ACCIDENT

Aircraft Type and Registration:	Grumman AA-1B, G-BDLS
No & Type of Engines:	1 Lycoming O-235-C2C piston engine
Year of Manufacture:	1975
Date & Time (UTC):	17 November 2005 at 1239 hrs
Location:	Near Bugbrooke, Northamptonshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	80 hours (of which 6 were on type) Last 90 days - 4 hours Last 28 days - 1 hour (flying hours estimated)
Information Source:	AAIB Field Investigation

Synopsis

A recently qualified pilot was on a flight with a passenger when the aircraft entered a spin. The pilot was unable to recover from the spin and the aircraft crashed. The pilot and passenger were fatally injured. The aircraft had no apparent defects prior to the accident although it was found to be overweight and the Centre of Gravity (CG) was beyond the aft limit. It is considered that a combination of the aircraft's weight, its CG being out of limits, and the pilot's inexperience, all lead to the aircraft unintentionally entering a spin. The aircraft was not certified for spinning.

History of the flight

The pilot kept his aircraft in a hangar at Cranfield Airport and at about 1000 hrs on the day of the accident he telephoned the hangar staff to request they tow the aircraft outside. The pilot arrived later that morning with a passenger and had the aircraft refuelled, asking the refueller to completely fill the tanks. The refueller confirmed that he filled each wing tank full as instructed, the fuel receipt showed the aircraft was refuelled with 47 litres of Avgas at 1140 hrs. Neither the hangar staff nor the refueller noted anything unusual with the aircraft.

The pilot and passenger boarded the aircraft and after starting the engine called ATC for taxi instructions at

1200 hrs, informing them that they would be departing for a local flight to the north. There was a delay in receiving their taxi instructions due to the number of aircraft operating at the time, but the pilot was eventually cleared to taxi for Runway 21 and the aircraft took off at 1218 hrs. Three minutes later the pilot transferred to London Information, his initial call being at 1222 hrs:

> "GOLF BRAVO DELTA LIMA SIERRA GRUMMAN AA ONE DEPARTED CRANFIELD TWO MILES NORTH OF WOBURN ENROUTE NORTHAMPTON FOR NAVIGATION EXERCISE RETURNING TO CRANFIELD ALTITUDE ONE THOUSAND SIX HUNDRED FEET VFR ESTIMATE NORTHAMPTON AT THREE FIVE REQUEST FLIGHT INFORMATION SERVICE"

The pilot was given a flight information service and at 1237 hrs he reported to ATC that he was overhead Northampton at 5,000 feet and that he estimated being overhead the town of Corby at 1250 hrs. At 1239 hrs the pilot made the following distress call.

> "MAYDAY MAYDAY MAYDAY GOLF LIMA SIERRA HAS GONE INTO A SPIN LOSING HEIGHT RAPIDLY"

No further transmissions from the pilot were received.

Witnesses described seeing an aircraft at about this time in a flat spin, descending near the village of Bugbrooke, about 17 nm north-west of Cranfield. The aircraft was seen to spin through between five to eight rotations before hitting the ground in a field. Witnesses described hearing the engine stop and seeing a white trail coming from one wing tip when it was in the spin. Members of the public were quickly at the aircraft where they found the pilot had died and the passenger had sustained serious injuries. The passenger was able to say a few words to the first person at the scene, but was not able to say what had happened. The emergency services arrived a few minutes later and the passenger was transferred to hospital by air ambulance, but died that evening from his injuries.

Weather

The Cranfield ATIS broadcast, valid at 1200 hrs, reported the following weather conditions: wind, 300º at 8 kt; visibility 15 km; cloud, FEW at 2,000 feet; temperature +5ºC; dew point, 0ºC; QNH: 1017 mb.

An aftercast obtained from the Met Office, described the weather in the vicinity of the accident site at 1200 hrs as: wind at 5,000 feet, 330º at 24 kt with no evidence of turbulence in the area; visibility between 20 to 40 km with some shallow cumulus cloud between 2,000 to 2,500 feet.

