



SHERIFFDOM OF GLASGOW AND STRATHKELVIN AT GLASGOW

[2019] FAI 46

GLW-B1473-18

DETERMINATION OF SHERIFF PRINCIPAL C D TURNBULL

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

into the deaths of

**GARY LOUIS ARTHUR; ANTHONY LYNDON COLLINS; JOSEPH ROBERT CUSKER;
COLIN GIBSON; ROBERT JAMES JENKINS; JOHN McGARRIGLE; SAMUEL BELL
McGHEE; KIRSTY MARY NELIS; MARK EDWARD O'PREY; and DAVID IAIN TRAILL**

30 October 2019

FINDINGS

The Sheriff Principal, having considered the information presented at the inquiry,
determines in terms of section 26 of the Inquiries into Fatal Accidents and Sudden Deaths etc
(Scotland) Act 2016 (hereinafter referred to as "the Act") that:-

F1. In terms of section 26(2)(a) of the Act:

1. Gary Louis Arthur, born 26 June 1965, who resided in Paisley, died at or
about 2222 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street,
Glasgow;

2. Anthony Lyndon Collins, born 10 October 1970, who resided in Glasgow, died at or about 2222 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow;
3. Joseph Robert Cusker, born 22 February 1954, who resided in Glasgow, died at or about 1125 hours on 12 December 2013 at Glasgow Royal Infirmary, Castle Street, Glasgow;
4. Colin Gibson, born 13 September 1980, who resided in Ayr, died at or about 2222 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow;
5. Robert James Jenkins, born 8 January 1952, who resided in East Kilbride, died at or about 2222 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow;
6. John McGarrigle, born 6 January 1955, who resided in Cumbernauld, died between at or about 2300 hours and at or about 2330 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow;
7. Samuel Bell McGhee, born 5 July 1957, who resided in Glasgow, died between at or about 2300 hours and at or about 2330 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow;
8. Kirsty Mary Nelis, born 11 October 1977, who resided in Inverkip, died at or about 2222 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow;

9. Mark Edward O'Prey, born 14 August 1969, who resided in East Kilbride, died between at or about 2300 hours on 29 November 2013 and at or about 0100 hours on 30 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow; and
 10. David Iain Traill, born 19 November 1962, who resided in Lochwinnoch, died at or about 2222 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow.
- F2. In terms of section 26(2)(b) of the Act, the accident resulting in the deaths occurred at or around 2222 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow.
- F3. In terms of section 26(2)(c) of the Act, the causes of the deaths were as follows:
1. Gary Louis Arthur died of a head injury due to an aircraft crash;
 2. Anthony Lyndon Collins died of head, neck and chest injuries due to an aircraft crash;
 3. Joseph Robert Cusker died of multiple organ failure, due to neck and chest injuries, due to an aircraft crash;
 4. Colin Gibson died of traumatic asphyxia due to an aircraft crash;
 5. Robert James Jenkins died of a head injury due to an aircraft crash;
 6. John McGarrigle died of chest injuries due to an aircraft crash;
 7. Samuel Bell McGhee died of chest injuries due to an aircraft crash;

8. Kirsty Mary Nelis died of head, neck and chest injuries due to an aircraft crash;
9. Mark Edward O'Prey died of head, neck and chest injuries due to an aircraft crash; and
10. David Iain Traill died of head, neck and chest injuries due to an aircraft crash.

F4. In terms of section 26(2)(d) of the Act, the cause of the accident resulting in the deaths was that:

1. (a) the engines of the Eurocopter Deutschland EC135 T2+ helicopter, with registration G-SPAO, owned and operated by Bond Air Services Limited, then carrying out operations on behalf of Police Scotland, flamed out sequentially while the helicopter was airborne, as a result of fuel starvation, due to depletion of the contents of the supply tank; and (b) and the said David Iain Traill was unable to successfully perform an autorotation and landing of the helicopter.
2. the contents of the supply tanks depleted due to the failure of the pilot of the helicopter, the said David Iain Traill, to ensure that at least one of the helicopter's fuel transfer pump switches was set to ON.

F5. In terms of section 26(2)(e) of the Act, precautions which (i) could reasonably have been taken; and (ii) had they been taken, might realistically have resulted in the accident resulting in the deaths, and therefore the deaths, being avoided would have been:

1. for the pilot of the helicopter, the said David Iain Traill, to have followed the procedure set down in the Pilot's Checklist – Emergency and Malfunction Procedures in respect of the LOW FUEL 1 and / or LOW FUEL 2 warnings; and

2. for Airbus Helicopters Deutschland GmbH to have included within the fuel contents indication system a warning and associated aural attention-getter which activated where both fuel transfer pumps had been switched OFF.

F6. In terms of section 26(2)(f) of the Act, there were no defects in any system of working which contributed to the deaths.

F7. In terms of section 26(2)(g) of the Act, the other facts which are relevant to the circumstances of the deaths are as follows:

1. The quantities of fuel displayed on the fuel quantity indication system of the helicopter contradicted the LOW FUEL warnings.

RECOMMENDATIONS

The Sheriff Principal, having considered the information presented at the inquiry, makes no recommendations in terms of 26(1)(b) of the Act.

NOTE

1. Introduction and Contents

[1] At 2222 hours on 29 November 2013, a Eurocopter Deutschland EC135 T2+ helicopter, with registration G-SPAO, owned and operated by Bond Air Services Limited, then carrying out operations on behalf of Police Scotland (which I refer to in this determination as “G-SPAO”), descended at a high rate onto the roof of a public house, the Clutha Vaults, Stockwell Street, Glasgow (which I refer to in this determination as “The Clutha”) causing the roof to collapse.

[2] As a consequence of this accident, the pilot and two police air observers on board G-SPAO and seven customers within The Clutha died. The ten people who died were Gordon Louis Arthur; Anthony Lyndon Collins; Joseph Robert Cusker; Colin Gibson; Robert James Jenkins; John McGarrigle; Samuel Bell McGhee; Kirsty Mary Nelis; Mark Edward O’Prey; and David Iain Traill.

[3] This determination follows an inquiry into the circumstances of those deaths, held under the provisions of the Act. It is made up of 27 parts and four appendices, namely:

1.	Introduction and Contents	paragraphs	[1] – [3]
2.	The Legal Framework	paragraphs	[4] – [11]
3.	Participants and Representation	paragraphs	[12] – [22]
4.	The Inquiry Process	paragraphs	[23] – [30]
5.	The Issues	paragraphs	[31] – [35]
6.	G-SPAO	paragraphs	[36] – [42]

7.	The Final Flight	paragraphs	[43] – [62]
8.	The Times and Causes of the Deaths		
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	Gary Louis Arthur	paragraphs	[66] – [70]
	Antony Lyndon Collins	paragraphs	[71] – [77]
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	John McGarrigle	paragraphs	[93] – [97]
	Samuel Bell McGhee	paragraphs	[98] – [102]
	Kirsty Mary Nelis	paragraphs	[103] – [109]
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9.	The AAIB Report	paragraphs	[125] – [133]
10.	The AAIB’s Conclusions:		
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	Contributory Factors	paragraph	[138]
	Findings in Fact	paragraphs	[139] – [142]
11.	The Cause of the Accident Resulting in the Deaths	paragraphs	[143] – [147]

12.	The Fuel System:		
	Introduction	paragraph	[148]
	Fuel Tank Arrangement	paragraphs	[149] – [154]
	Fuel Transfer	paragraphs	[155] – [163]
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	Fuel Contents Gauges	paragraphs	[167] – [173]
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13.	Captain Traill’s Relevant Training and Knowledge	paragraphs	[181] – [202]
14.	Why Were G-SPAO’s Fuel Transfer Pumps Switched Off?	paragraphs	[203] – [225]
15.	Pilot’s Checklist – Emergency and Malfunction Procedures	paragraphs	[226] – [230]
16.	Low Fuel Warnings and Related Issues	paragraphs	[231] – [268]
17.	Did Captain Traill Believe He Had Switched The Fuel Transfer Pumps Back On?	paragraphs	[269] – [276]
18.	Erroneous Fuel Indications		
	Introduction	paragraphs	[277] – [280]
	G-NWEM	paragraphs	[281] – [282]
	G-POLD	paragraphs	[283] – [292]
	Discussion	paragraphs	[293] – [319]
19.	Did the CAD Fail Prior to the Accident	paragraphs	[320] – [321]
20.	Engine Flame Out Issues	paragraphs	[322] – [330]

21.	Autorotation	paragraphs	[331] – [339]
22.	Reasonable Precautions	paragraphs	[340] – [387]
23.	Defects in any System of Working	paragraphs	[388] – [411]
24.	Other Relevant Facts	paragraphs	[412] – [444]
25.	Recommendations	paragraphs	[445] – [471]
26.	The Time Taken to Hold This Inquiry	paragraphs	[472] – [511]
27.	Conclusion	paragraphs	[512] – [515]

Appendices

1. List of Witnesses
2. The Issues
3. Overview of G-SPAO's Final Flight Path
4. Extracts From The Pilot's Checklist - Emergency and Malfunction Procedures

2. The Legal Framework

[4] Fatal accident inquiries are now governed by the terms of (a) the Act; and (b) the Act of Sederunt (Fatal Accident Inquiry Rules) 2017 (hereinafter referred to as “the Rules”). In this determination, unless otherwise stated, references to sections are to sections of the Act; and references to rules are to rules within the Rules.

[5] The purpose of a fatal accident inquiry is set out in section 1(3). It is to (a) establish the circumstances of the death or deaths; and (b) consider what steps (if any) might be taken

to prevent other deaths in similar circumstances. It is not the purpose of a fatal accident inquiry to establish civil or criminal liability (see section 1(4)). A fatal accident inquiry is inquisitorial, not adversarial (see rule 2.2.(1)).

[6] A single inquiry may be held into the deaths of more than one person if it appears to the Lord Advocate that the deaths occurred as a result of the same accident (see section 14(1)(b)). The present inquiry, held under section 1, was held into the ten deaths which occurred as a result of the accident at The Clutha on 29 November 2013.

[7] Section 1(2) provides that an inquiry is to be conducted by a sheriff. In terms of section 3(5) of the Courts Reform (Scotland) 2014 Act, the sheriff principal of a sheriffdom may exercise in his or her sheriffdom the jurisdiction and powers that attach to the office of sheriff. As has long been the case, inquiries attracting a significant degree of public interest are regularly presided over by sheriffs principal. The procedure at an inquiry is to be as ordered by the sheriff (see, in particular, rule 3.8.(1) and rule 5.1) or, in this case, the sheriff principal.

[8] Anthony Lyndon Collins (hereinafter referred to as “Constable Collins”) and Kirsty Mary Nelis (hereinafter referred to as “Constable Nelis”) were police officers who each held the rank of constable. David Iain Traill (hereinafter referred to as “Captain Traill”) was a helicopter pilot. In the cases of Constable Collins; Constable Nelis; and Captain Traill the present inquiry was a mandatory one in terms of sections 2(1) and (3), their deaths having been the result of an accident which occurred in Scotland and whilst they were acting in the course of their employment. In the cases of the remaining seven deceased persons the inquiry was a discretionary one; the Lord Advocate, having considered that their deaths

occurred in circumstances giving rise to serious public concern, decided that it was in the public interest for an inquiry to be held into the circumstances of their deaths.

[9] As soon as possible after the conclusion of the evidence and submissions in an inquiry, the presiding sheriff must make a determination setting out certain findings and such recommendations (if any) as the sheriff considers appropriate. A determination under section 26 is to be in Form 6.1 (see rule 6.1)

[10] The findings the sheriff is required to make are set out in section 26(2), namely, (a) when and where the deaths occurred; (b) when and where any accident resulting in the deaths occurred; (c) the cause or causes of the deaths; (d) the cause or causes of any accident resulting in the deaths; (e) any precautions which (i) could reasonably have been taken; and (ii) had they been taken, might realistically have resulted in the deaths, or any accident resulting in the deaths, being avoided; (f) any defects in any system of working which contributed to the deaths or any accident resulting in the deaths; and (g) any other facts which are relevant to the circumstances of the deaths.

[11] The making of recommendations is discretionary. The recommendations which the sheriff is entitled to make are set out in section 26(4). The recommendations must be directed towards (a) the taking of reasonable precautions; (b) the making of improvements to any system of working; (c) the introduction of a system of working; and (d) the taking of any other steps which might realistically prevent other deaths in similar circumstances. Recommendations may (but need not) be addressed to (i) a participant in the inquiry; or (ii) a body or office-holder appearing to the sheriff to have an interest in the prevention of deaths in similar circumstances.

3. Participants and Representation

[12] The procurator fiscal represents the public interest in a fatal accident inquiry. In this inquiry, the procurator fiscal was represented by Sean Smith QC and Gordon Lamont, advocate.

[13] The families of six of those persons who died as a result of the accident were represented in the inquiry. The Dean of Faculty, Gordon Jackson QC and Alan Macleod, advocate appeared for Gordon Arthur, the father of Gary Louis Arthur. Donald Findlay QC and Victoria Young, advocate appeared for Mary Kavanagh, the partner of Robert James Jenkins. Keith Stewart QC and Claire Mitchell, advocate appeared for John McGarrigle junior, the eldest child and nearest known relative of John McGarrigle. Anthony Graham QC and Louise Arrol, advocate appeared for James Diver, the eldest child and nearest known relative of Samuel Bell McGhee. Jonathan Brodie QC and Dana Forbes, advocate appeared for Ian O'Prey, the father of Mark Edward O'Prey. Shelagh McCall QC and David Adams, advocate appeared for Dr Lucy Thomas, the fiancée of Captain Traill.

[14] The families of the remaining four people who died, Constable Collins; Joseph Robert Cusker; Colin Gibson; and Constable Nelis chose not to participate in the inquiry.

[15] In addition to the families who participated, a further eight parties participated in the inquiry. Roddy Dunlop QC and Emma Toner, advocate appeared for Airbus Helicopters Deutschland GmbH (who I refer to in this determination as "Airbus"), the manufacturer of G-SPAO. Peter Gray QC appeared for Babcock Mission Critical Services Onshore Limited (who I refer to in this determination as "Babcock"), the operators of G-SPAO and employer of Captain Traill. Andrew Brown QC appeared for Safran Helicopter Engines (who I refer to

in this determination as “Safran”), the manufacturer of G-SPAO’s engines. Helen Watts, advocate appeared for the Department for Transport and the independent branch thereof, the Air Accidents Investigation Branch (who I refer to in this determination as “the AAIB”). Barry Smith, advocate appeared for the Civil Aviation Authority, (who I refer to in this determination as “the CAA”). James A.F. Reid, solicitor appeared for Police Scotland, the employer of Constable Collins and Constable Nelis and the organisation for whom G-SPAO was operating at the time of the accident on 29 November 2013. Gavin Anderson, advocate appeared for the British Airline Pilots' Association (who I refer to in this determination as “BALPA”).

[16] The European Aviation Safety Agency (who I refer to in this determination as “EASA”) were also a participant in the inquiry. EASA were represented at each of the preliminary hearings. Prior to the final preliminary hearing, on 3 April 2019, EASA made the decision (and advised the court) that they did not actively seek to participate in the inquiry further, however, they wished to monitor and understand the evidence, and to learn any lessons they could from it. EASA also wished to retain the opportunity to make closing submissions if so advised. This was achieved by EASA retaining participant status. Ultimately, EASA concluded (and advised the court) that they did not intend to make closing submissions.

[17] For completeness, it is appropriate that I record certain further matters in relation to participation in the inquiry.

[18] Firstly, an application to participate in the inquiry was made by Evelyn Mitchell, the half-sister of Captain Trill. I refused that application on 20 September 2018. My opinion of

that date is reported under court reference [2018] SC GLA 55 and is available on the Scottish Courts & Tribunals Service (who I refer to in this determination as “SCTS”) website¹.

[19] Secondly, an application to participate in the inquiry was made by Alan Crossan, the sole shareholder and director of (i) Clutha Bars Ltd, which operated The Clutha at the time of the accident; and (ii) Firthport Ltd, the owners of The Clutha premises at the time of the accident. On 20 September 2018 I granted the motion of senior counsel for Mr Crossan, Mhairi Richards QC, and allowed Mr Crossan’s application to participate be withdrawn. No fresh application to participate in the inquiry was made by Mr Crossan. No application to participate in the inquiry was made by either Clutha Bars Ltd or Firthport Ltd.

[20] Thirdly, the Scottish Fire and Rescue Service and the Scottish Ambulance Service both participated in the inquiry until the final preliminary hearing. By that stage, it had become apparent that no participant in the inquiry had any criticism of the steps taken by employees of those organisations in the aftermath of the accident. Accordingly, I permitted both the Scottish Fire and Rescue Service and the Scottish Ambulance Service to withdraw as participants in the inquiry.

[21] Lastly, on 20 September 2018, I granted an application to participate in the inquiry by George David Young (who I refer to in this determination as “Captain Young”), the day-shift pilot of G-SPAO on the day of the accident. Subsequently, on 21 November 2018, I granted BALPA’s application to participate in the inquiry. That application having been

¹ See <http://www.scotcourts.gov.uk/docs/default-source/cos-general-docs/pdf-docs-for-opinions/2018scgla55.pdf?sfvrsn=0>

granted, it became unnecessary for Captain Young to be separately represented in the inquiry, therefore, I permitted Captain Young to withdraw as a participant in the inquiry.

[22] I am grateful to all those appearing in the inquiry and to those instructing them for their valuable and professional contributions, and for the assistance they gave to me during the course of the inquiry. This was a substantial inquiry attracting considerable public interest. A significant amount of uncontroversial evidence was agreed. Through the diligence and industry of those appearing, the inquiry was conducted with great efficiency, allowing the evidence to be heard in a far shorter timescale than had been envisaged at the outset of the inquiry process.

4. The Inquiry Process

[23] A notice of an inquiry was given by the procurator fiscal under section 15(1) on 26 July 2018. Having considered that notice, in terms of rule 3.2.(2), I ordered the procurator fiscal to appear before me in chambers on 1 August 2018 to discuss the first order. That having happened, I pronounced a first order on 9 August 2018, assigning a number of preliminary hearings and the date for the commencement of the inquiry.

[24] Preliminary hearings took place on 3 October 2018; 4 December 2018; 11 January 2019; 5 February 2019; and 3 April 2019. The court's interlocutors relative to those preliminary hearings were published on a page of the SCTS website dedicated to the inquiry².

² See <http://www.scotcourts.gov.uk/the-courts/court-locations/clutha-fai>

[25] The first order in the inquiry also directed that any person who had not been given notice under section 17(1) but who wished to appear at the preliminary hearing assigned for 3 October 2018 was to make application in accordance with rule 3.5. Similar provision was made in the interlocutors relative to the preliminary hearings which proceeded on 3 October 2018 and 4 December 2018. A number of applications to participate in the inquiry were made. I heard those applications on 20 and 28 September; and on 21 November, all 2018.

[26] A number of orders were made by me to identify both the matters considered likely to be in dispute at the inquiry and any matter contained within the report by the AAIB aircraft accident report with which issue was taken by the participants. These aspects of the inquiry process are considered below in Parts 5 and 9 respectively.

[27] The participants entered into three separate joint minutes of agreement in terms of rule 4.10. As a consequence, it was not necessary for the participants to formally present information to the inquiry concerning the facts and productions stated within the joint minutes, each of which was read to the inquiry.

[28] In terms of rule 4.12, I permitted the preparation and intimation of notices to admit on three separate occasions. Ultimately, there were before the inquiry two such notices for the procurator fiscal and notices for Dr Thomas and for the CAA. No objection was taken to any fact or production set out in these notices. As such, it was not necessary for the participants to present information to the inquiry concerning the matters stated within the notices, each of which was read to the inquiry.

[29] The use of joint minutes and notices to admit played an important part in the efficient conduct of the inquiry. It is worthy of note that the reading of the joint minutes and notices to admit alone took up more than three hours of court time.

[30] The inquiry heard evidence from 46 witnesses over 31 court days between 8 April and 18 July 2019. Details of the witnesses who gave evidence to the inquiry are set out in Appendix 1 below. At my direction, participants lodged written submissions and were heard in relation to those on 5 August 2019. The written submissions were subsequently published on the SCTS website³. At the hearing on 5 August 2019 the procurator fiscal undertook to lodge supplementary submissions addressing the time that had elapsed between the accident and the commencement of the inquiry process. These submissions are considered below in Part 26.

5. The Issues

[31] The ethos underlying the Rules includes the early identification of matters considered likely to be in dispute at the inquiry. In terms of rule 3.7, unless the sheriff orders otherwise, the written note participants are required to lodge before the first preliminary hearing is to contain, amongst other things, the matters which they consider are likely to be in dispute at the inquiry. Whilst the procedure at a preliminary hearing is to be as ordered by the sheriff (see rule 3.8.(1)), at the preliminary hearing (or by the last preliminary hearing) the sheriff must, amongst other things, establish any matters which are likely to be in dispute at the inquiry (see rule 3.8.(2)(e)).

³ See <http://www.scotcourts.gov.uk/the-courts/court-locations/clutha-fai>

[32] In an inquiry of the complexity of this one, the early identification of any matters which were likely to be in dispute has added significance. That said, having regard to the volume of material participants required to consider, I concluded that it was unrealistic to expect participants to identify the matters which were likely to be in dispute at the inquiry in the prescribed time available between the date of the first order and the date of the first preliminary hearing (see rule 3.2).

[33] Accordingly, the first order of 9 August 2018, amongst other things, dispensed with the requirement for participants to lodge a note in accordance with rule 3.7 in advance of the first preliminary hearing. At that preliminary hearing, held on 3 October 2018, I made an order appointing each participant to lodge with the sheriff clerk a written note setting out the matters specified in paragraphs (a) to (d) of rule 3.7 in advance of the preliminary hearing assigned for 4 December 2018.

[34] I made a similar order at the preliminary hearing held on 4 December 2018, effectively requiring participants to lodge updated notes in advance of the preliminary hearing assigned for 5 February 2019. The procurator fiscal undertook to produce an updated list of the matters considered by the parties as likely to be in dispute at the inquiry in advance of that preliminary hearing.

[35] At the preliminary hearing held on 5 February 2019 the procurator fiscal was ordered to lodge with the sheriff clerk a list of the matters then identified as likely to be disputed at the inquiry. Provision was also made for participants to intimate any additional matters in dispute. Ultimately, there was before the inquiry an agreed list of matters that would be in dispute at the inquiry (referred to as a "Consolidated List of Issues"). Having regard to the

considerable public interest in this inquiry, I directed that the list of issues should be published on the SCTS website⁴. For ease of reference, that list is reproduced as Appendix 2 to this determination.

6. G-SPAO

[36] G-SPAO was an EC135 T2+ type helicopter, manufactured by Eurocopter Deutschland. Eurocopter Deutschland became Airbus Helicopters (Deutschland) in or around January 2014. G-SPAO was owned and operated by Bond Air Services Limited (hereinafter referred to as “Bond”). After the accident, in or around May 2014, Bond was acquired by Babcock. In or around April 2016, Bond's name was changed to Babcock Mission Critical Services Onshore Limited reflecting the change in ownership which had taken place.

[37] G-SPAO was manufactured in 2007, with build serial number 0546, and was powered by two Turbomeca Arrius 2B2 turboshaft engines. It was fitted with Test Fuchs fuel transfer pumps. The properties of the fitted fuel transfer pumps are considered further below in Part 12 and in Part 22.

[38] Maintenance information in relation to G-SPAO can be found at paragraph 1.6.9 of the AAIB Report (see Part 9 below). That paragraph records that G-SPAO was maintained in accordance with the manufacturer's recommendations and servicing routines. The majority of the recorded maintenance work to G-SPAO consisted of routine servicing operations, minor defect rectifications and role equipment changes. The routine servicing operations

⁴ See <http://www.scotcourts.gov.uk/docs/default-source/fatal-accident-inquiries/clutha-list-of-issues-05-04-19.pdf?sfvrsn=2>

include a daily hot (engines running) compressor washing procedure, in accordance with the Engine Maintenance Manual (“EMM”).

[39] Of particular relevance are the maintenance activities carried out to G-SPAO during November 2013. These included cold compressor washes of the engines both on 2 November 2013, and on the night of 17/18 November 2013. Later during November 2013, the No 1 engine injector manifold was changed. An engine power assurance check was carried out on 28 November 2013.

[40] In the months leading up to the accident, issues arose with G-SPAO’s fuel contents indication system (considered below in Part 12). In July 2013 an issue arose with the fuel contents indication system on G-SPAO whereby it was giving inaccurate over / under readings. As a consequence, the aft fuel sensor in G-SPAO’s main tank was replaced. Checks carried out thereafter raised issues with the forward fuel sensor in the main tank, which was replaced by the sensor unit that had been removed from the aft position. In October 2013 an issue arose with G-SPAO’s No 1 supply tank cell contents sensor, causing it to be replaced. A further issue arose with the main fuel tank aft contents sensor, which was (again) replaced. During this work a further issue arose with the No 2 supply tank quantity indication sticking at 11 kilograms (“kg”) with the tank empty. To address this issue, the No 2 supply tank cell contents sensor was removed, cleaned, flushed with clean fuel and dried with warm air.

[41] Every time a sensor was removed for replacement or cleaning, the fuel tanks were drained of all fuel, refilled and functionally checked, in accordance with the aircraft maintenance manual (“AMM”). There were no defects recorded in G-SPAO’s Tech Log, or

entries for work carried out, after any of the three flights conducted on 29 November 2013, prior to the accident flight.

[42] At the time of the accident G-SPAO had 6,351 airframe hours and had made 9,385 landings. It held a certificate of airworthiness issued by the CAA on 14 August 2008. Its airworthiness review certificate was valid until 4 September 2014.

7. The Final Flight

[43] The AAIB Report (see Part 9 below) contains a description of the final flight of G-SPAO at paragraph 1.1.2. This was created from an amalgamation of recorded data and other evidence obtained by the AAIB. Additionally, the AAIB produced (see Figure 1 on page 7 of the AAIB Report) an overview of G-SPAO's flight path, which shows G-SPAO's track from its point of departure to the location of the accident.

[44] Additionally, for the purposes of the inquiry, Airbus prepared a video depiction of the final flight. This video was based upon data from G-SPAO's on board computer systems; radar information transmissions; and evidence of the pre take-off fuel quantity retrieved during the AAIB's investigation of the accident. Helpfully, the video sought to depict the general sequence of visual and noise indications on the Caution and Advisory Display ("CAD") when caution conditions and warning conditions, were (or were programmed to have been) triggered.

[45] The description of the final flight of G-SPAO which is set out below is drawn from (a) paragraph 1.1.2 of the AAIB Report; and (b) the evidence heard by the inquiry. In

addition, the overview of G-SPAO's flight path contained within the AAIB Report is reproduced at Appendix 3 to this determination.

[46] On 29 November 2013 G-SPAO was operated by the day-shift pilot, Captain Young, and refuelled three times, twice at Inverness and again after its return to the Glasgow City Heliport ("GCH"). Captain Young did not experience any abnormal indications or defects with G-SPAO and, on handover to the pilot on the night-shift, Captain Traill, he informed him that there were 400 kg of fuel on board.

[47] After receiving clearance from air traffic control ("ATC") to operate in the Glasgow Control Zone, G-SPAO departed GCH at 2044 hours. On board were the pilot, Captain Traill and two police air observers, Constable Nelis and Constable Collins. Each of those on-board G-SPAO was in possession of a set of night vision goggles.

[48] Initially, G-SPAO tracked towards the Oatlands district of Glasgow, about two nautical miles ("nm") south-east of GCH. This was a non-routine task, to assist in the search for a person believed to have been struck by a train. At 2046 hours, the front seat observer, Constable Nelis, made a routine transmission to the Police Scotland control room, using an Airwave radio, informing them that G-SPAO was "en route to Inglefield Street". This transmission was acknowledged. Three minutes later, the Police Scotland control room contacted G-SPAO with a general enquiry which Constable Nelis responded to.

[49] G-SPAO remained in the Oatlands district, at an altitude of approximately 800 feet above mean sea level ("ft amsl"), for around 33 minutes. During this period the crew were in communication with police officers on the ground, via Airwave radio. When no-one was found, all the resources that had been involved in the search, including G-SPAO, were stood

down by a police sergeant who was in attendance on the ground. At 2121 hours, Captain Traill advised Glasgow ATC that they were “complete south side” and requested clearance to route towards Dalkeith, Midlothian, about 42 nm east of GCH. This request was approved. In the course of the investigation into the accident it was subsequently calculated that, at this point, the fuel remaining on G-SPAO would have been approximately 273 kg.

