



Advisory Circular

Subject: Prevention and Recovery from Aeroplane Stalls

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1.0 INTRODUCTION

- (1) This Advisory Circular (AC) is provided for information and guidance purposes. It describes an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards. This AC on its own does not change, create, amend or permit deviations from regulatory requirements, nor does it establish minimum standards.

1.1 Purpose

- (1) The purpose of this document is to provide guidance to operators, pilots, flight crews and Transport Canada personnel for the prevention and recovery from stall events.
- (2) This AC provides best practices and guidance for training, testing, and checking within existing regulations, to ensure correct and consistent responses to unexpected stall warnings and stick pusher activations.
- (3) This AC emphasizes reducing the angle of attack (AOA) as the most important response to a stall event. This AC also provides guidance for operators and training providers on the development of stall and stick pusher event training.

1.2 Applicability

- (1) This document is applicable to all Transport Canada Civil Aviation (TCCA) employees, operators, manufacturers, training providers, pilots, flight crews, and to individuals or organizations exercising privileges granted to them under an External Ministerial Delegation of Authority.

1.3 Description of Changes

- (1) Not applicable.

2.0 REFERENCES AND REQUIREMENTS

2.1 Reference Documents

- (1) It is intended that the following reference materials be used in conjunction with this document:
 - (a) *Aeronautics Act* (R.S., 1985, c. A-2);
 - (b) Part VI, Subpart 04 of the *Canadian Aviation Regulations (CARs) – Private Operators*;
 - (c) Part VII, Subpart 03 of the CARs – *Air Taxi Operations*;
 - (d) Part VII, Subpart 04 of the CARs – *Commuter Operations*;
 - (e) Part VII, Subpart 05 of the CARs – *Airline Operations*;
 - (f) Standard 723 of the CARs – *Air Taxi*;
 - (g) Standard 724 of the CARs – *Commuter Operations*;
 - (h) Standard 725 of the CARs – *Airline Operations*;
 - (i) Transport Canada Publication TP 9685E, Revision 2 – January 1998 (Revised 01/2005) – *Aeroplane and Rotorcraft Simulator Manual*;
 - (j) TP 14727E, Second Edition, (11/2007) – *Pilot Proficiency Check and Aircraft Type Rating, Flight Test Guide (Aeroplanes)*;

- (k) Aviation Performance Solutions (APS) Emergency Maneuver Training, 2009, Version 2 – *Caution, Wake Turbulence!*;
www.apstraining.com/ebook
- (l) Boeing Aero Magazine, Issue No. 03; 1998, 3RD Quarter – *Aerodynamic Principals of Large Airplane Upsets*;
http://www.boeing.com/commercial/aeromagazine/aero_03/fo/fo01/index.html
- (m) Civil Aviation Authority (U.K.), Third Edition, reprinted February 1988 – *Handling the Big Jets*, D.P. Davies;
- (n) Federal Aviation Administration Advisory Circular (FAA AC) 120-109, 2012-08-06 – *Stall and Stick Pusher Training*;
- (o) Federal Aviation Administration (FAA) Airplane Upset Recovery Training Aid (AURTA)
http://www.faa.gov/other_visit/aviation_industry/airline_operators/training/media/AP_UpsetRecovery_Book.pdf;
- (p) Federal Aviation Administration (FAA), 14 Code of Federal Regulations (CFR) Part 60, , Flight Simulator Training Device Initial and Continuing Qualification and Use, amendment 60-2, dated 30 May 2008;
- (q) Flight Safety Foundation, Flight Safety Digest, Understanding the Stall-recovery Procedure for Turboprop Airplanes In Icing Conditions, April 2005;
- (r) Joint Aviation Requirements, JAR-FSTD A, Aeroplane Flight Simulation Training Devices, Initial Issue, 1 May 2008.

2.2 Cancelled Documents

- (1) As of the effective date of this document, the following document is cancelled:
 - (a) Commercial and Business Aviation Advisory Circular (CBAAC) No. 0247, 2005-08-24, *Training and Checking Practices for Stall Recovery*;
 - (b) Policy Letter No. 172, 2005-08-24, *Training and Checking Practices for Stall Recovery*.
- (2) By default, it is understood that the publication of a new issue of a document automatically renders any earlier issues of the same document null and void.)

2.3 Definitions and Abbreviations

- (1) The following **definitions** are used in this document:
 - (a) **Aerodynamic Stall:** An aerodynamic loss of lift caused by exceeding the aeroplane wing's critical angle of attack (synonymous with the term "stall").
 - (b) **Aeroplane Upset:** An aeroplane in flight unintentionally exceeding the parameters normally experienced in operations or training. An aeroplane upset is characterized by the existence of a least one of the following parameters:
 - (i) pitch attitude greater than 25 degrees nose up; or
 - (ii) pitch attitude greater than 10 degrees nose down; or
 - (iii) bank angle greater than 45 degrees; or
 - (iv) within the above parameters, but flying at airspeeds inappropriate for the conditions.

- (c) **Angle of Attack (AOA):** The angle between the oncoming air, or relative wind, and a defined reference line on the aeroplane or wing.
- (d) **Approach-to-Stall:** Flight conditions bordered by stall warning and aerodynamic stall.
- (e) **Crew Resource Management (CRM):** Effective use of all available resources: human resources, hardware, and information.
- (f) **Critical Angle of Attack:** The AOA that produces the maximum co-efficient of lift beyond which an aerodynamic stall occurs.
- (g) **Cruise Configuration:** The aerodynamically clean configuration representative of cruise or enroute flight.
- (h) **First Indication of a Stall:** The initial aural, tactile, or visual sign of an impending stall, which can be either naturally or synthetically induced.
- (i) **Flight Simulation Training Device (FSTD):** A full flight simulator (FFS) or a flight training device (FTD).
- (j) **Hysteresis:** The phenomenon in which the values of a physical property lags behind changes in the effect causing it.
- (k) **Instructor Operating Station (IOS):** The interface panel between the FSTD instructor and the FSTD.
- (l) **Landing Configuration:** Starts when the landing gear is down and a landing flap setting has been selected during an approach until executing a landing, go-around, or missed approach.
- (m) **Manoeuvre-Based Training (MBT):** Training that focuses on a single event or manoeuvre in isolation.
- (n) **Scenario-Based Training (SBT):** Training that incorporates manoeuvres into real-world experiences to cultivate practical flying skills in an operational environment.
- (o) **Secondary Stall:** A premature increase in AOA that results in another stall event during stall recovery, prior to a stable flight condition being established.
- (p) **Stall:** An aerodynamic loss of lift caused by exceeding the critical angle of attack.

A stall is characterized by any or all of the following indications:

- (i) buffeting, which could be heavy at times; or
 - (ii) a lack of pitch authority; or
 - (iii) a Lack of roll control; or
 - (iv) inability to arrest descent rate; or
 - (v) stall warning activation; or
 - (vi) stick pusher activation (if equipped).
- (q) **Stall Event:** Anytime the aeroplane develops indications of an approach-to-stall or aerodynamic stall.
 - (r) **Stall Recovery Procedure:** The manufacturer-approved aeroplane-specific stall recovery procedure. If a manufacturer-approved recovery procedure does not exist, the aeroplane-specific stall recovery procedure developed by the operator based on the stall recovery template in Section 8.0 of this AC.
 - (s) **Stall Warning:** A natural or synthetic indication provided when approaching a stall that may include one or more of the following indications:

- (i) aerodynamic buffeting (some aeroplanes will buffet more than others);
 - (ii) reduced roll stability and aileron effectiveness;
 - (iii) visual or aural cues and warnings;
 - (iv) reduced elevator (pitch) authority;
 - (v) inability to maintain altitude or arrest rate of descent;
 - (vi) stick shaker activation (if installed).
- (t) **Startle:** An uncontrollable, automatic muscle response, raised heart rate, blood pressure, etc. elicited by an event that violates a pilot's expectations.
- (u) **Stick Pusher:** A safety system that applies downward elevator pressure to prevent an aeroplane from exceeding a predetermined AOA in order to avoid, identify, or assist in the recovery of an aerodynamic stall.
- (v) **Surprise:** An unexpected event that violate's a pilot's expectations and can affect the cognitive processes used to respond to the event.
- (w) **Tailplane Stall:** A nose-down pitch upset induced by the stall of the tailplane because of ice contamination.
- (x) **Takeoff or Manoeuvring Configuration:** The aeroplane's normal configuration for takeoff, approach, go-around, or missed approach until all flaps/slats are retracted. Retractable landing gear may be extended or retracted.
- (y) **Threat:** Events or errors that occur beyond the influence of the flight crew, increase operational complexity and must be managed to maintain the margin of safety.
- (z) **Uncoordinated Flight:** Flight with lateral acceleration, such as slipping or skidding in a turn.
- (aa) **Undesired Aircraft State:** A position, condition, or attitude of an aircraft, including low energy states that reduces or eliminates safety margins.
- (ab) **Unsafe Situation:** A situation which has led to an unacceptable reduction in safety margin.
- (2) The following **abbreviations** are used in this document:
- (a) **AC:** Advisory Circular;
 - (b) **ATC:** Air Traffic Control;
 - (c) **AURTA:** Airplane Upset Recovery Training Aid;
 - (d) **CG:** Centre of Gravity;
 - (e) **FAA:** Federal Aviation Administration;
 - (f) **FFS:** Full Flight Simulator;
 - (g) **FTD:** Flight Training Device;
 - (h) **GPWS:** Ground Proximity Warning System;
 - (i) **LOC-I:** Loss of Control – Inflight;
 - (j) **LOFT:** Line Oriented Flight Training;
 - (k) **NSP:** National Simulator Program;
 - (l) **OEM:** Original Equipment Manufacturer;

- (m) **PIO:** Pilot Induced Oscillation;
- (n) **SA:** Situational Awareness;
- (o) **SME:** Subject Matter Expert;
- (p) **SOP:** Standard Operating Procedure;
- (q) **TAWS:** Terrain Awareness Warning System;
- (r) **TCCA:** Transport Canada Civil Aviation.

