Advisory Circular

Subject: **Assessing the Effect of Carrying External Loads on Aircraft**

Issuing Office:	Standards		
Activity Area:	Qualifying	Document No.:	AC 500-004
File No.:	5009-32-4 U	Issue No.:	01
RDIMS No.:	4535611 V3	Effective Date:	2009-02-17

TABLE OF CONTENTS

1.0 INTRODUCTION 2
1.1 Purpose 2
1.2 Applicability 2
1.3 Description of Changes 2
2.0 REFERENCES AND REQUIREMENTS 2
2.1 Reference Documents 2
2.2 Cancelled Documents 3
2.3 Definitions and Abbreviations 3
3.0 BACKGROUND 3
4.0 CLASSIFICATION OF EXTERNAL LOADS 4
4.1 Minimum Effect 4
4.2 Other Than Minimum Effect 4
4.3 External Load Equipment 4
5.0 DESIGN REQUIREMENTS 4
5.1 Size and Weight 4
5.2 Position 5
5.3 Tie-Down 5
5.4 Emergency Entry 5
5.5 Carriage of Passengers 5
5.6 Structural 6
5.7 Limitations 6
5.8 Flight Manual Supplement Information 6
5.9 Flight Tests 7
6.0 PAST DESIGN APPROVALS 10
7.0 CONTACT OFFICE 10
APPENDIX A—EXTERNAL LOAD CLASSIFICATION AND DESIGN CHANGE APPROVAL PROCESS FLOW CHART 11

1.0 INTRODUCTION

This Advisory Circular (AC) is provided for information and guidance purposes. It may describe 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

The purpose of this AC is to describe a means to assess the effect of an external load carried on an aircraft and to obtain a corresponding design approval, as may be required. This material applies to fixed wing floatplanes and helicopters with class A external loads of both private and commercial air operators.

1.2 Applicability

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

1.3 Description of Changes

The content of this document is derived from that previously contained in Appendix A of AC 500-011, Issue 01. Additional guidance is now added with respect to helicopter Class A external loads, the need for proving flights, as well as a flow chart of the external load classification and design approval process.

2.0 REFERENCES AND REQUIREMENTS

2.1 Reference Documents

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*;

(b) Part V, Subpart 7 of the CARs—*Flight Authority and Certificate of Noise Compliance*;

(c) Part V, Subpart 11 of the CARs—*Approval of the Type Design of an Aeronautical Product*;

(d) Part V, Subpart 13 of the CARs—*Approval of Modification and Repair Designs*;

(e) Part VI, Subpart 2 of the CARs—*Operating and Flight Rules*;

(f) Part VI, Subpart 5 of the CARs—*Aircraft Requirements*;

(g) Part VII, Subpart 2 of the CARs—*Aerial Work*;

(h) Part VII, Subpart 3 of the CARs—*Air Taxi Operations*;

(i) Standard 571 of the CARs—*Maintenance*;

(j) Chapter 523 of the Airworthiness Manual (AWM)—*Normal, Utility, Aerobatic and Commuter Category Aeroplanes*;

(k) Chapter 527 of the AWM—*Normal Category Rotorcraft*;

(l) Advisory Circular (AC) 500-011, Issue 02, 2009-02-17—*Restricted Category Certification of Small Aeroplanes and Helicopters for Special Purpose Operations*; and

(m) Federal Aviation Administration AC (FAA AC) 43.13-2B—*Acceptable Methods, Techniques, and Practices - Aircraft Alterations*.

2.2 Cancelled Documents

As of the effective date of this document, the following document is cancelled:

(a) Commercial and Business Aviation Advisory Circular (CBAAC) No. 0232R2—*Carriage and Reporting of External Loads Carried - Exemption to Section 703.25 and Paragraph 605.03(1)(b) of the Canadian Aviation Regulations*.

2.3 Definitions and Abbreviations

The following definitions and abbreviations are used in this document:

(a) **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].

