NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, DC 20594

April 30, 2020

Onboard Image, Audio, and Data Recorder

Specialist's Factual Report
By Sean Payne

1. EVENT

Location:	Hazelhurst, Wisconsin
Date:	April 26, 2018
Aircraft:	Airbus Helicopters AS350B2, N127LN
Operator:	Air Methods Corporation
NTSB Number:	CEN18FA149

2. SUMMARY

On April 26, 2018, about 2243 central daylight time (CDT), a Eurocopter AS 350 B2 helicopter, N127LN, impacted trees and terrain during cruise flight near Hazelhurst, Wisconsin. The pilot and two crewmembers were fatally injured. The helicopter was destroyed during the impact. The helicopter was registered to and operated by Air Methods Corporation as a Title 14 *Code of Federal Regulations* Part 91 repositioning flight. Night visual meteorological conditions were reported in the area about the time of the accident, and the flight was operating on a company visual flight rules flight plan. The flight originated from the Dane County Regional Airport-Truax Field (MSN), near Madison, Wisconsin, about 2104 and was destined for the Howard Young Medical Center Heliport (60WI), near Woodruff, Wisconsin.

3. GROUP

A group was convened on December 4th and 5th, 2018 at the Vehicle Recorder Laboratory at NTSB headquarters in Washington, D.C. The group consisted of the following members:

Chairman:	Sean Payne Mechanical Engineer National Transportation Safety Board (NTSB)
Member:	Ed Malinowski Investigator-In-Charge (IIC) NTSB

Member:	Scott Tyrrell Accident Investigator, Rotorcraft Standards Staff Federal Aviation Administration (FAA)
Member:	Sophie Bascoul Safety Investigator Bureau d'Enquêtes et d'Analyses (BEA)
Member:	Manny Figlia Director, Aviation Safety Airbus Helicopters
Member:	Cory Cummins Director of Flight Safety Air Methods Corporation

4. DETAILS OF INVESTIGATION

On May 7, 2018, the National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following image, audio and parametric data recording device:

Recorder Manufacturer/Model:	**Appareo Vision 1000**
Recorder Serial Number:	**VIS-FG06**

4.1. Appareo Vision 1000 Recorder Description

The Appareo Vision 1000 device is a small self-contained image, audio, and data recorder. The unit is typically mounted in the overhead of aircraft's cockpit and records a cockpit image at a rate of four times per second. In addition to cockpit images, the device is also capable of recording two tracks of audio that are synchronized with the image data. The unit also contains a GPS receiver that receives GPS satellite-based aircraft time, position, altitude, and speed. In addition to the GPS position, the Appareo unit also has a self-contained real-time inertial measuring unit that provides 3-axis accelerations as well as aircraft pitch, roll and yaw data.

The two recorded audio tracks can be wired to record the following inputs: an external audio source such as the aircraft's intercom or radios and audio picked up by a microphone mounted internal to the Vision 1000 unit. In this installation one input was determined to be external aircraft audio that was wired to the helicopter's intercom and recorded pilot and crew communication. The other track only picked up very loud engine and/or transmission sounds from the helicopter and was determined to have been recorded by the Vision 1000's internal microphone.

The Appareo unit records the image, audio and parametric data on a removable SD[1] memory card that is inserted into the unit. Depending on card size, this removable memory retains approximately the last two hours of image and audio data and about the last 100 hours of parametric data. In addition to the removable memory the Vision 1000 is also equipped with a memory module that is mounted internal to the unit. This internal memory contains an exact duplicate of the data stored on the removable card.

The Appareo unit on this aircraft was connected to the aircraft's electrical bus. Any time the battery switch is turned on the Appareo unit will start to record audio, images and data. The Vision 1000 unit creates a new file for every electrical power application and can create multiple files for the same power cycle if the recording time exceeds a certain time limit.

4.2. Appareo Vision 1000 Damage

Upon arrival at the NTSB Vehicle Recorder Division, it was evident that the Vision 1000 device had sustained heavy impact damage. The device's external mounting case was destroyed. The associated SD card was cracked through the silicon die, rendering it unusable. The SD card was not crash protected and was unrecoverable. Figure 1 shows the Vision 1000 device and the associated SD card.