3.0 FOCUS

- (1) The key focus of this Advisory Circular (AC) includes the following core principles:
 - (a) Prevention of stall events through effective recognition, avoidance, and recovery should they be encountered;
 - (b) Reduction of Angle of Attack (AOA) is the most important response when confronted with a stall event;
 - (c) Evaluation criteria for a recovery from a stall or approach-to-stall does not mandate a predetermined value for altitude loss and should consider the multitude of external and internal variables which affect the recovery altitude;
 - (d) Realistic scenarios that could be encountered in operational conditions including stalls encountered with the autopilot engaged;
 - (e) Pilot training which emphasizes treating an “approach-to-stall” the same as a “full stall,” and execute the stall recovery at the first indication of a stall;
 - (f) Incorporation of stick pusher training into flight training scenarios, if installed on the aircraft.

4.0 BACKGROUND

4.1 Prevention and Recovery from Aeroplane Stalls

- (1) The purpose of this AC is to provide guidance for the development of effective training and evaluation methods for the prevention and recovery from aeroplane stall events. The term “prevention” as used in this AC refers to any pilot’s actions to be aware of present or potential threats and their escalation in order to avoid a stall event. “Recovery” refers to any pilot actions to return to a desired aircraft state from a developing or fully developed stall.
- (2) Evidence exists that some pilots are failing to avoid conditions that may lead to a stall, or failing to recognize the insidious onset of an approach-to-stall during routine operations in both manual and automatic flight. Evidence also exists that some pilots may not have the required skills or training to respond appropriately to an unexpected stall or stick pusher event, especially if startled or surprised.
- (3) Effective stall prevention and recovery training may also prevent aeroplane upsets, which have occurred because of a pilot’s inappropriate avoidance or or reaction to a stall event. Aeroplane upsets in turn have led to Loss of Control – Inflight (LOC-I) accidents, which are currently the leading cause of fatalities in aviation accidents world-wide.

- (4) This AC intends to provide best practices and guidance for training, testing, and checking for pilots and flight crews, within existing regulations and standards, to ensure correct and consistent responses to unexpected stall warnings and stick pusher activations.
- (5) Stall training should always emphasize reduction of AOA as the most important response when confronted with any stall event.
- (6) The guidance within this AC applies to the operation of fixed wing aeroplanes, including propeller driven and turbojet powered aeroplanes used in commercial air services and private operations. Operators should tailor their training programs specifically to their aeroplane types and associated operating conditions and capabilities.
- (7) Appendix 5 of this AC provides guidance related to airborne icing induced stalls and aeroplane upsets. This appendix summarizes the adverse effects of airborne icing on the aerodynamics and handling qualities of aeroplanes and provides guidance on the awareness, prevention and recovery from ice contamination induced stalls and aeroplane upsets.

4.2 Regulatory Basis

- (1) The regulatory basis for this guidance is Part VII of the *Canadian Aviation Regulations (CARs)* training standards which require that training be provided for an approach to a stall and recovery. This guidance material updates previous Transport Canada Civil Aviation (TCCA) guidance material (Commercial and Business Aviation Advisory Circular (CBAAC) 0247) applicable to training and checking practices for stall recovery.
- (2) The CARs standards require that training for recovery from an approach to a stall be carried out, both where ground contact is imminent and where ground contact is not a factor. It must be emphasized that the most important response and priority in stall recovery is reducing the AOA. Actions to recover altitude can only be taken after stall recovery has been achieved.

4.3 Interpretation the CAR Training Standards

- (1) This AC is consistent with previous TCCA guidance material (CBAAC 0247), which focused on eliminating a procedure which focuses on “powering” out of a near-stalled condition with an emphasis on a minimum loss of altitude. CBAAC 0247 stated that, although a successful recovery may be possible at low altitudes, this “powering out” technique may be totally inadequate during manoeuvring flight or during flight with icing contamination or at high altitude, due to the lack of excess thrust.
- (2) The standards which require training for recovery from an approach to a stall with ground contact imminent should not be interpreted to mean that an aeroplane should be powered out of a high angle of attack condition and any altitude loss avoided even though close to the ground.
- (3) Reducing AOA is the only effective recovery action from any high AOA condition, even though a loss of altitude will most likely occur. Although thrust may supplement the recovery, thrust is not a primary control. Reducing AOA at the first indication of stall is more effective in minimizing altitude loss than attempting to power out and subsequently encountering a stall or aeroplane upset.

Note: *The terms thrust and power are meant to be used synonymously within this AC. In general the term thrust applies to turbojet powered aeroplanes while the term power applies to propeller driven aeroplanes.*

4.4 Appropriate Recovery from High Angle of Attack Flight

- (1) It must be understood by pilots that a stall or an approach to a stall is a condition associated with an excessive wing angle of attack where smooth airflow over the wing is disrupted and lift is lost.

At the angles of attack approaching a stall, drag is very high and the thrust available for acceleration or climb may be marginal. Acceleration could be very slow if engines are at idle thrust, thus extending a recovery. Attempting to power out of an approach to a stall may actually result in a stall or aeroplane upset. Wing-mounted engines may further exacerbate this situation, due to their nose-up pitching moment contribution at higher thrust settings. Most industry and regulatory bodies have come to the consensus that the first step to affect stall recovery is to reduce the wing angle of attack.

- (2) An approach to a stall should not be treated as a controlled flight manoeuvre. All recoveries from an approach to stall should be done as if an actual stall has occurred. It can be very difficult to recognize the insidious onset of a stall event or distinguish the difference between an approach to a stall and an actual stall. The onset of a stall and associated loss of control from a near stall condition can be rapid and unexpected. The goal of minimizing altitude loss must be secondary to recovering from the stall. Altitude recovery should only be attempted after stall recovery has been completed.

5.0 INDUSTRY GUIDANCE

5.1 Airplane Upset Recovery Training Aid

- (1) The Federal Aviation Administration (FAA) with industry input developed the Airplane Upset Recovery Training Aid (AURTA), which was originally published in 1998. This document was updated in 2008 with the insertion of supplemental information that dealt specifically with high altitude operations. The AURTA is available from the FAA at:
http://www.faa.gov/other_visit/aviation_industry/airline_operators/training/media/AP_UpsetRecovery_Book.pdf
and from the Flight Safety Foundation (FSF) at:
<http://flightsafety.org/archives-and-resources/airplane-upset-recovery-training-aid>
- (2) The AURTA in general is focused at large aeroplanes with 100 seats or more and swept wing aeroplanes operating at high altitude. The AURTA nonetheless contains valuable guidance which applies to smaller propeller driven and turbojet powered aeroplanes.
- (3) Supplement #1 of the AURTA provides comprehensive guidance applicable to high altitude flight and stall aerodynamics. This supplement also includes Line Oriented Flight Training (LOFT) scenarios for high altitude turbojet powered aeroplanes.

5.2 AURTA Definition of Stall – Operational Criteria for Stall Recognition

- (1) The AURTA definition of a stall provides clear operational criteria for the recognition of a stall:

“Stall: An airplane is stalled when the angle of attack is beyond the stalling angle (critical angle of attack). A stall is characterized by any of, or a combination of the following:

- (a) Buffeting, which could be heavy at times;
- (b) A lack of pitch authority;
- (c) A lack of roll control;
- (d) Inability to arrest descent rate.

Notes:

1. *The criteria (indications) for the AURTA definition of a stall and the definition for stall warning provided in this AC are very similar. The intensity of these indications will increase with increasing AOA, i.e. these indications will be more intense and pronounced at the stall vs. at stall warning. In all cases the correct response to any of these indications is to reduce the AOA.*
2. *Although not provided in the AURTA definition of a stall, the above indications will likely be accompanied by the activation of a stall warning device such a stick shaker. The activation of a stick pusher, (for those aeroplanes equipped with a stick pusher) should be considered to be a clear indication of a stall.*
3. *The lack of roll control may be indicated by an uncommanded roll off, which should be considered as an indication of a stall.*

5.3 AURTA Definition of Aeroplane Upset – Operational Criteria for Aeroplane Upset Recognition

- (1) Inappropriate responses to a stall event can lead to an aeroplane upset or a LOC-I accident. The AURTA definition of an aeroplane upset provides clear operational criteria for the recognition of an aeroplane upset.

“Airplane Upset: While specific values may vary among airplane models, the following unintentional conditions generally describe an airplane upset:

- (a) Pitch attitude greater than 25 degrees nose up;
- (b) Pitch attitude greater than 10 degrees nose down;
- (c) Bank angle greater than 45 degrees;
- (d) Within the above parameters, but flying at airspeeds inappropriate for the conditions.”

Notes:

1. *The pitch attitude and bank angle parameters provided in the AURTA definition of airplane upset should be carefully considered with the phase of flight the aeroplane is in. For example, during high altitude cruise an unintentional pitch attitude or bank angle at much less than the values provided in the above definition could be considered to meet the criteria of an aeroplane upset.*
2. *Flight crews should initiate actions to prevent and recover from an aeroplane upset well before reaching the parameters provided in the above definition, if unintentional pitch, roll or yaw rates begin to develop.*
- (2) The AURTA definitions of a stall and upset are related. When an aeroplane is stalled, it may not be upset in terms of pitch and bank attitude, but is at an inappropriate airspeed for the conditions. An aeroplane may also be stalled in any attitude, and may be stalled while upset in a nose high or nose low pitch attitude.
- (3) **In all cases of an aeroplane upset, the aeroplane must be first recovered from a stall before any other upset recovery action is initiated.**

- (4) A comprehensive training program for the prevention and recovery from a stall event should be closely associated with training for the prevention and recovery from aeroplane upsets.

6.0 STALL TRAINING PHILOSOPHY

6.1 General Philosophy

- (1) An effective stall training curriculum should provide pilots the knowledge and skills to avoid undesired aircraft states that increase the risk of encountering a stall event or, if not avoided, to respond correctly and promptly to a stall event.

6.2 Training Philosophy

- (1) While basic aerodynamics and stall training are typically accomplished as part of a pilot's private, commercial, and airline transport pilot qualifications, it is important to reinforce this basic training throughout their careers. Training providers should ensure that pilots are thoroughly familiar with the characteristics associated with the specific aeroplane including the aerodynamic principles related to high AOA flight and stalls. Training providers should also understand that some pilots may need to unlearn previous stall recovery procedures based on their prior experience.
- (2) This AC describes the approach-to-stall and stick pusher training that a pilot should receive when employed by an operator. This training may be completed either as stand-alone training or incorporated into other training areas (i.e., Crew Resource Management (CRM), adverse weather training, etc.). Training providers and operators should include approach-to-stall and stick pusher (if installed) training for pilots during:
 - (a) Initial training;
 - (b) Type rating training;
 - (c) Requalification training;
 - (d) Differences training (if differences exist in stall warning or stall recovery procedure);
 - (e) Upgrade training; and
 - (f) Recurrent training.
- (3) Any operator training program for the awareness, prevention and recovery from aeroplane upsets must clearly teach that an aeroplane must first be recovered from a stall, before any other aeroplane upset recovery action is initiated.

