FOLLOWING AN INQUIRY HELD AT PAISLEY DURING 1ST TO 27TH NOVEMBER 2001 IN THE DEATHS OF WILLIAM GEORGE HENDERSON AND OTHERS (AIRTOURS)

Sheriffdom of North Strathclyde

Inquiry held

under Fatal Accidents and Sudden Deaths Inquiry (Scotland) Act 1976

DETERMINATION

by

Bruce Alexander Kerr, QC

Sheriff Principal of the Sheriffdom of North Strathclyde

Following an inquiry held at Paisley during the First to Twenty-seventh days of November Twenty Hundred and One into the deaths of

William George Henderson (dob 14 October 1945), who resided at 3 Bourtree Brae, Lower Largo, Fife;

John Robertson Easson (dob 17 October 1950) who resided at Crosby Farm, Bride, Isle of Man;

Colin James Finnie (dob 4 January 1967), who resided at 2 Lamberton Gardens, Perceton, Irvine;

Pauline McGinley or Moyes (dob 21 July 1961), who resided at Erinvale, Carman Road, Renton, Alexandria;

Helen Robertson Steven (dob 21 July 1971), who resided at 6 Glennan Gardens, Helensburgh;

Pauline Anne MacIver (dob 20 May 1968), who resided at 29 Atlin Drive, New Stevenston;

Lynn Rachel McCulloch (dob 19 July 1974), who resided at 19 Broomfield Walk, Kirkintilloch;

and

Linda Joy Taylor (dob 14 April 1970), who resided at 40 Eglinton Crescent, Troon.

PAISLEY, 24 September 2002

The Sheriff Principal under and in terms of section 6(1) of the Fatal Accidents and Sudden Deaths Inquiry (Scotland) Act 1976 makes the following determination:-

The deaths took place at Blackstoun Farm, Blackstoun Road, Linwood, Renfrewshire in consequence of an aircraft accident involving Cessna G-ILGW at or about 12.35 pm (BST) on 3 September 1999.

The cause of the deaths was the said aircraft accident. The causes of the said aircraft accident were:-

a progressive breakdown of the accessory gear train in the left hand engine of the aircraft due to a failure of the torsional viscous damper to perform its proper function on account of its internal condition which had become defective, leading to a gradual and spasmodic but eventually complete loss of power from that engine; and

the failure of the pilot in command of the aircraft to retrieve the emergency situation which had arisen on account of his inability to discern in the circumstances which beset him and the short time available to him which of his two engines was the true source of the power loss experienced by him, with the consequence that he mistakenly closed down the wrong (non-faulty) engine as he executed a turn in order to return to the airfield from which he had recently taken off, thus losing all power and control of the aircraft.

There were no reasonable precautions whereby the deaths and the said aircraft accident might have been avoided.

There were no defects in any system of working which contributed to the deaths and the said aircraft accident.

The following further facts are relevant to the circumstances of the deaths:-

The torsional viscous damper in the left hand engine of the aircraft had become internally defective because the silicone fluid within it had become contaminated with fine metallic particles and had consequently solidified thus losing its viscosity. Because it no longer had its designed capacity to dampen or absorb vibration in the engine effectively a tooth in the shaftgear of the starter adapter, although relatively new, broke off on account of metal fatigue and initiated the progressive breakdown referred to at (b)(i) above.

The circumstances which beset the pilot in command of the aircraft at the time when he was attempting to discern which of his two engines was failing and which contributed to his inability to do so correctly included the following:-

The aircraft was fully laden at or about its maximum permissible take-off weight of eight thousand four hundred pounds.

The aircraft was flying at low height when the emergency commenced (not much more than two hundred feet above ground) and did not gain much further height thereafter.

There was a coincidence of conflicting signals or indications which were misleading and affected the assessment of whether there was an engine fault and if so in which engine. Approximately contemporaneously with the commencement of the progressive breakdown of the accessory gear train in the left hand engine there occurred a backfire due to the presence of swarf in the relatively new right hand engine which had been recently installed and was still within its probationary period. The resultant noise (a "thud or bang") was heard by the commander of the aircraft among others and excited suspicion in his mind as to the reliability of his new right hand engine. At the same time any yaw to the left caused by the failure of the left hand engine was not a pronounced yaw on account of the gradual and spasmodic nature of the breakdown which was occurring and was masked by an idiosyncratic tendency of the particular aircraft to sideslip leftwards after take-off.

The pilot in command of the aircraft elected to attempt a return to the airfield on a single engine as his training and experience of flying twin-engined aircraft had taught him to do. He adhered to this plan even although he had no clear indication as to which engine was good and which was faulty. Under great pressure to make rapid decisions he did not consider or at least did not elect to attempt a controlled forced landing in the fields ahead of him which would probably have produced a more favourable outcome and a greater number of survivors among those on board the aircraft. He turned back instead towards the airfield and mistakenly chose to close down the remaining good engine.

The seats and their attachments in the aircraft complied with the airworthiness requirements applicable at the time when the Cessna 404 had been designed. They had not been improved or upgraded since the aircraft was manufactured, there being no regulatory requirement for such improvement to be made even if it were possible to do so. The seats were unable to withstand the force of the impact when the crash occurred and collapsed or became detached, thus increasing the disabling injuries sustained by the occupants of the aircraft and reducing any chance they might have had of escaping the fire which broke out shortly after the impact of the aircraft with the ground.

Apart from the defect which gave rise to the progressive breakdown of the accessory gear train in the left hand engine the aircraft was otherwise in good condition and well maintained at the time of the accident.

The two pilots on board the aircraft (Messrs Easson and Henderson) were competent and proficient. The first pilot or commander (Captain Easson) was highly experienced, especially in flying twin-engined piston-driven aircraft, and was fully trained in accordance with the standards prevailing in September 1999. The said pilots had not ingested alcohol or drugs and were adequately rested.

The Cessna 404 Titan Ambassador G-ILGW was correctly classified and certified by the CAA within their Performance Group C of the Transport Category (Passenger).

BAK

NOTE:

Representations and procedures

At this inquiry there appeared a number of parties who were represented as follows:-

(i)The Crown, who were represented by Mrs M Ramage, Principal Procurator Fiscal Depute and Mr J Robertson, Procurator Fiscal Depute.

(ii)The families of six of the deceased (those who were passengers in the aircraft) and the three survivors of the accident, who were represented by Mr G W Lamont, Advocate.

(iii)Airtours plc, who were represented by Mr G J Clarke, Advocate.

Edinburgh Air Charter Ltd (now known as Air Charter (Scotland) Ltd) and the executors of the late Captain Easson, who were represented by Mr P B Cullen, QC.

(v)Vibratech Inc., who were represented by Mr E M MacKechnie and Ms L Cameron, Solicitors.

(vi)The Civil Aviation Authority, who were represented by Mr D L Stewart, WS.

On the morning of the fifth day of the inquiry (Wednesday 7 November 2001) Mr MacKechnie on behalf of Vibratech Inc. sought and was granted permission to withdraw from further appearance at the inquiry. There was no appearance at the inquiry for Cessna, Teledyne or Yorkshire Light Engineering, nor on behalf of the executors of the late William George Henderson.

The court had throughout the inquiry the assistance in terms of section 4(6) of the 1976 Act of an assessor having special knowledge of matters of aeronautical engineering, namely Dr Douglas G Thomson, Head of the Department of Aerospace Engineering at the University of Glasgow. Dr Thomson attended to hear evidence on twelve out of the seventeen days of the inquiry, being the days on which evidence was led which related to matters of engineering bearing upon the causes of the accident.

The Crown led evidence from forty-one witnesses and the other parties elected to lead no additional evidence. Two joint minutes were lodged and read out by the clerk of court containing agreements between the parties as to (i) the cause of the deaths (namely "aircraft accident") and (ii) the negative findings of two toxicologists on their examination of blood samples taken from the bodies of Messrs Easson and Henderson, the pilots. Submissions after the close of the evidence were made by the Crown and each of the parties aforementioned.

Terminology and matters for determination

Reference has already been made to 12.35 pm (BST) as the approximate time of the deaths. References will be found below to "1135 hours" plus some seconds as the time of certain events: these times are GMT (or UTC which is used internationally for aircraft movements) and are therefore the same time as 12.35 pm (BST) referred to above.

In this note frequent use is made of certain abbreviations, of which the following is a brief glossary:-

AAD-Additional Airworthiness Directive

AAIB-Air Accidents Investigation Branch

BST-British Summer Time

CAA-Civil Aviation Authority

CSB-Critical Service Bulletin (of Teledyne Continental, manufacturers of the engines)

GASIL-General Aviation Safety Information Leaflet

GMT-Greenwich Mean Time

JAA-Joint Aviation Authorities

RPM-revolutions per minute

UTC-Co-ordinated Universal Time

In what follows I refer to the failure of the left hand engine, or more accurately its incipient failure, i.e. the initial disruption of the accessory gear train, as "the critical event". That was the occurrence which on 3 September 1999 gave rise to the crisis which led to the deaths and, albeit the deaths were not thereby rendered inevitable, without it they would not have occurred at all. Whether the critical event was precisely or only approximately coincident with the "thud or bang" heard by the survivors in the aircraft and apparently by Captain Easson is a matter discussed below.

The Air Accidents Investigation Branch produced in July 2001 a comprehensive and thorough report (Crown Production No 9) of the incident which was spoken to and much referred to in evidence at the inquiry. It covers all aspects of the event and I have not found reason from the evidence heard at the inquiry to disagree in any fundamental way with its findings or observations. It forms a most useful compendium of information on the whole incident and it is unnecessary to repeat here all that is said in it. Instead in what follows I concentrate attention on those aspects of the event which bear directly on the matters requiring to be determined in terms of section 6(1) of the Fatal Accidents and Sudden Deaths etc. Inquiry (Scotland) Act 1976. The chief of these, and the only one attended with any substantial doubt or obscurity, is the cause or causes of the accident which resulted in the deaths. There is no real uncertainty about where or when the deaths occurred nor any doubt that they were all caused directly by the air accident, whether in consequence of the initial impact or of the immediately subsequent fire. Nor is there much difficulty associated with the conclusions to be drawn on the subsidiary issue of "survivability", namely that an improved design of the aircraft's seating and attachments could have made the crash more survivable but that it remains imponderable whether any of the occupants of the aircraft who survived the initial impact would in fact have been able to escape the effects of the fire in the circumstances even with an improved design. These last matters were not controversial at the inquiry and it was clear equally that there were no shortcomings affecting the outcome in the activities of the emergency services or the actings at the crash site of Mr Connell who was deserving only of the highest praise for what he did in the time available to him. For these reasons I do not in the subsequent sections of this note discuss each and every element in the history of the aeroplane, the pilot and the accident to which reference is made in the AAIB report and instead confine my attention to those elements which bear upon the conclusions which I reach from the evidence heard at the inquiry on the important matters relative to the cause(s) of the accident.

Prior history of aeroplane and engines

The Cessna 404 G-ILGW was built in America in 1980. Cessna ceased production of this type in 1982 but many remain in use today. This particular aircraft spent its early years in America until it was transferred to Germany for several years. There is no reason to think from the available evidence that it was not properly maintained during its American life and even a hint in the evidence that it may have had some connection at one stage with drugs in the western hemisphere did not incline anyone who had later knowledge of it to think that its maintenance had been then neglected. During the years it spent in Germany it was well maintained and the only defect connected therewith at that time seems to have been a "short-cut" taken by one engineer in filling in a weighing form without fully re-weighing the whole aircraft, but there was on the evidence no reason to think that this lapse in procedure had any adverse effect on its condition in September 1999 or any connection with the accident.

In July 1995 a fully reconditioned ("remanufactured") left hand engine of the GTSIO-520 series was fitted, being the engine which eventually malfunctioned on 3 September 1999. Its starter adapter shaftgear and its crankshaft gear were of the modified type referred to in CSB 94-4 issued on 13 June 1994 and the torsional viscous damper attached to the farther end of the starter adapter shaft was new (or nearly new) having been manufactured in

January 1995. The right hand engine at that time did not have the modified form of these components but it was not the right hand engine eventually involved in the accident on 3 September 1999.

