IN THE SHERIFFDOM OF GLASGOW AND STRATHKELVIN AT GLASGOW

UNDER THE INQUIRIES INTO FATAL ACCIDENTS AND SUDDEN DEATHS ETC (SCOTLAND) ACT 2016

WRITTEN SUBMISSIONS

on behalf of

DR LUCY THOMAS

in the Fatal Accident Inquiry into the deaths of

GARY LOUIS ARTHUR
ANTHONY LYNDON COLLINS
JOSEPH ROBERT CUSKER
ROBERT JAMES JENKINS
JOHN MCGARRIGLE
SAMUEL BELL MCGHEE
KIRSTY MARY NELIS
MARK EDWARD O'PREY and
DAVID IAIN TRAILL

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OVERVIEW

[1] At 22:19 hours on 29 November 2013, Captain David Iain Traill contacted Glasgow Air Traffic Control (ATC) to advise that G-SPAO had completed its tasks in the Bothwell area. He received clearance to enter controlled airspace in order to return to Glasgow City Heliport, which he acknowledged.[1] Police Air Observers Kirsty Mary Nelis and Anthony Lyndon Collins were on-board. PC Collins was filling in routine paperwork. No-one one in the cockpit indicated to the ground that there was anything amiss at any point during the aircraft's flight that night. Within approximately two minutes of the contact with ATC, the right hand engine of G-SPAO had flamed out, followed 32 seconds later by the left hand engine.

[2] There can be no doubt that following the engine flameouts, Captain Traill made significant efforts to save the aircraft and its occupants. He had overcome the worst of any initial stress response and was taking the appropriate actions.[2] On two occasions, Captain Traill recovered the rotor speed. He carried out a flare manoeuvre – a sign that he was again trying to recover the rapidly decreasing rotor speed or that he was trying to cushion the landing.[3] Captain Traill was an extremely accomplished and experienced pilot yet he was unable successfully to complete an autorotation landing. It was acknowledged by the test pilot for the manufacturer that, where there is fuel starvation in both engines at the height at which G-SPAO and without an open area in front of it, the aircraft was doomed.[4] In reality, it is highly improbable that any pilot could have successfully landed G-SPAO at night, in an urban environment, from a height of approximately 500-600 feet within a time frame of less than 10 seconds.

[3] The NVM recovered from the aircraft records that Low Fuel warnings had illuminated, and the associated audio alerts had been repeatedly acknowledged by the pilot. There was usable fuel in the aircraft's main tank. The transfer pumps had stopped pumping fuel to the supply tanks. The Pilot's Checklist procedure for a Low Fuel Warning tells the pilot to check the fuel indication in the main tank and if positive, check the transfer pump switches are on. If the warning remains on, the pilot is instructed to land within 10 minutes. The switches were in the OFF position. The pilot did not land within 10 minutes of the Low Fuel warnings remaining on.

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[1] Crown Production (CP) 1190
[2] CP1320, page 20, paragraph 5.9 (All references are to electronic page numbers)
[3] Marcus Cook, Day 3, page 111, lines 12-19; Prior, Day 30, page 199, line 18 to page 120, line 19
[4] Rene Nater, Day 9, page 183, lines 1-20

[4] The question at the heart of this inquiry is "Why?" The only sensible answer is that Captain Traill evaluated the situation and had good reason to conclude (albeit wrongly) that the Low Fuel warnings did not reflect a genuine emergency situation and that G-SPAO's engines were being fed from the supply tanks. Given that the Low Fuel warnings apparently activated before the tasks at Bothwell, PC Nelis and PC Collins must also have been satisfied that the warnings did not reflect a genuine emergency situation.[5] Otherwise, in light of what the Inquiry has learned of the character, training, experience, competence and practice of the three individuals on-board, either the transfer pumps would have been turned back on and/or, if the warnings persisted, the aircraft would not have carried out the tasks at Bothwell and would have returned to the heliport, landing well within the prescribed 10 minutes.

[5] The EC135 has a history of the Caution Advisory Display (CAD) giving erroneous or spurious fuel indications. In particular showing the supply tanks as full, when they are in fact depleting. That display can be combined with an indication that there is fuel in the main tank which is reducing. Contamination of a fuel sensor with water or other contaminant is a known cause of this phenomenon. But contamination is not found to be present in every instance of this phenomenon.

[6] There have been numerous other types of anomalous fuel indications on the CAD. Not all of them are explained by the application of the algorithm or the logic of how the fuel system works. They can be intermittent. They include anomalous readings on G-SPAO's CAD in 2013.

[7] In terms of contamination, the EC135 has a history of water and/or chemical cleaning agent entering the fuel system in a variety of ways. That problem has never been fully resolved by the manufacturer.

[8] The investigation by the AAIB and the testing by Airbus are not sufficient to rule out the possibility that there was contamination in the supply tank fuel sensors on G-SPAO on 29 November 2013. Even if the Inquiry concludes that contamination can be ruled out in relation to G-SPAO, contamination does not explain all instances of erroneous fuel readings about which the Inquiry has heard. Thus the Inquiry should conclude it was probable that Captain Traill was misled by the fuel indications on the

[5] Professor Dalton, Day 31, page 113, line 14 to page 114 line 9; CP1320, page 13, paragraph 5.4.2

CAD into thinking not only that there was ample fuel in the supply tanks to feed the engines, but that the transfer pumps were on, whether as a result of contamination or other unidentified cause.

ISSUES IN THE INQUIRY[6]

Issue 4(i): How fuel was managed on the aircraft and in particular why both transfer pumps were switched OFF, rendering unusable the otherwise usable fuel in the main tank

[9] According to expert witness Mark Prior, it is possible that the conditions existed for a Forward Fuel Pump (F PUMP FWD) caution to illuminate during the task at Dalkeith.[7] Mr Prior explained the deficiencies of or differences in the Airbus approach to the flight trial conducted by Rene Nater. Mr Nater conceded that it is challenging to try and replicate the features of the G-SPAO flight and that different pilots may carry out a manoeuvre in different ways.[8] Mr Nater described two ways in which the pilot might execute the descent towards Dalkeith.[9] Marcus Cook described a further alternative method.[10]

[10] Mr Prior was robustly examined by the Crown with reference to the data obtained from the NATS radar and his evidence as to the way in which G-SPAO likely descended towards Dalkeith, namely that there was a nose down descent followed by a flare manoeuvre resulting in a higher nose up attitude.[11] He also clearly described how the aircraft would have flown the orbit around Dalkeith in windy conditions.[12] Mr Prior's analysis and responses were cogent and well-reasoned.

[11] Mr Nater stated that while he was orbiting, he was allowing the aircraft to drift in the wind.[13] He suggested that this would reduce the sloshing of fuel in the tank thus reducing the likelihood of the timer for the forward transfer pump being reset. He suggested that in the wind, the aircraft would have had to make more significant bank angle changes and would also have quite big pitch attitude changes, making the fuel slosh more.[14] That evidence would however, appear to be at odds with his earlier

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[6] Dr Thomas makes submissions only in respect of issues 4(i); 4(ii); 4(iv); 4(v); 4(vi); 4(viii); 4(ix); 4(x); 4(xiv); 4(xv); 5; 6(i); 6(iii)
[7] Cp1340, page 28, paragraph 7.2.4
[8] Nater, Day 9, page 202, line 21 to page 203, line 8
[9] Nater Day 9, pages 167, line 4 to 169, line 7
[10] Cook, Day 2 page 104, lines 7-18
[11] Mark Prior, Day 30, pages 52-60
[12] Prior, Day 30, pages 61-63
[13] Day 9, page 156, lines 3-5
[14] Day 9, page 157, line 2 to page 158, line 2

evidence that roll is not a factor in the exposure of the transfer pumps because you do not get sloshing with a turn, only with turbulence.[15]

[12] Mr Prior's evidence ought to be preferred to that of Mr Nater and that of the AAIB. It is supported by the evidence of Craig Trott that in an analogous fuel state with an identically configured aircraft (G-BZRS) he experienced a F PUMP FWD caution when he adopted an attitude similar to that to be expected in the orbit over Dalkeith.[16] Captain Trott also noted that his experience of G-SPAO was that a forward pump caution would illuminate.[17]

[13] Mr Prior's evidence is also supported by the experience spoken to by numerous G-SPAO pilots and air observers. There was clear evidence that both F PUMP FWD and AFT cautions are a frequent and regular feature of police operations. They are experienced as a matter of routine and pilots are well-practised in switching off transfer pumps in response. Captain Traill was one of the most accomplished pilots flying G-SPAO and he had over five years' experience of police operations at the time of the accident. There would be no reason, other than a F PUMP FWD caution, for him to have turned off the forward transfer pump.

[14] The Inquiry should conclude it is probable that the F PUMP FWD caution illuminated and the transfer pump was switched off over Dalkeith in accordance with the proper procedure.[18]

[15] In relation to the aft transfer pump, both Mark Prior and the AAIB concluded that the conditions existed for the aft transfer pump to be exposed for a period in excess of three minutes in the approach to Bothwell.[19] Mark Prior again gave cogent evidence as to why the Airbus trial by Rene Nater should be distinguished.

[16] Given the fuel state at the material time, the Inquiry should conclude that the F PUMP AFT caution illuminated on the return journey from Dalkeith towards Bothwell

[15] Day 9, page 144, lines 12 to page 145, line 16
[16] Craig Trott, Day 28, page 97, line 16 to page 99, line 12 and page 103, lines 1-8
[17] Trott, Day 28, page 154, line 23 to page 155, line 14
[18] in contrast to the Crown's submission paragraph 4.1.1, last sentence
[19] CP1340, page 28, paragraph 7.2.3

and that Captain Traill turned off the aft transfer pump in accordance with the proper procedure.[20]

[17] What reminds the pilot to turn the pump back on? Captain Rooney gave an example of an occasion when he forgot to turn the transfer pumps back on. He was alerted by an anomaly on the fuel indication system, namely that the supply tanks were depleting when they should not be.[21] It may be suggested by the manufacturer that the presence of the original F PUMP caution on the CAD reminds the pilot that the pumps are still off but it appears that is not necessarily an effective reminder.[22] It should be borne in mind, in that regard, how routine such cautions are on police operations.

Issue 4(ii): Whether the Pilot's Checklist was available to the pilot

[18] The cards relating to emergency procedures for Double Engine Failure (cards E.6.1/E.6.2) were not recovered.[23] It cannot be determined whether these were available to the pilot during the accident flight.

Issue 4(iv): At what stage did the Low Fuel warnings likely occur

[19] If the Low Fuel warnings illuminated somewhere in the expected range, then according to Mark Prior's calculations, the earliest the Low Fuel 1 warning illuminated was approximately 2159. The latest it illuminated was 2204. This relates to the period as the aircraft approached Bothwell.[24]

[20] It is not possible to calculate when the Low Fuel 2 warning illuminated. It must have been after the initial Low Fuel 1 warning given the information recovered from the NVM.[25] Both warnings ought to illuminate at around the same time because the fuel should be at the same level (as opposed to quantity) in each supply tank. In this instance, the warnings did not come on at the same time and it is likely there was a gap of time between the second Low Fuel 1 warning and the first Low Fuel 2 warning illuminating. That is because fuel had spilled over from Number 1 into Number 2 supply

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[20] in contrast to the Crown's submission paragraph 4.1.1, last sentence
[21] Andrew Rooney, Day 25, page 61, line 10 to page 62, line 11
[22] e.g. Holger Mendick, Day 8, page 146, lines 20-23
[23] Joint Minute of Agreement 3, paragraph 2
[24] CP1340 (Prior Report), page 32, paragraph 7.4.1; CP327, page 18, paragraph 1.1.2
[25] CP327, page 45, Table 3

tank, thus changing the level of fuel in Number 2 tank and delaying the triggering of the Low Fuel 2 warning.

[21] It is not known whether a Fuel Caution illuminated on the CAD prior to the first Low Fuel warning due to absence of any recovered data relating to the CAD.

