AIRSHOW ACCIDENT AND INCIDENT REVIEW 2015

Des Barker

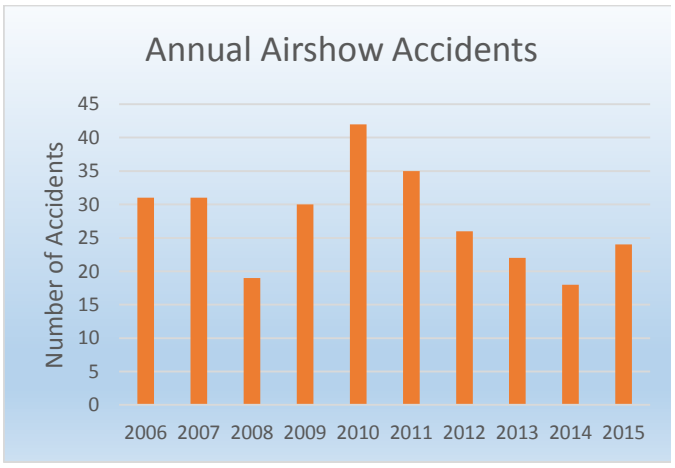
The tenets expressed in this review are those of the author and addresses a sample of significant accidents and incidents at aerial events worldwide in 2015, both during the actual events and during rehearsals and includes, airshows, air races, flypasts, and air capability demonstrations; in fact, any event at which an aircraft is displayed or rehearses for a public air event in which the flow of the event is jeopardised.

Des Barker

Introduction

So, the question the display community has been asking since 2011 has been answered. Since the disastrous 2010 display season during which the highest number of airshow accidents were recorded, the 'in your face' safety campaigns launched by ICAS, EAC and ASSA delivered a significant decrease in accidents. The concern was always, were we seeing a definite decrease worldwide accruing from the contributions of the display pilots, safety officers, air bosses, airshow organisers and spectators, or was it just a statistical spike? Unfortunately, there are no accurate figures available for the number of air events worldwide, nor the number of hours flown annually from which to draw scientific conclusions.

In absolute terms though, from 42 accidents and incidents in 2010, to 18 in 2014, the downward trend has now been reversed with 24 accidents and incidents during 2015. Not Good! So, where to now? Resilience remains the only course of action available. It is pointless to sit back and just accept what the cards have dealt.



Statistical analysis of airshow accidents and incidents over the past 10 years shows a year on year average of 28 accidents per annum but with a decreasing trend since 2011. What does the sudden 2015 break with the downward trend mean?

What is clear however, is that we will have to recommit the entire display community to pushing a safety agenda aggressively across the entire spectrum of airshow participants – we cannot afford to just continue and accept the average of 28 accidents/incidents over the previous ten years. We can't afford to just accept what the dice have dealt with the associated loss of life? Based on the fickleness of human judgement in the low level display environment, we need to understand that we are the weakest link in the safety chain.

It is pointless to introduce additional regulations, there are already enough in place; what is required, however, is to zero in on human factors across the entire airshow community, from first responders, through vendors, safety officers and display pilots alike, through a continuous 'in your face' safety programme.

Sadly, and at the expense of melodrama, there is nothing new under the sun. Due to the fickleness of man's decision making, highly experienced pilots have in some cases, continued making the same errors in judgement over the past 105 years of airshows?

2015 STATISTICAL OVERVIEW

Casualties

A total of 24 accidents and incidents were recorded, an unacceptable loss rate with 44 casualties in which 11 pilots lost their lives, 3 pilots and one crew member were injured, and once again a passenger was killed – when will we ever learn that the passenger seat on a display merely increases the casualty toll in the event of an accident.

As long as display pilots continue to offer passengers the opportunity to fly with during the display, we will continue to lose an additional life unnecessarily. There can never be a good reason to

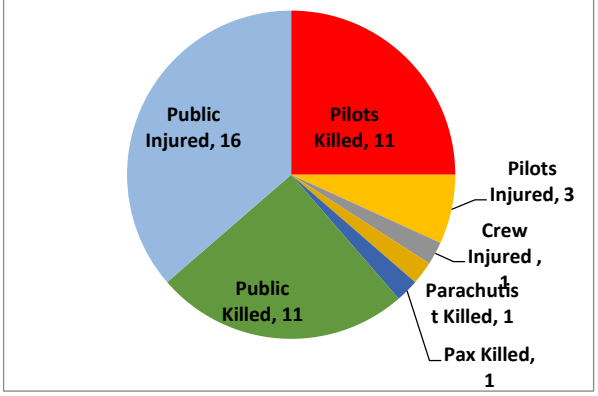
take a passenger on a low level display - and then of course there was the Hunter Shoreham accident.

Breaking with the impressive performance of no spectators involved in accident statistics for 2014, 11 members of the public were killed and 16 injured on the A27 highway in the UK by the rogue behaviour of the Hawker Hunter at the Shoreham RAFA airshow.

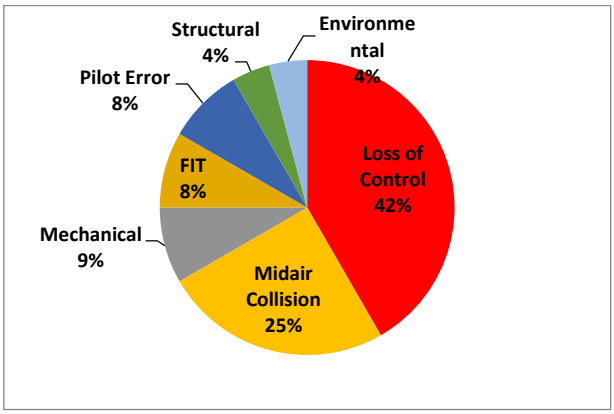
Fatalities remain untenable if the airshow community is to continue to exist without regulatory and insurance interventions since both could impose additional constraints on the ability to host air events. Sponsors are not generally amenable to supporting events in which fatalities occur; not good for branding at all!

Causal Factors

After four years in succession in which Machine (mechanical failure) at 29% was the most significant contribution to airshow accidents and not the historical Flight-Into-Terrain (30%), 2015 saw Loss of Control as the most inordinate contribution at a staggering 42% - the highest ever recorded, versus the historical average of 17%. Three of the Loss-of-Control accidents resulted from tumbling manoeuvres; display pilots flying sport aero category aircraft failed to regain control from 'out of control' situations; a concerning trend in which accidents from 'out of control' manoeuvres continues unabated each year.



Categorisation of airshow accident casualties 2015.



Airshow accident and incidents 2015 by causal factors.