In January 1998 the aircraft was imported to Great Britain having been purchased in December 1997 from its German owners by Captain Easson's company Edinburgh Air Charter Limited. It was subjected to the usual inspections and tests by the CAA on the import of an aircraft from abroad and on 2 February 1998 duly certificated with an appropriate certificate of airworthiness. Thereafter it entered service with Edinburgh Air Charter and was maintained at all appropriate intervals by engineers of Aircraft Engineers Ltd of Edinburgh (a company created by John Easson but by 1998 no longer owned by him) and in particular by or under the close supervision of their chief engineer, Adnan Soojeri. In general there was no reason to think from the evidence or the demeanour of Mr Soojeri that he had been anything other than fully attentive to the maintenance of this aircraft and had carried out all checks, inspections, repairs and replacements required in a proper and reliable manner.

During the period of its service with Edinburgh Air Charter until the accident there occurred two events of note involving the left hand engine of G-ILGW. On 5 November 1998 while en route from Glasgow to Benbecula the pilot (Walter Alexander) detected some "rough running" of the left hand engine when about half an hour into the flight at a cruise level of some 8000 feet. This consisted of intermittent irregular misfiring of the left hand engine combined with a marginal loss of manifold pressure. Mr Alexander decided to close down the left hand engine and return to Glasgow on a single engine. This he did and on later inspection the problem turned out to have been an electrical one due to the malfunctioning of a magneto. Mr Alexander regarded this as not a critical incident and in my view it is not relevant to the mechanical malfunction which brought about the accident of 3 September 1999. The second event and its consequences in February/March 1999 bore a much closer relation to that mechanical malfunction of 3 September 1999 and are narrated and discussed immediately below in a separate paragraph. Apart from these two events there was generally no evidence to indicate that the engines of G-ILGW had been maltreated or allowed to run roughly for substantial periods by Edinburgh Air Charter's pilots, several of whom gave evidence at the inquiry. Captain Easson himself was the pilot who chiefly flew the Cessna 404 and I am satisfied from the evidence relative to his overall competence and proficiency and professionalism that he would not have allowed the engines to run in any damaging manner. It thus appears that the GTSIO engines fitted to this aircraft, although prone by their design to develop high levels of torsional vibration, were not subjected to any undue levels of such vibration imposed on account of their handling by the pilots of the aircraft.

On or about 23 February 1999 the left hand engine of G-ILGW was found to be malfunctioning while the aircraft was at Newcastle airport. There was a problem with the starter adapter which turned out to be connected with a defective spring in the clutch mechanism and it became necessary to fly down from Edinburgh a spare starter adapter which had been taken at an earlier date (in the summer of 1998) out of the right hand engine when a modified starter adapter was fitted in accordance with CSB 94-4. The spare starter adapter was duly fitted and G-ILGW flown back to Edinburgh. The spare starter adapter was

not however of the modified type and its shaftgear was thereafter run in conjunction with the modified crankshaft gear which had come with the reconditioned left hand engine fitted in 1995 for a period of 38 hours while the modified starter adapter which had malfunctioned at Newcastle was sent away to Yorkshire Light Engineering at Leeds for repair. Before sending it to Leeds Mr Soojeri had conducted an inspection of its shaftgear teeth and had observed a degree of wear by pitting on them which he drew to the attention of Yorkshire Light Engineering although the chief problem was thought to relate to the clutch mechanism/spring. This wear had concerned him because the shaftgear, being of the modified type, should not have shown such wear. He then conducted an inspection of the crankshaft gear teeth using a 10x magnifying glass but observed no significant wear on them and so put the engine back into service for 38 hours with the spare starter adapter. At Leeds the starter adapter's clutch mechanism was repaired and a new shaft (with integral gear) was fitted by Yorkshire Light Engineering. They removed the existing torsional damper from the old shaft and fitted it to the new one. The existing torsional damper was retained in use despite the first two paragraphs of the M85-11 service bulletin of Teledyne Continental issued in July 1985. On or about 22 March 1999 the repaired starter adapter was returned from Yorkshire Light Engineering at Leeds and refitted by Aircraft Engineers Ltd at Edinburgh. At that time Mr Soojeri conducted a further inspection of the crankshaft gear teeth and again observed on them no significant wear: their condition appeared to be the same as 38 hours previously. The left hand engine accordingly proceeded from that point in further service with a starter adapter fitted with a new shaft (and integral gear) and a crankshaft gear showing no defect but with the same torsional damper attached to the starter adapter shaft as had been in use prior to 23 February 1999. This state of affairs continued for 255 hours until the accident occurred on 3 September 1999. Since the old shaftgear on 23 February 1999 showed signs of wear/distress/pitting on the teeth and since the new shaftgear seems to have lasted in service for only 255 hours before breaking up and losing a tooth the most reasonable inference, when regard is had also to the solidified state of the torsional viscous damper internally as examined after the crash, is that the torsional damper was not performing its function correctly during at least the summer of 1999 (and perhaps earlier) to reduce the transmission of torsional vibration (and hence fatigue damage) to the accessory gear train and in particular to the starter adapter shaftgear whose teeth broke up at the critical event on 3 September 1999 (see further below).

The only witness adduced from Yorkshire Light Engineering was Mr Hooks whose job it had been at Leeds to assess what repairs were required to the starter adapter: these consisted of replacing an over-worn spring in the clutch mechanism and replacing the starter adapter shaft on account of spalling to the shaftgear teeth. This was confirmed by the documents to be found in Crown production no 59. Mr Hooks was familiar with the Teledyne service bulletin M85-11 (Crown production no 39) concerning the circumstances in which consideration should be given to replacement of the torsional damper but his position was that for various reasons of interpretation of that bulletin and the circumstances of the starter adapter's repair it did not appear appropriate for the torsional damper to be replaced at the time of the starter adapter's journey to Leeds for this repair. In the first place compliance was looked for "at major overhaul", i.e. when the engine becomes life-expired after 1600-plus hours, and not when a part such as the starter adapter had been merely sent for repair. In the second place Yorkshire Light Engineering did not have access to the needle bearing (which had remained in the crank case or engine-block in the aircraft) so as to be able to assess whether it too exhibited signs of fatigue damage in addition to that seen on the starter adapter shaftgear teeth. In the third place the bulletin speaks of the "adapter shaft", on which distress was not here detected, not of distress to the shaftgear and its teeth: in

particular no distress was detected on the shaft in the area normally seated within the needle bearing. In the fourth place Yorkshire Light Engineering did inspect the torsional damper (externally) and seeing nothing wrong with it affixed it to the new shaft; the torsion bar rig referred to in the bulletin for evaluation of the torsional damper was not available to Yorkshire Light Engineering (being situated in America) and they had at the time no reason to suspect the damper nor any knowledge at that time that wear such as was apparent on the shaftgear teeth might indicate some internal defect in the torsional viscous damper. The critical service bulletin in its later versions (CSB 94-4B, C and D) (Crown production nos. 44, 45 and 46) which would have furnished this information was not issued until after the accident. Mr Hooks was asked questions only about the manner in which the torsional damper was normally affixed to the starter adapter shaft (which involved inter alia a keyed journal and a highly torqued nut with a circlip) but was not asked about the adequacy of the manner in which Yorkshire Light Engineering had on this particular occasion in February/March 1999 gone about affixing the original torsional damper of the starter adapter sent to them for repair to the new shaft fitted by them. It appears that after the accident certain damage was found to the starter adapter shaft and key at the journal on which the torsional damper was seated, including some fretting whose cause probably preceded the accident, but the evidence relative to the causes of this damage was ambiguous and included the probability that much of it may have resulted from traumatic loads imposed during the breakdown of the engine on 3 September 1999. There was not evidence before me at the inquiry sufficient to warrant my concluding that there had been shortcomings in the affixing by Yorkshire Light Engineering of the torsional damper to the new starter adapter shaft such as might have left the former insecurely seated on the latter.

On or about 5 August 1999 a "new" right hand engine was installed into G-ILGW in place of that which had come with the aircraft from Germany eighteen months previously. This engine had recently been "remanufactured" (by Teledyne), i.e. rebuilt by the engine manufacturer using new or reconditioned parts meeting new blueprint requirements, ready for a service life of 1600-plus operating hours. Between 5 August and 3 September 1999 it had completed some 35 to 38 operating hours and so was still well within its probationary period of 50 operating hours at the time of the accident. There was no evidence to indicate that any significant difficulties had yet been experienced with it by the time of the accident.

As earlier mentioned the aircraft G-ILGW was imported from Germany in January 1998. As part of the inspections and tests conducted at that time for the granting of the required UK Certificate of Airworthiness the aircraft was subjected to an airworthiness flight test which was carried out on 1 February 1998 by Messrs Easson and Hastings, the latter in the role of observer. The test was conducted with the aeroplane operating at its maximum weight of 8400 lbs (as near as possible). Captain Easson was approved to conduct the test by the CAA's flight test department by special arrangement effected by Mr Pattinson, one of the CAA's aircraft maintenance standards surveyors. The flight test was carried out on 1 February 1998 and its report formed Crown production no 60. Earlier Mr Pattinson had on 21 January 1998 conducted a full inspection of the aircraft, which he found to be in satisfactory condition, as reflected in his report forming Crown production no 101. Accordingly Mr Pattinson on 2 February 1998 issued the appropriate UK Certificate of Airworthiness in respect of G-ILGW.

Those who flew Cessna 404 G-ILGW with any frequency testified that this particular aircraft had an idiosyncratic tendency to drift in a leftward direction shortly after take-off. This was not regarded by them as anything in the nature of a defect but merely as an idiosyncrasy, every aircraft being to some extent different from every other, and caused them no real concern as to the safety of the aircraft. The drift to the left was not very pronounced and was viewed as a small discrepancy: the effects of the wind were often much greater.

Prior history of pilots

Commander

Captain John Easson was approaching his forty-ninth birthday at the time of the accident and was regarded by those who knew him professionally and who flew with him as a highly experienced and proficient pilot of aircraft of the type including the Cessna 404 (i.e. multi-engined piston-driven and in particular twin-engined Cessna aircraft). He had had a commercial pilot's licence since 1990 and was qualified also as an instructor and examiner of other pilots on single and multi-engined passenger aircraft in the category not exceeding 5700 kg in weight. He had nearly 4200 hours of flying experience in total whereof some 2200 hours were on twin piston-engined Cessna aircraft (the Cessna 404 involved in the accident being the most recent acquisition of the type by Edinburgh Air Charter who also owned and operated a number of other twin-engined Cessnas). Since January 1998 he had flown 757 hours on such aircraft (and only 15 hours on single-engined aircraft) whereof 173 hours had been on the Cessna 404. His flying and medical qualifications were fully up-to-date and he had in particular undergone a base proficiency test (as required at intervals by the regulations) as recently as 29 August 1999 when Mr Tinson, a CAA pilot examiner, had adjudged him entirely competent. This test included a simulated engine failure after take-off. On 3 September 1999 at the start of the flight Captain Easson had not ingested drugs or alcohol (as found after his death by the toxicologists) and had not been flying an aeroplane for at least sixty hours (and so was adequately rested). His colleagues with whom he flew and the inspectors of the CAA with whom he had professional dealings viewed him as one of the best pilots on aircraft of this general type to be found in the UK.

Second pilot

There was at the inquiry much less evidence as to the proficiency of Captain Henderson (but none to suggest he was anything other than entirely competent) and in the absence of a cockpit voice recorder it is not known what part if any he played in the events of the brief flight. All three of the survivors gave evidence but their memories unsurprisingly did not extend to any precise recollection of what happened in the cockpit after the emergency had developed. He was approaching his fifty-fourth birthday on 3 September 1999 and was fully qualified to fly an aircraft of this type having held a commercial pilot's licence since April 1998 and having accumulated a total of more than 2000 flying hours (although the majority of these were on single-engined aircraft for which he had an instructor's qualification).