6.3 Instructor/Evaluator Standardization

- (1) Instructors and evaluators should be appropriately qualified and receive training in the subject areas contained in this AC. Knowledge of the subject areas contained in this AC ensures accurate stall training and minimizes the risk of negative training.
- (2) Instructor/evaluator training should focus on the practical application of these principles and the evaluation of a pilot's understanding of the aeroplane's operating characteristics.
- (3) Instructors/evaluators must have a clear understanding of the Flight Simulation Training Device (FSTD) limitations that may influence the approach-to-stall training/testing/checking including:
 - (a) A particular FSTD's acceptable training envelope;

- (b) Load Factor (G loading) awareness/accelerated stall - factors absent from the FSTD's programming that could be experienced in flight and the effect on stall speed, aeroplane behaviour, and recovery considerations;
- (c) Motion cues—limitations of motion cues typically present in most simulators after the first indication of stall;
- (d) Significant deviations from validated flight manoeuvres could result in significant degradation in simulator fidelity.

6.4 Testing and Checking

6.4.1 Recovery Procedures

- (1) This AC emphasizes both recognizing a stall event and completing the proper approach-to-stall recovery procedure. This AC provides training and evaluation profiles based on realistic scenarios. Training and evaluation profiles that require a specific set of precise entry and recovery procedures should not be used.
- (2) Recovery profiles that emphasize zero or minimal altitude loss and/or the immediate advancement of maximum thrust should not be used. Emphasis is placed on recognition and avoidance of those conditions that may lead to a stall event.
- (3) Recovery procedures should emphasize:
 - (a) The immediate reduction of the aeroplane's AOA;
 - (b) Management of thrust; and
 - (c) Returning the aeroplane to a safe flying condition.

Note: *Training providers should adjust their stall evaluation criteria as appropriate and train their evaluators in these changes. The primary goal of testing and checking should be to evaluate a pilot's immediate recognition and response to a stall warning and their timely, correct accomplishment of the stall recovery procedure.*

6.4.2 Evaluation Parameters

- (1) The evaluator is responsible for establishing the flight conditions associated with the approach-to-stall configuration being evaluated. While the pilot may fly the entry profile, they are not being evaluated on the entry. The satisfactory completion of the event is based on the pilot's immediate response to a stall warning and the accomplishment of the proper stall recovery procedure.

6.4.3 Evaluation Criteria

- (1) Evaluation of the recovery from an approach-to-stall should never be based on altitude loss. Pilots should be evaluated on their timely response and effective use of available energy (i.e., altitude and airspeed) during stall recovery. The evaluator should consider the variables that are present at the time of the stall warning and their effect on the recovery.
- (2) Evaluation criteria are:
 - (a) Prompt recognition of stall event;
 - (b) Correct application of the approach-to-stall recovery procedure; and
 - (c) Recovery of the aeroplane without exceeding the aeroplane's limitations or the application of inappropriate control inputs which, in the actual aeroplane, could lead to exacerbation of the situation.

6.4.4 Realistic Settings

- (1) An approach-to-stall checking event in the FSTD may be manoeuvre based or scenario-based with an entry altitude consistent with normal operating environments. The entry parameters, including weight and balance, should be within aeroplane limitations to ensure adequate performance for recovery from the first indication of a stall.
- (2) During training and for demonstration purposes, the pilot may be asked, to ignore some aural and visual indications of an impending stall, in order to practice the more difficult control movements, such as those needed to recover from the stick shaker.
- (3) During checking, the pilot should be evaluated on recovering at the first indication of a stall, even if it is based on an aural, visual or other indication that occurs before the stick shaker or stick pusher (if installed).

7.0 TRAINING METHODOLOGY

7.1 General

- (1) The training methodology for approach-to-stall training should follow a building block approach of first introducing essential concepts and academic understanding before progressing to the practical application of those skills in the FSTD environment. Similarly, familiarity with aeroplane characteristics and development of basic recovery handling skills through manoeuvre-based training should precede their application in scenario-based training. This progressive approach will lead to a more complete appreciation of how to recognize an impending stall, respond appropriately in situations of surprise or startle, and recover effectively when required.
- (2) Training providers should develop training curriculums that provide pilots with the knowledge and skills to prevent, recognize, and recover from stall events. These training curriculums should contain the elements described in this section.

7.2 Ground School/Academic Training

7.2.1 Academic Knowledge

- (1) Academic instruction establishes the foundation from which situational awareness (SA), insight, knowledge, and skills are developed. Academic knowledge should proceed from the general to the specific. Having pilots share their experiences about stall related encounters or events is a useful way of bringing theoretical knowledge into an operational perspective.

Note: TCCA recommends incorporation of applicable sections of the AURTA on stall aerodynamics and high altitude stalls into an operator's stall prevention training programs. The AURTA is available on the web from the FAA at:

http://www.faa.gov/other_visit/aviation_industry/airline_operators/training/media/AP_UpsetRecovery_Book.pdf.

7.2.2 Stall Prevention Training Curriculums

- (1) The following knowledge areas should be included in all stall prevention training curriculums:
 - (a) The understanding that a reduction of AOA is required to initiate recovery of all stall events (approach-to-stall and aerodynamic stall);
 - (b) An awareness of the factors that may lead to a stall event during automated and manual flight operations including:
 - (i) AOA versus pitch attitude;

- (ii) Decaying airspeed;
 - (iii) Weight;
 - (iv) G loading and Load Factor, Bank angle;
 - (v) Centre of gravity (CG);
 - (vi) Thrust and lift vectors;
 - (vii) Thrust settings and application of thrust;
 - (viii) Autopilot and Autothrottle protections;
 - (ix) Wind shear;
 - (x) Configuration;
 - (xi) Altitude;
 - (xii) Mach effects;
 - (xiii) Uncoordinated flight and improper use of rudder;
 - (xiv) Misuse of automation;
 - (xv) Loss of situational awareness; and
 - (xvi) Contamination (ice (insects, fluids or other contaminants on some aeroplane types with sensitive wings)).
- (c) Recognition of the stall warning indications, including, flight instrument indications and understanding of need to initiate the stall recovery procedure at the first indication of a stall;
 - (d) An understanding that an inappropriate response to an aeroplane stall may lead to an aeroplane upset and vice versa;
 - (e) An understanding of the necessity to recover from a stall before any other upset recovery action is initiated;
 - (f) Operation and function of stall protection systems in normal, abnormal, and emergency situations, including the hazards of overriding or ignoring stall protection system indications. Awareness of the factors that may lead such systems to fail, as well as degraded modes, indications, or behaviours that may occur with system failures;
 - (g) For FBW aeroplanes, the flight envelope protections available, including stall protection in normal and alternate or degraded laws and an understanding of FBW stability and control characteristics. An understanding that although FBW aeroplanes may be protected from stalling, they may still enter an Undesired Aircraft State (UAS) e.g., low-energy situation;
 - (h) Effectiveness of flight control surfaces and the order in which the control surfaces lose and regain their effectiveness with increasing and decreasing AOA (e.g., ailerons, spoilers etc.) and an understanding that AOA should be reduced to increase the effectiveness of ailerons for roll control;
 - (i) Differences between transport category aeroplane certification and general aviation aeroplane certification regarding use of flight controls at high AOA. For example, transport category aeroplanes are certified to retain the ability to raise a wing, with full aileron deflection if needed, all the way up to stick shaker;
 - (j) Specific stall and low speed buffet characteristics unique to the aeroplane type and any implications for the expected flight operations and aeroplane-specific stall recovery procedure;

- (k) Principles of high altitude aerodynamics, performance capabilities and limitations including high altitude operations, and flight techniques;
- (l) Buffet boundary and margins in flight planning and operational flying and discerning the indications between low speed and high speed buffet;
- (m) Proper stall recovery procedure;
- (n) Crew resource management associated with stall awareness, prevention and recovery including the need to recognize and confirm indications of a stall prior to initiating the recovery actions;
- (o) Effect of icing contamination on aerodynamics, air data sensors and stall protection systems;
- (p) An understanding whether a specific aeroplane type is prone to tailplane stall induced upset and if prone, the indications of tailplane stall and recovery procedures;
- (q) The necessity for smooth, deliberate, and positive control inputs to avoid unacceptable load factors and secondary stalls;
- (r) Avoiding cyclical or oscillatory control inputs to prevent exceeding the structural limits of the aeroplane;
- (s) Hazards associated with the inappropriate use of flight controls such as rudder (e.g. attempting to roll wings level using rudder, instead of using all available aileron control);
- (t) Structural considerations, including explanation of limit load, ultimate load, and the dangers of combining accelerative and rolling forces (the rolling pull) during recovery;
- (u) An understanding of the need for nose down elevator inputs to reduce AOA and increase roll control at low pitch attitudes and large bank angles, including bank angles greater than ninety degrees;
- (v) Differences in aeroplane performance (thrust available) during high versus low altitude operations, the effects of those differences on stall recovery, and the anticipated altitude loss during a recovery;
- (w) Stall-related accidents, incidents, data for the specific aeroplane type or class; and
- (x) For aeroplanes equipped with a stick pusher, an understanding of stick pusher function and operation and recommended recovery actions in response to stick pusher activation. The pilot should understand if a stick pusher is designed to activate prior to or beyond the critical angle of attack.

7.3 Simulator Training

- (1) Training providers are encouraged to use the highest level Full Flight Simulator (FFS) available when developing their approach-to-stall training curriculums. The primary emphasis is to provide the pilot with the most realistic environment possible during approach-to stall training/evaluation. Motion in a FFS should be used when a pilot needs to feel the stimulus and develop skill-based recognition and recovery behaviors that rely on motion. Appendix 3 provides additional considerations applicable to FSTD's.

