ACCIDENT

Aircraft Type and Registration:	Yak-52, G-LENA
No & Type of Engines:	1 Vedeneyev M-14P piston engine
Year of Manufacture:	1983
Date & Time (UTC):	22 July 2006 at 1846 hrs
Location:	Bournemouth Airport, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed, with post crash fire
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	2,500 hours (of which 34 were on type) Last 90 days - 8 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

Following a pleasure flight in the local area, the aircraft made an approach and a high-speed, low-level pass adjacent to the runway threshold, in front of a group of onlookers. Witnesses saw the aircraft pitch up to an attitude of 30º to 40º and climb to a height of around 200 ft, before starting a climbing roll to the right. The roll continued, the aircraft became inverted and entered a near-vertical rolling dive from which it did not recover. It impacted the ground and caught fire. The impact was not survivable and both the pilot and his passenger received fatal injuries.

Examination of the wreckage failed to reveal any malfunction of the aircraft. It was, however, established that the passenger, occupying the rear seat, only used the lap strap elements of his seven-point harness. The reason for the pilot losing control of the aircraft could not be positively established. It was possible however, for the rear seat crotch strap buckle to have become trapped in the flight controls in such a manner as to prevent the pilot from applying corrective left roll control inputs.

Background to the flight

The flight had been arranged by friends of the passenger, who held a National Private Pilot's Licence (NPPL), as part of his 60th birthday celebrations. They had contacted the pilot of G-LENA, knowing him to be a co-owner of the aircraft, and had asked him to take the passenger for a flight from Bournemouth Airport.

Although they offered to cover some of the costs of the flight, the pilot declined any contribution. The pilot and passenger had not previously flown together, but were acquainted.

On the day of the accident, a licensed engineer travelled to Compton Abbas Airfield, where the aircraft was normally based, to carry out a 50 hour check on G-LENA. Members of the syndicate which owned the aircraft assisted with the check and also attempted to resolve a defect affecting the intercom system. They removed, inspected, and re-soldered headset sockets in the cockpit.

The work proceeded without difficulty and, when it was complete, a ground run was carried out which showed the engine to be operating normally. Subsequently, an inspection was carried out to ensure that no oil leaks were present. Two syndicate members then flew the aircraft on a short local flight which, reportedly, did not include aerobatics.

When the pilot arrived at Compton Abbas, he met other members of the syndicate and discussed the weather and his planned flight to Bournemouth. He prepared the aircraft for flight, replacing the parachutes with cushions and, in due course, boarded G-LENA. He carried out his pre-flight checks and took off for Bournemouth. The aircraft landed without incident, taxied to a parking position outside a flying club and shut down.

Here, the passenger and a large number of his friends and family had gathered, both in the club house and on its patio. This overlooked the threshold of Runway 26 and the area to the south and west - the area in which the aircraft later impacted the ground.

In due course, the pilot and passenger met and discussed the intended flight at some length. Witnesses recalled that the discussions centred on the passenger's desire for a pleasurable flight around the local area and that he did not wish to experience aerobatics.

History of the flight

Before boarding the aircraft, the pilot gave his passenger a safety briefing. The pilot then occupied the front cockpit, his passenger the rear, and photographs taken at the time show both wearing their shoulder harnesses as they sat in the aircraft. The pilot attempted to start the engine but the pressure in the on-board air reservoir, required to operate the starter motor, became depleted before the engine became self-sustaining. The pilot and passenger disembarked and the pilot flew, in another aircraft, to Compton Abbas, where a compressed air cylinder was obtained. He then returned to Bournemouth and re-boarded G-LENA with his passenger.

A friend of the passenger assisted him into the aircraft and noticed that he did not secure the shoulder straps of the seven-point harness. He offered him assistance, but the passenger declined, stating that he would not require the shoulder straps. It was not established whether the pilot was aware that his passenger was wearing only the lap strap element of the harness; it was established during the investigation that the crotch strap was also unsecured. The engine was started using air from the external compressed air cylinder.

The aircraft taxied out and took off from Runway 26. The takeoff appeared normal until the aircraft became airborne, when it was seen to remain very low over the runway whilst accelerating. The landing gear was seen to retract and the aircraft entered a 'zoom climb' before departing to the south-west.

It was not established what happened from the time the

aircraft departed to the south-west until it approached the airfield from the south-east. At 1844 hrs the pilot called Bournemouth Tower. He reported in the circuit on left base leg and requested "A LOW APPROACH AND GO AROUND AND THEN JOIN DOWNWIND RIGHT TO LAND". He was instructed to report on final approach and, in due course, when the controller observed the aircraft on approach, he cleared it for a low approach and go-around. These transmissions between the aircraft and ATC all appeared normal.

Witnesses at various locations on the airport observed the aircraft's approach. Some recalled a 'puff of smoke' during the latter stage of its approach, co-incident with a change in the engine note, which suggested to many an increase in engine power. Some witnesses commented that part of the approach was flown level, a few hundred feet above the surface, and that the aircraft then dived towards the Runway 26 threshold area, gaining speed. Witnesses agreed that the engine note, from the power change on the final approach until the accident, was constant and indicative of a high power setting. The final part of the approach to the airfield was seen by witnesses to have been flown towards an area between the runway threshold and the flying club.

Witnesses saw the aircraft pitch up and enter a 'zooming climb'; a pitch attitude of 30º to 40º nose up was typically recalled. After reaching a height of approximately 100 ft to 200 ft, the aircraft began to roll to the right[1]. Some witnesses described this as appearing to be possibly an entry to a barrel roll, and all agreed that the aircraft appeared to be under control as the roll began. A witness on the south side of the airport considered it possible that the pilot intended to climb out with the aircraft inverted. However, once the aircraft had reached the inverted position, witnesses described seeing the nose pitch towards the ground and realised that something was wrong. Some recalled a noticeable yaw just before the pitching began, and one stated that this was "as though full rudder had been applied". Another witness, an experienced flying instructor who taught aerobatics, recalled that, as the aircraft began to roll, the airspeed seemed to be decrease noticeably and that, by the time it had rolled through 90º, the aircraft's attitude "was not appropriate for a barrel roll". The aircraft continued to roll and pitch rapidly until it struck the ground.

At 1845 hrs, there was a very brief transmission from the aircraft, in a voice recognisable to be that of the pilot, the nature of which indicated that he realised the aircraft was in grave danger.