Aircraft description

The Grumman AA-1B is a two seat, low wing aircraft fitted with a fixed tricycle undercarriage, sliding canopy and side-by-side seating. The aircraft is powered by a Lycoming four cylinder, horizontally opposed, air cooled, carburettor equipped piston engine with a power rating of 108 BHP, which drives a two bladed fixed pitch propeller. The wings incorporate a non-tapered tubular spar, which is used to form the two fuel tanks. Each tank contains 9.9 imperial gallons of useable fuel and is selected by a three position valve located beneath the instrument panel which can be selected to OFF, LEFT or RIGHT. Each tank has a fuel contents sight glass, mounted on the left and right side of the cockpit wall. The aircraft is also equipped with conventional manual flying controls operated by a system of pulleys, cables, rods and torque tubes. The flaps are operated by an

electric actuator connected to the flap torque tube. An elevator trim tab is fitted to the right elevator, which is operated by a trim wheel situated between the two seats. Movement of the trim wheel causes a control rod to be screwed in or out of the trim control screw jack mounted at the base of the fin. G-BDLS was also equipped with a stall warning system which had the angle of attack vane mounted near the right wing tip.

The Type Certificate for the AA-1B specifies the Maximum Take-Off Weight (MTOW) and Centre of Gravity (CG) range (in inches aft of the datum) as follows:

Maximum Take-off weight	1560 lbs
Maximum baggage	100 lbs
Centre of gravity at 1560lb	+78.25 in to +80 in

The aircraft was equipped with an Air Speed Indicator (ASI) marked in mph and knots which, in line with normal convention, had the flap, normal and caution operating ranges marked with white, green and yellow arcs. The marks on the ASI corresponded to stall speeds with power off, at a maximum weight of 1,560 lbs, of 61 mph with flaps (V_{s1}), and of 64 mph without flaps (V_{so}). These speeds were displayed on a placard fitted to the aircraft instrument panel. The placard also showed the increase of stall speed with bank angle:

	Bank Angle (degrees)			
	0	20	40	60
Flaps up	64 mph	66 mph	73 mph	91 mph
Flaps down	61 mph	63 mph	70 mph	86 mph

Aircraft handling

Longitudinal stability

The stability of an aircraft is its ability to return to its original flight condition following a disturbance from an external force such as air turbulence. A stable aircraft is one where the aircraft returns to its original flight condition following a disturbance, whereas an unstable aircraft is one where the aircraft will continue to deviate from the original flight condition. The longitudinal stability is dependent on the relative position of the aircraft aerodynamic centre to the CG and adequate longitudinal stability is normally achieved by ensuring that the CG remains forward of the aerodynamic centre. If an aircraft is loaded such that the CG is behind the specified aft limit, then the longitudinal stability of the aircraft will reduce and the aircraft might possibly become unstable in pitch. The impact on aircraft handling is that the pilot will need to apply more nose down elevator trim than normal and there will also be an increase in control sensitivity, which would make it more difficult to control the aircraft in pitch.

Stall speed

A light aircraft will always stall at the same angle of attack regardless of the airspeed, weight or load factor. Therefore, given that the lift from a wing is dependent on the angle of attack and the aircraft airspeed, the effect of increasing the aircraft weight is to increase the airspeed at which the stall will occur.

Spinning

A spin, which is characterised by a high rate of descent and a high yaw rate while the aircraft is in a stalled condition, can occur when a wing drops as the aircraft enters the stall. Not all aircraft are certified for spinning and there is no assurance that on these aircraft types

recovery from a spin is possible under all circumstances. Such aircraft types are, therefore, required to be fitted with a placard stating that spins are prohibited. G-BDLS was fitted with such a placard on the instrument panel in front of the pilot.

The position of the CG can have a significant effect on an aircraft's ability to recover from a spin. Even when aircraft are certified for spinning, a CG aft of the rear limit can make it more difficult, or even impossible, to recover from a spin.