Issue 4(v): Why, having acknowledged the Low Fuel warnings, did the pilot not complete the actions detailed in the pilot's checklist

[22] Captain Traill was a very experienced pilot. He was regarded by colleagues as "professional"[26], someone who followed rules and procedure[27] and "very competent".[28] By 29 November 2013 he had flown over 5,595 hours, mostly in helicopters.[29]

[23] Captain Traill was trained to fly helicopters by the Royal Air Force ("RAF"). He carried out operational flights in active warzones in the Boeing Chinook HC2/3 (a twin-engine helicopter like the EC135). He was an RAF Instrument Flying Examiner on the Chinook HC2/3 as well as the RAF's Chinook display pilot in 2007. He was rated by the RAF as an "above average" pilot.[30]

[24] After leaving the RAF in 2008, Captain Traill underwent Bond's EC135 Type Rating Training programme. This took place between 23 – 27 June 2008.[31] He had accumulated 646 flying hours on the type by the date of the accident.[32]

[25] Captain Traill had been trained in the use of the aircraft's fuel system. Reference is made to paragraphs [210] to [220] below. He had also been trained in Crew Resource Management (CRM).[33]

[26] CRM involves the pilot and the police observers flying the aircraft as a crew.[34] While the pilot has the final say in matters relating to the control of the aircraft, any

[26] Police Constable Graham, Day 6, page 144, lines 23 to 24; Trott, Day 28, page 158, line 15
[27] Police Constable McLaren, Day 6, page 95, lines 18 to 20; Rooney Day 25, page 108, lines 4 - 5
[28] PC Graham, Day 6, page 144, lines 23 to 24; Rooney, Day 25, page 107, lines 23 to 24; Trott, Day 28, page 158, line 15
[29] CP327, page 21, paragraph 1.5.1
[30] CP327, page 21, paragraph 1.5.1
[31] BALPA Notice to Admit, paragraphs 3z – 3cc
[32] CP327, page 21, paragraph 1.5.1
[33] CP327, page 21, paragraph 1.5.1
[34] Inspector Whyte, Day 13, page 175, lines 2-6

member of the crew can demand that the aircraft land where they have concerns. It is expected that the pilot would respond to such a request.[35]

[27] CRM also plays a critical role in the standard operation of the aircraft. Pilots and observers are taught to discuss the operational use of the aircraft as a team. This includes planning scheduled and unscheduled tasks. By necessity, this involves the pilot discussing the fuel state of the aircraft and its endurance with the observers both in the air and on the ground.[36]

[28] As part of CRM, observers are trained to call out cautions and warnings shown on the aircraft's CAD and Warning Unit[37]. In response, pilots are to acknowledge and respond to the observer. Where the pilot fails to do so, or where an observer believes that the pilot's response is in adequate, the observer is expected to challenge the pilot[38]. If they are dissatisfied with that response, the aircraft will land.[39]

[29] Captain Traill's observers during the accident flight, Constables Collins and Nelis, were experienced.[40] Their colleagues expected that they would have called out cautions and warnings as they appeared.[41] Air observers would be encouraged, in the event of a warning, to ask the pilot what he was going to do about it and if he wanted any help.[42]

[30] The evidence clearly rules out sabotage of the aircraft. That is clear from the analysis by Mark Prior and Professor Polly Dalton. Captain Traill's efforts to save the aircraft and its occupants prove that there was no sabotage. Deliberate risk-taking has also been excluded having regard to the behaviour of the air observers.[43]

[31] The only logical explanation for why Captain Traill did not land within 10 minutes of the Low Fuel warning is that he considered it safe to continue the flight. That

[35] Chief Inspector McMaster, Day 6, page 61, line 19 to page 62, line 3, page 69, lines 1-11
[36] PC Graham, Day 6, page 143, lines 1 to page 144, line 18; Inspector Whyte, Day 13, page 177, line 20 to page 178, line 1
[37] Chief Inspector McMaster, Day 6, page 61 lines 1-10; PC Graham, Day 6, page 129, line 2 to page 132, line 5; Inspector Whyte, Day 13, page 146, line 5 to page 148, line 12
[38] PC Graham, Day 6, page 129, line 2 to page 132, line 5; Inspector Whyte, Day 13, page 175, line 2 to page 177, line 5
[39] Chief Inspector McMaster, Day 6, page 61, line 19 to page 62, line 3, page 69, lines 1-11; PC McLaren, Day 6, page 108, lines 4 to 9
[40] PC McLaren, Day 6, page 101, lines 15-21 and page 102, lines 5-8; Inspector Whyte, Day 13, page 153, line 20-21
[41] PC McLaren, Day 6, page 101, line 22-25 and page 102, lines 11-13
[42] Cook, Day 3, page 65, lines 21-25
[43] CP1320, paragraph 5.4.2

must mean that he considered there was sufficient fuel on board to complete the tasks at Bothwell and return safely to the heliport, and that the engines were being fed with that fuel. In other words, he must have concluded that the Low Fuel warnings did not represent a genuine emergency situation.

[32] Pilots in flight are managing the aircraft using a combination of skills, knowledge and experience. They are relying on their ground school training where they learned how to fly. They are bringing to bear their type-specific training. They are using their flying experience. They are assisted by the Pilot's Checklist which provides instructions or guidance for situations that may occur but a lot of the assessment and analysis of a situation comes from training and experience.[44] The somewhat linear approach suggested at times – that on receiving a Low Fuel warning, a pilot would immediately turn to the relevant card in the Pilot's Checklist – ignores the evaluation process that will be undertaken by the pilot based on his general flying experience, his experience of the particular aircraft, and his experience of the flight up until that point.[45] If in that initial evaluation, the pilot concludes that the warning is spurious or an error, he may decide that it is unnecessary to refer to the Checklist card and to complete the emergency procedure.

[33] It is human nature first to evaluate based on general awareness of the situation, which brings to bear prior experience.[46]

[34] The type-specific training for the EC135 instructs the pilot that it is possible that a caution or warning will come on unnecessarily and that the pilot should check the indication against its associated instrument to verify that there actually is an emergency situation.[47] This accords with the natural process of evaluation described by Professor Dalton.

[35] Therefore, prior to undertaking the checklist procedure for a Low Fuel warning, a pilot will most likely evaluate the situation first by making the cross check with the associated instrument. The associated instrument for a Low Fuel warning is the fuel contents indication on the CAD.

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[44] Rooney, Day 25, page 176, line 17 to page 177, line 12
[45] The Crown concede that such an evaluation process is appropriate at paragraph 4.9.15
[46] Professor Dalton, Day 31, page 106 lines 6-15; CP1320, page 11, paragraph 5.3
[47] CP214, G-SPAO Flight Manual, page 136

[36] On the accident flight, there may have been a number of reasons to treat the Low Fuel warnings with scepticism.[48]

[37] Because of the lack of recovered data, it is not known whether a fuel caution appeared on the CAD before the Low Fuel warnings. The Inquiry has heard of examples both in flight and in testing of the fuel system, where the amber fuel caution has not illuminated prior to the Low Fuel warning.[49] If it did not, that may have been a factor in causing Captain Traill to be sceptical about the Low Fuel warnings. The manufacturer, after the incident at Barton with G-NWEM, acknowledged that a Low Fuel warning may come on without the pilot having received a fuel caution first.[50]

[38] The Low Fuel 1 warning was intermittent. On three occasions, the warning light extinguished. At the calculated time of the first Low Fuel warning, Captain Traill's mental calculation would have indicated that there was sufficient fuel on board that he ought not to be receiving such a warning. According to the AAIB, G-SPAO arrived at Bothwell with 122kgs of fuel on board.[51] According to Mark Prior's reverse calculation there was 120 kgs on board.[52] By then, G-SPAO had been in flight for approximately 1 hour and 22 minutes. At an average fuel burn of 200 kgs per hour, and a fuel load of 400 kgs at take-off, the pilot would have calculated there was approximately 126 kgs on board – meaning sufficient for full supply tanks and a quantity in the main tank.

[39] The fact that the Low Fuel warnings did not both illuminate at the same time may also have caused scepticism[53], particularly given that Low Fuel 1 appears to have extinguished again after Low Fuel 2 had illuminated. Although pilots may have had an awareness that the CAD and Low Fuel warnings were separate systems, it does not appear that pilots had any knowledge that Low Fuel warnings could be intermittent by reason of sloshing fuel. Even if Captain Traill did have that knowledge, it would seem unusual to him that Low Fuel 1 was intermittent due to sloshing at a time when Low Fuel 2 was constantly illuminated (given that both warnings should illuminate when fuel

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[48] CP1320, paragraph 5.4.5; Dalton, Day 31, e.g. page 114, line 10 to page 117, line 5
[49] e.g. G-POLD, see CP1078 (Scirocco Report 13/3/18); NTA Number 2 for the Crown, paragraph 12; CP1293 and Andrew Alford, Day 27, page 17, line 17 to page 18, line14; G-NMID, CP531, page 3 et seq; Mortimore, Day 26, page 93, lines 16-18; G-HBOB, CP377; Bryan Meredith, Day 17, page 6, lines 19-20
[50] CP249
[51] CP327, page 18, paragraph 1.1.2
[52] CP1340, page 25
[53] Prior, Day 30, page 98, lines 10-22

is at the same level). That would suggest sloshing only in one tank, which would make no sense based on the pilots' knowledge at that time.

[40] The absence of recovered data relating to the CAD, and the absence of cockpit voice or image recorders, mean that the Inquiry cannot definitively know what the fuel contents indication displayed to Captain Traill. However, as noted elsewhere, given the evidence of Captain Traill's experience, competence and professionalism, the Inquiry can and should conclude that it is probable that the indication shown on the CAD contradicted the Low Fuel warning.

[41] The likelihood of that being so is enhanced by the evidence relating to the crew's behaviour. Had the CAD clearly indicated a low fuel state such as would trigger a Low Fuel warning, it is inconceivable that the Air Observers would have asked Captain Traill to carry out the tasks at Bothwell, Uddingston and Bargeddie.

[42] At the estimated time of the Low Fuel warnings and in light of the calculated fuel state, it is probable that the CAD indicated that the supply tanks were full. Had it been displaying the true state of affairs, the Low Fuel warning would have been verified by its associated instrument and no reason has been advanced why Captain Traill would not have followed the procedure in the Pilot's Checklist. No reason has been advanced why Anthony Collins and Kirsty Nelis would have allowed the flight to continue.

[43] At the time of the accident, there was no instruction to the pilot in the flight manual or checklist that in the event of a contradictory fuel indication on the CAD, he should prioritise the Low Fuel warning procedure. The Inquiry has heard evidence from one senior pilot that, if he considered a Low Fuel warning to be spurious, he may (at least as at 2013) not follow the procedure to land within 10 minutes.[54]

[44] Following the incident involving G-NWEM at Barton, the manufacturer issued, first, a safety information notice on 16 December 2013.[55] This advised pilots that the Low Fuel warnings were generated by a separate independent switching logic and that the warning lights operate correctly even if the fuel gauge is inaccurate. It went on to tell pilots to follow the Low Fuel warning procedure notwithstanding the fuel quantity indication.

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[54] Rooney, Day 25, page 85, line 18 to page 95, line 17

[55] CP249

[45] Thereafter the manufacturer issued an Alert Service Bulletin on 19 December 2013. This stated that the first analysis of the Barton incident showed that the fuel quantity indication in the supply tanks could be incorrect. It temporarily amended the Flight Manual (which later became a permanent revision) to include in the Pilot's Checklist card for Low Fuel warning, the instruction, "The Low Fuel Warning Overrules the Fuel Quantity Indication."[56] Presumably the manufacturer thought that such an instruction was necessary in order to clarify matters.

[46] The Inquiry has heard evidence about whether and, if so, when a PAN call or MAYDAY call ought to have been made by Captain Traill. In terms of the agreed consolidated list of issues, it should be noted that issuing a PAN or MAYDAY call forms no part of the Pilot's Checklist for Low Fuel warning.[57]

[47] Failure to make a PAN or MAYDAY call, should one have been appropriate, did not cause or contribute in any way to the accident.

[48] Therefore, the Inquiry should make no finding on the question of whether a MAYDAY or PAN call ought to have been made, it being irrelevant.

[49] However, given the evidence introduced on this question, it will be addressed here.

[50] The various manuals to which pilots on police operations for Bond were to have regard are apt to confuse in relation the declaration of an emergency situation by the aircraft commander.[58]

[51] The flight was being flown under Visual Flight Rules (VFR) and the VFR fuel policy applied.[59] It was flown at night. It was not flown under Instrument Flight Rules (IFR). The AAIB report is incorrect to make reference to the IFR Final Reserve Fuel being

[56] CP468, ASB EC135-28A-019
[57] CP66, page 22
[58] The conflicting statements as to fuel requirements were noted by Prior (CP1340, e.g. page 41, Table 4), Day 30, pages 100, line 9 to page 118, line 2; and by Cook (e.g. Day 2, page 112, lines 7-15)
[59] CP1290, page 76, paragraph 3.4 (Police Air Operations Manual Part 1); Rooney, Day 25, page 52, line 18 to page 53, line 5; Trott, Day 28, page 131, lines 4-21; Cook, Day 2, page 115, lines 3-7

applicable.[60] Marcus Cook, of the AAIB, was unable to explain why the AAIB decided not to apply the VFR FRF of 67 kgs.[61] He went on to express the view that night flights are IFR.[62] While that may reflect the general CAA rules, it ignores the Police Air Operations Manual, which allows night operations to be flown VFR. Craig Trott confirmed that police operations at night should be distinguished from IFR.[63] Cook stated the AAIB had made an assumption that the pilot was planning to land with 85 kgs as the FRF.[64]

[52] The Police Air Operations Manual part 1 provides that for VFR Radius of Action operations (which the accident flight was) the contingency fuel required is fuel for 30 minutes at endurance speed.[65] Endurance speed is 170 kgs per hour. This calculation therefore results (coincidentally) in a figure of 85 kgs which under PAOM part 1 would be the applicable Final Reserve Fuel (FRF) amount.[66]

[53] The Bond Operations Manual, part B3, provides for a FRF amount of 67 kgs for VFR and 85 kgs for IFR. There is no reference to suggest that VFR flights at night attract a different FRF from other VFR flights. It also notes that there is a Minimum Land On Allowance of 40 kgs, and that the Company policy is that an aircraft should not land with less than 60 kgs of fuel in the tanks.[67]

[54] It is possible that Captain Traill was operating to a FRF of 67 kgs because he was flying a VFR flight and the operator's manual does not differentiate a night flight. In the Easy Weigh system, Captain Traill had selected the MLA Day (rather than night) option.[68]

[55] The Bond Operations Manual, part B3, instructs that a PAN call should be made if it appears to the commander that the FRF may be required and that if the FRF is reached, a MAYDAY call should be made.[69]

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[60] CP327, page 90, paragraph 2.1.3
[61] Day 2, page 116, line 22 to page 117, line 2
[62] Day 3, page 103, lines 7-9
[63] Day 28, page 131, lines 18-21
[64] Day 3, page 45, lines 13-18
[65] CP1290, page 77, paragraph 4.3(c)(ii)
[66] Craig Trott, Day 28, page 83, line 6 to page 84, line 6
[67] CP225, page 166
[68] CP518, page 2
[69] CP225, page 166

[56] In contrast, the Bond Operations Manual, part A, states that an emergency condition can be considered to exist if the Commander believes that the helicopter will land below MLA (which is 40 kgs).[70] The Police Air Operations Manual, part 2, similarly refers to a landing with not less than the minimum landing allowance.[71]

[57] While it is company policy not to land below 60 kgs, it is far from clear that this, rather than 40 kgs, would necessitate a MAYDAY call (and the associated MOR to the CAA) in terms of Bond Ops Manual part A or PAOM part 2.