The aircraft impacted the ground in a steep nose-down attitude, at relatively high speed. A severe fire broke out immediately and members of the Aerodrome Fire and Rescue Service, who had observed the accident from their facility, deployed and arrived on scene very promptly and extinguished the fire. The severe nature of the impact meant that this was not a survivable accident.

Weather

A special meteorological observation immediately after the accident stated that the wind was 250º/9 kt, visibility 10 km or more with no cloud below 5,000 ft and no cumulonimbus. The temperature was 21ºC, dewpoint 15ºC and the QNH (mean sea level pressure) was 1016 hPa.

The pilot

The pilot had received conversion training on the Yak-52 in Ukraine in 1992, including training in aerobatics and

Footnote

[1] Some witnesses recalled the aircraft rolling to the left but analysis of the available evidence suggests that the roll was to the right. The Yak-52 rolls more rapidly to the right than left, and right is thus the preferred direction for a rolling manoeuvre.

formation flying. This training had included eight hours dual flying and 35 minutes solo time. He did not, however, fly a Yak-52 again until 2004 after purchasing a share in G-LENA, when he received a one hour dual familiarisation training flight before flying the aircraft solo.

Another member of the group which owned G-LENA, who was a former military fast-jet pilot and instructor, carried out a 'spin and aerobatics' check with the pilot in October 2005, and a currency check in January 2006. The flights included erect and inverted normal spins, erect flat spins to the right, loops, barrel rolls and stall turns to the right. He stated that neither flight gave him any cause for concern and that all manoeuvres were flown "perfectly competently, but without much flair". He described the pilot as "competent but slightly lacking in confidence" and, when discussing the circumstances of the accident, stated that he felt that "it would be very out of character for him to perform a low level pass, followed by a low level manoeuvre".

Another experienced military pilot and instructor, who had flown with the pilot, described him as a "solid and safe aviator". He added that he would not have expected him to fly unauthorised aerobatic manoeuvres at low level.

The chief flying instructor at G-LENA's base commented that the pilot liked to fly aerobatics "at considerable height", and that any low level aerobatic manoeuvre would have been "completely out of keeping with his character".

The passenger

The passenger held a National Private Pilots Licence (NPPL), and had 1,545 hours flying experience on single and twin-engine piston aircraft. A friend of the passenger, with whom he had flown extensively around Europe, commented that he was "a very competent and able pilot, very calm and relaxed", and that he was not likely to "want to throw an aeroplane about or anything like that". A personal friend, who had been on motorcycling and skiing holidays with the passenger, remarked that he was "a very cautious man" and "very stable and careful".

Recorded data

The aircraft was in VHF radio communication with ATC at Bournemouth, and recordings covering the period of the flight were available for the investigation.

Bournemouth Airport's radar is not recorded, and therefore no data was available to assist with the investigation. NATS, a provider of air traffic control services throughout the UK, does record radar data from its network of radar heads. However, coverage in the Bournemouth area proved to be very poor; the accident flight was not recorded.

A portable GPS receiver was on board the aircraft at the time of the accident but, despite exhaustive efforts by the AAIB, other investigative organisations and the unit's manufacturer, meaningful data was not recovered from this unit.

Two CCTV cameras captured images of the aircraft as it flew past the flying club prior to pulling up into the final manoeuvre. Analysis of these images was carried out by the National Imagery Exploitation Centre. This indicated that, before pulling up into a climb, the aircraft had flown level at a height estimated to have been about 50 ft, and that its mean ground speed at that time was 340 ±35 kph[2] (183 ± 19 kt). The aircraft's

Footnote

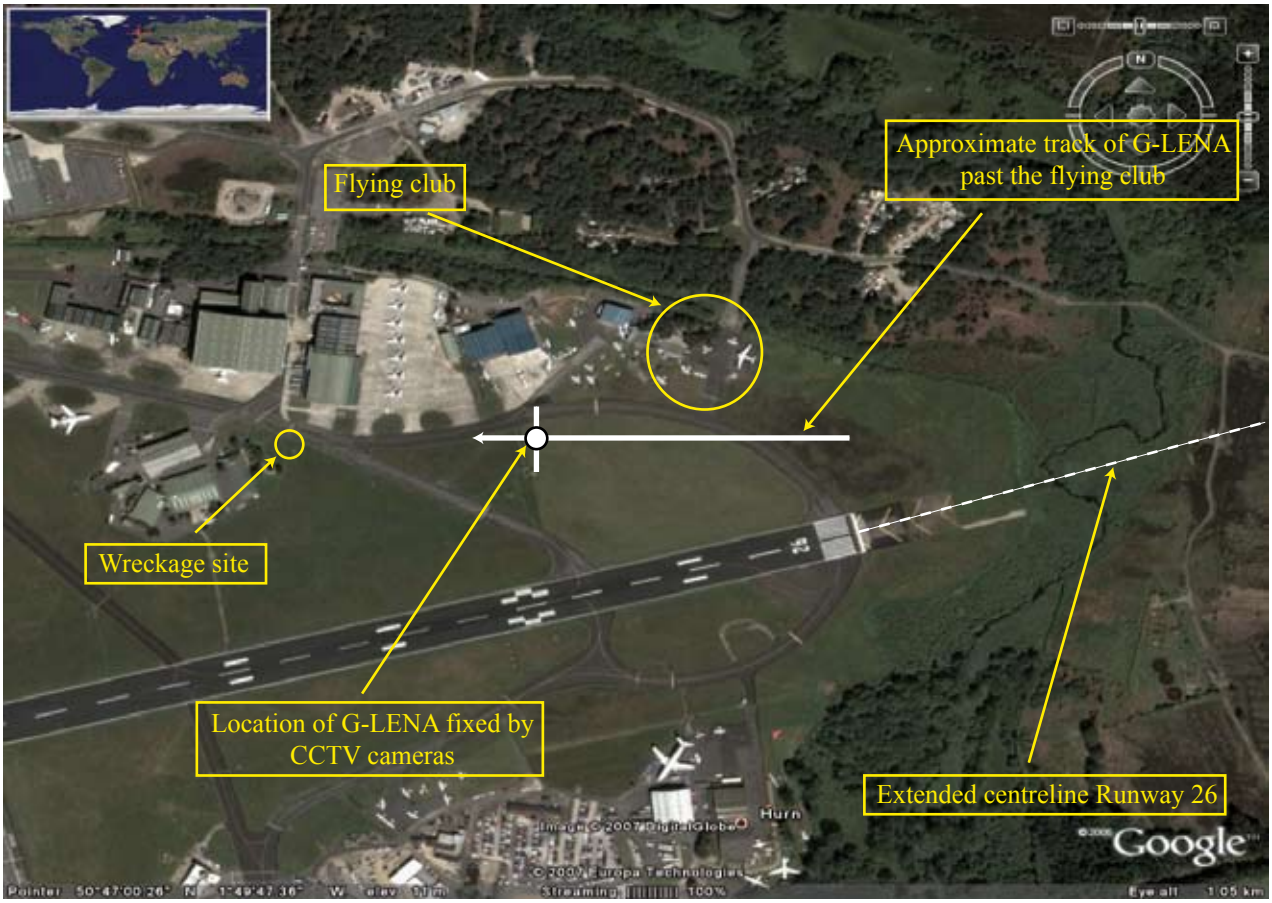
[2] The Yak-52 is typically fitted with an airspeed indicator calibrated in kph, and Yak-52 pilots commonly refer to speeds in these units.