Grumman AA-1B spinning characteristics

There have been a number of spinning accidents involving the AA-1 series of aircraft. The AA-1, which preceded the AA-1B, was subjected to a spin evaluation trial during which difficulty was experienced in recovering the aircraft. As a result both the CAA and FAA currently prohibit spinning on the AA-1 series of aircraft.

It was not known if the pilot had access to, or had read, an owner's manual, but none was found and for the purposes of the investigation a copy of the aircraft manual had to be obtained from another owner. The manual describes the AA-1B as:

> *'the most responsive and high performing light aircraft on the scene today'.*

It goes on to describe the stall characteristics as:

> *'conventional in all configurations with elevator buffeting occurring 3 mph above the stall'.*

The manual also states:

> *'an audio stall warning horn begins to blow steadily 5 to 10 mph above the actual stall'.*

There are numerous warnings throughout the manual reminding the pilot that spins are prohibited including one in the section on stalling which states:

> *'Avoid uncoordinated use of the controls at the stalling speed as this may result in a spin. SPINS ARE PROHIBITED'.*

Nevertheless the manual does describe the recovery technique to be used in the event of an inadvertent spin. The owner of the manual examined described his AA-1B as being a very responsive aircraft, which is quick to loose speed, particularly in a turn.

Maintenance and fault history

The aircraft had been regularly maintained in accordance with the Light Aircraft Maintenance Schedule. The last maintenance activity recorded in the aircraft log book was an Annual Star undertaken on the 15 June 2005 at 2369:20 airframe hours. The aircraft was last weighed on 23 June 2004 and the Certificate of Airworthiness was signed on 17 June 2005.

The last entry recorded in the aircraft log book was made on the 7 August 2005 at 2381:55 airframe hours; this was the last flight made by the previous owner. Data stored on the GPS, landing charges and fuel receipts found in the aircraft indicated that the pilot had flown six flights with a total duration of approximately 6.5 hours between purchasing the aircraft and the start of the accident flight. The previous owner, and the maintenance organisation who undertook the Annual Star, have stated that the aircraft was in good condition for its age with no known faults or problems.

Aircraft weight and balance information

The aircraft weight and balance at the time of the

accident was estimated by using the known fuel load at takeoff, the empty weight established at the last aircraft weighing, the weights of the occupants provided by the pathologist and the weight of the baggage as weighed by the AAIB after the accident. The result of the CG calculation was as follows:

Phase	Weight	Centre of Gravity aft of datum
Takeoff	1,740lb (180lb over MTOW)	+80.65 in (0.65 aft of rear limit)
Spin	1,715lb (155lb over MTOW)	+80.47 in (0.47 aft of rear limit)

Crash site examination

The aircraft crashed in a small muddy field of winter wheat and came to rest orientated on a heading of 196º(M). In order to make the aircraft safe, and enable medical assistance to be provided to the pilot and passenger, the emergency services removed the structure from around the top of the cockpit, switched off the magnetos and electrical switches and cut the electrical leads to the battery. They also caused considerable disruption to the ground around the aircraft. Nevertheless, impact marks in the soft ground indicated that the aircraft struck the ground in a nearly level attitude, whilst yawing to the right (clockwise) with little or no forward motion.

Both wings had been badly damaged by the main wheels being forced into the lower surfaces and there was no evidence of fuel in either of the wing fuel tanks. All the control surfaces were found to be intact and continuity of the primary controls was established. There was also no evidence of a control restriction having occurred. Mud marks on the right wing tip fairing, damage to the right aileron trim tab and pitot probe mounted on the left wing, distortion of the tail pylon and fin all indicated that the aircraft was rotating to the right when it struck the ground.