In many cases, the impact attitude of the aircraft approached the horizontal, implying the height budget for the manoeuvre was inadequate by a small margin only, which leads one to believe that the energy loss is not consistent enough to provide the pilot with an absolute error margin.

There is no doubt that the energy losses during gyroscopic tumbling manoeuvres is not an exact science and that a scientific study into energy loss during tumbling manoeuvres is required to quantify energy management and error budgets for such downline manoeuvres.

A 'quick win' could be for all display pilots that include high energy tumbling manoeuvres in their routine to understand the inconsistent and unpredictable energy loss and to maintain situational awareness regarding the aircraft's trajectory; to terminate the manoeuvre at the first sign of the aircraft's trajectory transitioning to a downward vector - gyroscopic manoeuvres at low heights is not for amateurs!

Mid-air collisions, for an unknown reason, also showed a dramatic increase from 15% to 25% and involved a total of 6 of the 24 (25%) accidents. From full time professional military teams to private civilian teams, including the *Flying Bulls, Jupiter, Team Aerodynamix, QBR Team, Grasshoppers* and even the US Army *Golden Knights* parachuting team which certainly begs the question as to the standard of formation aerobatics at airshows.

There is some good news, Flight-Into-Terrain was down from the historical average of 30% to only 8%.

Of major concern was Man's contribution to the airshow accident statistics at a staggering 83%, 12% greater than the historical average of 71% - serious introspection should be undertaken by the airshow display pilots in the 2016 season.

Focus must shift to the mind of the display pilot in understanding tumble aerodynamics, philosophies such as 'plan continuation bias' and normalisation of deviance, etc it would be prudent to include such topics at the annual airshow safety conventions worldwide.

Of concern was the first occurrence of catastrophic structural failure to the carbon composite Giles G-202 and MX2 aircraft. The knowledge and understanding of composites fatigue loading and stressing during high energy manoeuvres, in the marterial sciences world, is also not an exact science.

A DISCUSSION ON ENERGY MANAGEMENT (REPEAT FROM 2014 REPORT)

To understand the essence of surviving low level display flying, it would be prudent to first define the scope and extent of controlling an aircraft safely during a manoeuvre, in the case of vertical manoeuvres. The pilot's tasks are typically:

- energy management,
- management of the display line, and
- management of the surface threat.

Threat and energy management must be coupled with sound judgement where the threat is constituted by the close proximity to the ground and is most critical due to the reduced decision making time. Considering the annual average loss rate of three aircraft to spins and tumbling manoeuvres, a prudent question is: "are all pilots sufficiently 'au fait' with the dynamics of tumbling manoeuvres and spins", not the actual entry and exit techniques, but the extent of energy losses that occur during such manoeuvres and the consequent height required to regenerate energy to effect a safe recovery.

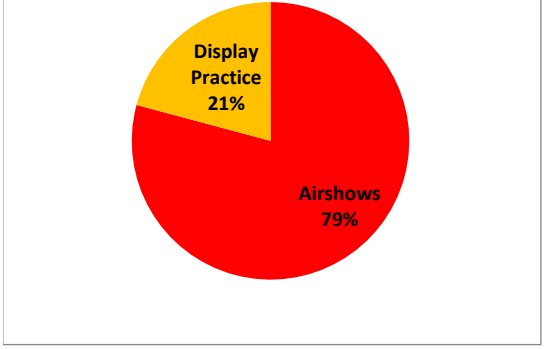
A possible effort by all display flying communities worldwide would be for pilots to revisit the theory of tumble manoeuvres and spins from the perspective of the physics involved. Most modern fighter pilots will have been exposed to the work of Colonel John Boyd (USAF), the father of energy management theory and also decision making via the OODA loop process.

Is the term 'entropy'[1] understood and even considered by pilots involved in high energy 'stuff', not standard loops, straight rolls and barrel rolls, but those manoeuvres in which, arguably, the aircraft is 'out of control' during a segment of the manoeuvre and in which energy losses are not accurately predictable, viz. avalanche, Ruade and spinning, both erect and inverted. Manoeuvres in which the trajectory is a function of inertia, aerodynamics and torque and in which energy loss is not consistently repeatable and is often manifested by an aircraft impacting in a near horizontal attitude implying that an additional fifty feet could have saved a life.

Considering Boyd's work on energy management in fighter tactics, it is necessary for display pilots to understand that when flying manoeuvres close to the ground, they should not only be considering total energy and the classic conservation of energy theory in which in a perfect system, energy is a constant. No, they must subconsciously, consistently be considering the rate of change of energy with time viz. the rate of change of height with time and the rate of change of kinetic energy with time; the differential equating to the momentum of the aircraft ie mass x velocity.

A heretical question. The question of whether bringing competition aerobatics tumbling sequence minimum height limits into the airshow display box should possibly be considered; the competition box lower limits are much higher than the zero foot waiver granted to airshow display pilots.

Ultimately, the combination of climb rate (a direct function of specific excess power) and the momentum at that specific moment in relation to the height above ground level, is the actual criteria mitigating for a safe recovery or not. Another output from energy manoeuvring theory is that of 'corner speed', the speed which maximum normal acceleration can be pulled without structural damage to the aircraft and the maximum turn rate can be generated while sustaining energy. How many pilots have under duress of 'ground rush' continued to pull maximum elevator up instead of unloading to achieve corner velocity before pulling for maximum pitch rate. A scientific research effort in an attempt to quantify the dynamics of tumbling manoeuvres will be continued in 2016.



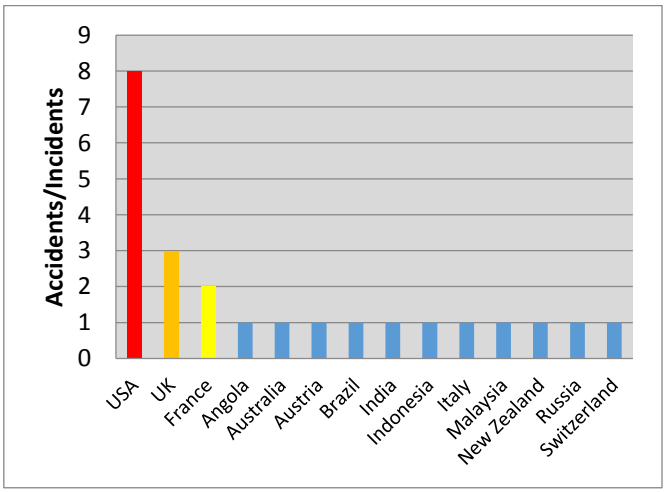
Airshow accident/incidents 2015 by event category.

