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Title	Helicopter ditching and water impact occupant survivability
NPA Number	NPA 2016-01

UK CAA (European.Affairs@caa.co.uk) has placed **17** unique comments on this NPA:

Cmt#	Segment description	Page	Comment	Attachments
203	CS 27.563 Structural ditching provisions	22 - 23	**Page No:** 22 & 29 **Paragraph No:** CS 27.563 Structural Ditching Provisions (a), AMC 27.563 (a)(1)(iii) and AMC 27.563 (b)(3) **Comment:** The reference to two-thirds rotor lift should be deleted. **Justification:** The removal of two-thirds rotor lift is justified and recommended in Appendix B, Item 9 (see page 199). This has been incorporated in AMC 27.801 (b)(10) on page 31, but not in the above references. **Proposed Text:** Modify the existing text as follows (deleted text ~~struck through~~): CS 27.563 (a) *Forward-speed landing conditions.* The rotorcraft must initially contact the most critical wave for reasonably probable water conditions at forward velocities from zero up to 56 km/h (30 knots) in likely pitch, roll, and yaw attitudes. The rotorcraft limit vertical - descent velocity may not be less than 1.5 metres per second (5 ft/s) relative to the mean water surface. ~~Rotor lift may be used to act through the centre of gravity during water entry throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight. A maximum forward velocity of less than 30 knots may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out touchdown.~~ – AMC 27.563 (a)(1)~~(iii) A rotor lift of not more than two-thirds of the design maximum weight may be used to act through the rotorcraft's centre of gravity during water entry.~~ – AMC 27.563 (b)(3) The landing structural design consideration should be based on water entry ~~with a rotor lift of not more than two-thirds of the maximum design weight acting through the rotorcraft's centre of gravity~~ under the following conditions:	
204	CS 27.801 Ditching	23 - 24	**Page No:** 24 **Paragraph No:** CS 27.801 Ditching (e) **Comment:** The statement “With capsize mitigation” in the bottom left cell of the	

			table needs to be qualified. **Justification:** The risk assessment presented at Item 10 in Appendix B of NPA 2016-01 (starting on page 200) from which the corresponding target probability of capsize is derived assumes that the consequences of capsize are mitigated to no worse than CS 27.1309 major. If they are not, a different target probability of capsize would be required. **Proposed Text:** Add to the existing text as follows (new text underlined): With capsize mitigation to no worse than CS 27.1309 major.	
205	CS 27.805 Flight crew emergency exits	24 - 25	**Page No:** 24 & 25 **Paragraph No:** CS 27.805 Flight crew emergency exits (c) **Comment:** The CS should require that flight crew emergency exit operating devices must be accessible with inertia reel seat belts locked. **Justification:** The exit will not fulfil its purpose if the flight crew member cannot reach the operating device. It is possible for inertia reel seat belts to lock in an accident (e.g. G-WNSB), restricting the movement of the flight crew member. **Proposed Text:** Add to the existing text as follows (new text underlined): "… The operating device for each ditching emergency exit (pull tab(s), operating handle, etc.) must be marked with black and yellow stripes, and must be accessible with the flight crew member's seat belts locked."	
206	3.2.2. Draft amendment to CS-27 — Book 2, AMC 27.563 Structural ditching provisions	28 - 30	**Page No:** 28 **Paragraph No:** AMC 27.563 Structural Ditching Provisions (a)(1)(ii) **Comment:** The descriptions of the horizontal and vertical velocities are not entirely clear. **Justification:** It was agreed in RMT.0120 that it would no longer be necessary to take account of water particle velocity. The definitions of horizontal and vertical velocities need to correctly reflect this. Note that this is also to ensure consistency with AMC 27.801 (c)(5)(i) & (ii) on page 34. **Proposed Text:** Modify the existing text as follows (new text underlined, deleted text ~~struck through~~):	

