Crash Analysis

Prepared by: Frederick Wagner, Sylmar Hang Gliding Association Safety Director, June 2015

Table of Contents

Summary

At 3pm May 9th, the pilot was thermalling somewhere between 100-200ft above the top of Towers (AKA Contract Point). The pilot appears to initiate a right turn into lift when suddenly the glider begins to go weightless and gets forced out of the right turn and rolled to the left. The left roll (and perhaps nose down pitch) was strong enough for the glider to have flipped upside down. The pilot fell into the sail towards the back of the glider. At this point, it appears that the left outboard leading edge section broke; evidence of stressed luff line clip and the manner in which the leading edge broke indicate strong negative loads. Analysis of the on-board video suggests a combination of an initial roll followed by pitch rotation (perhaps accompanied by rotational spinning) until the glider struck the hillside with force causing fatal trauma. Time estimate is 6 seconds from the initial rollover to ground impact.

The investigation team included Master rated pilots, instructors, an aeronautic engineer pilot, an aircraft crash investigation engineer pilot, a hang glider designer pilot, and two of the 3 pilots that launched that day with the crashed pilot. A few additional people were consulted for their expertise.

This report is a synthesis of the team's findings.

Investigation Data

- Track log from Flytec 6030 variometer, and some track and data visualizations
- Video from an on-board Go Pro camera, from launch to an estimated 1-2 seconds before impact
- Photo of the glider, taken from the Search and Rescue helicopter
- Photos of the glider the morning after the crash
- Investigation of the recovered glider
- Autopsy information (no health issues, fatal trauma injury on crash)

Pilot

- H4 Advanced rated pilot, flying at his home site
- First solo flight was in March 2001

Equipment

- North Wing Freedom 170 single surface glider
- High Energy Sports Tracer harness

Track Log Information

Time of Flight: 13:57:02 to 14:59:52 PT, on May 9, 2015

Location: launched Kagel Mountain, crashed 80 feet SSW of Contract Point

14:59:22 glider headed SE, alt 3655’ descending @ 283.8fpm
14:59:42 glider headed NW. 10sec before end of flight, glider was @ 3570’ descending @ 627.7fpm
A rapid IAS (indicated airspeed) deceleration begins to show up in the track log going from 24.7 to well below stall speed in about 5 seconds
14:59:52 glider headed N, alt 3409’ descending @ 550.6fpm, however there is no IAS (indicated airspeed). Ground speed shows 9, but assume this is related to GPS catching up due to slow recording rate.

Note: see Appendix for full track log analysis.

Weather Conditions

- Broken cloudy skies
- Strong sun angles (41 days prior to the longest day of the year)
- Launch winds were estimated at 12-20 mph
- Strong lapse rate reported between the launch and landing zone (2000' vertical drop)
- The 3 other pilots of the launching group reported the air was “active”/”highly active”. One of them – a pilot with decades of Kagel experience -- said he was pitched up to 45 degrees in roll, weightless, above the Kagel ridge during his flight, for the first time ever.
- Reviewing the 1 hr, 4 min on-board flight video, it appears the conditions were not particularly turbulent that day. The pilot flew the Kagel ridge for 45 minutes, remaining below launch. Special Note: the pilot flew for 10 minutes near the Towers, in moderate conditions, before encountering the fatal inversion-inducing turbulence.