position over the ground was determined at one point, illustrated in Figure 1, when two images from different cameras were captured at the same time; this supported witness information that the aircraft was to the north of the runway centreline as it flew past the flying club.

Relevant Yak-52 details

The aircraft is an all metal two-seat, tandem, single-engine low-wing monoplane, originally designed and manufactured as a military basic training aircraft in the Eastern bloc. Yak-52 aircraft are now relatively commonplace[3] in the UK and are often used for aerobatic flying and training. The aircraft is cleared to operate up to load factors of +7g and -5g.

The never-exceed speed (V_{NE}) of the Yak-52 is 420 kph (227 kt) and its design manoeuvring speed (V_A) is 360kph (194 kt). Its published stalling speed, with power off in 1g normal flight, is 105 kph (57 kt), and in inverted flight is 140 kph (76 kt). One highly experienced aerobatic pilot who flew G-LENA regularly, stated that the inverted power-off stalling



Google Earth™ Mapping Service/Europa Technologies

Figure 1

Diagram illustrating accident site location, Runway 26 threshold area, estimated track of G-LENA and location of the flying club in relation to the accident site

Footnote

[3] There are approximately 70 Yak-52 aircraft on the UK register. (March 2007 data)

speed of the aircraft was closer to 160 kph (86 kt). The available evidence regarding the final moments of the flight was discussed with several other experienced Yak-52 display pilots. They considered that to decelerate from the high-speed run-in to a power-on inverted stall, in a properly controlled fashion, would result in a much greater climb than the few hundred feet mentioned by witnesses.

Accident site

The wreckage of G-LENA was examined on-site both on the night of the accident and the following day. The aircraft had struck the ground on a grassed area between a taxiway and some commercial buildings, Figure 1.

The wreckage site was compact and, although the fuselage and wings were lying flat and the correct way up on the ground, it was clear that the aircraft had impacted in a very steep nose-down attitude, estimated at 80° below the horizontal. The engine, which had become detached from the fuselage in the impact, lay embedded in the ground at this attitude and it was evident that the remainder of the aircraft had rebounded slightly before falling back onto its underside. The impact occurred on a heading of 170°M and the general character of the wreckage indicated that the aircraft's speed had been moderately high and that it had not been in a spin at the time it struck the ground.

Initial wreckage examination

The complete aircraft was present at the accident site which indicated that there had been no pre-impact structural failure of the airframe. The distribution of fragments of the wooden propeller over a wide area to the north of the impact site strongly suggested that the engine had been running at high power. The landing gear and the flaps were in the retracted position at impact.

The structure between the engine and the rear of front cockpit had been completely disrupted in the impact and a severe fire had destroyed much of this region. The wings had remained attached to this damaged structure and, apart from crushing of both leading edges, they were relatively undamaged and had only been superficially affected by the post-impact fire. The rear cockpit was more intact and had been less affected by fire than the front cockpit. The fuselage aft of the rear cockpit, including the empennage, was largely undamaged either by impact forces or fire.

A small, short-handled flat-bladed screwdriver was found lying on the floor of the rear cockpit; it had been damaged in the fire and some of the plastic handle material had melted[4]. This was removed and subjected to particular scrutiny, as a previous accident to a Yak-52 (G-YAKW, 5 January 2003, AAIB Bulletin 10/2003) was caused by just such a screwdriver becoming jammed in the elevator controls at the rear of the aircraft. The aircraft crashed after a vertical manoeuvre, fatally injuring both occupants. (Following this accident, a barrier was required to be fitted behind the rear cockpit on all UK registered Yak-52 aircraft, under Mandatory Permit Directive (MPD) 2004-006, issued by the CAA in April 2004, to prevent debris travelling down the fuselage. G-LENA was fitted with such a barrier.)

It was noted that a small zipped bag, fitted in the rear cockpit, had burnt through in the fire. Members of the syndicate which owned G-LENA reported that no tools were routinely kept in the aircraft.

Footnote

[4] Such a tool is necessary to carry out the pre-flight check on the Yak-52.

Detailed examination

The wreckage of the aircraft was transported to the AAIB facility at Farnborough, where, within the limitations imposed by the disruption and fire damage associated with the front cockpit, a detailed check of the integrity of the flying controls was carried out. No evidence of disconnections was found. However, close examination of the roll control system in the wings revealed indicators consistent with the right aileron being in the trailing edge up position and the left aileron in the down position at the time of impact, ie a roll input to the right. Several of these indicators are shown in Figures 2 to 5.