[58] In any event, when it crashed, G-SPAO was found to have 73 kgs of usable fuel on-board. It was 2.7nm from the heliport. That was apparently sufficient fuel to land above 60 kgs (if applying the company policy).[72] If the pilot's understanding (based on Operator's manual part A and PAOM part 2) was that it was either the company policy of 60 kgs or the MLA of 40 kgs which applied to the identification of a developing emergency situation, then neither a PAN call nor a MAYDAY call would have been required.[73]

[59] Mark Prior noted that G-SPAO had landed on numerous occasions with a fuel state below 67 kgs but he had seen no Mandatory Occurrence Reports indicating that a MAYDAY call had been made.[74] The Crown re-examined Mr Prior as to whether he could confirm whether or not there were MORs in existence. Given that Mr Prior was an expert witness instructed by the Crown, and given the content of his report, the Inquiry may find it surprising that, if MAYDAY calls had indeed been made, that the Crown did not lead evidence of the associated MORs, given the length and thoroughness of the investigation into this incident.

[60] As submitted above, the Inquiry should make no finding regarding a PAN or MAYDAY call. Should the Inquiry consider making such a finding, it should be that the various manuals were contradictory as to the stage at which a PAN or MAYDAY call should be made.

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[70] CP224, page 183, paragraph 8.1.7.2
[71] CP208, page 46, paragraph 2.5.3, 1(b)
[72] Cook, Day 3, page 47, lines 6-12
[73] Cook, Day 3, page 105, lines 19-22
[74] Prior, Day 30, page 118, lines 3-24; CP1340, page 41

Issue 4(vi): Whether the timing and/or the initially intermittent character of the Low Fuel warnings contributed to the Pilot's Checklist procedure not being completed

[61] This is addressed under issue 4(v) above.

Issue 4(viii): Whether the pilot believed the fuel transfer pumps were operating notwithstanding the Low Fuel warnings, because he believed he had switched the fuel transfer pumps back ON, and if so whether the design or layout of the switches contributed to such errors occurring

[62] Given that police pilots routinely and frequently switched transfer pumps off and on again, it is highly unlikely that Captain Traill activated the Prime Pump switches in error.

[63] Having said that, had the CAD accurately reflected the low fuel state necessary to trigger the warnings (i.e. if it had shown depleting supply tanks but with fuel in the main tank), it is inconceivable that Captain Traill would have neglected to turn the transfer pumps back on. The warning would have been called out by the Air Observers. They would have demanded a response from Captain Traill. The response would be to acknowledge the warning, check the fuel levels on the CAD, and if the supply tanks were depleted with fuel still in the main tank, to turn the pumps back on. An unsatisfactory response or a failure to act by a pilot in this situation would have resulted in continued challenge by the observers, culminating, if necessary, in a demand to land the aircraft.

[64] As noted above, Captain Andrew Rooney gave an example of an occasion where he had forgotten to turn the pumps back on after returning to level flight. What drew the matter to his attention was an "anomaly" on the fuel gauge which he spotted in a routine indication check – namely that his supply tanks were depleting when they should not be.[75] When combined with Low Fuel warnings, there is no basis to think that the effect on Captain Traill of a similar "anomalous" display on the CAD on G-SPAO would have been any different. He would have seen the supply tanks depleting and he would have turned the pumps back on.

[75] Rooney, Day 25, page 61, line 10 to page 62, line 11

Issue 4(ix) Whether the pilot believed the transfer pumps were operating notwithstanding the Low Fuel warnings, as a result of erroneous fuel indications being displayed on the CAD

[65] The submissions on this issue should be read in conjunction with the submissions in respect of issue 4(x) below about root causes of erroneous fuel indications.

[66] There are at least two examples illustrating that the CAD on an EC135 can display full supply tanks and a decreasing main tank content at time when either the main tank was empty or when the transfer pumps were switched off. In both instances, the fact that the supply tanks were depleting would not be known to the pilot. In both instances, if it happened in flight, it would look to the pilot as though the transfer pumps were in fact operating and replenishing the supply tanks.

[67] The first (where the main tank was empty) was the Barton incident involving G-NWEM on 11 December 2013. G-NWEM had been experiencing spurious main tank fuel indications – with fluctuations of 30-40 kgs in flight.[76] It was kept in a lower fuel state pending the sensor being changed. On the 4th sortie of the day, the forward and aft fuel pump cautions illuminated. The CAD showed 30 kgs in the main tank. The pilot assumed this to be spurious and that the main tank was empty. Later when G-NWEM was defueled, it was confirmed that the main tank was indeed empty.[77] As Captain Taylor continued the flight, the CAD indication for the supply tanks did not decrease even though the tanks were depleting. There was no amber caution at any stage. The Low Fuel warnings came on with the CAD still reading 47/43 kgs. The main tank reading continued to decrease and on shut down the CAD displayed 47/16/43 kgs.

[68] Captain Taylor was not misled by the indications on the CAD into thinking that the supply tanks were being replenished only because he knew of the spurious main tank indications and disregarded that reading.

[69] The reduction in the main tank reading (from 30 kgs eventually to zero) cannot be explained by the "headroom" effect.

[76] CP557

[77] Price, Day 16, page 57, lines 13-24

[70] When the aircraft was defueled by David Price, the CAD readings went from 47/14/43 to 10/3/43 when No 1 tank was drained and from 10/3/43 to 10/0/13 when No 2 tank was drained. Accordingly, the main tank reading reduced 14 kgs (having already reduced from 30 to 16 kgs in flight). The headroom when the main tank is full has a capacity of around 50 kgs. However, when the main tank is empty, the only relevant part of the headroom is that between the top of the dividing wall in the supply tank (below which the supply tank fuel quantity totals 90 kgs) and the overflow channel. That is because when the main tank is depleted, any fuel reaching the overflow channels will flow back into the main tank (and thus not fill the full headroom capacity). The space between the top of the dividing wall and the overflow channel accounts for 9-10 kgs of fuel.[78]

[71] Following Barton, Bond grounded its fleet and carried out fuel indication checks on all its aircraft. Nine aircraft failed the test.[79] The existence of "drift" (i.e. over-reading) in the sensors was widespread.

[72] The other incident (where the transfer pumps were switched off, yet the main tank was showing as depleting) was G-POLD on 13 March 2018. Captain Andrew Mortimore testified that should the main tank deplete for more than three minutes or by more than 10 kgs, he would be suspicious because that cannot be accounted for by the headroom effect. He has seen it do that and reduce by more than 13 kgs on one occasion.[80] In G-POLD, that was the situation (during Alford's tests) – the main tank contents were seen to reduce for a period of 19 minutes and by a quantity of 24 kgs.[81]

[73] Both examples illustrate that where the supply tank contents are being depleted below their full level of 47/43 (i.e. it is not fuel in the headroom which is being burned), it can appear to the pilot that the supply tanks are being replenished while the main tank is decreasing. That is how the CAD behaves when the transfer pumps are running.

[74] In relation to the Crown's submissions at paragraphs 4.9.19 to 4.9.27, in assessing what would have become obvious to the pilot over what time period, it must be borne in mind that, for the majority of the time following the Low Fuel warnings, the

[78] Mendick, Day 7, page 44, lines 5-14
[79] CP557, page 2
[80] Mortimore, Day 26, page 126, line 23 to page 127, line 6 and page 127, line 23 to page 128, line 6
[81] CP1293 and Alford Day 27, page26, line 12 to page 27, line 8

pilot is engaged in tasks at Bothwell, Uddingston and Bargeddie. Each involved right hand orbits which place a high workload on the pilot, particularly in windy conditions. In order to perform the manoeuvres, the Inquiry heard that pilots will be looking out of the right hand window and leaning over to the right in their seat to give the Observer maximum opportunity with the FLIR.[82] In that situation, it was acknowledged by a number of witnesses that the pilot's focus is not on the CAD but is outside the aircraft.

[75] If, as is submitted below in relation to issue 4(x), the CAD presented Captain Traill with erroneous indications, namely full supply tanks and a depleting main tank, he may well have been misled into thinking the transfer pumps were ON.

Issue 4(x): What the root cause or causes were of any such erroneous fuel indications and whether they were adequately investigated and acted upon prior to the accident

[76] Prior to the accident, the EC135 had a decade-long history of fuel indication issues and problems with both main and supply tanks sensors. Indication problems persist to this day, on occasion requiring aircraft to be grounded.[83]

[77] The manufacturer provided a spreadsheet listing the monthly fuel sensor returns for a period of six years prior to the accident and the period following the accident. The lists cover both supply and main tank sensors and are replete with reports of fuel indication issues including fluctuations and indications of the tank showing full when it is empty.[84]

[78] The Inquiry heard of many instances of fluctuating fuel indications, in particular in the main tank, and of supply tank indications not reflecting the actual quantity of fuel on board.

[79] One cause of the latter issue has been identified as contamination of the supply tank sensor(s) by water or another contaminant. It has been established that the presence of a contaminant between the concentric tubes of the sensor can cause the CAD to indicate that a greater quantity of fuel is in the tank than is actually on board.

[82] Cook, page 94, line 23 to page 95, line 8, PC Graham, Day 6, page 142, lines 6-17
[83] Mortimore, Day 26, page 134, lines 17-22 and page 135, lines 4-9
[84] CP1324, spreadsheets at pages 32-54 (prior to accident) and pages 55-60 (post-accident); Mendick, Day 9, pages 36-41

[80] There have also been examples of supply tank over-reads where, on investigation, no contamination has been found either in the sensor, or in the fuel system (as illustrated by the absence of any water in drained fuel).

[81] In relation to main tank fluctuations, some of these have been explained by the effect of different pitch attitudes on the design of the fuel system. Some have been explained by the logic of the fuel system algorithm (the "headroom" effect) as well as the conservative estimating of the main tank quantity at particular pitch attitudes when one main tank sensor may be exposed more than the other. But there are a number of spurious fuel system indications that remain entirely unexplained.

[82] A pattern emerges from the evidence that a fluctuation in the main tank indication would draw a pilot or engineer's attention. On investigation, it was often discovered that one or both supply tank sensors were faulty, and the CAD was displaying an over-read. Whether that pattern is coincidental or whether there is a connection between main tank fluctuations and a developing issue with the supply tank sensors cannot be definitively established. One pilot, who has paid close attention to fuel indication issues, considered that the main tank fluctuations may indicate the beginning of supply tank sensor failure.[85]

[83] The Inquiry has also heard evidence of spurious fuel indications, the cause of which has never been identified. In addition, there have been instances of fuel migrating from one part of the system to another, again without explanation.

[84] Under this issue, the fuel system issues on the EC135 will be examined. Thereafter submissions will be made in relation to fuel system issues on G-SPAO. The Inquiry will be invited to conclude that it is probable Captain Traill was faced with indications on the CAD which contradicted the Low Fuel warnings as a result of contamination or another unidentified cause. The Inquiry will be invited to conclude that the fuel indication system on the EC135 was and remains unreliable.

[85] Trott, Day 28, page 147, lines 1-2

Fuel system issues on the EC135:

G-NMID/G-POLD

[85] In June 2007, G-NMID experienced significant fluctuations in main tank fuel levels. Captain Mortimore kept a record of 25 flights and the fuel indication at 8 stages of flight.[86] While there were issues with Captain Mortimore's arithmetic on the flight record, he confirmed he had accurately recorded the various fuel indications from the CAD. At a higher fuel state, Captain Mortimore accepted that the fluctuations were explained by the attitude of the aircraft and the logic of the fuel indication system (that the fuel in the headroom is ascribed to the main tank contents). But at a lower fuel state (at the end stages of flights) the fluctuations were not explained by the attitude of the aircraft. Captain Mortimore concluded that the lower level fluctuations may indicate that there is contamination in the sensor(s).[87] There was no evidence of contaminated fuel either in the source fuel or from testing of the aircraft.

[86] On 24 August 2007, it was planned that an engineer would carry out a fuel quantity check on G-NMID, as a result of Mortimore's record of 25 flights. Pilots on 23-24 August were asked to maintain a lower than normal fuel state. The pilot's attention was attracted when a Low Fuel 2 warning came on while the CAD displayed 43 kgs in the No 2 supply tank.[88] After various actions, including another flight, the aircraft was defueled. All tanks were drained until there was no more fuel. At the start of the defueling, the CAD read 47/50/43 – a total of 140 kgs. Only 79.3 kgs of fuel was removed from the aircraft which represented an error of 44%. The total quantity removed and where it was removed from demonstrated that the CAD was over-reading in relation to all three tanks.[89] Captain Mortimore considered this demonstrated contamination was present in the sensors and it was later reported that contamination was found.[90]

[87] What is of note is that prior to the sensors being removed, a test was carried out in accordance with the AMM to check the fuel indications. The aircraft was refuelled in specified amounts. When no fuel had been added and therefore the supply tank readings

[86] CP527
[87] Day 26, page 143, lines 17-21
[88] CP1375
[89] Mortimore, Day 26, page 58, lines 9-14
[90] Mortimore, Day 26, page 56, lines 13-15; CP830, page 4

should have been zero, the CAD indicated 5/13 kgs.[91] During the test, when 304 litres had been added to the main tank and the supply tanks were still empty the No 2 supply tank reading increased by one to 14 kgs. Nothing had been added to the sensor or the tank. This fluctuation in over-read replicates what was seen during the G-NWEM tests (where the supply tank readings changed from 10/14 to 11/17 without any fuel or water being added to the supply tank sensors). These examples may illustrate that the level of over-read is not constant.[92]

[88] The refuelling test on G-NMID establishes that an over-read can be masked within the tolerances of the gauge at higher fuel states because the aircraft passed the test even though there was clearly an over-read in both supply tanks.[93]

[89] Thereafter the aircraft had its sensors changed, although it is not known which sensors.[94]

[90] All daily fuel checks relating to G-NMID and its source fuel had been clear of contamination. The absence of contamination in fuel checks indicates that the contamination was never in sufficient quantity to collect at the sump. It was only in the late stage of the flight in the early hours of 24 August that the problems with supply tank indications became apparent. That was because G-NMID was in a low fuel state.[95] Prior to that date, what had been apparent (from June) was not an over-read but fluctuating main tank indications particularly in lower fuels states in the end stages of flight.

