

**NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Vehicle Recorder Division
Washington, D.C. 20594**



**GROUP CHAIRMAN'S FACTUAL REPORT OF
INVESTIGATION
Onboard Image Recorder Factual Report
WPR15FA021**

**By
Sean Payne**

WARNING

The reader of this report is cautioned that the transcription of a cockpit image and audio recording is not a precise science but is the best product possible from a Safety Board group investigative effort. The transcript or parts thereof, if taken out of context, could be misleading. The transcript should be viewed as an accident investigation tool to be used in conjunction with other evidence gathered during the investigation. Conclusions or interpretations should not be made using the transcript as the sole source of information.

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division

Washington, DC 20594

October 27, 2014

Onboard Image Recorder

Group Chairman's Factual Report By Sean Payne

1. EVENT

Location: Ridgecrest, California
Date: October 24, 2014
Aircraft: Slingsby T-67M 260, N456FR
Operator: National Test Pilot School
NTSB Number: WPR15FA021

2. GROUP

On February 25, 2015 a video group was convened at the National Transportation Safety Board (NTSB) Vehicle Recorder Laboratory.

Chairman: Sean Payne
Mechanical Engineer
National Transportation Safety Board (NTSB)

Member: Joshua Cawthra
Investigator-In-Charge
NTSB

Member: Gregory Lewis
Director
National Test Pilot School (NTPS)

Member: Scott Glaser
Operations Manager
Flight Research Inc.

3. SUMMARY

On October 24, 2014, about 0900 Pacific daylight time, a Slingsby T67M-260, N456FR, was substantially damaged when it impacted terrain near Ridgecrest,

California. The airplane was registered to L'Avion Inc., Mojave, California, and operated by the National Test Pilot School under the provisions of Title 14 *Code of Federal Regulations* Part 91. The flight instructor and passenger were fatally injured. Visual meteorological conditions prevailed and no flight plan was filed for the instructional flight. The local flight originated from Mojave Airport (MHV), Mojave, about 0832.

4. DETAILS OF INVESTIGATION

On October 28, 2014 the NTSB Vehicle Recorder Division received the following image device(s):

Recording Device:	GoPro Hero 3+ Black Edition
Serial Number:	H3B+B031 41DAA12

4.1. Recorder Description

The GoPro HERO 3+ Black Edition is a compact, lightweight, POV¹ digital camera enclosed in a ruggedized housing that allows the camera to be mounted in a variety of positions using an array of supported accessories. The camera supports 1080 HD² as well as other lower quality recording resolutions at higher frame rates. The camera can be set to record still images simultaneously or independently of a video stream at a resolution of up to 12 megapixels.³ The camera includes a wide angle aspherical f/2.8 glass lens that provides a maximum of 170 degrees viewing angle. The camera supports recording to micro SD⁴ cards up to 64 GB in size. A built in Wi-Fi⁵ module allows users to connect to the camera either via an accessory remote control or via a smart phone app that permits camera control and image transfer.

4.2. Recorder Damage

The GoPro camera arrived to the NTSB Vehicle Recorder Division in an undamaged state. The lens and rear communications port was found to have trace amounts of debris. The SanDisk SDXC memory card also arrived undamaged and was found seated in the GoPro's memory card slot inside the watertight enclosure. The memory card was read out normally on a PC using a forensic write blocker. Figure 1 shows the condition of the GoPro Hero, figure 2 shows the condition of the 64 GB SanDisk SDXC memory card.

¹ POV – Point of View Shot – A photography technique that records the character's viewpoint from a singular camera location mounted in a manner that represents the character's field of view.

² HD – High Definition – A resolution generally consisting of greater than 480 lines of horizontal resolution.

³ Megapixel – (MP) – A count of a million pixels in an image or used to express the number of individual image sensor elements on a digital camera image sensor.

⁴ SD – Secure Digital – a standard for nonvolatile memory card used in portable devices.

⁵ Wi-Fi – A local area wireless technology that allows electronic devices to exchange data over a network.



Figure 1. The condition of the GoPro Camera.



Figure 2. The condition of the micro SD card.

4.2.1. Video Files

The majority of the files were delivered in an MP4⁶ format of 1920 x 1080 pixels in resolution at 30 frames per second with a 48kHz audio track. Since the camera was enclosed in a watertight case, and the microphone is enclosed inside this case, the audio track only captured muted engine and cockpit noises.

⁶ MPEG-4 Part 14 -- A digital multimedia container format used to store video and audio.

During portions of the recording, some muffled vocal comments by the instructor and student could be heard.