(b) **Helicopter Class A external load**: An external load that cannot move freely, cannot be jettisoned and does not extend below the landing gear [Source is subsection 101.01(1) of the CARs].

(c) **Minimum effect**: The effect to aircraft performance and flight characteristics is minimal and does not require the pilot to have additional proficiencies beyond those normally required for the applicable pilot type rating.

3.0 BACKGROUND

(1) Section 703.25 of the 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 on-board, 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.

(2) 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 standard certificate of airworthiness issued pursuant to section 507.02 of the CARs, it is issued to an aircraft that conforms to an approved type design and that is fit and 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 standard 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.

(3) If the carriage of an external load operation takes place without this capability being part of the approved type design, the operation is conducted without the benefit of certain provisions that decrease the risks inherent in these types of operations. 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.

(4) The TCCA Working Group On External Loads, established on December 1, 1997, was formed to address the issues involving the carriage of external loads. This working group agreed that the carriage of external loads outside the provisions of a TC or an STC needs certain conditions to be met to offset the risks that are assumed in these activities. The working group found that the risks could be mitigated by regulation if the regulation:

(a) concisely defined what external load operations would be permitted without a TC or STC (i.e. applicability);

(b) set out under what conditions those operations may take place; and

(c) would be supported by the appropriate advisory material.

(5) The working group made specific recommendations for the amendment of the CARs, including the addition of a requirement to conduct proving flights prior to permitting the carriage of an external load.

(6) In 1997, as an interim means to mitigate risk, 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, 2008. The conditions of the exemptions remained constant, 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.

4.0 CLASSIFICATION OF EXTERNAL LOADS

4.1 Minimum Effect

Based on industry experience, the following external loads are considered to have a 'minimum effect' on an aircraft and do not require a design approval or acceptance however the appropriate technical data must be used:

(a) snowshoes;

(b) skis;

(c) hunting rifles;

(d) fishing rods; and

(e) other items of the same size, shape and weight as items (a) through (d).

4.2 Other Than Minimum Effect

(a) The carriage of any other external load not identified in section 4.1 must be approved. Please see sections 5.0 and 6.0, and Appendix A of this AC.

(b) In the case of an external load that has other than a minimum effect, and there is no recurring need to carry this type of external load (i.e. this is a one-time occurrence), the operator should obtain the appropriate flight authority in accordance with Subpart 507 of the CARs.

4.3 External Load Equipment

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 aircraft.

5.0 DESIGN REQUIREMENTS

Subsections 5.1 to 5.9 of this AC are the minimum considerations to obtain a design approval to carry an external load that is other than 'minimum effect'. Additional requirements may also apply, as appropriate, from the applicable portions of the standards of airworthiness contained in the basis of certification for the aircraft. Any application for a design approval requires comprehensive technical evaluation and substantiation.

5.1 Size and Weight

(1) The maximum size and weight of the external load, as well as limitations on the positioning of the load, must be determined. The effect of the asymmetric load must be addressed when the load is carried on one side of the aircraft. The maximum weight that may be so carried may be limited by

aileron authority available to keep the wings level during take-off. This applies particularly when a dense load, such as lumber, is carried.

(2) When a boat or canoe is carried as an external load on an aeroplane, the performance requirements discussed in AC 500-011 apply. Take-off, climb and landing performance need not be addressed provided the maximum certified take-off weight (MCTOW) is reduced by twice the weight of the external load. Where the basic approved MCTOW is 3000 lbs and the boat weight is 100 lbs, the maximum approved take-off weight, including the boat, would be 3000 lbs - (2 x 100) lbs = 2800 lbs.

(3) When a boat or canoe is carried on a helicopter as a Class A external load (not slung), the maximum rotorcraft gross weight with external load secured may not exceed the maximum internal load gross weight.

5.2 Position

(1) For floatplanes, the external load must be positioned to that it does not catch and retain a significant volume of water during take-off and landing.

(2) It must be shown that the position of the external load 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;

(d) propeller or rotor thrust; and

(e) airflow in the vicinity of any air intake or exhaust ports.