[91] In late February 2012, G-NMID experienced another fuel indication problem.[96] Pilots reported fluctuations in the gauge.[97] Captain Mortimore carried out a time-staged test at the start of which, he turned off the transfer pumps. At that point the CAD indicated 47/150/43 kgs. After 5 minutes with pumps off, the CAD displayed 42/139/43 and Low Fuel 2 warning was illuminated. After 7.5 minutes both Low Fuel warnings had illuminated, and the CAD displayed 40/138/43. The fuel caution had not displayed.[98] The supply tanks were thereafter drained. A total quantity of 58 kgs was

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[91] CP1375, page 4
[92] CP744, pages 1 and 2
[93] Mortimore, Day 26, page 138, lines 1-14
[94] Mortimore, Day 26, page 62, lines 14-23
[95] Mortimore, Day 26, page 66, line 23 to page 67, line 7
[96] CP531, page 3 onwards
[97] Mortimore Day 26, page 77, lines 16-19
[98] Mortimore, Day 26, page 93, lines 16-18

removed. When supply tank 2 was emptied, it was still displaying 43 kgs.[99] The supply sensors were replaced.

[92] On 23 March 2012, the No 1 fuel quantity sensor failed in spite of having been replaced two months before.[100]

[93] In 2007 and 2012, it was main tank fluctuations which drew the attention of the pilots and started the investigation which led to discovery of supply tank sensor over-read. The main tank fluctuations remain apparently unexplained.[101] At lower fuel states, the main tank fluctuations may signal contamination in the supply tanks sensor(s).[102]

[94] In March 2018, G-POLD (formerly G-NMID) experienced another fuel indication fluctuation issue.[103] In flight, Captain Shanks received both fuel pump cautions and turned the transfer pumps off. The CAD displayed 47/50/43 kgs. At least seven minutes later, the main tank contents indication was continuing to reduce but the supply tank indications remained constant. On landing, the CAD read 47/32/43 kgs.

[95] Captain Shanks carried out ground runs totalling a period of 18 minutes. After 6 minutes, the CAD displayed 47/25/43. After a further 12 minutes, the CAD displayed 47/7/37 kgs. The transfer pumps had remained off since being turned off in flight.

[96] Engineer investigations confirmed both supply tanks were over-reading.[104]

[97] There was no contamination in G-POLD's fuel tank prior to Captain Shanks' flight. The bowser from which the aircraft was fuelled was clear of contamination. G-POLD had not been rinsed/washed prior to Captain Shanks' flights that day.[105]

[98] Both supply tank sensors were removed and checked for any signs of defects or contamination. There were none. The sensors were subsequently tested, and no fault

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[99] Mortimore, Day 26, page 88, lines 13-18
[100] CP531; Mortimore, Day 26, page 89, lines 1-3
[101] Mortimore, Day 26, page 103 lines 1-19
[102] Mortimore, Day 26, page 143, lines 17-21
[103] NTA No2 for Crown; NTA for Dr Thomas; CP1078; CP1080; CP1128; CP1293
[104] CP1293
[105] NTA No2 for Crown, paragraphs 11 and 17

was found. Water was then injected into the sensors and the frequency was noted to "jump around rather erratically".[106]

G-NWEM

[99] The incident at Barton on 11 December 2013 is summarised under Issue 4(ix) above. In short, the aircraft experienced fluctuating main tank indications, followed by an over-read in the supply tank indications.

[100] Significant testing was undertaken given the proximity of the incident to the G-SPAO accident. Both the AAIB and the manufacturer were involved.

[101] What is of significance is that the fuel which was drained from G-NWEM (by David Price) was tested and found to be free of contamination.[107] Thereafter, the aircraft was left to stand to allow any further fuel, water or other contaminant to make its way to the sump. The sump was then drained via the drain valve. That fuel was tested for water and none was present.[108]

[102] G-NWEM experienced a further fuel indication issue in 2014.[109] Fluctuations in the main tank indication were observed by the pilot (Captain Allan Bryers). These increased over a series of flights from 3-5 kgs to variations as large as 10-25 kgs. A fuel system indication check was then carried out and supply tank sensor 2 failed because it indicated full at a time when the Low Fuel warning illuminated. When that sensor was removed, cleaned and refitted, the aircraft passed the test. This occurred only a few months after G-NWEM's sensors had been replaced following Barton and when operators were acutely conscious of the need to avoid contamination with water.

[103] While in the 2018 G-POLD and 2013 G-NWEM incidents, it was established that there was less fuel on board than had been indicated on the CAD, there was no evidence of failed fuel reconciliations in respect of other occasions of established supply tank over-reads (including those discussed below). The Inquiry heard from Captain Mortimore about the fuel reconciliation process. Originally it involved noting the fuel used, working out how much was required and then once that had been dispensed,

[106] NTA for Dr Thomas, paragraphs 9 and 17
[107] Vickery, Day 5, page153, lines 1-3
[108] CP744, page 2 (approx 100 mls was drained)
[109] CP391

cross-checking the gauge on the bowser with the quantity now displayed on the CAD. A more sophisticated reconciliation process was introduced by NPAS in 2014 involving a computerised programme as part of the weight and balance programme which allows a percentage accuracy figure to be obtained.[110]

G-KRNW

[104] In September 2015, Captain Bryers experienced main tank fuel indications varying by uncommon amounts in G-KRNW culminating in the fuel indication going from 100 kgs to 64 kgs while taxiing from the runway to the hangar. He noted that, contrary to his experience, over two days the supply tanks did not deplete even where the main tank fuel level was low.[111] The main tank sensor was removed and found to be contaminated with sludge. The absence of a decrease in the supply tank readings was not explained.

G-SASB – The air ambulance

[105] On 2 January 2014, Captain Craig Trott was flying the air ambulance (G-SASB) when he experienced a phenomenon that was the opposite of what happened with G-SPAO on 23 November 2013[112], in that when he was in hover the CAD read 46/70/42 kgs. A total fuel quantity of 158 kgs. On landing, the main tank level decreased, and the reading was 46/54/42 kgs. A total fuel quantity of 142 kgs.

[106] Captain Trott only noticed the fluctuation because the aircraft as at a lower fuel state than normal and because this was shortly after the crash and pilots were paying particular attention to fuel indications.

[107] The investigation of the defect on G-SASB is recorded in the associated MOR.[113] The tanks were drained, starting with the main. When it was empty, the CAD displayed 8 kgs in the main tank. Thereafter the supply tanks were drained in turn. After 10 litres was removed from No 2 supply tank, the main tank indication was 0 kgs. The Low Fuel warning came on in No 2 supply tank below the expected range, at an indication of 19 kgs. A total of 190 litres (152 kgs) were drained from the tanks. After both supply tank

[110] Mortimore, Day 26, page 146, line16 to page 147, line17
[111] CP408; Allan Bryers, Day 24, page 53 and page 70, lines 17-23
[112] As discussed below, on 23/11/13, G-SPAO's main tank reading increased on landing
[113] CP370

sensors were removed, cleaned and refitted, the CAD read 0/0/0 kgs. It was considered that the cause was faulty sensors (either supply tank sensors or supply and main tank sensors), not the design of the system.[114] Given the quantity of fuel drained from the aircraft, it cannot be determined whether the CAD reading of 158 kgs in hover was an over-read or the total CAD reading on landing of 142 kgs was an under-read. Both figures are within the tolerance of the fuel indication system and it was only the fact that the pilot happened to notice the unexpected fluctuation which caused the pilot to conclude that the fuel indication system was faulty.

Other Bond operated EC135s

[108] Bryan Meredith of Bond spoke to numerous occurrence reports detailing other instances of fuel indication issues. A number of these were discovered during the monthly fuel system indication test which Bond instituted following the Barton incident. Those of relevance are summarised below.

[109] G-CGPI on 1 July 2013 at Glasgow heliport – No 1 supply tank appeared to be indicating full regardless of how much fuel was on board. The transfer pumps were turned off and fuel in the supply tanks burned till empty. The CAD still indicated 47 kgs for No 1 supply tank. The sensor was changed, and the problem resolved. There was no report of any failed fuel checks.[115]

[110] G-HBOB on 3 February 2014. This aircraft failed the Bond scheduled fuel system indication check. The Low Fuel warning illuminated before the fuel caution and No 2 tank was continuously indicating 43 kgs.[116] Both supply tank sensors were replaced. Mr Meredith concluded there was contamination in the sensors.[117]

[111] G-DORS on 4 February 2014.[118] The No 2 supply tank indication was seen to fluctuate, and that consumption of main tank contents appeared static at some stages. The aircraft received an engine wash in the middle of that day's flights. At the end of the flights, all sensors were removed, and water residue was found in the main tank aft sensor and in No 1 (not No 2) supply tank sensor. Some of the changes in indication may

[114] Trott, Day 28, page149, lines 7-12 and page 154, lines 16-21
[115] CP506
[116] CP377
[117] Meredith, Day 17, page 6, lines 19-20
[118] CP378

be attributable to flight attitude and the design of the tank system. But it illustrates (contrary to the evidence of Holger Mendick – discussed below) that contamination with water can be confined only to certain parts of the system. It also illustrates that the fact that water from an engine wash may enter either the No 2 supply tank and the main tank does not prevent No 1 sensor becoming contaminated (even though No 2 is uncontaminated).[119]

[112] G-NWAE on 8 April 2014.[120] This is another aircraft which failed the Bond scheduled monthly fuel system test. No 2 supply tank indication showed 43 kgs even though the Low Fuel 2 warning was illuminated. It was resolved by cleaning No 2 sensor.

[113] It should be noted that David Price confirmed that all the Bond aircraft were checked every day for water in the fuel tank.[121] In addition, where an aircraft failed the monthly fuel indication test, there was a specific requirement to check the fuel which had been removed from the aircraft for water.[122] The absence of any record on the MOR of water contamination in the fuel suggests that there was no contamination found in the fuel on any of these occasions. That undermines the evidence suggesting that where there is contamination, water will be discoverable.

[114] G-HWAA on 18 April 2014.[123] This was another aircraft which failed Bond's periodic fuel indication test because it displayed an over-read. The Low Fuel 2 warning illuminated when the CAD displayed 43 kgs. The No 2 sensor was cleaned and refitted, and the problem resolved. On this occasion, the engineer reports positively that no contamination was found. That is of note because it means either that it is possible to have a contaminated sensor causing an over-read but on inspection (at a time when engineers know that is what they are looking for) whatever was the contaminant has been lost. Or it demonstrates that there are as yet unidentified causes for over-reading supply tank sensors other than contamination. This being an aircraft failing the monthly test, the drained fuel would have been checked for contamination. None is reported.

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[119] Meredith, Day 17, page 68, lines 19-24
[120] CP385
[121] Price, Day 15, page 109, lines 11-25
[122] Price, Day 16, page 153, line 19 to page 154, line 4
[123] CP387

[115] G-SPHU on 9 November 2014.[124] Again during Bond's periodic test, Low Fuel 1 warning illuminated when CAD displayed 46 kgs. The aircraft was defueled, and No 1 supply indication was 16 kgs when the tank was empty. The sensor was replaced.

[116] G-OMAA on 17 November 2014 and on 2 March 2015.[125] On both occasions the aircraft failed the periodic fuel system check.

[117] In November 2014, during the test a F QTY FAIL caption illuminated and No 2 supply CAD indication displayed no fuel. However, what is noteworthy is that when the aircraft was being defueled, both supply tank indications were too high when the Low Fuel warnings illuminated. In other words, it appears that the problem with No 2 supply indication changed from being that it displayed no fuel, to it displaying too much fuel. This again may illustrate that the frequency resulting from the different dielectric caused by contamination need not be at constant. Here it was initially sufficient to cause a FAIL (i.e. the frequency was so low as to be recognised as impossible by the system), yet later it was not sufficient to cause a fail and so caused an over-read.

[118] It is also of note that during the original test in November 2014, no problem was noted with No 1 indication. But during defueling (in order to fix the problem with No 2 sensor), the No 1 indication was clearly an over-read. This illustrates that an over-read can occur suddenly, and without being brought about by an emulsification event (as discussed in more detail below in relation to the accident flight). The problem was resolved by cleaning and refitting the sensors which appears to confirm contamination must have been the problem.

Fuel system issues on G-SPAO

[119] Since its delivery, G-SPAO had thrown up a variety of fuel system issues. Craig Trott described a number of these and took a particular interest in logging and investigating them. Some have been explained to his satisfaction either by the design of the fuel system or by the logic of the algorithm. But some remain unexplained.