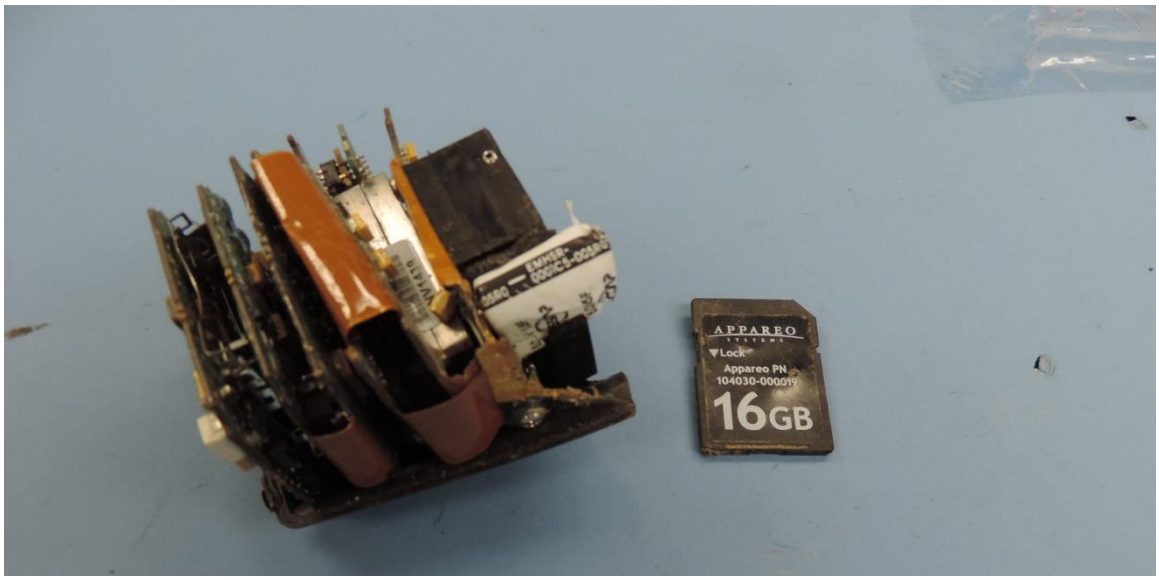

Figure 1. The Appareo Vision 1000 device and the associated SD card, as received.

4.3. Appareo Vision 1000 Data Recovery

The device was disassembled in the laboratory and the internal non-volatile memory (NVM) was extracted from the unit. The internal NVM is shown in figure 2.

[1] SD – Secure Digital – A type of nonvolatile memory card used extensively in portable devices.

Figure 2. The internal NVM as it was extracted from the device.

The internal NVM was undamaged. The internal NVM was de-soldered from the device and each NVM chip was read using a Xeltek series 6000 chip reader. The chip reader produced two binary images of the contents of the NVM. Using manufacturer supplied conversions, the binary data was attempted to be converted back to image, audio and parametric data. This conversion process resulted in the recovery of approximately the last 8 minutes of recorded images, the last 20 minutes of recorded audio and no parametric data. The manufacturer supplied conversion process was unable to recover the entire dataset, and large portion of the accident flight was not available for review at this time. The group transcription exercise was postponed until all data could be conclusively recovered.

The memory chips were then brought to the manufacturer's facility in Fargo, North Dakota to attempt to recover data from the entire accident flight. During the visit to the manufacturer, it was discovered that the manufacturer did not have a provision to read the binary content of the device's internal NVM memory chip. Due to this issue, the memory chips had to be installed in a surrogate device of the same model and legacy and downloaded. The certification process for this unit did not require the manufacturer to have tools available to read the internal memory chip, nor did it address how data would be recovered post-accident since the device was not designed to be crash protected.

Under the supervision of the NTSB specialist, the NVM was soldered into a working surrogate Vision 1000 device. The device was then downloaded normally with the accident NVM installed in the surrogate Vision 1000.

Each time power is applied to the unit, a set of data files is created. The downloaded files from the repaired device contained over 270 power cycles worth of data. By design, approximately the last two hours of files will contain image, audio and parametric data. Files outside of the last two hours of operation contain parametric data only.