7.3.1 FFS Capabilities and Limitations

- (1) As an aeroplane approaches a stall, it typically becomes less stable and, in some cases, may even become unstable. This may be characterized by degraded, ineffective or reversed control inputs, or uncontrolled departures from stable flight conditions in roll or pitch. Motion feedback is particularly important as a system becomes less stable, where visual information may not provide timely feedback. The human eyes are relatively slow compared to the vestibular system and visual information may not even be available, depending on the situation or scenario. In the approach-to-stall regime, FFS motion cueing can provide significant benefits to recognizing changes to the airplane stability, and applying proper recovery techniques.
- (2) Hexapod motion systems, characteristic of Full Flight Simulators, are unable to create sustained positive or negative g-loading. During recovery from a stall event, the aeroplane may undergo unloading or, in some cases, positive loading, which FFS motion systems cannot replicate.
- (3) Buffet is an important indication of stall and the approach to stall. For some aeroplane types, buffet may be the first indication of stall at high altitude or in icing conditions. For training, it is important that the onset and amplitudes of the buffet components are consistent with the occurrence of stall warning and the stall break or critical stall angle of attack. Considerable variation may exist in buffet onset and randomness in the buffet magnitude depending on entry rate and load factor.
- (4) In consideration of FFS capabilities and limitations, instructors/evaluators should:
 - (a) Be familiar with the capabilities and limitations of a particular FSTD and ensure that all pilots undergoing training or checking are aware of these limitations to mitigate negative training;
 - (b) Recognize indications of increasing instability with angle of attack, through the available cues, and emphasize that the reduction of angle of attack is the primary method in regaining control;
 - (c) Provide feedback to the student pilot on the g loading and that would have been encountered during the recovery, as a function of the airspeed;
 - (d) Emphasize the importance of recognizing the development and increase in buffet severity as a function of the flight condition.

7.3.2 Manoeuvre Based Training

- (1) This training focuses on the mastery of an individual task or tasks. Manoeuvre based training should include prevention and recovery training with an emphasis on the development of required motor skills to satisfactorily accomplish stall recovery. Sample Manoeuvre Based Training (MBT) training scenarios are provided in Appendix 2. Minimal emphasis should be placed on decision-making skills during manoeuvre based training:
 - (a) Manoeuvres:
 - (i) Manoeuvre-based training should include the following tasks:
 - (A) takeoff or Manoeuvring configuration approach-to-stalls;
 - (B) clean configuration approach-to-stalls; and
 - (C) landing configuration approach-to-stalls.

Note: The three preceding Manoeuvres represent three flight configurations. The flight configuration should be appropriate to the stall scenario. For example, training in the clean configuration should be conducted in a high altitude stall scenario.

(b) Stall Scenarios:

(i) The three tasks should be trained using realistic scenarios in the following conditions:

- (A) Level flight and turns using a bank angle of 15 to 30 degrees,
- (B) Manual and automated (autopilot and/or auto-throttle, if installed) flight,

Note: While it may be difficult to use the auto-throttle during manoeuvre-based training since the auto-throttle is usually disconnected and thrust reduced to idle, it is important to teach disconnecting the autopilot and auto-throttle during stall recovery and to develop scenarios where the auto-throttle is engaged.

- (C) Visual, instrument and night flight conditions;
- (D) High and low altitudes; and
- (E) Various weight and balance conditions within aeroplane limitations.

Note: The applicable Commercial Air Service Standards for approach to stall and recovery require training when ground contact is imminent. The reduction of AOA is still the first action required to initiate recovery of all stall events (approach-to-stall and aerodynamic stall) whether ground contact is imminent or not. Training when ground contact is imminent should emphasize awareness of reduced terrain clearance and other indications and alerts such as radio altitude, and GPWS or TAWS alerts.

(c) Emphasis Items:

(i) The following items should be emphasized during manoeuvre-based training:

- (A) How changes to factors such as weight, centre of gravity, G loading, bank angle, altitude and icing affect the handling characteristics and stall speeds of the aeroplane,
- (B) Abrupt pitch up and trim change commonly associated when the autopilot unexpectedly disconnects during a stall event. This dramatic pitch and trim change typically represents an unexpected physical challenge to the pilot when trying to reduce AOA. In some aeroplanes, this may be exacerbated by an additional pitch up when the pilot increases thrust during stall recovery,
- (C) Expected stall warnings for the specific aeroplane type, including flight instrument and artificial stall warning indications, buffeting, handling characteristics and other indications,
- (D) Reducing AOA is the proper way to recover from a stall event. Pilots must accept that reducing the aeroplane's AOA may often result in altitude loss. The amount of altitude loss will be affected by the aeroplane's operational environment (e.g., entry altitude, aeroplane weight, density altitude, bank angle, aeroplane configuration, etc.). At high altitudes, stall recovery may require thousands of feet,
- (E) Differences between high and low altitude stalls; pitch rate and sensitivity of flight controls, thrust available for recovery, and altitude loss,
- (F) The need to apply nose down elevator inputs to reduce AOA when stalled at excessively low pitch attitudes and/or at large bank angles, including bank angles exceeding ninety degrees,

- (G) Noises associated with stick shakers and autopilot disconnect aural alerts or alarms can cause confusion in the cockpit,
- (H) Understanding that early recognition and return of the aeroplane to a controlled and safe state are the most important factors in recovering from stall events. Only after recovering to a safe manoeuvring speed and AOA should the pilot focus on establishing an assigned heading, altitude, and airspeed,
- (I) The effects of malfunctioning and/or deferred equipment on stall protection and stick pusher systems.

7.3.3 Stick Pusher Training

- (1) For aeroplanes equipped with a stick pusher, pilots should accomplish academic training and practical training in an FFS. It is important for pilots to experience the sudden forward movement of the control wheel during stick pusher activation.
- (2) It has been observed during training that, regardless of previous academic training, pilots (on their first encounter with a stick pusher) usually resist the stick pusher and immediately pull back on the control wheel rather than releasing pressure as they have been taught. Therefore, pilots should receive practical stick pusher training in a FFS in order to develop the proper response (allowing the pusher to reduce AOA) when confronted with a stick pusher activation.
- (3) Stick pusher training should be completed as a demonstration/practice exercise, including repetitions, until the pilot's reaction is to permit the reduction in AOA even at low altitudes.
- (4) Deliberate activation of the pusher is not a checked or tested manoeuvre.

7.3.4 Scenario Based Training

- (1) The goal of Scenario Based Training (SBT) is to develop decision-making skills relating to stall prevention and recovery during LOFT. SBT would normally be used during the later stages of an initial type training course and during recurrent training.
 - (a) Scenarios:
 - (i) when possible, scenarios should include incident and accident events and occurrences to provide realistic opportunities to see how threat situations may develop and how they should be managed during line operations. Sample SBT lesson plans are provided in Appendix 2.
 - (b) Briefing:
 - (i) pilots should not normally be briefed that they are receiving SBT. The concept is line-oriented flying, which allows the pilots to recognize and manage the expected or unexpected stall threats as they develop during normal operations.

7.3.5 Other Considerations

- (1) Startle:
 - (a) Startle has been a factor in stall incidents and accidents. Although it may be difficult to create the physiological response of startle in the training environment, if achieved, startle events may provide a powerful lesson for the flight crew. The goal of using startle in training is to provide the crew with a startle experience which allows for the effective recovery of the aeroplane. Considerable care should be used in startle training to avoid negative learning.

- (2) Prevention Training:
- (a) Prevention training provides pilots with the skills to recognize conditions that increase the likelihood of a stall event if not effectively managed. Prevention training must include the operator's standard operating procedures (SOP) and CRM for proper avoidance techniques and threat mitigation strategies. Desired training goals for prevention training should include the following:
 - (i) proper recognition of operational and environmental conditions that increase the likelihood of a stall event occurring;
 - (ii) knowledge of basic stall fundamentals, factors that affect stall speed, stall characteristics for the specific aeroplane and any implications for the expected flight operations;
 - (iii) proper aeronautical decision-making skills to avoid stall events (effective analysis, situational awareness, resource management, mitigation strategies, and breaking the error chain through airmanship and sound judgment);
 - (iv) proper recognition of signs of an impending stall so pilots can recognize conditions that can lead to a stall event;
 - (v) application of CRM and effective crew coordination principals to analyze and confirm the indications of a stall event with other crew member(s) prior to initiating the appropriate recovery actions;
 - (vi) the effects of auto-flight and unexpected disconnects of the autopilot and/or autothrottle; and
 - (vii) proper recognition of when the flight condition has transitioned from the prevention phase and into the recovery phase.

8.0 STALL RECOVERY TEMPLATE

8.1 Aeroplane Commonalities

- (1) Aeroplane manufacturers (Airbus, ATR, Boeing, Bombardier and Embraer) have created a stall recovery template (Table 1 (with additional TCCA information described subsequently)) that provides commonality among various aeroplanes that could be used by current and future aeroplane manufacturers to develop aeroplane-specific stall recovery procedures.
- (2) For operators of aeroplanes for which the manufacturer does not publish a stall recovery procedure, TCCA recommends the stall recovery template's use as a reference when developing operator specific stall recovery procedures (Table 1).

8.2 Aeroplane Differences

- (1) The basic steps were identifying aeroplane differences (stick pushers, stick shakers, turbojets versus turboprops, wing-mounted engines, tail-mounted engines, fly-by-wire and non-fly-by-wire, etc.), finding the commonalities, and proceeding to find a simple, easily understandable stall recovery template. In addition to presenting the recovery steps, the template also provides the rationale for each step of the procedure to enable manufacturers to better determine the applicability to their specific aeroplane.

8.3 Stall Recovery

- (1) The stall recovery template for manufacturers is provided in Table 1, Stall Recovery Template (with Associated Rationale). Although the procedures should apply to the majority of today's aeroplanes, manufacturer-recommended procedures may deviate from those included in this AC due to specific aeroplane characteristics. Specific items, such as configuration changes (e.g., slat or flap extension), that could be required at a specific point during the recovery procedure are not included in the template, but will be included in a specific procedure for a particular aeroplane. Manufacturers are expected to deviate from this template if required because of specific aeroplane operating characteristics.
- (2) TCCA has provided additional information to the original template pertaining to the appropriate use of rudder and returning to the desired flight path. Refer to Table 1 Template steps 3 and 6.
- (3) The stall recovery template can be reduced into the following steps as immediate action items to execute, at the first indication of a stall. Although not in the exact same sequence as the steps in the template, these steps should be committed to memory, to aid in execution of the stall recovery procedures.