Events on 3 September 1999 prior to the critical event

The flight on 3 September 1999 which ended in the crash at Blackstoun Farm was a "positioning flight" of a type frequently performed before by Captain Easson using this same aeroplane whereby Airtours chartered the Cessna 404 with two pilots to carry their aircrew from Glasgow to Aberdeen for them to man a much larger aircraft (a Boeing 757) to take holidaymakers from Aberdeen to Majorca and back. Several of the Airtours aircrew who died on 3 September 1999 (indeed perhaps all of them) had been carried previously on such a positioning flight from Glasgow to Aberdeen by Captain Easson in the Cessna 404 G-ILGW. Familiarity with the routine did not however mean that any corners were cut or any procedures not fully and properly followed out. The whole available evidence indicated that Captain Easson was a punctilious commander who saw personally to all checks and loading procedures being correctly performed before the flight.

The aeroplane had last flown (apparently to Tiree and back) on 30 August 1999 when the pilot was William Stewart. It had sat since then on the apron at Glasgow Airport and had received 190 litres of additional fuel in preparation for the positioning flight to Aberdeen. The fuel had been loaded evenly into the wing tanks on 2 September by employees of Execair who gave evidence at the inquiry and there was no reason for me to think they had not done so competently or had allowed water to enter the fuel tanks. On 3 September prior to the flight Captain Easson had himself checked the fuel for possible water from condensation in the tanks (a standard pre-flight check since condensation can follow from the aeroplane standing idle for a period) and I have no reason to think that he performed those checks in any way improperly or inadequately.

On 3 September 1999 at or about midday (BST) the passengers (9 in number) and their baggage were loaded into G-ILGW by or under the supervision of Captain Easson himself but neither the passengers nor the baggage were individually or specifically weighed, there being no regulatory or obvious requirement to do so. Instead the normal assessments were made by applying standard weights (approved by the CAA) for each male and each female passenger, none of whom were especially or unduly large in height or girth so as to require to be weighed individually. Similarly a standardised assessment was made for the baggage since each passenger had a normal size and shape of bag and none appeared especially large or heavy so as to require to be weighed individually. In addition there was a small quantity of stationery and sugar to be taken to Aberdeen for the purposes of Execair. I have no reason to think that any greatly excessive weight beyond the normal was allowed aboard the aeroplane in respect either of passengers or baggage. The weight distribution was supervised by Captain Easson and I have no reason to think that it was ordered otherwise than correctly and competently. Nevertheless the fact remains that the aircraft was fully loaded (9 passengers and 2 crew) and so was taking off at or around its maximum permitted weight of 8400 lbs. The AAIB performed in retrospect a calculation of the likely maximum and minimum weights from the best data available to them (see page 16 of their report). From this they concluded that G-ILGW weighed at take-off not less than 8320 lbs nor more than 8600 lbs. Even if the actual weight was as high as 8600 lbs (i.e. 200 lbs or 2.4% over the maximum permitted weight) however I do not consider in light of the conclusions reached below that that small excess (if it existed) over the maximum permitted figure of 8400 lbs contributed materially to the occurrence of the accident: the fact that the aircraft was at or around its maximum take-off weight had an effect in the situation which arose but the fact (if it were the fact) that it exceeded that weight in a small degree had in my view no additional effect.

Once loaded the aircraft proceeded to taxi down from the apron along taxiway A to holding point A1 at the northeast end of the main runway 23. Near the start of this journey G-ILGW crossed the path of Peter Hansen, an electronic and mechanical engineer, who heard sounds from an engine (which he thought but was not certain to be the engine nearer to him) of what he took plainly to be misfiring as the aeroplane passed from his right to his left at a distance from him of some fifteen feet. His impression was of an engine not firing on every stroke when being accelerated or "revved up". Shortly thereafter G-ILGW passed along the taxiway and came to a halt in front of William Stevenson, a plane-spotter standing at the perimeter fence near holding point A1 who took a photograph of the plane (Crown production no 123). He was approximately 100 feet away but heard and saw nothing abnormal about the aircraft.

The aeroplane joined the short queue of aircraft at the holding point A1 near the northeast end of runway 23 and once given clearance took off under the control of Messrs Westwood and Kirkwood (air traffic controllers) in front of a Boeing 767 piloted by Messrs Eatough and Losardo who were positioned at the northeast end of the runway in line directly behind G-ILGW. The aeroplane was being flown by Captain Easson at take-off, who was seated on the left hand side of the cockpit, and he was in radio communication with air traffic control until the point at which he made an emergency broadcast. The take-off roll and subsequent initial climb appeared entirely normal to all observers, with G-ILGW becoming airborne at about the "crossroads" of the two runways and the flaps and landing-gear being thereafter retracted in normal fashion. In particular the co-pilots of the Boeing 767 behind G-ILGW on the runway, who seem to have been positioned for the best view, noticed nothing unusual about the take-off, although Mr Eatough was too busy with checks of his own to watch the Cessna until it was already airborne. In particular also neither of them saw the Cessna yaw to the left although Mr Eatough observed it after take-off to be offset some fair distance ("quite a way left") to the left of the centreline of the runway: this he at first put down to a yaw on account of the absence of a crosswind, which he thought was rapidly corrected, but he confirmed that he did not see an actual yaw take place.

Occurrence and cause(s) of critical event

The AAIB produced in appendix A to their report a chart of the "most probable flight path" in their opinion of the Cessna G-ILGW during its brief flight on 3 September 1999. Along the path they have marked five points (A, B, C, D, E) at which they suggest on the evidence available to them certain things happened. On the evidence available to me from that heard at the inquiry I am not inclined to differ markedly from the views proponed by the AAIB in their chart as to the flight path followed and the points along it at which important events occurred. The only respect in which I would differ is in thinking, from the evidence of the various eyewitnesses on the ground whose testimony I heard, that the true path of the flight may have been slightly further to the south between points B and C, i.e. somewhat to the south side between those points of the A737 rather than immediately above it. This however makes little or no difference to the other views I have formed as to what happened and why.

At or about point A, a position above runway 23 approximately level with the northern end of the International Pier of the airport buildings or slightly further to the southwest where taxiway Z comes in from the right-hand side, a "thud" or "bang" (as the noise was variously described) was heard by those within the aircraft, emanating apparently from the right-hand side. All three of the survivors recalled hearing the noise and all agreed that their impression at the time was of its coming from the right-hand side. One of them (Hugh O'Brien) had a clear recollection of seeing Captain Easson in the cockpit straining to see or hear from his right-hand side what the noise or its source might be. The same witness later saw a disparity between the needles on one dial among the instruments in the cockpit but he was not sure which instrument that was. The noise occurred only once and the aeroplane continued to climb. At or about the same time, however, a loss of full engine-power began to be experienced and the rate of climb diminished. This was in fact due to an incipient breakdown of the accessory gear train in the left engine although, for reasons discussed below, that fact never became clearly apparent to Captain Easson. The breakdown of that accessory gear train continued progressively thereafter for some time, resulting in an overall diminution in the output of power from the left engine to the point where (somewhere at or beyond point C on the presumed flightpath) it ceased entirely to transmit torque to the propeller which then "windmilled" as it was not feathered and in place of generating forward thrust produced instead a "drag" effect. This gradual decrease in power output was not however uniform or linear but occurred in all probability (on the evidence of Mr Coghill) in an oscillatory or spasmodic fashion with intermittent and irregular surges in power occurring on a decreasing scale. By the time the Cessna 404 reached point A it was already airborne with flaps and landing gear retracted or retracting and a glide back to the ground from that point would in any event have taken the aircraft beyond the end of the runway before landing. Captain Easson was accordingly already committed by that point to continuing the flight.

The breakdown of the accessory gear train was immediately caused by the shearing off of a tooth from the starter adapter shaftgear which had already suffered distress from pitting/spalling and had a fatigue fracture at its base. This in turn had been due to excessive stress over a period from torsional vibration in the engine. Such torsional vibration was intended in the design to be absorbed by the operation of inter alia the torsional viscous damper. The damper was not the only vibration-absorbing device incorporated into the design of an engine which was inherently more prone to vibration on account of the fact that its propeller shaft was offset from the crankshaft by a reduction gearing in order to maximise efficiency: there was also a lesser system of mobile counterweights on the crankshaft flanges but the damper was the primary means of controlling vibration and, being situated at the aft end of the engine, was probably the more important dampening device for the accessory gear train. The torsional viscous damper was intended to operate by differential movement between a steel outer casing (which revolved on and with the starter adapter shaft) and a relatively heavy bronze flywheel or rotor suspended freely within the casing in a viscous silicone fluid which allowed it to move independently but not completely unrestrainedly. The bronze flywheel was coated on its outer surfaces with a chromium skin in order to provide a harder material on the outside to reduce the risk of the bronze itself (a relatively soft material) being worn away. It was ascertained however from later internal examination of the damper, which was cut open at the premises of Teledyne in Alabama subsequently to the accident, that for some reason unknown or at least not explained the chromium skin had unfortunately come into excessive contact with the outer steel casing and had over a period of time become worn away with the consequence that minute particles of the chromium skin had impregnated the silicone fluid and caused it to lose its viscosity and solidify with a dry granular appearance. The silicone fluid had, as the AAIB report put it,

become heavily congested with fine metallic particles from the materials of the rotor and casing (all as fully explained in paragraph 1.12.5 of the AAIB report). There was no evidence available to me at the inquiry to explain with any clarity how or why or over what period this wearing contact had occurred (one possible cause was said to be "vibration") but the consequence appears to have been that the silicone fluid having become congested and ultimately solidified ceased to act as a viscous damping medium within the damper so that the damper as a unit ceased to have the designed effect of dampening, reducing or eliminating the torsional vibration stresses imposed on the accessory gear train by the operation of an engine having an offset propeller shaft. Unfortunately the torsional viscous damper from the left engine seems to have been cut open for internal examination at the premises of the engine manufacturer before anyone thought of first conducting some operational tests on it to see how far reduced its dampening effectiveness or efficiency had become. Tests were later conducted at the premises of the damper manufacturer on some thirty-one other torsional viscous dampers of the same type which showed various degrees of reduced effectiveness and revealed when sectioned varying degrees of contamination and solidification of the viscous silicone fluid within. The details of these tests and their results are set out in Appendix E of the AAIB's report (Crown production number 9). The actual torsional viscous damper involved in the accident on 3 September 1999 was not however so tested. The evidence tending to suggest that the torsional viscous damper had thus lost its internal viscosity and so its dampening effectiveness was not greatly tested, challenged or contradicted during the inquiry hearing before me and it must remain a matter of speculation whether it would have been had Vibratech Inc not withdrawn their representation on the fifth day and if so to what effect. On the evidence relating to this subject as it stood before me by the close of the inquiry the only reasonable inference to be drawn was that the chief cause of the deterioration of the starter adapter shaftgear to the point where one of its teeth broke off was most probably the increasingly ineffective state and operation of the torsional viscous damper as it progressively lost its internal viscosity due to the gradual solidification of its silicone fluid over a period whose length cannot be determined and may have been years, but may have been only a few months or even a matter of weeks. This, it appears, had permitted the vibrations of the engine to take their toll on the teeth of a new shaftgear of the modified type over the short timespan of only 255 hours of flying time.

The shearing off of the shaftgear tooth appears most probably to have occurred during that phase of flight when the engines were subjected to the greatest strain, namely during take-off and the initial climb of a fully-laden aircraft. The effects of that event, although progressive and not absolutely immediate, were in the end rapidly catastrophic for the left-hand engine. The sheared-off tooth became involved with the mesh between the starter adapter shaftgear and the crankshaft gear so that the majority of the remaining teeth on those two gears were broken off or stripped and so flattened to their roots. Similar effects were then felt on the teeth of the camshaft and idler gears below and above the crankshaft gear and in addition the haphazard prescence of extra pieces of metal between the gears (in the shape of broken-off teeth moving about in places where they should not have been and where there was no room for them) caused excessive strain to be placed on the crankcase housings and on the axles of the idler gear and one of the magneto gears (the first-mentioned axle being known as the "idler pin"). The eventual consequence was that those two housings gave way or burst and the idler pin became unseated so that the integrity of the crankcase and the functioning of the idler pin and magneto drive were lost irrevocably and the engine could no longer function even defectively. There was a suggestion in evidence from Mr Coghill to the effect that one of these terminal events could have been

capable of producing a noise which might penetrate within the cabin and sound to the occupants of the aircraft like a "bang" and there was evidence from other witnesses to the effect that external noises heard by the occupants of a cylinder (such as an aircraft fuselage) can be very difficult to pin down as to direction and may often give a misleading impression as to their source. Mr Coghill did not however maintain that the rupture of housings in the crankcase or the disintegration of the idler pin or any of the other events in the breakdown of the accessory gear train would necessarily have produced a noise sufficient to penetrate to the occupants within the cabin and cockpit, merely that it or they could have done so. From this description of the breakdown it is I think not difficult to envisage that, as suggested by Mr Coghill and other witnesses, the loss of power from the left engine and the loss of thrust from its propeller was very probably a progressive and not a sudden event (albeit spread over a period of less than two minutes) and that the progressive decline may well have been punctuated spasmodically by renewed surges of power as the engine "picked up" again at intervals during its deterioration.