Analysis of In-Flight Video

- Video shows normal flying equipment function during the flight
- On-board video showed the full 1 hour, 4 minute flight

Video Clip Time	Time to End of Video	Interpretation of Final Video (This is an attempt to interpret glider orientation, but it's impossible to determine that with much certainty)
:13 seconds	:06 seconds	Pilot is turning right, looking right, towards lift

Video Clip Time	Time to End of Video	Interpretation of Final Video (This is an attempt to interpret glider orientation, but it's impossible to determine that with much certainty)
:14	:05	Right wing gets lifted without pilot input / left wing is pushed downwards
:15	:04	Negative lift waves travel across the glider, left wing to right wing. Pilot looks left.
:15	:04	Negative lift on both wings (billowed down). Harness lines have slack.
:15	:04	Feet of pilot are going up. Both wings have negative lift. Glider appears to be nose-down to ~40 degrees nose down from horizontal level flight.
:15	:04	Glider appears to be getting inverted in roll to the left. Both wings show negative lift billowing.
:16	:03	Glider appears to be in nose-down orientation, and feet contact the sail.
:16	:03	Glider appears to be ~120 degrees nose-down orientation from level flight (30 degrees beyond nose-down). Feet are in sail to right of the keel. Pilot is hanging onto the control bar by his hands.
:16	:03	Glider appears to be ~155 degrees beyond nose-down orientation from level flight (180 degrees would be “glider is on it's back, tail forward”).Pilot's hands disconnect.
:16	:03	Glider appears to be in ~225 degrees nose-down orientation from level flight (270 would be nose up) – tail is down, glider seems inverted. Pilot is lying on the keel, towards the tail of the glider.
:17	:02	Glider appears to be in nose up orientation. Right wing tip comes into frame of the camera – it's broken and flopped into view of the camera mounted on the cross-bar. [The camera mount rotates on the crossbar after these frames]
:18	:01	Glider appears to be in nose up orientation, and the right wing tip is folded in.
:18	:01	Glider appears to be inverted, and ~235 degrees from horizontal level flight (180 would be tail-forward, upside down, 270 would be nose up). Pilot is at the rear of the trailing edge, helmet on the keel and body on the left side of the keel but mostly hanging beyond the trailing edge. Hang strap appears loaded.

Video Clip Time	Time to End of Video	Interpretation of Final Video (This is an attempt to interpret glider orientation, but it's impossible to determine that with much certainty)
:19	:00	Right wing tip is folded over.
		** The video recovery expert estimates the camera impacted the ground 1-2 seconds after the last recovered frame.**

Observed Glider Damage

Major damage points:

1. Left leading edge broken outboard the crossbar junction
2. Right leading edge broken inboard the crossbar junction
3. Keel tube broken at the control frame apex. The keel tube stinger (outboard the haul back bolt) broken and bent in multiple places
4. Hook for the luff lines (cables holding up the trailing edge) was stretched open
5. Lateral tear in the Mylar portion of the sail

Details:

The glider was retrieved from the mountainside at about 11:30 AM on Sunday, May 10. The crash site was at N 34° 20.498', W 118° 24.461', about 50 feet below the southern-most structure on Contract Point. Aside from a lot of footprints, the only item on the scene was the glider itself, upside down, with the nose pointed downhill. The glider had extensive damage from some combination of failure in flight, impact with the ground, damage as the glider came to rest, and perhaps also from the previous evening's rescue efforts. The left leading edge was broken aft of the crossbar junction, where it had been bent downwards without significant torsion. The right leading edge was broken forward of the crossbar junction, also bent downwards. The keel was broken just aft of the control bar apex, again bent downwards, and broken a second time just aft of the haul-back tang. The end of the keel was mangled; perhaps it had been caught between rocks while the glider came to rest or during the rescue. The crossbars were undamaged, as was the entire control frame: downtubes, basetube, and wheels. The lower rigging (side wires, nose wires, rear wires) was intact, as were all the attachment points. The kingpost was straight, with minor marks on the top cap that indicated some contact with the ground. The upper nose wire and upper left side wire were both broken where they joined the kingpost. The luff lines were all intact and properly hooked to the kingpost, though that hook had been stretched so much that its gate no longer closed.

The sail was extensively torn in nearly every panel. In the main panels, the Mylar fabric appeared to have been pulled apart, leaving rents several feet long. The broken left leading edge had torn through both the sail's leading edge pocket and the Mylar insert. There were other sail tears that were likely caused by chaparral branches. Many of the battens were bent, the most extreme being a couple of midspan battens on the left side that had been bent downwards nearly ninety degrees beyond their original shape. Both tip wands were intact, and the hang loop was in good condition.

