cause of the accident was "the in-flight separation of the vertical stabilizer [airplane fin] as a result of loads above ultimate design created by the first officer's unnecessary and excessive rudder pedal inputs."[23] Ultimate loads on the airplane structure are the limit loads (1.0) multiplied by a safety factor, usually 1.5 (as for the vertical stabilizer). An airplane is expected to experience a limit load once in its lifetime and is never expected to

[23] NTSB Aircraft Accident Report NTSB/AAR-04/04, p. 160. See footnote 5 on p. 6.

experience an ultimate load.[24] For the AA587 accident, loads exceeding ultimate loads ranged from 1.83 to 2.14 times the limit load on the vertical stabilizer [25], as a result of four, full, alternating rudder inputs known as "rudder reversals."

Significant rudder reversals events are unusual in the history of commercial airplane flight, having occurred during just five notable accidents and incidents, with AA587 being the only catastrophic accident resulting from rudder reversals.[26] Ultimate loads were exceeded in two of the other notable rudder reversal accidents, the Interflug incident (Moscow, February 11, 1991) and American Airlines Flight 903 (AA903) (near West Palm Beach, Florida, May 12, 1997).[27] For the Interflug incident, with multiple rudder reversals, loads of 1.55 and 1.35 times the limit load were recorded; and for AA903 (eight rudder reversals), a load of 1.53 times the limit load was recorded.[28] A catastrophe similar to AA587 was averted in these two events only because the vertical stabilizer was stronger than required by design standards.[29] In a fourth event—Air Canada Flight 190 (AC190) (over the state of Washington, January 10, 2008)—with four rudder reversals, the limit load was exceed by 29 percent.

In transport category airplanes, rudder inputs are generally limited to aligning the airplane with the runway during crosswind landings and controlling engine-out situations, which occur predominately at low speeds. At high speeds, the pilot normally directly

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[24] NTSB Aircraft Accident Report NTSB/AAR-04/04, p. 31, n. 53.
[25] NTSB Aircraft Accident Report NTSB/AAR-04/04, p. 104.
[26] FAA Aviation Rulemaking Advisory Committee. Flight Controls Harmonization Working Group. Rudder Pedal Sensitivity/Rudder Reversal Recommendation Report, Nov. 7, 2013. (ARAC Rudder Reversal Report). This Report identifies four notable rudder events to which we add the Interflug incident discussed in the NTSB AA587 Report.
[27] NTSB Aircraft Accident Report NTSB/AAR-04/04, pp. 106-109.
[28] NTSB Aircraft Accident Report NTSB/AAR-04/04, pp. 104.
[29] NTSB Aircraft Accident Report NTSB/AAR-04/04, pp. 38-39.

rolls the airplane using the ailerons.[30] If the pilot does use the rudder to control the airplane at high speeds, there will be a significant phase lag between the rudder input and the roll response because the roll response is a secondary effect of the yawing moment generated by the rudder.[31] The roll does not result from the rudder input directly. Even if the rudder is subsequently deflected in the opposite direction (rudder reversal), the airplane can continue to roll and yaw in one direction before reversing because of the phase lag. The relationship between rudder inputs and the roll and yaw response of the airplane can become confusing to pilots, particularly with the large yaw and roll rates that would result from large rudder inputs, causing the pilots to input multiple rudder reversals.

Following the AA587 accident, in November 2004 the NTSB released Safety Recommendation A-04-56 recommending that the FAA modify part 25 “to include a certification standard that will ensure safe handling qualities in the yaw axis throughout the flight envelope….”[32] In 2011, the FAA tasked the Aviation Rulemaking Advisory Committee (ARAC) to consider the need for rulemaking to address the rudder reversal issue. ARAC delegated this task to the Transport Airplane and Engine subcommittee, which assigned it to the Flight Controls Harmonization Working Group (FCHWG). One of the recommendations of the ARAC Rudder Reversal Report, issued on November 7, 2013, was to require transport category airplanes to be able to safely withstand the loads imposed by three rudder reversals. This proposed rule adopts that recommendation. The

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[30] An aileron is a hinged control service on the trailing edge of the wing of a fixed-wing aircraft, one aileron per wing.
[31] The yaw axis is defined to be perpendicular to the wings and to the normal line of flight. A yaw movement is a change in the direction of the aircraft to the left or right around the yaw axis.
[32] NTSB Safety Recommendation A-04-56, Nov. 10, 2004.

ARAC report indicates that requiring transport category airplanes to safely operate with the vertical stabilizer loads imposed by three full-stroke rudder reversals accounts for most of the attainable safety benefits. With more than three rudder reversals, the FCHWG found little increase in vertical stabilizer loads.

