Transport Canada Transports Canada

Advisory Circular

Subject: **External Loads on Aeroplanes – Approval Process and Flight Test Considerations**

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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 on the process for obtaining an external load approval on small aeroplanes in the Normal category. It specifically applies to single engine floatplanes. This material applies to both private and commercial air operators. This AC does not provide guidance on "specialty" external loads such as towed or slung loads.

(2) A significantly large external load strapped to the struts of a fixed wing floatplane is considered a major modification and therefore requires a full airworthiness approval. The testing of an aeroplane with an external load is potentially demanding, and obtaining a full airworthiness approval for an external load might prove to be difficult because of possible changes to the aeroplane's handling qualities and performance created by the load's unfavourable profile. As a result, it might not be practical, or safe, to attempt some of the flight tests that are usually associated with granting an airworthiness approval.

(3) Recognizing this potential challenge, this advisory circular is intended to provide guidance on both the administrative and practical aspects of obtaining an airworthiness approval to allow the carriage of an external load on an aeroplane. For areas of the regulations where compliance cannot be found on some aeroplanes due to safety related concerns, an equivalent level of safety concept is proposed as the most logical way forward to obtaining an approval. Prohibitions, limitations, and restrictions will be recommended as the mechanisms for a finding of equivalent safety, recognizing that these tools are currently used as best practices in our industry today.

1.2 Applicability

(1) This document applies to Transport Canada Civil Aviation (TCCA) personnel, delegates, and the aviation industry.

1.3 Description of changes

(1) Due to the number of changes incorporated into this issue, readers should review the content of the entire document. The major changes from the previous issue are:

- (a) The applicability to helicopters with class A external load has been removed
- (b) The requirement for an approval for all external load operations as reflected in new text in paragraph 3.0(5) and new section 5.0, has been added
- (c) Section 6.0 has been rewritten to add recommendations, content to the Aeroplane Flight Manual Supplement (AFMS), as well as an extensive update of flight test guidance write-up; and
- (d) Section 7.0 has been updated with additional information and terminology update.

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) Part I, Subpart 1 of the *Canadian Aviation Regulations* (CARs) - Interpretation - https://lois-laws.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-100.01

(b) Part V, Subpart 7 of the CARs - Flight Authority and Certificate of Noise Compliance - https://lois-laws.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-507.01

(c) Part VI, Subpart 2 of the CARs - Operating and Flight Rules - https://lois-laws.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-602.01

(d) Part VI, Subpart 5 of the CARs - Aircraft Requirements - https://lois-laws.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-605.01

(e) Part VII, Subpart 2 of the CARs - Aerial Work - https://lois-laws.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-702.01

(f) Part VII, Subpart 3 of the CARs - Air Taxi Operations - https://lois-laws.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-703.01

(g) Standard 571 of the CARs - Maintenance - https://www.tc.gc.ca/en/transport-canada/corporate/acts-regulations/regulations/sor-96-433/part5-standards-standard571-1971.htm

(h) Chapter 523 of the Airworthiness Manual (AWM) - Normal Category Aeroplanes - https://www.tc.gc.ca/en/transport-canada/corporate/acts-regulations/regulations/sor-96-433/part5-standards-523-menu-696.htm

(i) Advisory Circular (AC) 521-004 - Changes to the Type Design of an aeronautical product - https://www.tc.gc.ca/en/services/aviation/reference-centre/advisory-circulars/ac-521-004.html

(j) Federal Aviation Administration Advisory Circular (FAA AC) 23-8C- Flight Test Guide for Certification of Part 23 Airplanes- http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/BC4325AD70E84FF58625795D00635D7C?OpenDocument

(k) Federal Aviation Administration Advisory Circular (FAA AC) 43.13-2B - Acceptable Methods, Techniques, and Practices - Aircraft Alterations - http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/11E144125D63FE548625740A00731B4A?OpenDocument&Highlight=43.13-2b; and

(l) “Using GPS to Determine Pitot-Static Errors” – National Test Pilot School, Mojave, California https://www.ntps.edu/information/downloads.html.

2.2 Cancelled documents

(1) Not applicable

(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) **Finding of equivalent safety (FES)**: A FES is used in this AC as an acceptable means of mitigating the risks associated with non-compliance to flight test standards as a result of carrying an external load. Also known as Equivalent Level of Safety (ELOS) or Equivalent Safety Finding (ESF)

(b) **Flight authority**: A certificate of airworthiness, special certificate of airworthiness, flight permit or validation of a foreign document attesting to an aircraft's fitness for flight, issued under Subpart 507 of the CARs, or a foreign certificate of airworthiness that meets the requirements of Article 31 of the Convention on International Civil Aviation [Source is subsection 101.01(1) of the CARs]; and

(c) **Minimal effect**: The effect to aeroplane performance and flight characteristics is minimal and does not require the pilot to have additional proficiencies beyond those normally associated with the aeroplane type. In addition, the emergency egress provisions continue to meet the applicable standards of airworthiness.

(2) The following **abbreviations** are used in this document:

(a) **AFM**: Aeroplane Flight Manual

(b) **AFMS**: Aeroplane Flight Manual Supplement

(c) **AME**: Aircraft Maintenance Engineer

(d) **AWM**: Airworthiness Manual

(e) **CG:** Centre of Gravity

(f) **C of A**: Certificate of Airworthiness

(g) **CAR**: Canadian Aviation Regulation

(h) **DAR**: Design Approval Representative

(i) **FAA**: Federal Aviation Administration

(j) **FES**: Finding of equivalent safety

(k) **IAS**: Indicated Airspeed

(l) **GPS**: Global Positioning System

(m) **PEC:** Position Error Correction

(n) **STC**: Supplemental Type Certificate

(o) **TC**: Type Certificate

(p) **TCCA**: Transport Canada Civil Aviation

(q) **TCDS**: Type Certificate Data Sheet

(r) **VFR**: Visual Flight Rules; and

(s) **VMC**: Visual Meteorological Conditions.