[1] Stealing from the thermodynamics principles, entropy, the amount of energy unavailable to do work.

Event Categorisation

Historically, 73% of accidents and incidents occurred during actual displays versus practice. Although there was a significant regression in 2013 when the percentage of accidents occurring at actual air events increased by 14%, to 85%, in 2015 the ratio of actual airshows versus practice decreased to 79%. This significant disparity begs the question: "Why"? This phenomenon can possibly best be explained by the fact that the pressure to perform during the actual event watched by spectators and at times under hostile atmospheric conditions, places additional stress on the pilot to 'press' the display to capability limits.

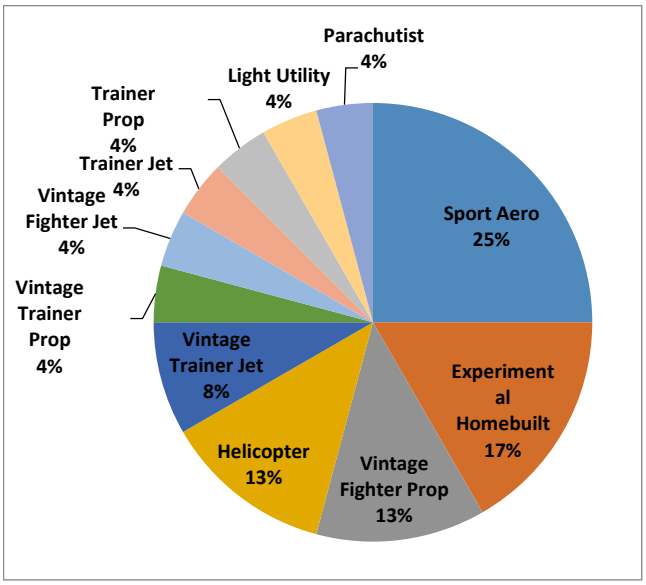
There are often cases in which the conditions during rehearsal are less than ideal and pilots then elect to postpone rehearsals until conditions improve. The problem is that on show day under less than ideal conditions, with the demands from the event organiser and pilot's wanting to meet their fee commitments, sometimes 'press' the performance and environmental boundaries under conditions for which they may not have practiced. The military adage of "fight like you train" is especially relevant; 'display like you practice' – anything else is pushing the error budget.



Airshow accidents and incidents 2015 by country.

Accidents by Country

24 accidents in fourteen different countries. The USA, by virtue of its significantly greater number of airshows annually, experienced eight accidents and incidents followed by the United Kingdom 3, France 2, while Angola, Australia, Brazil, India, Indonesia, Italy, Malaysia, New Zealand, Russia and Switzerland all suffered one accident each. Sadly, there are no accurate statistics regarding flying hours flown in practice and during air events against which to make more statistical sense of the accident figures.



Airshow accidents and incidents 2015 by category.

Aircraft Categories

Bearing in mind the reduced participation of military aircraft at airshows worldwide and the increased number of Vintage aircraft, Sportaero, and Experimental/homebuilt aircraft on the display circuit, the aircraft categorization essentially reflected the main participants involved in accidents with Vintage aircraft at 29%, Sport Aero at 25% and Experimental at 17%.

What was of concern was the fact that once again vintage aircraft, as was the case in 2011 through 2014, continued to make up the biggest proportion of aircraft types involved in the accidents and incidents. Since there has been a significant increase year on year in vintage aircraft actively participating in airshows annually, this is more than likely going to remain the trend in the future.

2015 ACCIDENT/INCIDENT OVERVIEW

1. 16 JANUARY 2015: SCHMIDT ALBERT D AERO AVENTURA II AMPHIBIAN (FLORIDA, USA)

An experimental, amateur-built Schmidt Aventura II amphibian was substantially damaged when it impacted terrain at the Sebring Regional Airport while participating in the annual

Manufacturer's Show Case, killing pilot Dennis Day and student pilot-rated passenger Jason Spinks when the aircraft crashed just off the main runway.

According to eyewitness reports, the airplane was performing the fifth 'fly-by' when it pitched up, rolled to the left, and descended nose down until it impacted the ground. As is usually the case, different eye witnesses reported the accident from different aspects. One eyewitness reported audibly observing the engine "cut out or reducing power" just prior to the nose down descent. Another eyewitness reported the "tail appeared to flutter" and that the "flutter" was in the vicinity of the elevator trim.

A low energy impact as the aircraft stalled was sufficient to kill both pilot and passenger.

A video recording made by one of the witnesses showed that the airplane departed, climbed to about 300 feet agl, made a 180° left turn, and performed a pass down the runway. After executing another 180° turn, the airplane performed another low pass down the runway, then entered a left turn, the bank angle increased until the wings were almost perpendicular to the ground, the nose of the airplane dropped and the airplane descended in a nose-down attitude to ground impact.

It is likely that, during the low altitude flyby, the pilot inadvertently entered an aerodynamic stall while manoeuvring and did not have sufficient height to recover. The National Transportation Safety Board determined the probable cause of this accident as the pilot's failure to maintain control while manoeuvring at low altitude, which led to the airplane exceeding its critical angle-of-attack and experiencing an aerodynamic stall.[2]

2. 21 JANUARY 2015: SUD-AVIATION SA-316B ALOUETTE III (SAURIMO, ANGOLA)

A commission of inquiry was set up to investigate the crash of a helicopter of the National Angolan Air Force (FAN) during a flying display at Saurimo base, celebrating the *39th Anniversary of the Angolan Air Force*.

Following on from a series of steep turns and stall turns, the Alo III was brought into the hover on the parade ground in front of the spectator enclosure and aggressive 'bowing to the spectator' pitching manoeuvres commenced. During the second 'bow', the main rotor cut the tail off the helicopter and in the process, approximately one half of one blade was chopped off.

Unable to maintain control without a tail boom, the unrestrained aircraft impacted the ground directly in front of the spectators that were seated around the parade ground; resulting injuries to the pilot and co-pilot.[3]

Considering the close proximity of the maneuvering chopper to the parade spectators, the results could have been catastrophic – sometimes we just don't understand how lucky we can get, or was this a case of divine intervention? The bottom line is that any aerial event, even in the military, should be preceded by a safety assessment with minimum distance from the spectators and soldiers on parade of primary concern.

'Loss of visual' remains the single biggest threat to formation integrity and airshow

3. 19 FEBRUARY 2015: AERO INDIA 2015: ZLIN 50XL *FLYING BULLS* (BANGALORE, INDIA)

How close can one get to a catastrophic accident and walk away from it? There is a thin line between skill and divine intervention – could the cliché, "getting home on a wing and a prayer" be particularly relevant in this case? The *Red Bull* team, made up of three of their four Zlins, were

[2] NTSB Identification: ERA15FA102, downloaded 1 February 2015.
[3] ASN Wikibase Occurrence # 173195 downloaded 28 November 2015.

reportedly at the apex of an outside loop and at the point at which they started the 'pushover split', two of the aircraft collided.