(a) **CENTRALIZE/ANALYZE**

- (i) **CENTRALIZE** (Position Primary Flight Controls (Elevator, Aileron and Rudder) into an approximately neutral position);
- (ii) **ANALYZE** (Recognize and Confirm Situation);

(b) **DISCONNECT** Autopilot/Autothrottle (Step 1 of Template);

(c) Steps 2 to 6 of template can be summarized as:

- (i) **PUSH** (Apply forward pressure on elevator control to reduce AOA);
- (ii) **POWER** (Set power/thrust as required);
- (iii) **RUDDER** (Apply only as necessary to control sideslip),
- (iv) **ROLL** (Apply aileron input to level the wings);
- (v) **CLIMB** (Establish a flight path away from terrain and complete the recovery).

Note: *Pilots should be trained to be fully familiar with the operational criteria for the recognition of a stall (Section 5.2 of this AC) and Aeroplane Upset (Section 5.3 of this AC) in order to readily recognize the situation to initiate prompt recovery action. This training should be reinforced during recurrent training.*

- (4) Appendix 4 provides guidance for stall training to be conducted in aeroplanes instead of FSTD's as permitted by the CARs.

Notes:

1. *Operators should work with their aeroplane manufacturer(s) to ensure they have the manufacturer-approved, aeroplane-specific stall recovery procedure in their operating manual.*
2. *The manufacturer's procedures take precedence over the recommendations in this AC.*

TABLE 1 — STALL RECOVERY TEMPLATE (WITH ASSOCIATED RATIONALE)

1	Autopilot and autothrottle.....Disconnect
Rationale	While maintaining the attitude of the aeroplane, disconnect the autopilot and autothrottle. Ensure the pitch attitude does not increase when disconnecting the autopilot. This may be very important in out-of-trim situations. Manual control is essential to recovery in all situations. Leaving the autopilot or autothrottle connected may result in inadvertent changes or adjustments that may not be easily recognized or appropriate, especially during high workload situations.
2	a) Nose down pitch control.....Apply until indications of stall and/or stall warning significantly diminish or disappear. b) Nose down pitch trim.....As Needed
Rationale	a) Reducing the angle of attack is crucial for recovery. This will also address autopilot-induced excessive nose up trim. b) If the control column does not provide sufficient response, pitch trim may be necessary. However, excessive use of pitch trim may aggravate the condition, or may result in loss of control or high structural loads.
3	a) Rudder.....Apply only as necessary to control side-slip b) Ailerons.....Roll to Wings Level
Rationale	Wings Level flight orients the lift vector for recovery. Ailerons should be used as the primary roll control. Rudder should only be used to control side-slip and to assist in roll control after full use of ailerons has been made. Caution – Rudder input must be applied judiciously. For swept wing aeroplanes, rudder pedals should first be neutralized and only applied if ailerons do not have sufficient effectiveness for roll control. Caution – There is normally a delayed roll response to rudder input, which can lead to yaw/roll coupling and Pilot Induced Oscillations (PIO), especially on swept-winged aeroplanes.
4	ThrustAs Needed
Rationale	During a stall recovery, maximum thrust is not always needed. A stall can occur at high thrust or at idle thrust. Therefore, the thrust is to be adjusted accordingly during the recovery. For aeroplanes with engines installed below the wing, applying maximum thrust may create a strong nose-up pitching moment if airspeed is low. For aeroplanes with engines mounted above the wings, thrust application creates a helpful pitch-down tendency. For propeller-driven aeroplanes, thrust application increases the airflow around the wing, assisting in stall recovery.

5	Speed Brakes/Spoilers.....Retract
Rationale	This will improve lift and stall margin.
6	a) Return to the desired flight path. b) Perform appropriate checklist items
Rationale	Apply gentle action for recovery to avoid secondary stalls then return to desired flightpath. Assess the situation once control has been completely regained, to avoid a repetition of the stall event. Perform the appropriate checklist items to ensure the aeroplane is in the appropriate configuration.

9.0 CONCLUSION

- (1) Operators should amend their training programs to include the content of this AC.

10.0 INFORMATION MANAGEMENT

- (1) Not applicable.

11.0 DOCUMENT HISTORY

- (1) Not applicable.

12.0 CONTACT OFFICE

For more information, please contact:

Chief, Commercial Flight Standards (**AARTF**)

E-mail: AARTInfoDoc@tc.gc.ca

Suggestions for amendment to this document are invited, and should be submitted via:

AARTInfoDoc@tc.gc.ca

Original signed by Aaron McCrorie

Aaron McCrorie
Director, Standards
Civil Aviation
Transport Canada

*Transport Canada documents or intranet pages mentioned in this document are available upon request through the
Contact Office*

APPENDIX 1 — SAMPLE DEMONSTRATIONS

- (1) Two demonstrations were constructed using the philosophies and concepts described in this Advisory Circular (AC). The first is an approach-to-stall recovery with only idle thrust available that emphasizes the need to reduce the angle of attack (AOA) to recover from a stall. The second is a stick pusher demonstration (if equipped).
- (2) Training providers are encouraged to develop additional demonstrations to fit their training needs. The examples should be easily tailored to any transport category aeroplane. The examples given are not intended to be limiting in any way. They are simply provided as a framework for development of a training curriculum.

Note: *The manufacturer's procedures take precedence over the recommendations in this AC.*

EXAMPLES OF “DEMONSTRATION FOR STALL TRAINING”

DEMONSTRATION 1	Approach-to-stall recovery with only idle thrust available
PURPOSE	This <i>demonstration</i> is only intended to show that the aeroplane will return to controlled flight by simply reducing the angle of attack (AOA). It does not show the pilot the complete procedure for recovering from an aerodynamic stall or approach-to-stall.
OBJECTIVE	The pilot will recover from an approach-to-stall by reducing the AOA without applying thrust.
EMPHASIS AREAS	<ul style="list-style-type: none"> • Crew coordination; and • AOA management.
CONSIDERATIONS	This demonstration may be completed in any aeroplane configuration or any altitude that allows a recovery.
DEMONSTRATION ELEMENTS	<ul style="list-style-type: none"> • At level flight, reduce thrust to idle; • Increase AOA to achieve the first indication of a stall without regard to holding altitude; • Upon the first indication of a stall, direct the crew to recover solely by lowering the nose to reduce the AOA; • The demonstration is performed with only idle thrust.
COMPLETION STANDARDS	The instructor will advise the student that the manoeuvre is complete when the student understands the need to reduce AOA for stall recovery.
DEMONSTRATION 2	Stick Pusher Demonstration (if installed)
PURPOSE	The pilot understands that stick pusher activation is a stall event safety device that must be relied upon and not overridden. The stick pusher is an automated control input when the aeroplane approaches the critical AOA. If not resolved, the condition that activated the stick pusher will lead to a full aerodynamic stall and possible loss of control. The pilot should be able to perform the appropriate actions should stick pusher activation occur.
OBJECTIVE	The pilot will allow the stick pusher to reduce the AOA to prevent an aerodynamic stall and then perform the correct recovery procedure without resisting the stick pusher.
EMPHASIS AREAS	<ul style="list-style-type: none"> • Recognition. • Crew coordination. • AOA management: Allow the pusher to reduce the AOA and observe its effectiveness in preventing the aerodynamic stall (may be accomplished with or without additional thrust).

	<ul style="list-style-type: none"> • Audible and visual warnings (environment and aeroplane cueing). • Effects of altitude on recovery. • To avoid possible negative training, the instructor should inform the student all approach-to-stall indications leading up to the pusher must be disregarded in order for the pusher activation to occur. • This is a good opportunity to demonstrate and reemphasize all approach-to-stall cues. • Crewmember understanding for aeroplanes equipped with a stick pusher, recommended recovery actions in response to stick pusher activation, including activation when in close proximity to the ground or at cruise altitude.
FSTD SET-UP CONSIDERATIONS	This demonstration may be completed in any aeroplane configuration or any altitude that allows for a recovery.
DEMONSTRATION ELEMENTS	<ul style="list-style-type: none"> • In level flight, reduce thrust to idle. • AOA should be increased to achieve the activation of the stick pusher. • Review approach-to-stall indications as they occur. • Upon stick pusher activation, direct the crew to allow the pusher activation and then initiate recovery procedure.
COMPLETION STANDARDS	<ul style="list-style-type: none"> • The pilot releases back-pressure at pusher activation and allows it to reduce the AOA. • Recovers to the manoeuvring speed appropriate for the aeroplane's configuration without exceeding the aeroplane's limitations. It is probable that some loss of altitude will occur during the recovery. • The manoeuvre is considered complete once a safe speed is achieved and the aeroplane stabilized in level flight.

APPENDIX 2 — SAMPLE TRAINING SCENARIOS

- (1) Three scenarios were constructed using the philosophies and concepts described in this Advisory Circular (AC). They include clean configuration (high altitude), takeoff, and landing configuration approach-to-stalls.
- (2) Training providers and operators are encouraged to develop additional scenarios that fit their training needs.
- (3) The examples should be easily tailored to any transport category aeroplane. The examples given are not intended to be limiting in any way, they are provided as a framework for developing a training curriculum.

Note: *The manufacturer's procedures take precedence over the recommendations in this AC.*

SCENARIO 1	CLEAN CONFIGURATION APPROACH-TO-STALL (HIGH ALTITUDE)
INSTRUCTOR ROLE	Implement scenarios that result in an unexpected approach-to-stall near the aeroplane's maximum operating altitude.
OBJECTIVE	<p>The pilot will recognize the stall warning and immediately perform the stall recovery procedure.</p> <p>The pilot should demonstrate willingness to trade altitude for airspeed to accomplish an expeditious recovery from a stall event.</p>
EMPHASIS AREAS	<ul style="list-style-type: none"> • Recognition and recovery. • Crew coordination. • AOA management. • Out of trim control forces at autopilot disconnection. • Aural and visual warnings (environment and aeroplane cuing). • Surprise and startle. • Roll instability and buffeting. • Effects of multiple levels of automation. • Effects of altitude on recovery. • There is no predetermined value for altitude loss and maintaining altitude during recovery is not required. • Airway/oceanic tracks and Reduced Vertical Separation Minimum (RVSM) considerations. • Situational awareness (SA) while returning to desired flightpath after the stall recovery, including such items as heading, altitude, other aircraft, and flight deck automation.
FSTD SETUP CONSIDERATIONS	<p>This scenario will be conducted near maximum operating altitude for the specific aeroplane weight and temperature. Crew distractions may be used (e.g., minor malfunctions, air traffic control (ATC) instructions, weather). Use of simulator capabilities to induce approach-to-stalls may include:</p> <ul style="list-style-type: none"> • Airspeed slewing. • Attitude changes. • Aeroplane weight and center of gravity (CG) changes. • Environmental changes. • Systems malfunctions (e.g., full or partial pitot/static blockage, artificial thrust reduction, surreptitious disabling of automation).