5.3 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.

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

(3) The use of a cargo rack is the suggested means of securing a Class A external load to a helicopter. Cargo racks are referenced in Chapter 7, Section 2 of FAA AC 43.13-2B.

5.4 Emergency Entry

Emergency entry to or egress from the aircraft must not be unduly 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 aircraft and these must be readily visible to persons attempting to exit the aircraft.

5.5 Carriage of Passengers

Up to four passengers may be transported in an aircraft carrying boats or canoes as external loads in accordance with the following:

(a) the aircraft is not being used for operations with loads exceeding the MCTOW, as detailed in paragraph 5.1(3) of AC 500-011;

(b) the MCTOW and gross take-off weight reduction, detailed in paragraph 5.1(2) of this AC, is specified as a limitation, or else compliance with the climb requirements of the basis of certification has been demonstrated;

(c) the aircraft is operated by day visual flight rules (VFR) only;

(d) the aircraft is operated within an approved flight envelope wherein acceptable flying qualities have been demonstrated;

(e) emergency egress from the passenger compartment is not unduly impeded by a boat or other externally mounted cargo. There must be clearly marked escape routes, and the passengers must be briefed before each take-off if alternate escape routes are required; and

(f) for aeroplanes, a placard must state that intentional spinning is prohibited.

5.6 Structural

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

(2) The pilot, or appropriately authorized personnel, checks the attachment areas for damage after each carriage of an external load.

5.7 Limitations

The following limitations are suggested for aircraft carrying external loads, except as otherwise determined by the design approval process:

(a) maximum speed 100 kt;

(b) maximum bank angle 30º;

(c) day VFR operations only;

(d) intentional spinning prohibited;

(e) intentional side-slipping prohibited; and

(f) boats and canoes are to be carried partially inverted, stern forward.

5.8 Flight Manual Supplement Information

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

(2) For aircraft with an approved Flight Manual, a Flight Manual Supplement (FMS) must be provided. Please see sections 523.1581 or 527.1581 of the AWM. For other aircraft, an addendum to an operating manual or other appropriate publication would be acceptable. The FMS must:

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

(b) shall contain limitations and procedures associated with the carriage of external loads, including:

(i) a detailed description of the proposed means, which are readily repeatable, of locating and securing each load to the aircraft (see subsection 5.3 of this AC);

(ii) identification of any special equipment required such as temperature gauges, and mirrors;

(iii) the type of load(s) approved such as the approved size(s), maximum/minimum dimensions, maximum weight;

(iv) areas of the flight envelope where minor instabilities have been identified; and

(v) a statement that declares that spin recovery in the externally loaded configuration has not been demonstrated.

5.9 Flight Tests

(1) An applicant must conduct flight tests of the proposed configuration and provide an FMS in accordance with this AC to obtain an approval.

(2) Conditions for conducting a proving flight of an aeroplane include:

(a) the flight shall be conducted away from built-up areas;

(b) only crew members shall be on-board;

(c) the effect of the external load on the aircraft's operating weight and the centre of gravity shall be determined;

(d) if necessary and possible, the pilot or crew member shall observe the load in flight; and

(e) all manufacturer limitations shall apply.

(3) Proving flight check list for an aeroplane must assess the following:

(a) A proving flight must be performed to determine the operating limitations and procedures in accordance with paragraphs 5.9(3) (b) through (k) following:

(b) Maximum Weight—The maximum gross take-off weight of an aircraft must be reduced by twice the weight of any external load attached or the aircraft must demonstrate its capacity to climb at a rate of:

(i) for single engine aircraft, 100 feet per minute at a density altitude of 5000 feet at the gross weight, speed and configuration chosen for the proving flight; and

(ii) for multi-engine aircraft, 100 feet per minute at a density altitude of 5000 feet at the gross weight, speed and configuration chosen for the proving flight, and must be able to demonstrate positive rate of climb with one engine inoperative.