[120] Captain Trott described an occasion in June 2011 when he landed G-SPAO at Islay.[126] There were two problems. The second problem (fuel flowing from supply to

[124] CP399
[125] CP400 and CP404

main tank in flight) was later explained by the Information Notice 2381-I-28, albeit the Notice contained an error.[127]

[121] The first problem at Islay was different. Captain Trott had shut the aircraft down with a fuel indication on the CAD of 47/145/43 kgs (No 1 supply / main / No 2 supply). G-SPAO was parked on level ground. The engines were not run for any purpose and the aircraft was not moved. Two hours later when he returned to the aircraft, the Low Fuel warning was illuminated and the fuel indication on the CAD was 27/183/23. That suggested that fuel had migrated from the supply tanks to the main tank. He confirmed that this was what had happened by switching on the transfer pumps, which replenished the supply tanks. However, the supply tanks never reached capacity (landing with indication of 43/44/37 kgs). Captain Trott confirmed that what happened and why it happened has never been explained.[128]

[122] On 9 October 2011, Captain Trott experienced the No 1 Fuel Quantity Fail caption for 5 seconds. Thereafter the CAD displayed as normal.[129] This was followed two days later by the No 1 Fuel Quantity Fail caption illuminating intermittently and was replaced by an engineer.[130] This is an example of an indication problem appearing intermittently.

[123] In April 2012, Captain Trott reported another intermittent fault with the CAD fuel indication. He recorded "Fuel quantity degrade plus No 1 supply tank intermittent." He explained that in relation to the No 1 supply tank fuel gauge, it altered between working properly (i.e. showing a standard fuel reading) and then not working properly (not showing a reading).[131] The problem was a faulty supply tank sensor. Again, what is of note is that the fault appeared to be intermittent, not constant.

[124] G-SPAO experienced a number of issues in 2013.

[125] On 3 July 2013, engineer William Taylor carried out a 50-hour cold compressor on G-SPAO.[132] The following day, water was found in the daily fuel check sample. It was

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[126] CP336
[127] CP472; Trott, Day 28, page 138, lines 1-4
[128] Trott, Day 28, page 136, lines 7-14
[129] CP190, page 126; Trott, Day 28, page 54, line 16 to page 55, line 9
[130] CP190, page 124
[131] CP191; Trott, Day 28, page 142, lines 11-15
[132] CP108, page 231

described as "water consisted of small milky coloured droplets and appeared to be mainly from the No.2 Engine Supply Tank".[133] The procedure for a failed fuel check was that further fuel would be drained and only when a clear sample was obtained, would the aircraft be flown.

[126] On 8 July 2013, Captain Rees recorded that on the 6th flight the aircraft's fuel contents indications were "over/under reading".[134] Supervising engineer Paul Booth removed the aft main tank fuel sensor during the early hours of 9 July 2013. He replaced it with a new sensor. He then carried out a calibration test. At that time, the fuel contents indication for the main tank continued to misread. Mr Booth suspected that the forward main tank sensor was defective. He raised a deferred defect as a replacement sensor was not available.[135] He replaced the forward main tank sensor on 11 July 2013.[136]

[127] On 30 September 2013, G-SPAO was refuelled to a CAD reading of 310 kgs in the main tank. It was left standing on level ground with engines off. About two hours later, Captain Trott discovered that the main tank reading was 295 kgs. He contacted Bond's case maintenance co-ordinator, James Remfry.[137]

[128] On 1 October 2013, Mr Remfry confirmed that two replacement main tank sensors would be ordered to Bond's main base at Staverton Airport. These were to be received within a week. Once received, a plan would be actioned to replace the faulty sensors.[138]

[129] Captain Trott confirmed that this fuel tank fluctuation had not been explained other than, in his view, there being a fuel sensor issue beginning to emerge.[139]

[130] There was no evidence led before the Inquiry indicating that the replacement sensors referred to by Mr Remfry were received at Staverton and thereafter fitted to G-SPAO.

[133] CP507, page 2, Crown NTA No1, paragraph 45
[134] CP108, page 224
[135] CP108, page 224
[136] CP108, page 222
[137] CP335, pages 3-4
[138] CP335, page 2
[139] CP335; Trott, Day 28, page 144, lines 1-5

[131] On 10 October 2013, Captain Kitchen reported that during the 4th flight of the day, the fuel indication for G-SPAO's No 1 supply tank failed. The F QTY FAIL caption also displayed. He recorded this in the tech sector log.[140] The following day, Paul Booth and Iain Taylor carried out work to resolve this fault. That included replacing No 1 supply tank sensor and the aft main tank sensor. During defueling it was noted that the No 2 supply tank sensor displayed 11 kgs when the tank was empty. No 2 sensor was removed, cleaned, dried and refitted. Thereafter the problems were resolved.[141]

[132] On 23 November 2013, Captain Trott again experienced fluctuations in the fuel indications in G-SPAO with the main tank level decreasing on take-off and in transition from hover to cruise.[142]

[133] Captain Trott considered there were two potential causes of the main tank fluctuations. One may be the pitch attitude of the aircraft at take-off. His view was, however, that this was less likely because it was not a particularly high fuel level. The other potential cause was that it was an emerging fuel sensor issue in the main tank.[143]

[134] The issue was discussed by a pilot (probably Captain Rowley) and Paul Booth, the engineer.[144]

[135] There was no reference to this issue in the tech logs for G-SPAO for the period from 23 November 2013 until the accident.[145] However, a Post-It note stating "Fuel Fluctuations" was stapled to the page for 24 November 2013 in the Glasgow City Heliport engineer's diary.[146]

[136] In the Base Maintenance Shift Supervisor's end of shift report for 27 November 2013, Mr Booth recorded that the "[f]uel contents after refuelling drops after a period of time in main tank. Main fuel probe in AOs bin when if we get time to change it".[147]

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[140] CP182, page 161
[141] CP109, pages 154-157
[142] CP108; Trott, Day 28, page 58, line 6 to page 61, line 12
[143] Trott, Day 28, page 61, line 16 to page 62, line 18 and page 148, lines 1-2
[144] Paul Booth, Day 12, page 106, lines 5-16
[145] CP182, pages 77-88
[146] CP272, page 167
[147] CP226, page 2

[137] As illustrated by G-NMID, G-POLD, G-NWEM, G-KRNW, G-SASB, main tank fluctuations often appear to precede supply tank sensor indication issues. No evidence was led before the Inquiry that following Captain Trott's report of fuel fluctuations on 23/23 November 2014 that G-SPAO's main tank fuel sensors were replaced.

29 November 2013

[138] On the day of the accident flight, Captain Young took G-SPAO to Inverness. An examination of the fuel figures on his kneeboard and in the Tech Log reveals a discrepancy in the fuel indications on the CAD when compared with the fuel dispensed and the average fuel burn.[148] The possibility of either an over or an under-read was identified from the figures themselves.[149] The readings did not concern Captain Young because he was working to a 10% tolerance at high fuel states.[150] He was unaware of the manufacturer's description of the tolerance (2% capacity and 4% actual contents).[151] Captain Young's 10% builds in a considerable margin for error and an over-read or an under-read may be masked.

[139] Captain Young suggested that the discrepancies in departure and arrival figures may be explained by manoeuvres he was carrying out, but he did not explain in any detail what those were and he was relying entirely on what he had written on his kneeboard being what was shown on the CAD.[152] Having said that, he did accept that there may in fact be discrepancies but they are within the 10% tolerance.[153]

[140] Manoeuvres would seem an unlikely explanation at least for the last flight between Inverness and Glasgow. While there was an element of that flight involving a missing person search, it can only have lasted approximately 15 minutes (the flight to Inverness took 1 hour 10 minutes; the return flight 1 hour 25 minutes). Captain Young himself noted the search concluded quickly.[154]

[141] It is possible that on the day of the accident, the CAD indications were unreliable but that this was masked by the 10% tolerance being applied.

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[148] George Young, Day 22, pages 82 to 106; CP202, page 129; CP34
[149] Day 22, page 92, lines 8-25
[150] Young, Day 22, page 93, lines 10-11
[151] Young, Day 22, page 97, line 17-25
[152] e.g. Young, Day 22, page 89, lines 4-8
[153] Young, Day 22, page 98, lines 8-17
[154] Young, Day 22, page 100, lines 16-18

[142] As has been seen in relation to other EC135s, fuel indication issues can be intermittent. It is also possible that the level of over-read is not constant.

[143] Mark Prior noted that in the month preceding the accident, there were variations in the calculated Specific Gravity which were too large to be accounted for by the fuel itself. He concluded that these variations were a symptom of errors in the fuel dispensing equipment or in G-SPAO's fuel indication system.[155]

[144] The Crown seek a finding in fact (number 45) that there was no evidence that the fuel contents display system was operating incorrectly in the lead up to the accident. That appears to be lifted from the AAIB report.[156] It is important to note, however, that Robert Vickery explained what was meant by that. It meant only that there was no evidence that during the accident flight itself, the fuel system was displaying incorrectly. He was not referring to any previous flights.[157] As can be seen from the paragraphs above, there were a number of queries as to G-SPAO's fuel contents indications in the period leading up to the date of the accident.

[145] What can be seen in the weeks preceding the accident is that there may have been errors in G-SPAO's indication system (illustrated by the variations in Specific Gravity); that there were main tank fluctuations during November 2013 which may have been the sign of a developing fuel sensor issue; that it does not appear that the main tank fuel sensors were changed prior to the accident; and that on the day of the accident, there may have been discrepancies appearing in the indications on the CAD during Young's flights. In the 125 flights preceding the accident flight, G-SPAO had not landed with less than 100 kgs on board and therefore any anomalous indications which become apparent only at low fuel states would be missed.

The accident flight

[146] As submitted above, the Inquiry should conclude that it is probable that Captain Traill was faced with CAD indications which contradicted the Low Fuel warnings, and

[155] CP1340, page 18, paragraph 6.2.2.1
[156] CP327, page 85, paragraph 2.2.6
[157] Vickery, Day 5, page 156, line 20 to page 157, line 6

which satisfied him that the warnings did not reflect a genuine emergency. That is the only sensible explanation for his and the Air Observers' conduct.

[147] The Inquiry may not be able to reach a definitive conclusion about the cause or nature of the contrary indications. But there is ample evidence to support a conclusion that the CAD indication system on EC135s with the same model of sensors as fitted to G-SPAO was unreliable and in particular that the supply tank indications were susceptible to indicating that there is more fuel available to the engines than is actually on board.

[148] As noted above, there are examples of erroneous fuel indications where contamination is not present and may not in fact be the cause.[158] An erroneous indication resulting from an as yet unidentified cause cannot be excluded.

[149] Contamination has been shown to be the cause of over-reading supply tank indications. It also appears sometimes to be the cause of issues with main tank indications. The Crown submit that the possibility of contamination has been excluded in relation to G-SPAO. That submission should not be accepted.

[150] The Crown submit that there was no evidence of water contamination from source fuel or refuelling in wet weather in relation to G-SPAO. They go on to note that the fuel samples from G-SPAO's main tank post-accident were free from contamination.[159] However the Inquiry has heard evidence that there were a number of occasions when operators had reported fuel indication issues and no fault was found with the sensor and no quantifiable contamination of the fuel was found either.[160] Further, the Inquiry has heard of fuel sources that were free of contamination, as were aircraft fuel tanks on the daily check and yet over-reads occurred.[161]

[151] As noted below in Issue 6(i), the engine washing regime enables water to enter the fuel system. This is avoided where a "hot" wash is done (i.e. with engines running). Water ingress has been proven to occur during the 50-hour chemical clean and during a daily "cold" wash. On 29 November 2013, engineers commenced, then aborted the 50-

[158] See in particular G-HWAA
[159] Crown submissions, paragraph 4.9.6 and 4.9.7
[160] Robert Vickery, inter alia, Day 5, page 120, lines 13-18
[161] See above re aircraft which failed the Bond monthly fuel system indication test

hour chemical clean. They replaced it with a cold wash because the aircraft was required for a task.[162]

[152] The question arises why Captain Young did not experience any faulty indications on the CAD. As noted above, it is possible that he did but these were masked by the tolerance he applied.

[153] Even if there were no discrepancies, the evidence demonstrates that there can be a gap of time between a cold wash being carried out and water entering the fuel system and/or that the problem of an over-read can arise without there having been a wash prior to flight. Examples include G-POLD (18 March 2018) and G-SPAO in July 2013. It was further noted in G-POLD that water could appear in a fuel sample 24-48 hours after a cold wash (including still in an emulsified form), in spite of the fact that it is thought that the aircraft had been flying in between.[163] In G-DORS, the chemical wash had been carried out 4 days before emulsified water/fuel was discovered in the daily fuel check.[164]

[154] It has been suggested that in order for a sensor to become contaminated with water, water must become emulsified. It should be noted that it has not been suggested that this is the only mechanism. The manufacturer claims that the tests show that emulsification occurs by the water being agitated through the transfer pumps. The tests could not replicate the significant vibration of a helicopter in flight and therefore it cannot be excluded that vibration could also agitate fluid sufficient to cause an emulsion.

[155] It was conceded that water can enter the system in an already emulsified state.[165] Mr Mendick also conceded that he cannot completely rule out that water not in an emulsified form may enter the sensor.[166] G-OMAA in November 2014, is an example of an over-read in a supply tank sensor which occurs without an "emulsification event" such as fuel being pumped through the transfer pumps from the main to supply tanks.[167]

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[162] Taylor, Day 18, page 74, lines 5-24
[163] Mortimore, Day 26, pages 144 line 22 to page 145, line 24
[164] CP504; David Price, Day 16, page 77, lines 12-18
[165] Mendick, Day 9, page 109, line 9 to page 110, line 6
[166] Mendick, Day 9, page 111, line 23 to page 112, line 11
[167] See above with reference to CP400

[156] It is submitted by the Crown that the evidence shows that emulsification would result in the water being circulated around the whole of the fuel system. That is contradicted by, for example, G-DORS.[168]

[157] The AAIB consider that unless there is constant agitation, water will precipitate out of the emulsion and be discoverable in the fuel/fuel tanks.[169] The Crown rely on that evidence.[170] But Mr Vickery's evidence is contradicted by the findings in relation to G-NWEM (Barton). There, the conclusion was that water had entered the sensor and caused an over-read. Yet the fuel drained from the aircraft was tested for water and none was detected. Thereafter, the aircraft was allowed to stand to permit any small globules of water to run down into the sump, along with remaining fuel clinging to the sides of the tank. The sumps were drained and 100 mls removed. That was tested for water and there was none. The "precipitation" theory that water will be found around the bottom of the tank is disproved by G-NWEM.