3.0 Background

(1) The practice of carrying external loads on aeroplanes in Canada is almost as old as the history of flying aeroplanes in this country. There is no doubt that the early growth of northern Canada was accelerated due to the ability to transport canoes, boats, equipment, and supplies lashed to the struts of floats on aeroplanes. Carrying external loads on floatplanes has been an integral part of aviation in Canada, and Transport Canada recognizes that it will continue to be an integral part of aviation in Canada.

(2) Section 703.25 of the *Canadian Aviation Regulations* (CARs) has been in effect since the CARs came into force in 1996. This section prohibits air operators from operating an aircraft while carrying an external load with passengers onboard, except where carriage of the external load has been authorized in a Type Certificate (TC) or Supplemental Type Certificate (STC). While section 703.25 of the CARs prohibits carrying an external load with passengers on-board, it does not clearly prohibit unauthorized carriage of external loads when there are no passengers. Thus, some operators have misinterpreted the regulation as allowing carriage of external loads when there are no passengers on-board.

(3) Paragraph 605.03(1) (b) of the CARs requires that no person shall operate an aircraft in flight unless the aircraft is operated in accordance with the conditions set out in the flight authority. Where the flight authority is a certificate of airworthiness issued pursuant to section 507.02 of the CARs, it is issued for an aircraft that conforms to an approved type design and that is safe for flight. Pursuant to section 507.11 of the CARs, the flight authority remains in force only so long as the aircraft continues to meet the conditions subject to which the flight authority was issued. Therefore, a certificate of airworthiness would not continue to be in force where an external load is carried and this capability was not approved as part of the type design, either in the TC or STC.

(4) In 1997, in response to industry concerns regarding the approval process for external loads, commercial air operators were provided with an exemption to section 703.25 and paragraph 605.03(1) (b) of the CARs. This exemption was renewed several times, with the final exemption expiring on December 31, 2010. The conditions of the exemptions remained constant during this time period, with the exception that the conduct of proving flights was required in the exemptions issued from February 08, 2000 onward, and exemption-usage reporting requirements were added in 2006.

(5) Transport Canada and industry have recognized that if the carriage of an external load operation takes place without the configuration being part of the approved type design, the operation is conducted without the benefit of safeguards that decrease the inherent risks. A TC or STC that includes provisions for the carriage of certain types of external loads will set out conditions that may diminish those risks. Diminishing those risks is a key part to providing safer operations. For this reason, no further exemptions to the operating rules will be provided to industry. Henceforth, a design approval will be required for all external loads operations**,** with few exceptions as afforded by current regulations and listed in this AC.

4.0 Classification of external loads

4.1 Minimal effect

(1) Based on industry experience, the following small external loads are considered to have a 'minimal effect' on an aeroplane and do not require a design approval or acceptance:

(a) Snowshoes and skis

(b) Hunting rifles

(c) Fishing rods

(d) Other items of the same size, shape, and weight as the above items. Consideration should be given to ensuring that small pipes, small tubes, etc, are not open to the airstream, as drag effects on performance and handling can be marked

(e) Miniature digital cameras mounted in areas of non-interference with flight controls, static ports, Pitot tubes, or pilot’s vision. Non-interference includes direct physical and flow disturbance interferences (for example, the impact of vortex shedding on a control

surface or a flight instrument). High angle-of-attack scenarios should also be considered; and

(f) A combination or a number of the above items, with the condition that the cumulative effect of these loads still qualifies as "minimal".

(2) The general considerations in sections 6.2 and 6.3 regarding positioning and securing of the load also apply.

(3) It is recognized that judgement must be exercised when assessing the acceptable number, size, shape and weight of combined loads that could qualify as 'minimal effect'. If there is any doubt, it should be assumed by default that the load does not have a 'minimal effect',

(4) The loads that are assessed as having 'minimal effect' - as described in paragraph 4.1(1) - are not considered "installed parts" for the purpose of maintenance activities under Subpart 571 of the CARs. They are therefore not subject to what are considered aircraft maintenance activities, and in particular there is no need for an installation sign-off by an Aircraft Maintenance Engineer (AME) or a maintenance logbook entry when the load is attached or removed from the aeroplane.

(5) A note should be added to the journey log when carrying external loads.

(6) The installation of attachment devices designed to carry external loads (e.g. racks, mounting hardware) is considered an aeroplane modification and is subject to Subpart 571 of the CARs. These are devices permanently attached to the aeroplane. This installation can be assessed as a major modification or a “not major” (minor) modification. If assessed as a non-major modification, this installation can be performed as part of the process under Subpart 571 of the CARs with an AME sign-off based on appropriate technical data.

4.2 Other than minimal effect

(1) The carriage of any other external load not identified in section 4.1 must be approved in accordance with Subpart 521 of the CARs and comply with the standards in Chapter 523 of the Airworthiness Manual (AWM), or the standards associated with the aeroplane’s certification basis.

(2) In the case of an external load that has other than a minimal effect, and there is no recurring need to carry this type of external load (i.e. this is a one-time occurrence), the operator can elect to obtain the appropriate flight authority in accordance with Subpart 507 of the CARs as an alternative to obtaining a full airworthiness approval.

4.3 External load equipment

(1) This AC does not include guidance on external load equipment such as attachment devices that carry a slung external load, a towed external load or an external load for dispersal. Pursuant to section 702.45 of the CARs, the attachment device used to conduct these kinds of aerial work operations is required to be approved as part of an STC or an airworthiness approval relating to the operational configuration of the aeroplane.

5.0 Options for approval

5.1 Design approval

(1) The options for the new design approval chosen by the applicant will depend on the certification basis and the characteristics of the aeroplane / external load combination. These characteristics require determination through flight test.

(2) For modified aeroplanes that are shown to fully comply with the certification basis of their original type design or supplemental type design, while carrying external loads, a supplemental type certificate could be sought in the Normal Category. Passengers would be allowed for this type of approval, subject to 6.4 and 6.5.

(3) For some aeroplanes, showing compliance with the lateral / directional stability requirements out to full rudder deflection might not be practical or safe for some airframe / external load combinations. In addition, for those aeroplanes that have a type design certification basis that requires a demonstrated recovery from a one turn spin, it might not be practical to demonstrate this capability with an external load. In both these cases, a supplemental type certificate could be sought in the Normal Category with a finding of equivalent safety (FES) proposed as part of the certification basis. See Appendix B for a sample FES template. Limitations would be required in the AFMS (or equivalent, see section 6.7(2)) that reflect the FES and mitigate the associated risks of non-compliance, and minimize exposure in the associated areas of the flight envelope. Passengers would be allowed for this type of approval, subject to 6.4 and 6.5.