[50] At 2122 hours, Constable Nelis informed the Police Scotland control room that they had been “stood down” from the first task and were heading towards Dalkeith, for a routine surveillance task. G-SPAO initially transited at an altitude of 2,000 ft amsl and, as it cleared Glasgow Control Zone to the east, Glasgow ATC advised Captain Traill to contact Edinburgh ATC. On initial contact, Edinburgh ATC instructed Captain Traill not to fly above 2,000 ft amsl and to route via the Cobbinshaw (Reservoir) visual reporting point. As G-SPAO approached Cobbinshaw, Edinburgh ATC cleared Captain Traill to fly direct to Dalkeith, not above 3,000 ft amsl. This was to allow G-SPAO enough vertical clearance above the Pentland Hills, to the south of Edinburgh.

[51] Just before arriving at Dalkeith, Captain Traill informed Edinburgh ATC that he would be operating over Dalkeith at a height of about 800 ft; would be remaining outside Edinburgh’s Control Zone; and would be “hovering there (for) about five to ten minutes”. G-SPAO arrived at Dalkeith at 2141 hours, with an estimated 203 kg of fuel, and commenced its task at 2142 hours. It remained there for about three minutes, at an altitude of approximately 1,200 ft amsl.

[52] On completion of this task, at 2145 hours, G-SPAO flew back towards Glasgow, with approximately 192 kg of fuel remaining. Captain Traill advised Edinburgh ATC that they

were “complete Dalkeith” and requested clearance to climb to 3,000 ft amsl, routing via Cobbinshaw. Edinburgh ATC cleared G-SPAO to enter the Edinburgh Control Zone, initially not above 2,000 ft amsl, and re-cleared it to not above 3,000 ft amsl a few minutes later. After flying at 3,000 ft amsl for three minutes, G-SPAO descended to 2,000 ft amsl, on Edinburgh ATC’s request, as it passed Cobbinshaw.

[53] At 2156 hours, Edinburgh ATC requested that Captain Traill inform them when he needed to contact Glasgow ATC and told him that there was no known traffic to affect G-SPAO en route. In response, Captain Traill advised Edinburgh ATC that they were routing south of the restricted area at Shotts, North Lanarkshire. Two minutes later, at 2158 hours, Captain Traill advised Edinburgh ATC that he was contacting Glasgow ATC. One minute after that, at 2159 hours, he called Glasgow ATC and informed them of G-SPAO’s position, south of the restricted area, and that G-SPAO was heading towards Bothwell, South Lanarkshire “before recovery” (i.e. before returning to GCH). Glasgow ATC cleared G-SPAO to enter the Glasgow Control Zone, not above 2,000 ft amsl, which was acknowledged by Captain Traill. Having been at that altitude for five minutes, G-SPAO descended to 1,500 ft amsl for two minutes, as it approached Bothwell.

[54] At 2206 hours, G-SPAO arrived at Bothwell with an estimated 122 kg of fuel remaining on board and orbited once, to the right, while it carried out a routine surveillance task. This took approximately two minutes. It then flew north-west, for about 1.5 nm, and commenced a three minute task at Uddingston, South Lanarkshire at 2209 hours, with an estimated 113 kg of fuel remaining. Again, G-SPAO orbited once to the right. As G-SPAO left this task, it initially tracked west-south-west for nearly one minute, before turning onto a north-easterly track and flying about 1.5 nm towards Bargeddie, North Lanarkshire.

[55] At 2214 hours, with an estimated 100 kg of fuel remaining, G-SPAO carried out a further routine surveillance task, orbiting three times to the right at Bargeddie.

[56] No radio transmissions were received from Captain Traill during each of the three surveillance tasks which were carried out at Bothwell, Uddingston and Bargeddie respectively.

[57] At 2219 hours, Captain Traill informed Glasgow ATC that they were “complete” in the Bothwell area and were returning to GCH. Glasgow ATC confirmed that G-SPAO was clear to enter the Glasgow Control Zone, not above 2,000 ft amsl, and this clearance was verbally acknowledged by Captain Traill. There was no indication of any fault with G-SPAO or any other concern. At this time, the fuel remaining was calculated to have been 86 kg. No further radio transmissions were received from Captain Traill.

[58] The procurator fiscal instructed an expert witness, Captain Mark Prior, to provide an opinion on certain matters relative to the accident. As part of his work, Captain Prior carried out modelling to identify the fuel remaining at each phase of G-SPAO’s final flight. Captain Prior’s conclusion was that the modelling of the fuel content at each phase of the flight shown in the AAIB Report was a credible approximation of the fuel contents of G-SPAO at the points narrated. Captain Prior’s own calculations produced very similar figures to those contained within the AAIB Report.

[59] G-SPAO tracked towards GCH at an altitude of about 1,000 ft amsl, with a ground speed of approximately 100 knots (“kt”). Between 2221:35 hours and 2221:45 hours, when G-SPAO was about 2.7 nm east of GCH, the right engine of G-SPAO flamed out, leaving

Captain Traill with one engine inoperative (“OEI”). Approximately 32 seconds later, about 1.8 nm east of GCH, the left engine of G-SPAO flamed out.

[60] After the second engine had flamed out, the ROTOR RPM warning caption illuminated, accompanied by its aural tone. This indicated that the speed of the rotor had decreased below 97%. This warning then extinguished, re-illuminated and extinguished again. It finally re-illuminated and stayed on for the remainder of the flight, as G-SPAO descended. The last recorded radar position, at 2222:19 hours, showed G-SPAO at an altitude of approximately 390 ft amsl, close to the accident site.

[61] G-SPAO was seen by several witnesses over Glasgow city centre prior to the accident. During the final part of its descent, some of the witnesses described hearing noises. Craig Welsh heard a “sort of whining sound and then there was two distinct thuds”; Ernest Docherty described it as being “like an old car trying to start”; and Andrew Bergin described it making a “spluttering sound”. There was then silence, as G-SPAO descended rapidly. A successful autorotation and flare recovery were not achieved. G-SPAO struck the roof of The Clutha, with a high rate of descent and in an upright attitude. G-SPAO came to rest embedded in the building. The AAIB determined that G-SPAO’s main rotor blades and Fenestron tail rotor were not rotating at the moment of impact. The force of the impact caused the roof of The Clutha to collapse onto members of the public within the premises, with G-SPAO coming to rest within the bar.

[62] That accident caused the ten deaths with which this inquiry is concerned. In terms of section 26(2)(b) I have determined (see Finding F2 above) that the accident resulting in the

deaths occurred at or around 2222 hours on 29 November 2013 at the Clutha Vaults, Stockwell Street, Glasgow. That finding addresses issue 2 for the inquiry.

8. The Times and Causes of the Deaths

Introduction

[63] Two of the matters the sheriff is required to address in his or her determination are (i) when and where the death occurred; and (ii) the cause or causes of the death (see subsections 26(2)(a) and (c) respectively). This part of the determination considers these matters, which are issues 1 and 3 for inquiry. In this context, regard also requires to be had to rule 4.11.(3), namely, the duty incumbent upon participants to endeavour to agree certain matters.

[64] In this inquiry, the participants entered into a joint minute which covers most of the matters set out in rule 4.11.(3). Whilst, in each case, there is no controversy over the location of each deceased's death, the same, perhaps regrettably, cannot be said for the date and time of certain of the deaths considered below. The submissions for the procurator fiscal (see Appendix, paragraph 1.1 thereof) assert that when and where each of the deaths occurred (issue 1) is a matter of agreement. That assertion is made by reference to the joint minute referred to above. On a closer examination of that joint minute, however, the precise timing of each of the deaths is not a matter of agreement (it is the date and time at which each deceased person's life was formally pronounced extinct that is agreed). It therefore falls to the court to resolve those issues in discharging the obligation incumbent upon it in terms of section 26(2)(a), referred to above. It is important to emphasise that the evidence which

underpins the findings I have made in this regard is found within the joint minute I have referred to and the post-mortem examination reports referred to therein.

[65] Perhaps surprisingly in some instances, it is notable that none of the participants to the inquiry chose to make any submissions on this issue. As explained below, it has been possible, on the evidence, to determine the time of death in the majority of cases. However, in three cases (namely, those of Mr McGarrigle; Mr McGhee; and Mr O'Prey) the available evidence and the inferences I have concluded I am legitimately entitled to draw from it are such that all that has been possible is an approximation and a finding that the deaths occurred between certain points in time. The legitimacy of such an approach is supported by Carmichael, *"Sudden Deaths and Fatal Accident Inquiries"* (3rd ed.) at paragraph 5-66, considering the equivalent provision of the previous legislation, the Fatal Accidents and Sudden Deaths Inquiry etc (Scotland) Act 1976 ("the 1976 Act").

Gary Louis Arthur

[66] Mr Arthur was born on 26 June 1965. He was aged 48 at the time of his death. He lived in Paisley. He was employed as a sales advisor. Mr Arthur was a customer within The Clutha at the time of the accident. He was discovered by members of the emergency services shortly after they attended the incident. He was found trapped by rubble within The Clutha by firefighters Francis Reynolds, Thomas (Grant) McRavey and James Donald. He had no pulse. He was freed and carried to an open window.

[67] Mr Arthur was subsequently examined and his life was formally pronounced extinct by paramedic Stephen Rutherford at 2250 hours on 29 November 2013.

[68] A post mortem examination of the body of Mr Arthur took place at the Southern General Hospital, Glasgow on 30 November 2013 at 1730 hours. The pathologists' conclusion, which I accept (see Finding F3.1 above), was that the cause of Mr Arthur's death was head injury due to an aircraft crash.

[69] I have considered carefully the agreed facts surrounding Mr Arthur's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 6 February 2014. In that report they conclude that Mr Arthur suffered a severe traumatic brain injury consistent with a very short survival period.

[70] In light of the available evidence, I am satisfied that Mr Arthur's death was instantaneous. As set out above in Finding F1.1 above, I find that Mr Arthur died at or about 2222 hours on 29 November 2013.

Anthony Lyndon Collins

[71] Constable Collins was born on 10 October 1970. He was aged 43 at time of his death. He lived in Glasgow. He was employed as a police constable and was one of two police air observers on board G-SPA0 at the time of the accident. Shortly after 2300 hours on 29 November 2013, firefighters Stephen Burns and Andrew Bradley reached the helicopter. Constable Collins was discovered on the rear passenger seat, positioned behind the pilot's seat. He was trapped within the wreckage. He was found to have no pulse. This was confirmed shortly thereafter by paramedic James Scambler.

[72] Constable Collins was subsequently examined and his life was formally pronounced extinct by specialist paramedics Anthony Connelly and John Hollis at 1049 hours on 30 November 2013.

[73] Constable Collins died during the course of his employment with the Police Service of Scotland, Tulliallan Castle, Alloa. He had been a police constable for 18 years and a police air observer since 2007.

[74] A post mortem examination of the body of Constable Collins took place at the Southern General Hospital, Glasgow on 1 December 2013 at 2035 hours. The pathologists' conclusion, which I accept (see Finding F3.2 above), was that the cause of Constable Collins's death was head, neck and chest injuries due to an aircraft crash.

[75] It is appropriate to add that a toxicology report dated 31 December 2013 relating to Constable Collins was prepared. All samples taken from Constable Collins were analysed for alcohol and drugs and gave negative results.

[76] I have considered carefully the agreed facts surrounding Constable Collins's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 6 February 2014. In that report they conclude that the severity of the injuries sustained by Constable Collins was such that his death would have been instantaneous.

[77] In light of the available evidence, I am satisfied that Constable Collins's death was instantaneous. As set out above in Finding F1.2 above, I find that Constable Collins died at or about 2222 hours on 29 November 2013.

Joseph Robert Cusker

[78] Mr Cusker was born on 22 February 1954. He was aged 59 at time of his death. He lived in Glasgow. He was retired from his occupation as a local authority housing manager. Mr Cusker was a customer within The Clutha at the time of the accident. He was discovered close to the entrance doors by a fellow customer and a number of persons within The Clutha assisted in removing him from the building.

[79] Mr Cusker was attended to by firefighter Ryan Blease and crew commander Paul McKenna, who administered oxygen. He was thereafter attended to by paramedics Paul Stewart and David O'Hara. Mr Cusker was taken to Glasgow Royal Infirmary. He had multiple injuries.

[80] Mr Cusker was treated within the Intensive Care Unit of Glasgow Royal Infirmary. His condition deteriorated. His life was pronounced extinct at 1125 hours on 12 December 2013 at Glasgow Royal Infirmary by Kathryn Puxty, specialist registrar.

[81] A post mortem examination of the body of Mr Cusker took place at the Southern General Hospital, Glasgow on 12 December 2013 at 1730 hours. The pathologists' conclusion, which I accept (see Finding F3.3 above), was that the cause of Mr Cusker's death was multiple organ failure, due to neck and chest injuries due to an aircraft crash.

[82] In light of the available evidence, as set out above in Finding F1.3 above, I am satisfied and find that Mr Cusker died at or about 1125 hours on 12 December 2013. Mr Cusker's death was as a direct result of the injuries sustained by him in the accident of 29 November 2013.

Colin Gibson

[83] Mr Gibson was born on 13 September 1980. He was aged 33 at time of his death. He lived in Ayr. He was employed as an immigration officer. Mr Gibson was a customer within The Clutha at the time of the accident. He was discovered by firefighters Francis Reynolds and Thomas (Grant) McRavey. He was trapped by rubble, debris and part of the helicopter. On examination he was found to have no pulse. This was confirmed at 0100 hours on 30 November 2013 by special operations paramedics James Rogge and Emma Park.

[84] Mr Gibson was subsequently examined and his life was formally pronounced extinct by special operations paramedics Anthony Connelly and John Hollis at 1335 hours on 30 November 2013.

[85] A post mortem examination of the body of Mr Gibson took place at the Southern General Hospital, Glasgow on 2 December 2013 at 1815 hours. The pathologists' conclusion, which I accept (see Finding F3.4 above), was that the cause of Mr Gibson's death was traumatic asphyxia due to an aircraft crash.

[86] I have considered carefully the agreed facts surrounding Mr Gibson's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 7 February 2014. In that report they conclude that Mr Gibson suffered multiple blunt injuries and associated areas of pressure indentation which were in keeping with having been sustained following a building collapse.

[87] In light of the available evidence, I am satisfied that Mr Gibson's death was almost instantaneous. As set out above in Finding F1.4 above, I find that Mr Gibson died at or about 2222 hours on 29 November 2013.

Robert James Jenkins

[88] Mr Jenkins was born on 8 January 1952. He was aged 61 at time of his death. He lived in East Kilbride. He was employed as a gas company customer service advisor. Mr Jenkins was a customer within The Clutha at the time of the accident. He was discovered on 1 December 2013 within The Clutha by firefighting personnel including watch commander Mark Tungatt and firefighter William Cameron. He was trapped in rubble and debris beneath the helicopter. On examination Mr Jenkins was found to have no pulse.

[89] Mr Jenkins was subsequently examined and his life was formally pronounced extinct by special operations paramedics Anthony Connelly and John Hollis at 1434 hours on 1 December 2013.

[90] A post mortem examination of the body of Mr Jenkins took place at the Southern General Hospital, Glasgow on 2 December 2013 at 1245 hours. The pathologists' conclusion, which I accept (see Finding F3.5 above), was that the cause of Mr Jenkins's death was head injury due to an aircraft crash.

[91] I have considered carefully the agreed facts surrounding Mr Jenkins's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 6 February 2014. In that report they conclude that Mr Jenkins suffered a severe head injury.

[92] In light of the available evidence, I am satisfied that Mr Jenkins's death was instantaneous. As set out above in Finding F1.5 above, I find that Mr Jenkins died at or about 2222 hours on 29 November 2013.

John McGarrigle

[93] Mr McGarrigle was born on 6 January 1955. He was aged 58 at time of his death. He lived in Cumbernauld. He was a writer. Mr McGarrigle was a customer within The Clutha at the time of the accident. He was discovered by first responding firefighting personnel including crew commander Scott McKechan and firefighter Ross Boyd. Mr McGarrigle was trapped underneath a large amount of debris and rubble a short distance from the left front entrance door. He was found to be unconscious with a faint pulse.

[94] Taking Mr McGarrigle's location when found; the location of the helicopter (both of which are set out in a number of floor plans, the terms of which were agreed by joint minute); and the time the helicopter was reached by firefighters, I am satisfied that Mr McGarrigle was found alive at or about 2300 hours. It is a matter of agreement that, shortly thereafter, he was attended to by paramedic Julie McIntyre. No pulse was detected.

[95] At 0100 hours on 30 November 2013 Mr McGarrigle was examined by special operations paramedics Anthony Connelly and John Hollis. There was no sign of life. Mr McGarrigle's life was formally pronounced extinct by special operations paramedics Anthony Connelly and John Hollis at 1249 hours on 30 November 2013.

[96] A post mortem examination of the body of the Mr McGarrigle took place at the Southern General Hospital, Glasgow on 2 December 2013 at 1800 hours. The pathologists'

conclusion, which I accept (see Finding F3.6 above), was that the cause of Mr McGarrigle's death was chest injuries due to an aircraft crash.

[97] I have considered carefully the agreed facts surrounding Mr McGarrigle's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 6 February 2014. In that report they conclude that Mr McGarrigle suffered significant chest injuries. The available evidence is, in my view, sufficient to permit me to conclude that Mr McGarrigle died shortly after 2300 hours, therefore, as set out in Finding F1.6 above, I find that Mr McGarrigle died between at or about 2300 hours and at or about 2330 hours on 29 November 2013.

Samuel Bell McGhee

[98] Mr McGhee was born on 5 July 1957. He was aged 56 at time of his death. He lived in Glasgow. He was employed as a car wash maintenance man. Mr McGhee was a customer within The Clutha at the time of the accident. He was discovered by firefighters Andrew Bradley and Joseph Gorrance. He was trapped beneath debris and rubble. A pulse was detected. The firefighters were unable to free Mr McGhee due to the mass and weight of the debris.

[99] Taking Mr McGhee's location when found; the location of the helicopter (both of which are set out in a number of floor plans, the terms of which were agreed by joint minute); and the time the helicopter was reached by firefighters, I am satisfied that Mr McGhee was found alive at or about 2300 hours. It is a matter of agreement that, shortly thereafter, he was examined by paramedics James Scambler and Julie McIntyre at which time no pulse was detected.

[100] At approximately 0100 hours on 30 November 2013 Mr McGhee was examined by special operations paramedics James Rogge and Emma Park. There was no sign of life. Mr McGhee's life was formally pronounced extinct by special operations paramedics Anthony Connelly and John Hollis at 1022 hours on 30 November 2013.

[101] A post mortem examination of the body of Mr McGhee took place at the Southern General Hospital, Glasgow on 1 December 2013 at 1430 hours. The pathologists' conclusion, which I accept (see Finding F3.7 above), was that the cause of Mr McGhee's death was chest injuries due to an aircraft crash.

[102] I have considered carefully the agreed facts surrounding Mr McGhee's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 3 February 2014. In that report they conclude that Mr McGhee suffered severe injuries, mainly to his chest. The circumstances relevant to the timing of Mr McGhee's death are similar to those relative to Mr McGarrigle's death. The available evidence is, in my view, sufficient to permit me to conclude that Mr McGhee died shortly after 2300 hours, therefore, as set out in Finding F1.7 above, I find that Mr McGhee died between at or about 2300 hours and at or about 2330 hours on 29 November 2013.

Kirsty Mary Nelis

[103] Constable Nelis was born on 11 October 1977. She was aged 36 at time of her death. She lived in Inverkip. She was employed as a police constable and was one of two police air observers on board G-SPAO at the time of the accident. Shortly after 2300 hours on 29 November 2013, firefighters Stephen Burns and Andrew Bradley reached the helicopter within The Clutha. Constable Nelis was discovered strapped in the front passenger seat. She

was trapped within the wreckage and instrumentation. She was found to have no pulse and showed no signs of life. This was confirmed at 0100 hours on 30 November 2013 by specialist paramedics James Rogge and Emma Park.

[104] Constable Nelis was subsequently examined and her life was formally pronounced extinct by specialist paramedics Anthony Connelly and John Hollis at 1046 hours on 30 November 2013.

[105] Constable Nelis died during the course of her employment with the Police Service of Scotland, Tulliallan Castle, Alloa. She had been a police constable for 13 years and a police air observer since 2012.

[106] A post mortem examination of the body of Constable Nelis took place at the Southern General Hospital, Glasgow on 2 December 2013 at 0145 hours. The pathologists' conclusion, which I accept (see Finding F3.8 above), was that the cause of Constable Nelis's death was head, neck and chest injuries due to an aircraft crash.

[107] It is appropriate to add that a toxicology report dated 31 December 2013 relating to Constable Nelis was prepared. All samples taken from Constable Nelis were analysed for alcohol and drugs and gave negative results.

[108] I have considered carefully the agreed facts surrounding Constable Nelis's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 6 February 2014. In that report they conclude that Constable Nelis sustained severe and extensive injuries.

[109] In light of the available evidence, I am satisfied that Constable Nelis death was instantaneous. As set out above in Finding F1.8 above, I find that Constable Nelis died at or about 2222 hours on 29 November 2013.

Mark Edward O'Prey

[110] Mr O'Prey was born on 14 August 1969. He was aged 44 at time of his death. He lived in East Kilbride. He was employed as a window cleaner. Mr O'Prey was a customer within The Clutha at the time of the accident. He was discovered by firefighters Francis Reynolds, Thomas (Grant) McRavey and Colin Clarke. Mr Reynolds and Mr McRavey also discovered Mr Arthur shortly before 2250 hours on 29 November 2013 (see paragraph [66] above).

[111] Paramedic Stephen Rutherford attended shortly thereafter. Mr Rutherford had formally pronounced Mr Arthur's life extinct outside The Clutha at 2250 hours (see paragraph [67] above). On the available evidence I am satisfied that Mr Rutherford did so prior to entering The Clutha and attending to Mr O'Prey who was trapped by rubble from the waist down. Mr O'Prey was moving his head and mumbling. An oxygen mask was fitted. Mr O'Prey's breathing was shallow.

[112] Mr O'Prey was thereafter attended to by paramedic Helen Robert. It is not possible to identify when she did so from the available evidence, other than it was not before 2300 hours on 29 November 2013. Ms Robert was unable to find a pulse. Mr O'Prey had an irregular breathing pattern and a low respiratory rate. Ms Robert fitted an airway in Mr O'Prey's mouth. She could not administer any further medical assistance to Mr O'Prey due to his low respiratory rate, his heavily trapped position and the restricted access to him.

[113] At 0100 hours on 30 November 2013, Mr O'Prey was examined by special operations paramedics James Rogge and Emma Park. There was no sign of life. Mr O'Prey was subsequently examined and his life was formally pronounced extinct by special operations paramedics Anthony Connelly and John Hollis at 1257 hours on 30 November 2013.

[114] A post mortem examination of the body of Mr O'Prey took place at the Southern General Hospital, Glasgow on 2 December 2013 at 1300 hours. The pathologists' conclusion, which I accept (see Finding F3.9 above), was that the cause of Mr O'Prey's death was head, neck and chest injuries due to an aircraft crash.

[115] I have considered carefully the agreed facts surrounding Mr O'Prey's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 6 February 2014. In that report they conclude that Mr O'Prey sustained severe injuries to his head, neck and chest. That evidence and the evidence of Ms Robert's attendance upon Mr O'Prey are strongly suggestive of Mr O'Prey dying shortly after Ms Robert had attended to him, as best she could in the circumstances.

[116] The evidence before the inquiry is, perhaps regrettably, only of sufficient quality as to enable me to find that Mr O'Prey died between at or around 2300 hours on 29 November 2013 and at or around 0100 hours on 30 November 2013. That conclusion is reflected in Finding F1.9 above

David Iain Traill

[117] Captain Traill was born on 19 November 1962. He was aged 51 at time of his death. He lived in Lochwinnoch. He was employed as a helicopter pilot. By 29 November 2013 he

had flown over 5,595 hours, mostly in helicopters. He had been trained to fly helicopters by the Royal Air Force (“RAF”). He carried out operational flights in active war zones 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. After leaving the RAF in 2008, Captain Traill undertook Bond’s EC135 Type Rating Training programme. This took place between 23 and 27 June 2008. Captain Traill had accumulated 646 flying hours on the EC135 by the date of the accident.

[118] Captain Traill was the pilot of G-SPAO at the time of the accident. Shortly after 2300 hours on 29 November 2013 firefighters Stephen Burns and Andrew Bradley reached the helicopter with paramedic James Scambler. Captain Traill was discovered in the front right-hand (i.e. the pilot’s) seat. He was compressed by wreckage and debris. He was found to have no pulse.

[119] At approximately 0100 hours on 30 November 2013 Captain Traill was examined by specialist paramedics James Rogge and Emma Park. He had no pulse. There was no sign of life. Captain Traill’s life was formally pronounced extinct by specialist paramedics Anthony Connelly and John Hollis at 1035 hours on 30 November 2013.

[120] Captain Traill died during the course of his employment with Bond Air Services Limited, Gloucestershire Airport, Staverton, Cheltenham. He had been a helicopter pilot with them for five years at the time of his death.

[121] A post mortem examination of the body of Captain Traill took place at the Southern General Hospital, Glasgow on 1 December 2013 at 1935 hours. The pathologists’ conclusion,

which I accept (see Finding F3.10 above), was that the cause of Captain Traill's death was head, neck and chest injuries due to an aircraft crash.

[122] It is appropriate to add that a toxicology report dated 31 December 2013 relating to Captain Traill was prepared. All samples taken from Captain Traill were analysed for alcohol and drugs and gave negative results.

[123] I have considered carefully the agreed facts surrounding Captain Traill's death and, in particular, the findings of the pathologists as set out in their post mortem examination report dated 6 February 2014. In that report they conclude that Captain Traill sustained severe and extensive injuries.

[124] In light of the available evidence, I am satisfied that Captain Traill's death was instantaneous. As set out above in Finding F1.10 above, I find that Captain Traill died at or about 2222 hours on 29 November 2013.

9. The AAIB Report

[125] The investigation of air accidents is the responsibility of the AAIB, a part of the Department for Transport. At the time of the accident, the AAIB's operations were governed by the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 ("the 1996 Regulations"). It is pertinent to note that those regulations were repealed on 9 April 2018. The AAIB's operations are now governed by the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 ("the 2018 Regulations").

[126] In his evidence to the inquiry, the Deputy Chief Inspector of Air Accidents, Philip Sleight described the purpose of an aircraft accident or incident investigation as being to

investigate the circumstances (of an accident or incident) and to make recommendations with the intention of preventing recurrence. Mr Sleight stressed that the purpose of an AAIB investigation was not to apportion blame or liability. In his words, the investigation was all about encouraging safety actions and making safety recommendations with a view to preventing the occurrence of a subsequent accident or incident in similar circumstances.

[127] This evidence is grounded in the terms of regulation 4 of the 1996 Regulations, which is in the following terms:

“The sole objective of the investigation of an accident or incident under these Regulations shall be the prevention of accidents and incidents. It shall not be the purpose of such an investigation to apportion blame or liability.”

Whilst expressed differently, the essence of regulation 8 of the 2018 Regulations is the same.

In their report in relation to the accident, the AAIB stress that it is inappropriate for their reports to be used to assign fault or blame or to determine liability since neither their investigations nor their reporting processes are undertaken for that purpose.

[128] The AAIB carried out a lengthy and extensive investigation into the accident. The investigation was carried out under the provisions of Regulation EU 996/2010 and the 1996 Regulations, and with the participation, in accordance with established international arrangements, of the Bundesstelle für Flugunfalluntersuchung of Germany, representing the state of design and manufacture of the helicopter, the Bureau d’Enquêtes et d’Analyses pour la Sécurité de l’Aviation Civile of France (“the BEA”), representing the state of design and manufacture of the engines, and the National Transportation Safety Board of the USA, representing the state of design and manufacture of the Full Authority Digital Engine Controls on the engines. They were supported by advisors from the helicopter manufacturer (i.e. Airbus), the BEA and the engine manufacturer (i.e. Safran). EASA, the

CAA and the helicopter operator (i.e. Bond) also assisted the AAIB. The AAIB's report on the circumstances of the accident was submitted to the Secretary of State for Transport and thereafter published on 23 October 2015, almost two years after the accident. The report, AAR 3/2015, entitled "Report on the accident to Eurocopter (Deutschland) EC135 T2+, G-SPAO Glasgow City Centre, Scotland on 29 November 2013"⁵ (which is hereinafter referred to as "the AAIB Report") is both detailed and comprehensive. Its authors, Marcus Cook, Peter Wivell and Robert Vickery, each gave evidence to the inquiry and spoke to the matters for which they were responsible within the AAIB Report.

[129] The speciality of air accidents in the context of fatal accident inquiries, and the weight to be given to reports such as that prepared in relation to the accident with which this inquiry is concerned, were each the subject of comment by Sheriff Principal Pyle at paragraph [7].3.1 of his determination following the fatal accident inquiry into the deaths of John Barkley and others, as a consequence of the accident involving the Super Puma helicopter, registration G-REDL on 1 April 2009⁶ (which I hereinafter refer to as "the Super Puma FAI").