Emergency Response

Pilot crashed at 3pm. He was not believed to be flying with a radio. Around 4pm, other pilots in the landing zone asked if anyone had seen the missing pilot in awhile. One pilot said that the missing pilot had flown for more than 3 hours, 6 weeks earlier. At 4:20pm, one pilot left to check the emergency LZ next to Olive View hospital. At 4:45pm, another pilot left to travel East (to Pasadena) taking a radio to call for the missing pilot from the freeway. At 5:35pm, pilots had been dispatched to check all the common emergency LZs for the missing pilot, prior to a 911 call. There was reluctance to call 911 prior to the emergency LZ checks. 911 was called at approximately 6:10pm by one of the instructors. The sheriff helicopter arrived first, followed by the Search and Rescue helicopter. The sheriff helicopter had been on another air operation, some distance away.

Looking Back: Opportunities for this Pilot to have Averted Crash

A number of ideas were posed to the investigation team, which included Master rated pilots, glider designers, and an instructor. No ideas received received broad support except one: the pilot needed more altitude to survive that turbulence. And, it was noted that at the time of the accident the pilot was flying at a popular altitude for the conditions he had experienced in the previous hour and 3 minutes of flying. The unfortunate reality seems to be that in Nature turbulence exists that overpowers hang gliders, and it is not well-predicted by the turbulence encountered previously.

Looking Forward: Opportunities to Prevent Such Crashes by Other Pilots or Reduce Risks

Awareness

- Turbulence exists invisibly that can invert your glider immediately.
  In this accident, the fatal turbulence was not predicted by the conditions experienced in the hour and 3 minutes prior to the accident – including the 10 minutes flying at the accident location immediately before the accident occurred.
  A week prior to this accident, a pilot named Wolfi was similarly inverted by turbulence. His wings collapsed, and he survived only due to a successful parachute deployment. (That video is currently on YouTube).

- Proximity to the ground is a big risk factor. Altitude is required for recovery from turbulence-induced loss of control, as well as for emergency parachute deployment.

Training and Preparation

There may be techniques that pilots could benefit from programming into their “middle-brain” (the part that handles life-threatening situations without cognitive thought), such as:

- Rapid parachute deployment under certain circumstances
- Effective recovery of aerodynamic control after turbulence-induced stalls, turns, rolls, and/or pitches

Additional training suggested by this fatal accident:

- When flying near terrain, always have at least one escape route or exit plan before hitting turbulence or strong sink.
- Practice evasive actions while flying at safe altitude in benign conditions.
- Reconsider your definition of safe clearance from terrain
- Reconsider your definition of safe speeds to fly when close to terrain

Suggested:

As a training issue, pilots may not appreciate the full dangers of flying low and slow in active air. To address the “low” aspect, suggest as a rule of thumb that a pilot should maintain enough altitude that at any time and without warning, he could be “locked out” and complete a full 360 degree turn towards the hill, in the day’s biggest sink, without hitting the terrain. To address the “slow” aspect, the risks when flying close to the terrain are similar to those when landing, and so speed margins should be similar as well: one’s flight speed should be at least stall speed plus 1.5 times the maximum gust factor of the day.

Given the complexities of requesting helicopter search and rescue operations and the commonly-perceived costs of ordering an unnecessary rescue:

- Handy detailed instructions/best practices for ordering helicopter rescue operations can lead to quicker emergency response times. (911 operators may need guidance for fastest response)
- Flying with regular radio check-ins can lead to quicker emergency response times

Opportunities to Reduce Risks – from Juan Corral (glider designer on the investigation team)

The unfortunate fatal accident of one of our friends, and the investigation afterwards as to what caused it, were the reasons I wanted to write down my experience regarding the risks we take when we fly.