5.2 Flight permit

(1) For those activities that require the carriage of an external load for a “one time occurrence" a Flight Permit – Specific Purpose could be sought as a flight authority, instead of a Certificate of Airworthiness (C of A). In this case, a design approval would not be necessary. The Operating Conditions of the Flight Permit - Specific Purpose could limit or prohibit the carriage of passengers as part of its operating conditions but would not necessarily do so in all cases.

(2) See Appendix A for a summary of these choices.

6.0 Design considerations

(1) This section is to be considered when showing compliance with the appropriate airworthiness standards and obtaining a design approval to carry an external load that has other than 'minimal effect'. Any application for a design approval requires comprehensive technical evaluation and substantiation.

6.1 Size and weight

(1) The maximum size and weight of the external load must be determined in order to provide appropriate limitations in the AFMS governing the load that can be safely carried. It is recommended that the worst-case load sought for approval is flight tested, so as to be able to take credit for similar shaped loads of lesser weight, lower profile drag, or more favourable aerodynamic qualities. Historically it has been shown that profile drag alone provides more of an adverse effect on handling qualities, while both profile drag and weight adversely affect aeroplane performance. For example, asymmetric, dense loads such as lumber have been shown to require aileron deflections that can infringe on the control force requirements of the airworthiness standards.

(2) Compliance with the climb requirements of the Airworthiness Manual, or with the certification basis, is required. Usually, the maximum take-off weight of the aeroplane will have to be reduced in order to compensate for the loss of performance due to the external load. As a rule of thumb, decreasing the maximum take-off weight of the aeroplane by twice the external load’s weight has been shown to provide a good starting point for risk mitigation and data gathering during flight test.

6.2 Positioning of load

(1) For aeroplane operating off water, the external load must be positioned so that it does not catch and retain a significant volume of water during take-off and landing. Also, regardless of the take-off or landing surface, all loads should be secured in such a manner that flight in rain does not cause water to be retained and increase the weight of the aeroplane. The use of a cover may be beneficial when carrying canoes, kayaks, boats and other objects susceptible of retaining large amounts of water. If a cover is used, it must be part of the approval and flight test configuration, and tie-down aspects (see section 6.3) should be considered.

(2) Once the safe confines of the external load's position and orientation on the aeroplane has been determined, limit markings on the floats or structure have been shown to aid in the consistent placement of the load for future operations.

(3) It should be shown that the position of the external load (including its attachments) does not adversely affect the:

(a) travel of the flight controls

(b) operation of the undercarriage or flaps

(c) airflow in the vicinity of the Pitot or static air sources that may cause a change to aeroplane position errors

(d) propeller thrust

(e) airflow in the vicinity of any air intake or exhaust ports. Care should be taken in the positioning of the load so as not to cause damage from hot exhaust gases

(f) airflow over any critical flying surface, such as the elevator or rudder

(g) compliance with emergency egress as detailed in 6.4; or

(h) pilot's visiblity during all phases of flight or ground/water operation. For example, wheel position indicators on amphibious aeroplanes should remain clearly visible.

(4) See 6.8(4)(h), 6.8(4)(i) and 6.8(4)(j) for information on the effect of load position and centre of gravity (CG) on stability and control.

6.3 Tie-down

(1) A single failure of a tie-down strap, rope or fitting must not be hazardous. Stacked lumber must be fastened together to form a unit such that no single piece(s) may come loose from the stack. Symmetric stacking of lumber on each float has been shown to result in better flight characteristics than stacking lumber asymmetrically on only one float. Approval will only be granted for the configuration tested and proven in flight test.

(2) A load may be secured directly to a floatplane float strut, or special provisions such as a boat rack may be made for the carriage of external loads. A repeatable and reliable means of securing the load to the aeroplane must be determined and specified in the AFMS. The load must be tightly restrained and held immobile. An external load may not touch or be attached in any way to the wing struts, unless continued compliance with applicable structural requirements is shown.

(3) For all tie-down systems, a continuously secure tie-down should be ensured, so that it does not loosen during flight. For example, ratchet straps should have a positive lock on the ratchet mechanism.

(4) Care should be taken to ensure that the tie-down system does not leave any loose ends that can flutter and buffet during flight, possibly damaging the load or the aeroplane.

(5) Manufacturer's instructions for the tie-down systems, if applicable, should be followed, including any maintenance requirement.

(6) Attachment means (ropes, straps) may degrade over time and maintenance instructions (including inspections) should be considered.

6.4 Emergency egress

(1) Emergency egress from the aeroplane must not be impeded by carriage of the external load, particularly in the take-off and landing configurations. Any special procedures required or alternate egress routes must be clearly marked on the aeroplane and these must be readily visible to persons attempting to exit the aeroplane.

6.5 Carriage of passengers

(1) Passengers may be transported in an aeroplane carrying external loads provided that:

(a) The carriage of passengers is permitted by the flight authority. Where passenger carriage is permitted by the flight authority, compliance with all applicable standards of airworthiness related to occupant safety and emergency egress must be met. This may or may not result in further limitations on the maximum number of passengers.

(b) If emergency egress routes differ from those specified in the AFM or operating manual for the basic aeroplane, the passengers must be briefed on the specific differences prior to each flight.

6.6 Structural

(1) The applicable aeroplane structure shall be protected from chafing, dents or damage caused by vibration or shifting of the external load.

(2) The affected aeroplane structure shall meet the applicable strength and deformation requirements under the airborne loads imposed by the modification, in all approved configurations of external load carriage.

6.7 Aeroplane Flight Manual Supplement information

(1) Information necessary for safe operation of the aeroplane must be furnished by means of suitable documents, markings and / or placards.