The entire accident flight was recorded and included image, audio and parametric data. A short flight previous to the accident was also recorded and included image, audio and parametric data. The second previous flight to the accident contained some image and audio data, but a full set of parametric data. Parametric data

existed back until early February 2018, about two and half months prior to the accident.

Figure 3 is a screenshot taken from the recorder that shows an example of the camera's image on the flight previous to the accident. The pilot has been redacted from this image.

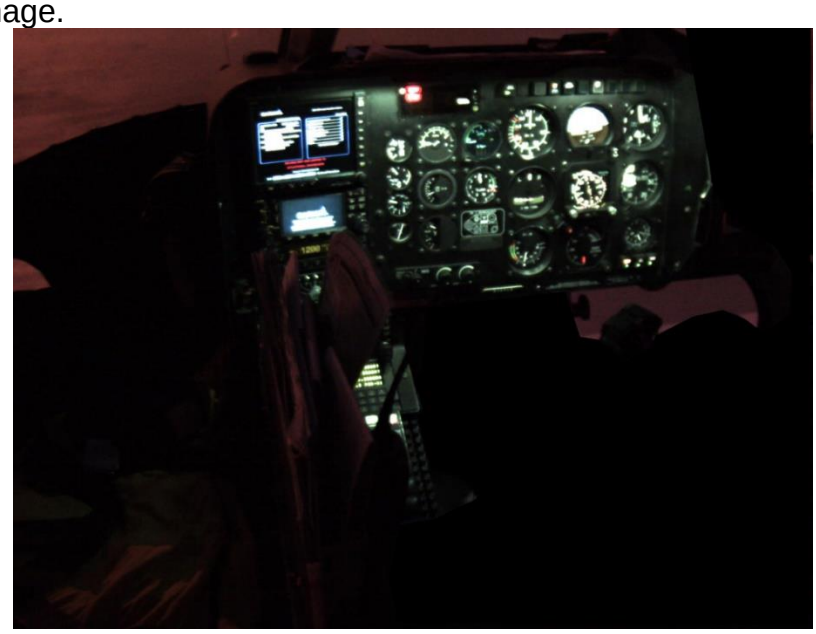

Figure 3. A capture from the Appareo image recorder, serial number VIS-FG06 installed on N127LN, taken prior to the flight previous to the accident flight. The pilot has been redacted.

4.4. Timing and Correlation

Timing information was recorded as UTC. The time recorded by the device was offset to CDT, which was the local time of the accident. CDT is five hours different from UTC.

To convert the Appareo recorded time to CDT, the following formula is applied:

Appareo Vision 1000 Time – 18,000 seconds = CDT

The format given for this report is HH:MM:SS.00, where HH stands for the number of hours, MM, the number of minutes and SS.00, the number of seconds to the nearest hundredth.

4.5. Appareo Vision 1000 Parametric Data Description

As discussed in section 4.3 of this report, parametric flight data was available all the way back to Feb 12, 2018. The last three sets of files associated with the last three power cycles of the camera also contained audio and video data.

A log of the accident pilot's flights were provided by the operator. This log is provided as attachment 1 to this report. All flights in which the pilot logged night

hours were extracted from the Vision 1000's data set. The flights provided below in figure 4 were extracted and are provided as attachment 2 to this report. Appendix A describes the parameter names and unit abbreviations.

File Number	Date	Start Time	End Time	Duration
1679	2-Mar	00:10:00	00:16:00	00:06:00
1680	2-Mar	00:43:00	01:10:00	00:27:00
1681	2-Mar	01:29:00	02:09:00	00:40:00
1691	4-Mar	19:57:00	20:15:00	00:18:00
1692	5-Mar	06:06:00	06:26:00	00:20:00
1693	5-Mar	06:53:00	08:25:00	01:32:00
1694	5-Mar	08:49:00	08:57:00	00:08:00
1699	8-Mar	06:09:00	06:49:00	00:40:00
1700	8-Mar	07:14:00	08:05:00	00:51:00
1768	21-Mar	22:59:00	23:37:00	00:38:00
1769	22-Mar	00:04:00	00:35:00	00:31:00
1770	22-Mar	00:49:00	00:59:00	00:10:00
1771	22-Mar	01:20:00	02:26:00	01:06:00
1773	22-Mar	06:50:00	07:17:00	00:27:00
1774	22-Mar	07:23:00	08:39:00	01:16:00

Figure 4. Parametric Data Containing Previous Night Flights by the Accident Pilot

Parametric data containing information from the accident flight was extracted and provided in .CSV format as attachment 2.