[158] That water would precipitate out of an emulsion shortly after the agitation stops is also contradicted by the experience with G-SPAO in July 2013. A 50-hour chemical clean took place on 3 July 2013. On 4 July during Check A – which is carried out prior to any flight and therefore after the aircraft has been standing – milky coloured droplets were found in the fuel sample, mainly from No 2 supply tank.[171]

[159] Similarly, with G-DORS[172], the aircraft had been standing overnight before the daily fuel check was done, which dispensed emulsified liquid.[173]

[160] The accident pre-dated the incident with G-NWEM and as Mr Vickery conceded, at the time of their initial investigations into the crash, the AAIB did not know that they should be looking for water.[174] The sensors were only removed from G-SPAO once it had been lifted from the Clutha, the fuel drained, and thereafter placed on a lorry and transported to Farnborough. The sensors were removed into a tray containing absorbent paper towels.[175] They were tested in a plastic tray after removal.[176]

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[168] Referred to above; CP378
[169] Robert Vickery, Day 5, page 181, line 21 to page 182, line 7
[170] Crown submissions, paragraph 4.9.9
[171] CP507, page 2; Crown NTA No 1, paragraph 45
[172] CP504
[173] David Price, Day 16, page 76, lines 13-20
[174] Vickery, Day 5, page 151, lines 17-19
[175] Vickery, Day 5, page139, lines 1-5

[161] The test of the sensors was not conducted until during 2014. They had not been stored in a condition to preserve any water, which would have dried out.[177] In any event, there have been other occasions described where a sensor has been misreading and when removed is dry and on testing behaves normally, for example G-NWEM. That was the experience of the operator across the board.[178]

[162] The AAIB Chief Investigator, Robert Vickery, conceded that it was possible that there may have been water within the sensors during the accident flight and that it exited the sensor during the crash or subsequent recovery and transport and was lost.[179] As an engineer, Stuart Weir, acknowledged, even when everyone knew to be looking for water contamination, it is extremely difficult, if not impossible to find.[180]

[163] In their submissions, the Crown suggest that contamination in G-SPAO can be ruled out in part because on examination, there was no evidence of corrosion or pitting of the sensors such as to suggest a build up of contamination.[181] While the presence of pitting may indicate contamination, there was no evidence of such defects in relation to the sensors in G-POLD yet the sensors were behaving as if contaminated.[182]

[164] The tanks were not swabbed for water.[183] Mr Vickery said that there were no water globules seen in the tank of G-SPAO when it was examined at Farnborough. This was a visual observation by him and others. However it appears that the knowledge of what water in the tank may look like (i.e. that it would be little globules on the side of the tank) only appears to have been gained later when he attended the rig tests at the manufacturer's site.[184] In addition, during the tests after Barton, G-NWEM was left to stand to allow any such tiny water globules to run down the sides of the tank along with any remaining fuel. The tanks were then drained entirely, and no water was found.

[165] The conclusion of the manufacturer that the sensors on G-SPAO were not contaminated, spoken to by Mr Mendick, is predicated upon the AAIB having definitively

[176] Vickery, Day 5, page147, lines 10-18
[177] Vickery, Day 5, page 150, line 24 to page 151, line 8
[178] Vickery, Day 5, page 153, lines 4-13 and line 22 to page 154, line 1
[179] Vickery, Day 5, page 151, lines 20-24
[180] Stuart Weir, Day 21, page 73, lines 13-21
[181] Crown submissions, paragraph 4.9.10 with reference to CP863
[182] NTA for Dr Thomas, paragraph 9
[183] Vickery, Day 5, page 142, lines 20-25
[184] Vickery, Day 5, page 61, lines 8-11 and page 62, lines 18-24

ruled out the presence of any water in the fuel system.[185] Such a definitive conclusion simply cannot be drawn based on the AAIB's investigation and what is known about incidents on other aircraft. It should be noted that the AAIB do not appear to have had the benefit of the evidence concerning fuel indication issues on aircraft other than G-NWEM. In particular, there is no suggestion that they were aware of the detail of G-NMID and G-POLD.

[166] Fuel calculations have been carried out in relation to the accident flight. It appears that G-SPAO likely had on board approximately the quantity of fuel displayed on the CAD at the start of the flight. That is in contrast to G-NWEM (Barton) and G-POLD (March 2018) where it was established that there had been less fuel on board than originally thought based on the CAD readings.

[167] If the calculations are correct (bearing in mind Captain Trott's evidence that a pilot may get a greater endurance from a fuel load of 400 kgs when he is engaged in low power orbits for a period)[186], then the water must have begun to affect the sensor only during the accident flight. That does not preclude the possibility that water was already present in the sensor – as noted above, an over-read may be masked by the tolerance of the gauge or the tolerance applied by the pilots. It is clear, in any event, that only one or two droplets or water may be required for an over-read.[187]

[168] Holger Mendick suggested that in order for contamination to occur in a single flight, there would have to be a significant amount of water. He distinguished G-NWEM on the basis that it had a cumulative build-up of contamination over days, weeks or months. But he also stated that such a build up of contamination would leave traces of water in the tanks more generally.[188] Yet, as can be seen from the test of G-NWEM's decanted fuel, that is not necessarily so. The same can be seen in respect of those aircraft failing the Bond monthly test.

[169] It was noted by the AAIB that water entering the fuel system after a cold wash seemed to happen after a few flying hours. It was noted that the in service experience

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[185] Mendick, Day 7, page 95, line 18 to page 97, line 7and Day 8, page 105, line 6 to page, 106, line 1; CP 748, page 4
[186] Trott, Day 28, page 126, lines 18-22
[187] CP227, page 1
[188] Mendick, Day 8, page 34, lines 8-17

was that this phenomenon was random and could not be predicted.[189] Thus, the possibility of water from the cold wash carried out on the morning of 29 November entering the system after a few hours (in other words during the accident flight rather than Captain Young's sorties) cannot be excluded.

[170] The Inquiry should conclude that it is probable that Captain Traill was confronted with misleading CAD indications and that the likely cause was contamination or some other unidentified cause.

Were the root causes adequately investigated and acted on prior to the accident?

[171] Prior to the accident, in spite of being aware of numerous fuel sensor indication issues, including over-reads caused by contamination, the manufacturer had no mandated procedure for testing the integrity of the fuel system on a periodic basis. Bond created their own following Barton/G-SPAO.[190] Thus developing contamination issues could go undiscovered with over-reads being masked within the tolerance of the gauge.

[172] The manufacturer knew, at least at January 2013, that water could become trapped in the fuel sensors, causing either a sensor fail/degrade or an over-read. It was not until after the accident and the Barton incident that the manufacturer took steps to modify the sensor to prevent water becoming trapped. As further discussed under Issue 6(i) below, no good reason was presented as to why the manufacturer failed to address the sensor design issue and chose instead only to investigate the water ingress issue. The manufacturer also failed to take sufficient steps to prevent or mitigate water ingress prior to the accident.

[173] The issues identified with the fuel indication system have not been resolved. Captain Mortimore, now Head of the National Police Air Service, testified that he relies more on "dead reckoning" and timing than he used to. He remains concerned by the behaviour of the fuel indication gauges at lower fuel levels.[191] He and other pilots stated that such explanations as had been provided by the manufacturer had not explained all of the spurious fuel indications they had experienced.[192] Captain Mortimore described

[189] CP327, page 68, paragraph 1.16.3
[190] Price, Day 16, page 73, lines 17-23
[191] Day 26, page 131, lines 19-25
[192] Mortimore, Day 26, page 125, line 23 to page 124, line 3; see references to Trott's evidence above re G-SPAO and G-SASB

the fuel indication numbers on the EC135 as "jumping around". He noted that as recently as the week prior to his testimony, from the top of a descent in flight to ground, the fuel indication dropped from 90 kgs in the main tank to 7 kgs over a space of approximately 4 minutes.[193]

[174] The Inquiry should conclude that the fuel indication system of EC135s fitted with the fuel sensors of the type in G-SPAO is unreliable particularly in lower fuel states. The Inquiry should further conclude that prior to the accident insufficient steps were taken by the manufacturer to investigate and act on the root causes of erroneous fuel indications.

Issue 4(xiv): Why autorotation, flare recovery and landing were not completed successfully

[175] Dr Thomas does not challenge the description given of autorotation at paragraphs 4.14.1 to 4.14.3 of the Crown's submissions.

[176] However, she does challenge paragraph 4.14.4 of the Crown's submissions; that there is no reason in principle why the helicopter could not at least enter autorotation. The implication is that the pilot ought to have been able to sustain autorotation and successfully land the aircraft. Dr Thomas disagrees for the following reasons.

[177] Captain Traill was faced with a very short period of time within which to react. First, the time between engine flameouts was dramatically reduced from anything that a pilot may have expected. Second, when the second engine flamed out, he had only one to two seconds to react.

[178] G-SPAO's second engine flamed out at approximately 22:22:16. At that time the aircraft was flying at approximately 610 ft.[194] An EC135 has a normal rate of descent of around 2,000ft per minute in a stable autorotation.[195] That rate of descent is higher where a stable autorotation is not able to be maintained.[196] The rate of descent provided Captain Traill with approximately 8 seconds[197] to react to the second engine flameout,

[193] Day 26, page 134, lines 17-22
[194] CP327, page 50, paragraph 1.11.8.1, fig 9
[195] CP327, page 79, paragraph 1.17.3.2
[196] Marcus Cook, Day 3, page 110, lines 20 to 22
[197] CP 327, page 92, para 2.1.5

establish a stable autorotation and successfully land the aircraft. He had to do this while also managing a high stress and workload situation in circumstances where several audio and visual warnings are activated in the cockpit and both he and his air observers are likely to be have been shocked.

[179] The manoeuvrability of the aircraft is limited in the event of double engine flameout. Captain Traill could only direct the aircraft to landing sites within approximately 5 to 20 degrees of either side of its nose.[198] The aircraft was over an urban area. It could not be manoeuvred to open ground. Within his limited scope for manoeuvre, Captain Traill had to identify a landing site clear of buildings, overhead wires, road vehicles, street furniture and other obstacles.

[180] It was night. The landing light and RADALT were without power. The location of the SHED BUS switch may have contributed to this. In any event, the RADALT would be of limited use given the variability in height of what was below the aircraft. In such conditions estimating closure rates and altitudes is very difficult.[199]

[181] Captain Traill would be attempting to enter autorotation at a height of which he had no prior experience of in real life or training (autorotation training is discussed further below at paragraphs [225] – [226]).

[182] In order for an autorotation to be successful, it is critical for the pilot to lower the collective within one to two seconds of engine failure.[200]

[183] Captain Nater advised of a further type of autorotation, known as constant altitude autorotation. This is taught by the RAF.[201] Where this is attempted, the pilot has only one chance to pull the collective lever upwards to adjust the sink rate and cushion the aircraft for landing.[202]

[184] A successful sustained autorotation also involves flaring the aircraft. This can serve two broad purposes. First, to try to sustain the autorotation during the initial descent. Flaring the aircraft can recover rotor rpm where this has dropped and bring the

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[198] Rooney, Day 25, page 165, lines 19-25; Prior, Day 30, page 121, line 25
[199] Nater, Day 9, page 182, lines 10-20.
[200] Cook, Day 2, page 151, lines 11-21
[201] Nater, Day 9, page 181, line 10 to page 181, line 23
[202] Nater, Day 9, page 208, lines 6-8

aircraft's speed back to that which is required for autorotation. Second, to cushion the aircraft before landing.[203]

[185] The evidence recovered from the aircraft's NVM shows that Captain Traill was able to recover G-SPAO's rotor rpm to a sufficient level for the relevant warning to extinguish on two occasions.[204] This was despite the significant limitations he faced. This demonstrates that Captain Traill was attempting to enter or manage autorotation.[205] There was evidence that a flare manoeuvre was attempted. This was either an attempt to increase rotor RPM for a third time, or an attempt to cushion the landing. Either way, Captain Traill was clearly doing his best to save the aircraft and its occupants.

[186] Unfortunately, Captain Traill was unable to sustain the required rotor speed. This resulted in the manoeuvre's failure. Given the factors outlined above, the Inquiry should find that it is highly improbable that any pilot would have been able to enter a sustained autorotation and successfully land the aircraft in the circumstances in which Captain Traill found himself when the second engine flamed out.