2. Costs and Benefits of this Proposed Rule

Since the catastrophic AA587 accident, the FAA has responded to the risk posed by rudder reversals by requesting, through the issue paper process, that applicants for new type certificates show that their designs are capable of continued safe flight and landing after experiencing repeated rudder reversals. For airplanes with FBW systems, manufacturers have been able to show capability by means of control laws, incorporated through software changes and, therefore, adding no weight and imposing no additional maintenance cost to the airplanes. Many if not all of these designs have demonstrated tolerance to three or more rudder reversals. Aside from converting to an FBW system, alternatives available to manufacturers specializing in airplane designs with mechanical or hydro-mechanical rudders include increasing the reliability of the yaw damper and strengthening the airplane vertical stabilizer.

To estimate the cost of the proposed rule, the FAA solicited unit cost estimates from U.S. industry and incorporated these estimates into an airplane life cycle model. The FAA received one estimate for large part 25 airplanes and two estimates for small part 25 airplanes (business jets).

One of the business jet estimates was provided by a manufacturer specializing in mechanical rather than FBW rudder systems; therefore, that estimate reflects significantly higher compliance costs. This manufacturer's most cost-efficient approach to addressing the proposed requirement—although high in comparison to manufacturers who use FBW systems exclusively—is to comply with a strengthened vertical stabilizer. The cost of complying with a more reliable yaw damper was higher than strengthening the vertical stabilizer, and higher yet if complying by converting to a FBW rudder system for new models.

As a result of these high costs and other reasons set forth in the preamble, the FAA has decided that the proposed rule would not apply to airplanes with "unpowered" (mechanical) rudder control surfaces. An "unpowered" rudder control surface is one whose movement is affected through mechanical means, without any augmentation from hydraulic or electrical systems. Accordingly, the proposed rule would not apply to models with mechanical rudder control systems, but would apply only to models with FBW or hydro-mechanical rudder systems. The FAA solicits comments on the exclusion of airplanes with unpowered rudder control surfaces from the proposed rule and the corresponding inclusion of FBW and hydro-mechanical models.

The FAA estimates the costs of the proposed rule using unit cost per model estimates from industry for FBW models and our estimates of the number of new large airplane and business jet certifications with FBW rudder systems in the ten years after the effective date of the proposed rule. These estimates are shown in table 1. The FAA solicits comments, with detailed cost estimates, on our estimates.

Table 1. Cost Estimated for Proposed Rule: ($ 2016)

	Cost per Model	**No. of New FBW Models (10 yrs)**	**Costs**
Large Airplanes	$300,000	2	$ 600,000

Business Jets	$235,000	2	$ 470,000
Total Costs			$ 1,070,000

With these cost estimates, the FAA finds the proposed rule to be minimal cost, with expected net safety benefits from the reduced risk of rudder reversal accidents.

B. Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (Pub. L. 96-354) (RFA) establishes "as a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration." The RFA covers a wide range of small entities, including small businesses, not-for-profit organizations, and small governmental jurisdictions.

Agencies must perform a review to determine whether a rule will have a significant economic impact on a substantial number of small entities. If the agency determines that it will, the agency must prepare a regulatory flexibility analysis as described in the RFA. However, if an agency determines that a rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the RFA provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

As noted above, because manufacturers with FBW rudder systems have been able to show compliance by means of low-cost changes to control laws incorporated through software changes, the FAA estimates that the costs of this proposed rule to be minimal. Therefore, as provided in section 605(b), the head of the FAA certifies that this proposed rule will not have a significant economic impact on a substantial number of small entities.

C. International Trade Impact Assessment

The Trade Agreements Act of 1979 (Pub. L. 96-39) prohibits Federal agencies from establishing standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Pursuant to this Act, the establishment of standards is not considered an unnecessary obstacle to the foreign commerce of the United States, so long as the standard has a legitimate domestic objective, such as the protection of safety, and does not operate in a manner that excludes imports that meet this objective. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards.

The FAA has assessed the effect of this proposed rule and determined that its purpose is to protect the safety of U.S. civil aviation. Therefore, the proposed rule is in compliance with the Trade Agreements Act.

D. Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (Pub. L. 104-4) requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of $100 million or more (in 1995 dollars) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a “significant regulatory action.” The FAA currently uses an inflation-adjusted value of $155.0 million in lieu of $100 million.

This proposed rule does not contain such a mandate. Therefore, the requirements of Title II of the Act do not apply.

E. Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the FAA consider the impact of paperwork and other information collection burdens imposed on the public. The FAA has determined that there would be no new requirement for information collection associated with this proposed rule.

F. International Compatibility and Cooperation

(1) In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to conform to International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has determined that there are no ICAO Standards and Recommended Practices that correspond to these proposed regulations.

(2) Executive Order 13609, “Promoting International Regulatory Cooperation,” promotes international regulatory cooperation to meet shared challenges involving health, safety, labor, security, environmental, and other issues and to reduce, eliminate, or prevent unnecessary differences in regulatory requirements. The FAA has analyzed this action under the policies and agency responsibilities of Executive Order 13609, and has determined that this action would have no effect on international regulatory cooperation.