Team leader Radka Machova appeared to have lost visual on his left wingman Jiri Saller in his blind spot at nine o'clock low and 'bunted' his aircraft downwards, colliding with him during the *Aero India 2015* show. [4] Lead's right wing struck the left wingman's right wing and a further secondary strike by lead's propeller left the left wingman with marginal lateral control to recover to land.

Getting home on a 'wing and a prayer'? Photos: Bhagya Prakash.

Luckily, they were just about at show centre on the far side of the Yelahanka Air Force station runway so both aircraft were able to make successful emergency landings. First down was lead with half the length of each of the wooden prop blades missing, a damaged pitot tube and wing leading edge. The left wingman then landed with at least a meter of the right wing severely chewed up, including the aileron, thankfully both pilots were unharmed. The show was delayed for a half hour as a precautionary Foreign Object Removal parade was carried out.

Hundreds of onlookers, many of them schoolchildren, were barely 200 meters from the accident spot.' The fifty-six children from the Great Eastern International Public School who were squatting right on the tarmac, realised the full impact of the accident much later, which of course, could have had a rather grim outcome.

4. 15 MARCH 2015: KAI KT-1B WOONGBI *JUPITER AEROBATIC TEAM* (LANGKAWI, MALAYSIA)

Two Indonesian Air Force turboprop Korean Aircraft Industries KT-1B aircraft of the national aerobatics team, *Jupiter,* crashed after their wingtips clipped each other during aerobatic practice at the the *Langkawi International Maritime and Aerospace* (LIMA 2015) exhibition. The synchro-pair had split from the six-ship formation and were in an opposing level cross-over adjacent to show centre when they collided.

One of the aircraft crashed outside the perimeter of the Langkawi International Airport and the other in a village on the outskirts of the airport. All practice flights for aircraft on aerial displays were stopped as combat search and rescue helicopters were deployed to recover the pilots.[5] Both pilots ejected successfully with no collateral damage reported.

Mid-air collision between the synchro-pair during an opposition level crossover adjacent to show centre.

5. 29 MARCH 2015: RV *TEAM AERODYNAMIX* (ALABAMA, USA)

Another case of divine intervention? *Team Aerodynamix*, formerly known as *Team RV*, is a civilian team known for large formations of the popular RV-series of homebuilt experimental aircraft. Two aircraft, a Vans RV-8, and Vans RV-6 collided in mid-air while manoeuvring at the *Tuscaloosa Air Show,* fortunately no one was injured and both aircraft landed safely. The RV-8 was substantially damaged while the RV-6 sustained minor damage.

During the performance, the eleven aircraft of the team split into several smaller formations to perform aerobatics and other manoeuvres. Two of the formation were flying overhead at an altitude of 500 ft agl, while the pilot of an RV-8 intended to circle around the two airplanes from behind; an additional group of airplanes were simultaneously flying in the opposite direction.

[4] ASN Wikibase Occurrence # 173978 downloaded 30 November 2015.
[5] ASN Wikibase Occurrence # 174535 downloaded 23 December 2015.

While circling in a counter-clockwise direction, the RV-8 converged on the two airplanes flying in formation, and the propeller of the RV-6, which was flying on the right side of the formation contacted the right elevator and horizontal stabilizer of the RV-8.

The pilot of the RV-6 reported that he was flying straight and level and was focussed on the airplane flying in formation on his left side when the airplane began to experience a sudden severe vibration. Post-accident inspection of the airplane revealed that portions of the propeller were missing.

The pilot of the RV-8 reported that he began rolling to the left while positioned about 4 to 5 airplane lengths behind the two-ship. During his third roll, his airplane had overtaken the airplanes flying in formation during the final quarter of the roll. He observed one of the airplanes pass off his to his left and heard a 'bang' at that time.

Post-accident inspection of the RV-8 revealed that the outboard one-third of the right horizontal stabilizer, and the outboard two-thirds of the right elevator were separated.[6] Fortunately both aircraft were able to land at the airport immediately following the collision and the airshow resumed after a short stoppage.[7]

Remarkably the aircraft remained controllable and that asymmetric forces did not rip the engine from the fuselage. (Mark Almond/ malmond@al.com)

6. 03 APRIL 201: FLUGWERK FOCKE WULF FW190A (BLENHEIM, NEW ZEALAND)

A Flugwerk kit Focke Wulf aircraft suffered brake failure during the landing roll while taking part in a practice session for the weekend's upcoming *Classic Fighters Airshow* at Omaka Aerodrome. Display pilot Frank Parker walked away uninjured after the crosswind landing rapidly deteriorated into a ground loop when the right hand brake failed.[8]

Mechanical failure to vintage aircraft and rebuilds remains a challenge to accidents and incidents at airshows.

The aircraft had landed on the grass runway and Parker had to steer the plane with one brake but then it swung to the left and 'swapped ends' as it departed the runway, skidding backwards on its belly mounted external fuel tank. The undercarriage collapsed, the nose of the plane was slightly crushed and the wooden propeller blades broke upon impact with the ground. Bystanders rushed over to help but fortunately, Parker walked free from the plane uninjured.

A link rod in the right hand brake pedal mechanism failed in compression allowing the brake pedal to move over-centre and thus nullify any braking action to the right-hand wheel. The runway in use was 12 and at the time the wind was easterly at 10 to 15 kts, a quartering crosswind from the left had to be dealt with. It is suspected that the mechanism most probably failed during application of the brakes to counteract the crosswind component. The aircraft will require extensive repairs.

7. 22 APRIL 2015: EDGE 360 (OLD BUCKENHAM AIRFIELD, UK)

Investigators attempted to piece together a crash at Old Buckenham Airfield which killed aerobatics pilot, David Jenkins, 'Wildcat 3', during a practice display. A media launch was taking place at the airfield ahead of the *Old Buckenham Airshow*, which was planned for the first weekend in August.

Jenkins pulled up into a 45° upline, knife-edged right through 90° and entered a two-turn tumble manoeuvre which converted rapidly into a two turn erect left spin from which there was

[6] NTSB Identification: ERA15LA172A downloaded 23 December 2015.
[7] Aeronews Network "Team Aerodynamix: Planes Land Safely After Mid-Air Collision", date 2 April 2015.
[8] nzherald.com 3 April 2015 downloaded 23 December 2015.

insufficient height for recovery. The aircraft is understood to have come down within around 150 feet of a group of about twenty people gathered for the launch.[9][10]

A regular at UK aerobatics competitions, Jenkins was the British Aerobatics Advanced Champion in 2012 and 2013. He also represented Great Britain as a member of the British team at both European and World Aerobatic Championships. In 2012 the team achieved 4th place, just behind the USA, France and Russia.