Using parametric data from the accident flight provided in attachment 2, a KML[2] of the accident flight was created. The following 3 figures describe the accident flight.

Figure 5 is a Google Earth overlay oriented north-up. The entire route of the accident flight is shown. The accident flight originated at MSN around 21:02:40. Around 21:30, the route of flight deviated to the northwest. Around 21:32, the flight deviated again, this time to the north. The route of flight continued to the north until the accident occurred at 22:43:24. The majority of the groundtrack was oriented to the north, with some variation in both groundtrack and altitude.

Figure 6 is a Google Earth overlay oriented north-up showing the last six minutes of flight.

[2] KML – Keyhole Markup Language – a filetype for use with Google Earth.

Figure 7 is a Google Earth overlay oriented north-up showing the final moments of the recorded groundtrack.

4.6. Summary of Recording Contents

2nd Previous Flight to the Accident

The second previous flight to the accident was reviewed by the group. The flight was 1 hour 8 minutes and 19 seconds from Howard Young Medical Center Heliport, Woodruff, Wisconsin to University of Wisconsin Hospital and Clinic (WS27), Madison, Wisconsin. The recording began at 18:29:55. All three of the accident flight crew as well as a patient were onboard for this flight leg. The recorded data included only parametric data up until 19:02:42. At 19:02:42 recorded image and audio playback began.

During the entire recording, there was about a ten second portion of missing audio.

The pilot did not utilize NVGs[3], nor were the NVGs mounted on his helmet for this leg of the flight which occurred in daylight. The pilot wore gloves on both hands during the entire flight. The pilot was wearing the provided four-point helicopter restraint system. The pilot rested his left hand on his upper left thigh for majority of the flight.

The medical flight crew discussed complaints among employees about “twenty-fours.” The legend on page 12 provides definition for the transcript. The following conversation was transcribed:

19:03:08.0 MC2: I’m kind of curious about who complained about the twenty-fours on ground –

19:03:11.5 MC1 there was a couple complaints on that.

19:03:14.5 MC2 on ground - or tryin’ to prevent ground from goin’ to twenty-fours?

19:03:18.2 MC1: yeah tryin to prevent them from goin’ to type thing.

19:03:21.0 MC2: probably @HospitalMgmtEmployee.

[3] NVGs – Night Vision Goggles

[The MC discussed a hospital employee putting a poll on his social media page. They discussed the complaint from an air crew that "flew all day then got stuck on a ground truck all night due to weather – but the other one was a ground individual voicing their concerns."]

19:03:52.2 MC2: what annoys the # outta me about that is ya have the fricken' right to give yourself a rest period. You can say 'I'm not takin' anything for X amount of hours – don't call me.'

19:04:05.7 MC1: everybody's afraid to pull the trigger on that.

19:04:08.3 MC2: I - Ya know – that's - what'd they gunna do – call A-O-C - and your gunna tell A-O-C "I'm takin' my rest period. Kiss my ass."

19:04:15.7 MC1: yup.

19:04:18.0 MC2: that's the problem with twenty-fours around here – people don't know how to do that.

19:04:23.0 MC1: the funniest thing I find – in all the training we do – especially with Air Methods – it's – ya don't feel fit to fly – ya don't fly. so if ya call yourself off from flying – after calling in four times here – they start penalizing you by writing you up. Five is a written - six is a possible suspension – seven's definitely a suspension – eight you're terminated within a rolling twelve month period.

19:04:50.5 MC2: (for/after) whattt now?

19:04:52.5 MC1: you – you can have four – either sick calls or unexcused or even late - I mean late – your fifth – fourth one – you get a verbal talking to – your fifth one you get a written – your sixth is – might be a suspension – might be another written – seventh is definitely a suspension – eighth you could be terminated.