[130] In England and Wales, a very different system operates in relation to the investigation of deaths of the type which fall under the ambit of the 2016 Act. Nonetheless, the observations made by the then Lord Chief Justice (Lord Thomas of Cwmgiedd) at

⁵ See https://assets.publishing.service.gov.uk/media/5628ea4ded915d101e000008/3-2015_G-SPAO.pdf; this version of the AAIB Report is an updated one containing certain corrections published in March 2016. Details of the corrections made can be found at https://assets.publishing.service.gov.uk/media/56f27ddf40f0b6038800001c/AAR_3-2016_G-SPAO_Correction.pdf

⁶ See <http://www.scotcourts.gov.uk/search-judgments/judgment?id=be6486a6-8980-69d2-b500-ff0000d74aa7>

paragraphs 55 to 57 of the judgment of the court in *R (Secretary of State for Transport) v Her Majesty's Senior Coroner for Norfolk* [2016] EWHC 2279 (Admin) are instructive:

“55. I consider it important to underline the significance of paragraph 49 of the judgment of Singh J in the light of the submission made to us on behalf of the coroner that she had a duty to conduct a full inquiry into the accident as a death had occurred during the accident. The submission reflected the tendency in recent years for different independent bodies, which have overlapping jurisdictions to investigate accidents or other matters, to investigate, either successively or at the same time, the same matter. On occasions each body considers that it should itself investigate the entirety of the matter rather than rely on the conclusion of the body with the greatest expertise in a particular area within the matter being investigated. The result can be that very significant sums of money and other precious resources are expended unnecessarily.

56. The circumstances of the present case provide an illustration of what in many cases will be the better approach. There can be little doubt but that the AAIB, as an independent state entity, has the greatest expertise in determining the cause of an aircraft crash. In the absence of credible evidence that the investigation into an accident is incomplete, flawed or deficient, a Coroner conducting an inquest into a death which occurred in an aircraft accident, should not consider it necessary to investigate again the matters covered or to be covered by the independent investigation of the AAIB. ...

57. It should not, in such circumstances, be necessary for a coroner to investigate the matter *de novo*. The coroner would comply sufficiently with the duties of the coroner by treating the findings and conclusions of the report of the independent body as the evidence as to the cause of the accident. There may be occasions where the AAIB inspector will be asked to give some short supplementary evidence: However, where there is no credible evidence that the investigation is incomplete, flawed or deficient, the findings and conclusions should not be reopened. ...”

[131] As previously noted, the procedure at an inquiry is to be as ordered by the sheriff. In this case, having regard to the availability of the AAIB Report and the period of time between its publication and the giving of a notice of an inquiry by the procurator fiscal, I determined that it was essential to identify any matter contained within the AAIB Report with which issue was taken by the participants prior to the inquiry commencing.

Accordingly, the procedure ordered in relation to the determination of the matters considered likely to be in dispute at the inquiry applied equally to the identification of any issue that arose in relation to the AAIB Report.

[132] A consolidated list of those issues was prepared and lodged with the court prior to the commencement of the inquiry. The AAIB Report could, self-evidently, only have regard to the facts that had been determined up to the time of publication. The inquiry had the benefit of certain evidence that is not considered within the AAIB Report. Accordingly, rather than publish that list on the SCTS website, or append it to this determination, I have, where appropriate, dealt with the issues which were raised by the participants in this determination.

[133] The approach commended by the Lord Chief Justice in *R (Secretary of State for Transport)* is, in my view, an eminently sensible and pragmatic one. It is entirely consistent with the approach adopted by Sheriff Principal Pyle in the Super Puma FAI. My assessment of the evidence before the inquiry, and of the submissions made to the inquiry by the participants, is that there is no credible evidence to suggest that the AAIB investigation was incomplete, flawed or deficient. Accordingly, save to the limited extent set out in this determination, there is no basis upon which the AAIB's findings and conclusions should not be adopted in the manner I was invited to by the procurator fiscal and a number of other participants in the inquiry.

10. The AAIB's Conclusion

Introduction

[134] The conclusion reached by the AAIB is to be found in Part 3 of the AAIB Report (at pages 94 to 96). This comprises (a) 29 findings; (b) four causal factors; and (c) three contributory factors.

Findings

[135] In certain respects, it was accepted that certain of the AAIB's findings should have been expressed differently. Firstly, finding 7 as drafted implies that the FUEL caution was, in fact, displayed. In evidence, Mr Vickery agreed that it would be more accurate to say it is not known whether and when the FUEL caution caption was displayed. I have amended finding 7 (below) accordingly – the amendment being depicted by underlined text. Secondly, the fuel samples were taken from the main tank of G-SPAO. As drafted, finding 24 was not as clear as it might otherwise have been in this regard. This point was also put to Mr Vickery who agreed that, when tested, the fuel samples taken from the main tank of G-SPAO were unadulterated, free from water contamination and within specification. I have amended finding 24 (below) accordingly – the amendment being depicted by underlined text.

[136] Subject to the foregoing observations, the findings reached by the AAIB were as follows:

1. The pilot was properly licensed and qualified to conduct the flight, and was well rested.

2. The helicopter was certified, equipped and maintained in accordance with existing regulations and approved procedures.
3. The helicopter was not required to have and was not fitted with flight recorders. However, some recorded evidence was recovered from non volatile memory in the helicopter's systems.
4. The helicopter took off with about 400 kg of fuel.
5. The evidence indicated that the main tank forward and aft fuel transfer pumps were OFF from a point on the helicopter's route between Dalkeith and Bothwell.
6. There was no evidence to indicate that the fuel contents display system was operating incorrectly.
7. It is not known whether and when the fuel caution caption was displayed on the Caution and Advisory Display (CAD).
8. The LOW FUEL warnings were triggered during the flight, and it was estimated that this occurred before the helicopter reached Bothwell.
9. The LOW FUEL warning audio attention-getters were acknowledged five times.

10. It was calculated that the helicopter did not land within 10 minutes of the activation of a continuous **LOW FUEL** warning, as stipulated in the Pilot's Checklist Emergency and Malfunction Procedures⁷.
11. ATC was not advised of any problem with the helicopter.
12. Both engines flamed out due to fuel starvation, about 32 seconds apart, as the helicopter was returning to Glasgow City Heliport.
13. The single engine emergency shutdown checklist was not completed following the first engine flameout.
14. The radio altimeter and the steerable landing light ceased to be powered following the second engine flameout.
15. The **SHED BUS** switch was not selected to **EMERG**, to repower the radio altimeter and steerable landing light.
16. The rotor rpm decreased below 97% and recovered twice before it decreased a third and final time.
17. The main rotor blades suffered lead-lag resonance, which, on the EC135 type, occurs between 60 to 70% N_r (main rotor rotation speed) when a control input is made to change the pitch of the main rotor blades.
18. The transmission system, main rotor blades and Fenestron were not being driven and were not rotating at the point of impact.

⁷ See Appendix 4 to this determination

19. No significant pre-impact technical defect was identified in any part of the aircraft or its systems.
20. The No 1 and No 2 engine control switches were correctly configured for flight.
21. The No 1 and No 2 fuel shut-off valves were correctly set to **OPEN**.
22. There was no usable fuel in the supply tank cells when the engines flamed out.
23. There was 76 kg (73 kg usable) of fuel in the main tank when the engines flamed out.
24. When tested, the fuel samples taken from the main tank of G-SPAO were unadulterated, free from water contamination and within specification.
25. The impact forces were in excess of the design and certification crashworthiness requirements of the EC135 fuselage structure and crew seats.
26. The flexible fuel tanks exceeded their crashworthiness requirement and remained fuel-tight after impact.
27. The fuel sensors collapsed in accordance with their design during deformation of the fuel tanks.
28. There was no fire.
29. The accident was not survivable.

Causal Factors

[137] The causal factors identified by the AAIB investigation were as follows:

1. 73 kg of usable fuel in the main tank became unusable as a result of the fuel transfer pumps being switched OFF for unknown reasons.
2. It was calculated that the helicopter did not land within the 10-minute period specified in the Pilot's Checklist Emergency and Malfunction Procedures, following continuous activation of the LOW FUEL warnings, for unknown reasons.
3. Both engines flamed out sequentially while the helicopter was airborne, as a result of fuel starvation, due to depletion of the supply tank contents.
4. A successful autorotation and landing was not achieved, for unknown reasons.

Contributory Factors

[138] The contributory factors identified by the AAIB investigation were as follows:

1. Incorrect management of the fuel system allows useable fuel to remain in the main tank while the contents in the supply tank become depleted.
2. The RADALT (radio altimeter) and steerable landing light were unpowered after the second engine flamed out, leading to a loss of height information and reduced visual cues.

3. Both engines flamed out when the helicopter was flying over a built-up area.

Findings in Fact

[139] The making of findings in fact is not a required component of a determination following a fatal accident inquiry. Rule 6.1 provides that a determination is to be in Form 6.1, which in turn provides that the determination is to “Set out the facts”. Albeit made in the context of an inquiry under the 1976 Act and the then applicable rules, Sheriff Principal Pyle’s observations in relation to the making of findings in fact at paragraph [7] of his determination following upon the Super Puma FAI are still relevant.

[140] In this inquiry, the procurator fiscal proposed that I make 44 findings in fact. These are to be found in paragraphs 7 to 50 of the procurator fiscal’s written submissions⁸.

Certain of the participants proposed amended, alternative and / or additional findings in fact. Moreover, certain of the participants proposed amendments to the findings made by the AAIB and / or additional findings to those made by the AAIB. The two categories can be conveniently considered together.

[141] Findings in fact fall very much within the province of the lawyer. They are no longer a requirement in a judgment in an ordinary action in the sheriff court (see Ordinary Cause Rule 12.2) and, as noted above, are not required in a determination following a fatal accident inquiry. To present findings in fact in a determination, even in the manner suggested by the learned authors in “*Sheriff Court Practice*” (3rd ed.) at paragraph 17.04, would not be of assistance to a lay reader of this determination. Moreover, absent the

⁸ See <http://www.scotcourts.gov.uk/docs/default-source/fatal-accident-inquiries/clutha-fai/01-crown-submissions.pdf?sfvrsn=2>

making of hundreds of findings in fact, to proceed in such a manner would potentially present an incomplete picture. Written decisions, such as this determination, need to be written in a manner that, insofar as is possible having regard to the factual and legal issues which require to be considered, is comprehensible to the public⁹.

[142] Accordingly, notwithstanding the invitation to do so, I have elected not to make findings in fact; rather, I consider below the various aspects of the inquiry and set out the relevant facts under appropriate headings to assist intelligibility. In doing so, I address also the issues with which the inquiry is concerned (set out in Appendix 2), insofar as they have not already been addressed in this determination.

11. The Cause of the Accident Resulting in the Deaths

[143] A further matter the sheriff is required to address in his or her determination is the cause or causes of any accident resulting in the death (see sub-section 26(2)(d), which is issue 4 for the inquiry). The primary cause of the accident is not in doubt. Whilst airborne, G-SPAO's engines flamed out sequentially as a result of fuel starvation, due to depletion of the contents of the supply tank cells. This was caused by the fuel transfer pumps on G-SPAO being turned off by Captain Traill. There was no usable fuel in either supply tank cell when the engines flamed out. At the time of the accident, there was more than sufficient usable fuel (73 kg) in G-SPAO's main tank to permit it to return to GCH. Captain Traill was unable to successfully perform an autorotation (considered below in Part 21) and landing, causing the helicopter to crash in the manner described in Part 7 above.

⁹ See "Statement of Principles of Judicial Ethics for the Scottish Judiciary" at paragraph 9.4 – see <http://www.scotland-judiciary.org.uk/21/0/Principles-of-Judicial-Ethics>

[144] As set out above in Finding F4.1 above, I have found that the cause of the accident resulting in the deaths was that the engines of the Eurocopter Deutschland EC135 T2+ helicopter, with registration G-SPAO, owned and operated by Bond Air Services Limited, then carrying out operations on behalf of Police Scotland, flamed out sequentially while the helicopter was airborne, as a result of fuel starvation, due to depletion of the contents of the supply tank; and that Captain Traill was unable to successfully perform an autorotation and landing. That finding is based on causal factors 3 and 4 in the AAIB report (see paragraph [137] above).

[145] That much was not in issue before the inquiry. The central issue was why Captain Traill allowed the supply tanks to deplete to the point that they did when there was more than sufficient usable fuel available to him in the main tank to allow G-SPAO to return safely to GCH. It is, however, clear from the evidence that the accident was caused by Captain Traill's failure to ensure that at least one of the fuel transfer pump switches was set to ON (see Finding F4.2).

[146] For the reasons set out in Part 15 below, I have determined that that occurred due to the failure of the pilot of the helicopter, Captain Traill, to follow the procedure set down in the Pilot's Checklist – Emergency and Malfunction Procedures (hereinafter referred to as the "Pilot's Checklist") in respect of the **LOW FUEL 1** and / or **LOW FUEL 2** warnings (see Appendix 4 to this determination).

[147] It is appropriate to add that, whilst this was not the cause of the accident resulting in the deaths, for the reasons set out in Part 18 below, I am satisfied the quantities of fuel displayed on the fuel quantity indication system of G-SPAO contradicted the **LOW FUEL**

warnings. As set out above in Finding F7.1 above, I have found that this fact is relevant to the circumstances of the deaths.

12. The Fuel System

Introduction

[148] To properly understand the circumstances which led to the accident, it is necessary to set out in some detail certain aspects of the fuel system on G-SPAO. Having regard to the clarity with which these matters are explained in the AAIB Report, this part of my determination sets out the AAIB's explanations of the aspects considered, with a limited number of minor amendments, which I have made to assist understanding and to give some context against the matters considered in this determination.

Fuel Tank Arrangement

[149] The first aspect to consider is the fuel tank arrangement on G-SPAO. This is considered in the AAIB Report at paragraph 1.6.4.1 (and shown in Figure 3 in the AAIB Report) which, insofar as relevant to this determination and with my own minor amendments, I set out below in paragraphs, [150], [151] and [153].

[150] The aircraft fuel storage system in the EC135 consists of two impact-resistant tanks positioned beneath the cabin floor. The forward tank (known as the main tank), is a single volume without baffles or major internal obstruction, whilst the aft tank (known as the supply tank) has a longitudinal divider in its lower section, creating two separate cells, referred to as the No 1 (left) and No 2 (right) supply tank cells, respectively. These cells are connected by the undivided volume of the upper section of the supply tank. This feature of

the design permits fuel to move between the No 1 and No 2 supply tank cells. Fuel is drawn from the No 1 supply tank cell for the No 1 engine, whilst the No 2 engine draws fuel from the No 2 supply tank cell.

[151] The capacity of the No 1 supply tank cell is 49 kg, whilst the capacity of the No 2 supply tank cell is 44.5 kg. This difference is achieved by including an intrusion into the bottom of the No 2 supply tank cell. The 4.5 kg difference in volume is to provide a time interval between engine flame-outs, should fuel exhaustion occur. This is considered below in Part 20. The volume of the upper section of the supply tank is symmetrically disposed either side of the aircraft centre-line. The main tank capacity is 474.5 kg, which, when added to the capacity of the two supply tank cells, gives a total fuel capacity of 568 kg, of which 7.6 kg is considered to be unusable fuel.

[152] There are two further matters of significance. Firstly, the total fuel capacity of G-SPAO was 710 litres. Secondly, G-SPAO did not have self-sealing supply tanks. These two matters are of significance in determining the landing time following the receipt of a **LOW FUEL 1** and / or **LOW FUEL 2** warning.

[153] Two overflow channels connect the main tank to the supply tank. The overflow channels are positioned with their lower edges close to the level of the top of the supply tank divider. When the main and supply tanks are full of fuel (i.e. above the supply tank divider and overflow channel levels) fuel can flow freely between the main and supply tanks.

[154] The AAIB Report also explains the fuel tank vent system on an EC135 (see paragraph 1.6.4.2) and the engine fuel return and fuel tank vent system (see paragraph 1.6.4.2.1).

Fuel Transfer

[155] The second aspect of the fuel system on G-SPA0 which requires to be considered is the system of fuel transfer. This is considered in the AAIB Report at paragraph 1.6.4.2.2 which, insofar as relevant to this determination and with my own minor amendments, I set out in the following seven paragraphs, [156] to [162].

[156] Prime pumps (shown as “supply pumps” in Figure 3 in the AAIB Report) at the bottom of each supply tank cell feed their respective engine fuel control units, for starting the engines and during certain emergency conditions. They are normally OFF during flight.

[157] To ensure a constant transfer of fuel into the supply tanks, there are two electrical transfer pumps fitted towards the forward and aft (i.e. rear) ends of the main tank. The transfer pumps are referred to as the forward and aft transfer pumps, respectively. It is important to understand that in normal operation, one or both of these transfer pumps should be running constantly, to deliver fuel via non-return valves into a common transfer manifold. The manifold feeds two fuel delivery pipes, each of which passes through one of the two overflow channels, into the supply tank, terminating above the top of the No 1 and the No 2 supply tank cells respectively. Thus, with either or both transfer pumps delivering fuel and the engines running, both supply tank cells are continuously replenished from the main tank and the contents of the main tank will consequently decrease.

[158] Each fuel transfer pump is capable of delivering 10 kg of fuel per minute to the supply tank, which is three times the average rate of fuel consumption of both engines, combined (see paragraph [174] below). This excess fuel delivery capability means that, when the fuel level in the main tank is lower than the overflow channels, excess fuel in the supply

tank flows back into the main tank, via the overflow channels. Therefore, with one or more transfer pumps operating, the supply tank contents will be maintained at least level with the lowest point of the overflow channels, as long as a useable amount of fuel remains in the main tank.

[159] In flight, as the depth of the fuel in the main tank reduces and the pitch attitude of the helicopter changes, one or other of the transfer pump inlets can become uncovered, causing the associated pump to run dry. The dry running is detected by the helicopter's fuel control and indication system software, which produces an **F PUMP AFT** or **F PUMP FWD** caution caption on the caution and advisory display ("CAD") in the central panel display system ("CPDS") (see Part 14 below). The appearance of this caution caption prompts a procedure in the Pilot's Checklist (reproduced in Appendix 4 to this determination).

[160] The quantity of fuel in the main tank and the helicopter's pitch attitude determine when the fuel transfer pumps become exposed. With a small quantity of fuel in the main tank, only small positive or negative pitch attitudes are required for the transfer pumps to run dry. Similarly, larger pitch attitudes are required when there is a greater quantity of fuel in the main tank.

[161] An algorithm is built into the CPDS software to prevent intermittent fuel transfer pump captions appearing during dynamic manoeuvres in flight (a common occurrence in, for example, police operations) as the fuel moves about in the main tank. This inhibits the caption until there has been a continuous period of three minutes during which the pump has run dry. If, within the three-minute period, the pump becomes re-immersed in fuel, the three-minute delay is reset to zero to await the next dry running condition.

[162] The F PUMP AFT and F PUMP FWD caution captions will also illuminate after three minutes if the fuel transfer pumps are switched OFF while immersed in fuel or become blocked. A message is not provided for the situation where a pump has been switched OFF, after running dry, and is then re-submerged in fuel, however, it should be stressed that the F PUMP AFT and F PUMP FWD caution captions will be illuminated after three minutes if the fuel transfer pumps are switched OFF and remain illuminated until the fuel transfer pumps are switched back on.

[163] There is one aspect of paragraph 1.6.4.2.2 of the AAIB Report which, with the greatest of respect to the authors, appears to me to be incorrect. The passage which considers the dry running of the transfer pumps (see paragraph [159] above), concludes with the following sentence:

“Although the pumps are capable of running dry for up to 20 minutes, this feature is included in order to protect the pumps from running without fuel cooling or lubrication.”

G-SPAO was fitted with Test Fuchs pumps, which are capable of running dry for considerably longer than G-SPAO could stay in the air. Holger Mendick, a fuel system expert and compliance verification engineer with Airbus, confirmed that Test Fuchs pumps had been tested for five-hour dry run cycles twenty times each, a total of 100 hours dry running, without any signs of degradation. It appears that the passage of the AAIB Report quoted above does, in fact, apply to Globe pumps, which were fitted to earlier models of the EC135.

Fuel Sensors

[164] The third aspect of the fuel system on G-SPA0 which requires to be considered is the fuel sensors. This is considered in the AAIB Report at paragraph 1.6.5.1 which, insofar as relevant to this determination and with my own minor amendments, I set out in the following two paragraphs, [165] and [166].

[165] The fuel contents indication system includes four capacitance sensors, one positioned near each end of the main tank and one in each cell of the supply tank. They are each mounted on a removable metal plate, positioned at the geometrically lowest points in the tanks, and extend vertically for the full tank depth. The removable plates also carry the transfer and prime pumps in the main and supply tanks respectively. The different tank depths dictate that the main tank sensors are slightly longer than the supply tank sensors. The top of each sensor is located in a small rubber cup bonded into the structure of the tank.

[166] The fuel gauge displays are signalled by the variation in the frequency of the current in the circuits incorporating the tank level sensors. The sensors are typical of aviation fuel gauge units, being capacitors in which the "plates" take the form of concentric tubes and the dielectric is the material occupying the space between the tubes. With fuel occupying the full depth of a tank, the dielectric is aviation fuel, whilst in an empty tank the dielectric is air. The difference in dielectric characteristics between air and fuel results in a different capacitance, and different frequency, when the tank is full compared to that when it is empty. Hence, the low frequency created with a full tank of fuel contrasts with the high

frequency created by an empty tank. Proportionate frequencies are created at intermediate fuel levels.

Fuel Contents Gauges

[167] The fourth aspect of the fuel system on G-SPA0 which requires to be considered is the fuel contents gauges. This is considered in the AAIB Report at paragraph 1.6.5.2 which, insofar as relevant to this determination and with my own minor amendments, I set out in the following three paragraphs, [168] to [170].

[168] The frequencies generated by the four individual sensor circuits are processed by software within the CPDS unit to provide indications on the CAD, both pictorially and numerically, of the fuel masses allocated to the main tank and actually present in each of the supply tank cells.

[169] If a very low frequency registers, significantly below that appropriate to full fuel tanks, the software detects an impossible situation and the relevant pictorial and numerical fuel displays on the CAD are supplemented by **F QTY FAIL** or **F QTY DEGR** caution captions. The **F QTY FAIL** caption indicates that one of the supply tank sensors has failed or both main tank sensors have failed. Under these circumstances, the applicable graphic on the CPDS indicates zero. The CAD caption **F QTY DEGR** indicates that one of the two main tank sensors has failed and that the fuel tank indication is degraded and no longer reliable. In this case, the CPDS graphic will not change to zero but will show a fuel quantity based on a more conservative calculation within the indication algorithm, so as not to show more fuel than is available. The appearance of either the **F QTY FAIL** or **F QTY DEGR** caution caption also

prompts a procedure in the Pilot's Checklist. That particular procedure is not of significance to this determination, however, it can be found at Appendix A-2 of the AAIB Report.

[170] In the supply tank, the sensor tubes measure the fuel in their respective supply tank cell (i.e. on each side of the divider) and the fuel which is in the supply tank above the top of the divider. The measured contents detected by each sensor, less the fixed capacity of its supply tank cell, is added by the software to the amount in the main tank, to produce a total which is displayed as main tank contents. Thus, the fuel in the supply tank above the level of the divider is treated as part of the main tank contents for the purpose of the fuel contents indication system.

[171] As is explained in the AAIB Report at paragraph 1.6.5.3, to clarify and enhance the EC135 Training Manual, Airbus issued an Information Notice to operators of the EC135 in March 2014 (No. 2693-I-28, dated 5 March 2014, which is reproduced as Appendix B to the AAIB Report). Whilst this information notice was issued more than three months after the accident, the terms of paragraph 1.6.5.3 are worth setting out by way of explanation as to how the indication system operated at the time of the accident.

[172] The information notice explained in detail the logic of the supply and main tank contents indication system and the effect that aircraft pitch has on the movement of fuel and its quantity measurement. The information notice clarified the way in which the fuel in the supply tank above the divider is measured by the sensors and is allocated, by the software, to the main tank, being added to the actual quantity of fuel in the main tank. This is shown to the pilot on the display as a single main tank contents figure. In addition, the information notice detailed the effect that aircraft pitch has on fuel in the supply tank, as it rises and falls

within the sensors. If the fuel is at or above the divider level and aircraft pitch causes the fuel to rise up the sensor, it will be added to the main tank contents while that pitch angle remains.

[173] As a helicopter's pitch attitude changes during flight, the fuel within the main tank rises and falls around the forward and aft fuel sensors, which causes their outputs to differ. These varying outputs are taken into account in the fuel quantity indication software, which uses a set of algorithm tables within the display driver to compensate for positive and negative pitch. It is accepted that fuel movement may be dynamic in nature, so the system is designed to display conservative tank contents figures.

Fuel Consumption

[174] The issue of fuel consumption is considered at paragraph 1.6.6 of the AAIB Report. An examination of the records relative to G-SPAO indicated that its fuel consumption was, on average, 3.3 kg / min. The 3.3 kg / min figure is significant when considering the issues before the inquiry. The examination of the records relative to G-SPAO also showed that, over the course of 125 sectors (i.e. flights) flown, from the end of October 2013 to the date of the accident, the minimum landing fuel recorded was 100 kg, with an average landing fuel of 243 kg. The quantities recorded by the pilots and engineers in the Tech Log Sector Record are those read directly from the display on the CAD in G-SPAO. It is notable, as set out in paragraph [136] above, finding 23, that at the time of the accident G-SPAO was carrying only 76 kg of fuel.

Fuel Contents Cautions and Warnings

[175] The final aspect of the fuel system on G-SPAO which requires to be considered is the fuel contents cautions and warnings. This is considered in the AAIB Report at paragraph 1.6.7 which, insofar as relevant for this determination and with minor amendments I have made to assist understanding, is set out in the following five paragraphs [176] to [180].

[176] In addition to the fuel system caution captions already described, an amber fuel caution is triggered by the contents level software and displayed on the CAD display when the level in one of the supply tank cells drops below a certain quantity. This caution is normally activated when the No 1 supply tank cell content falls below between 34 and 36 kg or when the No 2 supply tank cell content falls below between 30 and 32 kg. The **FUEL** caution illuminates when the fuel level in either supply tank cell reaches the appropriate range and does not distinguish between the two cells.

[177] A separate low fuel warning system is signalled by thermistors (a resistor based on a semiconductor having high negative temperature coefficient of resistance) which are attached to the outside of the fuel sensor capacitance tubes in the supply tank cells. The fuel cools the thermistors, when covered, but, once the fuel level falls below the thermistors, the cooling ceases and the thermistors heat up, altering their resistance. This triggers the **LOW FUEL 1** or **LOW FUEL 2** red warning caption, as appropriate, to illuminate on the warning unit. An audio attention-getter, in the form of a gong, is also initiated. These warnings are activated when the fuel level falls below between 26 and 34 kg in the No 1 supply tank cell or below between 22 and 30 kg in the No 2 supply tank cell.

[178] In the context of this inquiry, it is vital to stress that the **LOW FUEL** warning feature is independent of the fuel contents indication system and the amber **FUEL** caution.

[179] When a helicopter is in a level attitude the thermistors will trigger at the same time, if the same quantity of fuel has been removed from both supply tank cells. However, one thermistor is mounted slightly forward of the other. As a consequence, when G-SPAO is not level, one thermistor will tend to trigger before the other. In addition, if a thermistor is just exposed, an increased nose-down attitude will temporarily cover the sensor, clearing the warning until more fuel has been used and the fuel sensor is exposed once more. The converse is true for an increased nose-up pitch attitude. Similarly, a lateral force, such as in an unbalanced turn, with the fuel level close to the thermistor, may generate an early warning or delay it. The tendency for a helicopter's pitch attitude or a lateral force to affect the onset of the LOW FUEL warning diminishes as the fuel levels in the supply tank cells decrease.

[180] As with the LOW FUEL warnings, the Pilot's Checklist contains the actions that should be taken when the amber FUEL caution illuminates. That particular procedure is not reproduced in this determination, however, it can be found at Appendix A-4 of the AAIB Report.

13. Captain Traill's Relevant Training and Knowledge

[181] The conduct of Captain Traill on 29 November 2013 requires to be viewed in light of the training he received and in light of his knowledge of certain matters. As noted above (see paragraph [117]), by that time he was a helicopter pilot of considerable experience.