The top engine mounts had failed allowing the engine to pivot forward by approximately 15º about the lower mounting brackets. The engine had suffered very little impact damage. No fuel was found in the fuel pipes or components between the fuel selector switch and the carburettor. Both propeller blades were undamaged and streaks of mud along the leading edge of one of the blades indicated that the propeller was not rotating when the aircraft struck the ground.

All the cockpit instruments, controls and circuit breakers were set in the expected positions for the cruise phase of the flight. Both occupants had been wearing three point harnesses, which had subsequently been released by the emergency services. The buckle and anchoring points on both harnesses were found to be intact. The back of the passenger's seat frame had failed close to the pivot point and the pilot's seat frame had failed at the left pivot point.

Stored in the baggage area behind the occupant seats was a cockpit cover, spare radio, flight bag, a second bag containing all the aircraft records, a towing arm and a can of oil.

Detailed wreckage examination

Stall warning system

All the components in the stall warning system were functionally tested and found to be serviceable. Whilst

the electrical wiring had been cut and damaged there was no indication that this damage occurred prior to the accident.

Flying controls

The flying controls were dismantled as far as possible and the cables, bearings, pulleys and control rods were examined. The condition of the components was typical for an aircraft of this age. All the controls operated in the correct sense and there was no evidence of any pre-existing fault or control restriction. Damage to the flap actuator indicated that when the aircraft crashed the flaps were retracted and damage to the control yoke was consistent with approximately 30° of left roll having been applied. It was not possible to determine accurately the position of the rudder and elevator. It was noted that the elevator trim control rod had been screwed almost fully into the trim jack, indicating that prior to impact, the aircraft had been trimmed close to, or at, the fully nose down position.

Fuel system

It was established, by filling the wing fuel tanks with water, that when the main wheels were forced into the lower surfaces of the wing they severed the fuel tank water drain pipes and punctured the right fuel tank. This damage allowed all the contents of the fuel tanks to quickly drain away. The fuel sight gauges had also shattered in the impact, allowing fuel to be released. The fuel selector and the electrical and mechanical fuel pumps were all assessed to be serviceable. The fuel selector was at the LEFT tank position and no fuel was found in the fuel line between the left tank and carburettor. However a small quantity of fuel was discovered in the fuel pipe between the selector valve and the right fuel tank.

Engine

Despite the force of the impact, the damage to the engine was mainly restricted to the controls, induction and exhaust systems. All of the accessories were found to be serviceable and the magnetos were successfully run on a test bed. The colour of the spark plugs indicated that all the cylinders were operating normally. Witness marks on the air inlet indicated that the carburettor heat was set at COLD, and the position and damage to the controls in the cockpit and on the carburettor indicated that the mixture was set at RICH and the throttle was near to the IDLE position when the aircraft crashed. The fuel bowl on the carburettor was approximately two-thirds full of fuel. The carburettor float, needle and valve all worked smoothly.

The engine was fully stripped and its condition was assessed as being typical of an engine of its age and usage, with no indication of any defect that would have led to its failure prior to impact.

Pathology

The post-mortem revealed no medical factors which could have contributed to the accident. The pathologist determined that the occupants had been subjected to a peak deceleration of 20 to 40g. The accident was non-survivable.

Radar

Radar recordings were obtained from Heathrow and Debden radars which showed the aircraft's flight. There were no returns recorded which might have indicated the presence of other aircraft in the vicinity either before or at the time of the accident.

Global Positioning System (GPS)

A portable GPS unit was recovered from the aircraft from which data was successfully downloaded. The GPS recorded UTC time, elapsed time, aircraft position in UK national grid coordinates, magnetic track and groundspeed. The latter was derived by point-to-point calculation of distance over time. Data was recorded at a variable rate depending on the aircraft manoeuvre, but did not exceed one sample every two seconds.

From the data log of the accident flight, the aircraft departed Cranfield at 1218 hrs and climbed at a rate of 350 ft/min to an altitude of 5,000 feet. The aircraft initially flew on a south-westerly track until it had crossed the M1 motorway before turning onto a north-westerly track of between 320°(M) to 330°(M) at a groundspeed of 60 to 65 knots.