[187] When Captain Nater was asked for his opinion as to whether a pilot could successfully complete an autorotation landing in the circumstances that Captain Traill found himself, he took the view that without a clear space immediately in front of them, the aircraft and its crew were "doomed".[206]

Issue 4(xv): Whether the ability to carry out autorotation, flare recovery and landing was compromised by the design of the cockpit layout

[188] The location of the SHED BUS switch may have contributed to the unavailability of the landing light as it is hard to locate.[207]

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[203] Cook, Day 3, page 111, lines 12–19, Prior Day 30, page 119, line 18 to page 120, line 19
[204] CP327, paragraph 2.1.5
[205] Cook, Day 3, page 112, lines 20-21; Prior, Day 30, page 123, lines 8-13
[206] Nater, Day 9, page 183, lines 1-20.
[207] CP327, page 87, paragraph 2.1.1

Issue 5(ii) and (iii): The precautions, if any, which could reasonably have been taken, and which, had they been taken, might realistically have resulted in the helicopter crash being avoided, including whether the crash might realistically have been avoided:

[189] The Test Fuchs pumps were designed such that running dry did not degrade the pump.[208] There was therefore no need for a pilot to turn off the transfer pumps in the event they were running dry. G-SPAO was fitted with Test Fuchs pumps. The manufacturer elected not to revise the flight manual or the pilot's checklist and therefore the instruction to pilots remained that in the event of a fuel pump caution caused by the pump running dry, the relevant transfer pump should be switched off. This leaves open the possibility of error by a pilot forgetting to turn the transfer pump back on as Captain Andrew Rooney admitted he had himself done.[209] If the Inquiry concludes that failure to turn the transfer pumps back on contributed to the accident, the Inquiry should also find first, that turning the pumps off was unnecessary; second, that Captain Traill was unaware of that (as were all pilots); third, that it would have been possible for the manufacturer to make a modification to stop the caution illuminating when the pumps ran dry due to lack of fuel.[210] Alternatively the Inquiry should find that the absence of a further alert to the pilot that the transfer pumps which had been turned off were re-immersed in fuel and could be turned back on contributed to the accident.[211]

Issue 6(i): Whether any aspect of the system of maintenance of G-SPAO, including its washing regime, contributed to the contamination of the fuel and/or fuel tank system with water

[190] The most likely but not the only possible reason for Captain Traill to have been presented with an over-reading fuel indication on the CAD is the presence of water in the aircraft's fuel sensors.

[208] Mendick, Day 7, page 98, lines 8-12
[209] Rooney, Day 25, page 61, line 10 to page 63 line 12
[210] Mendick, Day 8, page 157, lines 3-7
[211] Vickery, Day 5, page 97, lines 6-13

[191] The likely source of such water is the EC135's fuel return and vent line system. The purpose of this system is to return unused and unwanted fuel and fluids from the engine to the aircraft's fuel tanks.[212]

[192] This system connects the engine drain collector tank with the combustion chamber for the aircraft's engines. The unused and unwanted fluids from the combustion chamber are initially drained into the collector tank. Once this is filled sufficiently, the fluids travel through the piping of the fuel return and vent line system to the aircraft's expansion tank.

[193] The expansion tank is connected to the aircraft's fuel tanks by two pipes. The forward pipe leads to the main tank, the aft pipe leads to the No 2 supply tank. The attitude of the aircraft determines the section of the aircraft's fuel tank that any fluid escaping from the expansion tank flows to. If the aircraft had a nose up attitude (e.g. a 3.5 degree nose-up attitude when it is standing on the ground), the water would flow into the No 2 supply tank. In a level or nose-down attitude, it would flow the main tank.[213]

[194] The main cause of water entering this system is as a result of the 50 hour 'cold' compressor wash regime. Such a wash was attempted on the date of the accident flight but was not completed. This resulted in a 'cold' daily wash being carried out.[214]

[195] The presence of water in an aircraft's fuel tank is not unusual.[215] To test for its presence in its fleet of EC135s, Bond pilots would take samples of fuel from each of the aircraft's fuel tanks. These are first visually checked before a Shell water capsule is added.

[196] Such tests were carried out once a day, typically before the first flight. This testing tended to take place before a 'cold' compressor wash was carried out. Thus, where water or a water/cleaning solution mix entered an EC135's main or No 2 supply tank *immediately* after a cold compressor wash, this would not be picked up by the daily water testing regime.

[212] Vickery, Day 4, page 155, line 12 to page 156, line 18
[213] Mendick, Day 8, page 15, lines 12-21
[214] Taylor, Day 18, page 74, lines 5-24
[215] Vickery, Day 5, page 141, lines 7-12

[197] However, given that water within an EC135's expansion tank could transfer into its fuel tank at any time, it is not submitted that Bond's water testing regime contributed to the accident occurring.

[198] Due to the number of mechanisms through which water could enter the EC135s fuel system, the risk of water entering the fuel probes could never be eradicated. However, with specific reference to water entering the fuel system via the fuel return and vent line system, Bond's Head of Engineering, David Price, took significant steps to draw this risk to the attention of the manufacturer and seek a permanent solution.

[199] Mr Price's efforts commenced in 2003.[216] They were ongoing at the time of the accident and continued afterwards.[217] He instituted maintenance protocols with Bond during May 2013 that sought to eliminate the transfer of water into the EC135s fuel system[218] He pressed the manufacturer to provide a permanent fix which they failed to implement. Indeed, the manufacturer proposed that Bond, rather than themselves, should implement a fix.[219] This seems surprising given that the responsibility was on the manufacturer, as the EC135s type certificate holder, to ensure the ultimate airworthiness of the EC135.[220]

[200] During October 2007, Captain Mortimore delivered his PowerPoint presentation to the Police Eurocopter Users Group ("PEUG") regarding G-NMID's fuel system over-reading in August of that year.[221] This was raised with the manufacturer's representatives.[222] They noted that the problem was caused by environmental debris in the fuel system and that there had been two or three other instances fleet wide.[223]

[201] In 2009 the manufacturer was aware that the EC135s fuel indication system was producing over-readings. At that time, they believed the reason was that fuel was getting trapped in the sensors.[224]

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216 CP419, pages 3-4
217 E.g. CP419, CP431, CP433, CP442, CP451, CP452
218 CP263
219 CP433; CP452
220 Price, Day 15, page 74, line 18 to page 76, line 20 and page 87, line 19 to page 90, line 19
221 CP1376; Mortimore, Day 26, page 66, lines 6 to 7 and page 71, lines 18-24
222 Mortimore, Day 26, page 72, lines 10-23
223 CP830, pages 10-11; Mortimore, Day 26, page 73, line 24 to page 74, line 6
224 Mendick, Day 9, lines 8 to 15

[202] On 19 April 2012, Captain Mortimore delivered a further a further PowerPoint presentation to PEUG regarding G-NMID's fuel indication issues in January and February 2012.[225] Representatives of the manufacturer were present at that time and Captain Mortimore provided them with a copy of his presentation.[226]

[203] On 21 January 2013 the manufacturer released Information Notice No 2535-I-28.[227] This confirmed that water in the EC135s fuel system could cause either:

a. A F QTY DEG or F QGT FAIL caption to display; or
b. A fuel indication to over-read.

[204] Given the efforts taken by Mr Price and Captain Mortimore to highlight their concerns and the manufacturer's state of knowledge about the risk posed by water ingress into the EC135's fuel system by 21 January 2013, one might have expected the manufacturer to consider there was a flight safety issue.

[205] A reliable indication of fuel level and endurance is an essential piece of information to the pilot. Asked why, at the point in January 2013 when the manufacturer had realised the effect of water in the sensor, they did not begin to look at modifying the sensor, Holger Mendick's response was, "Why should we change a state of the art product which has no problem on 90-95% or even more of our helicopters […]"[228] This arguably reflects a degree of complacency on the part of the manufacturer prior to this fatal accident and the Barton incident.

[206] Due to the inability to identify a mechanical resolution to the water ingress issue, Bond obtained a concession from SAFRAN to only carry out 'hot' washes of the engines.[229] However, despite this and the investigations and modifications implemented by the manufacturer following the accident, during 2018 water was still being found in the fuel tanks of Babcock operated EC135s.[230]

[207] Had the water ingress issue been properly and timeously investigated by the manufacturer when they were first advised of it by Mr Price, it is likely that Bond may

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[225] CP531 and CP835
[226] Mortimore, Day 26, page 90, lines 4-22
[227] CP227
[228] Mendick, Day 9, page 100, lines 9-12
[229] Babcock Production 21; Price, Day 16 page 4, line 16 to page 9, line 14
[230] For example, CP1076 and Remfry, Day 20, page 79, line 7 to page 82, line 1

have changed their washing regime sooner. Whilst it cannot be said that this would have eliminated the risk of water ingress into the aircraft's fuel system, it would have significantly reduced it.

[208] In the circumstances, the Inquiry should find that the carrying out of 'cold' compressor washes contributed to the accident occurring as a result of the manufacturer's failure to thoroughly and timeously investigate the causes of water ingress into the EC135s fuel system via the fuel return and vent lines along with the manufacturer's failure to take steps to modify the fuel sensors once it was known that water was becoming trapped.

Issue 6(iii): Whether any aspect of the training of the pilots, in particular with regard to fuelling, pre-flight checks, the pilot handover procedure, the operation of the fuel contents indication system, erroneous fuel indications, the appropriate response to fuel cautions and warning, and the execution of an autorotation at night contributed to the accident occurring

[209] Dr Thomas' submission on this issue is made in three parts.

Training regarding the EC135 fuel system, fuel cautions and fuel warnings

[210] Dr Thomas adopts the submissions made by the Crown at paragraphs 6.3.1 to 6.3.5 and provides the following additional comments.

[211] Bond's EC135 Type Rating Training programme completed by Captain Traill is described in the BALPA Notice to Admit.[231] A 45-minute training session was dedicated to the EC135s fuel system. This included cautions and warnings relating to the fuel system.[232]

[212] During such type rating training, pilots were directed to the type's Flight Manual. Paragraph 7.6.3 of the Flight Manual deals with LOW FUEL 1/2 warnings. As at the date of the accident, that section did not record the independence of the fuel caution and fuel warning systems.[233]

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[231] BALPA Notice to Admit, paragraphs 3z – 3cc
[232] BALPA Notice to Admit, paragraph 3aa
[233] CP214, page 515

[213] Pilots are also supplied with and directed to the EC135 Pilot's Checklist. This incorporates the Flight Reference Cards ("FRC"). The FRCs provide instructions to pilots about how to respond to cautions and warnings in flight. Those instructions can include memory items.

[214] As at the date of the accident, the FRC relating to LOW FUEL warnings did not indicate that Low Fuel warnings took priority over the CAD fuel quantity indication.[234]

[215] As is recorded in the AAIB report[235], the aircraft maintenance manual ("AMM") for the EC135 incorrectly recorded that the flameout time between the No 2 and No 1 engine was three to four minutes. While the AMM is primarily for the use of engineers, the flameout timing detailed therein may have been passed on to pilots.

[216] Captain Mortimore was trained by Captain Laird of McAlpine Helicopters Limited. McAlpine Helicopters subsequently became Eurocopter UK Limited. Captain Laird advised Captain Mortimore during his EC135 type rating training that the time between engine flameouts was three to four minutes. Captain Laird added however, that he would be expect the pilot to land within two minutes.[236]

[217] The three minute timeframe was also spoken to by Captain Rooney.[237] However, Captain Trott was advised in training that the difference in flameout times was two minutes.[238]

[218] Therefore, while the information passed to pilots appears to have been inconsistent, it is always greater than the 32 seconds between engine flameouts which occurred during the accident flight.

[219] During their Licence Proficiency Check ("LPC") and Operators Proficiency Check ("OPC"), pilots would be trained in potential emergencies in the simulator. They could also be asked questions in relation to the operation of the EC135 systems, including the fuel system. There is no evidence to suggest that Captain Traill was assessed in relation

[234] CP212, page 226
[235] CP327, paragraphs 1.17.3.3, 2.1.5 and 2.1.5.1
[236] Mortimore, Day 26, page 148, line 22 to page 149, line 11 and page 150, line 25 to page 151, line 6
[237] Rooney, Day 25, page 116, line 23 to page 117, line 5
[238] Trott, Day 28, page 76, line 24 to page 78, line 5

to his response to a FUEL caution or LOW FUEL warnings during any LPC or OPC he sat between 2009 and the accident date[239].

[220] Prior to the accident, the manufacturer released the following information regarding the EC135's fuel system for pilots' information:

a. Information Notice No. 2381-I-2, dated 3 November 2011.[240] This provided information regarding the flow of fuel from the supply tank to the main tank at certain flight attitudes.
b. Information Notice No 2535-I-28, dated 21 January 2013.[241] This provided information about the effect of water ingress into the fuel system. It recorded the potential for F QTY DEDR and F QTY FAIL cautions and fuel indication overreads.

[221] Despite the release of these notices, the Inquiry heard evidence from pilots which suggested that, prior to the accident, their understanding of the independence of the fuel caution and fuel warning systems varied. Their knowledge of the possibility of contamination causing an over-read (rather than a sensor fail) also varied. What was apparent, however, was that following the accident, they all understood that the systems were separate and the significance of contamination.

[222] Following the accident (and Barton), the manufacturer has issued numerous documents to provide further or different information. This has assisted in developing pilot knowledge. In particular:

a. Safety Information Notice on 16 December 2013.[242] This explains that Low Fuel warnings are generated by a separate independent switching logic and that the warning lights operate even if the fuel gauge is inaccurate. It instructs pilots to follow the Low Fuel warning notwithstanding the fuel quantity indication.

239 See also, CP 327, page 91, para 2.1.4
240 CP472
241 CP227
242 CP249

b. Alert Service Bulletin EC135-28A-018, dated 19 December 2013.[243] This provides for a one time check of the EC135s fuel system due to the effects of fuel contamination.

c. Alert Service Bulletin EC135-28A-019, dated 19 December 2013.[244] This revised the relevant sections of the EC135 Flight Manual by confirming that the fuel warning system overrules the fuel quantity indication system.

d. Information Notice No. 2693-I-28, Revision 0, dated 5 March 2014.[245] This detailed the logic of the fuel supply indication for EC135s main and supply tanks. This includes confirmation that the fuel in the headroom above the supply tanks is apportioned to the main tank indication and the impact of the aircraft's attitude on this indication.

e. Information Notice No. 2693-I-28, Revision 1, dated 18 January 2018.[246] This clarified and supplemented the information provided regarding the logic of the fuel indication system given in the original version of this Information Notice.