(2) For aeroplanes with an approved Flight Manual, an Aeroplane Flight Manual Supplement (AFMS) must be provided. Please see section 523.1581 of the AWM. For other aeroplanes – typically older aeroplanes for which an AFM was not required, an addendum to an operating manual or other appropriate publication is acceptable as a replacement. In this AC, whenever a reference is made to the content of the AFM or AFMS, it is understood to apply to the AFM/AFMS if there is one, or the equivalent document, as the case may be. The AFMS must:

(a) Address those areas in the flight manual that are affected by the carriage of an external load

(b) Address the changes to the weight and balance chapter of the AFM, including the arm to be used in calculating the moment of the load. Also, if the CG envelope must be changed due to undesirable characteristics discovered in flight test, the new CG envelope must be documented and included; and

(c) Identify any special equipment required when carrying external loads (e.g. mirrors).

(3) In addition to those determined by the design approval flight testing process, the following sample limitations may be applicable for aeroplanes carrying external loads:

(a) Day VMC operations only. Flight over built – up areas to be avoided.

(b) Intentional spinning prohibited, and a statement that spin recovery has not been demonstrated (if a spin demonstration is required per the original certification basis and associated with an FES).

(c) The minimum approved maneuvering speed to be flown except for take-off and landing (If associated with an FES against the spin requirements).

(d) Intentional sideslips, beyond those determined in flight test required for moderate crosswind landings, are prohibited (if associated with an FES against the lateral / directional stability requirements).

(e) Boats and canoes are to be carried partially inverted, stern forward, or as detailed in the tie-down and lashing section of the AFMS as determined by flight test.

(f) The pilot, or appropriately authorized personnel, is to check the attachment areas for damage after each carriage of an external load.

(g) A detailed description of the proposed, readily repeatable and reliable, means of locating and securing each load to the aeroplane (see subsection 6.3 of this AC).

(h) The type of load(s) approved such as the approved size(s), maximum/minimum dimensions, and maximum weight.

(i) Areas of the flight envelope where minor handling quality effects have been identified; or areas of the flight envelope where major handling quality effects have been identified and mitigated via limitations.

(j) Vmax - Maximum allowable speed as determined by flight test.

(k) Maximum bank angle of 30°.

(l) Maximum number of passengers to be carried as a result of emergency egress compliance.

(m) Minimum tie-down rope or strap capacity.

(n) Flight into known or forecast icing conditions is prohibited.

6.8 Flight tests

(1) An applicant must conduct flight tests of the proposed configuration and provide a flight test report and an AFMS, or alternatives, in accordance with this AC to obtain an approval.

(2) A Flight Permit is required in order to conduct flight tests. The associated operating conditions for conducting a test flight of an aeroplane with an external load should include, but are not limited to, the following:

(a) Use as a commercial aeroplane prohibited

(b) Essential crew members only, no passengers

(c) Day VFR only; and

(d) Flight over built-up areas prohibited, and flight in congested airspace to be avoided.

(3) As explained in section 4.0 of this AC, an airworthiness approval must be obtained for an external load that does not qualify for “minimal effect” and is intended to be carried more than once. Therefore, the performance and handling requirements of the aeroplane’s original type design, or

modified design, certification basis must be met. If the performance and handling requirements of the aeroplane's certification basis cannot be met fully, a supplemental type certificate with an FES can be considered.

(4) The following flight test guidance, written in the context of an external loads approval, is intended to be of assistance for those personnel tasked with demonstrating compliance per the flight test requirements. This guidance addresses only a few of the performance and handling tests required and is not intended to be used as a substitute for FAA AC 23-8C- Flight Test Guide for certification of Part 23 Airplanes. Strong consideration should be given to procuring the services of a Test Pilot Design Approval Representative (DAR) to accomplish these tests. (See paragraph r.)

(a) Position errors – Care should be taken to not place an external load in a location where it can interfere with pitot and static sources. Fuselage mounted pitot and static sources are usually the locations considered at risk. If pressure fields are altered appreciably, errors in aeroplane airspeed indicators and altimeters can result. A position error check should be accomplished as a first step in an external load test program. A quick method of checking position errors is to do back-to-back performance stall checks (See (b) below). If changes in the stall speed, greater than three knots, are discovered then a detailed determination of the reasons for the change is warranted. It must be determined if the load is changing the stall speed or the position errors themselves. The most efficient procedure is to do a Position Error Correction (PEC) check without the external load, followed by a PEC check with the load installed. A GPS PEC check is one method that has proven to provide acceptable results with a minimum of flight test and dedicated instrumentation. This back-to-back comparison will clearly show any potential irregularities created by the external load's disruption of the pressure field around the sources. If errors are encountered, the load should be repositioned to a suitable location. If errors are not encountered, then for some reason the stall speed has changed and the considerations found in the next section apply. See AC 23-8C (Appendix 9) for FAA guidance on airspeed calibrations.

(b) Performance stall tests – Performance stalls are intended to confirm the heavy weight, forward CG, stall speed that is documented in the AFM. External loads may, in some cases, disrupt the airflow around the wing and could cause a premature stall (high wing aeroplanes have historically shown no change in stall speed due to a load mounted on the floats). Because most external load test programs will be relying on the cockpit reading of indicated airspeed, a back-to-back test program is warranted, and can be done in conjunction with the position error testing discussed above. With the aeroplane configured with no load, stalls using a one knot per second deceleration rate should be flown at all flap settings and the IAS reading noted. The stalls should then be repeated with the load, and the results compared to the no load case. Any changes noted will need further investigation, starting with a more detailed PEC check at speeds above the stall to rule out position errors. If changes to the actual stall speed are suspected, then it is possible that a truth pitot static system (e.g. experimental air data boom) will have to be utilized to determine the new calibrated stall speed (an acceptable tolerance for before and after stall speeds is three knots). These changes will need to be noted in the AFMS, and any procedures or performance that relies on stall speed need to be amended. As this procedure could be arduous for this type of modification, it is recommended that applicants consider the better option of finding a position for the external load that does not have an effect on the stall speed. During the stall tests, any change to the handling characteristics or buffet levels at all speed regimes should be noted for inclusion in the AFMS. See AC 23-8C for FAA guidance on stall testing.