[182] Captain Traill left the RAF in 2008 and underwent Bond's ground school training in June of that year. Captain Anthony Stevens qualified to instruct helicopter pilots on the EC 135 and to assess qualified helicopter pilots on their ability to fly the EC135 in 2008. Captain

Stevens qualified as a type rating instructor; as a type rating examiner; and as an instrument rating instructor in 2008. Captain Stevens was the instructor responsible for parts of Captain Traill's training in 2008.

[183] Captain Stevens was employed by Bond as their Chief Training Captain between May 2012 and February 2016. As such, he was responsible for the oversight of pilot training for all helicopter pilots employed by Bond. Captain Stevens was assisted in that task by a team of captains who worked under his supervision. That team comprised line training captains and type rating instructors / examiners.

[184] Captain Traill underwent Bond's ground school training in or around the period 23 to 27 June 2008. In or around the period 23 June 2008 to 15 July 2008, Captain Traill underwent Bond's initial EC135 type rating training programme.

[185] On 23 June 2008 Captain Stevens provided training to Captain Traill. The training session lasted three hours, of which a 15 minute part comprised training in relation to the location of fuel tanks and fuel lines.

[186] On 24 June 2008 Captain Stevens provided further training to Captain Traill. The training session lasted four hours and was conducted in a classroom-based environment. A 45 minute part of that training session comprised training in relation to the airframe fuel system. During that part of the training, Captain Stevens referred to slides which included mention of warnings and cautions pertinent to the fuel system as displayed on the EC135 CPDS and warning panel and reinforced the order of cautions and warnings which would be displayed in the event of a **LOW FUEL** situation as fuel contents reduced with consequent sequential loss of power to engines.

[187] The training on 24 June 2008 also covered the switching off, or repeated switching off, of “unsubmerged” fuel transfer pumps on illumination of the F PUMP AFT or F PUMP FWD cautions and the re-activation of those pumps. This training also covered the interaction between transfer pumps and prime pumps and the effect on fuel sensors of a “nose-up” or “nose-down” aircraft position, especially in the context of police operations often conducted at a hover.

[188] On 26 June 2008 Captain Stevens provided further training to Captain Traill. The training session lasted approximately one hour and was conducted in the helicopter simulator and related to the CDPS and to warning lights and instrumentation.

[189] It was Captain Stevens’s normal practice, during initial type rating training programmes of the sort given to Captain Traill in June 2008, to train pilots that, in the event of a LOW FUEL warning appearing, he or she should refer to and comply with the flight reference card emergency checklist, otherwise referred to as the Pilot’s Checklist¹⁰.

[190] It was Captain Stevens’s normal practice during initial type rating training programmes of the sort given to Captain Traill in June 2008, to train pilots on the order in which cautions and warnings would appear, should a flight be extended to the point where supply tank fuel contents start to reduce. Such training would include:

- (i) Amber cautions for (usually) the aft transfer pump running dry then the forward transfer pump running dry;
- (ii) Amber caution for the supply tank contents reducing; and

¹⁰ See Appendix 4 to this determination

(iii) Red warning for supply tank contents decreasing below the level of the thermistors, highlighting that this is an abnormal and emergency situation and the need to land within eight or ten minutes depending on fuel tanks fitted.

[191] It was normal practice that, during Bond's EC135 type rating training, pilots were trained to complete emergency procedures relevant to a double engine failure, including a safe forced landing by means of autorotation. It was normal practice that Bond's initial autorotation training would involve successful completion of approximately 30 autorotation landings in a simulator. All such autorotations undertaken in the simulator were completed to ground level and might simulate taking place over built-up areas.

[192] It was normal practice, during Bond's 6-monthly operator's proficiency check assessments, that pilots were required to demonstrate their ability to perform autorotation in the aircraft. Such autorotations would take place in daylight visual conditions (instigated at a height of 1500 to 2000 ft) and in cloud (instigated at not less than 3000 ft; this autorotation requiring reliance only on instrumentation in the absence of visibility). It was normal practice that, once each year, Bond pilots were required to demonstrate their ability to perform a helicopter autorotation in darkness. The autorotation in the operators' proficiency check was carried out in a simulator. That should be contrasted with the position in the 12-monthly licence proficiency check, in which autorotation is carried out in a helicopter.

[193] In each such circumstance, pilots were expected to enter autorotation in accordance with the Pilot's Checklist and thereafter to demonstrate, in so far as time and situation would permit, selection of and steering towards a suitable landing site, consideration of an engine re-light, activation of the SHED BUS, the issuing of warnings to passengers for an emergency landing and the making of a MAYDAY call. All such training autorotations

undertaken in a helicopter were carried out with engines at idle and took place in a safe location on an airfield away from built-up areas, to a safe height above ground and without a landing being completed. Autorotations in the simulator were usually intended to end up on a suitable area such as an airport; however, where the approach was misjudged or carried out away from an airfield location, the pilot would be expected to select the best site available and carry out an autorotative landing there.

[194] Prior to November 2013, the helicopter simulator was not used to simulate low fuel situations as the simulator was not set up to replicate the behaviour of a helicopter in this regard. The simulator was used to replicate fuel leaks so as to train pilots to monitor fuel levels and use during flight.

[195] In relation to Captain Traill's state of knowledge as at 29 November 2013, consideration must also be given to the terms of two information notices issued by Eurocopter / Airbus.

[196] Firstly, there is Information Notice No. 2381-I-28, issued on 3 November 2011, more than two years prior to the accident, and affecting, amongst other types, the EC135 T2+. This information notice related to the fuel system and, in particular, the supply tanks.

[197] Secondly, there is Information Notice No. 2535-I-28, issued on 21 January 2013, just over 10 months prior to the accident, and affecting, amongst other types, the EC135 T2+. This information notice (considered below at paragraph [279]) also related to the fuel system and, in particular water contamination of the fuel system, which issue is considered below in Part 18.

[198] The means by which information notices such as these were brought to the attention of pilots was spoken to in evidence by Captain Craig Trott. Captain Trott joined Bond in 2002 initially as a line pilot; then as a line training captain for a number of years; and then again as a line pilot, a role he continued to hold when giving evidence to the inquiry.

[199] In evidence, Captain Trott described, in general terms, how information from the manufacturer, such as Information Notices, would be drawn to the attention of a pilot. In relation to Information Notice No. 2381-I-28, Captain Trott was certain that he put a copy of this notice on the training board, which was located in front of the office in GCH then used by Captain Trott as a line training captain. Captain Trott spoke also of a "Pilots to read" folder in which was placed information that affected all pilots. That folder was kept in the operations room. A signatory list was placed at the front of the folder. Pilots were required to sign to confirm that they had read each item placed within the folder.

[200] In addition to the "Pilots to read" folder, Captain Trott described a "traffic light system" board which was located on the wall in the operations room. This had the name of each pilot and a double-sided counter, which was red on one side, and green on the other. It is part of the pre-flight procedures that pilots check this board. If an item was placed in the "Pilots to read" folder, each pilot's counter would be turned to display the red side. That indicated to a pilot coming on shift that there was an important document to read. Before flying, each pilot was required to (i) read the document; (ii) sign the signatory list to say he or she had read it; and (iii) turn his or her counter to display the green side. Captain Trott's recollection was that the chief pilot at GCH would have overall responsibility to ensure that each pilot read the document in question. In the event that the requisite steps outlined above

were not taken, Captain Trott's evidence was that the chief pilot would address that and ensure that the document was read by the pilot in question.

[201] Captain Trott had no reason to suspect that this process of conveying information to pilots was not followed in relation to both Information Notice No. 2381-I-28, issued on 3 November 2011, and Information Notice No. 2535-I-28, issued on 21 January 2013. I have no hesitation in accepting this evidence. Captain Trott was an impressive witness – he was clear and open in his answers to questions and clearly had a very good recollection of events.

[202] Accordingly, I am satisfied that Captain Traill was familiar with the terms of both Information Notice No. 2381-I-28 and Information Notice No. 2535-I-28.

14. Why Were G-SPAO's Fuel Transfer Pumps Switched Off?

[203] One of the issues for the inquiry, issue 4.1, was how fuel was managed on G-SPAO and, in particular, why both fuel transfer pumps were switched OFF, rendering unusable the otherwise usable fuel in the main tank.

[204] The starting point for a consideration of this issue is that the available evidence overwhelmingly confirms that that one or both of G-SPAO's fuel transfer pumps had been ON during much of the accident flight. This conclusion is supported by a combination of factors, namely, the duration of the accident flight (1 hour and 38 minutes); the quantity of fuel present in G-SPAO when it took off (400 kg); and the quantity of fuel recovered from the main fuel tank post-accident (76 kg). Put simply, if the fuel transfer pumps had never been ON, G-SPAO could not have flown for as long as it did and used as much fuel as it did.

[205] On the other hand, the combination of the quantity of fuel recovered from the main fuel tank post-accident; the absence of fuel in either supply tank cell; and the results of the AAIB's examination of the wreckage (which found the switches for both fuel transfer pumps to be in the OFF position) confirm that both fuel transfer pumps must have been in the OFF position for a period prior to the accident.

[206] As noted above (see paragraph [159]), in flight, as the quantity (and, consequentially, the depth) of the fuel in the main tank reduces and the pitch attitude of an EC135 changes, one or other of the transfer pump inlets can become uncovered, causing the associated pump to run dry. The AAIB's calculations (see paragraph [52] above) are that on completion of its task at Dalkeith, at 2145 hours, G-SPAO commenced its transit back towards Glasgow with approximately 192 kg of fuel remaining. Captain Prior's calculations are that either 181 kg or 188 kg of fuel remained at this point.

[207] From the available evidence, I am satisfied that one of G-SPAO's fuel transfer pumps continued to operate for a period after it had left Dalkeith and commenced its journey back towards Glasgow.

[208] I reach this conclusion on the basis of the fuel calculations, with which no issue was taken in the inquiry. The starting point is the lowest fuel figure calculated for the point at which G-SPAO's task at Dalkeith was completed, namely, 181 kg. Deducting from that figure the quantity of fuel recovered from G-SPAO's main tank post-accident, namely, 76 kg gives a figure of 105 kg. That figure is in excess of the capacity of the supply tank below the overflow channels, namely, 90 kg. The conclusion remains the same, even if one utilises the total capacity of the supply tank, namely, 93.5 kg, albeit with that quantity of fuel in the

supply tank, the overflow channels would come into play and fuel would likely be transferred back to the main tank.

[209] In either scenario the total of the supply tank capacity and the fuel recovered from the main tank is less than the amount of fuel calculated as having been aboard G-SPAO when it left Dalkeith. It is appropriate to add that it cannot be discounted that fuel subsequently moved from the supply tank to the main tank (as can occur when an EC135 flies with a nose down attitude – as demonstrated by the tests narrated at paragraph 1.16.8.1 of the AAIB Report). In those circumstances, the conclusion I have reached would remain valid, the only effect of such fuel movement being that the fuel transfer pump or pumps would have run for longer.

[210] The conclusion I have reached in this regard is supported by Captain Prior's report and evidence, namely, that it is highly improbable that both fuel transfer pumps were switched off simultaneously (there being no reason to perform such an action) and that the fuel contents of G-SPAO suggest that the second pump was switched off approximately 26 minutes before the accident, at which time G-SPAO was transiting back towards Glasgow.

[211] Accordingly, in the absence of any other explanation (there was none before the inquiry), the only conclusion that can be reached is that one or both of the fuel transfer pumps must have continued to operate for a period after G-SPAO had left Dalkeith and commenced its journey back towards Glasgow. The question which then falls to be considered is in what circumstances were the fuel transfer pumps on G-SPAO switched OFF?

[212] The nature of the activities carried out by G-SPAO at Dalkeith, a routine surveillance task during which approximately one minute of Forward Looking Infra-Red video was

recorded by the crew, was such as might create the circumstances in which the F PUMP FWD caution was illuminated. A trial flight was flown to try and replicate those conditions (see the AAIB Report at paragraph 1.16.8.1). The F PUMP FWD caution was not illuminated in the course of this trial flight.

[213] Airbus carried out its own flight trial. This is described at paragraph 1.16.9 of the AAIB Report. Airbus's conclusion was that, given the likely conditions and length of time G-SPAO was at Dalkeith, it was probable that the F PUMP FWD caution message did not illuminate there.

[214] In his report, Captain Prior concluded that it was possible that the forward fuel transfer pump could have been exposed during the tasking at Dalkeith, although the gap in the available radar data meant this could not be confirmed. In evidence, Captain Prior suggested that at this time, Captain Traill might have received a F PUMP FWD caution message and selected the forward transfer pump to OFF. In Captain Prior's evidence unless the forward transfer pump was turned off at that point, one would have to assume that both of the transfer pumps were switched off at the same time, which I took Captain Prior to regard as highly improbable. It is appropriate to add that Captain Prior had certain reservations regarding the Airbus flight trials, making the point that he was not persuaded that the helicopter in the flight trial had been flown at the correct profile.

[215] Captain Trott flew on the opposite shift to Captain Traill at the time of the accident and was, thus, experienced in flying G-SPAO. In relation to G-SPAO's task at Dalkeith, Captain Trott indicated that he would have expected to, and often would, receive a forward fuel transfer pump caution in that sort of scenario. Moreover, Captain Trott carried out an

experiment of sorts in G-BZRS, another Bond helicopter which was to all intents and purposes identically configured to G-SPAO. Captain Trott endeavoured to replicate the AAIB test flight whilst flying over Dalkeith at a fuel state similar to G-SPAO's during the accident flight. In the course of Captain Trott's flight the **F PUMP FWD** caution was illuminated.

[216] There is one further factor of significance. As set out in the submissions made on behalf of Dr Thomas, I have no hesitation in concluding that Captain Traill was an experienced pilot.

[217] As noted by Captain Prior, simultaneously switching off both fuel transfer pumps is inherently improbable. There is no evidence before the inquiry to support such a conclusion. Having excluded that possibility, all that remains is that the flight conditions over Dalkeith were such that the the **F PUMP FWD** caution illuminated and Captain Traill, properly, turned the forward fuel pump off. That is the step an experienced pilot would have taken in the circumstances contemplated. In my view, it is more likely than not that this is what happened over Dalkeith.

[218] On the evidence, I am satisfied that in the course of G-SPAO's activities at Dalkeith the **F PUMP FWD** caution illuminated, the quantity of fuel in its main tank and pitch attitude being such that the forward fuel transfer pump was exposed for three minutes, causing the associated pump to run dry. The relevant caution having illuminated on the CAD, Captain Traill followed the procedure set out in the Pilot's Checklist (reproduced in Appendix 4 to this determination).

[219] At this point in time, the fuel quantity in the main tank would not have been low. The evidence is strongly suggestive of both fuel transfer pumps being on at this point. As the main tank had within it sufficient fuel to keep both fuel transfer pumps wet, Captain Traill would have taken the necessary steps to ensure the fuel transfer pump was, in fact, operating and then moved the FUEL PUMP XFER-F switch to the off position, switching off the forward fuel transfer pump. It is probable that this occurred at or about the point immediately before G-SPAO left Dalkeith at 2145 hours.

[220] I turn now to consider the circumstances in which the aft fuel transfer pump came to be switched off. Again, a trial flight was flown to try and replicate those conditions (see the AAIB Report at paragraph 1.16.8.1). In this case, the trial flight replicated, as closely as possible, G-SPAO's radar profile from completion of the task at Dalkeith to the commencement of the task at Bothwell. During this trial the F PUMP AFT caution was illuminated.

[221] Again, Airbus carried its own flight trial to see if the F PUMP AFT caution caption could have illuminated whilst G-SPAO was transiting from Dalkeith to Bothwell. This flight trial is described at paragraph 1.16.9 of the AAIB Report. Airbus were unable to generate such a caution during their trial.

[222] In his report, Captain Prior suggests that a six degree nose down pitch altitude would be necessary to cause the aft transfer pump to become exposed with 73 kg of fuel in the main tank (that being the quantity of useable fuel discovered therein post-accident). Captain Prior calculated the necessary fuel quantities as having pertained at 2156 hours, following the initial descent from 3,000 feet to 2,000 feet as G-SPAO passed Cobbinshaw, as

described above in paragraph [52]. In Captain Prior's opinion, conditions such as would expose the aft fuel transfer pump existed approximately 26 minutes before the accident.

[223] On the evidence, I am satisfied that the **F PUMP AFT** caution caption illuminated at or about 2156 hours on 29 November 2013. The relevant caution having illuminated on the CAD, Captain Traill followed the procedure set out in the Pilot's Checklist. Again, at this point in time, the fuel quantity in the main tank would not have been low. The main tank had within it sufficient fuel to keep both fuel transfer pumps wet. It is probable that Captain Traill took the necessary steps to ensure that the aft fuel transfer pump was, in fact, operating and then moved the fuel pump **XFER-A** switch to the **OFF** position, switching off the aft fuel transfer pump.

[224] In conclusion, I am satisfied that, at separate points in G-SPAO's final flight, circumstances existed that caused Captain Traill to switch off both fuel transfer pumps; and that they were each properly switched off by Captain Traill. Regrettably, when switching off the second (i.e. the aft) fuel transfer pump, Captain Traill appears to have overlooked the fact that he had previously switched off the forward fuel transfer pump approximately 11 minutes earlier.

[225] The fuel control and indication system software does not give an alert when a pump that has been switched off is re-submerged in fuel. Accordingly, there was no additional caution to remind Captain Traill of this. However, where both fuel transfer pumps had been switched off, as was the case by 2156 hours on 29 November 2013, the CAD would have displayed to Captain Traill both the **F PUMP AFT** and **F PUMP FWD** caution captions. There was

no evidence before the inquiry to suggest that either caution caption was not working as intended.

15. Pilot's Checklist - Emergency and Malfunction Procedures

[226] Two of the issues for the inquiry relate to the Pilot's Checklist, firstly, whether this was available to Captain Traill (issue 4.2); and secondly, whether it was within the competence of a helicopter pilot qualified to fly G-SPAO on police duties (such as Captain Traill) to comply with the requirements of the Pilot's Checklist (issue 4.3).

[227] Captain Young confirmed to the inquiry that the Pilot's Checklist would normally be kept in the pilot's door pocket, which is located on the pilot's right-hand side. Mr Vickery confirmed that, post-accident, the flight reference cards from the Pilot's Checklist were found in and around G-SPAO "in a bit of a state of disruption". The cards were reassembled and two were found to be missing, neither of which is relevant to the matters considered in this determination. In particular, the reference cards relative to the FUEL caution and the LOW FUEL warnings were present.

[228] I am, accordingly, satisfied that the Pilot's Checklist was available to Captain Traill on 29 November 2013.

[229] Captain Prior was asked, in terms, whether it was within the competence of a helicopter pilot qualified to fly G-SPAO on police duties to comply with the requirements of the Pilot's Checklist. He confirmed that, in his view, it was. I accept that evidence. No contrary view was suggested to the inquiry.

[230] I am, accordingly, satisfied that it was within the competence of a helicopter pilot qualified to fly G-SPAO on police duties to comply with the requirements of the Pilot's Checklist.

16. Low Fuel Warnings and Related Issues

[231] As noted above in Part 12, the LOW FUEL warnings on G-SPAO were generated by thermistors, which are attached to the outside of the fuel sensor capacitance tubes in the supply tank cells. The AAIB investigation included the testing of the thermistors (which were undamaged by the crash). They were found to work correctly.

[232] The issue of LOW FUEL warnings is first considered at paragraph 1.1.2 of the AAIB Report. The immediately following paragraph sets out, with minor amendments, what is said in the relevant passage from that paragraph.

[233] The AAIB could not determine precise timings but it was calculated that, before G-SPAO reached Bothwell, Captain Trill was first presented with a LOW FUEL 1 warning caption, with the associated aural attention-getter. This aural attention-getter was acknowledged by Captain Trill. That is done by pressing the reset button on the cyclic, which has the effect of suppressing the aural attention-getter. The LOW FUEL 1 warning caption then extinguished, before re-appearing after an undetermined interval. The aural attention-getter again accompanied the LOW FUEL 1 warning caption. This aural attention-getter was also acknowledged by Captain Trill, in the manner previously described. The LOW FUEL 1 warning caption then extinguished again. The LOW FUEL 2 warning caption then illuminated, with the associated aural attention-getter, and was also acknowledged by Captain Trill. The LOW FUEL 1 warning caption then re-appeared for a third time (again

accompanied by the aural attention-getter), in addition to the LOW FUEL 2 warning caption. This LOW FUEL 1 warning caption was acknowledged by Captain Traill, before it extinguished, leaving the LOW FUEL 2 warning caption. The LOW FUEL 1 warning caption then re-illuminated once more (again accompanied by the aural attention-getter) and was, again, acknowledged by Captain Traill. After this, the LOW FUEL 1 and LOW FUEL 2 warning captions remained illuminated for the remainder of the flight.

[234] The information given in the immediately preceding paragraph is derived from the non-volatile memory of G-SPAO's warning unit. This is described in paragraph 1.11.4.3 of the AAIB Report, the non-volatile memory capturing the last 31 warning status changes on G-SPAO. These are set out in Table 3 to the AAIB Report (see page 33 thereof). The limitation with the non-volatile memory is that no time stamps are recorded against the warning status changes. Nevertheless, the information available to the AAIB was sufficient for them to conclude that the LOW FUEL warnings were triggered before G-SPAO reached Bothwell (see AAIB finding 8 – paragraph [136] above).

[235] In his report, Captain Prior considered the issue of the timing of the LOW FUEL warnings. He explained that if the two supply tank cells were holding the correct proportion of the remaining fuel, and the helicopter was flying on a level altitude, the LOW FUEL warning for each cell should have occurred at approximately the same time, as the fuel level in each tank would be similar. On the basis of the fuel recovered from G-SPAO and the time difference between the flame outs, Captain Prior concluded that the intended 4 kg differential between the supply tank cells was not present during the final part of the flight. In his opinion, that could account for the time difference between the LOW FUEL 1 and LOW FUEL 2 warnings.

[236] Based upon his own calculations and the fuel recovered from G-SPAO, Captain Prior estimated that the earliest time a **LOW FUEL 1** warning would have been generated was at approximately 2159 hours, this assuming that the upper warning threshold of 34 kg of fuel was in the No 1 supply tank cell when the **LOW FUEL 1** warning was generated. If the lower threshold of 26 kg was used to generate the warning then the earliest time a **LOW FUEL 1** warning could have occurred was at approximately 2204 hours. The **LOW FUEL 2** warning might have been generated slightly later than the **LOW FUEL 1** warning if the difference in fuel volumes between supply tanks was smaller than expected.

[237] Issue 4.4 for the inquiry is at what stage in flight did the **LOW FUEL** warnings likely occur? From the terms of the AAIB Report and Captain Prior's report, I am satisfied that a **LOW FUEL** warning was first illuminated between approximately 2159 hours and 2204 hours, as G-SPAO approached Bothwell.

[238] The steps a pilot should take upon receiving a **LOW FUEL** warning are clearly set out in the Pilot's Checklist. The relevant page is reproduced within Appendix 4 to this determination. The pilot should first check the fuel quantity indication. If there is a positive fuel indication in the main tank, he should then check that both fuel transfer pumps switches (i.e. forward and aft), are switched to **ON**; and that both fuel pump transfer circuit breakers (forward and aft) are in. Having done so, if the **LOW FUEL** warning light remains on, the pilot is instructed to switch off the air conditioning (if installed) (no air conditioning was installed on G-SPAO) and, if the outside air temperature was greater than 5 degrees centigrade, to switch the bleed air to **OFF**. Most importantly, where the **LOW FUEL** warning light remains on, in a helicopter such as G-SPAO, the pilot is instructed to land within ten minutes.

[239] Having determined when the LOW FUEL warnings commenced, it is appropriate to turn to issue 4.5, namely, why, having acknowledged the LOW FUEL warnings, did the pilot not complete the actions detailed in the Pilot's Checklist?

[240] As confirmed in the AAIB Report at paragraph 2.1.2, the AAIB investigation could not establish why Captain Traill, a pilot with over 5,500 hours flying experience in military and civilian helicopters, who had been a qualified helicopter instructor and an instrument rating examiner, with previous assessments as an above average pilot, did not complete the actions detailed in the Pilot's Checklist for the LOW FUEL 1 and LOW FUEL 2 warnings.

[241] The primary cause of the accident is set out in Part 11 above, however, as explained there, the central issue in this inquiry was why Captain Traill allowed the supply tanks to deplete to the point that they did, when there was more than sufficient usable fuel available to him in the main tank to allow G-SPAO to return safely to GCH.

[242] The absence of evidence of the discussions which took place between the crew in response to the LOW FUEL 1 and LOW FUEL 2 warnings, of which all three crew members would have been aware, is, as described in evidence by Mr Wivell, frustrating, however, that does not prevent the inquiry from drawing conclusions from the evidence before it.

[243] From the evidence before the inquiry, I am satisfied that (a) the thermistors on G-SPAO were working correctly; (b) that the LOW FUEL warnings were triggered before G-SPAO reached Bothwell; and (c) that Captain Traill was aware of, and acknowledged, the LOW FUEL warnings. G-SPAO crashed 16 minutes after it had reached Bothwell, therefore there was sufficient fuel on board G-SPAO to have permitted it to land within the ten minute period mandated by the Pilot's Checklist, had that been necessary.

[244] A number of pilots gave evidence to the inquiry in relation to the actions required by the Pilot's Checklist when confronted by a LOW FUEL 1 and/or a LOW FUEL 2 warning. With one exception, those pilots presented a clear and consistent view of what a pilot should do in such circumstances: the steps set out in the Pilot's Checklist should be followed and the helicopter landed within the stipulated ten minute period, in the event that the preceding steps did not cause the LOW FUEL warnings to be extinguished.

[245] The exception to that view was Captain Andrew Rooney. Captain Rooney was the Bond senior pilot, Scotland and chief pilot for the Police Air Support Unit at the time of the accident. I confess to having some difficulty with the evidence given by Captain Rooney on the issue of whether, when confronted by a LOW FUEL warning (or warnings), a pilot would check that the fuel transfer pumps were, in fact, on (as mandated by the relevant flight reference card within the Pilot's Checklist). Ultimately, Captain Rooney's evidence was that there was a "75% chance" that a pilot would carry out such a check.

[246] Captain Rooney's evidence on this important issue was, correctly in my view, categorised as an "outlier" in the submissions made on behalf of Airbus. I am unable to accept Captain Rooney's evidence in this regard. All the other pilots who gave evidence on this issue were, as I have said, clear and consistent as to what should be done: upon receipt of the LOW FUEL warnings a check should have been performed to ensure that the fuel transfer pumps were, in fact, on.

[247] Dr Thomas submitted that the only logical explanation as to why Captain Traill did not land within ten minutes of receiving the LOW FUEL warnings is that he considered it safe to continue the flight. However, that proposition disregards entirely the fact that before

determining whether or not to land, the Pilot's Checklist requires the pilot to check the quantity of fuel in the main tank and to ensure the fuel transfer pumps were on.

[248] I am satisfied that both the fuel transfer pumps switches were in the OFF position at the point in time the LOW FUEL warnings were triggered. Had one or both of them been switched back on by Captain Traill at that point in time G-SPAO would not have crashed, standing the amount of fuel that was available for transfer from the main tank. The fuel transfer pumps were not switched back on by Captain Traill.

[249] If Captain Traill had switched one or both of the fuel transfer pumps on and the LOW FUEL warnings were, for some reason, not extinguished, there was more than sufficient fuel on board G-SPAO to have permitted it to land safely within the ten minute period mandated by the Pilot's Checklist. Subsequent to the triggering of the LOW FUEL warnings, Captain Traill appears to have made no attempt to land G-SPAO, until the second engine flamed out.

[250] I have found that a precaution which (i) could reasonably have been taken; and (ii) had it been taken, might realistically have resulted in the deaths, or any accident resulting in the deaths, being avoided would have been for Captain Traill to have followed the procedure set down in the Pilot's Checklist in respect of the LOW FUEL 1 and / or LOW FUEL 2 warnings (see Finding F5.1). Had Captain Traill done so, G-SPAO would not have crashed and ten lives would not have been lost.

[251] The evidence before the inquiry, regrettably, cannot explain why Captain Traill acted as he did. It is, however, clear beyond peradventure that Captain Traill's failure to follow the procedure set down in the Pilot's Checklist caused the accident. The procurator fiscal submits that issues 4.6, 4.8 and 4.9 focus for discussion three separate hypotheses purporting

to explain why the actions required by the relevant section of the Pilot's Checklist were not completed. As the procurator fiscal concedes, each hypothesis is to a greater or lesser extent a matter of speculation. Each of these issues is considered below.

[252] Issue 4.6 is whether the timing and/or the initially intermittent character of the LOW FUEL warnings contributed to the Pilot's Checklist procedure not being completed. Four matters are of significance in relation to this issue.

[253] Firstly, as noted at paragraph [179] above, the nature of the LOW FUEL warning system on helicopters such as G-SPAO is such that a thermistor which had been exposed for the requisite period of time can be covered in fuel, thus clearing the warning until more fuel is used and the thermistor is again exposed. In such circumstances an "intermittent" LOW FUEL warning can arise.