			(ii) The <u>ground speed</u>~~velocity relative to the wave surface~~ should be in a range of 0–56 km/h (30 kt) with a ~~vertical~~ descent rate of not less than 1.5 m/s (5 ft/s) ~~relative to the mean wave surface~~. No account need be taken of the wave particle velocity.	
207	3.2.2. Draft amendment to CS-27 — Book 2, AMC 27.563 Structural ditching provisions	28 - 30	**Page No:** 29 **Paragraph No:** AMC 27.563 Structural Ditching Provisions (b)(3)(i) & (iv) **Comment:** The descriptions of the horizontal and vertical velocities are not entirely clear. **Justification:** It was agreed in RMT.0120 that it would no longer be necessary to take account of water particle velocity. The definitions of horizontal and vertical velocities need to correctly reflect this. Note that this is also to ensure consistency with AMC 27.801 (c)(5)(i) & (ii) on page 34. **Proposed Text:** Modify the existing text as follows (new text <u>underlined</u>, deleted text ~~struck through~~): (i) ~~forward velocities~~ <u>ground speed</u> of 0–56 km/h (30 kt) ~~relative to the mean wave surface~~; (iv) ~~vertical~~ descent <u>rate</u> ~~velocity~~ of 1.5 m/s (5 ft/s) or greater ~~relative to the mean wave surface~~.	
208	AMC 27.801 — Ditching	30 - 36	**Page No:** 31 **Paragraph No:** AMC 27.801 Ditching (b)(9) **Comment:** Certification by comparison with a similar rotorcraft type should only be permitted where the comparison rotorcraft has been certificated using the new test procedure detailed in AMC 27.801(e). **Justification:** The current test procedures have been discredited and no further credit should be taken for any results so obtained. **Proposed Text:** Modify the existing text as follows (new text <u>underlined</u>, deleted text ~~struck through~~): (9) Tests with a scale model of the appropriate ditching configuration should be conducted in a wave tank to demonstrate satisfactory water entry and flotation stability characteristics. Appropriate allowances should be made for probable structural damage and leakage. Previous model tests and other data from rotorcraft of similar configurations that have already been substantiated based on ~~equivalent~~ test conditions <u>equivalent to AMC 27.801(e)</u> may be used	

			to satisfy the ditching provisions.	
209	CS 29.563 Structural ditching provisions	63 - 64	**Page No:** 63, 70 & 71 **Paragraph No:** CS 29.563 Structural Ditching Provisions (a), AMC 29.563 (a)(1)(iii) and AMC 29.563 (b)(3) **Comment:** The reference to two-thirds rotor lift should be deleted. **Justification:** The removal of two-thirds rotor lift is justified and recommended in Appendix B, Item 9 (see page 199). This has been incorporated in AMC 29.801 (b)(10) on page 73, but not in the above references. **Proposed Text:** Modify the existing text as follows (deleted text ~~struck through~~): CS 29.563 (a) *Forward -speed landing conditions.* The rotorcraft must initially contact the most critical wave for reasonably probable water conditions at forward velocities from zero up to 56 km/h (30 knots) in likely pitch, roll, and yaw attitudes. The rotorcraft limit vertical - descent velocity may not be less than 1.5 metres per second (5 ft/s) relative to the mean water surface. ~~Rotor lift may be used to act through the centre of gravity during water entry throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight. A maximum forward velocity of less than 30 knots may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out touchdown.~~ AMC 29.563 (a)(1)~~(iii) A rotor lift of not more than two-thirds of the design maximum weight may be used to act through the rotorcraft's centre of gravity during water entry.~~ AMC 29.563 (b)(3) The landing structural design consideration should be based on water entry ~~with a rotor lift of not more than two-thirds of the maximum design weight acting through the rotorcraft's centre of gravity~~ under the following conditions:	
210	CS 29.801 Ditching	64 - 65	**Page No:** 65 **Paragraph No:** CS 29.801 Ditching (i) **Comment:** I. The rule should require that the post-capsize survivability features must reduce the consequences of a capsize to no worse than CS 29.1309 major. II. The rule should require that the survivability features be crash resistant. **Justification:**	

			I. The target probability of capsize of 29 % stated in CS 29.801 Ditching (e), is contingent on the consequences of capsize being no worse than major. If worse than major, a lower target probability of capsize must be applied which would significantly impact the scope of the testing required. II. The majority of the lives saved quoted in the RIA (38/55) relate to survivable water impacts; the post-capsize survivability features will not deliver the safety benefit claimed in the RIA if they do not function following a survivable water impact. **Proposed Text:** Add to the existing text as follows (new text <u>underlined</u>): The rotorcraft design must incorporate appropriate post-capsize survivability features to enable all passenger cabin occupants to safely egress the rotorcraft, taking into account the human breath hold capability. <u>The features provided must be shown by analysis or test to reduce the consequences of capsize to no worse than CS 29.1309 major, and must be resistant to or tolerant of likely damage in the event of a survivable water impact.</u>	
211	CS 29.805 Flight crew emergency exits	66	**Page No:** 66 **Paragraph No:** CS 29.805 Flight crew emergency exits (c) **Comment:** The rule should match CS 27.805 in terms of marking of the operating device. The rule should also require that flight crew emergency exit operating devices must be accessible with inertia reel seat belts locked. **Justification:** The operating device needs to be marked with black and yellow stripes in order to be visible under water. The exit will not fulfil its purpose if the flight crew member cannot reach the operating device. It is possible for inertia reel seat belts to lock in an accident (e.g. G-WNSB), restricting the movement of the flight crew member. **Proposed Text:** Add to the existing text as follows (new text <u>underlined</u>): <u>The operating device for each ditching emergency exit (pull tab(s), operating handle, etc.) must be marked with black and yellow stripes, and must be accessible with the flight crew member's seat belts locked.</u>	
212	CS 29.809 Emergency exit arrangement	66 - 67	**Page No:** 67 **Paragraph No:** CS 29.809 Emergency exit arrangement (j) **Comment:** The CS should require that ditching emergency exits not be	