The GoPro was mounted to the right side of the aircraft's canopy using a GoPro suction cup mount. The camera provided a view of the right wing. Within the field of view, the right wing was visible from root area near the right side of the aircraft to the right wingtip. The right aileron and a large portion of the right flap were visible. The movement of the right aileron and flaps were noticeable throughout the recording. Additionally, a reflection of inside the cockpit could be seen during portions of the recording when lighting conditions were favorable. The reflection was mostly the torso of the student, in the right seat, who was wearing a green flight suit. Occasionally the instructor, in the left seat, could be seen in the reflection wearing a blue flight suit and wearing a silver jewelry band on his right wrist. At times the left seat pilot and instrument panel became distinguishable. Figure 3 shows the field of view of the rightward facing GoPro camera for most of the recording.



Figure 3: A digital illustration of the field of view of the canopy mounted GoPro Hero 3+ Black.

The SD card file structure contained video files consistent with a GoPro recording continuously and in normal operation. Seven MP4 video files were discovered on the SD card. The files, duration of recording, and timestamp information is shown below in Table 1. The file structure and associated file durations were consistent with a GoPro camera segmenting large video files in approximately 4 GB chunks and eventually shutting down upon depletion of battery power.

Table 1. Video files found on the SDXC memory card.

Filename	Timestamp Information	Duration (MM:SS)	Contained Accident?
GOPR0101.MP4	08:19:15	17:25	No
GOPR10101.MP4	08:36:40	17:25	No
GOPR20101.MP4	08:54:04	17:25	Yes
GOPR30101.MP4	09:11:29	17:25	Post Impact
GOPR40101.MP4	09:28:55	17:25	Post Impact
GOPR50101.MP4	09:46:20	17:25	Post Impact
GOPR60101.MP4	10:03:44	8:38	Post Impact

4.3. Timing and Correlation

Timestamp information used for this report was read from each video file's EXIF⁷ metadata. The EXIF metadata displayed the camera's internal time clock setting which was set by the user at an unknown time. A time offset was attempted to be established to a recognized and accurate time source. When the camera was powered in the NTSB laboratory, the EXIF time information indicated the internal clock had been reset since the accident and a time offset was unable to be established. This was likely a result of the camera's battery being depleted and found in a discharged state.

The provided timestamp information from the EXIF metadata was determined to be in approximate agreement with other timing information used in this case. The EXIF metadata was used as the only source time for this report.

4.4. Summary of Recording Contents

The section below summarizes flight events in chronological order. Where possible, maneuvers were matched to their associate flight "event" as published on the flight test card "Firefly BFAP F9" which was found in the aircraft wreckage. A copy of the flight test card can be found in the public docket for this accident. Between the flight events listed below, the aircraft was either climbing or maneuvering normally to set up for the next flight event as described on the test card. The time format presented is HH:MM:SS.

Preflight, Takeoff and Initial Flight Activities

The first file, GOPR0101.mp4 began recording at 08:19:15. The engine was running and the aircraft was sitting at idle on the NTPS ramp at Mojave Air and Space Port (KMHV), Mojave, California. The aircraft began taxiing at approximately 08:20:06. At 08:22:35 the aircraft reached a run-up near Runway 26 and became stationary. The reflection of the student was seen in the canopy, his head was visible and he appeared to be looking at the instrument panel or a checklist. At 08:23:08, an increase in engine noise consistent with an engine run-up was noted. By 08:23:56, the aircraft returned back to a low power setting. The flaps became set at the takeoff position while in the run-up area at 08:24:43. The

⁷ EXIF – Exchangeable Image File Format – a format specifying formats and ancillary tags used by digital imaging devices.

canopy was closed shortly thereafter. By 08:26:11, the aircraft began taxiing again. The aircraft crossed the hold short line for Runway 26 and lined up on the runway. By 08:26:51, the aircraft had begun the takeoff roll. Rotation occurred around 08:27:09 and the flaps were brought up as the aircraft climbed out. Around 08:37:30, the power setting was changed and the aircraft appeared to have leveled off.

Around 08:38:00, the power setting was reduced to near idle and the aircraft began to enter a maneuver consistent with a wings level stall. The aircraft entered an idle glide, the nose appeared to gradually increase in pitch, the sound of wind noise near the camera decreased steadily, and the stall horn activated at 08:38:35. Shortly after, at 08:38:46, the aircraft nosed down slightly in a stall and by 08:38:46, power was returned to a higher power setting (engine noise level increased) and the aircraft had recovered from the event.

Upon comparing the events of the video to the flight test card, it was determined that the above event was "Event 2" and that "Event 1" and "Event 3" were not flown. The following portion of the report references maneuvers based upon their name on the flight test card.