(c) Take-off speed—the speed at which a clean transition can be made from a take-off run to the initial climb must be established; where a load is secured to one side of the aircraft only the effect of the asymmetric weight distribution must be considered. For float aeroplanes, pilots should ensure they have sufficient aileron authority available to lift the heavy float out of the water.

(d) Minimum Operating Speed (V_{MIN})—a minimum operating speed should be determined. At this speed, the aircraft should be free of any stalling indication or tendency and is 5% above the speed at which there is any stall buffet or any tendency to pitch or roll that is not easily controlled. This speed should be determined at a safe altitude with idle power applied by slowly reducing speed from a typical cruising speed. Various flap settings that would be used operationally should be checked.

(e) Maximum level flight speed (V_{MAX})—an appropriate safe maximum speed should be determined. At 1.1 times this speed, the aircraft should be readily controllable and free of any unusual buffet and/or vibration. This speed should be at least 25 mph greater than V_{MIN}.

(f) Manoeuvre capability—it should be possible to fly a sustained, coordinated level turn using 30 degrees of bank at 1.3 times V_{MIN}. A 45 degree bank excursion should not be hazardous. A maximum recommended bank angle when flying the external load should be specified. It should be determined that sideslip angles that could be encountered during flight operations would not present a hazard. It would be usual to prohibit intentional sideslipping with an external load mounted but some unintentional encounters cannot be ruled out.

(g) Speed—a recommended cruising speed (V_{CRUISE}) should be established. This speed should not be less than 1.6 times the V_{MIN}. Steady, level, coordinated flight must be possible at this speed with:

(i) The longitudinal control forces trimmed to zero;

(ii) The lateral control forces (measured at the center of the pilot's grip) not exceeding approximately 5 lbs (2.2 kg); and

(iii) The directional control forces not exceeding approximately 20 lbs (9 kg).

(h) Stability—with the aircraft established in level coordinated flight at V_{CRUISE}, it should be possible to abandon the controls for 5 seconds without any hazardous attitudes developing.

(i) Descent—at some safe altitude, the aircraft's flying qualities should be checked in descent with various flap settings (up to maximum extension) and power settings (down to idle) at speeds between V_{MIN} and V_{MAX} (or the flap speed limit). No unusual pitch characteristics, oscillations, buffet or vibration should be encountered. A recommended approach speed and configuration should be determined. This speed should not be less that 1.25 times V_{MIN} (for the recommended flap setting). In this condition it should be possible to trim the longitudinal control forces to zero and to maintain a wings level attitude using no more than approximately 20 lbs (9 kg) of pedal force and/or approximately 5 lbs (2.2 kg) aileron force.

(j) Procedures:

(i) Conduct pre-flight checks to ensure proper location and security of the load, and to determine any other special checks or operating procedures associated with the carriage of the external load.

(ii) Conduct post-flight checks to ensure the aircraft structure was protected from chafing, dents or damage caused by vibration or shifting of the external load.

(k) Documentation—any limitations and/or special procedures associated with the carriage of the external load must be detailed in an FMS, or similar document that would be accessible to the pilot. The effects on range and endurance should be addressed in this document.

(4) The conditions for conducting a proving flight for a helicopter are:

(a) the flight shall be conducted away from built-up areas;

(b) crew members only on-board;

(c) a means of securing the load to the helicopter in a repeatable manner needs to be developed and documented. There must be no possibility of the load or attaching components coming loose in flight;

(d) if necessary the pilot or crew member shall be able to observe the load in flight;

(e) the external load must not interfere with pitot or static ports or the airflow in the vicinity of of any inlet or exhaust ports;

(f) the external load must not impede normal or emergency egress from the helicopter;

(g) the aircraft's operating weight and the centre of gravity shall not exceed the published limits with the external load in place (weight and centre of gravity limits may need to be re-established for a particular load/configuration but the new limits must not exceed the basic limitations including the lateral centre of gravity limits);

(h) catching, soaking up or otherwise retaining water needs to be considered if the helicopter is operated from water or in rain;

(i) asymmetric loading must be very carefully addressed and lateral centre of gravity limits observed. For helicopters where mast bending moments are of significance (helicopters

with 3 or more blades) the aerodynamic effects of the asymmetrical configuration must be addressed by test or analysis;

(j) test and analysis, as required, to determine the effects of possible increased fatigue on helicopter structure and components (the attachment of an external load to a helicopter will, for some helicopters, result in altering the aircraft's normal vibration characteristics, this can negatively effect structural components inducing pre-mature failure); and

(k) all manufacturer limitations apply.