In trying to find the cause of the accident – and perhaps prevent other accidents from happening -- it became clear to me that our friend was not flying in conditions that were extreme or out of the ordinary. Nor was he doing anything different than what many of us do routinely.

He appears to have been at the wrong place at the wrong time.

This was very sobering for me. There is usually a “smoking gun” or a clearer reason or cause. I looked hard for either that one mistake he might have made while flying, the weather conditions, or a problem with the glider that would explain the accident. I really wanted to find it, but I was reminded one more time of the risks that come with flying.

So in finding ways in which to reduce some of the inherit risks that come from flying, I have a few points for you to consider:

1) The risks we are willing to take to fly and to soar
2) The airspeeds we fly in turbulent air
3) The stability of our hang gliders as it relates to our airspeed

1) Taking greater risks

If we want to find lift and soar for long periods of time, we will routinely fly close to the mountain. Flying near the typical thermal trigger zones increases our chances of finding lift, but also poses additional risks. We are often successful in finding lift this way, and we are very often rewarded with a good climb that will extend our flight. This is often the most dangerous time for us as we are close to the ground, often trying to fly slower, and we are flying around the lift trigger areas where the roughest and most turbulent air can be found.

We have gotten good at "working the hill", we have developed great sensitivity to the air texture and refined our skills that allow us to imagine where the lift may be, and we are successful most of the time.

But let us not forget that this is another one of the risks we take when we fly. The acts of taking off and landing have their own risks, we take special precautions and use specific techniques to minimize the risk during takeoff, during approach and in landing.

The act of soaring close to the hill is an additional risk that also needs to be constantly evaluated. Some of our common questions in the air are:

How close can I get?

How much can I slow down?

Where is the drift taking me?

The reality is that the majority of us pay more attention to the dangers during takeoff and landing. But once we are airborne, we focus on finding lift. We often do not leave much safety margin for the worst case scenarios like getting turned into the hill, getting blown behind the mountain and into the rotor, or a more extreme situation like getting flipped upside down without enough altitude to recover or have a successful parachute deployment.

These are only a few of the scenarios that could happen, in which we would find ourselves in big trouble.

Maintaining higher speeds and greater distances to the terrain are choices that can reduce risk.

2) Airspeeds we fly in turbulent air

A hang glider is much more susceptible to air-induced shifts of relative angles of attack when flying close to the hill. This is due to mechanical turbulence and gusts related with lift or sink. These angle of attack changes can have huge effects on how the glider flies and where it’s going. We are often overpowered and can momentarily lose control of the direction of flight.

Getting "locked out" is loss of control!

Having to wait for the glider to respond to our input is a loss of control!

If this is hard for you to believe, imagine if this happened to your car while driving: locking you out into a turn and your having to wait for it to respond.

We have come to accept and even expect the fact that at some point in our flight we will get pushed out, locked out, or turned around when we don't want to.

Again, this is accepting that at some point in the flight we will lose control!

Turbulence also has a significant effect on our airspeed. The faster we fly the less effect it will have over us, and the slower we fly the more influence it will have over us. It’s about the differential between the winds we fly in, and the airspeed we fly at.

We mostly fly at airspeeds between 28-35 mph. On an average day we will fly in wind speeds that are somewhere between 15-22 mph. The difference between the two is only about 13mph - not very much!

As an example:

If a small aircraft flies at around 120mph, in 15-22 mph winds, the difference between that is about 98 mph. The wind will not have the same effect on them.

The rotational wind speeds that can be found in a thermal or "dust devil" near the hill are often greater than a 13 mph differential. This means that the gusts that we are likely to encounter in turbulent air can easily overpower us.

The slower we fly, the greater the effects of turbulence over us and the more likely we are to find ourselves in situations that are difficult to recover from.

So, to reduce the risk of loss of control, additional airspeed and more separation from the mountain is highly recommended.