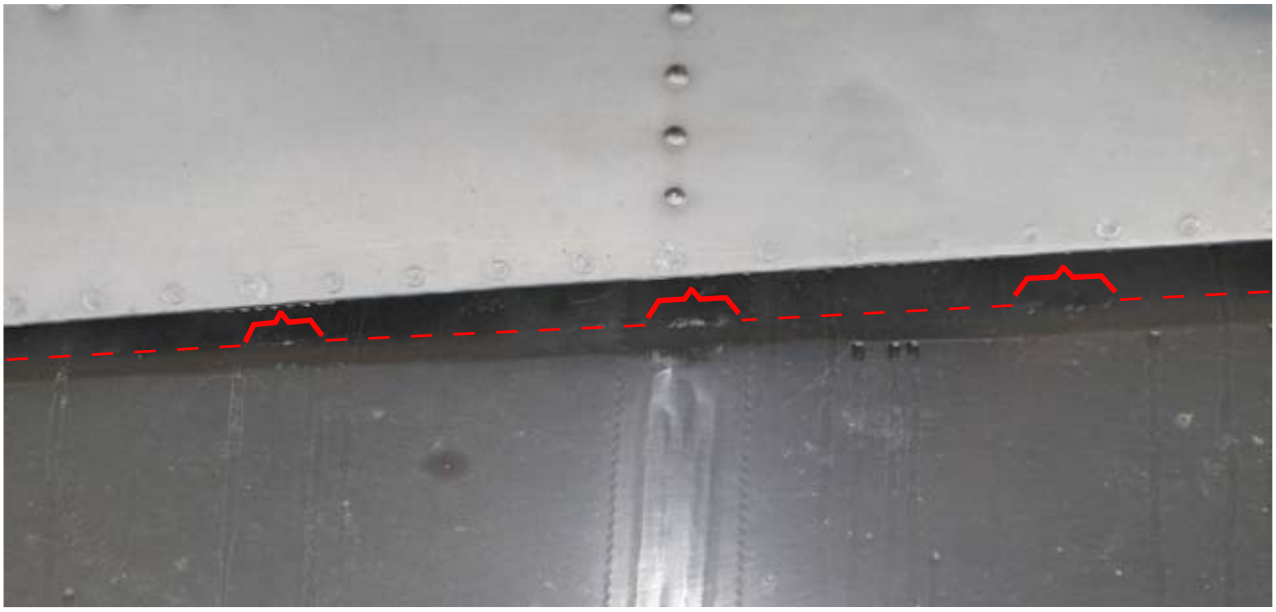


Figure 2

Witness marks on top surface of right aileron from shroud edge made when aileron trailing edge was up

Figure 3

Witness marks of right aileron inboard edge against wing structure with right aileron trailing edge up

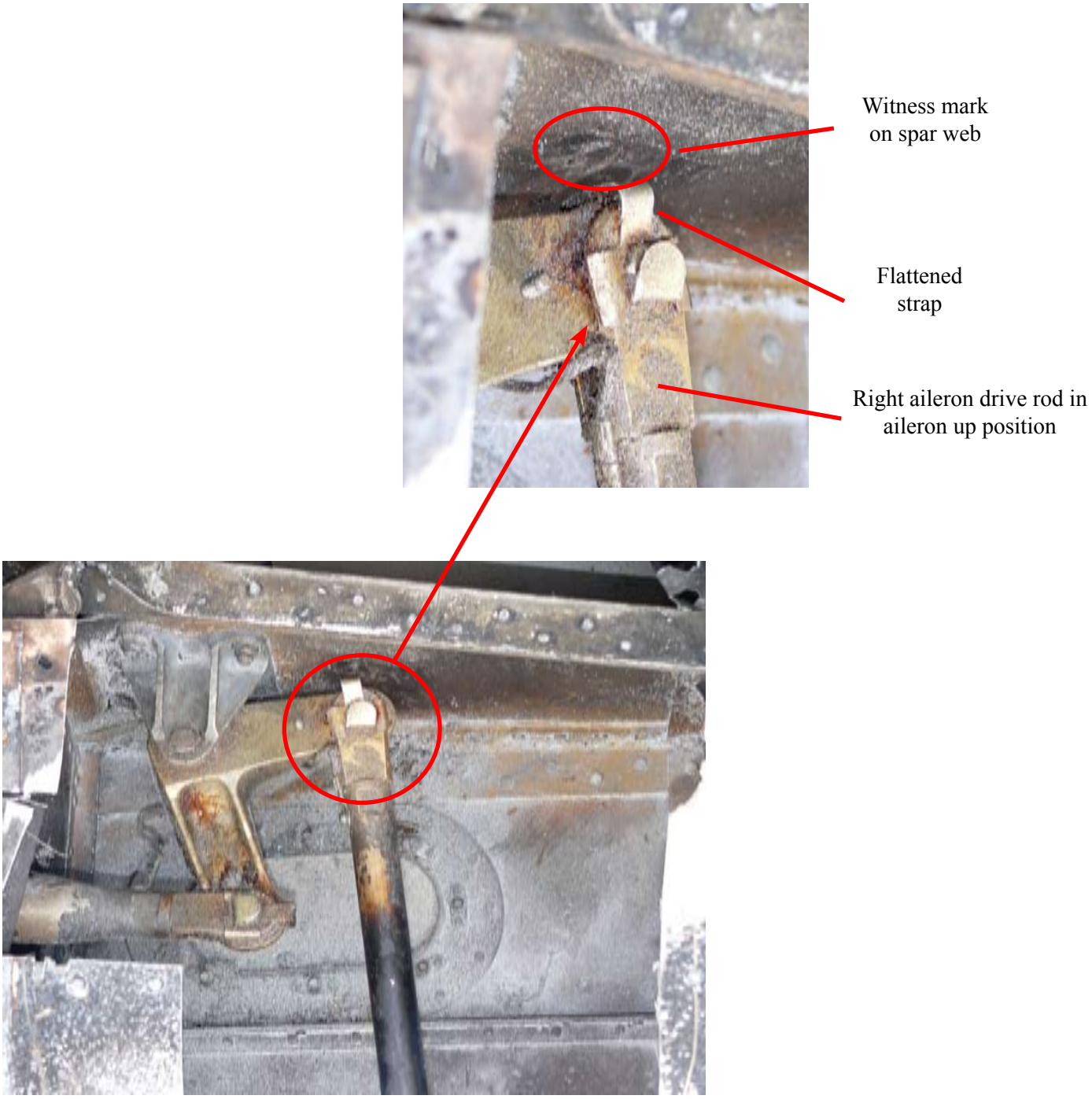


Figure 4

Right aileron drive bellcrank in aileron trailing edge up position.
Note witness marks against rear face of the wing spar and flattening of safety strap (inset picture)