G. Environmental Analysis

FAA Order 1050.1E identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this rulemaking action qualifies for the categorical exclusion identified in paragraph 312f of Order 1050.1E and involves no extraordinary circumstances.

V. Executive Order Determinations

A. Executive Order 13132, Federalism

The FAA has analyzed this proposed rule under the principles and criteria of Executive Order 13132, "Federalism." The agency has determined that this action would not have a substantial direct effect on the States, or the relationship between the Federal Government and the States, or on the distribution of power and responsibilities among the various levels of government, and, therefore, would not have Federalism implications.

B. Executive Order 13211, Regulations that Significantly Affect Energy Supply, Distribution, or Use

The FAA analyzed this proposed rule under Executive Order 13211, "Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use" (May 18, 2001). The agency has determined that it would not be a "significant energy action" under the executive order and would not be likely to have a significant adverse effect on the supply, distribution, or use of energy.

C. Executive Order 13771, Reducing Regulation and Controlling Regulatory Costs

This proposed rule is not expected to be an EO 13771 regulatory action because this proposed rule is not significant under EO 12866.

VI. Additional Information

A. Comments Invited

The FAA invites interested persons to participate in this rulemaking by submitting written comments, data, or views. The agency also invites comments relating to the economic, environmental, energy, or federalism impacts that might result from adopting the proposals in this document. The most helpful comments reference a specific portion of the proposal, explain the reason for any recommended change, and include supporting data. To ensure the docket does not contain duplicate comments, commenters should send only one copy of written comments, or if comments are filed electronically, commenters should submit only one time.

The FAA will file in the docket all comments it receives, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking. Before acting on this proposal, the FAA will consider all comments it receives on or before the closing date for comments. The FAA will consider comments filed after the comment period has closed if it is possible to do so without incurring expense or delay. The agency may change this proposal in light of the comments it receives.

Proprietary or Confidential Business Information: Commenters should not file proprietary or confidential business information in the docket. Such information must be sent or delivered directly to the person identified in the FOR FURTHER INFORMATION CONTACT section of this document, and marked as proprietary or confidential. If submitting information on a disk or CD ROM, mark the outside of the disk or CD ROM, and identify electronically within the disk or CD ROM the specific information that is proprietary or confidential.

Under 14 CFR 11.35(b), if the FAA is aware of proprietary information filed with a comment, the agency does not place it in the docket. It is held in a separate file to which the public does not have access, and the FAA places a note in the docket that it has received it. If the FAA receives a request to examine or copy this information, it treats it as any other request under the Freedom of Information Act (5 U.S.C. 552). The FAA processes such a request under Department of Transportation procedures found in 49 CFR part 7.

B. Availability of Rulemaking Documents

An electronic copy of rulemaking documents may be obtained from the Internet by—

1. Searching the Federal eRulemaking Portal (http://www.regulations.gov);
2. Visiting the FAA's Regulations and Policies Web page at http://www.faa.gov/regulations_policies or
3. Accessing the Government Printing Office's Web page at http://www.gpo.gov/fdsys/.

Copies may also be obtained by sending a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267-9680. Commenters must identify the docket or notice number of this rulemaking.

All documents the FAA considered in developing this proposed rule, including economic analyses and technical reports, may be accessed from the Internet through the Federal eRulemaking Portal referenced in item (1) above.

List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend chapter I of title 14, Code of Federal Regulations as follows:

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. 106(f), 106(g), 40113, 44701, 44702 and 44704.

2. Add § 25.353 to read as follows:

§ 25.353 Rudder control reversal conditions.

For airplanes with a powered rudder control surface or surfaces, the airplane must be designed to withstand the ultimate loads that result from the yaw maneuver conditions specified in paragraphs (a) through (e) of this section at speeds from V_{MC} or the highest airspeed for which it is possible to achieve maximum rudder deflection at zero sideslip, whichever is greater, up to V_C/M_C. The applicant must evaluate these conditions with the landing gear retracted and speed brakes (and spoilers when used as speed brakes) retracted. In computing the loads on the airplane, the applicant may assume yawing velocity to be zero. The applicant must assume a pilot force of 200 pounds when evaluating each of these conditions:

(a) With the airplane in unaccelerated flight at zero yaw, the flight deck rudder control is displaced as specified in § 25.351(a) and (b).

(b) With the airplane yawed to the overswing sideslip angle, the flight deck rudder control is suddenly displaced in the opposite direction.

(c) With the airplane yawed to the opposite overswing sideslip angle, the flight deck rudder control is suddenly displaced in the opposite direction.

(d) With the airplane yawed to the subsequent overswing sideslip angle, the flight deck rudder control is suddenly displaced in the opposite direction.

(e) With the airplane yawed to the opposite overswing sideslip angle, the flight deck rudder control is suddenly returned to neutral.

Issued under authority provided by 49 U.S.C. 106(f) and 44701(a) in Washington, DC, on July 2, 2018.

Dorenda D. Baker,
Executive Director, Aircraft Certification Service.
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