The perceived "thud or bang"

There remain outstanding the questions whether it is possible and whether it is necessary or helpful to reach a concluded view as to what was in fact the true cause of the "thud or bang" perceived by the occupants of the aircraft to come apparently from their right-hand side. One possibility is that mentioned in the preceding paragraph, namely that it was indeed one of the terminal events in the breakdown of the accessory gear train and the left engine. This would mean that the "thud or bang" was not a coincidence but it has the difficulty, not however beyond possible explanation, that all observers who heard it were wrong as to which side of the aeroplane it came from. If one accepts the idea that an external noise may well mislead persons inside an aircraft fuselage as to the direction of its source, even to the extent of producing an impression directly opposite to the truth, then it is perhaps not difficult also to accept the idea that it could affect all observers in the same manner with the consequence that all three survivors and Captain Easson seemed together to labour under the same error of perception. It would mean also that the occurrence at or near point A was a final breakdown of the left-hand engine rather than an incipient breakdown of the accessory gear train which took some further time to bring about a complete loss of power from that engine and I prefer the view that the left-hand engine continued to power the flight, albeit decreasingly and spasmodically, for some distance beyond point A.

Other possible sources of the "thud or bang" which were canvassed in evidence at the inquiry included (i) birdstrike, (ii) water in the fuel and (iii) "swarf" in the new right-hand engine. As to the possibility of a birdstrike this is in my opinion ruled out effectively by the complete absence of evidence of any remains of birds found in or near the aeroplane or its wreckage after the crash. The experienced AAIB witnesses had no doubt that some such remains would have been found had there been a birdstrike. The possibility of water in the fuel giving rise to imperfect combustion of a weakened mixture within the engine cylinders (although an event which would have left no trace) would be more likely to manifest itself by rough running than by a loud noise or backfire and is rendered unlikely if the evidence be accepted tending to indicate that the Execair employees loaded the additional fuel without letting water enter the fuel tanks and that Captain Easson on 3 September 1999 properly checked the fuel prior to the flight for water condensation in the tanks. I am inclined to accept

that evidence and accordingly that these operations were correctly carried out and that water in the fuel was not the cause of the noise heard from the right-hand side of the aircraft at point A. The third possibility canvassed was of "swarf" in the right-hand engine, ie. fine metallic debris remaining in the engine from the manufacturing or remanufacturing process which could find its way into the area of the exhaust valves and cause them to close incompletely thus allowing combustion or the noise of combustion to escape into the exhaust system and cause a backfiring effect. Like the possibility of water in the fuel but unlike that of a birdstrike such an effect caused by swarf in the engine would have left no subsequent trace. The right-hand engine was, as noted above, well within its probationary period of 50 hours since remanufacture as "new" and may well have still contained swarf. Had the "thud or bang" emanated from the right-hand engine for this reason the observers within the aircraft who heard it would all have correctly identified the direction whence it came and its source. The prescence of swarf in one engine may also have accounted for the misfiring heard by Peter Hansen as the Cessna G-ILGW crossed his path on its journey along taxiway A, albeit Mr Hansen was not certain which engine was producing the noises he heard and an alternative possible explanation for the misfiring perceived by him could be that the breakdown of the accessory gear train had already commenced even at that early stage before the strain of actual take-off had yet been placed on the left-hand engine. A further possibility is that he heard misfiring of the type commonly associated with uneven running of an engine not yet fully warmed up.

If it were necessary to determine the true cause of the "thud or bang" for present purposes then for myself I prefer the view that it was the presence of swarf in the new right-hand engine which produced it. On the available evidence I discount the possibilities of birdstrike and water in the fuel, both of which could have occurred on either side of the aeroplane and both of which would have been entirely coincidental in the sense that there was nothing inherent in the condition of the aircraft at the time which could have given rise to them. The first (birdstrike) is supported by no positive evidence and the second (water in the fuel) is cast in a negative light by the evidence of the Execair employees and Captain Easson's pre-take-off inspection. The idea that a final rupture of parts of the left-hand engine's crankcase and accessory gear train caused the noise heard by those within the fuselage means that they were all deceived as to its direction, is based upon a mere suggestion of Mr Coghill that such noise penetration could have occurred and places the loss of power and propeller thrust from the left-hand engine too soon in the sequence of events: had that loss of power and thrust occurred as early as point A it is doubtful that G-ILGW could have progressed as far as point E before crashing and the rest of the evidence inclines me to think that the left-hand propeller did not impose a "drag" effect on the aircraft's flight until point C had been reached at the earliest. I therefore prefer the remaining explanation of swarf in the right-hand engine, a phenomenon well known to produce backfiring. This too would in one sense have been a coincidence but the evidence shows that the conditions for it to occur on the side of the aircraft where it was perceived did exist, namely the presence of a "new" remanufactured right-hand engine still within its probationary period.

Having come to the view that a backfire from swarf in the right-hand engine was the most likely cause of the noise heard by the passengers and pilot, I should add that it is not in my view essential for the purposes of this determination to reach a fixed conclusion on this particular matter. It is sufficient that an unusual (and therefore presumably somewhat alarming) noise in the nature of a "thud or bang" was heard at or about point A very shortly

after take-off and that it was perceived by Captain Easson in particular as having emanated from the right-hand side of his aircraft. Its precise cause perhaps is of lesser moment than the fact that at that early stage after take-off the commander had heard or thought he had heard a suspicious noise from his right. He knew that the right-hand engine was a new one and still within its probationary period. He may not have known or thought whether it was due to swarf or some more serious cause but he knew or thought that it betokened something unusual or amiss with his right-hand engine and the significant inference which I draw from the event is that from that moment on it is reasonable to think that Captain Easson was doubtful of the reliability of his right-hand engine and viewed it thenceforth as suspect. This had I think certain consequences for his handling of the situation as it developed rapidly thereafter and these consequences are considered more fully below.

Events subsequent to critical event

At the time when the "thud or bang" was heard within the aircraft (at or about point A on the suggested flight path) one of the eventual survivors was taken by the AAIB to have estimated the height of the aircraft to be some 200 feet above ground level (from looking out just beforehand to the left at the airport and M8 motorway). As earlier stated the aircraft continued to climb from point A toward point B on the suggested flight path but at a diminishing rate of climb and so gaining less height than it normally would. At the same time it was moving out toward the left hand side (as observed by Messrs Eatough and Losardo) in accordance with its usual idiosyncratic tendency to sideslip leftwards after take-off and perhaps also to some extent under the influence of a yaw created by the decreasing power output and hence thrust of the left-hand engine relative to that of the right-hand engine. Any such yaw would however have been unlikely to be at all pronounced given the gradual and spasmodic nature of the breakdown in the accessory gear train of the left-hand engine which was under way and it may not have been readily noticeable or discernible as a yaw to Captain Easson who from his knowledge of the aircraft would have been expecting it to move leftwards after take-off in any event, there being in effect no crosswind in either direction and instead a moderate southwesterly breeze blowing at 16 knots from a direction of 230 degrees almost straight up the runway (see radio message at 1133 hours + 38 seconds recorded in Crown production number 22). It must have been very apparent to the commander at this period that something was seriously wrong in that his aircraft was gaining insufficient height and was suffering a significant loss of power from at least one engine at a critical stage in the flight when it was fully loaded. That power loss was however not sudden and it appears probable that the commander was as yet unable to detect which engine was at fault. That at least is the implication of the message transmitted to air traffic control at or about point B at 1135 hours + 10 seconds, which is recorded (in Crown production number 22) as "three whiskey we do have an emergency just like to return". Since the take-off the only radio message prior to that emergency call was a routine permission some five seconds earlier from air traffic control telling Captain Easson that he could turn towards Dumbarton at his own convenience once he had attained a height of 500 feet. This elicited the almost immediate response quoted above which the air traffic controllers observed was given in a strained and not clearly recognisable tone of voice, implying that the transmitting pilot knew himself to be in trouble. The wording of the emergency message is significant for two reasons: (first) the reference to "an emergency" without further specification fits with the idea that the commander was as yet unable to determine where the fault lay and (secondly) the expressed desire simply "to return" implies that the commander's first and natural reaction to

a difficulty (which he must have viewed as an engine problem) in a twin-engined aircraft was to return to base at the airport on the remaining good engine without further ado. Three seconds later air traffic control affirmed that a return to the airfield would be in order and asked the next aeroplane in line for take-off (Eatough and Losardo) to vacate the runway at the next taxiway. Thereafter no communication was received from the Cessna G-ILGW until it crashed sometime between 1135 hours + 40 seconds and 1135 hours + 48 seconds. The total flight time (from commencement of take-off at 1133 hours + 43 seconds) was thus almost exactly two minutes. At about point C on the suggested flight path Captain Easson began to execute a right hand turn in order to commence his return to the airfield. It is apparent however from all that happened at that stage of the flight, so far as can be deduced from the evidence at the inquiry, that the commander's suspicions remained centred on the right hand engine from which he thought he had heard the "thud or bang" and which he knew to be recently installed and still within its probationary period. The evidence from the wreckage at the crash site relative to the fuel selector knobs and valves I interpret as demonstrating that at some point prior to the final descent (and probably prior to point C) the commander switched over the fuel lines so that the right hand engine could draw fuel from the left hand tank, which I take to be indicative of a concern on his part that a loss of power from the right hand engine might be due to a fuel supply problem to that engine which he sought to rectify by letting it draw fuel from the opposite tank instead of that on its own side which had been supplying it in normal fashion at take-off. When precisely he took this step cannot be said because the only evidence bearing on the matter comes ex post facto from the crash site but it must be assumed to have been done prior to the decision (see below) to close down the right hand engine and feather its propeller and it seems most reasonable to think that such a step would have been one of the earlier attempts made to rectify the loss of power. From what we now know it is clear that the attempt must have been unavailing but the fact that it was made supports the view that Captain Easson's chief suspicion was that his right hand engine was failing for some reason.

The evidence of the wreckage at the crash site also indicates that the right hand propeller was when it reached the ground in a condition close to being feathered, i.e. about to be completely feathered or just coming out of feather. Either way the clear indication is that the commander had operated the controls to feather the right hand propeller or (less probably in the time available) feathered it and then started to de-feather it realising a mistake had been made. This finding fits with the evidence of the eyewitnesses on the ground who spoke to observing the aircraft crossing the A737 but not gaining and then losing height and noticing the right hand propeller slowing markedly to an eventual halt while the left hand propeller continued to turn at a constant speed. At the same time they heard engine spluttering noises followed by silence before the aircraft hit the ground. These observations are consistent with the right hand engine being closed down and its propeller feathered after point C on the suggested flight path had been reached while the left hand propeller had not been feathered and was "windmilling".

From all of the foregoing I deduce that as the aircraft progressed from point B to point C on the suggested flight path it ceased to gain any height and the left hand propeller ceased to receive power from the left hand engine so that it began to "windmill". After the right hand turn was commenced at point C the left hand propeller began to exert a "drag" effect and the execution of the steep turn on reduced power rapidly degraded the airspeed. At some stage prior to reaching point D the commander knew that in order to maintain the aircraft in flight

he had to feather the propeller of the faulty (and now inoperative) engine but he still did not know which engine that was and opted mistakenly to close down the engine of which he remained chiefly suspicious, namely the right hand engine. The consequence was that all power and thrust were now lost and the aircraft descended rapidly from point D in a steep dive to the ground at point E where it crashed.