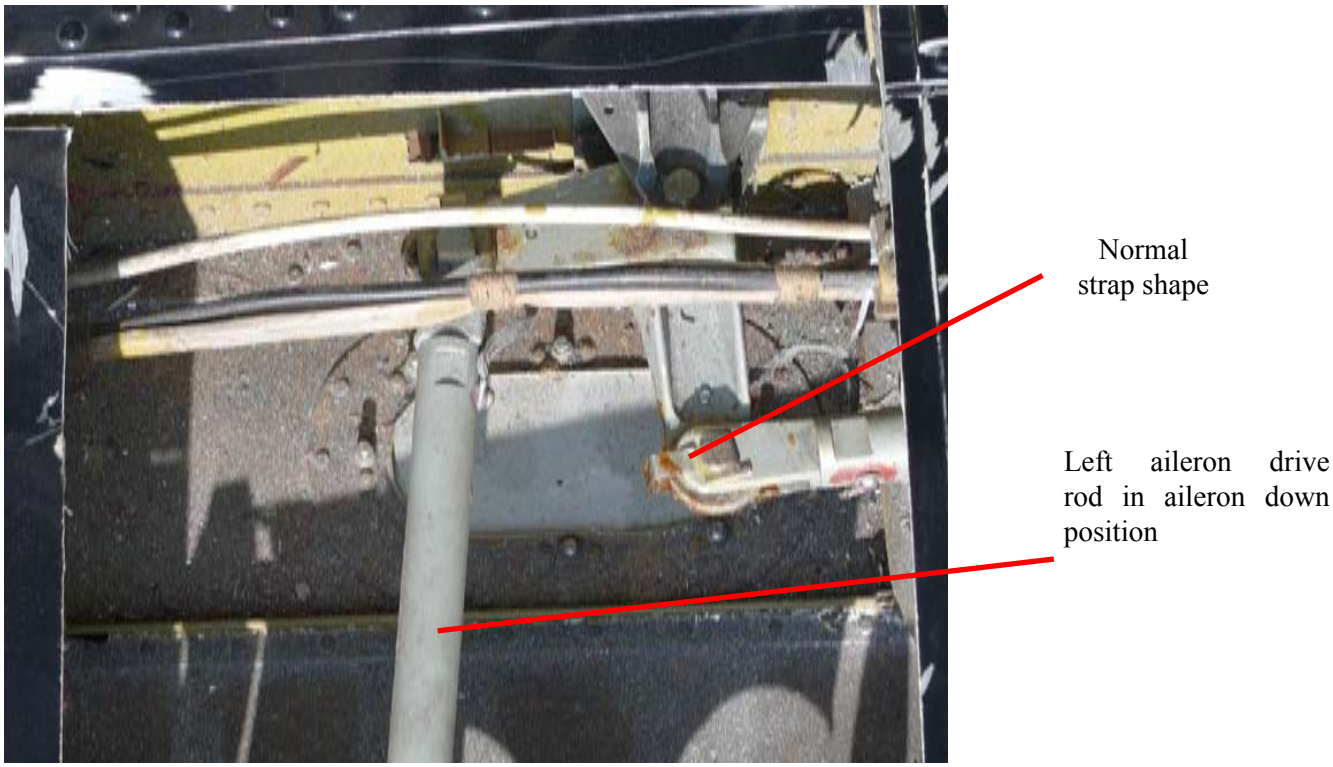


Figure 5

Left aileron drive bellcrank in aileron trailing edge down position

The aileron control linkages in the wings, shown in Figures 4 and 5, were locked in the right roll position by crush damage in the fuselage.

The screwdriver, which had been found in the rear cockpit, was examined for signs of damage consistent with interference with any of the flying control mechanisms. No identifiable mechanical damage was found, although plastic material from the aircraft had melted over part of the handle, rendering any damage in that area impossible to see.

Occupant harnesses

G-LENA was equipped with seven-point seat harnesses in both cockpits, each comprising two shoulder straps, a crotch strap and dual lap straps. When all are employed, the two shoulder straps, which have slotted metal fittings at their free ends, are inserted on to the tongues of the upper lap belt buckle. When the lap belt is fastened, the shoulder straps are secured. The single crotch strap locates similarly on the lower lap belt buckle. When all belts are assembled, the harness is adjusted to restrain the occupant securely.

Several of the harness attachment points to the aircraft's structure, in both cockpits, were found to have failed in overload; these failures were consistent with being occasioned during the impact, Figure 6.

The front cockpit harness fittings were found indicating that the lap straps and the shoulder straps were in place, Figures 7. The crotch strap had not been used.

The harness in the rear cockpit, however, was found with the two lap belts fastened, but neither the two shoulder straps nor the crotch strap had been inserted, Figure 8.

Figure 6

Example of seat belt attachment overload

Figure 7

Front cockpit upper lap strap fittings, as found, showing shoulder straps secured to the lap strap

Figure 8

Rear cockpit dual lap-strap buckles, as found

It had not been necessary for the emergency services to release the seat belts during victim recovery operation, due to the failures of the attaching structure and melting of the belt fabric.

The possibility that the unsecured shoulder straps might have fallen behind, or been positioned behind, the rear seat was considered. Had this been the case, their potential to interfere with the rudder and elevator controls was examined. The rudder control cables and elevator mechanism in this area are mounted on a fuselage frame in the lower part of the fuselage. G-LENA was fitted with an oil tank for a smoke generation system; this was located on a shelf behind the rear seat approximately level with the passenger's head. This effectively formed a barrier to the straps being placed over the top of the seat, but a gap did exist between the sides of the seat back and the fuselage skin on each side. Tests were conducted on another Yak-52, to examine the potential for the unsecured shoulder straps to enter these gaps and hang down, possibly interfering with the flight controls. The tests indicated that the straps would have to be deliberately inserted through the gaps: they would not naturally fall behind the seat. It was determined that the straps, as adjusted on G-LENA, were long enough to touch the flight control mechanisms.

Immediately forward of the tank, the shoulder straps attachment fitting to the airframe was found in place and, although the upper section of these straps had been burnt away, residual molten material remained attached to the right side of the dual fitting. In addition, the metal fittings at the ends of the two rear cockpit shoulder straps were found in the general debris recovered from the cockpits. One was attached to a relatively long section of the left strap, which had suffered fire damage at is uppermost end and the other to the lower section of the right strap, which was severely burnt. Examination of the area behind the rear seat, which had been affected to a relatively small extent by the post-crash fire, failed to reveal any evidence that the shoulder straps had been located in that area at the time of the accident.