			susceptible to jamming in the event of distortion of the fuselage. **Justification:** Most of the avoidable fatalities have resulted from survivable water impacts where the rotorcraft structure will likely be subject to loads in excess of normal ditching load, and where the rotorcraft is virtually certain to capsize immediately. It is therefore essential that the ditching emergency exits are of a design that is not susceptible to jamming. **Proposed Text:** Add to the existing text as follows (new text underlined): (1) the design of ditching emergency exits, including their means of operation, markings, lighting and accessibility, must be optimised for use in a flooded and capsized cabin, and must not be susceptible to jamming in the event of distortion of the fuselage;	
213	CS 29.1415 Ditching equipment	68 - 69	**Page No:** 69 **Paragraph No:** CS 29.1415 Ditching equipment (b)(1) **Comment:** At least two life rafts must be installed. This used to be clear in the CS text, but now isn't. **Justification:** A minimum of two life rafts are required in case one is rendered unusable due to puncturing (increasingly likely with the increasing use of carbon fibre in rotorcraft construction), or because either one cannot be deployed due to high winds (the life raft on the windward side of the rotorcraft will be blown against the side of the rotorcraft and unusable). **Proposed Text:** Add to the existing text as follows (new text underlined): "(1) The number of life rafts installed must be no less than two and no smaller than that stipulated in Regulation (EU) No 965/2012. …"	
215	CS 29.1415 Ditching equipment	68 - 69	**Page No:** 69 **Paragraph No:** CS 29.1415 Ditching equipment (c) **Comment:** Constant wear life preservers must be clearly mandated. The purpose/relevance of this new text is not clear. **Justification:** It is not possible to don a life preserver in due time in the cramped environment of a helicopter cabin, especially where immersion/survival suits are required and/or in the event of capsize. **Proposed Text:**	

			Modify the existing text as follows (deleted text struck through): (c) If life preservers are stowed, they must be installed in a way that they are readily available to the crew and passengers. The stowage provisions for life preservers must accommodate one life preserver for each occupant for which certification for ditching is requested by the applicant .~~Life preservers. If Regulation (EU) No 965/2012 allows for life preservers not to be worn at all times, they must be stowed within easy reach of each occupant while seated in the rotorcraft.~~	
216	3.2.4. Draft amendment to CS-29 — Book 2, AMC 29.563 Structural Ditching Provisions	70 - 71	**Page No:** 70 **Paragraph No:** AMC 29.563 Structural Ditching Provisions (a)(1)(ii) **Comment:** The descriptions of the horizontal and vertical velocities are not entirely clear. **Justification:** It was agreed in RMT.0120 that it would no longer be necessary to take account of water particle velocity. The definitions of horizontal and vertical velocities need to correctly reflect this. Note that this is also to ensure consistency with AMC 29.801 (c)(6)(i) & (ii) on page 77. **Proposed Text:** Modify the existing text as follows (new text underlined, deleted text ~~struck through~~): (ii) The ground speed~~velocity relative to the wave surface~~ should be in a range of 0–56 km/h (30 kt) with a ~~vertical~~ descent rate of not less than 1.5 m/s (5 ft/s)~~ relative to the mean wave surface~~. No account need be taken of the wave particle velocity.	
217	3.2.4. Draft amendment to CS-29 — Book 2, AMC 29.563 Structural Ditching Provisions	70 - 71	**Page No:** 71 **Paragraph No:** AMC 29.563 Structural Ditching Provisions (b)(3)(i) & (iv) **Comment:** The descriptions of the horizontal and vertical velocities are not entirely clear. **Justification:** It was agreed in RMT.0120 that it would no longer be necessary to take account of water particle velocity. The definitions of horizontal and vertical velocities need to correctly reflect this. Note that this is also to ensure consistency with AMC 29.801 (c)(6)(i) & (ii) on page 77. **Proposed Text:** Modify the existing text as follows (new text underlined, deleted text ~~struck through~~): (i) ~~forward velocities~~ ground speed of 0–56 km/h (30 kt) ~~relative to the mean wave surface~~;	