19:04:11.5 MC2: got ya

19:04:12.0 MC1: and a doctor's note does not even count. you gotta apply for family medical leave and get it cleared that way to have it taken off – that's the only way – otherwise that's how it sits.

19:04:21.0 MC2: that's stupid.

19:04:21.7 MC1: so tell me if I don't feel good enough to fly – how I'm supposed to keep me safe and everybody else safe when you're gunna penalize me for it.
[There was no input from the pilot during the above conversation.]

Throughout the portion of the recording that contained image playback, the pilot adjusted his boom microphone and scratched his chin a number of times.

Frequently, when the pilot spoke, on VHF or through ICS to the crew, the pilot moved his left arm and pushed his boom-mic toward his mouth.

Around 19:03:06, 19:07:49, 19:09:25, 19:22:53, and 19:32:51, the pilot made a quick motion of his left arm in the vicinity of his helmet as described in the accident flight.

Around 19:24:59, a medical crew member stated, “you’re awfully quiet @Pilot.” The pilot stated, “Just taking it all in.” The crew members went on to discuss a dissatisfaction in going to Madison, Wisconsin and one of the medical crew members chimed in that it was better to go to Madison at the start of the shift rather than at the end of the shift.

The EGPWS and aural radar altimeter alert functions performed normally.

The crew demonstrated appropriate Crew Resource Management (CRM) throughout the flight.

The medical crew communicated with the patient about the progress of the flight at various times throughout the flight.

The flight ended at 19:38:12 after shutdown at WS27.

Previous Flight to the Accident

A 13 minute and 22 second minute long previous flight on the day of the accident was reviewed by the group. All three of the accident flight crew were onboard for this flight leg. The previous flight was a leg from WS27 to MSN. The previous flight data included audio, video and parametric data. The audio and parametric data recorded and played back continuously for the entire flight, with no interruptions or anomalies.

The video and audio recording began at 20:25:19. Video playback became sporadic around 20:26:44. Video playback returned to a smooth state at 8 minutes and 14 seconds into the recording, at 20:33:33. Though the video playback became sporadic for most of the recording, in a few frames the pilot made a quick motion of his left arm in the vicinity of his helmet as described in the accident flight. It was not possible to quantify the amount of times the pilot performed this action in the 13 minute and 22 second recording due to the inconsistent play back of the video frames.

The EGPWS and aural radar altimeter alert functions performed normally.

The crew demonstrated appropriate Crew Resource Management (CRM) throughout the flight.

The group determined the short flight was not remarkable and no additional information was noted from the video, nor was there audio of crew conversation that was determined to be pertinent to the accident investigation.

Accident Flight

The Vision 1000 unit provided a field of view as shown in figure 3. The recording was captured at night, as such, the image was dark, most of the instrument panel indications could be distinguished, but it was difficult to determine details of the accident pilot and some of his movements. In general, large movements by the accident pilot were discernable and transcribed, however, due to lighting conditions, it is possible that not all physical actions by the accident pilot were detected. The medical crew members were not visible in the image.

Ground lighting was visible on the image recording through the helicopter's chin bubbles. In general, ground lighting appeared when the helicopter flew over populated areas when compared to the helicopter's GPS flight track. No adverse weather was visible through the portions of the windscreen that were captured on the image recording. In general, adverse weather conditions did not appear to be present.

Visible movement of the accident pilot's body on the image recording indicated that the helicopter had experienced light turbulence in the first three quarters of the accident flight. During the last phase of flight, just prior to the accident, the overall movement of the pilot appeared to indicate that the helicopter was traveling through smooth air. Neither the flight crew or the accident pilot commented on the light turbulence during any portion of the flight.

The pilot was seated in the pilot's seat on the right side of the helicopter. In general, the pilot had his left hand either on the collective or resting on his upper left thigh throughout the recording. Times in which the pilot moved his hands around his body (with the exception of adjusting the boom mic), slightly changed seating position or fidgeted were noted in the transcript. Times when the pilot changed frequencies on the communications radios were noted in the transcript where possible. When the accident pilot utilized the helicopter's communications radio, he typically used his left hand to adjust his boom microphone in the vicinity of his mouth prior to making a radio transmission. This action was not noted throughout the transcript.