(c) Climb performance tests – Aeroplane Performance is degraded with an external load attached. The goal of this climb performance testing is to determine the aeroplane's

capability to climb safely after take-off or during a baulked landing. This will be accomplished by either determining what the maximum take-off weight of the aeroplane / load combination will be such that it ensures compliance with the standards, or documenting the fact that no weight penalty is required at all. If no weight penalty is required, many operators will realize an increase in their useful load allowed when compared to operations using previous external loads philosophy.

(d) In the past it has been thought that if the weight of the load is doubled, and then subtracted from the maximum weight of the aeroplane that has been shown to comply with the appropriate climb requirements, the weight and drag effect of the load is approximately compensated for. This is not an empirical rule, only a rule-of-thumb intended to be used as a starting point for flight test. Some floatplanes will require that the weight of the load be more than doubled, before the subtraction from the maximum take-off weight, while others will comply with the climb requirements with less or no maximum take-off weight penalty at all. It is recommended that the rule-of- thumb be used as a starting point for climb performance tests, as risk mitigation to discovering that the load degrades climb performance to an unsafe level for the test aeroplane. When the maximum weight of the aeroplane that results in satisfactory climb performance is found, any changes to the AFM must be documented in the AFMS as a limitation. When reviewing the certification basis, it shouldl be noted that climb requirements became much more stringent with the introduction of CAR 3 – 1956.

(e) Usually, for legacy aeroplanes used for external loads operations in Canada, there are two pertinent climb paragraphs that require a compliance demonstration: normal climb and baulked landing climb. Normal climb is intended to show appropriate climb performance in the take-off configuration and flown at the AFM 50 feet speed. The baulked landing climb is intended to show appropriate climb performance following a go-around from an approach to a landing without any change to the configuration, and flown at the AFM approach speed. The pass / fail criteria for each of these tests is different. In order to reduce the amount of climb testing required, some applicants who have operations that do not rely on the advantages of a landing flap have chosen to limit their landing flap to the flap used for take-off. In doing so, the baulked landing climb now becomes equivalent to a normal climb if the aeroplane is equipped with straight floats without amphibious capability. If this option is chosen, an appropriate AFMS limitation will be required to limit the landing flap and to ensure that the correct speed is flown during a baulked landing climb.

(f) Good climb performance data rely on smooth, stable, air conditions. These conditions are usually associated with early mornings, before summertime temperatures have had a chance to affect the local air mass. In order to minimize the effects of windshear, climbs should be conducted 90 degrees to the winds aloft and repeated on reciprocal headings. Leaning of the fuel mixture during the climbs, as per the AFM, is acceptable in order to achieve maximum obtainable climb horsepower. See AC 23-8C for FAA guidance on climb performance testing.

(g) Trim tests – The basic certification requirements ensure that prolonged control forces carried by the pilot during flight are minimized. Adding either symmetric or asymmetric loads to the exterior of an aeroplane has the potential to increase these prolonged control forces, in all axes. While trim devices might compensate for these changes to the moments affecting the balance of the aeroplane, it is possible that the trim devices will not have enough authority to reduce the prolonged control force to zero. Aeroplanes that do not have aileron or rudder trim are especially at risk because of the possible full-time requirement for aileron or rudder control input to maintain the aeroplane in coordinated flight. The best location of the load, and the resulting minimization of prolonged control

forces, will vary from aeroplane type to aeroplane type and can only be determined through careful flight test. See AC 23-8C for FAA guidance on trim tests.

(h) Stability tests - General - Aeroplane stability is degraded as the centre of gravity moves aft, and the restoring arms from the tailplane or stabilizer surfaces are shortened. When this is combined with the destabilizing effects of an external load as explained above, it is possible to degrade overall stability to dangerous levels. Testing should always start at forward CG and only move aft as required to satisfy the centre of gravity envelope that is operationally realistic. In order to protect from characteristics that may exist at aft CG, it is permissible to limit the CG of the aeroplane when carrying an external load to the forward part of the envelope via an AFMS limitation. See AC 23-8C for FAA guidance on stability tests.

(i) Directional stability tests – In general, floatplanes tend to have weaker directional stability (the tendency of the aeroplane to return to a zero-sideslip condition when disturbed in yaw, i.e. to weathercock into the airstream) because the surface area ahead of the CG is increased by the float installation. Any surface area ahead of the CG will tend to counteract the directional weathercock stability created by the vertical surfaces of the empennage. Due to the design of the float installation and its relationship to the CG of the aeroplane, the axes most likely to be affected by the external load are the yaw and roll axes which affect directional and lateral stability respectively. Most of the airworthiness requirements applicable to modern aeroplanes require that directional stability be positive for sideslip angles appropriate to the aeroplane. However, it is not reasonable to expect that an aeroplane on floats encumbered with an external load will be able to demonstrate full compliance with the directional stability requirements. If additional operating limitations are included in the AFMS to compensate for the lack of a full directional stability demonstration, then the safety concerns regarding the non- compliance can be mitigated. If intentional sideslips, other than for moderate crosswind landings, are prohibited via an AFMS limitation, then the sideslip envelope of the aeroplane can be controlled to the point where only limited, or appropriate, sideslip angles need to be assessed in flight test (consideration should be given to the required crosswind capability if the aeroplane is equipped with amphibious floats, necessitating its landing on runways where minimizing crosswinds is not possible). For aeroplane / load combinations that do not comply with the type design basis of certification, a supplemental type certificate with a FES could be issued under these circumstances.

(j) Lateral stability tests - Lateral stability (the tendency to roll in the same direction as a rudder input during a steady-heading sideslip) is also adversely affected with the addition of an external load. In this case, with the load positioned so it catches the free stream directly during an onside slip, it is possible that the force acting on the load will counteract the dihedral effect that usually is responsible for rolling the aeroplane in the direction of the rudder input. Again, an AFMS limitation that prohibits intentional sideslips, other than for moderate crosswind landings, would limit the angles of sideslip that need to be tested to only those associated with crosswind landings (consideration should be given to the required crosswind capability if the aeroplane is equipped with amphibious floats, necessitating its landing on runways where minimizing crosswinds is not possible). Again, a supplemental type certificate with a FES could be issued under these circumstances.