<p>SCENARIO ELEMENTS</p>	<ul style="list-style-type: none"> • At level flight with the autopilot on, introduce an event or reduce thrust to less than adequate for manoeuvring flight. • Upon recognizing the first indication of a stall, perform the stall recovery procedure. • The necessity for smooth, deliberate, and positive control inputs to avoid increasing load factors and secondary stalls. • During recovery, if the pilot is aggressive and increases load factor too early, approach-to-stall cues should be recognized and appropriate action taken to decrease load factors to avoid stick pusher activation (if installed). • If stick pusher activates, it must be allowed to act and then appropriate recovery action should be taken.
<p>COMPLETION STANDARDS</p>	<ul style="list-style-type: none"> • The pilot will perform a deliberate and smooth reduction of angle of attack (AOA). • Positive recovery from the stall event takes precedence over considerations of altitude loss. • Appropriate application of thrust to accelerate and enable an expeditious recovery. • The return of the aeroplane to safe flight without encountering a secondary stall. • The manoeuvre is considered complete once a safe speed is achieved and the aeroplane stabilized. • Satisfactory crew coordination must be demonstrated.
<p>COMMON STUDENT ERRORS</p>	<ul style="list-style-type: none"> • Recovery is attempted with thrust instead of reducing AOA. • Under/over control of pitch inputs. • Incorrect or excessive use of rudder • Student fails to recognize impending secondary stall. • Reluctance to sacrifice significant altitude. • Failure to distinguish between high speed and low speed stall. • Increasing the load factor too quickly and getting secondary approach-to-stall cues or stick pusher activation.

SCENARIO 2	TAKEOFF APPROACH-TO-STALL WITH PARTIAL FLAPS
INSTRUCTOR ROLE	Implement scenarios that result in an unexpected approach-to-stall on departure prior to flaps being fully retracted.
OBJECTIVE	The pilot will recognize the stall warning and immediately perform the stall recovery procedure, then resume the assigned departure.
EMPHASIS AREAS	<ul style="list-style-type: none"> • Recognition and recovery. • Crew coordination. • AOA management. • Out-of-trim control forces at autopilot disconnect (if engaged). • Aural and visual warnings (environment and aeroplane cueing). • Surprise and startle. • Roll instability and buffeting. • Effects of multiple levels of automation. • Effects of altitude on recovery. • SA while returning to desired flightpath after the stall recovery, including such items as heading, terrain, altitude, other aircraft, and flight deck automation. • There is no predetermined value for altitude loss, and maintaining altitude during recovery is not required.
FSTD SETUP CONSIDERATIONS	<ul style="list-style-type: none"> • The scenario will be conducted during takeoff and/or departure, at an altitude that will allow for a recovery. • Crew distractions may be used (e.g., minor malfunctions, air traffic controller instructions, weather). Use of simulator capabilities to induce approach-to-stalls may include: <ul style="list-style-type: none"> • Airspeed slewing. • Attitude changes. • Aeroplane weight and CG changes. • Environmental changes. • Systems malfunctions (e.g., full or partial pitot/static blockage, artificial thrust reduction, surreptitious disabling of automation).

SCENARIO ELEMENTS	<ul style="list-style-type: none"> • During departure, reduce thrust to less than adequate to maintain airspeed and climb rate. • Upon recognizing the first indication of a stall, perform the stall recovery procedure. • During recovery, the pilot should not allow the aeroplane to reach the AOA for the stick pusher to activate. • If the stick pusher activates, it must be allowed to act and then appropriate recovery action should be taken by the pilot. • When recovery is assured, adjust the pitch attitude to initiate a climb to the assigned departure altitude.
COMPLETION STANDARDS	<ul style="list-style-type: none"> • The pilot will perform a deliberate and smooth reduction of AOA. • Positive recovery from the stall event takes precedence over minimizing altitude loss. • Appropriate application of thrust to accelerate and enable an expeditious recovery. • The return of the aeroplane to safe flight without encountering a secondary stall. • The manoeuvre is considered complete once the flight reaches and stabilizes at the assigned departure altitude. • Satisfactory crew coordination must be demonstrated.
COMMON STUDENT ERRORS	<ul style="list-style-type: none"> • Recovery is attempted with no loss of altitude. • Recovery is attempted without recognizing the importance of pitch control and AOA. • Rolling wings level prior to AOA reduction. • Failure to roll wings level to improve performance. • Incorrect or excessive use of rudder. • Losing SA and failing to return to assigned flightpath or follow ATC instructions after recovery.

SCENARIO 3	LANDING CONFIGURATION STALL
INSTRUCTOR ROLE	Implement scenarios that result in an unexpected approach-to-stall during an approach.
OBJECTIVE	The pilot will recognize the stall warning and immediately perform the stall recovery procedure, then commence missed approach.
EMPHASIS AREAS	<ul style="list-style-type: none"> • Recognition and recovery. • Crew coordination. • AOA management. • Out-of-trim control forces at autopilot disconnect (if engaged). • Aural and visual warnings (environment and aeroplane cueing). • Surprise and startle. • Roll instability and buffeting. • Effects of multiple levels of automation. • Effects of altitude on recovery. • SA while returning to desired flightpath after the stall recovery, including such items as heading, terrain, altitude, other aircraft, and flight deck automation. • There is no predetermined value for altitude loss and maintaining altitude during recovery is not required.
FSTD SETUP CONSIDERATIONS	<ul style="list-style-type: none"> • The scenario will be conducted during approach to landing in the landing configuration, at an altitude that will allow for a recovery. Crew distractions may be used (e.g., minor malfunctions, ATC instructions, weather). Use of simulator capabilities to induce approach-to-stalls may include: <ul style="list-style-type: none"> • Airspeed slewing. • Attitude changes. • Aeroplane weight and CG changes. • Environmental changes, and System malfunctions (e.g., full or partial pitot/static blockage, artificial thrust reduction, surreptitious disabling of automation).

SCENARIO ELEMENTS	<ul style="list-style-type: none"> • At 1,000 feet above ground level (AGL), reduce thrust to be inadequate to maintain a safe speed or descent angle, and results in an increase in AOA to maintain glidepath. • Upon the first indication of a stall, perform the stall recovery procedure. • During recovery, the pilot should not allow the aeroplane to reach the AOA for the stick pusher to activate. • If the stick pusher activates, it must be allowed to activate and then the pilot should then take appropriate recovery action. • When recovery is assured, adjust the pitch attitude to initiate a climb to comply with missed approach instructions.
COMPLETION STANDARDS	<ul style="list-style-type: none"> • The pilot will perform a deliberate and smooth reduction of AOA. • Positive recovery from the aerodynamic stall or approach-to-stall takes precedence over minimizing attitude loss. • Appropriate application of thrust to accelerate and enable an expeditious recovery. • The return of the aeroplane to safe flight without encountering a secondary stall. • The manoeuvre is considered complete when safe speed has been achieved and the pilot initiates the missed approach. • Satisfactory crew coordination must be demonstrated.
COMMON STUDENT ERRORS	<ul style="list-style-type: none"> • Recovery is attempted with no loss of altitude. • Recovery is attempted without recognizing the importance of pitch control and AOA. • Rolling wings level prior AOA reduction. • Failure to roll wings level to improve performance. • Incorrect or excessive use of rudder. • Losing SA and failing to return to assigned flightpath and complete a missed approach, or follow ATC instructions after recovery.

APPENDIX 3 — FLIGHT SIMULATION TRAINING DEVICE CONSIDERATIONS

1.0 SUMMARY OF SIMULATOR CAPABILITIES

- (1) Flight Simulation Training Devices (FSTD) which replicate transport category aeroplanes and are appropriately qualified by Transport Canada Civil Aviation (TCCA) can be reliably used for training to the first indication of a stall, which includes angles of attack up to the stall warning.

Note: *Training of manoeuvres applies only to Full Flight Simulators (FFSs) which have motion, and not to fixed base FSTDs.*

1.1 High-Altitude Stalls or Stalls with Moderate Bank Angles

- (1) If approach-to-stall training includes high-altitude stalls or stalls with moderate bank angles that significantly differ from objectively validated flight conditions, training providers should conduct additional testing to ensure adequate fidelity in these training manoeuvres (such as verification of stall warning speeds, stall buffet speeds, etc.).

1.2 Stick Pusher Demonstrations

- (1) FFSs may be used beyond the first indication of stall for demonstrations of the stick pusher (if installed), however, training providers should conduct additional testing to ensure that the FFSs stick pusher force complies with the design requirements specified by the manufacturer to ensure that it accurately represents the aeroplane.
- (2) Training providers desiring to conduct stick pusher demonstrations as part of a TCCA approved flight training program are encouraged to contact the TCCA National Simulator Program (NSP) for additional guidance in evaluating an FSTD for such manoeuvres.

1.3 Training Beyond Approach to Stall AOA's

- (1) For training to, or past, the AOA's associated with the approach to a stall, additional testing and validation of the specific FSTD may be necessary because of the variations among FSTDs. While some FSTDs may have the fidelity allowing training past the approach-to-stall condition, the potential of negative training exists if simulated flight in this regime is not properly evaluated (through objective testing and evaluation by a Subject Matter Expert (SME) pilot experienced in the stall characteristics of the aeroplane). TCCA does not recommend training to angle of attack (AOA) beyond the approach to the stall, unless the FSTD is properly evaluated, because the roll and yaw characteristics of the FSTD may not be representative of the aeroplane.

2.0 BACKGROUND INFORMATION

- (1) FSTD qualification standards are currently defined in Transport Canada Publication TP 9685.