A question was canvassed in evidence at the inquiry as to whether Captain Easson's action in operating the levers on the control console in the cockpit to close down the right hand engine and feather its propeller was taken with the deliberate intention of closing that engine down or whether he operated those levers mistakenly under extreme pressure thinking and intending to close down the left hand engine having correctly assessed it to be the source of the trouble. There is however no evidence to indicate that he had succeeded by then in making that correct assessment. There is nothing to show whether he had looked out to his left hand side and observed a windmilling propeller on his left hand engine. We know little if anything in the absence of a cockpit voice recorder about what discussion if any was going on in the cockpit or what deductions if any were being made from the cockpit instruments if they were being looked at. There is in short nothing to indicate that Captain Easson's initial suspicion of the reliability of his right hand engine had been displaced. In addition I think it inherently improbable that Captain Easson would, even in an extreme situation, have made the mistake of pulling the wrong set of levers. On balance therefore I reach the conclusion that the closing down of the right hand engine was the consequence of a deliberate decision on his part to opt for that engine as still being the more suspect of the two in his mind.

Very shortly before the impact at point E Captain Easson managed to level the aircraft's attitude substantially but the speed of the impact was nevertheless high. The aircraft hit a stiff hedge and an embankment and was brought to a halt. Fire then broke out. Eight of the occupants of the aircraft were killed either on impact or by the fire or by a combination of the two having sustained injuries which disabled them from escaping in sufficient time. One survivor managed to scramble out of the aircraft and was helped away by Mr Connell who had arrived on a tractor and then pulled two other survivors from the wreckage before the fire prevented him from effecting any further rescue. The three survivors had been seated toward the rear of the aircraft. The remaining occupants perished however including the two pilots.

Inability or failure to recover: possible explanations

Had there been no breakdown of the accessory gear train of the left hand engine there would have been no air accident. For the probable reasons earlier discussed such a breakdown occurred but it did not thereby become inevitable that a crash of the aircraft with fatal consequences should ensue. Had that breakdown occurred at a later stage in the flight or even at the stage when it did but in different circumstances the commander might well have been able to rescue the situation and return to base or effect a forced landing without serious mishap. Circumstances however conspired on this occasion against Captain Easson and his passengers with the consequence that all his great experience and proficiency proved inadequate to save them from death or injury. The conspiracy of circumstance arose out of the elements considered below.

The whole event took place against a background of low height and a fully laden aircraft at or just after take-off. The options open to the commander were therefore at their most limited and his room for manoeuvre or time to consider those options were at their most circumscribed. Had the crisis arisen at a substantially greater height it could probably have been overcome. Whether the outcome would have been different with a half-laden or substantially lighter aircraft I do not think can be said with any assurance on the evidence led at the inquiry. The occurrence of a difficulty in such a circumstance is of course not very unusual and the problems presented by low height and maximum permissible weight should not of themselves have been insuperable in the absence of other adverse factors. Indeed if the mechanical breakdown which gave rise to the crisis was going to occur at all it was more likely to occur at or around the time of take-off than at any other time, that being the stage at which the components in the accessory gear train would be placed under greatest strain. Passenger aircraft are designed and subsequently categorised with a view to such failures being manageable when other conditions are relatively normal.

The nature of the breakdown which occurred was progressive and spasmodic and so in all probability produced no pronounced yaw of which the pilot could immediately take notice and account. Whether he would have felt a "dead foot, dead engine" effect is therefore doubtful. Further and in any event this aircraft was known to the commander to have an idiosyncratic tendency to slideslip leftwards after take-off in the absence of a crosswind which would probably have masked in his mind any slight yaw which may have occurred. One of the chief "cues" from which the pilot of a twin-engined aircraft would normally deduce which of his engines was failing was thus probably absent for Captain Easson on this occasion.

Even more importantly in my view there occurred by unfortunate coincidence a noise from the right hand side of the aircraft just after take-off at the same time or very nearly the same time as the critical event, i.e. the start of the breakdown of the accessory gear train in the left hand engine. The commander knew that he had a new (or remanufactured) right hand engine still within its probationary period but the occurrence of an unusual "thud or bang" from it followed fairly immediately by an apparent loss of engine power and an inability to maintain a normal rate of climb must have raised in his mind not unnaturally a substantial suspicion that the right hand engine was the source of the trouble. Nothing occurred thereafter during the brief flight of less than two minutes to clearly displace that suspicion and especially not any pronounced or noticeable yaw to indicate that the trouble lay with the left hand engine. It appears to me probable therefore that that suspicion remained with Captain Easson right up to and including the moment at which (having first switched over the fuel supply without beneficial effect) he elected to close down the right hand engine in the hope of thus maintaining the aircraft in flight for a return to the airfield. It was however only a suspicion, however strong, and I do not think that he can have formed a definite opinion as to which of his two engines had failed either at the time when he decided to return to the airfield or even when he felt himself finally compelled to opt for closing down one engine or the other. No doubt he opted for the one which seemed to him the most likely and clearly he must have been doing so in the agony of the moment under great stress but it turned out to be the wrong one. Nothing occurred in the course of the brief flight to reinforce that suspicion or, so far as the evidence goes which is available to me, to detract from it.

A matter on which there was some but not a great deal of evidence at the inquiry was that of the cockpit instrumentation. It was apparent that certain of the instruments in the cockpit could have given an indication of a differential power output from the two engines, most notably the dial showing engine RPM which had two needles (each marked with a small letter for one engine). One of the survivors had from the rear of the aircraft observed the two needles on one dial pointing in different directions but he was too distant to discern which needle related to which engine. In the absence of a cockpit voice recorder there was no evidence before me to indicate whether either pilot looked at this or any other instrument during the two-minute flight or whether the commander instructed the second pilot to do so or whether any discussion took place or any information was passed as to what the instruments appeared to be indicating. One witness stated in evidence (Mr Whidborne) that a fairly "considered study" would be required in order to ascertain which needle was saying what about which engine and in order to assess what might be the significance of that information; and he rather doubted whether time or opportunity existed in the circumstances prevailing for such an examination and assessment usefully to be made. On this matter therefore I am left in the position of being unable to say on the evidence whether no instrument was looked at in the difficult situation which had arisen or whether the instruments were studied but misinterpreted or found to yield no helpful information which could be understood and applied in the time available.

In addition it appears that Captain Easson was pre-disposed or at least inclined by his training to the view that the wise course to adopt when engine trouble is experienced in a twin-engined aircraft is to close down the troublesome engine and return to the airfield (or at least to an airport) on the remaining engine (as Mr Alexander had done successfully with this same aircraft on 5 November 1998). The commander's intention to do so had been signalled to air traffic control by his emergency message at 1135 hours + 10 seconds and he thereafter adhered to that intention. That seems to be a sensible plan if the pilot knows he has one good engine and one failing engine, provided also he knows which is which: after all it is better to return to a runway with all emergency facilities if one can be reasonably sure of getting there than to attempt a forced landing in a field or even rougher terrain. But if it is not clear which engine is the failing one the question arises whether it might be better to glide forward to a forced but gradual landing in a field north of Linwood rather than risk having to shut down what might turn out to be the good engine in an attempt to return to the airport runway. In the event the good engine was on this occasion closed down and the urgent need to opt in a state of uncertainty for feathering one propeller or the other may well have been brought about largely by the very act of entering the steep right hand turn in order to return to the airport. What would have been the outcome if a decision had been made (as if in a single-engined aircraft) to abandon the airport and glide forward to a landing in a field in a gradual descent along a roughly straight line must be an imponderable. It cannot be said with any certainty that such a course would have saved the lives that were lost or avoided the injuries: the most that can be said is that there might well have been a more favourable outcome. It is however plain that the decision to execute a right hand turn in order to return to the airport played a substantial part in what happened as one of the precipitating causes (along with the "drag" effect of the unfeathered but powerless left hand propeller) of the rapid degradation of airspeed which immediately preceded the crash.

Essentially therefore the sequence of events, reduced to its simplest terms, was that an emergency having arisen at a critical stage in the flight for mechanical reasons beyond his control the commander made and adhered to a decision to return to the airport without knowing at all surely which engine was at fault, executed a right hand turn on diminishing power for that purpose, closed down the wrong engine thus losing control of the aircraft and so failed to recover the situation created by the emergency. So summarised that account does not read well for a commander of Captain Easson's experience or indeed for any commander but there were other factors present as discussed above. The decision to return to the airport can be seen with hindsight as a misjudgement in the circumstances but it was in accordance with the training and natural inclination of a pilot accustomed to flying twin-engined aircraft and it may be that, contrary to the deduction I have made, Captain Easson had a definite albeit erroneous view as to which engine was at fault having made his mind up against the right hand one. The closing down of the wrong engine has to be viewed as a mistake and a fatal one too but I do not regard it on the evidence heard at the inquiry as a mistake which no competent commander would have made in the circumstances nor as one for which he can properly be blamed although the responsibility for it was his. Rather I consider that the emergency placed him in a most difficult predicament shortly after take-off in a fully-laden aircraft at low height faced as fate dictated with conflicting indications or "cues" by which he became confused in the short time available to him to assess the position and make vital decisions under great stress. The "cues" which might have pointed him to the faulty engine became masked and there happened by misfortune to arise an important indication pointing him to the wrong engine because it was very new. These conflicting messages proved in the stressful situation too much even for his great experience and I think he became (to choose a non-dictionary word which perhaps best describes it) "bamboozled" by them into making in the agony of the moment a fatal error. He might perhaps have avoided placing himself in the critical situation of having to make a choice fraught with risk at the last moment had he departed, contrary to his natural inclination, from the initial decision to return to the airfield and opted instead for a forced landing in the fields ahead of him. In the particular combination of circumstances which arose here however even the most experienced and proficient commander was tragically unable to save the situation created by the emergency.

Categorisation of aircraft types

The Cessna 404 is a Transport Category (Passenger) aeroplane certified by the CAA as within "Performance Group C" which is defined as comprising "aeroplanes with a performance such that a forced landing should not be necessary if a power unit fails after take-off and initial climb". The phrase "initial climb" is not further defined but I take point A, where the "thud or bang" occurred, to be in this case beyond take-off and well into the phase of "initial climb" since a height of some 200 feet had been achieved (albeit further height was yet to be attained) and Captain Easson could not from that point have descended again directly onto the runway but would instead have landed beyond the end of it.

The performance groups were discussed to some extent in evidence and suggestions were made in closing submissions to the effect that (a) the CAA should now re-order and re-word its performance groups in order to dispel confusion which was said to exist between them and within each of them; and (b) the Cessna 404 should no longer be classified within

performance group C as being an aircraft for which a forced landing may be necessary in the situation envisaged. This last submission was founded on inter alia the proposition that "may be necessary" does not in the context bear the same meaning as "should not be necessary" and would have the effect that the Cessna 404 should cease to carry passengers commercially altogether.

With these propositions I do not agree. The definition in performance group C does not to my mind mean that no forced landing will ever be necessary nor any accident ever occur in any circumstances for an aircraft falling within the definition. Nor does it mean that because an accident occurred in the situation envisaged by the definition the Cessna 404 must be wrongly classified or that the definition must be defective. It does not mean either that because a performance group C aircraft (which apart from the faulty engine was in good order) suffered an accident or had to make a forced landing in the situation envisaged there must have been some failure on the part of the pilot amounting to some culpable or avoidable error: it might mean that but not necessarily. What it means in the present context is that this aircraft would have been able to climb away and return to land at the airfield on the single right hand engine if the left hand engine had been correctly and promptly identified as the faulty one and closed down with its propeller feathered. In this respect on the evidence led before me at the inquiry I reach the same conclusion as did the AAIB in their report at paragraph 2.1.3 (at page 41) and paragraph 2.13 (at pages 61 and 62).