(k) Flying the lateral / directional stability test points - Directional stability is demonstrated utilizing a wings level skid technique, and lateral stability is demonstrated utilizing a steady heading sideslip technique. See AC 23-8C for FAA guidance on flying lateral / directional stability test points.

(l) Handling stall tests – While performance stall tests are designed to define stall speeds, handling stall tests are intended to show freedom from unsafe handling characteristics during a stall. The handling stall requirements applicable to aeroplane in industry today

vary depending on the basis of the original certification. Regardless of the standards used at the time, all demonstrations require that no unsafe attitudes or characteristics be obtained while stalling the aeroplane in the pre-defined attitudes and configurations. A demonstration of satisfactory power on wings level stalls is sufficient for the scope intended for an external loads flight test program. See AC 23-8C for FAA guidance on wings level power on handling stall tests.

(m) Spin tests – Even though the Airworthiness Manual requires all single engine aeroplanes comply with the spin requirements, as do early FAA requirements for aeroplanes with a maximum weight of 4000 pounds or less, it is not reasonable to require an aeroplane with an external load to be spun in flight test. Again, if additional operating limitations are included in a FES and AFMS to compensate for the lack of a spin demonstration, then the safety concerns regarding the non-demonstrated compliance can be minimized. In this case, it would be appropriate to include a limitation that defines a minimum maneuvering speed to be flown, other than for take-off or landing. This speed can be chosen based on the results of the handling characteristics noted during the stall tests. For those aeroplanes that have a certification basis of Part 23 / Chapter 523 of the AWM, or CAR 3 for aeroplanes of 4000 lb or less, a supplemental type certificate with a mitigating FES could be issued. See section 5.0 for information on approval options.

(n) Ground and water handling characteristics – In addition to cruise flight, aeroplane handling during the taxi, take-off, or landing phase can be affected by the placement of an external load. For example, if normal water take-offs require a significant amount of rudder for directional control during the low-speed portion of the run, an external load might exacerbate the rudder requirement to the point where rudder control becomes limited. Or, during crosswind operations, the size and position of the load might reduce directional control during taxi and other low speed operations such as take-off initiation and landing completion. As a result, it is possible that an external load could compromise the minimum crosswind requirement of the applicable airworthiness standards. The optimum placement of the load should be identified, so as to minimize the control deflections required beyond those which are required for normal aeroplane operation.

(o) Crosswind testing should be included in the test program to verify the sideslip envelope cleared during the lateral / directional testing.

(p) See AC 23-8C for FAA guidance on ground and water handling characteristics testing.

(q) High speed tests – Many external load approvals impose a reduced maximum speed. This has the benefit of decreasing the loads that must be substantiated for structural compliance and reducing the possibility of vibration and buffeting from the load during flight. Once a maximum speed (Vmax) is set as a goal, whether it is the type design speed or a reduced speed, flight test is required to demonstrate satisfactory handling and freedom from vibration and buffet. Flight test out to 110% of the proposed Vmax speed will provide a suitable margin to cater for inadvertent operational speed excursions. Flight conducted at speed above maximum AFM speeds should be limited to straight, unaccelerated flight. The applicant should ensure that the actual speeds to be tested have been properly incorporated in the structural design substantiation prior to flight tests. See AC 230-8C for FAA guidance on high-speed testing.

(r) Managing an external loads flight test program – As with any flight test program, enlisting the support of a Test Pilot or Flight Analyst Delegate is highly recommended for this type of project. A Flight Test Delegate will be able to assist in compliance planning, test plan formulation, efficient and safe execution of planned flight tests, and the preparation of a final report in a format that will be accepted by Transport Canada. If the organization does not have a Flight Test Delegate on staff, external Flight Test DARs may be used for

that purpose. For information on Flight Test DARs in Canada, contact your Regional Certification Office or the National Aircraft Certification Branch in Ottawa.

(5) The limitation section of the AFMS may require a limitation prohibiting the use of the autopilot, if applicable, when external loads are carried. The autopilot can obscure undesirable flight characteristics.

7.0 Past design approvals

(1) STCs have been issued for a number of boat and canoe racks, particularly for the DHC-2 Beaver and DHC-3 Otter aeroplanes. The status of these approvals has not changed; they remain valid. A number of Canadian-registered aeroplanes have been granted serialized STCs, or one-off type design change approvals, for the carriage of external loads; these approvals also remain valid. Applicants are reminded that some manufacturers have already been granted approvals for the carriage of canoes or boats, as documented on the TCDS. Although the aeroplane might not be in production any longer, it could still be possible to obtain drawings from the manufacturer or service provider for the installation of a factory approved boat rack.

(2) New STCs or serialized STCs for aeroplane types previously cleared for the carriage of external loads may be possible without TCCA Headquarters flown flight tests if:

(a) The proposal is structurally acceptable; and

(b) The applicant submits an appropriate flight test report, and flight or operating manual supplement in accordance with this AC.

(3) TCCA Headquarters participation in flight testing may be required for an aeroplane type not previously approved for flight with an external load, or if an applicant's flight tests reveal characteristics that are marginal for demonstrating compliance to the appropriate standards.

(4) For more information concerning previous design approvals for the carriage of external loads that may apply to their aeroplane, operators should contact their respective TCCA regional office. Operators may also refer to the TCCA web site at the following address to search for design approvals applicable to their aeroplane: https://wwwapps.tc.gc.ca/saf-sec-sur/2/nico-celn/c_s.aspx?lang=eng

8.0 Information management

(1) Not applicable.