[254] Secondly, as explained in paragraph [233] above, it is only the LOW FUEL 1 warning caption which illuminated and extinguished. Moreover, the nature of the non-volatile memory on which the various warnings are recorded is such that the period over which the LOW FUEL 1 warning caption illuminated and extinguished on three occasions before it illuminated again for the remainder of the flight simply cannot be determined.

[255] The LOW FUEL 2 warning caption was not intermittent. It illuminated and remained on continuously from that point for the remainder of the flight. As noted above at paragraph [177], the LOW FUEL 2 warning caption illuminates with between 22 and 30 kg of fuel in the No 2 supply tank cell.

[256] Thirdly, it is clear from the evidence before the inquiry that a **LOW FUEL** warning was an extremely unusual event.

[257] Fourthly, as I have concluded, that the **LOW FUEL** warnings were triggered before G-SPAO reached Bothwell.

[258] Having regard to the procedure a pilot is expected to follow upon the illumination of a **LOW FUEL** warning, the timing of such a warning will, ordinarily, have no effect whatsoever on whether or not the Pilot's Checklist procedure is completed. An exception to this might be one in circumstances such as are considered below at paragraphs [261] to [266] in relation to issue 4.7.

[259] Having regard to the matters of relevance to the issue I identify above, my conclusion is that the initially intermittent character of the **LOW FUEL 1** warning did not contribute to the Pilot's Checklist procedure not being completed by Captain Traill. The **LOW FUEL** warnings were triggered before G-SPAO reached Bothwell. The Pilot's Checklist procedure ought to have been followed, irrespective of any doubt which may have existed on the part of Captain Traill, an issue to which I return below in Part 18.

[260] Before turning to the remaining hypotheses (issues 4.8 and 4.9), it is appropriate in this part to consider issue 4.7, namely, whether there have been other instances of **LOW FUEL** warnings not being followed.

[261] In evidence, two police air observers, Constable Alan Graham and Constable Niall McLaren spoke to what I conclude from their evidence was a single incident, which occurred on an unidentified date at some point between 2007 and 29 November 2013, in

which Captain Traill was the pilot and **LOW FUEL** warnings illuminated as his helicopter made its approach to land.

[262] Constable Graham described the incident as follows:

“(The) Low fuel warnings 1 and 2 came on just as we landed on one occasion. It was with Dave Traill, we came into land, and we were just about landing and one came on, and just as we touched down the other one came on.”

Constable Graham confirmed that his fellow police air observer on that occasion was Constable McLaren.

[263] Constable McLaren only recalled experiencing one instance of LOW FUEL warnings in his time as a police air observer, prior to 29 November 2013 (for the avoidance of any doubt, he did not speak to experiencing any LOW FUEL warnings after that date). That evidence, taken with Constable Graham’s evidence that he was accompanied by Constable McLaren on the occasion that he (i.e. Constable Graham) experienced a LOW FUEL warning causes me to conclude that they were both describing the same incident.

[264] Constable McLaren described the incident as follows:

“My recollection of it was that the low fuel warning came on on our final approach to the base, so within, know, 30 seconds of landing or so.”

Constable McLaren could not recall if one or both LOW FUEL warnings illuminated.

[265] The evidence of Constable Graham and Constable McLaren is such that I cannot conclude that Captain Traill did not follow a LOW FUEL warning on the occasion they described. In any event, in the circumstances they described, landing the helicopter is clearly the safest course to follow (and the final step in the Pilot’s Checklist procedure in the event of a LOW FUEL warning).

[266] Captain Rooney spoke in evidence to a police task at the conclusion of which, as he returned to GCH with the heliport in sight and within possibly less than a minute of landing, the red LOW FUEL warnings came on. The illumination of these had not come as a surprise to Captain Rooney on that occasion. Captain Rooney proceeded to land the helicopter.

[267] There was no other evidence before the inquiry which was suggestive of a LOW FUEL warning not being followed.

[268] In conclusion in relation to issue 4.7, there was no evidence before the inquiry of other instances in which LOW FUEL warnings were not followed.

17. Did Captain Trill Believe He Had Switched The Fuel Transfer Pumps Back On?

[269] Issue 4.8 is whether Captain Trill 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. This issue is predicated upon the hypothesis that Captain Trill inadvertently switched on the prime pumps instead of the transfer pumps.

[270] The No 1 and No 2 prime pumps are used during the engine start procedure to supply a positive head of fuel to the engine driven low pressure and high pressure pumps. After engine start the prime pumps are normally selected OFF and remain so throughout flight. When G-SPA0 was examined by the AAIB, after stabilisation of the accident site, both prime pump switches were found to be in the ON position (see AAIB Report at paragraph 1.12.2). However, photographs taken by Chris Burns, an SPA Scene Examiner,

appear to show at least one of the prime pump switches in the OFF position – the other switch being obscured in the photograph in question.

[271] As noted at paragraph 2.2.7.1 of the AAIB Report, as the supply tank prime pump switches are not guarded or gated, they could have been moved during the impact sequence or the victim recovery operation, prior to the helicopter being lifted from the building. The fact that the position of one of the prime pump switches moved between the time of the photographs taken by Mr Burns and the AAIB's examination of G-SPAO is suggestive of such an event occurring. Nevertheless, the conclusion reached in the AAIB Report, namely, that the pre-impact position of the prime pump switches could not be verified beyond doubt is one which I regard as appropriate in light of the evidence before the inquiry.

[272] As submitted by the procurator fiscal, there was no other evidence directly supporting the hypothesis that Captain Traill inadvertently switched on the prime pumps instead of the transfer pumps; and certain evidence militating against it.

[273] Firstly, the nature of police operations required pilots, such as Captain Traill, to routinely and frequently switch transfer pumps off and on again. As such, it is highly unlikely that Captain Traill activated the prime pump switches in error. Moreover, even if he had done so, the CAD would have displayed a **PRIME PUMP** caution and the transfer pump cautions would have continued to display.

[274] Secondly, the evidence before the inquiry overwhelmingly suggested that experienced pilots simply would not make an error of this nature. Captain Allan Byers confirmed in evidence that he had never confused the prime pumps and the transfer pumps and that no other pilot had told him that they had ever made such an error. Captain Rooney

indicated that his practice was always to look at the switches he wished to operate; that he had never confused the prime pumps and the transfer pumps; and that no other pilot had told him that they had ever made such an error.

[275] Whilst I accept that it would be *possible* for the prime pump switches to be erroneously selected when the pilot intended to select the transfer pump switches, the evidence overwhelmingly suggest that, in practice, such a scenario is improbable, even before one comes to consider what would be displayed on the CAD in that event.

[276] In conclusion, it is, in my view, vanishingly unlikely that Captain Traill believed the fuel transfer pumps were operating, notwithstanding the LOW FUEL warnings, because he believed he had switched the fuel transfer pumps back ON. In light of that conclusion, it follows that the design or layout of the switches had no bearing on the events of 29 November 2013.

18. Erroneous Fuel Indications

[277] Issues 4.9 and 4.10 both relate to erroneous fuel indications. As such, they are conveniently considered together. Issue 4.9 is 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. Issue 4.10 is 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.

[278] The starting point in a consideration of these issues is conveniently summarised at paragraph 1.6.9.1 of the AAIB Report, which is in the following terms:

“The operator (i.e. Bond) had experienced occasional erroneous fuel quantity indications on EC135 helicopters. When diagnostic or rectification action was taken, no fault with the fuel sensor or quantifiable contamination of the fuel was found. Replacement of the fuel sensor units seemed to correct the fault. The evidence suggested that water contamination may have been the root cause but the exact mechanism was not fully understood. As a precaution, the manufacturer issued (Information Notice) 2535-I-28 on 21 January 2013..., drawing operators’ attention to the possibility of water contamination and reiterating the procedures set out in the AMM to mitigate the problem.

When the manufacturer tested the fuel sensors that were returned from the worldwide fleet, for repair, it found about 70% had no fault.

Across the operator’s EC135 Emergency Medical Services (EMS) fleet, maintained under a cold compressor washing schedule, there were instances of water and engine cleaning fluid ingress into the fuel systems. On a number of occasions this seemed to result in erroneous or unusual contents indications. Both these repetitive issues occurred randomly over a period of at least ten years.”

[279] As set out above (see paragraph [202]), I am satisfied that Captain Traill was familiar with the terms of Information Notice No. 2535-I-28. That information notice is reproduced as Appendix C to the AAIB Report. Insofar as relevant for present purposes, the information notice states (the underlining is mine):

“EUROCOPTER has been informed about several fuel quantity indication failures. Following the replacement of the affected fuel probe, the indication returned to normal and the functional check of the fuel quantity indication system has been performed successfully.

When the subject probes have been returned to EUROCOPTER for repair, the probes showed no external damage or contamination within the two concentric metal tubes and most of the probes have been tested, with the result, “no fault found” (NFF). To investigate the reason for these NFF's EUROCOPTER performed several tests to simulate the failures. As a result from these tests, the most probable root cause is contamination of the fuel probe with water.

These tests have shown - when water is entering the space between the two concentric metal tubes of the probe - it will decrease the output signal (frequency) of the probe. In case of a high concentration of water, the frequency can decrease to such a level that the CAD recognizes the probe

as failed - showing either an F QTY DEGR or F QTY FAIL caution on the CAD. Also there is a potential risk that the CAD shows a higher fuel quantity level compared to the actual fuel level within the fuel tank system."

[280] In summary therefore, by January 2013 the potential risk of the CAD displaying a higher fuel quantity compared to the actual quantity of fuel on-board had been identified; and pilots, including Captain Traill, had been made aware of that potential risk.

G-NWEM

[281] On 11 December 2013, less than two weeks after the accident, an incident occurred involving another Bond EC135 T2+ helicopter, G-NWEM. The circumstances of that incident are set out at paragraph 1.16.2 of the AAIB Report. Put shortly, following reports of contradictory fuel indications and low fuel warnings, a ground run was carried out, during which the main fuel tank contents were seen to deplete, with the forward and aft fuel transfer pumps OFF; whilst the supply tank contents continued to present as full. When the main tank contents had depleted to approximately 20 kg, the LOW FUEL 1 and then the LOW FUEL 2 warnings illuminated on the warning unit, with the supply tank cells continuing to present as full. At no stage did the FUEL caution illuminate.

[282] The AAIB Report, at paragraph 2.2.6.1, noted that following the tests conducted as a result of the G-NWEM incident, it became apparent that the problems noted were related to water ingress via the fuel tank vent system following cold compressor washing operations. This water was then emulsified in the fuel as it was moved around the fuel tanks by the transfer fuel pumps. That also explained why the sensors, having been removed and transported, arriving dry at the manufacturer and free of any contamination, performed correctly during tests in uncontaminated fuel.

G-POLD

[283] Another incident of note involving an EC135 T2+ helicopter, G-POLD (which had previously been registered as G-NMID), occurred on 13 March 2018. The circumstances of that incident were the subject of a Notice to Admit. No objection having been taken to that Notice to Admit, and no contrary evidence having been presented to the inquiry, I am content to adopt what is stated therein.

[284] In the evening of 13 March 2018 Captain Andrew Shanks piloted the EC-135 T2+ helicopter registration G-POLD. He flew the third flight of that day. He was not involved in the earlier two flights. At around 2010 hours he took off from Birmingham airport. At around 2150 hours he returned to Birmingham airport.

[285] The aircraft had landed after the second flight of the day with a CAD fuel reading totalling 278 kg. The aircraft was refuelled with 194 litres (155 kg). The aircraft left Birmingham airport at 2010 hours with the CAD displaying total fuel of 416 kg.

[286] At the first fuel check at level flight at 2015 hours at 2000 feet the CAD displayed total fuel of 427 kg. The increase in the total fuel reading at the first flight check is not unusual on take-off from Birmingham airport given the slope and direction of parking of aircraft.

[287] Fuel checks throughout the flight showed a fuel burn of 182 kg/hour. That was the burn rate Captain Shanks expected.

[288] The last task of the flight was a search on the edge of Birmingham airport. At the commencement of the search the CAD displayed 72 kg in the main tank and 47 / 43 kg in the left / right supply tanks.

[289] During the search both F PUMP FWD and F PUMP AFT cautions illuminated as expected. At this point the CAD displayed 50 kg in the main tank. Both fuel transfer pumps were then switched off.

[290] The task was completed five to seven minutes later. The aircraft returned a short distance to its base at Birmingham airport. During the return flight, Captain Shanks noticed that there was no reduction in the supply tank indications while the main tank indication was reducing. That attracted his attention. The aircraft landed with the CAD displaying 32 kg in the main tank and 47 / 43 kg displaying for the left / right supply tanks.

[291] Captain Shanks thought this was possibly unusual and therefore, in order to confirm the integrity of the fuel indication system, the aircraft was given a compressor rinse with engines running. The aircraft had not been rinsed earlier in the day. This was followed by a six minute drying run with engines at flight idle for at least three minutes. The transfer pumps were off. The CAD displayed the main tank level reducing to 25 kg. It continued to display the supply tank levels as 47 / 43 kg.

[292] Having spoken to an engineer, Captain Shanks carried out a further 12 minute ground run at flight idle. The transfer pumps were left off. The purpose of the exercise was to try to get at least one of the fuel cautions or warnings to illuminate. During the ground run, the main tank indications slowly reduced to 7 kg. The left supply tank display remained

at 47 kg. The right supply tank display reduced to 37 kg. At no time did the fuel caution or low fuel warnings illuminate. The aircraft was placed as unserviceable.

Discussion

[293] The conclusion I draw from the G-NWEM and G-POLD incidents is that, whilst the fuel transfer pumps are switched off, there have been instances of the supply tank cells of an EC135 T2+ continuing to present as full whilst the main tank contents present as depleting, when, in fact, the supply tank was depleting and the main tank was not. It is notable also that in each case the FUEL caution did not illuminate.

[294] It is notable also that G-SPAO had experienced problems with fuel indications in July and September 2013 and most recently on 23 November 2013, less than one week before the fatal accident.

[295] The procurator fiscal invites the court to conclude that there was no evidence of water contamination of G-SPAO's fuel tank, its sensors or its fuel during the accident flight. That submission is based upon the following considerations.

[296] There was no evidence of water contamination from source, or from refuelling in wet weather. The other two routes discussed in evidence were, firstly, water contamination following a cold compressor wash or clean; and, secondly, water contamination as a result of condensation.

[297] Water contamination following a cold compressor wash or clean may affect the CAD readings in two ways. Firstly, the micro-drops of water present in a fuel / water emulsion might themselves generate an over-reading, though tests spoken to in evidence by Mr

Mendick indicated that this was unlikely to be significant. Had a fuel / water emulsion been generated during the day of the accident, potentially causing the supply tank sensors to misread, in Mr Mendick's evidence, this would have left a trace of water throughout the fuel tank system. The fuel samples taken from G-SPAO's main tank were tested and found to be of the correct specification and free of contamination (see the AAIB Report at paragraph 1.16.1). Further, as spoken to in evidence by Mr Vickery of the AAIB, the AAIB thoroughly checked the inside of the fuel tanks for the presence of water and found none.

[298] Any water drops which had precipitated out of emulsion would fall to the bottom of the sensors. This could occur during the accident flight, if an emulsion was present. However, even if there was no emulsion present during the accident flight, there may have been a build-up of water contamination in the bottom of the sensors from earlier emulsifying events. Although the sensors included a drain hole, this appeared to be "just the right size to trap the water" in the evidence of Mr Vickery.

[299] There was no evidence of pitting of the sensors such as one might expect to find had there been a build-up of contamination. Further, had there been a build-up of contamination, it might be expected that this would already have had some effect on the CAD on the day of the accident. However, as the AAIB concluded (see AAIB Report, paragraph 2.2.6), there was no evidence that the fuel system in G-SPAO was indicating incorrectly in the lead up to the accident.

[300] Moreover, there was positive evidence that the CAD was reading 400 kg correctly at the start of the flight, since that would mean that the aircraft consumed 327 kg of fuel (there being 73kg of usable fuel found in the tank), which is consistent with the expected fuel consumption over 98 minutes of flight at 200kg / hour or 3.33 kg / minute i.e. 326.34 kg.

[301] Contamination of the sensors as a result of condensation was described by Mr Mendick as theoretically possible, but very unlikely. In order for condensation to cause an over-reading such that both supply tank sensors read full, and the main tank is seen as reducing, then the condensation would require to occur in both supply tank sensors, as well as neither main tank sensor. Against such a background, I accept Mr Mendick's evidence in this regard.

[302] A considerable body of evidence was placed before the inquiry in relation to fuel indication issues which arose in relation to a number of different helicopters. For reasons I explain below, I do not propose to address that evidence, however, a summary of it is to be found in the submissions for Dr Thomas at pages 22 to 29.

[303] There are a number of factors to consider in reaching a conclusion as to whether or not the quantities of fuel displayed on the fuel quantity indication system of G-SPAO contradicted the LOW FUEL warnings. Those advanced on behalf of the procurator fiscal support the conclusion that there was no evidence of water contamination of G-SPAO's fuel tank, its sensors or its fuel during the accident flight, from which it would logically follow that the quantities of fuel displayed on the fuel quantity indication system of G-SPAO did not contradict the LOW FUEL warnings.

[304] There are, however, a number of facts that support a contrary view. The circumstances of the G-NWEM and G-POLD incidents support the possibility that, while its fuel transfer pumps are switched off, the supply tanks of an EC135 T2+ can continue to present as full while the main tank contents present as depleting, when, in fact, the supply tank was depleting and the main tank was not. The circumstances of the G-NWEM incident support the possibility of the FUEL caution not illuminating prior to either or both LOW FUEL warnings illuminating (the LOW FUEL warnings did not illuminate in the G-POLD incident – see paragraph [292] above).

[305] From my assessment of the evidence relative to the other incidents involving EC135s, as against the facts of this accident, I can find nothing of significance in the context of this inquiry, beyond support for the proposition that the EC135 has a not insignificant history of issues with fuel indication. There are, however, three other matters of some significance.

[306] Firstly, it appears uncontroversial that after the LOW FUEL warnings had begun to illuminate, G-SPAO embarked on no less than three separate routine surveillance tasks at Bothwell, Uddingston and Bargeddie respectively. Moreover, I am satisfied, on a balance of probabilities, having regard to the estimated fuel present within G-SPAO when it arrived at Bothwell (122 kg); the amount of fuel recovered (76 kg); and the average burn rate (3.3 kg / min) that by no later than the point of commencement of the Bothwell task (at 2206 hours) both LOW FUEL warnings were illuminated and neither extinguished thereafter.

[307] Secondly, at 2219 hours, a mere three minutes before the accident, in his final radio transmission, Captain Traill informed air traffic control that G-SPAO was complete in the Bothwell area and was returning to GCH. There was no mention of any fault with G-SPAO,

or any other concern, in the course of that transmission or at any time previously during the accident flight.

[308] Thirdly, the evidence before the inquiry strongly suggests that the police air observers during the accident flight, Constable Collins and Constable Nelis, were experienced; that they would have called out cautions and warnings as they appeared; and that it is probable that, in the event of a warning, they would have asked Captain Traill to explain the situation and offered to assist. Despite having the means to communicate, neither Constable Collins nor Constable Nelis communicated any concerns. The only conclusion I can draw from this is that the police air observers were each satisfied with whatever explanation Captain Traill provided to them for the appearance of the **LOW FUEL** warnings.

[309] Whilst I am satisfied that Captain Traill received and ignored the **LOW FUEL** warnings, to accept the proposition that the fuel sensors on G-SPAO operated as they were intended to during the accident flight requires one to be satisfied that Captain Traill received and ignored the **FUEL** caution; and disregarded the accurate fuel quantity indications that would have appeared on the **CAD**. Such a proposition is so inherently improbable that I cannot accept it.

[310] There was no evidence, whatsoever, to suggest that Captain Traill deliberately caused G-SPAO to crash on 29 November 2013. Indeed, there is evidence (considered below in Part 21) to suggest that he made a valiant attempt to land G-SPAO after both engines had flamed out.

[311] That being the case, having regard to the foregoing matters, I can but conclude that it is more likely than not that the quantities of fuel displayed on the fuel quantity indication system of G-SPAO contradicted the LOW FUEL warnings, in a manner that persuaded Captain Traill that it was safe to continue flying. As set out above in Finding F7.1, I have found that this fact is relevant to the circumstances of the deaths. There are, however, two points that must be stressed in relation to this finding.

[312] Firstly, the contradictory fuel display is only of relevance until the illumination of the LOW FUEL warnings. At that point the actions set out in the Pilot's Checklist should have been performed by Captain Traill. Albeit not in the context discussed by Professor Polly Dalton in her evidence, by not carrying out the actions set out in the Pilot's Checklist, Captain Traill consciously took a risk in proceeding on the basis that the LOW FUEL warnings were in some way erroneous (when they were not). That decision had fatal consequences. There was no logical basis for preferring the (possibly erroneous) figures displayed on the CAD to the LOW FUEL warnings, particularly in circumstances where the fuel transfer pumps were both switched off.

[313] Secondly, whilst this is a fact relevant to the circumstances of the deaths, it neither caused nor contributed to them. As I have found (see Finding F4.2), the contents of G-SPAO's supply tanks depleted due to the failure of Captain Traill to ensure that at least one of G-SPAO's fuel transfer pump switches was set to ON.

[314] Whilst I have concluded that it is more likely than not that the quantities of fuel displayed on the fuel quantity indication system of G-SPAO contradicted the **LOW FUEL** warnings, the evidence before the inquiry is such that I am simply unable to determine what caused that.

[315] Against that background, I return to issue 4.9 which is 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.

[316] In light of my conclusions, my answer to this issue is that whilst I am satisfied that it is more likely than not that Captain Traill was confronted by erroneous fuel indications, one simply cannot overlook the fact that Captain Traill received both the **F PUMP AFT** and **F PUMP FWD** caution captions. Coupled with the erroneous fuel indications, it is likely that Captain Traill's failure to have regard to those cautions suggests that he believed that the transfer pumps were operating. At the point of the illumination of the **LOW FUEL** warnings, it is likely that Captain Traill's failure to perform the actions set out in the Pilot's Checklist suggests that he believed that the transfer pumps were operating.

[317] Issue 4.10 is 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. The evidence before the inquiry is such that, whilst I have been able to conclude that it is more likely than not that Captain Traill was confronted by erroneous fuel indications, the available evidence does not permit me to say with any degree of confidence what the root cause or causes of such indications were. This precludes me from forming any

view as to whether they were adequately investigated and acted upon. The submissions made on behalf of the procurator fiscal (see paragraphs [296] to [301] above) highlight the difficulties in this regard.

[318] Furthermore, standing the conclusion I have reached regarding the cause of the accident, and the fact that prior to this accident, the EC135 had accumulated more than three million flying hours over a period of twenty years, without any reported instance of fuel starvation (see the AAIB Report at paragraph 1.18.2.2), I have formed the view that, even had the evidence permitted an examination of this particular issue (which it does not), to have embarked upon it would have strayed beyond the purpose of a fatal accident inquiry, namely, to (a) establish the circumstances of the deaths; and (b) consider what steps (if any) might be taken to prevent other deaths in similar circumstances (see section 1(3) of the Act). The underlined words “in similar circumstances” cannot be overlooked.

[319] The particular circumstances of this accident appear to be unique. Had Captain Traill performed the actions set out in the Pilot’s Checklist, the accident would not have happened. As noted above, there had not previously been a reported instance of fuel starvation in an EC135.

19. Did The CAD Fail Prior To The Accident?

[320] Issue 4.11 is whether there was a failure of any part of the CAD prior to the accident. During the AAIB’s investigation, the CAD was thoroughly examined (see the AAIB Report at “Summary”, page 2). The AAIB Report notes that if the CAD had failed during the accident flight a fault relating to communications between the CAD and the vehicle and

engine monitoring display (“VEMD”) would have been recorded in the VEMD’s non-volatile memory. No such fault was recorded.

[321] I conclude, therefore, that there was no failure of any part of the CAD prior to the accident.

20. Engine Flame Out Issues

[322] Both issues 4.12 and 4.13 relate to certain matters concerning engine flame outs. As such, they are conveniently considered together. Issue 4.12 is a straightforward one, namely, what steps were open to a helicopter pilot qualified to fly this helicopter after both engines flamed out. Issue 4.13 is whether the designed time-interval between engine flame-outs was compromised by the design of the fuel tank system and, in particular, the undivided volume above the supply tanks, which, depending on the attitude of the helicopter, might have allowed fuel to migrate from one supply tank cell to another.

[323] Issue 4.12 can be dealt with briefly. The actions a pilot should take after both engines flamed out (referred to as a Double Engine Failure) are set out in the Pilot’s Checklist. The relevant flight reference card (E-6-2) sets out a number of conditions and indications of that state and directs that the pilot should perform an autorotation (which is considered further below in Part 21). The action is shown in bold on the flight reference card, denoting that it is what is termed a “memory item”, that is one which the pilot should know to perform without the necessity of referring to the Pilot’s Checklist.

[324] Turning to issue 4.13, the starting point of a consideration of this issue is to identify what the designed time-interval between engine flame-outs actually was. The position was

complicated by what Airbus accepted was an error in the System Description Section (“SDS”) of the EC135 Aircraft Maintenance Manual (“AMM”). At the time of the accident, the AMM stated that the purpose of the 4 kg difference in volume between the two supply tank cells was to allow time for a pilot to set the fuel transfer pumps to ON, if both pumps had unintentionally been selected OFF. It stated, incorrectly, that the time between the right (No 2) and left (No 1) engines flaming out would be three to four minutes. The AAIB Report noted, at paragraph 2.1.5.1, that Airbus were taking corrective action to amend the potential engine flameout interval to a more accurate figure in the revision of the SDS manual scheduled for publication in December 2015.

[325] I cannot accept the proposition advanced on behalf of Mr Arthur (at paragraph 1(iii) of his submissions) that this error in the SDS may have contributed to Captain Traill’s decision to discount the LOW FUEL warnings as unreliable. There appears to me to be no nexus between the two issues. The time interval only comes into play when the first engine flames out. Self-evidently, if Captain Traill had elected to discount the LOW FUEL warnings as unreliable (which I have concluded is likely to have been the case) he cannot have been contemplating a double engine flame out. If he had been contemplating a double engine flame out, the LOW FUEL warnings would be consistent with that.

[326] The design of the supply tank is described in the AAIB Report at paragraph 1.6.4.1 under the heading “Tank arrangement”. The relevant section is in the following terms:

“The No 1 supply tank cell capacity is 49 kg, whilst the No 2 cell is slightly smaller at 44.5 kg. This difference is achieved by including an intrusion into the volume at the bottom of the No 2 cell. The 4.5 kg difference in volume is to provide a time interval between engine flame-outs, should fuel exhaustion occur.”

[327] The designed time interval between engine flame outs is, accordingly, the time it would take the second engine to burn 4.5 kg of fuel, following the first engine flame out, provided that both supply tank cells contain the same level of fuel when the first engine flames out. The AAIB's calculations, based on the helicopter's average fuel consumption rate and consultation with the manufacturer, showed that this represents a flight time of no more than 1 minute and 30 seconds with the second, left engine in OEI mode, before it too will flameout if the fuel transfer pumps are OFF and the fuel in the supply tank cells is exhausted (see the AAIB Report at paragraph 2.1.5).

[328] Having identified the designed time-interval between engine flame-outs, I turn to consider whether this was compromised by the design of the fuel tank system. The short answer to that proposition is that it was. G-SPAO's right engine flamed out at a point between 2221:35 hours and 2221:45 hours, when it was approximately 2.7 nm east of GCH; the left engine flamed out 32 seconds later, about 1.8 nm east of GCH.

[329] As noted at paragraph 2.1.5 of the AAIB Report, the shorter than designed time interval between flame outs suggests that there was a lower level of fuel in the left supply tank cell, possibly due to fuel spilling from the left cell to the right cell, when the fuel levels were near the top of the divider. Trials confirmed that this can occur during unbalanced flight, the undivided volume above the supply tank cells permitting fuel to migrate from one supply tank cell to the other.

[330] To conclude in relation to this issue, the purpose of the designed time interval is to prevent a simultaneous double engine flame out and to permit the helicopter to fly with one engine inoperative. As noted in the SDS, this is to guard against unintentional non-

activation of both fuel pumps in the main tank with the consequential depletion of both supply tank cells. The intention is to give the pilot sufficient time to activate the fuel pumps in the main tank. Whilst clearly not a significant period, 32 seconds appears to me to have been a long enough period to switch on the fuel transfer pumps. The only conclusion I can draw is that when the first engine flamed out, Captain Traill failed to identify that both transfer pumps were switched OFF.