I do not consider therefore that the Cessna 404 was incorrectly classified by the CAA into their performance group C. Had Captain Easson been able to identify the left hand engine as the source of the power loss and feather its propeller at an early stage (as he and other pilots are trained to do) he would very probably have succeeded in rescuing the situation by a return to the airfield on the remaining engine as he intended at the time of his radio message at 1135 hours + 10 seconds at point B. The expectations of the definition in performance group C would thus have been fulfilled. The whole question in the present case is why was it that he did not know and was unable to determine that the left hand engine was the one at fault. The answer to that, as already discussed, lies in the conflicting or misleading signals with which he was exceptionally presented. On the one hand there appears to have been no clear indication (such as a pronounced or noticeable yaw) that the left hand engine was failing progressively while on the other hand there had been a suspicious noise from the new and still probationary right hand engine. The result must have been prolonged doubt followed by a mistaken election under extreme pressure to close down the wrong engine. Although a forced landing should not have been necessary if normal procedures had been followed, it became necessary in the abnormal and exceptional situation which arose. The commander however did not change his mind after point B to opt for a forced landing of his own choosing despite the continuing doubt with the consequence that an election to shut down one engine or the other was forced upon him along with a forced landing not of his choosing. None of the foregoing however means that the aircraft was wrongly classified: it means instead that although it was correctly classified the normal procedures were not or could not be followed out so that a forced landing became on this occasion necessary.

Nor do I consider that the evidence at this inquiry into this accident goes far enough to demonstrate that any real benefit would be derived from an exercise in re-ordering or re-

wording the CAA's performance groups (although I appreciate from the evidence heard that the present six groups may have grown up somewhat haphazardly). It was suggested that the categorisation of his aircraft may affect a pilot's awareness or perception of what his aircraft can do or achieve and that the wording of the definitions in the performance groups might affect the willingness of pilots to consider a forced landing as an option. I do not believe however that the performance group or the wording of its definition has any real influence on the thinking of a pilot who has to handle an emergency such as that faced by Captain Easson. I cannot imagine that he or any other pilot similarly placed could have been thinking to himself during the 120 seconds of this brief flight that since this was a performance group C aircraft as classified by the CAA it must or certainly should be possible to get back to Glasgow Airport safely and that accordingly other expedients such as forced landings were not to be contemplated. Rather his thinking and that of any other pilot in such an emergency is much more likely to have been informed by his own training as a pilot and experience of his aircraft and by his consequent instilled or intuitive reactions to the signals coming rapidly to him in the developing situation: these could be expected to remain the sources of his inspiration in dealing with an emergency however the performance groups might be re-ordered or re-worded by the CAA.

Training of pilots

Considerable attention was devoted to this topic in course of the inquiry, which in light of the observations I have made in the immediately preceding sections seems to me in retrospect to have been appropriate. Captain Easson was a highly experienced pilot who had very recently been tested routinely for proficiency and been found entirely competent. He had as part of that test dealt with a simulated single-engine failure such as here occurred but created suddenly not gradually, without conflicting or misleading signals, at greater height and with less aircraft weight. The techniques there practised were to correctly identify the failing engine, close it down and proceed on a single engine as if returning to the nearest airport. These are the standard procedures to follow when flying a twin-engined aeroplane which Captain Easson had spent the great majority of his time doing for at least the past eighteen months.

On 3 September 1999 however he was faced with a difficulty in determining which of two engines was failing, a difficulty (unbeknown to him) in detecting or understanding and taking account of a progressive engine failure and a question (which he may or may not have addressed) whether a return to the airport was in the circumstances the best course to adopt. It was his failure or inability despite all his experience to recognise and resolve or reconcile these difficulties and that question in the short time available to him and the extreme circumstances besetting him which led to the accident and the deaths. In such a situation, as it appears to me from the evidence at the inquiry of other experienced pilots, it is the intuition derived from his training and accumulated experience on which a pilot has to draw and rely in seeking to solve the problems confronting him: these things are not done by reference at the time to written instructions (albeit flight or operations manuals may have been studied previously in course of training) nor by reference to categorisation of aircraft into performance groups.

We did not of course hear evidence from Captain Easson and it may well be that for all his long experience he had never yet had to deal with a progressive engine failure. It may well be also that for all that experience he had never yet had the difficult task of determining from conflicting signals which one of two engines was the failing one. Certainly the combination of a progressive engine failure on the one side contemporaneously with indications of possible engine trouble from a probationary engine on the other must be an unusual event indeed. In addition there was a clear recognition among the flying experts who gave evidence at the inquiry of the possibility that pilots of twin-engined aircraft might develop a "mindset" or fixed attitude towards the course to be adopted in the event of an engine failure, namely to close down one engine and proceed to or back to an airport on the other. From the fact that he first intimated (at 1135 hours + 10 seconds at point B) an intention to adopt such a course, which I accept was a reasonable position to adopt at that time, but then adhered to it and began to execute the turn necessary for it even although he cannot have had a clear and convincing basis for deciding that the right hand engine was at fault (at least no such basis of which I have been made aware) I am inclined to think that Captain Easson, again despite all that experience, probably had such a mindset in his approach to the problem and may well not have even considered an elective forced landing as a realistic solution even although the terrain around Linwood on its north side is in general terms not unsuited to such a landing manoeuvre. Counsel who appeared for his executors (and for Edinburgh Air Charter Limited) at the inquiry submitted in his closing speech that on the information available to us "all the decisions and judgements made by Captain Easson were correct (or at the very least reasonable) in the particular circumstances as they presented themselves to him" and among these he included the decision to attempt to return to the airfield, which he said had not been criticised by the AAIB. I agree with counsel and the AAIB that that decision was a reasonable one at the time of the transmission to air traffic control at 1135 hours + 10 seconds when the aircraft was still climbing or at least in level flight (see the AAIB report at paragraph 2.12.2 on page 60) and may have been still under sufficient power at point B. I am however less sure that adherence to it was still a reasonable decision once it became apparent, as it must have done very shortly thereafter, that the aircraft would no longer climb although it was still not clear which engine was failing and I am inclined to think that a pilot of more flexible approach from his training might then have thought twice (albeit he would have had to do so rapidly) about altering his intention and changing his mind away from a 180 degree turn when he still did not know which engine was the faulty one. The decision to adhere to the initial decision to return to the airfield was not separately referred to by counsel and the AAIB refer to the changed circumstance that the aircraft ceased to climb only as a possible explanation for the feathering of the right hand propeller.

It is with all these considerations in mind that I am inclined to suggest (see below) that the CAA should consider means of expanding somewhat the training of pilots in these particular areas. It would in light of this accident be beneficial if the CAA were to consider requiring the inclusion in training programmes for pilots of (first) some greater reference than there has been hitherto to the possibility that an engine failure may sometimes be progressive and spasmodic and not linear or sudden; (secondly) some fuller emphasis on improving techniques for determining in multi-engined aircraft which of the engines is the failing one; and (thirdly) some greater emphasis on the need for flexibility in selecting a landing solution where necessary from the options available and in particular not excluding a forced landing such as would be undertaken in a single-engined aircraft from the options to be realistically contemplated where engine failure occurs in a twin-engined aircraft but doubt exists or persists as to the identity of the faulty engine. The Crown suggested in their closing submission that a recommendation might usefully be made along these lines, pointing out

that the accident which was the subject of this inquiry occurred despite the presence of a highly skilled and experienced pilot. In this the Crown were supported by counsel for the families of the majority of the deceased and by counsel for Airtours plc, their employers. Counsel for the executors of Captain Easson and Edinburgh Air Charter Limited adopted a neutral position on this matter but wished it made clear, which I have no difficulty in accepting, that Captain Easson had to be viewed in any event as highly trained according to the approved standards in force at 3 September 1999. Messrs Whidborne and Barnet of the AAIB said in evidence that their organisation had given great consideration to this matter but had refrained from making a recommendation about it. The solicitor appearing for the CAA pointed out that his clients were not a body of infinite resource and submitted that since the AAIB had made no such recommendation I should not do so either. He spoke of a risk of "information overload" and suggested that in any event training aimed at increasing forced landing awareness would not have altered the outcome of this incident because the commander clearly believed until the final moments that he had one good engine and sufficient power to maintain flight. He referred me on several aspects to the evidence of Mr Macleod (a pilot by profession now employed by the CAA in their Personnel Licensing Department as Senior Flight Examiner at their test centre at Leeds) among others. While I accept that the commander believed until the end that he had one good engine sufficient to fly the point which continually impresses itself upon me is that he did not have the vital piece of knowledge, namely which of the two engines was the good one --- or if he thought he knew the right hand engine to be the faulty one that incorrect view was based on insufficient information to justify it. Mr Macleod's testimony I regarded as generally valuable to the inquiry but his evidence on this particular point (closing down the faulty engine and continuing on the surviving engine without a forced landing) was entirely based on the questioner's implied premise that the pilot knows which engine is which (at page 2904 of the transcript of evidence at the inquiry) and his later references (at pages 2918 and 2919) to difficulty in ascertaining which is the failing engine were in answer to questions about progressive engine failure and not about whether to attempt a forced landing rather than close down an engine which might turn out to be the wrong one. I am inclined therefore to prefer the approach on the matter of the Crown, Airtours and the families of the deceased passengers and have included below what I consider to be an appropriate recommendation. I have some doubt as to whether it will be sufficient to leave matters in this regard merely to an article or other discussion in the GASIL quarterly bulletin but I have to leave it to the CAA in the end to identify the best means of most effectively expanding or improving pilot training in the areas indicated.

Survivability: aircraft seating, etc

It does not appear to me necessary or beneficial to say here much if anything more on this topic than has already been very fully stated by the AAIB in their report, particularly at paragraphs 1.6.9, 1.12.2, 1.12.9, 1.15.4, 1.16.4, 1.16.5 and 2.14.1 thereof. These matters were not controversial at the inquiry nor attended with any great mystery or difficulty of understanding. The evidence heard at the inquiry on the subject was for these reasons brief and did not materially add to or detract from the findings of the AAIB in their report. Mr Whidborne stated that had the seats not become detached the passengers' chances of survival would have been enhanced and Mr Carter said that their prospects would have been improved had there been improved seating or upper torso restraints incorporated in their seatbelts. These statements are echoed by Finding 11 at page 65 of the AAIB Report

and it cannot in my view be said even as a matter of probability, let alone with any certainty, which if any of the deceased would have survived and if so in what condition had more up-to-date seating requirement regulations (introduced at the end of the 1980s) been applied to this aircraft.

The descent of the aircraft from point D to point E on the suggested flight path was steep and rapid. Although the commander had succeeded in substantially levelling the aeroplane's attitude by the time of its impact with the ground its speed of descent at that point was still rapid. The aircraft then collided with a stiff hedge and an embankment. The seats and their attachments or supports were consequently subjected to excessive stresses and so collapsed or became detached and moved forwards and to the right hand side. In addition the passengers had only lap-restraining seatbelts and no upper torso restraints. Most of them sustained disabling injuries which prevented them from escaping the subsequent fire.

Late in the 1980s amendments had been introduced to upgrade the requirements and standards concerning impact loads for seats and other cabin equipment in various categories of aircraft including that known as "Part 23", into which fell the Cessna 404. These upgraded standards were however applied only to aircraft of new design coming forward for certification for the first time and accordingly were not applied to the Cessna 404. Had they been so applied it is probable that more seats than did so would have remained in place thus improving the passengers' prospects of survival, although to what extent must remain imponderable: the computerised "KRASH" test seemed to indicate that even then cabin disruption would still have occurred. The application by "retrofit" of later standards to older aircraft of earlier design is of course not easy but the AAIB in their report on this accident have in light of the facts summarised above made a recommendation (Recommendation 2001 - 40 at page 68 of their report) to the effect that the CAA should undertake a study in order to identify those standards which could effectively be applied retrospectively to existing aircraft or new aircraft of existing design. The Crown submitted at the close of the inquiry that I should here adopt that recommendation of the AAIB if only to reinforce it and I agree. The inquiry was informed in evidence by Mr Alcott of the CAA that they had accepted this recommendation and that an appropriate study was already under way. A report of this study was expected to become available in March 2002, whereafter consideration would be given to implementing its proposals through the JAA (Joint Aviation Authorities) in Europe by amendment of their operational requirements.

Recommendations considered

The AAIB in their report made three recommendations which are set out at pages 67 and 68 at the end thereof. At the inquiry there was evidence from their witnesses that they had considered some other possible recommendations but had either rejected these as not warranted in their opinion by the circumstances or refrained from making them because they could not (in some areas) find a suitable and workable recommendation to make.

The solicitor appearing for the CAA adopted the position at the close of the inquiry that the AAIB's three recommendations had all been adopted or accepted in one way or another by the CAA and no more should be made on the evidence available to the court.