9.0 Document history

(1) AC 500-004, **Issue 01**, RDIMS 4535611 (E), 4690683 (F), dated 2009-02-17 - Assessing the Effect of carrying External Loads on Aircraft

10.0 Contact us

For more information, please contact your Regional TCCA Certification Office. Contact information can be found at the link below:

https://tc.canada.ca/en/aviation/civil-aviation-contacts-offices#headquarters_and_regional

We invite suggestions for amendment to this document. Submit your comments to:

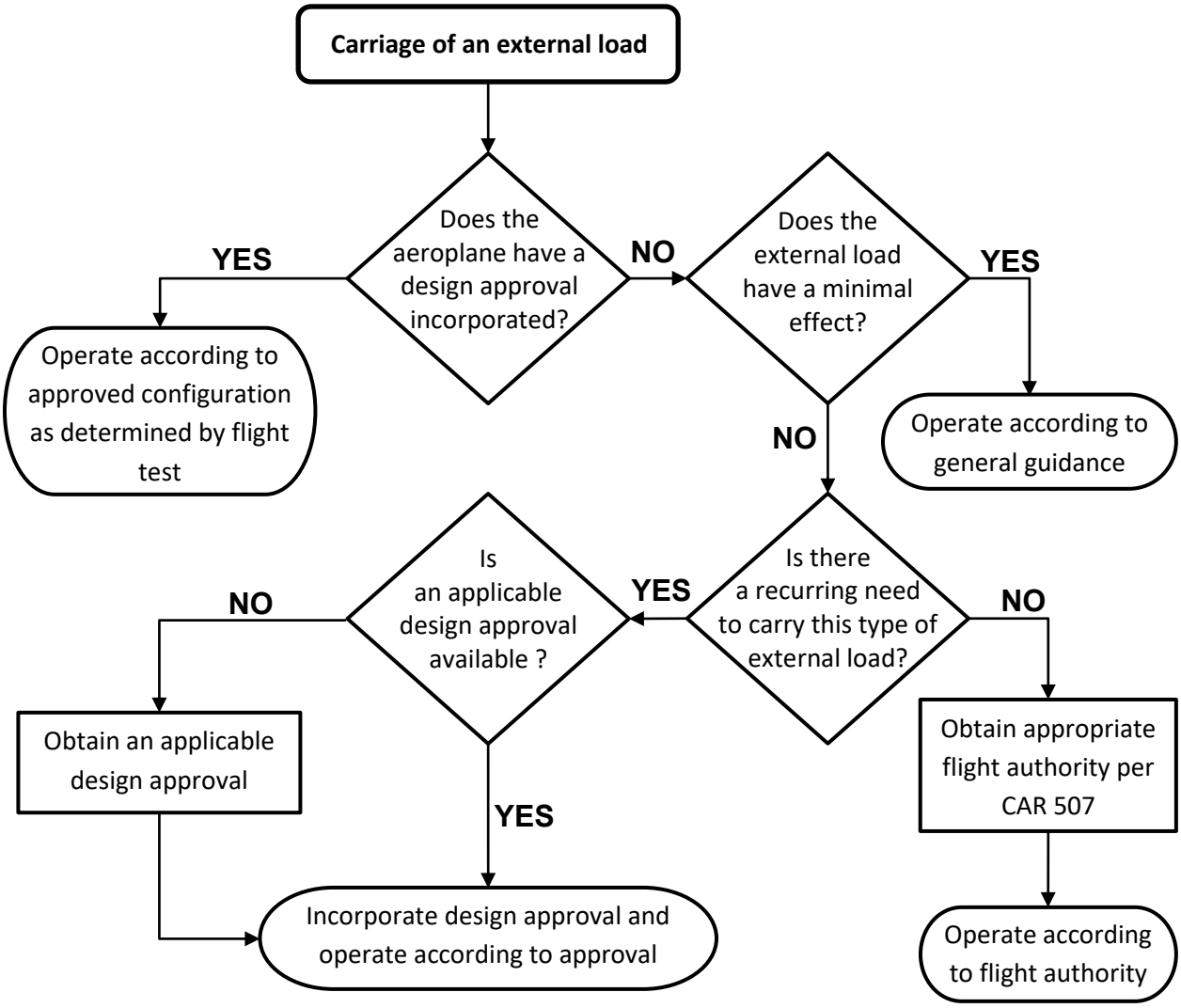
AART Documentation Services <AARTDocServices-ServicesdocAART@tc.gc.ca>

Original signed by

Stacey Mason
Director, Standards
Civil Aviation

Appendix A — External Loads classification and design change approval process flow chart

Figure 1: Design Change Approval process for an external load



This flowchart describes the steps and questions to determine the authority necessary to operate with an external load. The end options are to either operate an aeroplane with an approved configuration from a design approval, use general guidance for operation with loads with minimal effect, or to operate the aeroplane according to an appropriate flight authority under Subpart 507 of the CARs (CAR 507).

Appendix B — Sample Finding of Equivalent Safety G-3 Issue Paper

Project :	ABC – 2 External Loads	**Number:**	G-3	**Issue :**	1
		Date:			
File Number :		**Target:**	STC Certification		
RDIMS number:					
NAPA Number:		**Status:**	Open		
Specialist(s) :	Flight Test				
Subject:	Finding of Equivalent Safety				
Requirement(s) :	Lateral / Directional stability and Spin demonstration (if applicable) paragraphs from the basis of certification (For example – sections 523.177 and 523.221 of the AWM or CAR 3 1956 3.118 and 3.124)				

Statement of issue

The proposed attachment of an external load to the float struts of an ABC – 2 floatplane render the aeroplane potentially non-compliant with the lateral / directional stability and spin requirements of the basis of certification.

Lateral / directional testing has revealed safe characteristics out to approximately X % of full rudder travel, but due to flight safety concerns continued testing to greater rudder deflections has not been accomplished.

In addition, the demonstration of recovery from a one turn spin has not been accomplished due to flight safety concerns.

References

Transport Canada Advisory Circular AC 500-004, Issue xxx - External Loads on Aeroplanes - Approval Process and Flight Test Considerations

Discussion

The text of the relevant regulations from (e.g.) Chapter 523 of the AWM is quoted below:

523.177

(a)

(1) The static directional stability, as shown by the tendency to recover from a wings level sideslip with the rudder free, must be positive for any landing gear and flap position appropriate to the take-off, climb, cruise, approach, and landing configurations. This must be shown with symmetrical power up to maximum continuous power, and at speeds from 1.2 VS1 up to VFE, VLE, VNO, VFC/MFC, whichever is appropriate.

(2) The angle of sideslip for these tests must be appropriate to the type of aeroplane. The rudder pedal force must not reverse at larger angles of sideslip, up to that at which full rudder is used or a control force limit in section 523.143 is reached, whichever occurs first, and at speeds from 1.2 VS1 to VO.