21. Autorotation

[331] Both issues 4.14 and 4.15 relate to autorotation. As such, they are conveniently considered together. Issue 4.14 is why autorotation, flare recovery and landing were not completed successfully by Captain Traill. Issue 4.15 is whether the ability to carry out autorotation, flare recovery and landing was compromised by the design of the cockpit layout.

[332] Autorotation in a helicopter is a condition of descending flight where, following the failure of all engines, the rotor blades are driven solely by aerodynamic forces resulting from the airflow up through the rotor¹¹. In order to enter autorotation a pilot requires to maintain the rotor speed (N_r) of the helicopter. The aim is to maintain N_r as near to 100% as possible. The pilot requires to reduce the collective lever within one or two seconds of the second engine flaming out in order to maintain the N_r . This is a memory item on the relevant flight reference card. Reducing the collective lowers the pitch angle of the rotor blades and reduces drag. The minimum N_r from which rotor speed can be recovered is 75%. If the rotor speed drops below 75% then the helicopter will not be able to enter autorotation.

¹¹ See the AAIB Report at page 2, footnote 2

[333] In G-SPAO, the CPDS end of flight criteria were met “a few seconds” after the second engine flameout. This indicated that the N_r had decayed below the range that lead-lag resonance can occur (less than 60%). The blades sustained damage caused by lead lag resonance. Although the N_r was recovered on two occasions by Captain Traill it was not maintained. It decayed past the point at which it was recoverable (75%) within a few seconds of the second engine flaming out, at which point Captain Traill would have effectively lost control of the helicopter.

[334] Whilst it may be true to say that there was no reason in principle why the helicopter could not at least enter autorotation, the circumstances which confronted Captain Traill were such that, despite managing to recover the N_r on two occasions, he was unable to achieve autorotation. The AAIB Report suggests that a flare manoeuvre had been carried out during the final descent (see paragraph 2.1.1 at page 76 of the AAIB Report), which in the evidence of Captain Prior would be consistent with the N_r being recovered.

[335] At the point G-SPAO's second engine flamed out, it was at an altitude of just below 500 ft amsl (see the AAIB Report, paragraph 1.11.8.1, Figure 9). In evidence, the Airbus project pilot for the EC135, Rene Nater, explained that with both engines inoperative, a helicopter will descend at between 1,800 to 2,000 feet a minute, depending upon its weight. It will immediately be recognised that, even at the slower rate of descent, standing the altitude of G-SPAO at the point of the second engine flame out, Captain Traill had very little time to react.

[336] Mr Nater described autorotation at night as “extremely difficult”; a sentiment with which the expert witness led by the procurator fiscal, Captain Prior concurred, describing it

as “extremely demanding”. Captain Prior explained in his evidence that the height at which the second engine flames out is of considerable significance, the lower the altitude of the helicopter, the less time the pilot has available to carry out the necessary actions.

[337] Captain Traill required to establish a stable autorotation and successfully land the helicopter in a very short period of time. The extent of that period was not identified in evidence, however, having regard to the rate of descent spoken to by Mr Nater and the altitude of G-SPAO at the point of the second engine flaming out, it would appear to be somewhere within the range of ten to twenty seconds. The manoeuvrability of the helicopter is limited in the event of double engine flameout. Captain Traill could only direct the helicopter to landing sites within approximately 5 to 20 degrees of either side of its nose. The helicopter was over an urban area. 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. Finally, Captain Traill was attempting to enter autorotation at a height at which he had no prior experience.

[338] I am satisfied that Captain Traill was attempting to enter autorotation; and that a flare manoeuvre was attempted. I accept, as submitted by Dr Thomas, that Captain Traill did his best to save the helicopter and its occupants. The conclusion to which I am inexorably drawn from Mr Nater’s evidence is that, in the whole circumstances which confronted Captain Traill on the evening of 29 November 2013, when the second engine of G-SPAO flamed out, Captain Traill had no realistic chance of landing the helicopter safely. To this extent, the evidence before the inquiry does not support the fourth causal factor in the AAIB Report (see paragraph [137] above), namely, that a successful autorotation and landing was not achieved for unknown reasons.

[339] Turning to issue 4.15, namely, whether the ability to carry out autorotation, flare recovery and landing was compromised by the design of the cockpit layout, there was no evidence before the inquiry to suggest that this was the case.

22. Reasonable Precautions

[340] The court's determination must set out any precautions which (i) could reasonably have been taken; and (ii) had they been taken, might realistically have resulted in the crash being avoided (see section 26(2)(e)). If the sheriff considers it appropriate, he or she may make recommendations as to, amongst other things, the taking of reasonable precautions (see section 26(4); discussed at paragraph [11] above).

[341] It is important to stress at the outset that, to fall within the scope of section 26(2)(e), a precaution must be one which could reasonably have been taken prior to the accident; *and*, had it been taken, the crash might realistically have been avoided.

[342] As set out above (see paragraph [250]), I have found that a reasonable precaution would have been for Captain Traill to have followed the procedure set down in the Pilot's Checklist in respect of the **LOW FUEL 1** and / or **LOW FUEL 2** warnings. That precaution could reasonably have been taken prior to the accident. If it had been taken, the accident resulting in the deaths would have been avoided. Issues 5.1 to 5.6 for the inquiry invite a consideration by the court of six separate precautions, which I consider below.

Issue 5.1

[343] Issue 5.1 invites the court to consider whether it a reasonable precaution would have been to include within the fuel contents indication system a caution or warning that both

transfer pumps were switched OFF. In part at least, this issue is a rather curious one, having regard to the fact that the system already contains such a caution for each fuel transfer pump.

[344] Where both fuel transfer pumps are switched OFF, the contents of the supply tank will deplete; and when the requisite levels in the supply tank cells are first reached the FUEL caution will illuminate. Assuming that at least one fuel transfer pump is not switched on, the FUEL caution will be followed by the LOW FUEL warnings in relation to each supply tank cell. Within the Pilot's Checklist, the flight reference cards relative to both the FUEL caution and the LOW FUEL warnings each contain instructions to check that the fuel transfer pump switches are ON.

[345] Where a fuel transfer pump is switched off, a caution is displayed on the CAD – either F PUMP FWD; F PUMP AFT; or both depending upon the pump or pumps that have been switched off. When such a caution first appears it is accompanied by flashing bars and the illumination of the master caution, which both continue to display until they are acknowledged by the pilot, by way of the reset button on the cyclic. The caution or cautions only cease to display on the CAD if the pilot switches on the fuel transfer pump or pumps which had been turned off. Unless and until that occurs, the caution or cautions will continue to display on the CAD. I accept the submission made on behalf of Airbus that a pilot flying with transfer pumps switched OFF will always have an indication to that effect displayed on the CAD. In his evidence to the inquiry, Mr Mendick explained that these cautions (i.e. F PUMP FWD and F PUMP AFT) had been introduced to address the situation in which both fuel transfer pumps were (inadvertently) switched off.

[346] I am satisfied that the inclusion within the fuel contents indication system of a caution that both fuel transfer pumps were switched OFF is unnecessary and, therefore, cannot be a reasonable one. The introduction of such a caution would not have prevented the accident resulting in the deaths. The fuel contents indication system already contains such cautions by way of the F PUMP FWD and F PUMP AFT cautions.

[347] The inclusion within the fuel contents indication system of a warning that both fuel transfer pumps were switched OFF is, however, a quite separate matter. Perhaps surprisingly, the only the submissions made in support of the introduction of such a precaution were those made on behalf of James Diver.

[348] The AAIB concluded that both the main tank forward and aft fuel transfer pumps had been switched OFF by a point on the helicopter's journey between Dalkeith and Bothwell. The illumination of the F PUMP FWD and F PUMP AFT cautions from that point plainly did not cause Captain Traill to switch the fuel transfer pumps (or one of them) back on.

[349] Determining whether the presence of a particular precaution (which was not present at the time of the accident) might have realistically resulted in the accident being avoided is a matter of informed speculation, however, to determine whether the requirements of section 26(2)(e) are satisfied, the court is required to speculate; applying what was described by Sheriff Reith in her determination following the fatal accident inquiry into the death of Sharman Weir¹², as, "the wisdom of hindsight".

¹² Unreported, 23 January 2003 (Glasgow Sheriff Court)

[350] Essentially, adopting the language used by Sheriff Principal Lockhart in his determination following the fatal accident inquiry into the deaths of Annie Stirrat and others¹³ (“the Rosepark Care Home FAI”), I require to address the question of whether or not the inclusion within the fuel contents indication system of a warning that both fuel transfer pumps were switched OFF “might have made a difference”.

[351] The issue of why G-SPAO's fuel transfer pumps were switched off is considered above in Part 14. In that part I reached the conclusion that, when he switched off the aft fuel transfer pump, Captain Traill appears to have overlooked the fact that he had previously switched off the forward fuel transfer pump approximately 11 minutes earlier. At the point in time when he switched off the aft fuel transfer pump, Captain Traill had before him, on the CAD, cautions to the effect that both fuel transfer pumps were then switched off.

Moreover, on switching off the aft fuel transfer pump, he would also have seen flashing bars and the illumination of the master caution, which would have continued to display until such time as Captain Traill acknowledged the aft fuel transfer pump caution. The combination of those cautions was, it appears, not sufficient to cause him to switch the forward fuel transfer pump back on at that point; however, would a warning that both fuel transfer pumps were switched OFF and an associated aural attention-getter have done so?

[352] Having reached the conclusion that Captain Traill (a) inadvertently omitted to switch on the forward fuel transfer pump at the point in time at which he switched off the aft fuel transfer pump; and (b) appears to have overlooked the illumination of both the F PUMP FWD

¹³ See <http://www.scotcourts.gov.uk/docs/default-source/cos-general-docs/pdf-docs-for-opinions/2011-fai-18-rosepark.pdf?sfvrsn=2>; and, in particular, page 12, paragraph 8 thereof.

and F PUMP AFT cautions at that time, it seems to me that had Captain Traill received a warning on the helicopter's warning unit that both fuel transfer pumps were switched OFF; and had that warning been accompanied by an aural attention-getter (similar to that which accompanies the LOW FUEL warnings) there is a lively possibility that Captain Traill would have switched on the forward fuel transfer pump and, thus, the accident might realistically have been avoided.

[353] The distinction between cautions and warnings is self-evident; in general terms, the former being less significant than the latter. It is noteworthy that the CAD also contains advisory messages which are coloured green, resulting in a system which comprises messages in red; yellow (amber); and green. Such a system is one that would be readily understandable to a lay person, far less an experienced helicopter pilot.

[354] In this instance, the cautions did not have the desired effect relative to the fuel transfer pumps. Moreover, it has to be accepted that Captain Traill disregarded LOW FUEL warnings. However, I have concluded that he did so in circumstances where it is more likely than not that the quantities of fuel displayed on the fuel quantity indication system of G-SPAO contradicted those LOW FUEL warnings. For present purposes, the likely presence of such a contradiction is significant. It does not, in any way, excuse Captain Traill's apparent decision to disregard the LOW FUEL warnings, however, it does explain why he may have done so.

[355] I can conceive of no possible contradictory indication in relation to a warning of the type I am asked to consider under this issue. Indeed, assuming the CAD was functioning

properly (as it was on G-SPAO during the accident flight), the veracity of such a warning would have been supported by the presence of the **F PUMP FWD** and **F PUMP AFT** cautions.

[356] The question of reasonableness is directed to the precaution which is identified (see determination of Sheriff Principal Lockhart in the Rosepark Care Home FAI at page 12, paragraph 8). The fact that had Captain Traill followed the procedure set down in the Pilot's Checklist in respect of the **LOW FUEL 1** and / or **LOW FUEL 2** warnings the accident would not have occurred is not a relevant consideration in determining whether the proposed precaution is a reasonable one. The only remaining issue is the sufficiency of the evidence before the inquiry relative to it.

[357] Mr Mendick was the witness best placed to have addressed this issue. Regrettably, it was not explored with him. There was, however, no evidence to suggest that the inclusion of such a warning was impractical. Additionally, there was evidence in respect of the **LOW FUEL** warnings on an EC135, which are preceded by the **FUEL** caution. I also heard considerable evidence of a technical nature in relation to EC135 and was impressed by the knowledge and understanding of Mr Mendick. The fact that it was Airbus who produced a new sensor design, in an attempt to overcome the water issue, as opposed to the sensor manufacturer, is testimony to their technical abilities.

[358] In all the circumstances, I am satisfied that, prior to the accident, Airbus would have had the ability to include within the EC135's fuel contents indication system a warning that both fuel transfer pumps had been switched **OFF**. However, for the reasons discussed below in relation to issue 5.3, it appears to me possible that this issue has, to an extent, been

superseded by developments which have taken place subsequent to the accident. In these circumstances, I make no recommendation in relation to this precaution.

[359] In conclusion in relation to issue 5.1, I am satisfied that including within the fuel contents indication system a warning and associated aural attention-getter which activated where both fuel transfer pumps had been switched OFF is a precaution which could reasonably have been taken prior to the accident; and, had it been taken, the accident might realistically have been avoided.

Issue 5.2

[360] Issue 5.2 invites the court to consider whether a reasonable precaution would have been to include within the fuel contents indication system a caution or warning that a fuel pump, having been switched OFF, has since been submerged in fuel.

[361] The fuel control and indication system software does not give an alert when a pump that has been switched OFF is subsequently re-submerged in fuel. As each fuel transfer pump supplies fuel at a rate which is greater than that at which fuel can be consumed by both engines, switching off one transfer pump will not deplete the contents of the supply tank cells. The supply tank cells only begin to deplete when both transfer pumps are switched OFF.

[362] The position where both transfer pumps are switched OFF is considered above under issue 5.1. The system of cautions and warnings on the EC135 is such that, where both transfer pumps are switched OFF the pilot will first receive a FUEL caution. This will illuminate when between 34 and 36 kg of fuel are present in supply tank cell No 1; and

when between 30 and 32 kg of fuel are present in supply tank cell No 2 (see the AAIB Report at paragraph 1.6.7). In the event that the pilot does not switch on at least one fuel transfer pump upon receiving the FUEL caution, shortly thereafter he or she will receive the LOW FUEL warnings.

[363] In these circumstances, and having regard to the conclusion I have reached in relation to issue 5.1, I have formed the view that this precaution is not a reasonable one. The system of cautions and warnings on the EC135, and the reasonable precaution outlined above, obviate any need to include yet another caution, which, save for the case of Captain Traill, there is no evidence to suggest is needed.

Issue 5.3

[364] Issue 5.3 invites the court to consider whether it would have been a reasonable precaution to design the fuel tank system and fuel contents indication system in such a way that the fuel transfer pumps did not require to be switched ON or OFF during flight.

[365] G-SPAO was fitted with Test Fuchs fuel transfer pumps. Those are capable of running dry for considerably longer than G-SPAO could have stayed in the air (see paragraph [163] above). As a consequence, G-SPAO's fuel transfer pumps did not need to be turned off in order to protect them from possible damage due to dry running.

[366] Not all EC135s were fitted with Test Fuchs pumps. Some were fitted with Globe pumps. These do not have the same dry running capability as the Test Fuchs pumps. Globe pumps can become damaged if allowed to run dry during a flight. They have a dry running time of 20 minutes or so.

[367] As a consequence of the varying types of fuel transfer pump that are in use, the EC135 flight manual directs pilots to switch off a fuel transfer pump which has run dry for three minutes. At that point, a caution appears on the CAD (accompanied by flashing bars and the illumination of the master caution light). In evidence, Mr Mendick explained that the reason for this was to maintain a uniform and consistent instruction as a pilot would not know which type of pumps were fitted on whichever EC135 he or she was flying and that to have two sets of instructions as to the proper management of the fuel transfer pumps, depending on which type were fitted, had the potential to give rise to unnecessary confusion. It was important, Mr Mendick advanced, that emergency procedures should be clear and not compromised by a pilot being required to identify the type of fuel transfer pump present within the helicopter he or she was flying.

[368] I am satisfied that the position spoken to by Mr Mendick is the appropriate one. It ensures consistency and avoids the possibility of confusion. The submission made on behalf of Mr Arthur, namely, "that it should easily be possible for a notice or indication to be displayed in each helicopter to show which pumps are fitted" is unsupported by relevant evidence. A pilot would have to check the "notice", wherever that may be situated; no suggestion is given as to quite how an "indication" might be given. It seems to me that what is proposed in the submissions made on behalf of Mr Arthur is potentially more susceptible to human error than the clear instructions given in the EC135 flight manual. It is of considerable significance that the evidence given to the inquiry by pilots did not suggest any practical difficulty with the requirement to switch pumps on and off.

[369] The "run dry" caution has been removed as a feature on the latest versions of the EC135 which are fitted with Helionix software. A similar modification has not been made

retrospectively to the software on those EC135 helicopters which are fitted with Test Fuchs pumps.

[370] The system of cautions and warnings on G-SPAO was, in my view, a suitable one which provided a number of safeguards against the eventuality of both fuel transfer pumps being switched OFF. Those factors, combined with the fact that, prior to this accident, the EC135 had accumulated more than three million flying hours over a period of twenty years, without any reported instance of fuel starvation, cause me to conclude that it would not have been a reasonable precaution for the fuel tank system and fuel contents indication system of G-SPAO to have been designed in such a way that the fuel transfer pumps did not require to be switched ON or OFF during flight.

Issue 5.4

[371] Issue 5.4 invites the court to consider whether a reasonable precaution would have been to include within the fuel contents indication system a caution or warning in the case of anomalous or implausible combinations of outputs from the sensors. I can deal with this briefly.

[372] Firstly, there was no evidence before the inquiry to suggest that pilots had failed to notice anomalous or implausible combinations of outputs from the sensors. On the contrary, it was the anomalous outputs that attracted the attention of Captain Shanks in relation to the incident involving G-POLD in March 2018 (see paragraph [290] above). There was no evidence that the accident was caused by any anomalous or implausible combination of outputs. On the contrary, the accident was caused by Captain Traill's failure to take the appropriate steps following receipt of the LOW FUEL warnings.

[373] Secondly, as can be seen from Information Notice No. 2535-I-28, issued on 21 January 2013, were a high concentration of water to enter the space between the two concentric metal tubes of a fuel probe, it will decrease the output signal (frequency) of the probe to such a level that the CAD recognises the probe as failed and shows either an F QTY DEGR or F QTY FAIL caution on the CAD. To that extent at least, the fuel contents indication system already contains a caution in the case of anomalous or implausible combinations of outputs from the sensors.

[374] For these reasons, I have concluded that it would not have been a reasonable precaution to include within the fuel contents indication system a caution or warning of the type set out in this issue.

Issue 5.5

[375] Issue 5.5 invites the court to consider whether a reasonable precaution would have been to design the fuel tank system, and in particular the differential capacities of the supply tanks, in such a way as to ensure that the design objective of creating an interval of three to four minutes between engine flame-outs, or such other interval of time as would be represented by 4.5kg of fuel, or any other safe interval of time, was achieved.

[376] It is appropriate to stress at the outset that the design objective was not to create an interval of three to four minutes between engine flame-outs. As I have identified above (see paragraph [327]), the designed time interval between flame outs is the time it would take the second engine to burn 4.5 kg of fuel, following the first engine flame out, provided that both supply tank cells contained the same level of fuel when the first engine flamed out.

[377] The nature of the fuel tank arrangement in an EC135, such as G-SPAO, is considered above in Part 12 (see the section entitled "*Fuel Tank Arrangement*" at paragraphs [149] to [154] above). Put short, the supply tank has a longitudinal divider in its lower section, creating two separate cells which are connected by the undivided volume of the upper section. This feature of the design permits fuel to move between the No 1 and No 2 supply tank cells. There was no evidence before the inquiry to suggest how the 4.5 kg differential might be maintained without separating the supply tank cells entirely, thus preventing fuel moving from one supply tank cell to the other.

[378] The rationale behind the fuel tank arrangement in an EC135 was spoken to in evidence by Mr Mendick. The design is driven by airworthiness requirements. The EC135 is certified to carry out what are referred to as Cat A operations, that is the flying of certain operations over congested areas, such as cities. To obtain such certification a helicopter must have separate supply tanks for each engine. Mr Mendick explained that was the reason for the design of the EC135 fuel tank arrangement, it being the least complex way in which to achieve the requirements for Cat A operations. The accommodation of two separate supply tanks would be more complex.

[379] The absence of any evidence on the feasibility of providing separate supply tanks prevents me from concluding that such a precaution was a reasonable one. Irrespective of the position in that respect, there was no evidence to suggest that the accident would have been avoided even assuming that the time-equivalent of 4.5 kg had been available to the pilot.

Issue 5.6

[380] Issue 5.6 invites the court to consider whether a reasonable precaution would have been to have ensured that power to the radio altimeter (“RADALT”) and steerable landing light was automatically maintained in the event of a double engine flame-out.

[381] As noted in the AAIB Report, at paragraph 2.1.6:

“The RADALT and the steerable landing light are optional equipment and are not standard on the EC135 helicopter. However, a RADALT is required for UK police night flying operations, in accordance with Civil Aviation Publication (CAP) 612, Police Air Operations Manual, Part 1. In the event of an autorotation at night, if the shed bus switch is not changed from NORM to EMERG, a pilot will not have accurate height information on which to judge the flare and landing. Also, he will not have the benefit of the landing light to enhance the visual cues.”

[382] Earlier within paragraph 2.1.6 of the AAIB Report, it is explained that the pilot has the ability to recover non-essential electrical services (including the RADALT and the steerable landing light) in the event of a double engine flameout. Battery power is recovered to those systems when the guard is lifted and the SHED BUS switch is moved from NORM to EMERG. After the accident, the SHED BUS switch on G-SPAO was found guarded in the NORM position. The recommended procedure for autorotation is that this particular step is taken after autorotation has been entered and the N_T is stable. As that state was never achieved the position regarding the position of the SHED BUS switch is unsurprising. As a consequence, neither the RADALT nor the steerable landing light was available to Captain Traill after the second engine had flamed out.

[383] In these circumstances, the AAIB made a safety recommendation relative to EASA (safety recommendation 2015-030 – see the AAIB Report, at page 80) recommending that, when EASA required a radio altimeter to be fitted to a helicopter operating under an Air Operator's Certificate, they also stipulate that the equipment is capable of being powered in all phases of flight, including emergency situations, without intervention by the crew.

[384] A similar safety recommendation was made by the AAIB relative to the CAA (safety recommendation 2015-031 - see the AAIB Report, at page 80) recommending that, when the CAA required a radio altimeter to be fitted to a helicopter operating under an Police Air Operator's Certificate, they also stipulate that the equipment is capable of being powered in all phases of flight, including emergency situations, without intervention by the crew.

[385] In light of the recommendations made by the AAIB, I am satisfied that it would have been a reasonable precaution to have ensured that power to the RADALT and steerable landing light was automatically maintained in the event of a double engine flame-out. I turn, therefore, to consider whether, if such a precaution had been taken, might the crash realistically have been avoided?

[386] A RADALT only provides reliable information over flat surfaces, as opposed to congested areas such as the centre of Glasgow with its multitude of buildings of differing heights. Captain Prior gave evidence to the effect that without the steerable landing light and the RADALT, it would have been difficult for Captain Traill to have judged the height of his helicopter. In turn, that might have led to Captain Traill applying the collective at the wrong point. More telling, however, was Captain Prior's evidence that if the final ROTOR

RPM decay occurred early during the final descent then the loss of the RADALT and the landing light would have been immaterial; Captain Traill could no longer control the aircraft and it would not have mattered if the landing light worked or not.

[387] In light of the evidence of Captain Prior, and having due regard to the conclusion reached above in Part 21, namely, that Captain Traill had no realistic chance of landing the helicopter safely, even had the power to the RADALT and the steerable landing light been maintained in the event of a double engine flame-out, the crash could not realistically have been avoided.

23. Defects In Any System Of Working

[388] The court's determination must set out any defects in any system of working which contributed to the deaths or to any accident resulting in the deaths (see section 26(2)(f)). The issues before the inquiry invite the court to consider four matters.

Issue 6.1

[389] Issue 6.1 invites the court to consider whether any aspect of the system of maintenance of G-SPAO, including its washing regime, contributed to the contamination of the fuel and / or the fuel tank system with water.

[390] This issue is predicated upon the assumption that the fuel and / or the fuel tank system on G-SPAO were, in fact, contaminated with water. As set out in paragraph [317] above, whilst I have concluded that it is more likely than not that the quantities of fuel displayed on the fuel quantity indication system of G-SPAO contradicted the LOW FUEL warnings, the evidence before the inquiry is such that I cannot determine what caused that.

[391] There was no evidence which would entitle the court to find that the fuel, the fuel tank system or both of them were contaminated with water. Accordingly, there is no basis upon which the court would be entitled to hold that there was a defect of the type set out in this issue.

Issue 6.2

[392] Issue 6.2 invites the court to consider whether any aspect of the pre-flight check procedures contributed to the accident occurring. There was no evidence before the inquiry to suggest any issue with the pre-flight check procedures. Accordingly, there is no basis upon which the court would be entitled to hold that there was a defect of the type set out in this issue.

Issue 6.3

[393] Issue 6.3 invites the court to consider whether any aspect of the training of pilots, in particular, with regard to fueling, 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 warnings, and the execution of an autorotation at night, contributed to the accident occurring.

[394] The submissions made on behalf of the procurator fiscal focus on two aspects of training, namely, (i) training in respect of LOW FUEL warnings, and (ii) autorotation training. With the exception of Dr Thomas and BALPA (to whom I return below), the majority of the remaining participants in the inquiry either adopted those submissions or indicated that

they had nothing to add to them. The remaining participants made no submissions on this issue. Participants' written submissions are available on the SCTS website¹⁴.

[395] Standing the degree of consensus amongst participants on this issue, it is helpful to set out the procurator fiscal's submissions in some detail. I have addressed the issue of Captain Traill's relevant training and knowledge in Part 13 above.

(i) *Training re LOW FUEL warnings*

[396] The procurator fiscal submitted¹⁵ that there was no evidence to suggest that training was provided to Captain Traill other than in the manner in which it was normally provided to pilots. Initial type rating training for the EC135 included training specifically in relation to the fuel tank system and the fuel indication system. It included training in relation to cautions and warnings pertinent to the fuel system, and in particular the order of cautions and warnings that would be displayed in the event of a low fuel situation. Such training would normally have included the need to comply with the relevant flight reference cards in the Pilot's Checklist.

[397] The procurator fiscal submitted¹⁶ that, apart from this formal training, there may be a question as to whether pilots were provided with sufficient practical training in relation to low fuel situations and specifically the procedure to be followed in response to a FUEL caution or a LOW FUEL warning. This submission is made on the basis that the simulator was not used to simulate low fuel situations: the operator considering it unrealistic to instigate a scenario (pilot testing being based upon "scenarios" which are followed from start to finish)

¹⁴ See <http://www.scotcourts.gov.uk/the-courts/court-locations/clutha-fai>

¹⁵ At paragraph 6.3.2

¹⁶ At paragraph 6.3.3

that leads to a **LOW FUEL** warning. As a result a pilots would not have been assessed on their actions in the event of a **LOW FUEL** warning (see the AAIB Report, paragraph 2.1.4).

[398] The procurator fiscal submitted that it is difficult to say whether the absence of practical training in relation to low fuel situations contributed to the accident, going on to suggest that that possibility could perhaps not be excluded. In making that submission it was recognised that the reasons why the helicopter did not land within ten minutes of the **LOW FUEL** warnings were unknown.

[399] The submissions made on behalf of Dr Thomas on this issue¹⁷ adopted those made on behalf of the procurator fiscal and provided additional comments, of which the following are of significance.

[400] During type rating training, pilots were directed to the EC135 T2+ flight manual, paragraph 7.6.3 of which deals with **LOW FUEL** warnings. As at the date of the accident, that section did not record the independence of the fuel caution and fuel warning systems¹⁸. The evidence to the inquiry from pilots suggested that, prior to the accident, their level of understanding of the independence of the fuel caution and fuel warning systems varied¹⁹. As at the date of the accident, the flight reference card in the Pilot's Checklist relating to **LOW FUEL** warnings did not indicate that this warning took priority over the CAD fuel quantity indication²⁰. The information given to pilots in relation to the period of time between engine flameouts varied²¹. Until the issue by Airbus, post-accident, of the safety information notice;

¹⁷ At paragraphs [210] to [223]

¹⁸ See submissions for Dr Thomas at paragraph [212]

¹⁹ See submissions for Dr Thomas at paragraph [221]

²⁰ See submissions for Dr Thomas at paragraph [214]

²¹ See submissions for Dr Thomas at paragraphs [215] to [218]

alert safety bulletins; and information notices set out at paragraph [221] of the submissions for Dr Thomas, 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 caused²².