Note: *Alternate means of compliance are also available in FAA 14 CFR Part 60, Flight Simulator Training Device Initial and Continuing Qualification and Use and Joint Aviation Requirements, JAR-FSTD A, Aeroplane Flight Simulation Training Devices.*

- (2) Previously qualified FSTDs may not be capable of conducting training tasks to a full aerodynamic stall. The primary factors for this determination are as follows:
 - (a) Flight training requirements to date, are limited to approach-to-stall manoeuvres as opposed to full stall manoeuvres. As a result, most current FSTD stall training does not

extend to angles of attack much higher than that required to trigger the stall warning system.

- (b) While much of the development of an FSTD's aerodynamic model prior to a full aerodynamic stall can assume a certain extent of linearity in extrapolating performance and handling characteristics, this assumption is not valid at, or past, full aerodynamic stall where the aircraft dynamics are often unstable.
- (c) To fully evaluate the non-linear characteristics of a stall model, more test points in the form of objective or subjective tests are necessary to validate such models.

2.1 Stall Model Areas of Concern

- (1) Through the efforts of various working groups, several characteristics of a typical FSTD's stall model have been identified as areas of concern where potential negative training could occur due to a lack of fidelity in the representation of an aircraft's performance and handling characteristics:
 - (a) Lateral and directional handling characteristics;
 - (b) Stall buffet characteristics and onset speed;
 - (c) Stall hysteresis; and
 - (d) Stall handling characteristics in cruise and turning flight conditions.
- (2) Appropriate qualification of the simulator buffet is recommended. The buffet accelerations associated with aerodynamic stall are normally generated by the simulator motion system in the three translational axes: vertical, lateral and longitudinal. However, the vertical and lateral components are usually more significant.
- (3) The stall buffet onset and amplitude is usually modelled as a function of angle of attack or lift coefficient based on flight test data. This may result in incorrect buffet amplitudes once the critical angle of attack is exceeded, especially for models based on lift coefficients. Sometimes the stall buffet amplitude is modelled as a function of speed and weight, which can lead to incorrect buffet onset especially during accelerated stall. The simulator stall buffet onset point is matched with data; however, the simulator buffet onset amplitude may differ from the threshold amplitude used to identify it during the flight test. A threshold of ± 0.05 g is often used, which is the definition of initial buffet used for aeroplane certification. Note that this is higher than the thresholds typically used to define motion turnaround bumps of ± 0.02 g or ± 0.025 g.

3.0 FSTD EVALUATION RECOMMENDATIONS

- (1) While changes to the FSTD qualification standards are currently being developed, they are outside the scope of this advisory circular. It is highly recommended that all FSTDs being used for approach-to-stall training manoeuvres are specifically evaluated for such manoeuvres. Based upon existing and past qualification standards, a high level of confidence exists that current appropriately qualified FSTDs can provide an adequate level of fidelity in approach-to-stall training tasks that do not go beyond angles of attack associated with stall warning system activation. The following general evaluation guidelines are provided to assess an FSTD's suitability for use in high angle of attack (AOA) training manoeuvres:

3.1 Approach-to-Stall Training Maneuvers

- (1) To ensure a high level of FSTD fidelity, training manoeuvres should be conducted in conditions similar to objectively evaluated test conditions where possible (e.g., aircraft weight, environmental

conditions, stall entry rates, etc.). Current objective test requirements are for second-segment climb and approach/landing conditions.

- (2) For approach-to-stall training manoeuvres that are not objectively evaluated for FSTD qualification (such as cruise/high altitude approaches to stall and turning flight approaches to stall), the FSTD sponsor should conduct additional objective and subjective evaluation to determine adequate FSTD fidelity. This additional evaluation should include:
 - (a) Objective evaluation of stall warning and stall buffet speed against published aeroplane data (such as Aircraft Flight Manual (AFM) stall tables).
 - (b) Subjective evaluation by a SME pilot that is experienced in the approach to stall characteristics of the aeroplane.

3.2 Stick Pusher Demonstration Manoeuvres

- (1) The stick pusher activation speeds (or associated angles of attack) should be objectively evaluated against published aircraft data (such as the AFM stall tables).
- (2) The modeling of the stick pusher system or stall protection system should be based upon aircraft Original Equipment Manufacturer (OEM) provided simulation data or other suitable data to ensure correct activation speeds/angles of attack and cancellation logic.
- (3) The simulated stick pusher control forces and displacements should be validated against aircraft collected or OEM provided validation data to ensure the FSTD provides the correct control loading force cues.
- (4) Since a stick pusher demonstration manoeuvre will typically occur at angles of attack beyond the activation of the stall warning system, the FSTD's should be evaluated for satisfactory performance and handling qualities by an appropriately qualified SME pilot.

APPENDIX 4 — AEROPLANE-ONLY FLIGHT TRAINING PROGRAM

- (1) Part VII of the *Canadian Aviation Regulations* (CARs) training standards have provisions for the training for “approach to stall and recovery procedure” to be conducted in an aeroplane instead of an Flight Simulation Training Device (FSTD). Training in an aeroplane versus an FSTD is less effective and more limited in scope because of the reduced capability of an aeroplane as a training platform compared to a suitably qualified FSTD. An FSTD also eliminates hazards associated with stall training in an aeroplane. Operators are encouraged to seek out a suitably qualified FSTD where possible, to ensure that the stall recovery training, demonstrations and scenarios within this Advisory Circular (AC) can be effectively accomplished.
- (2) When conducting stall training in an aeroplane, operators should carefully review the stall recovery training demonstrations, and scenarios within this AC and adjust them accordingly. Some scenarios may not be possible, practical or safe to demonstrate in an aeroplane. For example, the introduction of crew distractions to introduce startle and surprise or high altitude training would not be appropriate for aeroplane demonstrations.
- (3) There is a possibility of excessive altitude loss or even an aeroplane upset during stall training. Minimum weather and lighting conditions should be established and areas of air traffic should be avoided. Stall training should be performed with sufficient clearance from cloud, a clearly visible horizon and during daylight conditions. The leading edges of lifting surfaces should be cleared of insects, sealant and any other contaminants prior to flight. Airborne icing conditions and any icing contamination should be avoided. The absence of any residual icing contamination should be confirmed immediately prior to commencing stall training, and training should not be conducted if any ice contamination is present.
- (4) Training to angle of attacks (AOA) beyond the indications of an approach to stall or to the activation of the stick pusher (if equipped) should not be conducted because of the potential hazard of encountering a stall or an aeroplane upset.
- (5) Operators should identify and mitigate all hazards associated with stall training prior to the commencement of stall training. As a minimum the following items should be addressed:
 - (a) Development of training plan specific to the aeroplane type:
 - (i) training demonstrations and scenarios to be flown;
 - (ii) roles and responsibilities of training pilot and training candidate;
 - (iii) minimum weather conditions including cloud cover, icing, minimum clearance from cloud and terrain and minimum lighting conditions;
 - (iv) aeroplane allowable weights, Centre of Gravity (CG) limits, and serviceability. A forward CG is normally the most stable aerodynamic configuration suitable for stall training;
 - (b) Pre-flight briefing:
 - (i) briefing of training plan elements (see above);
 - (ii) traffic and Air Traffic Control (ATC) considerations;
 - (iii) procedures to transfer control between training pilot and trainee;
 - (iv) review of all indications of an approach to a stall, and stall and upset in case a stall or upset are inadvertently encountered. The review of indications should include flight instrument indications, natural stall indications and stall protection system indications;

- (v) specific indications during an approach to a stall, where the entry should be discontinued and recovery initiated;
 - (vi) procedures to recover from an actual stall, stick pusher activation (if installed) or aeroplane upset if inadvertently encountered;
 - (vii) the criteria for transferring control to training pilot if necessary;
 - (viii) recognition of failures in stall protection system that may prevent artificial stall warning from functioning;
 - (ix) criteria when to discontinue training if conditions differ or are not within the parameters to those briefed.
- (c) In addition to the items briefed prior to the flight, the following items should be reviewed just prior to commencing stall training;
- (i) an assessment of the weather, lighting and traffic conditions in the training area, aircraft security and readiness of the flight crew;
 - (ii) an assessment of the condition of the aeroplane, stall protection systems and verification of weight, CG and configuration;
 - (iii) a brief review of the training manoeuvres to be conducted.

APPENDIX 5 — AIRBORNE ICING CONTAMINATION INDUCED STALLS AND AEROPLANE UPSETS**1.0 AIRBORNE ICING CONTAMINATION**

- (1) Icing contamination has been a causal factor in numerous stall and aeroplane upset accidents. This appendix summarizes the adverse effects of airborne icing on the aerodynamics and handling qualities of aeroplanes and provides guidance on the awareness, prevention and recovery from ice contamination induced stalls and aeroplane upsets.

1.1 Aerodynamic Effects of Airborne Icing

- (1) The classic aerodynamic effects of ice contamination on an aeroplane in flight can include:
- (a) Significantly reduced lift at the same angle of attack as an uncontaminated wing, accompanied by significant increases in drag and weight from ice accumulation.
 - (b) Increasing amounts of ice accumulation will result in decreasing airspeed or climb rates for a given power setting.
 - (c) Reduced thrust due to ice disrupting the airflow to the engine and/or degrading propeller efficiency. Ice ingested into a turbojet engine may induce a compressor stall and/or a flame out.
 - (d) Increases in stall speed and reduced maximum stall angle of attack as ice alters the shape of an airfoil and disrupts airflow.
 - (e) An abrupt stall without any of the aerodynamic warnings expected to precede a stall, or before stall warning systems such as stick shakers activate.
 - (f) Flight Control restrictions due to water flowing back into control surfaces and freezing.
- (2) Propeller driven aeroplanes including turbo-propeller (turboprop) powered aeroplanes affected by ice contamination do not have the substantial excess thrust of large turbojet transport aeroplanes to overcome the additional drag. There may be insufficient power available to maintain level flight at maximum power.
- (3) The adverse effects of icing contamination can increase rapidly in during an icing encounter. A large decrease in airspeed can occur within just a few minutes of entering icing conditions. Slow or overly sensitive control responses, airframe vibration and buffeting can be indications of increasingly severe icing effects.
- (4) Relatively small amounts of roughly textured ice can affect an aeroplane far more adversely than large amounts of ice. On some wing designs, dramatic increases in drag can occur with apparently insignificant amounts of rough ice accumulation
- (5) The certification of aeroplanes for flight into icing does not imply or provide protection against all icing conditions including freezing drizzle or freezing rain. Freezing precipitation can overwhelm ice-protection systems. Icing certification also assumes an aeroplane is clear of all ice during take-off.