EVENT 4:

At approximately 08:39:51 the engine noise reduced in level to a sound consistent with power being at idle. The pitch angle began to slowly increase as noted by the camera's orientation to the horizon. At 08:40:12, the stall warning horn was audible on the recording and the pitch angle continued to increase. The ambient noise of air rushing past the canopy/camera decreased. By 08:40:26, the nose began to drop slightly and the aircraft began to break left into a spin entry. The aircraft entered a spin to the left, the nose had pitched steeply down during the first portion of the first turn of the spin. By 08:40:29, the pitch attitude had become more neutral and one turn of the spin had been completed. Around 08:40:30, a slight movement of the right aileron was visible. A slightly larger deflection of the right aileron was visible at 08:40:31. By 08:40:33, the spin had stopped and the aircraft was still pitched nose down. The recovery began as the aircraft pitched back toward the horizon at 08:40:34. By 08:40:36, an increase in engine power was audible and the aircraft continued to level. By 08:40:40, the aircraft had recovered from the spin and was flying in a normal attitude.

During this maneuver, the aircraft had completed approximately two turns of the left hand spin by the time of recovery.

A small flying insect was seen on the video inside the cockpit around 08:42:25. It appeared to be a dragon fly or mosquito and was visible at other times throughout the three inflight recordings.

EVENT 5:

At approximately 08:43:38 the engine noise reduced in level to a sound consistent with power being at idle. The pitch angle began to slowly increase as noted by the camera's orientation to the horizon. The pilot and copilot's shadow

as well as a shadow of the canopy were visible on the wing and the shadow's movement along the wing is consistent with the aircraft's noted continued increase in pitch. At 08:43:59, the stall warning horn was recorded and the pitch angle continued to increase. The ambient noise of air rushing past the canopy/camera decreased throughout this portion of the recording. By 08:44:17, there was a slight buffet noticeable to the aircraft and nearly at the same moment, the aircraft began to break into a spin entry in the right hand direction. The right aileron deflected slightly upward. The spin began and the aircraft's nose pitched down sharply during the first portion of the first turn. Around 08:44:19, the aircraft had completed one spin to the right. Around 08:44:22, audio enhancement revealed the instructor stated the word "oscillating". At 08:44:23, the aircraft had completed two turns of the right spin. Three turns had been completed by 08:44:25. Four turns had been completed by 08:44:27. By 08:44:29, the aircraft had completed between 4 and $\frac{1}{4}$ and 4 and $\frac{1}{2}$ spins to the right and had stopped spinning with an increase in pitch beginning to a level attitude shown shortly thereafter.

Throughout the first part of the maneuver, the instructor's hands appeared in the canopy's reflection and showed him to be guarding the stick in the aft position. As the aircraft recovered, the reflection showed the instructor was no longer guarding the stick aft, but his hands were resting in his lap area.

Around 08:44:31, an increase in engine power was audible as the aircraft's pitch continued to increase. Around 08:44:36, the aircraft had become almost level and the engine continued to be audible at a climb or a high-power setting.

During the right-hand spin, the right aileron was slightly deflected upward and oscillating at a frequency associated with the aircraft's rotation. Voices were audible on the recording calling out the number of spin turns consistent with the time and number of spins performed during this maneuver. The aircraft oscillated slightly in pitch about every 2 seconds, nearly the same frequency as the rotation motion. The aircraft had completed 4 and $\frac{1}{4}$ to about 4 and $\frac{1}{2}$ turns during this maneuver.

At times, the instructor's hands were away from the controls in the canopy reflection during the non-accident portion of flight.

Table 2 presents information from the video recording during the spin encountered on event #5. A simple estimation of pitch attitude was obtained by measuring the chord of the main wing at the wingtip verses the visible horizon. The measurement was made with a protractor. The video was paused and the angle was measured during each spin when the wingtip met, or came close to the horizon. The spin number in which the measurement was taken is listed on the column on the left. The pitch attitude in degrees is listed in the column on the right. A negative pitch attitude represents the aircraft being nose down. The error was not quantified.

Table 2. Pitch attitude estimation during Event #5.