But here is where we make a choice between flying conservatively or taking more risk, and in most cases this is the difference between getting up or not!

The majority of the time we choose to take the risk and fly closer and a bit slower and hope for the best! Because the odds are low, and we are successful most of the time, a certain level of complacency and over-confidence develops in most of us. This is a dangerous attitude because the risk is still there.

The reality is that we are more like butterflies in the wind, and we often fly in conditions that overpower us – and we accept this as normal.

This is a choice we make. Because we get away with it time after time does not make the risk and potential danger any less.

3) Glider stability

Hang gliders have only a certain amount of aerodynamic stability built into them, and they are far from perfect. We are very susceptible to turbulence due to the low speeds we fly at. We have a pilot suspended below by straps only, not a rigid connection. If the glider were to end up upside-down and the pilot is not able to hang on to the base tube, he will then fall into the glider with a high probability of breaking it.

The dive recovery system of a hang glider -- like the luff lines, sprogs and or washout struts – work by supporting the trailing edge of the glider. As the airflow passes over the wing, it adds the necessary positive aerodynamic force for it to recover stable flight--but only as long as there is enough airspeed flowing over the wing to generate these aerodynamic forces.

Again, airspeed is needed for a hang glider to recover when it encounters severe turbulence that causes the glider to get pitched downward, or causes the glider and pilot to go weightless.

So when a hang glider is flying slow, it has the least aerodynamic pitch stability.

This means that a glider flying slowly is very susceptible to: getting hit by either a severe gust from above, a rapid negative rotation due to turbulence, a whip stall, or falling out of a strong thermal.

Under these circumstances the glider does not have a lot of resistance to rotation.

You do not need to understand how a hang glider achieves it stability or the physics behind it, but you would benefit from knowing that airspeed is essential to maintain stability and flight, and to reduce some of the risk associated with flying in turbulent air.

Summarizing:

Awareness of the risks is key: flying has inherit risk on its own, and there are additional risks that are increased by how we choose to fly. Understanding and accepting the potential consequences of those decisions will help us better manage risk and lower it as much as possible.

fly safe

Juan Corral

Appendix

Track Log Analysis – from Jeff Chipman

Recording Mode = Full Auto
Instrument recording interval = 10s

Only one track log present
Flight started 13:57:02
Flight Ended 14:59:52

Interestingly, the track shows most of the flight at Kagel was below launch height. Not until the glider went to Towers did the track show altitudes higher than launch. Max altitude of 3901' was achieved about 7 minutes before the end of the track log.

14:59:22 glider headed SE, alt 3655' descending @ 283.8fpm
14:59:42 glider headed NW. 10sec before end of flight, glider was @ 3570' descending @ 627.7fpm
A rapid IAS deceleration begins to show up in the track log going from 24.7 to well below stall speed in about 5 seconds
14:59:52 glider headed N, alt 3409' descending @ 550.6fpm. However, there is no IAS (indicated airspeed). Groundspeed shows 9, but assume this is related to GPS catching up due to slow recording rate.

At this point the track log records no further altitude changes or rate of climb changes. The instrument GPS location did move slightly, but might be attributed to GPS drift or settling due to low recording frequency.

Screen shot of SeeYou flight properties:

Pilot name: Markus Schaedler
Glider type: HANGGLIDER
Competition class: Unknown
Registration: FREEDOM 170
Competition number:

Takeoff: 13:57:02 at 3383ft (Sunrise: 05:56)
Soaring begin: 13:57:02 at 3389ft
Soaring end: 14:59:52 at 3409ft
Landing: 14:59:52 at 3409ft (Sunset: 19:43)
Duration: 01:02:50

5/14/2015 I added a video of the flight looking at the last few seconds if the flight concentrating on altitude, vertical speed, indicated airspeed.

5/15/2015 converted track log via GPSVisualizer, thinned the tracklog and clamped to the ground so terrain doesn't get in the way at the request of Juan Corral.