(b)

(1) The static lateral stability, as shown by the tendency to raise the low wing in a sideslip with the aileron controls free, may not be negative for any landing gear and flap position appropriate to the take-off, climb, cruise, approach and landing configurations. This must be shown with symmetrical power from idle up to 75 percent of maximum continuous power at speeds above 1.2 VS1 in the take-off configuration(s) and at speeds above 1.3 VS1 in other configurations, up to the maximum allowable speed for the configuration being investigated (VFE, VLE, VNO, VFC/MFC, whichever is appropriate) in the take-off, climb, cruise, descent and approach configurations. For the landing configuration, the power must be that necessary to maintain a 3 degree angle of descent in coordinated flight.
(effective 2016/08/04)

(2) The static lateral stability must not be negative at 1.2 VS1 in the take-off configuration, or at 1.3 VS1 in other configurations.

(3) The angle of sideslip for these tests must be appropriate to the type of aeroplane, but in no case may the constant heading sideslip angle be less than that obtainable with a 10 degree bank or, if less, the maximum bank angle obtainable with full rudder deflection or 150 pound rudder force.

[…]

(d)

(1) In straight, steady slips at 1.2 VS1 for any landing gear and flap positions appropriate to the take-off, climb, cruise, approach and landing configurations, and for any symmetrical power conditions up to 50 percent of maximum continuous power, the aileron and rudder control movements and forces must increase steadily, but not necessarily in constant proportion, as the angle of sideslip is increased up to the maximum appropriate to the type of aeroplane.

(2) At larger slip angles, up to the angle at which full rudder or aileron control is used or a control force limit contained in section. 523.143 is reached, the aileron and rudder control movements and forces must not reverse as the angle of sideslip is increased.

(3) Rapid entry into, and recovery from, a maximum sideslip considered appropriate for the aeroplane must not result in uncontrollable flight characteristics.

523.221

(a) Normal category aeroplanes. A single-engine, normal category aeroplane must be able to recover from a one-turn spin or a three-second spin, whichever takes longer, in not more than one additional turn after initiation of the first control action for recovery, or demonstrate compliance with the optional spin resistant requirements of this section.

(1) The following apply to one turn or three second spins:

(i) For both the flaps-retracted and flaps-extended conditions, the applicable airspeed limit and positive limit maneuvering load factor must not be exceeded;

(ii) No control forces or characteristic encountered during the spin or recovery may adversely affect prompt recovery;

(iii) It must be impossible to obtain unrecoverable spins with any use of the flight or engine power controls either at the entry into or during the spin; and

(iv) For the flaps-extended condition, the flaps may be retracted during the recovery but not before rotation has ceased.

(2) At the applicant's option, the aeroplane may be demonstrated to be spin resistant by the following:

(i) During the stall manoeuver contained in 523.201, the pitch control must be pulled back and held against the stop. Then, using ailerons and rudders in the proper direction, it must be possible to maintain wings-level flight within 15 degrees of bank and to roll the aeroplane from a 30 degree bank in one direction to a 30 degree bank in the other direction;

(ii) Reduce the aeroplane speed using pitch control at a rate of approximately one knot per second until the pitch control reaches the stop; then, with the pitch control pulled back and held against the stop, apply full rudder control in a manner to promote spin entry for a period of seven seconds or through a 360 degree heading change, whichever occurs first. If the 360 degree heading change is reached first, it must have taken no fewer than four seconds. This maneuver must be performed first with the ailerons in the neutral position, and then with the ailerons deflected opposite the direction of turn in the most adverse manner. Power and aeroplane configuration must be set in accordance with 523.201(e) without change during the maneuver. At the end of seven seconds or a 360 degree heading change, the aeroplane must respond immediately and normally to primary flight controls applied to regain coordinated, unstalled flight without reversal of control effect and without exceeding the temporary control forces specified by 523.143(c); and

(iii) Compliance with 523.201 and 523.203 must be demonstrated with the aeroplane in uncoordinated flight, corresponding to one ball width displacement on a slip-skid indicator, unless one ball width

displacement cannot be obtained with full rudder, in which case the demonstration must be with full rudder applied.

(b) Utility category aeroplanes. A utility category aeroplane must meet the requirements of paragraph (a) of this section. In addition, the requirements of paragraph (c) of this section and 523.807(b)(7) must be met if approval for spinning is requested.

[…]

Transport Canada Position

Transport Canada is recommending a finding of equivalent safety be applied to sections (e.g.) 523.177 and 523.221 as a result of mitigating restrictions and limitations being imposed on flight operations via the AFMS.

Due to the impracticality of showing full compliance to these sections via flight test, it is proposed that the following mitigating AFM limitations and prohibitions be adopted in support of the requested finding of equivalent safety.

- Flap XX steady heading sideslips using greater than XX % of rudder deflection are prohibited. This limitation will give credit to the envelope tested successfully during flight test and allow for some crosswind landing capability.
- Flap XX landings in direct crosswinds greater than XX knots are prohibited. This limitation will effectively limit the sideslip required to angles successfully tested during flight test.
- Except for the purposes of take-off and landing, flight operations below XX knots are prohibited. This limitation will enforce a minimum manoeuvring speed and minimize flight time in an area of the envelope where low speed stall / spin has a greater potential of occurring.
- Appropriate additional limitations as recommended by Transport Canada – National Aircraft Certification Flight Test, as listed below:

<insert limitations as appropriate>

Applicant Position (example)

“Loads r Us Inc.” concurs with Transport Canada’s recommendation for a finding of equivalent safety based on the mitigating limitations and prohibitions presented above.

Final Transport Canada Position

Transport Canada accepts the finding of equivalent safety as proposed for this project, subject to the following conditions:

1) NAC Flight Test sample flight test program for external loads is appended to this Issue Paper as guidance and will be used as the basis for project compliance. The guidance appended to this Issue Paper will be followed to the fullest extent practical.

2) All other requirements of the subject standards will be met.
3) The AFMS limitations and prohibitions listed in the “Transport Canada Position” above will be included in the AFMS.

Revision Summary

Edition 1 NC Created

TC OPI	SECTION	Signature	DATE
Aircraft Certification Engineer			