Counsel for the executors of Captain Easson and Edinburgh Air Charter Ltd expressed himself as having no difficulty with the AAIB's three recommendations nor with the position adopted by the Crown in relation to them (which went somewhat beyond them: see below). With regard to training of pilots he wished to emphasise that Captain Easson was highly trained in accordance with the approved standards in force as at 3 September 1999. A recommendation is made below concerning these training standards for the future but that does not imply that Captain Easson had allowed his own training to become deficient at the time of his and the associated deaths.

The Crown at the close of the inquiry suggested that the first and third of the AAIB's recommendations could and should properly be adopted by me without embellishment but that the second should be expanded to cover all commercial passenger-carrying aircraft. In this the procurator fiscal was supported by counsel appearing for the families of the deceased and injured passengers. The procurator fiscal in addition submitted that the evidence at the inquiry justified the making of a recommendation concerning pilot training with a view to heightening the profile of certain aspects of airmanship in multi-engined aircraft which had had a contributory bearing on the occurrence of this accident. In this she was supported by counsel appearing for the families and by counsel appearing for Airtours plc and I have accepted this submission.

Counsel for Airtours plc suggested in addition that there should be some expansion of the AAIB's first recommendation in order to enable an assessment of the risk which remained as yet unquantified of gear failure within a period of 200 hours from the last inspection. It does not appear to me that any great difficulty or undue expense will be associated with reporting of inspection results to the CAA for this purpose and I have accepted this suggestion which I consider sensible in light of the evidence heard at the inquiry relative to the reasons for the breakdown of the accessory gear train in the left hand engine.

Counsel who appeared for the relatives of the deceased passengers and for the three survivors went considerably beyond supporting the Crown on the matters of cockpit voice recorders and pilot training. He made in addition several further suggested recommendations of which I find only one to be sufficiently warranted by the evidence heard at the inquiry to merit adoption, namely that concerned with the general study of vibration in GTSIO piston engines which had been commenced by Mr Carter of the AAIB but then discontinued (on which see further below). His other suggestions I have not accepted for various reasons, either because I disagree with them on my interpretation of the evidence or because I think the evidence at the inquiry relating to them to be insufficiently compelling to justify them. It was suggested that the CAA should revise and re-order its "performance groups" and the aircraft within them; in particular it was suggested that the Cessna 404 should no longer be classified within performance group C. As indicated above however I do not consider this accident to demonstrate either that the Cessna 404 is wrongly classified or that performance group C is wrongly or confusingly worded. It was suggested also that an

assessment should be made of the feasibility of installing a feathering device into aircraft of this type but I do not consider the evidence available to warrant the view that any sufficiently reliable system could be devised for such an aircraft to justify the undertaking of such an investigation. It was suggested that the CAA should review the content of its base proficiency test for pilots in order to cover or maintain a check on such aspects of proficiency as loading the aeroplane, assessing its weight, flying it when at or near its maximum permissible weight and detecting correctly the direction of sources of external noise. In my view of the evidence however, the commander here correctly ascribed the "thud or bang" to his right hand engine and no deficiencies in the loading or weight of the aircraft contributed directly to the occurrence of the accident. While it is true that the fully-laden state of the aircraft placed the commander in an extreme situation for his handling of the emergency which arose for other reasons it was not itself a direct cause of the accident and Captain Easson had shown himself to be generally competent at handling the aircraft in his base proficiency test only a few days earlier. I do not see that enhanced training or testing of proficiency in flying the aircraft at or near its maximum permissible weight would have made a material difference to the outcome of the event on 3 September 1999. It was further suggested that the issue or renewal of a certificate of airworthiness for the aircraft should be accompanied by an engine check in accordance with TCM Service Bulletin CSB94-4, should see to the proper completion of a weight and balance schedule and should not be conducted by an owner-operator of the aircraft who is not on the CAA's approved list. The last two of these stipulations however relate to matters which played no part in causing the accident which is the subject of this inquiry and the need for the first is in my view superseded (so far as the causes of this accident are concerned) by the AAIB's first recommendation (Recommendation 2000-12) regarding repetitive inspections of starter adapter shaftgears and crankshaft gears every 200 hours to which effect was given by the AAD issued in June 2000.

Recommendations made

The recommendations which I think it appropriate to make in light of the evidence heard at the inquiry and my interpretation of it are five in number and are set out in an Appendix of Recommendations attached below. They do not all have the status of full-blown recommendations, one at least being couched more as a suggestion than a recommendation.

The first recommendation in the appendix is an extension of the AAIB's first recommendation (Recommendation 2000-12). That important recommendation of the AAIB is reiterated, chiefly because the Crown submitted sensibly that I should reinforce it, but it seems to me that something more could usefully be done to improve knowledge and further reduce the risk of any recurrence of the event which precipitated the emergency in the present case. The relationship between the defective condition of the torsional viscous damper and the damage to the starter adapter shaftgear teeth (or the crankshaft gear teeth) has not yet been fully understood or established as a matter of certainty: the findings both of the AAIB and of this inquiry on that matter remain in the realm of probability. The period from the fitting of the repaired starter adapter with new modified shaftgear but probably already defective torsional viscous damper until the breakdown of the accessory gear train was a mere 255 hours. It is not known precisely why it was so short nor whether in certain circumstances such a period

could have been even shorter. There was not at this inquiry evidence sufficient to demonstrate that any misfitting by Yorkshire Light Engineering of the torsional viscous damper on to the new shaftgear contributed to the brevity of the new shaftgear's life. At one point there was a suggestion that the period between mandatory inspections of the starter adapter and crankshaft gears should be only 100 hours but it appears that a 200-hour interval was in the end deemed sufficient even although knowledge was not complete as to the mechanisms which had given rise to a failure after 255 hours. There must therefore remain in our present state of knowledge some risk, as yet unquantified, that gear failure could occur within a period of 200 hours from the last inspection. In that state of affairs two further steps suggest themselves which strike me as sensible and not likely to cause undue expense or inconvenience, namely (first) that the result of each 200-hour inspection could and should be reported to the CAA for them to make some assessment of that risk and if necessary amend their AAD; and (secondly) that the torsional viscous dampers of any failed starter adapters should be sent to them for inspection rather than immediately discarded or otherwise disposed of. I have therefore expanded the AAIB's first recommendation to encompass these matters.

The second recommendation in the appendix is an extension to all commercial passenger-carrying aircraft of the AAIB's second recommendation (Recommendation 2001-38) which was in approximately similar terms but confined to such aircraft certified to carry more than nine passengers, which did not include this Cessna 404. Strictly speaking therefore the AAIB's recommendation would not apply to the aircraft G-ILGW involved in this accident and so would do nothing even if fully implemented to enhance understanding of an accident involving a similar aircraft were one to occur. The reason for the AAIB so restricting their recommendation did not seem to me satisfactory and this view was I think shared by the Crown and counsel who appeared for the families of the deceased and the injured passengers. That reason seemed to be based upon an idea that the prospect of having the recommendation implemented would be improved if it were confined to suggesting the extension to piston-driven aircraft of a requirement already applied to a category of turbine-driven aircraft of a particular specified capacity (namely those certified to carry more than nine passengers). The desirability of having at least a cockpit voice recorder in all commercial passenger-carrying aircraft appeared however not to be in doubt and the reasons for not doing so in an aircraft of this type thus far relate apparently to considerations of weight, space and protection and presumably therefore cost. Nevertheless it is highly probable, indeed almost certain, that we would all have known immeasurably more about this accident and the reasons for it had there been a cockpit voice recorder on board G-ILGW on 3 September 1999. This was fully acknowledged by Mr Whidborne in evidence and by the AAIB in their report and I can think myself of at least four crucial areas in which my own understanding of the whole event would have been greatly enhanced by knowledge of what went on in the cockpit during the short period when the vital decisions were being made. In the first place we might well have known whether the commander thought he knew which of his two engines was failing or whether he remained in doubt on this crucial matter until the end. If he had convinced himself that the right hand engine was the one at fault (whether reasonably on the data available to him or not) that might explain his adherence to the intention expressed by radio message to return to the airport. We might also have discovered whether he had information available to him bearing upon the decision which engine to close down of which we remain unaware. In the second place we would know what communings passed between the two pilots about the emergency and what part if any Mr Henderson played in the decisions which were made or whether alternatively there was little or no communication between them implying that Captain Easson left the second pilot out of

the process and did everything himself. In the third place we might know what use if any was made or attempted to be made of instruments (such as the RPM, fuel flow and manifold pressure indicators) which might have given an indication of how the two engines were performing relative to one another. In the fourth place we might well have known whether the commander did indeed at any stage contemplate any course other than a return as soon as possible to the airport (such as a forced landing in fields to the north of Linwood). So great in other words would have been the enhancement of our understanding of the accident from a cockpit voice recorder (it is less clear that a flight data recorder would in this instance have added greatly to our knowledge) that it seems unduly short-sighted to accept that the reasons for any future accident to a similar aircraft in passenger service may remain shrouded in obscurity without even addressing the feasibility of installing a cockpit voice recorder in future.

The third recommendation in the appendix is an adoption of the AAIB's third recommendation (Recommendation 2001-40) on seat standards to enhance survivability. I have endorsed it in order to reinforce it, as suggested by the Crown. From the evidence at the inquiry I understood it to have been already taken up by the CAA with an expectation that a report of the study referred to would become available in March 2002. It is to be hoped that appropriate action will thereafter follow on the report in accordance with the recommendation.

The fourth recommendation in the appendix is derived from suggestions made in closing submissions by the Crown and by those counsel who appeared for the families and survivors and for Airtours plc. In my opinion it is justified by the evidence heard at the inquiry bearing upon the causes of the accident and the deaths as I have interpreted that evidence. As indicated in earlier sections of this note I consider that the commander for all his experience became confused in the stressful situation which existed and the short time available by the occurrence of a progressive engine failure together with other conflicting signs as to which engine was the true source of the power loss which he was experiencing; in addition he was predisposed by all his training and experience in multi-engined aircraft to adhere to his initial plan to execute a 180 degree turn in order to return to the airfield and probably did not contemplate the alternative possibility of electing for a controlled forced landing even although it remained unclear when he commenced that manoeuvre which was the failing engine. It would be beneficial for the profile of these difficulties to be heightened in the training of those who pilot multi-engined aircraft so that there may be better understanding of how to deal with them on the rare occasions when they arise and in order to prevent or curtail the development of a fixed attitude or "mindset" whereby the first and usually preferred option (of a return on one engine to the airfield) may come to be viewed as the only available or only realistic course of action. It was suggested that a means of highlighting these matters might exist through the GASIL (General Aviation Safety Information Leaflet) quarterly bulletin or as part of the base proficiency test but that, as it appears to me, is really the very least that might be done and I am inclined to think that the CAA should apply their minds to devising some more effective method of incorporating them into the training programmes which exist for those who pilot multi-engined aircraft. It was suggested that scope might exist for the teaching of airmanship in such situations (power loss attended with doubt as to the source when flying at low levels) by the use of flight simulators and some consideration should in my view be given to that possibility: I appreciate that simulators specific to the Cessna 404 aircraft type are not readily available outside the USA but it is not

clear to me that such teaching would necessarily have to be done only on such a particular simulator and scope might exist for using simulators of multi-engined aircraft types more generally.

I have wondered whether something should be said in connection with training about use and interpretation of cockpit instruments and also, more widely, about instrument design and whether clearer instrumentation should be called for from aircraft manufacturers than that which appears to have existed in this Cessna 404. Both engines, for instance, shared the RPM and other dials in the cockpit on this aircraft, with two needles on the same dial bearing small identifying letters. Mr Whidborne in evidence agreed that instruments are one source among others which could assist in determining which engine is failing but expressed the view that on this aircraft a close look and some considered study would be required in order to assess from the instruments which engine was not performing correctly. That might be thought to be less than fully satisfactory but I appreciate that, as was pointed out earlier in evidence, there is limited space in an aircraft of this size for fuller cockpit instrumentation or any redesign thereof. In any event there is in the available evidence at the inquiry and in the absence of a cockpit voice recorder nothing to show what part if any reference to the cockpit instruments played in the commander's decision-making as to how to deal with the emergency with which he was faced. In that situation it is in my opinion inappropriate for me to embark on recommendations concerning cockpit instrumentation and I refrain from doing so on the view that there is in the inquiry insufficient evidence to form a proper basis for any such recommendation.