Spin No.	Pitch Attitude (degrees)
1	Positive attitude
2	-30
3	-33
4	-32

EVENT 6:

At approximately 08:48:27 the engine noise reduced in level to a sound consistent with power being at idle. During this time, the aircraft increased slightly in pitch as compared to the horizon. The shadow of the co-pilot and canopy on the right wing was moving in a manner consistent with this pitch increase. By 08:48:47, the stall warning horn began to sound. Pitch continued to increase slightly and steadily. A buffet of the aircraft was visible around 08:48:54 and a spin entry to the left began. At 08:48:56, a reflection of the pilot and co-pilot was visible. A green sleeved left hand was on the throttle. Additionally, a blue sleeve with a jewelry band was resting on a blue pant leg knee. By 08:48:58, one turn of the left hand spin had been completed. The reflection showed two blue sleeved hands not manipulating the aircraft's controls. By 08:49:00, two left hand spins had been completed. By 08:49:02, the third left spin had been completed. By 08:49:05, four left spins had been completed. By 08:49:06, the aircraft had stopped spinning and was pitched nose down. At this time, just over 4 and ½ left spins had been completed. Engine power was added smoothly and the aircraft recovered by 08:49:11.

Additional review of the reflection during the spin and during recovery indicated that the blue sleeved arms remained stationary during the entire maneuver. A voice was audible counting spins during the maneuver and additionally stating "full rudder" after calling out spin number 3.

Around 08:50, the reflection in the canopy showed the instructor pilot gesturing with his hand during flight and the student nodding his head. Throughout the next minute and half the instructor was gesturing with both hands while the student continued to nod as well as move his hand on and off the throttle area. The student's blue parachute harness straps were visible in the reflection, they appeared fastened. The position of the seatbelt harness could not be determined.

EVENT 7:

Below is a table summarizing the events of Event 7 which was the accident flight event. The aircraft entered an upright right spin in a manner consistent with the previous descriptions of flight card events. According to the test card, Event 7 was described as a 6 turn spin to the right.

After the bailout sequence was initiated, the group determined that the aileron position moved almost to the full right position which may have been due to releasing pressure on the control stick.

Table 3 provides a description of Event 7 and shows the time associated with each spin number and the visible right aileron position. Each line also contains a section for general remarks about other events that occurred in the spin sequence. Within the remarks section, there are voice comments that were transcribed by the video group. Voice comments appear in ***bold italics*** within the remarks section; the speaker is identified as either the student, the instructor or a responder. General noises also appear in ***[bold italics]*** and are enclosed within brackets ([]). An asterisk (*) indicates an unintelligible word.

At the entry of the spin, the both of the instructor's knees were visible in the canopy reflection and the instructor's right hand appeared to be on his right knee. The instructor's left hand was not visible. The student's left hand appeared to be gripping the center throttle. The student's right hand was not visible.

Table 3. A summary of events during flight event 7.

Time	Turn #	Aileron Position	Remarks
08:53:41:00	N/A	Neutral	Engine sound had decreased to idle.
08:53:58:00	N/A	Neutral	Stall warning horn began to sound.
08:54:05.50	N/A	Close to neutral	Aircraft began right departure.
08:54:08.10			<i>Student: one</i>
08:54:08.43	1	Slightly up	Observed hands were in the same position as discussed previously.
08:54:09.70			<i>Instructor: ** two</i>
08:54:10.73	2	Slightly up	Observed hands were in the same position as discussed previously.
08:54:12.83	3	Slightly up	<i>Student: three</i> Observed hands were in the same position as discussed previously
08:54:14.93	4	Slightly up	Observed hands were in the same position as discussed previously.
08:54:15.10			<i>Student: four</i> Observed hands were in the same position as discussed previously.
08:54:16.30			<i>Student: eighty knots. to the right. five.</i>
08:54:16.97	5	Slightly up	Only student's left hand is observed on the throttle. Instructor's right hand is now unseen.
08:54:18.20			<i>Student: six. recover. ** stick forward</i>
08:54:18.93	6	Slightly up	Pitch oscillation was damped out by this time.

Time	Turn #	Aileron Position	Remarks
08:54:20.20		Slightly up	Left arm of blue sleeve (instructor's left hand) moved toward and onto control stick. The stick appeared to be in the aft position. Student's left hand was no longer visible on the throttle. Student had removed his left hand from the throttle. The student's right hand was never clearly visible
08:54:21.03	7	Close to neutral	Instructor's left hand was visible on the control stick. The stick appeared to be slightly less aft than seen previously.
08:54:22.93	8	Slightly up	Instructor's left hand was visible on the control stick. The stick appeared to be slightly less aft than seen previously.
08:54:24.97	9	Slightly up	Instructor's left hand was visible on the control stick. The stick appeared to be in the aft position.
08:54:26.80	10	Close to neutral	Instructor's left hand was visible on the control stick. The stick appeared to be in the aft position.
08:54:28.50	11	Slightly up	Instructor's left hand was visible on the control stick. The stick appeared to be in the aft position.
08:54:30.47	12	Close to neutral	
08:54:31.97		Close to neutral	Left arm of blue sleeve was visible either making a forward motion or possibly a motion consistent with relaxing back pressure on the control stick. Position of instructor's hand on the stick appeared to have changed slightly. By the end of spin 12, the motion of the instructor's left hand blue sleeved forearm suggested that the stick was once again moved aft.
08:54:32.43	13	Close to neutral	
08:54:33.17		Slightly down	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:33.33		Close to neutral	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:34.20	14	Slightly down	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:36.23	15	Close to neutral	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:37.90			<i>Student: eight thousand * seventy five hundred</i>
08:54:37.97	16	Close to neutral	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:39.97	17	Close to neutral	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:41.87	18	Close to neutral	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.