[401] The submissions made on behalf of BALPA on this issue²³ are, essentially threefold. Firstly, that there was no evidence before the court upon which it could be satisfied to the required standard of proof that an absence of training was a contributory factor to the accident²⁴. Secondly, they invite the court to conclude that Captain Traill was appropriately trained that in the event of a LOW FUEL warning he should refer to, and comply with, the relevant flight reference card²⁵. Thirdly, they invite the court to conclude that the appropriate pilot response to a LOW FUEL warning is to consult the relevant flight reference card and comply with it²⁶.

[402] With the exception of Captain Rooney (discussed above at paragraphs [245] and [246]), each of the pilots who gave evidence to the inquiry in relation to the actions required by the Pilot's Checklist in the event of a LOW FUEL 1 and / or a LOW FUEL 2 warning presented a clear and consistent view of what a pilot should do. The steps set out in the Pilot's Checklist should be followed and the helicopter landed within the stipulated ten minute period, in the event that the preceding steps required by the Pilot's Checklist did not cause the LOW FUEL warning or warnings to be extinguished.

²² See submissions for Dr Thomas at paragraph [221]

²³ At paragraph 4.4.1

²⁴ See submissions for BALPA at paragraph 4.4.1.3

²⁵ See submissions for BALPA at paragraph 4.4.1.5

²⁶ See submissions for BALPA at paragraph 4.4.1.6

[403] That such a clear and consistent view emerges (and, in fairness to Captain Rooney, he was only “inconsistent” on one aspect) is testimony to the quality of training the pilots received. The evidence before the inquiry satisfies me beyond reasonable doubt that there was not a lack of practical training in relation to low fuel situations. Separately, I am satisfied that Captain Traill’s training did not contribute to the accident.

[404] The additional points raised in submissions by Dr Thomas (at paragraph [400] above) can be dealt with briefly. Whilst I accept that the section of the flight manual referred to did not record the independence of the fuel caution and fuel warning systems, it does not suggest that they were not independent. It is correct to state that the evidence to the inquiry from pilots suggested a varied understanding of the independence of the fuel caution and fuel warning systems, however, there was no such variance in relation to the actions that should be taken in the event of a LOW FUEL 1 and / or a LOW FUEL 2 warning. The same applies in relation to pilots’ understanding of the operation of the fuel system and how erroneous fuel indications and fluctuating fuel indications could be caused. On the basis of the evidence heard by the inquiry, I have no doubt that pilots know what actions should be taken in the event of a LOW FUEL 1 and / or a LOW FUEL 2 warning.

[405] The fact that as at the date of the accident the flight reference card relating to LOW FUEL warnings did not indicate that such warnings took priority over the CAD fuel quantity indication is, in my view, immaterial. I have dealt with the distinction between cautions and warnings above (see paragraph [353]). In a red / yellow (amber) / green scenario (such as the CAD) it does appear to me to be a quite remarkable proposition to suggest that a (red) warning should be ignored by reason of a contradictory (yellow) caution. The instructions in

that flight reference card are clear and concise. Had Captain Traill followed them, the accident would not have occurred.

[406] The information given to pilots in relation to the period of time between engine flameouts appears to have varied, however, I am driven to the conclusion that little attaches to this. The consistent evidence of pilots was to the effect that, with both engines operating, an EC135 such as G-SPAO would consume fuel at an average rate of 200 kg per hour, or 3.3 kg per minute. The different capacities of the supply tank cells are known to pilots – they are clearly displayed on the CAD. Performing the necessary calculation with these two pieces of information will inform a pilot that the period of time between engine flameouts is likely to be of in the order of one minute and 30 seconds, or thereby (see the AAIB Report at paragraph 2.1.5), assuming of course that the supply tank cell levels were the same when the first engine flames out. The issue of the transference of fuel between the supply tank cells is another issue altogether. In any event, G-SPAO should never have reached the stage of flying with one engine operative, far less suffering a double engine flameout.

(ii) *Autorotation Training*

[407] The submissions made on behalf of the procurator fiscal recognise the obvious practical constraints on carrying out autorotation training. The evidence of Captain Christopher Redfern, the head of flight operations for Babcock, who was a training captain at the time of the accident, was that he was unaware that if N_r was not maintained above 75%, it would otherwise be irrecoverable.

[408] The procurator fiscal raised the possibility that if pilots had never practised trying to establish autorotation at these low levels of rotor speed - or if they were not aware of the existence of a threshold below which they should not under any circumstances allow rotor speed to fall – it may be suggested that they were not adequately trained in that regard.

[409] Pilots are trained to apply the collective lever in order to maintain the N_r within the limits that trigger the ROTOR RPM warning, namely, between 97% and 106%. One is entitled to assume that they would endeavour to do so. It therefore follows that they will seek to maintain the N_r above 75% and the apparent absence of any specific training on the limit below which the N_r could not be recovered can have no practical effect. On the limited evidence heard in this respect, I am satisfied that pilots have been appropriately trained in relation to maintaining rotor speed. As discussed in Part 21 above, Captain Traill managed to recover the N_r on two occasions.

Conclusion re Issue 6.3

[410] For the reasons outlined above, I am satisfied that no aspect of the training of pilots contributed to the accident occurring. Accordingly, there is no basis upon which the court would be entitled to hold that there was a defect of the type set out in this issue.

Issue 6.4

[411] Issue 6.4 invites the court to consider whether the practice of the “day-shift” pilot handing the aircraft over already fuelled to the “night-shift” pilot contributed to the accident occurring. There was no evidence before the inquiry to suggest any issue with the practice of

the “day-shift” pilot handing the aircraft over already fuelled to the “night-shift” pilot.

Accordingly, there is no basis upon which the court would be entitled to hold that there was a defect of the type set out in this issue.

24. Other Relevant Facts

[412] The court’s determination must set out any other facts which are relevant to the circumstances of the deaths (see section 26(2)(g)). I have concluded that the fact that it is more likely than not that the quantities of fuel displayed on the fuel quantity indication system of G-SPAO contradicted the LOW FUEL warnings (see Finding F7.1; and paragraph [311] above) is one which is relevant to the circumstances of the deaths. The issues before the inquiry invite the court to consider two further matters in this regard.

Issue 7.1

CAA

[413] Issue 7.1 is whether, and the extent to which, the Safety Recommendations of the AAIB in their Report 3/2015 have been adopted and implemented. A Notice to Admit relative to this issue was lodged by the CAA. As set out below, it narrated the steps taken by the CAA in response to certain of the recommendations set out in the AAIB Report. No objection having been taken to that Notice to Admit, and no contrary evidence having been presented to the inquiry, I am content to adopt what is stated therein, insofar as the issues contained within that Notice to Admit have not already been addressed. I do so below in paragraphs [414] to [424].

[414] The AAIB Report made seven safety recommendations, of which four were directed to the CAA²⁷. The CAA actively reviewed the recommendations and responded to the AAIB with its intentions in their report, FACTOR F6/2015²⁸ dated 4 December 2015. The CAA was supportive of the safety recommendations and the intention to widen the fitment of suitable flight recording devices where appropriate. Accordingly, the CAA formally intimated to the AAIB on 7 December 2015 that it accepted the safety recommendations.

Flight Recorders

[415] Two of the four safety recommendations (2015-032 and 2015-033) were concerned with the fitment of flight recorders to police helicopters as current legislation and operating rules did not require helicopters of the type involved in the accident to be fitted with such devices. In this context, there are three types of flight recorder systems: (i) flight data recorders – which record technical and performance information from the aircraft systems and engines; (ii) cockpit voice recorders – which record voice and background noise; and (iii) airborne image recorders – which can record images of general cockpit view, including the instrumentation and crew.

[416] Each type of flight recorder system consists of sensors, power supply connections and wiring. They are required to record data in a crashworthy manner and meet internationally defined standards. A third safety recommendation (2015-034) recommended that the CAA should consider applying the requirements of safety recommendations (2015-032 and 2015-033) to state aircraft not already covered by these safety recommendations.

²⁷ See Section 4, page 97 et seq

²⁸ See <http://publicapps.caa.co.uk/docs/33/factor20156.pdf>

Radio Altimeters

[417] Safety recommendation 2015-031 recommended that when the CAA required a radio altimeter to be fitted to a helicopter operating under a Police Air Operator's Certificate it should be capable of being powered in all phases of flight, including emergency situations, without intervention by the crew. This resulted from the finding that the installed radio altimeter in G-SPAO, as with any other EC135 at the time, would have lost its primary electrical power by design in the circumstances of the accident thereby denying the pilot accurate height information.

Review and Consultation

[418] Following publication of the AAIB Report, the CAA reviewed the safety recommendations in detail and assessed how best to address the safety intent for both existing and future police helicopters and the wider state aircraft involvement. This involved exploring the technical and practical issues of making any changes to the requirements together with meeting and collaborating with the affected police operators to understand and quantify the impact that such changes might cause. The CAA needed to balance the potential safety enhancements of such requirements with the overall effect on the availability, viability and safety of the police helicopter force both in the short and longer term and the applicability to different state aircraft. Due to the very nature of their often hazardous operations, the CAA deemed it appropriate to limit the wider state aircraft involvement to search and rescue helicopters under contract to the Maritime Coastguard Agency.

[419] The CAA met with the police operators in December 2015 to discuss the safety recommendations and to explore the way forward to meet the safety intentions recommended by the AAIB.

[420] In its review, the CAA established various options that might meet the intent of the safety recommendations and produced a focussed consultation document laying out these options and likely impacts. As this is a very limited sector, this consultation was addressed to the three police helicopter operators and two search and rescue helicopter operators. The consultation was sent to those operators in October 2016. The AAIB were also kept informed. Following the consultation and responding to the feedback received, the CAA met with the operators in November 2016 and agreed a way forward in setting out new requirements for flight recorders. Due to the complexity and impact in terms of costs and aircraft availability, the CAA established proportionate requirements and agreed the timescales for compliance. These requirements have been actioned through changes to equipment exemptions for the lighter in-service helicopters (initially through ORS4 No. 1210) and new requirements for image recording in all police and search and rescue helicopters in addition to any fitted standard flight recorders.

Implementation of Safety Recommendations 2015-032 and 033

[421] These new flight recorder requirements were achieved by the issuance of Safety and Operational Directive SD-2016/006 on 22 December 2016. This details the background to the new requirements and directs the operators to reach compliance in a measured timescale. The requirements essentially differentiate between the then in-service helicopters and any that might be brought into service subsequently. Retro-fitting in-service helicopters is not a

trivial matter so a balance was set by the CAA to achieve the aims of the safety recommendations without losing the intent of the safety improvements. For new helicopters, the equipment can be specified and combined during manufacture more easily and cost-effectively. Additionally, operators will be required to establish procedures for the protection of any image data captured by the equipment in a similar fashion to that accorded to cockpit voice recorders.

[422] The CAA issued a Specification Note in July 2017 to assist operators in meeting compliance with Operational Directive SD-2016/006 by providing additional information and technical guidance. This information highlights the necessary technical specifications that should be followed and further recommendations. This was subsequently revised, following discussions with an aircraft modification company working on the design of the camera installations, and the updated version was sent to the operators in March 2018.

[423] SD-2016/006 was replaced with Safety and Operational Directive SD-2018/002 on 1 May 2018 due to the need to revise the compliance dates. Compliance with the new requirements must be met for current in-service helicopters by 31 March 2020 and on delivery for all new helicopters with an individual Certificate of Airworthiness first issued on or after January 2019. These dates were amended to reflect the availability of equipment and progress of the necessary operator procurement and implementation programmes. The extended period will assist in alleviating the need to withdraw line aircraft from UK emergency services cover during the process of upgrading. In fact, all affected aircraft being operated for or on behalf of Police Scotland and other emergency services in Scotland now have flight recorders fitted.

Implementation of Safety Recommendation 2015-031

[424] In response to safety recommendation 2015-031, the police operators quickly adapted their aircraft voluntarily and the CAA amended Leaflet 34-30 "Radio Altimeters and AVADs for Helicopters" of CAP 562 (Civil Aircraft Airworthiness Information and Procedures) in February 2017 to detail the requirements. This is now the technical standard to be met by state helicopters.

[425] No participant in the inquiry took issue with the steps taken by the CAA to ensure the safety recommendations made within the AAIB Report were met. It is unnecessary for me to comment further upon those steps. Furthermore, in light of the steps that have already been taken, it is not appropriate that I make recommendations under section 26(4) relative to the matters covered by the four safety recommendations directed to the CAA within the AAIB Report.

EASA

[426] Of the seven safety recommendations made in the AAIB Report, three were directed to EASA. Those are safety recommendations 2015-030; 2015-035; and 2015-036. Safety recommendation 2015-030 relates to the fitting of radio altimeters and is, to all intents and purposes, in identical terms to safety recommendation 2015-031, considered above (at paragraph [417]). Safety recommendations 2015-035 and 2015-036 relate to flight recorder requirements and image flight recorder requirements respectively.

[427] The inquiry heard no evidence in relation to the steps taken (if any) by EASA in relation to these safety recommendations. The extent of EASA's participation in the inquiry is as set out above at paragraph [16]. Importantly, EASA did not make any submissions at the conclusion of the evidence. In advance of the preliminary hearing on 5 February 2019, EASA lodged a note which set out their position in relation to the three safety recommendations directed to them. In light of the absence of evidence or submissions on these recommendations, I have concluded that it is appropriate to set out EASA's position in this determination. It should be stressed that the position as set out below is that which pertained in February 2019. It may not remain so as at the date of this determination.

Safety Recommendation 2015-030

[428] EASA's position was that there can be situations where electricity generation is lost and it is preferable not to automatically power the radio altimeter, because it is not a critical system and the battery must be preserved to support continued safe flight and landing. EASA considered the ability to perform the operation, even in emergency situations, without needing exceptional piloting skills to be of more relevance than operation without intervention. They highlighted the fact that the utility of radio altimeters is severely compromised if the terrain below the aircraft is not flat.

[429] Accordingly, EASA considered that this safety recommendation is not appropriate, however, usability without crew intervention is systematically assessed by them and if there are circumstances where the assessment favours this it will be required.

Safety Recommendation 2015-035

[430] EASA's position was that the availability of data recording does not directly assist pilots in emergencies and thus would not have prevented this accident but it can and has assisted with the prevention of future accidents. Commission Regulation (EU) No 965/2012 on air operations requires certain helicopters used in commercial air transport operations (including helicopters used for emergency medical services operations) to be equipped with flight data recorders and cockpit voice recorders ("CVR"). The carriage of CVR is required if the helicopter's maximum certified take-off mass ("MCTOM") is of more than 7000 kg, as well as if the helicopter's MCTOM is of more than 3175 kg and it was first issued with an individual certificate of airworthiness on or after 1 January 1987. Due to the economical life cycle time of a helicopter, it means that practically most helicopters with a MCTOM of over 3175 kg are equipped with a CVR.

[431] EASA Notice of Proposed Amendment (NPA 2017-03) was issued under EASA Rulemaking task RMT.0271 ('In-flight recording for light aircraft') and it recommends the recording of flight parameters for turbine engine helicopters with MCTOM greater than or equal to 2250 kg (which would cover aircraft of the same type as G-SPAO) when newly manufactured and used for commercial operations. EASA NPA 2017-03 was prepared by a rulemaking group representing the aviation stakeholders. The AAIB was represented on this group.

[432] NPA 2017-03 was made available for public consultation and the comments were reviewed together with a 'review group', another stakeholder group which also included the

AAIB. This review group confirmed the applicability of the lightweight flight recorder carriage requirements as proposed in NPA 2017-03. In particular, the analysis of the NPA 2017-03 regarding the recording of cockpit audio was confirmed. However, this review group also suggested to insert non-binding guidance material to the requirements proposed in NPA 2017-03, which advises to record additional information, including audio of the flight crew compartment. It should also be noted that when the proposals in NPA 2017-03 are adopted, the flight recorder carriage requirements applicable to helicopters operated in the EU will be aligned with ICAO²⁹ Annex 6 (Operation of aircraft) Part III (International operations with helicopters), which does not contain any standard prescribing the recording of cockpit audio for helicopters with a MCTOM of less than 7000 kg.

[433] EASA considered that the more appropriate way forward is voluntary installation through safety promotion channels for aircraft categories and for recording functions not captured by the requirements already applicable or proposed in NPA 2017-03. For that purpose, in the second issue of the certification specifications for standard changes and repairs (CS-STAN) dated 30 March 2017, Standard Change CS-SC104a (Installation of lightweight in-flight recording systems) was introduced. CS-SC104a enables the installation of a lightweight in-flight recording system on a non-complex helicopter³⁰ by a qualified maintenance engineer without a change approval (i.e. no need to get the installation design approved by the certification authority).

²⁹ International Civil Aviation Organisation

³⁰ A complex helicopter is a helicopter certificated:

- for a maximum take-off mass exceeding 3175 kg, or
- for a maximum passenger seating configuration of more than nine, or
- for operation with a minimum crew of at least two pilots. (cf. Art. 3(j)(ii) of Regulation (EC) 216/2008 and Art. 140(2)(b) of Regulation (EU) No 2018/1139)

[434] The issue of an alternate power source for the CVR has been considered within the framework of rulemaking task RMT.0249 'Recorders installation and maintenance thereof - certification aspects'. Under this rulemaking task, EASA published NPA 2018-03. This NPA proposed mandating an alternate power source for new type certificates of large aeroplanes and large rotorcrafts (through an amendment to the Certification Specifications for Large Aeroplanes (CS-25) and to Certification Specifications for Large Rotorcrafts (CS-29)), and for newly manufactured aeroplanes with a Maximum Certificated Take-Off Mass ("MCTOM") of 27000 kg (through an amendment to Commission Regulation (EU) No 965/2012 on air operations). While the need for alternate power sources for CVRs appears to be well-supported by investigations of accidents involving aeroplanes with an MCTOM of over 27000 kg, this is not indicated for lighter aeroplanes or helicopters.

[435] Cockpit voice recorders have a major privative element owed to the persons being recorded. At present, there is protection for that privacy applicable to EU operators (refer to Annex IV (Part-CAT) to Commission Regulation (EU) 965/2012, paragraph number CAT.GEN.MPA.195, point (f)).

Safety Recommendation 2015-036

[436] It is considered by EASA that the legal protection of cockpit image recorder data at global level is an essential pre-requisite to mandating image recording. ICAO had been working to establish standards on the carriage of cockpit image recorders and the legal protection of associated data and in 2016 it adopted amendments to Annex 6 applicable from 7 November 2019. As ICAO standards are not directly applicable in the ICAO contracting states, the transposition of these standards normally would require the adoption of national

legislation. In addition, the contracting states may decide to only partially implement these standards or with a later applicability date. Hence the adoption of ICAO standards on the protection of image recordings is only the first step toward legal protection of data from cockpit image recorders at global level. Within the EU, the transposition of these standards will require an amendment to the applicable EU regulation by the EU Commission, based on the proposal of EASA and after consultation with the member states.

[437] EASA NPA 2017-03 includes proposals to provide for the protection of privacy of cockpit image recordings. This is because the draft requirements proposed in EASA NPA 2017-03 allow for capturing flight parameters by the means of images of the main instrument panel. However, it is technically challenging to install image sensors in the cockpit of a small aeroplane or helicopter for that purpose, without capturing parts of the bodies of the flight crew members.

[438] EASA NPA 2017-03 was made available for public consultation and the comments were reviewed together with a review group which included the AAIB. This review group confirmed the applicability of the lightweight flight recorder carriage requirements as proposed in NPA 2017-03. In particular, this review group did not recommend to require the recording of images in addition to flight parameters in the case of helicopters. However, this review group also suggested to insert non-binding guidance material to the requirements proposed in NPA 2017-03, which advises to record additional information, including additional instrument indications (such as position of flight controls, position of engine controls, fuel and oil indications, aircraft configuration selection), and an external view of outside the aircraft. The guidance material intends to also indicate that this can be achieved by a flight recorder which includes a camera.

[439] The absence of evidence or submissions in relation to EASA's position in respect of the safety recommendations directed to them in the AAIB Report is regrettable. As can be seen from the position EASA advanced at the time of the preliminary hearing in February 2019, in certain respects, the issues raised by those safety recommendations are not without complexity. The information before the inquiry precludes me from commenting further upon those safety recommendations. In these circumstances, I cannot make recommendations under section 26(4) relative to the matters covered by the three safety recommendations directed to EASA within the AAIB Report.

Issue 7.2

[440] Issue 7.2 is whether, and the extent to which, the operator, helicopter manufacturer and engine manufacturer have taken necessary and appropriate safety actions following the accident, including those considered by the AAIB Report.

[441] The safety actions which had been taken, or which were being progressed, at the time of publication of the AAIB Report, are set out within Section 4 of the report, in paragraph 4.2. On 20 December 2013 Bond amended their final reserve fuel to 90 kg. On 19 December 2013, Airbus issued alert safety bulletins ("ASBs") in relation to erroneous fuel quantity indications; and amending the flight manual in relation to the LOW FUEL checklist (the ASBs are reproduced as Appendices D and E to the AAIB Report). A modification of the mechanical design of the fuel quantity sensor had been initiated, to reduce susceptibility of the sensor to water contamination. Changes to future avionics suites to simplify the operation of the fuel transfer pumps were underway (these have since been implemented – see paragraph [369] above). The engine manufacturer, Safran, issued a concession to Bond

on 8 December 2014 authorising the suspension of the cold compressor washing process, but continuing with the daily hot washing process in accordance with the EMM. In April 2014, Airbus issued a service bulletin recommending the retrofitting of vent hoses to the high pressure fuel pump drain lines. This modification was designed to prevent unwanted fluids held in the drain bottles being sucked through the high pressure fuel pumps during engine start-up and shut-down procedures.

[442] In addition to the measures set out in the AAIB Report, Babcock has incorporated the system check into the maintenance regime for the aircraft. The compressor wash concession by Safran to Babcock continues in operation. Accordingly, there is no requirement for a cold chemical clean. The daily wash is carried out as a hot wash. The hot wash regime removes any risk of water returning through the return-to-tank line. A new sector record page was introduced in July 2016. This now requires completion of 'planned fuel uplift' and 'actual fuel uplift' figures. Babcock has installed new tactile switch covers to the fuel transfer pump switches on all its aircraft. This has made the switches easier to identify from a visual point of view as well as from a feel point of view.

[443] Airbus has also taken a number of actions. The system check of the supply tank indication has now been incorporated into the maintenance regime for the aircraft. A modified probe (which has widened drainage holes) was designed by Mr Mendick and two of his colleagues. This has been available from 16 March 2018. The SDS of the AMM has been updated to delete the erroneous three to four minute time given between engine flameouts. A modified fuel transfer pump switch design has been developed. This has a guard and requires a double-action to switch the pump into the OFF position. The Helionix avionics suite is available in new aircraft. In addition to the changes made in relation to the

Test Fuchs pumps, this suite allows flight data monitoring. Once data is uploaded, it triggers an alert if fuel levels in the aircraft have gone below 90 kg.

[444] In conclusion in relation to issue 7.2, I am satisfied that the operator, helicopter manufacturer and engine manufacturer have each taken necessary and appropriate safety actions following the accident.

25. Recommendations

[445] Section 26(4) allows the court to make recommendations. Any recommendations made must be directed towards (a) the taking of reasonable precautions; (b) the making of improvements to any system of working; (c) the introduction of a system of working; and (d) the taking of any other steps which might realistically prevent other deaths in similar circumstances. Issue 7.3 for the inquiry is whether, and the extent to which, any recommendations should be made by the court.

[446] In the exercise of the discretion afforded to me, I have concluded that it not appropriate to make recommendations. The two reasonable precautions I have identified (see Findings F5.1 and F5.2) do not, of themselves, justify the making of related recommendations. Captain Traill's failure to follow the procedure set down in the Pilot's Checklist is inexplicable. The evidence before the inquiry, with one exception, presented a clear and consistent view of what a pilot should do in such circumstances. Whilst the inclusion within the fuel contents indication system of a warning and associated aural attention-getter which activated where both fuel transfer pumps had been switched OFF was a reasonable precaution which might realistically have resulted in the accident resulting in the deaths being avoided, the subsequent changes introduced by Airbus to the avionics suite

on the EC135 are such that the making of a recommendation in this regard is also unnecessary.

[447] The evidence before the inquiry is such, in my view, that the making of recommendations relative to improvements to any system of working, or the introduction of a new system of working, are not appropriate. The accident crash was fully investigated by the AAIB. They made what they regarded as appropriate safety recommendations which, at least in the case of the relevant United Kingdom authority (the CAA), have been implemented. The evidence before the inquiry does not permit me to identify any other steps which might realistically be taken to prevent other deaths in similar circumstances.

[448] The circumstances of the accident crash are, in my view, so unusual that it is improbable they will be repeated, even before the introduction of the subsequent safety actions outlined above. I am reinforced in that view by the fact that, until the accident crash, the EC135 had accumulated more than three million flying hours, over a period of twenty years, without there previously being a reported instance of fuel starvation.

[449] A number of the participants in the inquiry invited the court to consider making certain recommendations. As a matter of fairness to them, it is appropriate that I set out those proposed recommendations and explain why I have declined to make them. Where appropriate, I do so by reference to earlier parts of this determination.

Gordon Arthur

[450] The submissions for Mr Arthur invited the court to consider making three recommendations. Firstly, that the manufacturers of the EC135 (i.e. Airbus) be directed to

introduce a system of working whereby pilots who are flying helicopters installed with Test Fuchs pumps are not directed to turn these pumps off, when they become exposed.

Secondly, that greater training is afforded to pilots in relation to LOW FUEL warnings. This would also promote a better understanding of the mechanics of the fuel systems. Thirdly, that greater training is afforded to pilots in relation to the need and methods of maintaining rotor speed above 75% in order to ensure successful autorotation.

[451] The Test Fuchs pump issue is considered above in relation to issue 5.3 (see paragraphs [364] to [370]). For the reason set out therein, I do not regard the proposed recommendation as appropriate. The remaining two issues relate to pilot training. That issue is considered above in relation to issue 6.3 (see paragraphs [393] to [410]). For the reasons set out therein, I do not regard the proposed recommendations as appropriate.

John McGarrigle

[452] The submissions for Mr McGarrigle invited the court to consider making three recommendations.

[453] Firstly, the court should recommend the installation of voice recorders / black boxes so as to provide a more complete record of events leading up to any future accident, and to assist in identifying the thought processes of the pilot and air observers so as to identify acts or omissions leading to the accident; and moreover to allow a better understanding of the conduct of operations and the dynamics between pilot and crew members, so that such errors / problems as may be apparent may be examined and training improved upon.

[454] Having regard to the safety recommendations made by the AAIB, and the steps taken by the CAA in response to those recommendations, I do not regard the proposed recommendation as appropriate.

[455] Secondly, the court should recommend that there is no “self-reporting” of landing below the minimum fuel amount – this should be reported by those carrying out the fueling of the aircraft, who will know if the aircraft lands below the minimum fuel amount.

[456] Having regard to the flight data monitoring capability introduced by way of the Helionix avionics suite, and the fact that the evidence before the inquiry did not suggest this was an issue in practice, I do not regard the proposed recommendation as appropriate.

[457] Thirdly, the court should recommend that the AAIB should consider adhering to short time limits to complete investigations and reports - such as the one it completed in relation to the Clutha accident – perhaps a time limit of 12 months or thereby. The delay which has been occasioned by waiting a number of years before the AAIB completes its report in order that the FAI can take place informed of its contents was too long and the delay in itself has caused considerable stress and upset for those who lost people in the accident.

[458] There was no evidence before the inquiry to entitle the court to make such a recommendation. The time taken to hold this inquiry is a separate issue, which is considered below in Part 26. I have made certain observations in that part, however, I do not regard the proposed recommendation as appropriate.

James Diver

[459] The submissions for Mr Diver invited the court to consider making three recommendations.

[460] Firstly, that had G-SPAO been flown without the need to switch transfer pumps to OFF after three minutes of dry running, this accident would not have occurred. This procedure was *de facto* unnecessary on that aircraft. It was submitted that a recommendation be made that Test Fuchs pump equipped aircraft should be flown to parameters of those pumps, and not to the parameters of pumps historically used. This would involve the rewriting of a short part of the flight manual, and the splitting of type ratings. Alternatively, given that a maximum of 200 aircraft of a global fleet of 1,500 remain equipped with the older Globe pumps, these aircraft should be mandatorily retrofitted with Test Fuchs pumps. This would avoid any split in type rating, and would eliminate the fuel management procedure for dry running pumps across the whole fleet.

[461] The primary recommendation is in broadly similar terms to the first recommendation made in the submissions for Mr Arthur (see paragraph [450] above). For the reasons given above, I do not regard the proposed recommendation as appropriate.