(5) A proving flight check list for a helicopter must assess the following:

(a) A proving flight must be performed in order to determine the operating limitations and procedures in accordance with the following:

(b) Maximum level flight speed (V_{MAX}):

(i) An appropriate safe maximum speed should be determined. At 1.1 times this speed, the aircraft should be readily controllable and free of any unusual buffet and/or vibration;

(ii) V_{MAX} should not be less that 1.2 X the minimum power required speed; and

(iii) At speeds up to V_{MAX}, within the parameters of the weight and centre of gravity envelope established for the loading condition, it must be demonstrated that the helicopter is capable of continued safe flight without unusual skill or strength on the part of the pilot, after a sudden engine failure, followed by a one second delay (normal response time) before taking emergency action.

Note: *For single-engined helicopters, this would address the transition to auto-rotation. For multi-engined helicopters, an envelope for single-engine operation based on autorotative entry characteristics (failure of the second engine) should be established.*

(c) Manoeuvre capability - It should be possible to fly a sustained, coordinated level turn using 30 degrees of bank at V_{MAX}. A 45 degree bank excursion should not be hazardous. A maximum recommended bank angle when flying the external load should be specified.

(d) Speed - A recommended cruising speed (V_{CRUISE}) should be established. Steady, level, coordinated flight must be possible at this speed. Sideslipping at angles appropriate to the type should not cause difficulties or concerns.

(e) Descent - At some safe altitude, the aircraft's flying qualities should be checked in descent at various power settings including auto-rotation. No unusual pitch characteristics, oscillations, buffet or vibration should be encountered. Auto-rotative revolutions per minute (RPM) must remain within normal limits.

(f) Procedures:

(i) Conduct pre-flight checks to ensure proper location and security of the load, and to determine any other special checks or operating procedures associated with the carriage of the external load.

(ii) Conduct post-flight checks to ensure the aircraft structure was protected from chafing, dents or damage caused by vibration or shifting of the external load.

(g) Documentation - Any limitations and/or special procedures associated with the carriage of the external load must be detailed in a FMS, or similar document that would be accessible to the pilot. The effects on range and endurance should be addressed in this document.

6.0 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 aircraft have been granted Limited Supplemental Type Certificates (LSTC), or one-off type design change approvals, for the carriage of external loads; these approvals also remain valid.

(2) Additional LSTCs for aircraft previously cleared for the carriage of external loads may be possible without further TCCA 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 flight testing may be required if one or more of the limitations noted in sub-section 5.7 of this AC are not adhered to.

(4) For more information concerning previous design approvals for the carriage of external loads that may apply to their aircraft, 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 aircraft. http://www.tc.gc.ca/aviation/applications/nico-celn/

7.0 CONTACT OFFICE

For more information, please contact the:

Manager, Policies and Procedures (AARTC)

Phone: 613-990-3923
Fax: 613-952-3298
E-mail: martin.thieringer@tc.gc.ca

Suggestions for amendment to this document are invited, and should be submitted via the Transport Canada Civil Aviation Issues Reporting System (CAIRS) at the following Internet address:

http://www.tc.gc.ca/CivilAviation/ManagementServices/QA/cairs.htm

or by e-mail at: CAIRS_NCR@tc.gc.ca

D.B. Sherritt
Director, Standards
Civil Aviation

APPENDIX A—EXTERNAL LOAD CLASSIFICATION AND DESIGN CHANGE APPROVAL PROCESS FLOW CHART