This accident, like so many others, begs the question: "how is it possible that highly experienced pilots manage to get into a situation from which recovery is not possible? Is the error margin so small in performing tumble manoeuvres at low level that recovery is not 100% guaranteed? Statistically, it would certainly appear to be the case.

Responders attempt to recover the 'nosed-over' Hurricane at Dijon-Darois.

8. 24 MAY 2015: HAWKER HURRICANE (DIJON, FRANCE)

The accident occurred late afternoon on the airfield of Darois as a WWII vintage Hawker Hurricane left the runway and ended up on its nose after landing at Dijon-Darois at the airshow in La Ferté-Alais, fortunately with no injuries.

The accident aircraft was Hawker Hurricane P3351 which had an already chequered history before being taken to France in 2013. (Source: Bien Public)[11]

At this stage, the cause of the loss of control is unknown other than the display was being flown in rather strong wind conditions.

9. 30 MAY 2015: STAMPE SV-4 (BREUIL, FRANCE)

Airshow practice for the following day's *Breuil Airshow* as a Stampe departed controlled flight and crashed, killing the pilot Jean-Marie Bigot. Three aircraft took off, one of them a vintage Stampe SV-4. The aircraft had reportedly completed several manoeuvres when suddenly, at the exit of one of manoeuvres, the Stampe departed controlled flight before entering a spin and crashing to the ground.

Local specialists expressed their complete confusion: "We only know that there was a lot of wind." Despite their grief, the pilots, in conjunction with the airshow organisers, decided by mutual agreement to continue with the planned demonstration.[12]

Lead rolled into the wingman on recovering from the inverted during a 'mirror' flypast.

[9] Norwich Evening News 24, "Investigations continue at Old Buckenham Airfield where pilot David Jenkins died during an aerobatics display". Date 24 April 2015.
[10] ASN Wikibase Occurrence # 175604 downloaded 23 December 2015.
[11] ASN Wikibase Occurrence # 176364 downloaded 23 December 2015.
[12] ASN Wikibase Occurrence # 176535 downloaded 23 December 2015.

10. 31 MAY 2015; VANS RV-8/RV-7 *QBR TEAM* (ALBA ADRIATICA, ITALY)

Mirror passes and half-roll recoveries from the inverted position are not for amateurs…PERIOD! There was absolutely no way in hell lead could initiate a recovery from inverted from his formated position without at least an inverted pitch input to clear, prior to roll initiation. The only remaining question is whether or not there were other issues causing the roll and pitch down by lead. This one could have taken both pilots out but was extremely fortunate for the surviving pilot.

Two RVs were performing a formation aerobatics display at the *Alba Adriatica Airshow* above Tortoreto as horrified beach-goers watched the two aircraft suddenly drop. At the end of a 'mirror formation' level fly past, lead (top aircraft) initiated a left hand half-roll to erect while simultaneously pitching downwards into the wingman below him.

The RV-8 lost a wing and crashed into the sea, killing the pilot Marco Ricci; his body was recovered off the coast from inside his sunken aircraft. The wingman, Luigi Wilmo Franceschetti managed to ditch his RV-7 and escape with only minor injuries after the aircraft flipped over in the sea on landing.[13]

11. 27 JUNE 2015, 2015: EUROCOPTER EC 145 (MINNESOTA, USA)

Surprisingly not so unusual as one might think. The risk to any static display open to the public, is that inquisitive ignorance may prevail, with dire consequences.

"FAA Launches Investigation after Someone Accidentally Turns on Air Show Helicopter**"** was how the media reported the incident. There's two required switches that must be activated before the Chopper 5 engine could be started, that's the 'Power Switch' and the 'Engine 1' switch. The levers are typically marked 'power.

Cell phone video recorded during *Mankato's Minnesota Air Spectacular* captured the aftermath of someone accidentally turning on the '*Mayo One'* helicopter while it was on static display. The Mayo-One team quickly initiated shutdown procedures but not before two people suffered minor injuries when a sun shade toppled over in the wind generated by the moving blades.

Mayo Clinic's released the following statement "a Mayo-One helicopter was inadvertently powered up by a member of the public while the aircraft was parked on static display at the *Minnesota Air Spectacular in Mankato"*.[14]

12. 27 JUNE 2015: CHRISTEN PITTS S-2B (MISSOURI, USA)

The NTSB released its preliminary report from an accident at the *Cameron Air Show* which fatally injured air show pilot Steven O'Berg; the Christen Pitts sustained substantial damage when it impacted terrain during the airshow performance. The pilot's flight demonstration card used during the airshow indicated that he planned to do ten aerobatic manoeuvres during the flight, the ninth was a Lomcevak.

An airshow pilot who was familiar with the accident pilot's airshow routine, reported that the accident pilot intended to do a 45° knife-edge climb, perform the Lomcevak manoeuvre on the upline, and then continue the knife-edge climb.

Video recordings showed the aircraft entering into a shallow 20° upline knife-edge climb entering the Lomcevak via a climbing snap-roll to the left. The nose of the airplane suddenly pitched down and the airplane tumbled twice to the left while on a descending downline and then entered a left hand spin, completing about two and a half turns before impacting the terrain. The airplane impacted the trees in a steep nose-down attitude with a high vertical descent rate; there was no post impact ground fire.[15]

Reviewing a number of tumble accidents, this 'rogue' behaviour seems to be a not too unfamiliar phenomena, the Lomcevak transitioning to a high energy bleed, nearly 90° negative angle of attack as the aircraft enters a spin. Statistical evidence indicates that we do not have the ability yet

[13] ASN Wikibase Occurrence # 176546 downloaded 23 December 2015.
[14] 5 ABC News: "FAA Launches Investigation After Someone Accidentally Turns On A Helicopter", dated 29 June 2015.
[15] NTSB Identification: CEN15FA282 downloaded 20 December 2015.

to fully characterise the trajectory and energy rates of the various gyroscopic tumbling manoeuvres, and as such we will continue to pay the price annually if such manoeuvres are permitted to continue without some form of intervention.