However, further testing demonstrated that it was possible for the buckle on an unsecured crotch strap to interfere with the roll control mechanism beneath the rear seat, as a significant gap exists between the aft end of the rear cockpit floor and the seat. Here, it is possible and relatively easy for the strap buckle to become trapped between the pitch control rod[5] and fixed structure, and jam the control when either a right or left roll signal is applied, Figures 9 and 10. This jam has the potential to maintain a right or left roll input to the ailerons and prevent the input being cancelled or reversed. A gap also exists in the front cockpit, but tests showed that it would be significantly more difficult for the crotch strap to migrate to the flight control linkage area below the front seat. However, there was a potential for the strap to interfere with the controls in this area.

Detailed examination of this area in G-LENA revealed co-incident areas of damage and minor scuffing to the paint of the structural members and the pitch control rod, in the location that the strap buckle naturally adopts, should it migrate to this area, Figures 11 and 12.

A similar situation could have existed if the small screwdriver have become lodged in this area. However, the possibility that it could jam the roll system to the same extent as the buckle, was not established.

The pin which secured the top of the hinged seat back in the rear cockpit was identified in the wreckage and

Footnote

[5] The pitch control rod moves for and aft in response to pitch commands, but also laterally at its forward end as roll inputs are made.

Figure 9

View of structure beneath rear seat position of a similar aircraft to G-LENA showing controls with right roll applied

Figure 11

Crotch strap from G-LENA positioned in a similar manner to that shown in Figure 10. Paint damage was present to the upper and lower edges of the longitudinal structural member and on the upper section of the flap actuator casing. (Pitch control rod omitted)

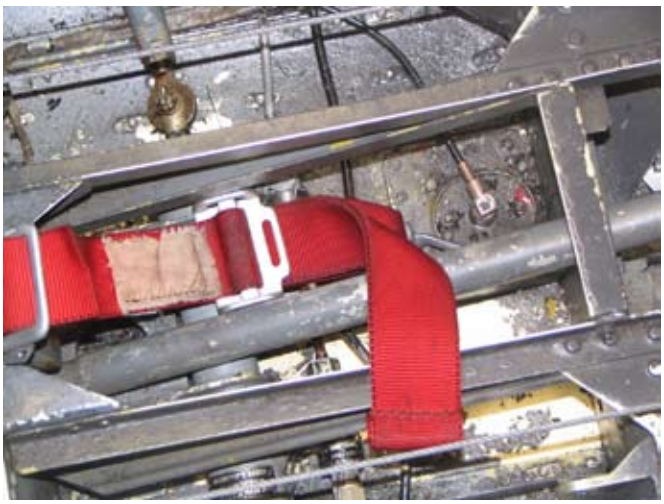


Figure 10

View showing crotch strap buckle jammed between the pitch control rod and fixed structure on a similar aircraft to G-LENA, with left roll being demanded but with the control stick positioned to the right

Figure 12

Paint damage to the pitch control rod in the area co-incident with the buckle location shown in Figure 11

witness marks showed that it was in place at the time of the accident.

Maintenance history

The aircraft's technical documentation was in order and it was noted that G-LENA had received a 50 hour check earlier on the day of the accident.

Pathology

Post-mortem examinations of the pilot and passenger were carried out by a specialist aviation pathologist. No evidence of any pre-existing medical condition in either person was identified and toxicological examination revealed no abnormalities. The cause of death was given as resulting from multiple injuries occasioned during an aircraft accident. The pathologist assessed the peak deceleration experienced by the occupants had been in excess of 200g.

Amongst 16 observations made by the pathologist when commenting upon the injuries sustained by the passenger, under the heading *'Fresh Injuries, Trunk',* three were considered to be relevant and are reproduced below:

'6. Across the front of the chest……. three well defined circular ring abrasions in a straight horizontal line……..; the central one approximately in the middle of the chest measures 110mm in diameter and each abrasion either side of this measured 80 mm in diameter. It is highly likely that these injuries originated from impact with aircraft instruments.

11. In the right quadrant of the abdomen, overlying the right costal margin, an abrasion measuring 150mm x 50 mm , oriented 10 to 4 0'clock; this possibly could have been caused by impact with the top of the control column.

13. In the right lower quadrant of the abdomen, a horizontal abrasion measuring 180mm x 20mm possibly caused by the harness lap belt.'

The location and nature of the injuries described above would be consistent with the passenger being seated normally, and with the control column positioned to demand a roll to the right, at the time of impact.

The possibility that the pilot and/or passenger had been affected by g loads during the pull-up prior to the loss of control was considered. Therefore, the pathologist was asked to comment on the possible physiological effects of positive g on the occupants. His observations are as follows:

'G induced loss of consciousness (g-loc) occurs in response to sustained levels of positive g. The loss of consciousness results from depletion of oxygen in the brain, largely due to impairment of the blood supply to the brain as a result of the effects of increased g on the circulation. Since the brain has a finite reserve of oxygen, g-loc will only occur if g is sustained; this is largely independent of the rapidity of onset of g, although whether an individual experiences visual symptoms prior to loss of consciousness can be influenced by the rate. While it is difficult to be precise about the levels and timing of g exposure in the final manoeuvre preformed by G-LENA, it would seem likely that the initial pull-up to a pitch angle of 30-40 degrees would not have lasted for more than a few seconds. Even if the maximum g-level to which the aircraft is stressed, +7g, had been attained in this manoeuvre, that level of g would need to be sustained for approximately 5-6 seconds to produce the potential for incapacitation. It

seems highly likely that the peak level of g sustained during the pull-up manoeuvre would have been significantly less than 7, and also that it would have been sustained for considerably less time than 5 seconds. In summary, it is felt that although the possibility of incapacitation due to positive g cannot entirely be excluded, it is highly unlikely to have been a causative or contributory factor in the accident.'

Additional information

The CAA publishes a series of Safety Sense Leaflets (SSLs), one of which, Leaflet 23, is entitled *'Pilots – it's YOUR decision'*. One paragraph of this highlights the problem of the temptation which may be felt by pilots to fly in a manner to impress passengers or bystanders. Part of the paragraph states:

'Audiences: are you impressing anyone?

In the review of fatal accidents, more than half of the low flying and aerobatic accidents involved an 'audience' – seldom at a formal air show, but more often to impress friends on the ground, at the clubhouse, or even passengers taken for a flight..'

The text from the SSL mentions *'the review of fatal accidents'* and this is a reference to the CAA *'Review of General Aviation Fatal Accidents 1985-94'*, published as CAP 667.