[462] The alternative recommendation is, in my view, impractical. It would be one directed to a number of operators, worldwide, none of whom participated in the inquiry. In such circumstances, there is no obligation to give a response to the recommendation (see section 28(1)(b)), far less comply with it. Until the accident crash, the issue this recommendation is designed to address appears never to have arisen. The clear evidence of the pilots to the

inquiry was that this is not an issue in day to day operations. I do not regard the proposed alternative recommendation as appropriate.

[463] Secondly, the court is invited to recommend that consideration ought to be given to the retrofitting of a red warning indicator, independent of the CAD, to inform pilots that both transfer pumps are set to OFF.

[464] As set out above (see paragraph [446]), whilst this was a reasonable precaution which might realistically have resulted in the accident resulting in the deaths being avoided, the subsequent changes introduced by Airbus to the avionics suite on the EC135 are such that the making of a recommendation in this regard is unnecessary.

[465] Thirdly, the court is invited to recommend that pilot training formally includes training in the manner of fuel detection across the two systems of capacitance tube senders to gauges, and thermistor generated LOW FUEL warnings. Specifically, the independence of the two systems should be emphasised, and precedence ordained to the LOW FUEL warnings. The lack of historical anomaly in the thermistor driven system ought to be emphasised to all EC135 rated pilots.

[466] This recommendation is in broadly similar terms to the second proposed recommendation identified in the submissions for Mr Arthur (see paragraph [450] above). For the reasons given above, I do not regard the proposed recommendation as appropriate.

Ian O'Prey

[467] The submissions for Mr O'Prey invited the court to consider making two recommendations.

[468] Firstly, the court should recommend that operators of the EC135 take steps to instruct their pilots (i) on the nature of the fuel differential in the supply tanks of the EC135; and the time-interval in flame-out on fuel starvation such differential may permit; and (ii) that flight conditions, in particular dynamic flying of the sort that police operations involve, may lead to fuel migration that significantly reduces, and potentially eliminates, such interval.

[469] This proposed recommendation is directed to pilot training. As I have concluded (see paragraph [410] above) that no aspect of pilot training contributed to the accident occurring, there is no basis upon which the court would be entitled to make a recommendation such as that proposed by Mr O'Prey.

[470] Secondly, the court should recommend that it is desirable that a time-interval be achieved between flame-out in situations of fuel starvation and, more particularly, that Airbus give consideration to ways in which the design intention might be ensured.

[471] In inviting consideration of such a recommendation, those representing Mr O'Prey properly recognised that the evidence before the inquiry did not address how a time interval of 1 minute and 30 seconds, or a greater time-interval, might be achieved. This issue is considered above in relation to issue 5.5 (see paragraphs [375] to [379]). In these circumstances, I do not regard the proposed recommendation as appropriate.

26. The Time Taken To Hold This Inquiry

[472] The accident occurred on 29 November 2013. The AAIB Report was published on 23 October 2015. A notice of an inquiry was given by the procurator fiscal on 26 July 2018. The

time taken to give notice of an inquiry was raised by a number of the participants in their submissions. It had previously been a matter of not insignificant public comment.

[473] At the hearing on submissions on 5 August 2019, senior counsel for the procurator fiscal proposed that the court allow a further period of time for written submissions to be lodged with the court, addressing only the question of the time elapsed between the date of the accident and the date upon which a notice of an inquiry was given by the procurator fiscal. I granted that application and written submissions were lodged with the court on 2 September 2019.

[474] In the following section, under the heading "*Crown Explanation*" I reproduce in full, unamended, the terms of the procurator fiscal's submissions on this issue. I offer certain observations in the following section, under the heading "*Discussion*".

Crown Explanation

[475] The Crown acknowledges that the time that has elapsed between the Clutha tragedy on 29 November 2013 and the convening of this Fatal Accident Inquiry has been longer than desirable. The delay has led to a protracted period of uncertainty for all parties and has compounded the distress suffered by bereaved relatives. The purpose of these submissions is to provide an explanation for that delay, by describing the investigative strategy which was required to ensure the independent, rigorous and thorough investigation of this complex case, and the investigative activity that was carried out throughout the period concerned, consistent with that strategy.

The AAIB Investigation

[476] The AAIB safety investigation commenced on 30 November 2013 and was conducted under the provisions of Regulation EU 996/2010 and the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 (the 1996 Regulations).

[477] The purpose of the AAIB investigation was to ascertain what led to the accident and to identify any safety issues which required to be addressed. The sole objective of such an investigation is the prevention of future accidents and incidents; it is not to apportion blame or liability on the part of any parties or individuals and it is not under the direction of the Crown. Whilst there was full information sharing by the Police with the AAIB, the regulatory framework and legislation under which the AAIB operates restricted the information which could be made available by them to inform the Police investigation.

The Police Scotland Investigation

[478] In parallel with the AAIB investigation, on 30 November 2013 an investigation was launched by Police Scotland under the direction of the Crown. An investigative strategy was established at an early stage to cover a number of matters: (i) the preservation of the scene; (ii) victim identification; (iii) support of the families of victims; (iv) the identification of key witnesses; and (v) establishing the circumstances of the crash.

[479] It was determined that the investigations into the Clutha and Sumburgh helicopter crashes (the latter involving the loss of the lives of four passengers off Sumburgh, Shetland on 23 August 2013) required dedicated resource and led to the establishment by the Crown

of the Helicopter Incidents Investigation Team (HIIT) drawing upon existing experience from the Health and Safety Investigation Unit (HSIU) of the Crown Office and Procurator Fiscal Service (COPFS).

[480] Police Scotland established a dedicated Major Investigation Team of detective officers to investigate the circumstances of the deaths under the direction of the Crown. The investigation was set up under the Home Office Large Major Enquiry System (HOLMES) reflecting the scale and complexity of the case. It was agreed at a very early stage that the Civil Aviation Authority (CAA), as regulator and the enforcing authority of civil aviation in the UK, would provide assistance to the Police Scotland investigation.

[481] The purpose of the parallel investigation by Police Scotland was to ascertain for the purposes of the Crown what had caused the tragedy and, further, to identify any potential criminality in relation to any individuals or corporate entities. Practically speaking that meant the AAIB's safety investigation would require to establish the technical cause of the crash before the Police and HIIT could assess the significance of the findings and use them to progress that side of the parallel investigation.

[482] While a great deal of work was carried out by Police Scotland from the date of the accident, limited information in relation to the AAIB's safety investigation was available due to the legislative framework within which a safety investigation must be conducted.

[483] Liaison with AAIB continued while their investigation was being carried out and in March 2015 the AAIB issued their draft report to interested parties, in terms of regulation 12 of the 1996 Regulations. That report informed the developing investigative strategy and

assisted to identify lines of inquiry that were necessary to ensure thorough investigation by the Crown.

[484] The publication of the final Aircraft Accident Report (AAR) on 23 October 2015 was an important milestone in the investigation and allowed Police Scotland and COPFS, in accordance with their respective duties and responsibilities, to refine the investigative strategy and conduct further investigations into some of the complex issues the report raised.

[485] Independent scrutiny and investigation by Police Scotland and COPFS was essential to determine whether there should be criminal proceedings or a Fatal Accident Inquiry. Documents ingathered and held by the AAIB for the purpose of their safety investigation were obtained in early 2016.

[486] Significant challenges which impacted on the time taken to commence the Fatal Accident Inquiry (FAI) process included statement gathering; examination of productions; and engagement with corporate bodies.

Statements

[487] Police Scotland obtained 2468 statements from over 2150 witnesses. These varied greatly in size and relevance and included lengthy statements obtained by using detailed interview plans as outlined below.

[488] Given the complex nature of the subject matter, it was agreed that it would be advantageous and efficient for HIIT to support Police Scotland to develop tailored interview plans to improve statement taking.

[489] Members of the HIIT team prepared detailed bespoke interview plans for the use of officers taking statements from a range of witnesses including pilots and engineers. The interview plan process was necessarily meticulous and required the focus of three solicitors in the HIIT team over many months. The composition of the plans required detailed knowledge of all material ingathered as at the date of preparation to ensure that the statements obtained achieved the required standard and covered all matters considered of potential relevance to participants in the FAI. That information gathering process continued throughout the investigation even after the commencement of the FAI.

[490] One example of the detailed preparation required in the case was the examination of technical logs and maintenance records for G-SPAO dating back to 2007. That piece of work was carried out by two solicitors and a case preparer over 3 months and used in the formulation of interview plans.

[491] Between January 2016 and July 2018 Police Scotland obtained a further 48 statements from witnesses employed by the operator at the time of the crash. Included within this figure are lengthy statements using witness interview plans developed by HIIT. The witness interview process timetable was informed by the availability of many of the pilot witnesses taking into account factors such as the operator's requirement to provide cover for the emergency service helicopters of Police Scotland and the Scottish Ambulance Service, and the strict requirement for pilots to have prescribed rest periods when not flying. Pilots could only be made available for a day or two at a time due to the impact on their ability to fly by a reduction in flying hours. Furthermore, one former employee of the operator was

working out with the UK and another was unavailable for a period of time due to personal circumstances.

[492] The interview of one pilot by Police Scotland was over the course of twelve days between June 2017 and March 2018, and another pilot over nine days between July 2017 and May 2018; these are included simply to demonstrate some of the challenges faced by the investigative team in ensuring a rigorous approach to a complex inquiry.

[493] Police Scotland, directed by the Crown, followed a tiered approach in the taking of statements, with senior management of the relevant organisations approached first followed by engineering / maintenance staff and then the pilots. Police Scotland required necessarily to deploy those officers from the MIT who had detailed knowledge and understanding of the subject matter, productions etc. so the interviewers were a close cadre of officers. This contrasts markedly with the approach that was taken at the outset of the investigation in relation to routine matters and eye witness evidence where that background knowledge was not a pre-requisite for general statement taking.

[494] The statements were taken over one hundred days, involving many hundreds of police man hours, but were assisted by the use of the bespoke interview plans which provided focus on key areas identified by HIIT as requiring to be fully explored. HIIT reviewed the statements as they were lodged and, where possible, sought to streamline future interviews in an effort to reduce the time involved in this aspect of evidence gathering.

[495] This process of statement taking only concluded approximately three weeks prior to the lodging of the First Notice (*sic*) on 26 July 2018.

Productions

[496] Almost 3000 productions were ingathered by Police Scotland and the vast majority of the productions used in the FAI were obtained and made available for the consideration of the Crown following the publication of the AAIB'S AAR, when the final findings became public and assisted the Crown in informing its investigative strategy.

[497] Productions were assessed and information extracted and collated to produce summaries of evidence to assist Crown Counsel to prepare for the FAI.

Engagement with corporate bodies

[498] In order to explore thoroughly the matters raised in the AAIB reports, it was necessary to engage with a number of corporate bodies in the UK and abroad, principally Bond (now Babcock Mission Critical Services Onshore) the operator of the helicopter and Airbus (manufacturer of the helicopter based in Germany).

[499] Given the status of the investigation, the Crown was unable to utilise mutual legal assistance provisions to ingather evidence from abroad and the engagement with corporate bodies relied entirely on co-operation and the evidence gathering process involving corporate bodies was effected through discussions and negotiation between the Police and the respective legal teams for the operator and manufacturer and, in other cases, they dealt directly with the companies.

[500] Information was provided in stages and required to be fully assessed for relevance and to inform further investigation. The material was also used in the framing of the interview plans.

[501] There was, in some instances, a requirement to explore what information was held by parties from a considerable time before the crash. Police Scotland required to carry out an examination of company records going back some ten years prior to the crash and it was also necessary for the Crown to continue with the process of ingathering material, both documents and statements, for use in the FAI after the lodging of the First Notice (*sic*).

Final Stages of the case investigation and preparation before lodging the First Notice

[502] The HIIT team submitted its initial report to Crown Counsel on 29 September 2017.

[503] On 13 November 2017 HIIT concluded its report for the consideration of Crown Counsel. That report fully considered the issue of potential criminal proceedings and the basis upon which an FAI should be held under The Inquiries into Fatal Accidents and Sudden Deaths etc. (Scotland) Act 2016. An FAI was mandatory in respect of the pilot and two air observers and discretionary in respect of those customers within the Clutha who lost their lives. On 14 November 2017 Crown Counsel instructed that there were to be no criminal proceedings and that a FAI was to be held. This was announced on 23 November 2017.

[504] The announcement included:

“The Helicopter Team will now work with Crown Counsel to focus further on the issues that it is considered the inquiry should address and put in place in the preparations for initiating the formal procedure for an inquiry.

The investigation by the police, with officers working closely with our Helicopter Team has, accordingly, necessarily been wide ranging. It has involved the collection and consideration of a significant volume of documentation, including highly technical manuals and guidance, as well as the taking of detailed statements from witnesses, including professionals in the aviation industry. Some of that material and information has been ingathered from organisations based abroad. In an investigation such as this, the Police and the Crown require to rely on the cooperation of companies and organisations in relation to, for example, provision of material and availability of witnesses for interview."

[505] In the notes to editors the media were advised that COPFS expected to be in a position to lodge the first notice to commence proceedings by the middle of 2018 and the First Notice (*sic*) was lodged on 26 July 2018.

Liaison with nearest relatives

[506] The nearest bereaved relatives have been advised of all significant developments throughout the investigation. They were informed of some of the challenges faced by investigators, including the highly complex nature of the investigation, the constraints on progress until the AAIB published their final report and the reliance on cooperation of corporate bodies in relation to the ingathering of evidence.

Discussion

[507] The issue of the time it takes to hold inquiries into deaths arising from accidents of this nature has previously been the subject of judicial comment. Sheriff Principal Pyle's observations at paragraph [52] of his determination following upon the Super Puma FAI are still relevant, albeit in this inquiry the issue of obtaining suitable premises played no part in the time taken to hold the inquiry. The efforts of the staff of the Scottish Courts & Tribunals Service in this respect are to be commended.

[508] If one accepts the specialist nature of air accident investigation, as outlined by the then Lord Chief Justice in *R (Secretary of State for Transport) v Her Majesty's Senior Coroner for Norfolk* (see paragraph [130] above), it is difficult but to conclude that at least part of the delay in this case has been caused by "different independent bodies, which have overlapping jurisdictions to investigate accidents or other matters, to investigate, either successively or at the same time, the same matter." If one recognises the differing roles and functions of those independent bodies a conundrum arises to which there is no easy solution.

[509] The extent to which the procurator fiscal was able to rely on the conclusion of the AAIB is unclear from the submissions made. However, the fact that it took more than two years from the publication of the AAIB Report to the decision that there were to be no criminal proceedings is surprising, notwithstanding the extensive work carried out by Police Scotland and HIIT in the intervening period. Ultimately, on any view, it took far too long to lodge a notice of an inquiry in this case, although it must be stressed that the inquiry itself was conducted with great efficiency for which all those responsible for its preparation and conduct are to be commended.

[510] I have no reason to infer that such resources as were made available to HIIT were not appropriately deployed. That causes me to conclude that HIIT were not sufficiently resourced to enable this inquiry to start far sooner than it did. I have no basis upon which to speculate why that is the case, although the competing demands on the COPFS budget are well understood. Ultimately, the provision of adequate resources is a matter for government.

[511] The traditional role of the procurator fiscal in the investigation of fatal accidents and sudden deaths is a valuable one that we should be slow to depart from. Setting timescales for the holding of fatal accident inquiries is, in my experience, impractical. They should be held as soon as practicable; however, what is practicable will inevitably vary from case to case. Unless suitable resources are in place to allow COPFS to properly discharge its functions in relation to fatal accident inquiries delays of the type seen in this case will continue to occur. I note, in passing, that an inquiry into the deaths caused by the Sumburgh helicopter crash in August 2013, referred to by the procurator fiscal (see paragraph [479] above) is still to be held.

27. Conclusion

[512] The events of 29 November 2013 changed forever the lives of many people. A number of them were present throughout many days of evidence in this inquiry. The dignity with which they did so is admirable. I extend the condolences of the court and of all who work within it to all those affected by this tragedy: to not only the friends and relatives of those who died, but to those who were injured that evening; and to those who must live with the events of it.

[513] The court is indebted to all those who have participated in the inquiry for their professionalism and for the efficiency with which it was conducted. An inquiry that could have taken far longer than it did was able to conclude within thirty two days. That was possible due to the efforts of the participants' representatives and all those who assisted in the inquiry, from those who displayed the productions; those who provided the simultaneous transcription of the evidence; the clerks of court; the court officers; and the

police officers. I would extend my thanks to each of them for their hard work and professionalism.

[514] The reason why G-SPAO crashed on 29 November 2013 is not in doubt. Its engines flamed out sequentially, as a result of fuel starvation, due to depletion of the contents of the supply tanks; and the pilot, Captain Traill being unable to successfully perform an autorotation and landing of the helicopter. The contents of the supply tanks depleted due to the failure of Captain Traill to ensure that at least one of G-SPAO's fuel transfer pump switches was set to **ON**.

[515] The central question for the inquiry is why did that happen? The answer is a simple one. Captain Traill ignored the **LOW FUEL** warnings he received. Had he followed the procedure set down in the Pilot's Checklist in respect of the **LOW FUEL 1** and / or **LOW FUEL 2** warnings, the accident would not have happened. Put another way, Captain Traill took a chance that the **LOW FUEL** warnings he received were erroneous. That was a conscious decision on his part. It was a decision that had fatal consequences for ten people.

Sheriff Principal C D Turnbull

Glasgow, 30 October 2019

Appendix 1

List of Witnesses

1. Andrew Bergin
2. Christopher Jarvie
3. Tariq Malik
4. David Newton
5. Brian Stewart
6. Craig Welsh
7. David McKernan
8. Ernest Docherty
9. Philip Sleight
10. Marcus Cook
11. Peter Wivell
12. Robert Vickery
13. Andrew Campbell
14. Colin MacAllister
15. Constable Niall McLaren
16. Constable Alan Graham
17. Holger Mendick
18. Rene Nater
19. Ralph Nicolai
20. Christian Bernhardt
21. Paul Booth
22. Andrew Bochel
23. Garry Rickard
24. Andrew Dowsing
25. James Bruce
26. Inspector Nick Whyte
27. Alexander Stobo
28. David Price
29. Bill Meredith
30. Constable Alistair Rennie
31. Ian Taylor
32. Martin Forster
33. James Remfry
34. Stuart Weir
35. Captain George David Young
36. Captain Christopher Redfern

37. Captain Allan Bryers
38. Captain John Taylor
39. Captain Andrew Rooney
40. Captain Andrew Mortimore
41. Andrew Alford
42. Captain Charles Ayto
43. Captain Craig Trott
44. Captain Stephen Kitchen
45. Captain Mark Prior
46. Professor Polly Dalton

Appendix 2

Consolidated List of Issues

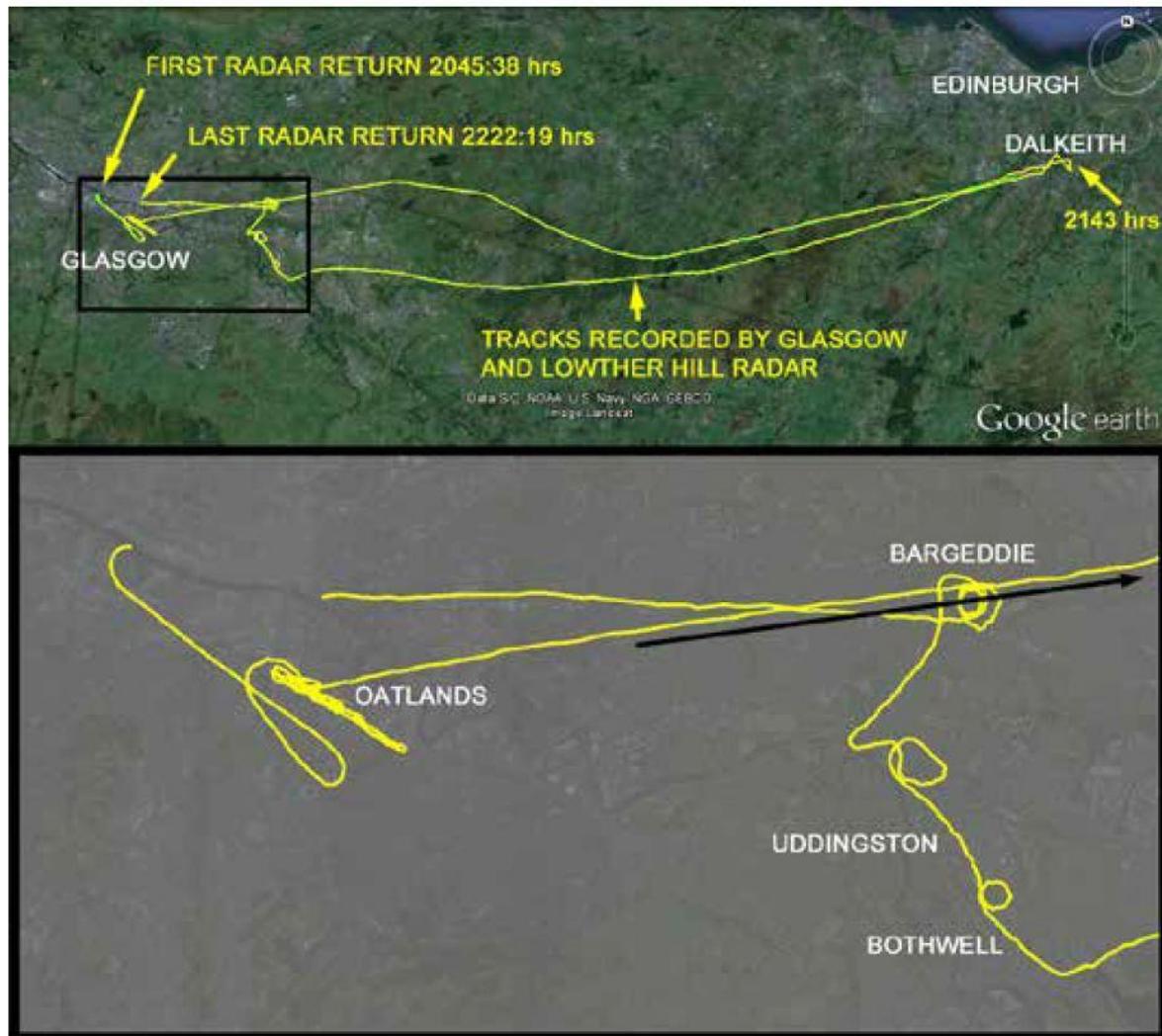
1. When and where each of the deaths occurred.
2. When and where the aircraft crash occurred.
3. The cause or causes of each of the deaths.
4. The cause or causes of the helicopter crash, including:-
 - 4.1. how fuel was managed on the aircraft and in particular why both transfer pumps were switched OFF, rendering unusable the otherwise usable fuel in the main tank;
 - 4.2. whether the *Pilot's Checklist* was available to the pilot;
 - 4.3. whether it was within the competence of a helicopter pilot qualified to fly G-SPAO on police duties to comply with the requirements of the *Pilot's Checklist*;
 - 4.4. at what stage in flight did the LOW FUEL warnings likely occur;
 - 4.5. why, having acknowledged the LOW FUEL warnings, did the pilot not complete the actions detailed in the *Pilot's Checklist*;
 - 4.6. whether the timing and/or the initially intermittent character of the LOW FUEL warnings contributed to the *Pilot's Checklist* procedure not being completed;
 - 4.7. whether there have been other instances of LOW FUEL warnings not being followed;
 - 4.8. 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;
 - 4.9. 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;
 - 4.10. 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;
 - 4.11. whether there was a failure of any part of the CAD prior to the accident;
 - 4.12. what steps were open to a helicopter pilot qualified to fly this helicopter after both engines flamed out;

- 4.13. whether the designed time-interval between engine flame-outs was compromised by the design of the fuel tank system and, in particular, the undivided volume above the supply tanks, which, depending on the attitude of the helicopter, might have allowed fuel to migrate from one supply tank to another;
 - 4.14. why autorotation, flare recovery and landing were not completed successfully;
 - 4.15. whether the ability to carry out autorotation, flare recovery and landing was compromised by the design of the cockpit layout.
5. 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:-
- 5.1. by including within the fuel contents indication system a caution or warning that both transfer pumps were switched OFF;
 - 5.2. by including within the fuel contents indication system a caution or warning that a fuel pump, having been switched OFF, has since been submerged in fuel;
 - 5.3. by designing the fuel tank system and fuel contents indication system in such a way that the fuel transfer pumps did not require to be switched ON or OFF during flight;
 - 5.4. by including within the fuel contents indication system a caution or warning, in the case of anomalous or implausible combinations of outputs from the sensors;
 - 5.5. by designing the fuel tank system, and in particular the differential capacities of the supply tanks, in such a way as to ensure that the design objective of creating an interval of 3-4 minutes between engine flame-outs, or such other interval of time as would be represented by 4.5kg of fuel, or any other safe interval of time, was achieved;
 - 5.6. by ensuring that power to the RADALT and steerable landing light was automatically maintained in the event of a double engine flame-out.

6. The defects, if any, in any system of working which contributed to the deaths or the accident, including:-
 - 6.1. whether any aspect of the system of maintenance of G-SPAO, including its washing regime, contributed to the contamination of the fuel and/or the fuel tank system with water;
 - 6.2. whether any aspect of the pre-flight check procedures contributed to the accident occurring;
 - 6.3. whether any aspect of the training of pilots, in particular, with regard to fueling, 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 warnings, and the execution of an autorotation at night, contributed to the accident occurring;
 - 6.4. whether the practice of the “day-shift” pilot handing the aircraft over already fueled to the “night-shift” pilot contributed to the accident occurring.
7. Any other facts which are relevant to the circumstances of the deaths, including:-
 - 7.1. whether, and the extent to which, the Safety Recommendations of the AAIB in their Report 3/2015 have been adopted and implemented;
 - 7.2. whether, and the extent to which, the operator, helicopter manufacturer and engine manufacturer have taken necessary and appropriate safety actions following the accident, including those considered by the AAIB in their Report 3/2015;
 - 7.3. whether, and the extent to which, any recommendations should be made by this Court.

Appendix 3

Overview of G-SPAO's Final Flight Path



[Reproduced from AAIB report – Figure 1, page 7]

Appendix 4

Extracts from the Pilot's Checklist – Emergency and Malfunction Procedures

1. LOW FUEL 1 and / or LOW FUEL

LOW FUEL 1	and/ or	LOW FUEL 2
LOW FUEL 1 (SYSTEM I)		LOW FUEL 2 (SYSTEM II)
and activated warning GONG		
1. Fuel quantity indication	–	Check
<u>If positive fuel indication in the main tank:</u>		
2. Both fuel pump XFER sw (F + A)	–	Check ON
3. Both fuel pump XFER circuit breaker (F + A)	–	Check in
<u>If FUEL LOW warning light remains on:</u>		
4. Air condition (if installed)	–	Switch OFF
5. Bleed Air	–	Switch OFF (if OAT > 5°C)
EFFECTIVITY For H/C with 680 liters fuel tank (673 liters if selfsealing supplytanks are installed)		
6. LAND WITHIN 8 MINUTES		
EFFECTIVITY For H/C with 710 liters fuel tank (701 liters if selfsealing supplytanks are installed)		
6. LAND WITHIN 10 MINUTES		
EFFECTIVITY All		

2

Note: G-SPAO had a 710 litre fuel tank.

2. F PUMP AFT and F PUMP FWD

F PUMP AFT	
(MISC)	
1. Fuel level in the main tank	– Check
<u>If main tank fuel quantity is sufficient to keep both fuel pumps wet:</u>	
2. FUEL PUMP XFER-A sw	– Check ON
3. XFER-A PUMP cb	– Check in
If F PUMP AFT indication remains on:	
4. FUEL PUMP XFER-A sw	– OFF
<u>If main fuel tank fuel quantity is low:</u>	
2. FUEL PUMP XFER-A sw	– OFF
<p>NOTE Each fuel transfer pump is capable of feeding more fuel than both engines will consume. In hover flight conditions the unusable fuel can be up to 71 kg. The quantity of unusable fuel can be reduced to 7.5 kg when flying with 80 KIAS or more.</p>	

F PUMP FWD	
(MISC)	
1. Fuel level in the main tank	– Check
<u>If main tank fuel quantity is sufficient to keep both fuel pumps wet:</u>	
2. FUEL PUMP XFER-F sw	– Check ON
3. XFER-F PUMP cb	– Check in
If F PUMP FWD indications remains on:	
4. FUEL PUMP XFER-F sw	– OFF
<u>If main tank fuel quantity is low:</u>	
2. FUEL PUMP XFER-F sw	– OFF
<p>NOTE</p> <ul style="list-style-type: none"> • Each fuel transfer pump is capable of feeding more fuel than both engines will consume. • In forward flight conditions the unusable fuel can be up to 59 kg. The quantity of unusable fuel can be reduced to 3.6 kg when flying with 80 KIAS or less. 	