Time	Turn #	Aileron Position	Remarks
08:54:43.93	19	Slightly down	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position. Aileron went slightly left half way through this turn.
08:54:45.80			<i>Student: six thousand five hundred</i>
08:54:45.90	20	Slightly down	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:47.90	21	Slightly down	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:48.90			<i>Student: six thousand feet</i>
08:54:50.03	22	Close to neutral	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:51.40			<i>Student: * * five thousand five hundred⁸</i>
08:54:52.17	23	Close to neutral	Instructor's left hand was in the immediate vicinity of the stick. The stick appeared to be in the aft position.
08:54:53.87		Close to neutral	An unknown arm was visible in the shadow on the wing moving toward the top part of the canopy
08:54:54.03	24	Close to neutral	
08:54:54.50			<i>[sound of canopy opening]</i>
08:54:54.53		Close to neutral	Reflection showed canopy began to open. Left arm of blue sleeve was still visible in the vicinity of the stick, congruent with an aft stick input.
08:54:55.00		Close to neutral	Canopy appeared fully open. From this time until impact, a reflection of the instructor showed his body in a seated position. The instructor appeared in a seated position until impact.
08:54:55.70			<i>[sound of wind noise until the time of impact]</i>
08:54:56.10	25	Close to neutral	A slight up and down movement of the instructor's head was visible.
08:54:57.83		Close to neutral	Student headset removal visible in shadow on wing.
08:54:58.17	26	Up	
08:54:59.87		Up	Shadow indicated arm grabbing upper canopy rail.
08:54:00.10	27	Up	
08:55:01.07		Up	Blue sleeved arm (instructor's right arm) shown in reflection grabbing canopy rail, student visible looking toward the right of the aircraft with right arm possibly right and forward. Student also visible grabbing upper canopy rail with left arm, using it to prop himself upward.
08:55:02.00		Up	Small portion of a black strap visible outside of the cockpit

⁸ Around this time in the recording, the group examined some audio comments possibly related to usage of the word "bailout", however, the group could not identify the speaker, or come to a consensus on whether or not there was even an audible spoken word.

Time	Turn #	Aileron Position	Remarks
08:55:02.07	28	Up	
08:55:03.77		Up	Shadow indicated student was about half way to standing up
08:55:04.10	29	Up	
08:55:05.80		Up	Shadow of student pilot almost completely standing and grabbing the upper canopy rail
08:55:06.13	30	Up	
08:55:07.37		Up	Student tossed headset
08:55:07.93		Up	Student stood and grabbed upper canopy rail
08:55:08.23	31	Up	Student headset visible dangling by wire on right wing
08:55:10.23	32	Up	
08:55:12.33	33	Up	
08:55:12.53		Up	Student's right foot outside of aircraft in a standing-like position
08:55:12.97		Up	Student's right foot stepping on wing
08:55:13.83		Up	Student jumping from right wing of aircraft and into an parachute arc position. The parachute's closing flap was in a closed position.
08:55:14.33	34	Up	
		Up	First indication of impact
08:55:15.30			[sound of impact] The camera view became obscured with debris for the remainder of the recording
10:01:10.00			A sound of a helicopter in close proximity to the camera location was audible
10:09:40.00			Responder: hey buddy! hey! hey! hey!
10:10:18.00			A sound similar to a human walking near the wreckage was audible
10:12:22.87			The last recording in the recording sequence ends

PITCH ATTITUDE ESTIMATION DURING EVENT 7:

Table 4 presents information from the video recording during the spin encountered on event #7. The table was created using the same methodology as Table 2. Measurements stopped when the camera position began to change as the canopy opened.

Table 4. Pitch attitude estimation during event #7.

Spin No.	Pitch Attitude (degrees)
1	-43
2	-45
3	-42
4	-41

Spin No.	Pitch Attitude (degrees)
5	-49
6	-56
7	-60
8	-60
9	-50
10	-51
11	-54
12	-55
13	-52
14	-43
15	-48
16	-48
17	-43
18	-41
19	-38
20	-52
21	-48
22	-50