The SSL 23 paragraph referred to specifically relates to handling and judgement issues. However, the margins for error are considerably reduced with very little time available to the pilot should a handling or technical difficulty arise.

Analysis

Engineering issues

Witness recollections were that the engine note was constant throughout the aircraft's final approach and up to the moment of impact. This, together with the aircraft's relatively high speed and the severe nature of the damage to the propeller at impact, all support the view that there had not been a loss of engine power prior to the accident.

Within the limitations imposed by the considerable impact and fire damage, the examination of the wreckage resulted in no evidence being found of pre-existing malfunction or failure, which might account for the accident. Witness descriptions of the entry to the final roll suggest that the aircraft was under control up to that point, and therefore no control jam or restriction was likely to have been present at that time. Flight control continuity was established as far as was possible and, therefore, whilst it is considered highly improbable that a malfunction of the aircraft precipitated the loss of control, this possibility cannot be completely ruled out.

In summary, the aircraft appeared to have been serviceable prior to the accident.

Operational issues

It was reasonably certain from witness evidence that the passenger in G-LENA did not wish to experience aerobatics on the flight. Although the pilot was capable of flying aerobatic manoeuvres, no evidence was discovered that he intended to do so. It was not established what occurred during the flight but, after takeoff, the aircraft was seen to gain speed at a low height following which a 'zoom climb' was performed before departing to the southwest. Towards the end of the flight, the aircraft approached the airfield from the southeast and the pilot

requested a low approach and go-around, for which permission was given by ATC.

When an aircraft is cleared by ATC to carry out a low approach and go-around, this is understood to mean that the aircraft will perform an approach at normal approach speed, in the landing configuration and along the runway extended centreline, as if to land. This would then be followed by the application of power to climb away either along the runway centreline or just to one side of it; the aircraft would not actually touch down. G-LENA made a low, high-speed, approach to the right of the runway centreline, across the front of the flying club where the passenger's family and friends were gathered, with the landing gear and flaps retracted, before pulling up. This was, therefore, not consistent with normal aviation practice for a low approach and go-around. However, having completed the fast low run, it would be natural to expect the aircraft to climb to a safe height prior to joining the circuit to land. The aircraft was seen to do this, but in a manner described by witnesses as a zoom climb, pitching up abruptly to an attitude of 30º to 40º.

The opinion of several experienced Yak-52 display pilots was that, to decelerate from the observed high-speed run-in to a power-on inverted stall, in a properly controlled fashion, would result in a climb of considerable height, more than the few hundred feet mentioned by witnesses. Therefore it is considered unlikely that an inverted stall occurred.

It is notable that the aircraft's speed during the run-in, determined as 340 kph (183 kt), was close to its design manoeuvring speed (V_A) of 360 kph (194 kt), the speed below which the application of full control deflection in any one axis will not cause damage to the aircraft. In the absence of any evidence to support the possibility that a malfunction precipitated the pull-up and roll to the right, and with the aircraft being flown at a speed below V_A, it is almost certain that that both the pull-up and the initiation of the roll to the right were intentional. However, there are various possible reasons why the roll continued to the right until the aircraft struck the ground, and these are considered below:

- There was no evidence of any pre-existing medical condition in either the pilot or passenger to suggest incapacitation. This conclusion is supported by the fact that the pilot made a short transmission shortly before the impact. Some forms of full or partial incapacitation may be brought on by 'g forces', such as those experienced during sustained positive g manoeuvres. However, medical opinion was that, although the possibility of incapacitation due to positive g cannot entirely be excluded, it is highly unlikely to have been causative or a contributory factor in the accident. Therefore, pilot/passenger incapacitation was not considered to be a causal factor in this accident.

- Both the pilot and his passenger were qualified and experienced aviators. The pilot was known as a generous and selfless individual, and indeed, had undertaken to carry the flight out at his own cost. The purpose of the flight was to provide a pleasant and novel birthday experience for the passenger, with the passenger having declared that he did not wish to experience aerobatics. However, it is likely that the passenger, who held a valid NPPL, may well have been offered the opportunity to handle the aircraft for some of the time during the flight. Therefore, the possibility

that the aircraft might have been flown by the passenger rather than the pilot, at the end of the flight, was considered. It could not be established whether the passenger would have accepted an opportunity to fly the low approach and go-around but, had he done so, it would have been out of character, and very unlikely for him to attempt, or be allowed to attempt, any unusual manoeuvres at low level or an abrupt pull-up at high speed. Moreover, he would have been aware that his shoulder harness and crotch strap were unfastened and, in light of this, would probably have flown the aircraft in a sedate manner, maintaining positive g. Therefore, it is considered very unlikely that the passenger was flying the aircraft immediately prior to the accident.

- The available evidence indicated that no aerobatics were to be performed during the flight. The passenger had expressed his desire not to experience aerobatics, and the pilot had removed the parachutes from the aircraft and replaced them with cushions. In addition, friends of the pilot were of the opinion that it would have been out of character for him to perform aerobatics at low level with or without a passenger. Nevertheless, the aircraft was seen to perform two pull-ups, one just after takeoff and one just before the accident and, although a pull-up from a relatively high speed may not be classified as 'aerobatics', these manoeuvres were inconsistent with the passenger's stated desire for a pleasurable flight and that he did not wish to experience aerobatics. The CAA SSL 23 highlights the temptation for pilots to fly in a manner which could 'impress', and identifies factors relevant in fatal accidents in the past. Low flying involving an audience, seldom at a formal air show but more often to impress friends on the ground at the clubhouse, or even passengers taken for a flight, are factors which have been identified. However, the balance of evidence suggests that it was highly unlikely for the pilot to have attempted an aerobatic manoeuvre after the final pull-up, having already requested the low approach and go-around "and then join downwind right to land", although this possibility could not be completely dismissed.

- In the positive g pull-up manoeuvre, the passenger, who was not experienced in, and appeared to be apprehensive of, aerobatics, may well have felt discomfort, particularly if such a manoeuvre had not been expected. It is possible that such discomfort might be mitigated by, for example, clasping the aircraft's structure or controls in an attempt to feel more secure. Also, without the restraining effects of the crotch and shoulder straps, the possibility is raised that the passenger might have slumped over the control column or 'submarined' to an extent through the lap straps during the pull-up, and interfered with the flight controls. However, this is considered unlikely because of the upright nature of the seating position in the Yak-52, the fact that the aircraft was progressively adopting a nose high attitude and that a similar manoeuvre was seen at the start of the flight with no apparent unusual consequences.