Conversations that were not aviation related were not transcribed verbatim. The majority of these conversations were related to hunting. The length of these conversations and participants in the conversation were noted.

Conversations related to flight operations or the safety of flight were transcribed verbatim.

All communications between the helicopter and various ground support bases and controllers were transcribed verbatim.

The last few moments of conversation, just prior to the helicopter's departure from a normal flight regime, were transcribed verbatim.

The image flickered throughout the entire image recording. This seemed to be a result of the camera system attempting to properly expose for low light conditions.

At no time was there evidence in the image and audio recording that there was any indication that the helicopter may have encountered a bird strike.

The transcript below is a detailed record of the image and audio recording recovered from the device.

Transcript of an Appareo Vision 1000 recorder installed on a N127LN, an Airbus Helicopters AS350B2, that crashed in Hazelhurst, Wisconsin, on April 26, 2018.

LEGEND

ALL	An instance in which all three crew members participated in a conversation
ATIS	Automated Terminal Information Service
CAM	Cockpit Area Microphone
CLRN	Clearance frequency
IMAGE	Comment from the image portion of the recording
MC1	Medical crew member #1
MC2	Medical crew member #2
Pilot	Pilot
RDO	Transmission over VHF
SpiritBase	Ascension Wisconsin Spirit Medical Transport communication center
TWR	Tower frequency
-?	Voice unidentified
*****	Unintelligible word
#	Expletive
@	Non-pertinent word, such as a name.
( )	Questionable insertion
[ ]	Editorial insertion