The fifth suggestion in the appendix I have refrained from according the status of a full recommendation since the evidence on which it proceeds consisted only of a number of things said to the inquiry by Mr R D G Carter, a senior inspector with the AAIB, chiefly in answer to questions by counsel for the families and survivors about an informal study of vibration effects in piston-driven aircraft engines on which he had embarked with a student and proceeded with for a limited period before coming to the view that in order to produce statistically meaningful results a much larger and more detailed study would be required which was beyond the resources then available to him. That evidence was in my view somewhat sketchy and the matter was not fully explored but enough was said for it to be clear that the study if pursued on a formal basis with performance of an appropriate statistical analysis would be likely to produce useful results for the understanding and containment of such vibration effects in such engines. Counsel for the families and survivors wished me to recommend positively that Mr Carter's study be resumed in order to produce a statistically meaningful result as to the reliability of the GTSIO engine but I do not consider the evidence to go far enough to warrant more than a suggestion that the CAA should look into and consider the possible resumption of such a study on a formal basis.

Summary of main conclusions

From the available evidence I find the most probable course of events leading to the accident and resultant deaths to have been the following.

At or about the time of take-off and initial climb a progressive breakdown commenced of the accessory gear train in the left hand engine when a gear tooth sheared off the starter adapter shaftgear. This was due probably to a failure over some time previously of the torsional viscous damper to perform adequately its function of dampening down or absorbing vibration in the engine on account of its own internal condition which was not readily examinable but had become defective in that the silicone fluid within it had become contaminated with metallic particles and so had lost its viscosity.

Contemporaneously, when the aircraft had attained a height of some 200 feet above the runway during its initial climb, a noise was heard (described as a "thud" or "bang") by the commander and others which emanated from the right hand engine. This was due probably to the presence of "swarf" causing a backfire in that engine which had been recently remanufactured and was still within its fifty-hour probationary period.

The commander experienced a loss of power and realised correctly that an emergency had arisen. The aircraft was climbing less rapidly than it should normally even when fully laden (as it was) and there was insufficient runway remaining to abort the take-off and land again on the runway. He had become suspicious of the reliability of his new right hand engine because of the noise he had heard from it. He experienced no pronounced yaw to the left because the nature of the breakdown in the left hand engine was progressive and gradual and also spasmodic. The aircraft was however moving leftwards in accordance with its normal idiosyncratic tendency to sideslip to the left after take-off. The commander although suspicious of one engine was unable to form a clear idea of which engine was the true source of the power loss. He broadcast a radio message indicating the occurrence of an emergency and an intention to return to the airfield.

The aircraft was now over the A737 road or just to the south of it. It continued to lose power and increasingly to climb less rapidly than it should or indeed to ascend at all. There is no evidence to indicate what if anything the commander deduced from his cockpit instruments as to which engine was the source of the power loss nor to indicate what discussion or communings if any took place between the commander and the second pilot. The commander decided to adhere to his original intention to return to the airfield and did not consider (or may have decided against) the possibility of a gradual descent to a forced landing in fields ahead to the north of Linwood. This was as it turned out a misjudgement, albeit made under great stress of low height in a fully-laden aircraft in a necessarily very limited period of time, which was born of the commander's predisposition from his training and experience to resolve such an emergency by closing down the malfunctioning engine and proceeding to an airport on the remaining engine. Clearly a landing back at the airfield on a runway would be safer for all than any forced landing if it could be achieved but for its achievement it was necessary to know which of the two engines was failing in order to close it down and feather its propeller. This the commander did not know with any degree of assurance but his mind was set in the direction of achieving if at all possible a return to the airfield from which he had just taken off.

The commander commenced a right hand turn necessary to return to the airfield, but on diminishing power since the left hand propeller was now "windmilling", and closed down the

engine which seemed to him most likely to be the faulty one, namely the right hand engine, and feathered its propeller. This was a mistake because the right hand engine was in fact the remaining good one and in consequence all power and control were lost. The mistake was due to the commander's inability to discern which engine was failing on account of conflicting signals by which he became confused in the extremely difficult and stressful circumstances which beset him. On the one hand he had a positive indication although not a strong one of something abnormal in his new right hand engine still within its probationary period. On the other hand he had, unusually, no clear indication that the left hand engine was the failing one on account of the nature of its progressive and spasmodic malfunction and because any slight yaw that may have been occurring was masked by the aircraft's tendency, peculiar to it but known to him, to slideslip leftwards after take-off. This difficulty was and remained with the commander from the start of the emergency and was never resolved until it was too late. As luck or fate would have it these unclear signals coincided with one another on 3 September 1999 by the combination of the new engine on one side and a relatively unusual progressive breakdown on the other. They occurred coincidentally at an early and critical stage in the flight and the commander, flying a fully-laden aircraft at low height, was despite all his experience overwhelmed by the combination of circumstances and the stress of the situation. I find it difficult to be sure or even to think it likely that any other commander would not have been similarly overwhelmed.

Once power and control were lost the aircraft descended rapidly to the ground and crashed in a field containing a stiff hedge and a slight embankment. Although the commander managed to achieve a nearly level attitude of the aircraft when it reached the ground after its steep descent, the speed of the impact was high and the seating within the cabin became detached or lost integrity so that eight of the eleven occupants died immediately or almost immediately as a result of injuries received at impact or a fire which rapidly broke out or a combination of the two. The seating and its attachments could have been more robust had upgraded standards required of later aircraft been applied retrospectively to aircraft of earlier design or manufacture such as the Cessna 404 G-ILGW. Such retrospective application is not however easy to achieve and it is not possible to say whether higher seat standards would in the circumstances of this accident have resulted in more survivors and if so with what injuries.

The aircraft G-ILGW itself was, apart from the defects which gave rise to the left hand engine failure, well maintained and even those defects were not such as could be readily discerned by those charged with its routine maintenance. A tighter regime of inspection has in consequence of this accident since been introduced by the CAA.

The commander (Captain Easson) was highly experienced and fully trained in accordance with the standards then prevailing. Despite this he was as stated above overwhelmed by the combination of circumstances with which he was faced and was unable to decide correctly in the time available which engine should be closed down and its propeller feathered. He was predisposed by his training to prefer a return to the airfield to any forced landing and seems in this state of mind not to have contemplated the latter despite having no clear basis for deciding which engine was at fault. Although a forced landing, even when elected for and controlled, must be inherently less safe than most landings at an airfield it would have avoided the need to choose in a state of doubt between the engines and might well on this

occasion have produced a more favourable outcome for the passengers (albeit not for the aircraft itself) but to what extent is impossible to say.

The Cessna 404 aircraft was not incorrectly classified by the CAA within their Performance Group C of the Transport Category (Passenger). Had the commander on 3 September 1999 succeeded in correctly identifying and promptly closing down the failing left hand engine and feathering its propeller he would in all probability have succeeded also in maintaining flight to return to the airfield on the remaining right hand engine.

Statutory requirements: Fatal Accidents & Sudden Deaths Inquiry (Scotland) Act 1976 section 6(1)

The place and time of the deaths and accident were readily determined and are set out under paragraph (a) at the outset of my determination above.

Under paragraph (b) I have set out the causes of the accident as briefly as possible. They are discussed at length in this note and I have summarised them with as little use of technical language as possible in the preceding section immediately above.

I have found under paragraph (c) that there were no reasonable precautions whereby the deaths and the accident giving rise to them might have been avoided. There are precautions which with hindsight might have avoided the accident and some or all of the deaths and it is worth noting in this connection that the statutory phrase in section 6(1)(c) is "might have been avoided". Such precautions include on the view which I take of the evidence the repetitive inspections of starter adapter and crankshaft gears in GTSIO-520 series engines which were made mandatory by means of an Additional Airworthiness Directive (AAD) of the CAA in June 2000; the training of pilots to consider a controlled forced landing as a realistic option when faced with engine failure even in a multi-engined aircraft; and the "retrofitting" into existing aircraft of some more stringent seat standards which might flow from the CAA study which was due to be reported in March 2002. In light of the experience of this accident these could be regarded as reasonable precautions now to be taken in order to avoid or minimise the prospect of any recurrence of a similar accident but I do not think they can be viewed as reasonable precautions which could have been thought of and taken in advance of this accident which occurred in consequence of such an unusual combination of circumstances.

Under paragraph (d) I have taken the view that there were no such defects in any "system of working". It does not seem to me that either the accident or the resultant deaths were bound up at all with any "system of working" in the traditional sense such as used to be associated with the performance of a job in a factory or on a construction site or down a mine; nor does it seem to me that either Captain Easson or anyone else on the aeroplane or associated with its maintenance can properly be thought of as having been doing anything in accordance with a "system" in any reasonable wider sense which had an effect in bringing about the accident or the deaths.

Under paragraph (e) I have sought to draw special attention to some of the more important elements in this most unfortunate event which are discussed in detail and at length in this note.

BAK

APPENDIX OF RECOMMENDATIONS

Starter adapter and crankshaft gears

Recommendation 2000-12 of the AAIB is here reiterated (requiring inspection of the starter adapter and crankshaft gears in GTSIO-520 series engines every 200 hours): made on 11 February 2000 and implemented by an AAD of the CAA in June 2000.

It is recommended in addition that the CAA should consider requiring that for a suitable period of time (whose duration they should determine) the result of each 200-hour inspection of the starter adapter and crankshaft gears in GTSIO-520 series engines (carried out under Critical Service Bulletin CSB94-4D or any subsequent edition thereof) should be reported to them, whether or not there has been any significant finding, in order to enable an assessment to be made of the still unquantified risk of gear failure occurring within a period of 200 hours from the last inspection; and that if necessary the 200-hour mandatory inspection requirement should then be reviewed and adjusted.

It is recommended further that the CAA should consider requiring that the torsional viscous damper of any starter adapter which is failed in course of routine maintenance on a GTSIO-520 series engine should be sent to the CAA for inspection by them or on their behalf with a view to establishing more clearly and so better understanding the nature of any connection between the condition of the torsional viscous damper and damage to gear teeth.

Carriage of flight recorders

It is recommended that the CAA should in conjunction with the JAA consider undertaking a study of the feasibility for the future of requiring the carriage by all commercial passenger-carrying aircraft of a flight data recorder and a cockpit voice recorder or at least of the latter.

Seat and seatbelt standards

Recommendation 2001-40 of the AAIB is here reiterated (to the effect that a study should be undertaken by the CAA of current seat standards which might be applied by "retrofit" to existing aircraft or those coming into service of existing design).

Pilot training

It is recommended that the CAA should in conjunction with the JAA conduct a review of the content of pilot training programmes bearing on those aspects of airmanship in piloting multi-engined aircraft which relate to the handling of an apparent loss of power where doubt exists as to its source, especially at low levels when climbing after take-off, and covering in particular the following areas, namely (i) understanding of and reactions to a progressive engine failure; (ii) the application of techniques to detect accurately which engine is the failing engine; (iii) awareness and consideration of the possibility of electing to undertake a forced landing as an option alternative where doubt persists as to the true source of a power loss to the standard course of closing down the faulty engine and returning to the airfield on the power of the remaining engine(s). It will be for the CAA to consider whether these matters can be sufficiently taught and emphasised through the GASIL quarterly bulletin or as part of the base proficiency test or whether, alternatively and preferably, some more effective means of incorporating them into training programmes should be devised and required (including consideration of the possible scope for teaching of airmanship in such situations by the use of simulators).

Vibration in piston-driven aircraft engines

It is suggested that the CAA might usefully consider whether a resumption could be undertaken on a formal basis of the study commenced informally by Mr Carter of the AAIB (using initially the CAA's mandatory occurrence reporting (MOR) database but later curtailed) of vibration in piston-driven aircraft engines in order to compare the GTSIO engine with others in this respect, with a view to ascertaining more fully the effects of vibration on such engines and improving methods of containing or minimising those effects. Such a study if resumed should include identification of similar usage profiles and performance of an appropriate statistical analysis.