At 1232:30 hrs the aircraft commenced a gradual turn onto a westerly track during which the groundspeed increased from 60 kt to 73 kt. The aircraft then made a more rapid change of track at 1234:17 hrs back onto a north-westerly track of 313°(M) during which the groundspeed reduced to a minimum of 49 kt before increasing again to about 68 kt.

The aircraft remained on a generally north-westerly track at 5,000 feet at a groundspeed of 68 kt until at 1237:05 hrs the groundspeed reduced again, this time to 39 kt, before returning to 60 kt.

At 1238:24 hrs, the track altered slightly onto 335°(M). At this time the groundspeed was 63 kt and the altitude was 5,100 feet. Between 1238:42 hrs and 1238:47 hrs the data shows a climb of 22 feet and a further climb over the next four seconds of 76 feet. The aircraft then commenced a high rate of descent, reaching a calculated maximum of 8,700ft/min. Subsequent data shows the rate of descent then reduced to a final rate of 2,200 ft/min. Groundspeed initially varied before reducing to less than 20 kt, consistent with the aircraft descending rapidly. Extrapolation of the data shows the aircraft impacted the ground at about 1239:55 hrs.

Pilot background

The pilot had been awarded an RAF Flying Scholarship in 1988 and had undergone a concentrated period of flying training with a civilian organisation at Cranfield Airport over a three and a half week period that summer. During this time he completed 25 hours flying, all on the Cessna 150.

His logbook shows no further entries until he once again started flying training at Cranfield, thirteen years later in the summer of 2001, with a different civilian flying school. This period of training lasted three and a half months during which time he completed 22.5 hours, all on the Piper PA38. This included a spinning training exercise on 22 September 2001. On this flight the instructor demonstrated two spins followed by the pilot entering and recovering from four spins, two to the left and two to the right. The pilot's flying ability was described as being generally above average although the instructor felt that, occasionally, the pilot could appear to be over confident in his own flying abilities.

The next logbook entry indicates that the pilot then stopped flying again for four years until in 2005 he undertook a ten day course at a flying school in the USA to complete his JAA Private Pilot's Licence. This involved 29.5 hours flying on the Cessna 152. This training included tuition on calculating aircraft weight and balance and students were required to complete weight and balance checks before flight. He finally gained his licence on 29 July 2005 since which time there were no further entries recorded in his logbook.

On the 27 August 2005 the pilot flew for around 35 to 40 minutes with the previous owner of G-BDLS before agreeing to purchase the aircraft. The previous owner remarked that the pilot flew the aircraft "nicely". A month later, on the 30 September 2005, the pilot collected the aircraft and flew it back to Cranfield with a passenger.

Analysis

The last radio call from the pilot, witness statements, ground marks and damage to the aircraft are all consistent with the aircraft entering a spin to the right (clockwise) from which it did not recover.

Engineering examination of the aircraft has revealed no pre-existing defects which may have caused the aircraft to either enter or fail to recover from the spin. Witness reports that the engine stopped prior to the impact are consistent with the lack of damage to the propeller blades and engine accessories. The position of the engine controls and lack of fuel in the pipe between the left fuel tank and carburettor suggests that during the spin the fuel in the left tank was forced outwards, towards the wing tip, leading to fuel starvation once the remaining fuel in the pipes had been exhausted. It is likely that the white trail seen coming from the aircraft was fuel leaking out from either the fuel tank filler cap, or vent system. However, the engine stopping should not on its own have prevented the aircraft from recovering from a spin.

The aircraft had the required placard stating "SPINS PROHIBITED" mounted in a prominent position on the instrument panel in front of the pilot. There was no evidence that the pilot had previously attempted to deliberately spin the aircraft and, therefore, it is unlikely that he was either unaware of the spin prohibition or had entered the spin deliberately. The pilot should also have been aware of the stall speed of the aircraft, which was clearly marked on the ASI and on the placard on the instrument panel.