Note 1: Times are expressed in Central Daylight Time.
Note 2: Only radio transmissions to and from the incident aircraft were transcribed.
Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.
Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control or condition of the aircraft. Typically a person's name.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:02:37.1 **START OF RECORDING** **START OF TRANSCRIPT**					
				21:02:37.1 **IMAGE**	The recording began as the pilot was performing a preflight with the engine running at [IDLE]. The portion of the preflight and start up sequence that the recorder captured, did not show any anomalies of the helicopter or its systems, the pilot, or the flight crew that would have precluded normal operations. The map light was in use and the instrument panel was lit with a white light. The pilot checked time on watch and wrote down the time. The pilot was wearing a flight suit and the pilot was in the process of putting on a flight helmet and gloves during the startup sequence. The helmet had night vision goggles mounted and available, but at this time, they were not in use. The pilot was wearing the helicopter's factory installed restraint system. The pilot appeared to be checking cyclic friction, around the same moment the pilot performed a hydraulic system check. The pilot programmed the helicopter's avionics. The radio altimeter was noted to be bugged at 300 feet AGL.
21:02:42.7 **CAM**	[Sound similar to radar altimeter alert.]				
21:03:21.5 **?**	[Sound similar to yawn. The pilot did not exhibit any movement consistent with a yawn.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:03:30.5 **MC1**	[Non-aviation comment. Comment ended at 21:03:32.3]				
21:03:32.3 **MC1**	[Non-aviation comment ended. Duration 1.8s.]				
		21:03:59.9 **MSN-ATIS**	[Incomplete broadcast of information papa at MSN.]		
		21:04:47.5 **Pilot-RDO**	aaand clearance one-two-seven lima november.		
		21:04:50.3 **MSN-CLRN**	helicopter one-two-seven Madison clearance.		
		21:04:53.2 **Pilot-RDO**	yeah we're at Wisconsin aviation like to depart direct north and we have papa.		
		21:05:02.3 **MSN-CLRN**	one two seven lima november ah roger what's the destination.		
		21:05:07.2 **Pilot-RDO**	uh we'll be go to back to our base Woodruff Wisconsin.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
		21:05:15.3 **MSN-CLRN**	roger. stand by.		
21:05:16.3 **MC2**	that's the one we got - I believe that's the right one.				
21:05:43.7 **?**	[Sound similar to sigh.]				
		21:05:44.4 **MSN-CLRN**	and sorry about that I had a (phone call) here uh - lima november - maintain V-F-R at or below three thousand your departure frequency's gunna be one-three-five-four-five squawk zero-four-six-one.		
		21:05:57.1 **Pilot-RDO**	alright we'll stay at or below three thousand V-F-R - was that one-thirty-five-forty-five and zero four six one seven lima november.		
		21:06:06.5 **MSN-CLRN**	seven lima november the read back is correct and you said you were ready for departure on the east ramp?		
		21:06:13.2 **Pilot-RDO**	yup we're ready to go.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
		21:06:15.0 **MSN-CLRN**	wind two six zero at four and altimeter's two niner seven eight and proceed on course to the north departure from the east ramp your own risk.		
		21:06:23.1 **Pilot-RDO**	alright just stay on this frequency?		
		21:06:24.9 **MSN-CLRN**	affirm -- uhhh one one niner point three please.		
		21:06:28.5 **Pilot-RDO**	alright nineteen three and we're cleared take off at our own risk on the east ramp.		
		21:06:33.4 **MSN-CLRN**	*.		
				21:06:55 **IMAGE**	The pilot brought engine RPM from [IDLE] to [FLIGHT].
		21:06:59.5 **Pilot-RDO**	Madison tower seven lima november's on the go to the north.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
		21:07:02.2 **MSN-TWR**	'copter seven lima november thanks.		
21:07:04.7 **Pilot**	alright lights are off everything's green all secure you guys ready?				
21:07:07.2 **MC1/MC2**	we're ready [Spoken in unison.]				
				21:07:14 **IMAGE**	The helicopter departed. The pilot started a pedal turn to the right to line up with his departure course almost immediately after liftoff.
				21:07:38 **IMAGE**	Pilot dimmed instrument panel and map lights.
				21:08:00 **IMAGE**	Pilot made a movement consistent with lowering the NVGs, however, it was unclear if the pilot had actually moved the NVGs into an in-use position.
				21:08:18 **IMAGE**	The pilot made a second movement consistent with lowering or adjusting the NVGs on his helmet.
21:08:18.6 **Pilot**	you guys alright back there?				
21:08:20.0 **MC1?**	yup.				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:08:20.4 **Pilot?**	alright.				
21:08:23.7 **MC1**	question is are you alright up there?				
21:08:26.0 **Pilot**	uhhh think so. good enough to get us home at least.				
21:08:29.1 **MC2**	right. [sound of chuckling.]				
21:08:30.6 **MC2**	what'd we got a head wind or anything?				
		21:08:32.9 **MSN-TWR**	‘copter seven lima november contact departure.		
		21:08:35.9 **Pilot-RDO**	departure. thanks. seven lima november.		
		21:08:41.8 **Pilot-RDO**	aaaand departure helicopter seven lima november is one-thousand-six-hundred.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
		21:08:46.6 **MSN-DEP**	helicopter one two seven lima november Madison departure radar contact altitude your discretion.		
		21:08:51.7 **Pilot-RDO**	altitude our discretion - seven - ONE-two-seven lima november.		
				21:09:00 **IMAGE**	[The pilot made a third movement consistent with adjusting NVGs, however, because of the darkness of the image, it was not possible to conclusively determine if the NVGs were actually in use. The movement lasted about 40 seconds.]
21:09:03.0 **ALL**	[Non-aeronautical conversation between all crew members, primarily MC1 and pilot. Conversation ended at 21:10:43.2.]				
21:10:43.2 **ALL**	[Non-aeronautical conversation ended at 21:10:43.2. Duration 1m40.2s]				
		21:10:49.8 **Pilot-RDO**	and helicopter seven lima november north frequency change.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				21:10:50 **IMAGE**	[The pilot made a movement consistent with adjusting NVGs, or adjusting his boom mic.]
		21:10:53.1 **MSN-DEP**	seven lima november squawk V-F-R frequency change approved.		
				21:10:55 **IMAGE**	[The pilot changed the transponder code to a display readout consistent with 1-2-0-0.]
		21:10:56.1 **Pilot-RDO**	frequency change - good night - seven lima november.		
21:10:59.3 **Pilot**	alright - now let's get off those guys.				
				21:11:00 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
21:11:07.4 **ALL**	[Non-aviation conversation between all crew members, primarily MC1 and pilot. Conversation ended at 21:12:40.5.]				
				21:11:43 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:12:25 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:12:40.5 **ALL**	[Non-aviation conversation ended at 21:12:40.5. Duration 1m33.1]				
21:12:40.9 **Pilot**	where's that lightning coming from?				
21:12:43.8 **MC1?/MC 2?**	didn't see it.				
21:12:44.6 **Pilot**	off the nose.				
21:12:50.4 **Pilot**	maybe it's heat lightning?				
21:12:55.1 **Pilot?**	ohhh what the hell?				
21:12:56.3 **Pilot**	ohhh that line that built up.				
21:12:58.4 **MC1?**	ohhh yeah look at that.				
				21:13:00 **IMAGE**	[The pilot adjusted the MFD. The pilot would occasionally adjust settings on the MFD in relation to other discussions about weather throughout the flight. Additionally, when weather was discussed, NEXRAD images on the MFD appeared consistent with the flight crew's conversation. It