13. 01 AUGUST 2015: FOLLAND GNAT *GNAT DISPLAY TEAM,* (CHESHIRE, UK)

The Heritage Aircraft Trust, operator of the Gnat Display Team announced the loss of one of its synchro-display team pilots, Kevin Whyman, at an airshow for *CarFest* at Oulton Park after the Gnat plunged to the ground in front of horrified spectators. Gnat, which operates three Folland Gnat aircraft, claim to be "the only civilian supersonic jet aerobatic display team in the world".

Eyewitness accounts point to a possible departure from controlled flight during a tight turning manoeuvre; indications were that the aircraft departed while in a level steep turn. Footage from the event showed a jet inverting before disappearing behind a line of trees and ploughing into the ground at a very steep dive angle.

The police also advised that the best thing and the safest thing to do was to carry on with the event, bearing in mind that there were 10,000 children at the event – and that is what they did.[16] No AAIB report available at this time.

14. 02 AUGUST 2015: MIL Mi-28N NIGHT HUNTER *GOLDEN EAGLES* (RYASAN, RUSSIA)

An Mi-28N military helicopter belonging to the Berkuty *(Golden Eagles)* crashed at the Dubrovichi range near Russia's Ryazan Air Base during an aerobatic display at the *Aviamix Air Show,* one of the most prominent in Russia, which also coincided with the international *Aviadarts* aerial combat competition as part of the International Army Games in Russia[17].

The Berkuty 4-ship diamond was running in directly towards the spectators and pitched up at show centre, simultaneously firing flares. At the apex of the pullup, lead appeared to initiate a torque turn to the left but after approximately 40° of turn, the turn direction reversed sharply and the Mi-28 entered an autorotative state descending vertically in a left hand autorotation at approximately 120°/sec, completing at least five autorotations from approximately 400 ft agl before impacting the ground.

The helicopter exploded and burst into flames on impact in a forest adjacent to the runway, unfortunately, the pilot died on impact - the co-pilot survived which was nothing less than a miracle.

According to the hospitalized pilot, the emergency alert system reported the failure of the hydraulic boost system at moment critique, as the torque turn was commenced – the worst place in the whole routine for such a failure. In the planning of the demonstration routine, who would have planned for such a critical failure at such a critical point of the demonstration?

According to the hospitalized pilot, the emergency alert system reported the failure of the hydraulic boost system at moment critique, as the torque turn was commenced.

15. 16 AUGUST 2015: VANS RV8 (NEW JERSEY, USA)

The incident happened at the *Greenwood Lake Airshow* to the *Redline Team* of RVs. Following the team landing, No 2 drew the attention of the

[16] ASN Wikibase Occurrence # 178185 downloaded 23 December 2015.
[17] The Moscow Times, "Russian Helicopter Crashes During Airshow", 3 August 2015.

spectators when, according to the show coordinator, the aircraft tipped over onto its propeller after the pilot apparently applied harsh braking, causing front end damage. The show was delayed for 10 minutes.[18]

It would appear that conflict arose between a journalist and the airshow organiser in which the journalist entered the AirBoss restricted area to get comment, but was requested to leave since it compromised safety by distracting the recovery effort.

It may be a good time to once again revisit the role and function of the media at air events and include media standard operating procedure briefings with the media prior to the commencement of the airshow. The media remains a critical component of airshow successes and as such, the development and maintenance of a strong relationship between the organiser and the media, is imperative.

16. 16 AUGUST 2015: GOLDEN KNIGHTS, (CHICAGO, USA)

What was supposed to be a great day of festivity at Chicago's *Air and Water Show* turned tragic when two skydivers collided in flight. One of the skydivers involved was Tim Holland of the Navy *Leap Frogs* skydive team, the other, Sergeant Hood of the *Army Golden Knights Parachute Team*.

The Army and Navy skydiving teams were performing a 13-man "bomb burst," which called for a 15 seconds circle. After the skydivers split from the formation in different directions, Hood and Holland collided in the air, knocking Hood unconscious. When he did not open his parachute, a safety device automatically opened his reserve chute, but unfortunately impacted a high rise building and fell about 22 stories

According to the show coordinator, the aircraft tipped over onto its propeller after the pilot apparently applied harsh braking, causing front end damage.

A witness reported seeing the reserve chute deployment, "he was coming in really low and appeared to be motionless. Holland landed on North Avenue Beach and broke his leg. The airshow continued Sunday but the skydiving teams cancelled their performances.[19]

17. 22 AUGUST 2015: HAWKER HUNTER T7 (SHOREHAM, UK)

In what was most probably the most dramatic public showing of an airshow accident in many years, the Hunter ran in at low level along the flight line to the north west of the public viewing area at Shoreham Airport where the *Royal Air Forces Association Airshow* was being held.

The aircraft entered a manoeuvre with both a vertical and rolling component, describing a type of 'quarter clover' trajectory at the apex of which it was inverted. Following the subsequent descent, the aircraft did not achieve level flight before it struck the westbound carriageway of the A27 in what appeared to be a 'superstalled condition'.

There was a consequential fireball and then another fireball about 100 yards along the extended flight path, probably momentum carrying the engine to the final point and the underwing fuel tanks separating. The aircraft broke into four parts on impact: cockpit, tail, left wing and main body, and right wing, destroying several cars in the process. Fuel escaping from the fuel tanks ignited in a large fireball and plume of smoke. Eleven people on the ground were killed and sixteen were injured.

Andy Hill, the pilot, held a valid display authorisation, issued by the UK CAA to display the Hawker Hunter to a minimum height of 100 ft during flypasts and 500 ft during standard category aerobatic manoeuvres; he was thrown clear of the aircraft in his ejection seat and miraculously survived the crash with critically serious injuries and was subsequently placed in a medically induced coma; he was released from hospital in September 2015. That he survived the crash impact and subsequent explosion of the aircraft, beggars belief.

Hill was cleared to commence his display and, remaining offshore, radar tracking showed he descended along the coast towards the airfield during part of which he flew inverted to check that there were no loose articles in the cockpit before his display.

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[18] NorthJersey.com, "Plane Damaged on Runway During Greenwood Lake Air Show", 16 August 2015.
[19] The Washington Post, "Decorated 'Golden Knight' Army Parachutist Dies in Airshow Dive" dated 17 August 2015.

Micro seconds before impacting the A27, the Hunter at high angle of attack.

The deadliest air show accident in the United Kingdom since the 1952 Farnborough Airshow crash which killed 31 people.

Having rolled upright and wings level, the descent was continued to 800 ft amsl and a right turn made to line up with the display line to the west of Runway 02/20 at Shoreham. The aircraft remained in a gentle right turn with the angle of bank decreasing as it descended to 100 ft amsl and flew along the display line. It commenced a climbing right turn to 1,600 ft amsl, executing a Derry turn to the left and then commenced a descending left turn to 200 ft amsl, approaching the display line at an angle of about 45º.