2.0 ICING INDUCED AEROPLANE STALL AND/OR UPSET

- (1) The adverse aerodynamic effects of airborne icing will result in a pre-mature wing aerodynamic stall and possible aeroplane upset compared to an uncontaminated aeroplane.
- (2) Airflow separation as a result of ice contamination is often unsymmetrical and one wing can stall before the other, leading to a roll upset. An upset may also be triggered if the auto-pilot suddenly disengages when control loads exceed limits.
- (3) A roll upset may also be triggered by the formation of an ice ridge ahead of ailerons. Such ice ridges are more likely in icing conditions involving Supercooled Large Droplets (SLD) where water droplets may flow back behind the protected surfaces before freezing. The airflow separation aft of the ice ridge can cause an aileron to auto-deflect without pilot input, triggering the upset.
- (4) A roll upset triggered by aileron auto-deflection can occur well before the normal symptoms of ice accretion are evident to the pilot. Such a roll upset may be preceded by abnormal or sloppy aileron control forces.
- (5) Autopilot engagement can mask an impending control surface auto-deflection. The control forces associated with the auto-deflection may be considerable and difficult to overcome.
- (6) Aeroplanes with unpowered (non-hydraulically powered) flight controls are more prone to control surface auto-deflection. Propeller driven and small turbojet aeroplanes typically have unpowered primary flight controls.
- (7) In some aeroplane types, ice contamination of the horizontal stabilizer may result in a nose-down pitch upset called Tailplane Stall. (Section 4 of this Appendix).

2.1 Awareness and Prevention

- (1) Ice protection systems should be activated promptly in accordance with the AFM and/or manufacturer's instructions upon entry into icing conditions. Prolonged flight in icing conditions should be avoided. Airspeed must not be allowed to decrease below the minimum airspeeds for flight in icing conditions. Immediate exit from icing conditions may be required if indications of rapidly increasing icing severity are present. A descent may be the only option to maintain airspeed and avoid a stall.
- (2) If significant or severe icing conditions are inadvertently encountered, pilots should consider the following actions to avoid a stall or roll upset:
 - (a) Disengage the auto-pilot and hand fly the aeroplane. (Firmly grasp the controls before disengaging the autopilot to prevent any control auto-deflection.) The auto-pilot may mask important clues or may self-disconnect when control forces exceed limits, presenting the pilot with abrupt unusual attitudes and control forces and a possible aeroplane upset.
 - (b) Reduce the angle of attack (AOA) by increasing airspeed and/or descending. Airspeed must not be allowed to decrease. A controlled descent may be necessary to maintain airspeed. If turning, roll wings level.
 - (c) Consider the extension of flaps (or slats), if retracted and within flap (or slat) limiting speeds, to increase stall margins.
 - (d) If flaps (or slats) are extended, do not retract them unless it can be determined that the upper surface of the wing is clear of ice. Retracting the flaps will increase the AOA at any given airspeed, possibly leading to a stall or roll upset.
 - (e) Set appropriate power and monitor airspeed (and AOA if possible). A controlled descent may be needed to maintain airspeed and control.

- (f) Limit control displacement and the rate of control application required for manoeuvring. Turbulence may trigger a stall or upset while manoeuvring.
- (g) In cases of severe icing, or when unable to maintain airspeed without descending an off-airport landing (forced landing) might be the only viable option to avoid a stall or upset.

3.0 STALL & UPSET RECOVERY

- (1) The recovery actions provided in Section 8.3 of this Advisory Circular (AC) (Table 1) apply for recovery from an ice contamination induced stall with the following additional considerations:
 - (a) At the first indication of a wing stall or upset – whether activation of a stick shaker, un-commanded roll, buffet or other aerodynamic cues, disengage the autopilot (if engaged), apply nose down pitch control to reduce the AOA.
 - (b) Ailerons should be used to roll the wings level and rudder applied judiciously and as necessary to control side-slip.
 - (c) In all cases, the most important action for recovery is reducing AOA by applying a nose-down pitch control input. Reducing AOA will also improve the roll control capability of the ailerons, and may reduce the control forces necessary to regain aileron control.
 - (d) Power should be increased to maximum for propeller driven aeroplanes to help increase airspeed and increase airflow over the wings. Thrust should be set as necessary for turbojet powered aeroplanes in accordance with the manufacturer's instructions.
 - (e) If retracted, the extension of slats and/or flaps to the first setting should be considered, if within flap limiting airspeeds.
 - (f) During recovery, excessive nose-up pitch rates should be avoided. Excessive nose-up pitch rates will increase load factor and AOA, which can trigger a secondary stall or upset.
 - (g) Slats and/or flaps should be set as appropriate to complete the recovery.

Note: The manufacturer's procedures and AFM information take precedence over the recommendations of this AC.

4.0 PITCH UPSET –TAILPLANE STALL

- (1) Certain aeroplane types are prone to a nose-down pitch upset because of ice contamination of the horizontal stabilizer, called tailplane stall. A nose-down pitch upset can occur, when airflow separation over an ice-contaminated horizontal stabilizer prevents this surface from providing the required download to balance the aeroplane. Aeroplanes with unpowered elevator control surfaces are more prone to this type of pitch upset.
- (2) A tailplane stall induced upset should not be confused with a wing aerodynamic stall. A tailplane stall requires special consideration and training because the recovery actions are essentially **opposite** to those for a wing stall. A tailplane stall is caused by airflow separation from the horizontal stabilizer, not the wing.
- (3) During a tailplane stall induced upset, there will be no artificial stall warning indications, such as a stick shaker, or stall warning horn, or the buffeting normally associated with a wing stall.
- (4) Unlike a wing stall, a tailplane stall can occur at relatively high speeds, well above the normal 1G stall speed and typically near the flap limit speed. The pitch down may occur without warning and may be uncontrollable.

- (5) A tailplane stall is most likely to occur when the flaps are extended to the landing position, combined with a nose down pitching manoeuvre, airspeed changes, power changes or flight through turbulence.
- (6) The AFM and manufacturer should be consulted to determine if an aeroplane is or is not prone to a tailplane stall. Training programs should include training for the recognition and recovery from tailplane stalls if the specific aeroplane type is prone to tailplane stall.
- (7) Flight crews should be made aware if their aeroplane type is, or is not prone to a tailplane stall induced upset. Taking corrective actions appropriate for a wing stall when the tailplane has stalled will exacerbate the tailplane stall induced upset and vice-versa.

4.1 The aerodynamics of a Tailplane Stall Induced Upset

- (1) The horizontal stabilizer (tailplane) is an aerodynamic surface which provides a downward balancing force to overcome an aeroplane's normal nose-down pitching moment. Ice accumulation on the tailplane will disrupt the airflow around the horizontal stabilizer and reduce its critical AOA.
- (2) Ice may first accumulate on the horizontal stabilizer, because of the shape and relatively thin airfoil profile of the horizontal stabilizer. Ice can accumulate on the horizontal stabilizer without any visible on the wings or any other parts of the airframe.
- (3) Application of flaps, especially near the flap limit speed, and/or changing power on propeller driven aeroplanes can increase the tailplane AOA because of an increase in downwash. A forward Centre of Gravity (CG) also will require a higher AOA from the tailplane to balance the aircraft.
- (4) A tailplane stall induced upset occurs when the critical AOA of the horizontal stabilizer is exceeded, causing it to stall, resulting in a rapid nose-down pitching motion.
- (5) The nose-down pitching motion associated with a tailplane stall, may trigger an aerodynamic overbalance of an un-powered elevator. The overbalance will result in an abrupt self-deflection of the elevator in an aircraft nose down direction. The control forces to overcome the elevator self-deflection may be very difficult to overcome.

4.2 Indications of an Impending Tailplane Stall

- (1) The following are the indications of an impending tailplane stall induced upset. These indications may first become apparent when the flaps are extended beyond the first setting:
 - (a) Sudden change in elevator force (pitch control moving nose down if not restrained);
 - (b) Elevator control pulsing or oscillation or any other abnormal or unusual pitch anomalies (possibly leading to pilot induced oscillations);
 - (c) An abnormal nose down trim change or reduction in elevator effectiveness. (This may not be detected if the auto-pilot is engaged.);
 - (d) A forward control column movement or nose down pitch change when the power setting is changed;
 - (e) An absence of any other indications of an approaching stall, such as artificial stall warning, airframe buffet, sudden wing drop etc.

4.3 Awareness and Prevention

- (1) The pilot should:
- (a) If an approach in icing conditions cannot be avoided, plan approaches to be flown at the minimum allowable flap settings for the conditions.
 - (b) Avoid abrupt pitching manoeuvres and power changes. Nose down pitching motion and power changes in propeller driven aeroplanes can increase the tailplane AOA.
 - (c) Fly the approach "on speed" for the configuration. Extension of flaps near flap limit speeds should be avoided.
 - (d) If symptoms occurred shortly after flap extension, immediately retract the flaps to the previous setting, and increase the airspeed to the minimum manoeuvring speed for the reduced flap setting.
 - (e) Apply sufficient power for the configuration and conditions. Observe the manufacturer's recommendations concerning power settings. High power settings may aggravate tailplane stall in some aeroplane types.
 - (f) Make any nose down pitch changes gradually, even in turbulent conditions.
 - (g) If equipped with a pneumatic de-icing system, operate frequently to remove ice from the tailplane.

Note: *The manufacturer's procedures and AFM information take precedence over the recommendations of this AC.*

4.4 Recovery Actions

- (1) The following recovery actions should be considered if a sudden, un-commanded nose down pitch occurs when combined with symptoms of an impending tailplane stall:

Warning:

The procedures for recovery from a tailplane stall and wing aerodynamic stall are essentially opposite. Improper identification of the event and application of the wrong recovery procedure may make an already critical situation even worse:

- (a) Disengage the autopilot if engaged.
- (b) Resist or restrain any nose down elevator motion.
- (c) Retract the flaps by one setting immediately, if a nose down pitching motion occurs after flap extension.
- (d) Restore power to the previous setting, if a nose down pitching motion occurs after a significant change in power.

Note: *The manufacturer's procedures and AFM information take precedence over the recommendations of this AC.*