			(iv) ~~vertical~~ descent rate ~~velocity~~ of 1.5 m/s (5 ft/s) or greater ~~relative to the mean wave surface~~.	
218	AMC 29.801 Ditching	72 - 80	**Page No:** 73 **Paragraph No:** AMC 29.801 Ditching (b) Explanation (9) **Comment:** Certification by comparison with a similar rotorcraft type should only be permitted where the comparison rotorcraft has been certificated using the new test procedure detailed in AMC 29.801(e). **Justification:** The current test procedures have been discredited and no further credit should be taken for any results so obtained. **Proposed Text:** Modify the existing text as follows (new text underlined, deleted text ~~struck through~~): (9) Tests with a scale model of the appropriate ditching configuration should be conducted in a wave tank to demonstrate satisfactory water entry and flotation stability characteristics. Appropriate allowances should be made for probable structural damage and leakage. Previous model tests and other data from rotorcraft of similar configurations that have already been substantiated based on ~~equivalent~~ test conditions equivalent to AMC 29.801(e) may be used to satisfy the ditching provisions.	
219	AMC 29.801 Ditching	72 - 80	**Page No:** 73 **Paragraph No:** AMC 29.801 Ditching, (b) Explanation (13) **Comment:** This AMC material should explicitly reference the air pocket solution as the default means of compliance with CS 29.801 (i). **Justification:** Throughout the December 2011 EASA Ditching Workshop and the nine formal meetings of EASA RMT.0120 held over a period of three years, the air pocket scheme was the only solution identified. This scheme, in the side-floating helicopter version, has been extensively researched by both EASA and UK CAA and shown to be both practical and effective. All issues associated with this scheme raised during the RMT.0120 meetings have been answered, and a system is currently being developed and certificated by an Australian manufacturer in conjunction with the Australian civil (CASA) and military authorities. It is important that the air pocket scheme be presented as the preferred means of compliance with the corresponding rule (CS 29.801 (i)) to ensure that any alternative solutions are subject to full and proper scrutiny via the AltMOC process. Note that the UK AAIB has recommended (SR 2016-019) that EASA mandate a version of the air pocket concept (the side-floating helicopter scheme). **Proposed Text:**	

			Add to the existing text as follows (new text underlined): According to CS 29.801(i), the rotorcraft design should incorporate post-capsize survivability features. These features should be realised by providing a post-ditching capsize floating attitude which will create an air pocket in the passenger cabin large enough for and accessible to all passengers with the emergency flotation system fully intact and with the critical float compartment failed. The probability of capsize used in the post-ditching stability tests does not preclude capsize, and a probability of 29 % has been retained even when operating within the sea conditions approved for ditching. The target probability of capsize of 29 % requires that the consequences of capsize be no worse than CS 29.1309 major. Without any mitigation, the consequences of capsize correspond to CS 29.1309 catastrophic. In order to provide risk mitigation if a rotorcraft were to capsize, suitable design provisions are required to allow more time for egress as escape time will exceed breath hold capability of at least some of the occupants for typical rotorcraft cabin layouts and in typical sea temperatures. While this will offer a safety benefit if a rotorcraft were to capsize post-ditching, the main safety benefit comes in survivable water impact events where the rotorcraft will likely capsize immediately. It therefore follows that the post-capsize survivability features should, as far as is practicable, function following a survivable water impact where damage to the emergency floatation system can be expected.	
220	AMC 29.801 Ditching	72 - 80	**Page No:** 78 & 79 **Paragraph No:** AMC 29.801 Ditching, (c) Procedures (8) **Comment:** This AMC material should promote the side-floating helicopter scheme as the default means of compliance with CS 29.801 (i). **Justification:** The side-floating scheme is superior to the alternative 'raised-floats' scheme because: I. The side-floating helicopter scheme has been extensively researched over many years by both EASA and UK CAA and shown to be both practical and effective. The raised-floats scheme has not been researched or tested. II. A side-floating scheme is currently being developed and certificated by an Australian manufacturer in conjunction with the Australian civil and military authorities. No comparable work is being performed for the raised-floats scheme. III. The side-floating scheme provides a greater increase in overall emergency floatation system crashworthiness through the addition of redundant floatation; the raised-floats version does not add any floatation. This is especially significant as most of the lives to be saved by the NPA accrue from survivable water impacts where the key factor is post impact operability of the emergency flotation system. IV. Modelling studies performed by independent experts have demonstrated that the side-floating scheme can be expected to maintain a usable air pocket in 75 % to 85 % of survivable water impact scenarios. No studies are known to have been	

performed for the raised-floats scheme, but it is very likely that it will be less effective in this regard as the scheme lacks the floatation unit redundancy provided by the side-floating scheme.