The aircraft was almost fully inverted at the apex of the manoeuvre at a height of approximately 2,600 ft amsl. During the descent the aircraft accelerated and the pitch attitude increased but the aircraft did not achieve level flight before it struck the westbound carriageway of the A27 at its junction with Old Shoreham Road.[20]

As a result of the accident, all civilian-registered Hawker Hunter aircraft in the United Kingdom were immediately grounded by the UK Civil Aviation Authority until further notice and restrictions were put in place on civilian vintage jet aircraft displays over land, limiting them to flypasts and banning high energy aerobatic manoeuvres.

Flying displays over land by vintage jet aircraft were significantly restricted until further notice, being limited to flypasts only, essentially prohibiting 'high energy' aerobatics. The CAA undertook to conduct additional risk assessments on all forthcoming civil air displays to establish if additional measures should be introduced.

The safety standards that must be met by all major civil air displays in the UK are among the very highest in the world and are regularly reviewed. All air display arrangements, including the pilots and aircraft, must meet rigorous safety requirements and individual display pilots are only granted approval following a thorough test of their abilities. So, as in almost all cases, adequate safety regulatory oversight exists but the fickleness of human judgement remains the weakest link in the safety chain.[21]

With the inordinate number of formation mid-air collisions in 2015, the question is: Are display pilots adequately competent for formation displays at airshows?

18. 23 AUGUST 2015: COMCO IKARUS C42B (DITTINGEN, SWITZERLAND)

With the trauma of the previous days' Hunter accident still fresh in the public's mind, the media announced that two Comco Ikarus C42, general aviation microlight aircraft belonging to the "*Grasshoppers Aerobatics Team* collided in mid-air during a three-ship display at the *Dittinger Flugtage*.

Grasshopper Lead and No. 2 were involved in the collision with the No. 2 impacting a road and damaging a house in the village of Dittingen; the aircraft disintegrated and burned, killing the pilot – amazingly, no one else in the village was injured.

[20] AAIB Special Bulletin: S3/2015 G-BXFI EW/C2015/08/04, dated 4 September 2015, downloaded 24 December 2015.
[21] AAIB Special Bulletin S4/2015 - Hawker Hunter T7, G-BXFI – update dated 21 December 2015.

Lead came down on the fence of a residence in the village of Dittingen after the deployment of the on-board ballistic parachute and was not injured.[22]

19. 28 AUGUST 2015: GILES G-202 (NEW YORK, USA)

"Andrew Wright Lost as Giles G-202 Suffers Fuselage Separation/Failure" was how the media reported the accident that saw the catastrophic structural failure of the Giles G-202 while practicing for the *New York Air Show*, at Stewart International Airport in Orange County. It had been a tough few weeks for the airshow industry, and now this.

The Giles G-202 suffered complete structural failure of the rear fuselage just forward of the junction of the horizontal and vertical tail planes. Wright had performed four manoeuvres and was about two minutes into the routine performing an aileron roll on 45° upline when the tail section twisted toward the right before completely snapping from the fuselage. With the aircraft out of control at such a low height, Wright had no chance to bail and perished on impact about 300 yards feet south of the runway.

The right wing eventually separated from the fuselage and came to rest about 30 feet from the main wreckage while the left wing was also separated and found adjacent to the main wreckage. Both wings showed heavy fragmentation of the leading edge and large sections had fractured and separated from each wing. The remainder of Fridays' flying activities were cancelled due to the tragic accident but the weekend activities continued as scheduled with the show being flown in honour of Andrew Wright.

Unfortunately; the Giles manufacturing operation, known as Akrotech Aviation, ceased operations over a decade earlier though there was some airframe support available through the Giles community. Both the G-200 and G-202 were subject to an Akrotech issued Service Bulletin #19 calling for inspections and upgrades to the rear fuselage. At least one known inflight breakup of a CAP 222 (based on the G-202) had been reported/documented in which a pilot was also lost.

Tailless and out of control following catastrophic structural failure, the Giles pitched up at low level leaving no opportunity for the pilot to bail out. (Benjamin Granucci)


The engine and right wing separated from Nigel Hopkins' composite structure MX-2 at the start of his sequence at the FAI 28th World Aerobatic Championships, two weeks prior to the Giles G-202 catastrophic failure.

The vertical stabilizer, horizontal stabilizer, and elevator remained relatively intact. The structure below and forward of the horizontal stabilizer was found fragmented and separated from the rest of the tail assembly. The rudder and its hinges were found completely separated from the vertical stabilizer.[23]

The accident happened just days after South African aerobatic pilot Nigel Hopkins narrowly escaped death when his MX2, also a carbon composite structure and a later version of the G-202, also suffered a catastrophic structural failure in which the entire engine and part of one wing departed the airplane during a practice session in France at the FAI 28th World Aerobatic Championships. Fortunately that accident did not end in tragedy as Hopkins managed to egress and bailed out from a very low height.

The prudent question that begs answers from composite designs. Have we managed to fully understand composite fatigue load spectrum on high performance aerobatic aircraft and the in-service integrity testing of composites? The gyroscopic forces on the airframe, engine and propeller during some manoeuvres is extreme to say the least.

[22] ASN Wikibase Occurrence # 178925 "Comco Ikarus C42" downloaded 23 December 2015.

[23] NTSB Identification: ERA15FA331, N18FJ, downloaded 20 December 2015.

What should be of major concern to composite sport plane display pilots is that material sciences do not yet have a full understanding of the composite fatigue loadings. The testing of such structures remains a black art despite infra-red thermography, ultrasonics and radiography – the behaviour and inspection of composites needs to be developed – it remains a 'black art'.

20. 29 AUGUST 2015: SPITFIRE REPLICA (BRISBANE, AUSTRALIA)

The pilot of a scale Spitfire scale replica had a lucky escape after he lost control of the aircraft on take-off at the *Watts Bridge Gathering of Eagles*. Considering what might have been, a very fortunate outcome especially as Watts Bridge is unusual in this day and age, allowing the public to mingle with the aircraft and to stand along the taxiway, watching proceedings.

Wing drop at lift-off resulted in the wingtip contact with the runway slewing the aircraft around in the direction of the spectators aligned along the runway.

Lift-off in a near three-point attitude, the right wing dropped and the wing tip slewed the aircraft around directly in the direction of the spectators aligned along the taxiway. The aircraft came to a stop mere metres from the spectator ribbons along the taxiway – once again, divine intervention since the aircraft momentum was not under control of the pilot.