The effect of being over the certified maximum weight with a CG outside the aft limit would have been to increase the stall speed and reduce the longitudinal stability. The position of the elevator trim was consistent with the pilot having selected full nose down trim and confirms a significantly aft CG position. Consequently, the aircraft would have been more sensitive in pitch and the pilot's workload in maintaining speed and height would have been greater than if the CG had been within limits.

Data from the GPS appears to indicate that the speed variations coincided with periods of increased cockpit work load. There were two major deviations in GPS ground speed observed in the recorded data. On the first occasion the ground speed dropped from approximately 63 to 49 kt which coincided with the aircraft making a change of track through approximately 40 degrees. The second major deviation occurred just prior to the pilot making a position report to ATC, when the groundspeed reduced from approximately 68 to 39 kt. Using the estimated wind conditions at 5,000 ft these minimum groundspeeds equated to airspeeds of approximately 72 and 61 kt respectively. For the aircraft at maximum certified weight the stall speed for the prevailing conditions would have been 64 mph (55 kt) wings level rising to 73 mph (63 kt) at 40 degrees of bank. For an overweight aircraft these stall speeds would have been higher; however it appears that the aircraft remained above the stall speed on these occasions. Consideration was given to there being a fault in the pitot static system,

which might have caused the ASI to over read; however the airspeed always recovered to the higher value and the variation appeared to coincide with some other activity.

The GPS data records no further notable loss of ground speed; however about two minutes after the second major deviation the aircraft entered the spin. GPS data shows that at that time there was a short but significant increase in the rate of climb to 1,140 ft/min. It is considered that this possibly required an increased angle of attack that exceeded that required to stall the aircraft and this resulted in the aircraft entering the spin.

The pilot had received training in spin recovery, however, this was limited to only one flight conducted some four years prior to the accident. It is unlikely that with such limited training an inexperienced pilot in this type of aircraft and with the CG outside the aft limit would have been able to recover the aircraft from the spin.

There is no evidence available to explain why the sudden increase in rate of climb occurred. There was no evidence of another aircraft in the area that might have acted as a distraction, or caused a disturbance through its wake vortices. The weather was also not thought to have been a factor. However, a combination of reduced aircraft stability and increased pilot workload may have been a factor.

It is not known if the pilot realised that the aircraft was overweight and outside its CG aft limit when he departed on the flight. He undertook weight and balance calculations during his training four months earlier and would have been tested on the importance of this aspect in order to gain his PPL. Yet there was no evidence of any weight and balance calculations having been made by the pilot for any of the flights he flew in this aircraft. The pilot's recent flying experience was fairly concentrated with his flying training undertaken in the USA over a 10 day period on a Cessna 152, which has different handling qualities to the Grumman AA-1B. There is no evidence that the pilot took the opportunity to fly with an instructor in order to familiarise himself with his new aircraft. CAA Safety Sense Leaflet 1 advises pilots that before they fly a new aircraft type they should study the Pilot's Operating Handbook or Flight Manual and be thoroughly familiar with the airframe limitations, operating speeds and weight and balance calculations. The leaflet also recommends that even if not legally required to do so, pilots of new aircraft should have one or more check rides with an instructor.

Conclusion

The aircraft was in the cruise at 5,000 feet when it stalled and entered a spin from which the pilot was unable to recover. It has not been possible to establish the exact cause of the aircraft stalling however no mechanical or environmental factors are thought to have contributed to the accident.

The pilot was properly licensed to carry out the flight and had received recent training in calculating an aircraft's weight and balance. The aircraft was however significantly overweight at takeoff and the CG was outside the aft limit. It is believed this would have made the aircraft less stable.

The aircraft type is prohibited from spinning because it has a history of being difficult to recover from the spin, a situation made worse on this occasion by the position of the aircraft's CG. Spin recovery under these circumstances would have been difficult to achieve.