V. The side-floating scheme provides above water escape routes for occupants, facilitating egress. The raised-floats scheme would require occupants to make an underwater escape from the air pocket which is inherently more stressful and hazardous, especially in the dark.

Note also that the UK AAIB has recommended (SR 2016-019) that EASA mandate a version of the air pocket concept (the side-floating helicopter scheme).

Proposed Text:

Modify the existing text as follows (new text underlined, deleted text ~~struck through~~):

(8) ~~One method of meeting t~~The post-capsize survivability provisions of CS 29.801(i) should be met by providing ~~is to create~~ a post-capsize rotorcraft floating attitude which will create an~~d~~ air pocket in the passenger cabin. This can most effectively be achieved by means of additional buoyancy placed high up on the cabin wall(s) to create a reversionary side-floating attitude with the windows providing above water escape routes. The side-floating helicopter scheme provides a post-capsize air pocket and increases the crashworthiness of the emergency floatation system by increasing floatation unit redundancy.

An air pocket will remove the time pressure for escape. Passengers will not need to immediately escape through a ditching emergency exit. They can utilise the air in the pocket for continued survival during the time needed for all to make their escape.

(i) The required additional buoyancy should not be placed in a location vulnerable to damage or likely to detach (e.g. the tail boom), but located away from the normal flotation units such as high up on the side of the fuselage in the form of passive buoyancy (e.g. buoyant cowlings), or redundant flotation units (or both). Any use of additional flotation units should be considered as part of the emergency flotation system and meet the same standards of float design. Consideration will need to be given to the automatic activation of additional floats and the inflation sequence to avoid possible damage from turning rotor blades or impact debris.

(ii) An alternative means of compliance may be to relocate the existing flotation units higher up on the sides of the fuselage to form the ‘wet floor’ concept. An air pocket would then form if the rotorcraft were to fully invert. If this scheme is adopted, appropriate means of escaping from the air pocket (underwater escape) should be provided, and the crash resistance of the scheme should be demonstrated by analysis or test to be equivalent to the side-floating scheme.

(iii) The size and shape of the air pocket should be sufficient to accommodate all passengers. A minimum volume per passenger, in the form of an elliptical column of 70 cm x 50 cm (27 in. x 19 in.) and height of 30 cm (1~~1~~2 in.) relative to the static waterline should be established and demonstrated as fitting into the air pocket, including with the critical float compartment failed. This will accommodate all passengers up to and including those classified as extra-broad (shoulder width ≥ 68.6 cm). As the rotorcraft will have capsized, seats will consume a significant amount of otherwise useable volume and this will need to be taken into consideration in the non-stroked position.

(iv) The air pocket should be accessible and immediately available without passengers needing to cross seat backs. Where the cabin is divided by the presence of seat backs, a sufficient volume of air to accommodate all passengers seated within that row should be provided. E.g., if there are three seats facing a further three seats, the minimum between-row air pocket should accommodate six passengers (six of the elliptical columns should fit). If all seats are forward-facing, and there are four seats in each row, the minimum air pocket should accommodate four passengers (four of the elliptical columns should fit).

(v) Egress from the air pocket will ideally be via exits with a significant portion remaining above the water line. It should be substantiated that egress is feasible, for ~~instance~~ example, that opening of the exit will remain reasonably easy (e.g. ~~not involve the need to find~~ the opening handle can be reached from the surface of the water in the air pocket ~~under an appreciable water depth~~) and that seats or other cabin items provide sufficient stepping points, if needed. Alternatively, if exits with a significant portion above the waterline will not be available, or the opening handle/handles is/are difficult to find, or if other obstacles to egress exist, it may be acceptable to mitigate this by an RFM limitation entry requiring all occupants to be provided with and trained in the use of a suitable emergency breathing system (EBS). This will allow occupants to deploy the EBS when in the air pocket, and then escape using its benefits. The provision of sufficient light in the air pocket to enable preparation for egress and actual egress, including at night, should be ensured.

(vi) Due to the unknown extent of damage, and inability to realistically predict the amount ~~of it,~~ that may occur in a survivable water impact event, the air pocket should satisfy the above design considerations in the ditching case, including with a single float compartment failed. For the side-floating helicopter scheme, ~~S~~such a design is expected to provide an adequate air pocket within the cabin in a high proportion of water impact events albeit the size and location of this air pocket cannot be predicted with any level of confidence.