The saving grace was the pilot immediately throttled back to idle realising that the aircraft was out of control. The pilot was not injured and the aircraft was repairable.[24]

21. 30 AUGUST 2015: PITTS SPECIAL S2B (FRIESACH, AUSTRIA)

The two-day air show at the airfield Hirt was cancelled and the crash site cordoned off as the crisis intervention team of the Red Cross consoled the families and the shocked spectators and members of the flight sports clubs Hirt.

The 50-year-old commercial pilot impacted the ground adjacent and very close to the approximately 500 spectators, not having fully recovered from a tumble manoeuvre. Out of control before impact, the result could have been devastating.

The Pitts entered the vertical and completed three tumbles of what appeared to be a Lomcevak which continued on a downline and with insufficient height to complete the recovery pull-out, the aircraft impacted a few hundred metres from the spectators, killing the pilot on impact making it the latest in a string of fatal incidents that have plagued airshows in 2015.[25]

Comment by an international aerobatic and airshow pilot: "This looks similar to the recent crash in Cameron, Missouri, with a Pitts (Ser No. 12). The thing I see here is not that the lower altitude is insufficient, it's that the pilots lose situational awareness".

22. 12 SEPTEMBER 2015: AERO VODOCHODY L-39 ALBATROS (TENNESSEE, USA)

Display pilot Jay Gordon was killed when his L-39 crashed during the final act at the *Wings Over Big South Fork Air Show* at the Scott Municipal Airport in Oneida. A witness located near the departure end of the runway stated that the airplane made a right turn after take-off and pitched-up to gain altitude when "the engine failed. The airplane subsequently entered a 'sliding turn' and descended nose first toward the ground".

The airplane impacted trees about two miles west of the departure end of runway 23 and was partially consumed by a post impact fire. Visual examination of the last stage turbine assembly did not reveal any damage consistent with an internal catastrophic failure. The airboss who cleared the airplane for take-off reported no distress calls or abnormal communications from the pilot prior to the accident.

Although the aircraft was equipped with ejection seats, the pilot did not eject. One ejection seat rocket motor was found discharged and one parachute was located in the debris path; however, its canopy was not inflated.[26] No accident board investigation report available.

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[24] ASN Wikibase Occurrence # 179152 downloaded 31 December 2015.
[25] ASN Wikibase Occurrence # 179134 downloaded 31 December 2015.
[26] NTSB Identification: ERA15FA353 Aerovodochody L-39 Albatross Preliminary downloaded 18 December 2015.

23. 31 OCTOBER 2015: SLICK 540 (SAN SALVADOR, BRAZIL)

"Squadron Textor Show" was one of the attractions of the *Air Saturday* event promoted by the Brazilian Air Force (FAB), in Barra. The presentation was part of the celebrations for the *Aviator's Day*, a celebration in honour of the first flight made by Santos Dumont in France in 1906.

The "*Squadron Textor Show*" consists of three aircraft, each of which is piloted by a family member consisting of a father and two sons team and is based in Rio Verde, Goiás. One of the sons, Andrew Textor was killed in the Slick that crashed into the sea near the Farol da Barra during the show.

Video analysis shows a pull-out from a loop into a 45° upline and then what appeared to be a half roll to the inverted being driven into an avalanche which after two autorotations continued on an inverted downline of approximately 60° before impacting the adjacent ocean in a near vertical attitude.

What is evident in many of the tumbling accidents is that although the pilot pulls into a steep upline, during the gyrations the trajectory is no longer on the upline but rather quickly converts to a descending, energy bleeding downline. It is questionable whether or not the pilot is able to maintain situational awareness and actually realise that the trajectory has transitioned to a downline before it is too late.

A question that begs asking is do pilots know and understand the dynamics of gyroscopic manoeuvres on energy conservation, particularly the rate of change of energy and attitude? Do they know and understand the energy bleed or 'entropy', the non-availability of energy caused by the manoeuvre? Do they know and understand the unpredictability of the trajectory of an out-of-control manoeuvre? If not, the airshow community can be assured that this will not be last accident caused by gyroscopic tumble manoeuvres at low level.[27]

24. 19 DECEMBER 2015: T-50 GOLDEN EAGLE (YOGYAKARTA, INDONESIA)

The accident occurred on the second day of an airshow celebrating the *70th Anniversary of the Air Force Flight School*, killing the pilot and co-pilot instantly. There was no ejection and no one on the ground was injured.

The KAI T-50 Golden Eagle, a U.S.-South Korean-made light attack aircraft, approaching the end of a well flown sequence, pulled up into the vertical for a half-loop, during inverted level flight, conducted a half-roll to erect, then commenced aileron rolls to the left on the downline, completing three aileron rolls.

From the video, shortly before impact, the rolling moment was stopped and the pilot commenced a pull-out from which there was insufficient height to recover; the aircraft impacting in a shallow 'super stalled' angle, with wings level crashing into the air force base complex near Adi Sutjipto Airport.

CONCLUSIONS

Statistically, 2015 was another lousy year in which the downward trend in accidents and incidents of the past four years was reversed. 24 accidents and incidents at airshows worldwide, 11 pilots killed, about average for a year over the last five years. Such a loss rate is unsustainable.

The disastrous casualty-count of the RAFA Shoreham Airshow Hunter accident placed the airshow community under the microscope as the public questioned the need for airshows and sponsors put serious consideration into their continued support of their branding with airshow events; 11 members of the public were killed and another 16 injured. A major contribution to this reversal was the inordinately high percentage 83% of MAN attributable accidents. Serious introspection by air bosses, safety officers and display pilots alike, will be required.

Focus MUST shift to the mind of the display pilot in understanding tumble aerodynamics, philosophies such as 'plan continuation bias' and normalisation of deviance, etc and it would be prudent to include such topics at the annual airshow safety conventions worldwide – it is clear that the handling skills in dealing with the unpredictability also leaves a lot to be desired.

The catastrophic structural failure to the carbon composite Giles G-202 and MX aircraft should serve as a new warning of the engineering requirement to better understand the dynamics of composite structures and in-service fatigue loads. The knowledge and understanding of composites fatigue loading and stressing during high energy manoeuvres, is not an exact science as yet.

The dramatic increase in mid-air collisions, from full time professional military teams to private civilian teams, including the *Flying Bulls, Jupiter, Team Aerodynamix, QBR Team, Grasshoppers* and even the US Army *Golden Knights* parachuting team, was a further cause for concern and raised the

[27] ASN Wikibase Occurrence # 180841 downloaded 31 December 2015.

question on the standards and skills level of the display pilots. The world airshow community is left with the unsolved problems that unites all of us, “don’t hit the ground”!