  Also, as witnesses gained the impression that the pull-up and initial part of the roll were under control, it seems likely that any inadvertent interference with the flight

controls would have occurred later in the roll, possibly as the aircraft began to adopt the inverted attitude. It is possible that if positive g was not maintained in such circumstances, an occupant who was not properly secured by a shoulder harness might fall toward the canopy, particularly if the lap belts were not fastened tightly. It is possible, even probable in this situation, that the occupant might grab at anything to hand, or restrict the movement of, or make an input to, the flight controls at a critical time, precluding a safe recovery of the aircraft to normal flight. However, the findings from the post-mortem examination of the passenger indicated that, at the moment of impact with the ground, he was almost certainly seated normally, with the lap strap positioned around his lower abdomen.

Witness recollections of a noticeable yaw prior to the final pitching motion suggested that an inverted stall or a significant control input, or both, occurred. It was not established with any certainty, but it was considered that the yaw could have resulted from the passenger's feet being inserted through the negative g straps on the rudder pedals, leading to an inadvertent rudder input as the aircraft became inverted.

Therefore, whether it was the pilot's intention to roll the aircraft in the climb, or make a turn to the right to join the circuit, the potential for the passenger to become displaced from the normal seated position and inadvertently interfere with the flight controls at a critical time, was considered possible but, in consideration of the post-mortem evidence, fairly unlikely. However, the possibility that the passenger may have felt insecure during the aircraft's final manoeuvres, as he was not fully strapped in, and may have inadvertently interfered with the flight controls, could not be fully dismissed.

- The origin of the short screwdriver found in the rear cockpit was not established. It may have been left in the aircraft, without the pilot's knowledge, after the maintenance action earlier that day, or it may have been placed on board the aircraft by the pilot, possibly in the small zipped stowage bag in the rear cockpit. A small-bladed, tool is necessary to carry out the pre-flight inspection of the Yak-52, and some pilots use a screwdriver similar to that found. The screwdriver found in the wreckage of G-LENA was above the remains of the rear cockpit floor, in a position where it would not have interfered with the flying control mechanisms in flight. Towards the rear of the cockpit a gap existed between the floor and the rear seat, through which this screwdriver could have passed. Had it done so in flight, then there would have been the potential for it to have lodged close to the pitch control rod and possibly restrict the operation of the roll circuit. No witness marks were identified indicating contact between the screwdriver and the structure beneath the seat. This, and the screwdriver's small size, indicate against the possibility that the screwdriver caused a restriction in the roll circuit at a critical moment in the flight, although this possibility cannot be fully dismissed.

- It was established that the two loose shoulder straps in the rear cockpit were very unlikely

to have restricted the operation of the flight controls, by falling down behind the passenger's seat. The remains of the two straps and their end fittings were recovered from the cockpit debris, with no evidence that these straps were in the area behind the seat at the time of the impact and subsequent fire. Had they been behind the seat, it would only have been possible for the straps to interfere with the rudder and elevator controls. Any such interference would most likely cause a restriction to the operation of the elevator control, rather than making any a positive input to the roll system. Therefore, it was concluded that it was very unlikely for the two unsecured shoulder straps to have precipitated an uncommanded roll input or restrict the roll circuit's operation.

- The tests carried out on the similar aircraft, however, revealed that it was possible for the buckle on the rear seat crotch strap to become trapped between the pitch control rod and fuselage structure. This would most likely happen once a significant roll input had been made, either to the left or right, thereby restricting the movement of the roll control system back to neutral or an opposite direction input. A restriction of this nature would be consistent with the continuous roll to the right seen by witnesses just prior to the accident. Evidence identified from the wreckage and the post mortem examination of the passenger, all indicated that the roll circuit was probably positioned to demand a roll to the right, at the time of impact. Although not determined positively, there was evidence to suggest that the buckle of the unsecured crotch strap might have become trapped between the structure and the pitch control rod beneath the rear seat, after the roll to the right had been initiated. Had it done so, then it would have been difficult if not impossible for it to have become free, particularly in the very limited time available to the pilot whilst the aircraft manoeuvred at low level. To release the buckle, the pilot would have had to make a further right roll input and induce negative g; this would not have been an intuitive action, particularly at such a low height and with the aircraft already rolling rapidly to the right.

The report on the earlier accident to G-YAKW contained the following Safety Recommendation:

> ***'Safety Recommendation 2003-71***
>
> *The CAA should require the Yak-52, and aircraft of a similar design operating on the UK register, to have fitted a method of preventing loose articles migrating to a position where they could interfere with the operation or jam flight controls.'*

In response to this recommendation, the CAA issued MPD 2004-006, requiring a barrier to be installed behind the rear cockpit to prevent debris travelling down the fuselage where it could become lodged in the elevator controls. However, no such barriers were required to be installed to protect other areas where control runs are vulnerable to becoming restricted by foreign objects. As the roll control mechanism on the Yak-52 is vulnerable to being jammed by loose objects, and as the investigation determined that a restriction of this circuit was a possible factor in the accident, the following Safety Recommendation is therefore made:

Safety Recommendation 2007-053

It is recommended that the Civil Aviation Authority review their response to AAIB Safety Recommendation 2003-71 with the intention of minimising the possibility of loose articles becoming jammed in any of the flight controls of Yak-52 aircraft on the UK register.

Conclusion

It was not positively established why control of the aircraft was lost as the aircraft rolled to the right, passing through the inverted attitude, after a fast run-in at low level and a pull-up. It was concluded that the pull-up, or 'zoom climb', after being given clearance by ATC for a low approach and go-around, was most probably a deliberate action by the pilot, similar to the initial zoom climb performed after takeoff. In the absence of any aircraft malfunction being identified, it was also concluded that the initiation of the roll to the right was probably intentional, but that a restriction and/or an uncommanded input, or inputs, to the flight controls occurred, which precluded a safe return to normal flight. The most likely cause of any restriction of the controls was that a buckle on the unsecured crotch strap may have become jammed in the flight controls. The fact that the passenger's shoulder and crotch straps were unsecured was considered a possible contributory factor, which could have led to the passenger feeling insecure and affecting the controls during the final part of the flight.