[223] Until this documentation was released by the manufacturer, the training and information provided by operators to pilots regarding the operation of the fuel system gave them an incomplete understanding of how it operated and how erroneous fuel indications and fluctuating fuel indications could be caused.

Pre – flight checks

[224] Pilots employed by Bond were also trained to carry out water contamination checks of the EC135's fuel tanks as part of their daily check procedure. Such checks would typically be carried out before any daily wash was completed.

[243] CP110
[244] CP111; CP468
[245] CP466
[246] CP867

Autorotation training

[225] Captain Traill received annual autorotation training in an aircraft as part of his LPC. He also received six monthly autorotation training in a simulator as part of his OPC.

[226] Whether in the aircraft or the simulator, the autorotation manoeuvre would be commenced between 1,500 to 2,000ft. The manoeuvre would be stopped in the aircraft at approximately 1,000ft for safety reasons. Autorotation would be carried out to the ground in the simulator. However, Captain Nater recorded that the final part of a simulated autorotation was unrealistic.[247]

Contribution of pilot training to the accident occurring

[227] It is not submitted that the training Captain Traill received in relation to pre-flight checks contributed to the accident. Further, for the reasons set out at paragraphs [176] to [187] above, it is not suggested that the autorotation training received by Captain Traill contributed to the accident occurring.

[228] On the basis that it is probable that the fuel indication displayed to Captain Traill was over-reading, the Inquiry should find that accident could have been avoided had the information and training given to pilots relating to the operation of the aircraft made clear that:

a. The fuel caution and fuel warning systems were entirely independent and did not operate on the same systems; and
b. That the fuel warning system took priority over the fuel caution system.

[229] Had this been made clear to Captain Traill, it is likely that his initial reaction on receiving a fuel warning would have been to land the helicopter at Glasgow City Heliport. It is likely that this course of action would have been supported by the observers.

[230] It is not thought that any other element of pilot training relating contributed to the accident occurring.

[247] Nater, Day 9, page 205, line 19 to page 206, line 5

PROPOSED FINDINGS IN FACT

[231] In part II of its submission, the Crown set out proposed findings in fact. This section discusses only those proposed Crown findings with which Dr Thomas disagrees or proposes are amended or supplemented. Thereafter, Dr Thomas sets out additional proposed findings.

AAIB Findings

[232] The Crown propose that the Inquiry adopt all the findings, causal and contributory factors identified in the conclusions to the AAIB report.[248] In relation to the AAIB findings, Dr Thomas makes the following submission:

[233] AAIB finding 6: should be amended to read "The absence of recovered data from the CAD means that it cannot be established what was displayed on the fuel contents display system."

[234] Thereafter the Inquiry should make the following additional finding: "It is probable that what was displayed on the fuel quantity indication system contradicted the Low Fuel warnings."

[235] AAIB finding 7: should be amended to read "It is not known *whether or* when the FUEL caution caption was displayed on the CAD." That this amendment was appropriate was accepted by Robert Vickery.[249]

[236] AAIB finding 24: should be amended to read "When tested, fuel samples taken from G-SPAO's *main tank* were unadulterated, free from water contamination and within specification." The appropriateness of this amendment was accepted by Mr Vickery.[250]

[248] Crown submissions, paragraph 5.
[249] Vickery Day 5, page 158, lines 17-19
[250] Vickery, Day 5, page 158 line 23 – page 159, line 5

AAIB Causal Factors

[237] AAIB Causal Factor 1: should be amended to read "73 kgs of usable fuel in the main tank became usable as a result of the fuel transfer pumps not being turned back on after the Low Fuel warnings were illuminated."[251] Thereafter the Inquiry should make a further finding that "The pilot turned off the transfer pumps in accordance with the correct procedure, having received forward and aft fuel pump cautions."

[238] AAIB Causal Factor 2: A further sentence should be added that "The pilot must have concluded that the Low Fuel warnings did not reflect a genuine emergency situation and that it was safe to continue. The Air Observers must have been satisfied with the pilot's course of action."

[239] AAIB Causal Factor 4: should be amended to read "A successful autorotation and landing was not achieved. It is highly improbable that any pilot could have successfully autorotated and landed the aircraft in the circumstances."

AAIB Contributory Factors

[240] AAIB Contributory Factor 2: should be amended to add a further sentence namely "The pilot has to switch the SHED BUS switch to EMERGENCY in order to repower the RADALT and landing light. The SHED BUS switch can be hard to locate in an emergency."

Crown's proposed findings

[241] The Crown has sought to summarise the AAIB findings between paragraph 7 and 50 of its submission.

[242] In relation to paragraph 8, in line 3, the word "successfully" should be inserted between "not" and "achieved". That is because it is clear that Captain Traill recovered rotor RPM on two occasions which means that autorotation was entered but not successfully maintained.

[251] Vickery, Day 5, page 160, lines 20-24

[243] In relation to paragraph 14, the second sentence should be amended to read "From an examination of the wreckage at the accident site, the switches for both transfer pumps were in the OFF position and must have been so before the accident, rendering usable fuel in the main tank unusable." What is critical is not how long the transfer pumps had been switched off, but rather than they were not turned on following the Low Fuel warnings.

[244] In relation to paragraph 16, delete the last sentence and substitute "Photographs taken by first responders appeared to show at least one of the prime pump switches in the OFF position. When examined by the AAIB after the accident site had been stabilised, both prime pumps switches were in the ON position. It cannot be established what position the prime pumps were in during flight."[252] That more accurately reflects the AAIB report.

[245] In relation to paragraph 20, delete "are" in line 2 and substitute "can be". If the frequency emitted is low enough, the fuel contents are not displayed at all because there is a sensor FAIL/DGR as set out in paragraph 21.

[246] In relation to paragraph 21, delete "also" in line 1.

[247] In relation to paragraph 25, delete "would" in line 1 and substitute "should".

[248] In paragraph 27, line 3, delete "dropped below" and substitute "falls within". Thereafter at the end of line 3, between "lights" and "illuminate", insert "should". At the end of the paragraph, after "set range", insert "or lower". Thereafter add the sentence "If fuel is sloshing in the tank, the thermistor may be exposed and then re-wetted (thus increasing and decreasing its temperature). This can cause the Low Fuel warning to go on and off again.

[249] In paragraph 29, at the start, delete "Firstly, the pilot was required" and substitute therefore "The first step on the checklist was'".

[250] In paragraph 32, before "Both Low fuel…", insert "Fuel calculations concluded". Thereafter delete "before the aircraft reached" and substitute "on the approach to".

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[252] CP327, page 58

[251] In paragraph 35, after "supply tank 2" and before "via", insert "or the main tank."

[252] In paragraph 37, delete "drip into" and substitute "enter the top of"[253].

[253] In relation to paragraph 38, delete the whole paragraph and substitute therefor, "Where the transfer pumps are running and fuel is being circulated around the fuel system for a sufficient period of time, emulsified fuel/water mix may spread around the entire fuel system. When water has entered the sensor, whether in an emulsified form or otherwise, it becomes trapped at the bottom of the sensor when its size and surface tension is such that it does not escape through the drain hole. One or two droplets of water are sufficient to cause the sensor to emit a frequency such that the CAD displays that there is more fuel present than is actually there (an over-read)."

[254] In relation to paragraph 39, in line 1 between "the" and "sides", insert "uninsulated".

[255] In relation to paragraph 40, line 2, delete "occasional".

[256] In relation to paragraph 41, line 1, delete "highlighted" and substitute "advised of". Thereafter in the last sentence, delete "made clear" and substitute "stated". At the end of the paragraph, add "The extent to which pilots were aware of the significance of this notice and the risk presented by an over-read varied prior to the accident."

[257] In relation to paragraph 43, line 2, delete "this was not implemented. Instead" and substitute "it was commenced but not completed. As a result,"

[258] In relation to paragraph 44, delete and substitute "The fuel drained from G-SPAO's main tank was free of contamination with water. The tank was visually examined, and no water was seen. At the time of the accident, investigators did not know to look specifically for water in the sensors and therefore no steps were taken to protect any water within the sensors during the recovery and transport of the helicopter. When the sensors were examined, it was some time after the accident and no water was found. Water would evaporate within a short period."[254]

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[253] Mendick, Day 8, page 80, line 14 to page 81, line 8

[254] Vickery, Day 5, page 27, line 19 to page 28, line 17, page 139, lines 1-5 and page 150, line 15 to page 151, line 24

[259] In relation to paragraph 45, delete and substitute "In the weeks leading up to the accident, there had been spurious fuel indications on G-SPAO in relation to the main tank. The sensors have not been replaced as had been planned."

[260] In relation to paragraph 46, line 3, delete "47 43 CAD unusable fuel" and substitute "The CAD would display the usable fuel only, namely 47/43".

[261] In relation to paragraph 48, at the end, add "Pilot knowledge as to the time between flameouts varied from being told it was 3-4 minutes to a couple of minutes."

[262] In relation to paragraph 49, at the end, add "The pilot recovered rotor speed on two occasions and carried out a flare manoeuvre. The pilot was attempting to save the aircraft and its occupants. It is highly improbable that any pilot could have successfully maintained autorotation and landed in the circumstances."

Additional proposed findings

[263] Dr Thomas submits the Inquiry should make additional findings to reflect the following:

[264] The crew of G-SPAO were experienced in their respective roles as pilot and air observers.

[265] The Air Observers had access to Airwave and VHF communications systems which enabled them to communicate with the ground (police or ATC) independently of the pilot.

[266] There were no transmissions from the aircraft during its final flight to suggest that anything out of the ordinary was taking place.

[267] The forward fuel pump cautions illuminated over Dalkeith. In response, the pilot turned off the forward transfer pump. That accords with the proper procedure where a pump has run dry due to the attitude of the aircraft.

[268] The aft fuel pump caution illuminated on the approach to Bothwell. In response the pilot turned off the aft transfer pump. That accords with the proper procedure where a pump has run dry due to the attitude of the aircraft.

[269] The type of pumps fitted to G-SPAO did not need to be turned off when they were running dry. The manufacturer had not amended the software or flight manual to reflect that. Pilots were therefore unaware that the pumps could remain on and the instructed procedure remained to turn the pumps off when a caution indicated the pump had run dry.

[270] When the Low Fuel warnings illuminated, the pilot must have had sufficient reason to consider it safe to continue.

[271] The Air Observers must have been satisfied that it was safe to continue after the Low Fuel warnings.

[272] The decision whether or not to carry out the tasks at Bothwell, Uddingston and Bargeddie was a collective one for the pilot and the observers.

[273] It is probable that the CAD gave a contradictory indication to the Low Fuel warnings, and in particular that it showed that there was fuel in the supply tanks and that they were being replenished.

[274] Where the CAD fuel contents indication is over-reading, it can appear to the pilot that fuel is being transferred from the main to the supply tanks, even though the transfer pumps are switched off.

[275] The most likely cause of an over-reading CAD display is contamination.

[276] The fuel contents indication on the CAD can also over-read or fluctuate for unknown reasons.

[277] The pilot did not sabotage the aircraft.

[278] The pilot was not engaged in deliberate risk-taking when he did not land the aircraft within 10 minutes of the Low Fuel warnings.

[279] There has been a history of anomalous fuel indications with the EC135 over many years. Some of these anomalies remain unexplained.

[280] The fuel indication system on EC135s fitted with sensors of the type in G-SPAO was and remains unreliable in low fuel states.

[281] The manufacturer had been aware that water could enter the fuel system of the EC135 through a variety of means since at least June 2003. The manufacturer has been unable to find a solution which prevents water entering the system.

[282] The manufacturer was aware of the problem of water being trapped in fuel sensors and causing an over-read by January 2013 but failed to take steps to modify the sensors until after the accident and the incident at Barton involving G-NWEM.

LEGAL FRAMEWORK

[283] In respect of the Crown's submissions as to how the Inquiry should treat the AAIB report, the following observations are made.

[284] At a preliminary stage by way of Rule 3.7 Note, Dr Thomas indicated her intention to challenge certain matters in the AAIB report. Among other matters, Dr Thomas intimated that she may challenge that there was no evidence that the fuel system in G-SPAO was indicating incorrectly in the lead up to the accident.

[285] While it is recognised that the AAIB are specialist investigators and their analysis should accordingly be given due deference, the Inquiry is not bound by or restricted to the AAIB's findings and analysis.

[286] The remarks in *R (SS for Transport) v Her Majesty's Senior Coroner for Norfolk* [2016] EWHC 2279 (Admin) cited by the Crown are obiter. They are made in the context of a judicial review considering the interpretation of an international Convention prohibiting disclosure of particular defined material and relevant domestic legislation. The coroner had ordered disclosure of material protected by the Convention and the domestic legislation. The coroner had done so in the exercise of statutory powers to require a person to produce material to her. There is no equivalent power for a sheriff in a FAI. The coroner, in so doing, was seeking to go behind the AAIB's investigations (in other words to have access to protected material considered by the AAIB to form her own view of it). That is not what is being done in this inquiry.

[287] In the present inquiry, Mr Vickery of the AAIB accepted that the conclusions in the report could and, on occasion, should be expressed differently. That entitles the Court to make different findings to the AAIB (as proposed by Dr Thomas in her rule 3.7 Note).

[288] In addition, the Inquiry has had the benefit of hearing evidence which was not apparently considered by the AAIB – in particular in relation to the history of anomalous fuel indication issues in numerous other EC135s. That evidence is potentially of assistance in seeking to determine what happened with G-SPAO, as well as in deciding whether the root causes of the accident had been properly investigated and acted upon. Such evidence was adduced (by the Crown in chief, as well as by other parties in cross)

without objection from any participant. Thus, the Crown itself introduced material which would permit the Inquiry (if it chooses to do so) to differ from or go beyond the conclusions of the AAIB.

Shelagh M McCall QC
David Adams, Advocate