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
					is not specifically noted for the remainder of the transcript.]
21:13:00.6 **MC1**	right on our flank.				
21:13:04.6 **MC1**	get around it?				
21:13:09.1 **MC2?**	ouuu.				
21:13:16.0 **MC1**	how far north can we get?				
21:13:19.1 **Pilot**	well - think we're gunna - wrap around the back side of it here.				
21:13:24.1 **MC1**	alright.				
21:13:25.0 **MC2**	give it the old reach around?				
21:13:26.3 **Pilot**	yup.				
21:13:29.2 **MC1/Pilot**	[Non-aviation description of weather routing, primarily MC1 and pilot. Conversation ended at 21:13:37.7]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:13:37.7 **MC1/Pilot**	[Non-aviation conversation ended at 21:13:37.7. Duration 8.5s]				
21:13:37.7 **Pilot**	well the thing is I looked up all the weather and there wasn't nothing.				
21:13:39.7 **MC2?**	ohhh - yeah there is.				
21:13:41.5 **Pilot**	all that probably just started poppin'.				
21:13:44.2 **MC2?**	ahhh.				
21:13:47.2 **MC1**	uhh I don't get worried until you tell me to get worried so we're good.				
21:13:51.5 **MC2**	yup. when the pilot starts sayin' oh # oh # oh # - that's when you start payin' attention.				
21:13:58.7 **MC2/Pilot**	[Quick non-aviation conversation between MC2 and				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
	pilot. Conversation ended at 21:14:05.0.]				
21:14:05.0 **MC2/Pilot**	[Quick non-aviation conversation ended at 21:14:05.0. Duration 6.3s.]				
21:14:05.3 **Pilot**	well we got an hour extra fuel to # around so we'll be alright.				
21:14:12.0 **Pilot**	well as long as it doesn't extend down this way but I'm not going through that 'cuz that's gunna be pretty thick.				
21:14:16.1 **MC1/MC2**	[Joking response by crew to pilot's weather routing decision.]				
21:14:22.7 **MC2?**	how far north is that?				
21:14:24.6 **Pilot**	weeell - it's -- we're not going east of it that's for sure. I was hoping it doesn't start extending down this way which it shouldn't - but --				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:14:37.0 **MC1**	we get to like Point [Stevens Point] area or is it before that?				
21:14:39.1 **Pilot**	it's east of Point already. I'm just gettin' through the back side of it here.				
21:14:45.1 **MC1?**	(uh huh).				
21:14:50.4 **MC2**	told you it was raining.				
21:14:52.0 **Pilot**	yeah. well you know that's what it is is that.				
21:14:57.2 **MC1**	it's kinda picked up.				
21:15:00.0 **Pilot**	just gotta figure out how far west we gotta go here. -- once we get around it then it’s back direct to the north.				
				21:15:10 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
21:15:20.3 **Pilot**					

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
	well that's all that wind we were picking up in Merrill. [Merrill, Wisconsin] it was only uhhh -- calm up at home - windy Mer- Wausau [Wausau, Wisconsin] and then uhhh - # in between but --				
21:15:40.1 **MC1**	(oh well) that happens.				
		21:16:00.2 Pilot-RDO	Spirit Base - Spirit Two on Custer [A VHF repeater in Custer, Wisconsin.]		
21:16:16.3 **Pilot**	I'm just glad it popped up on the screen there so we weren't right up into it. we can always get up towards it land and let it go through if we had to. not the end of the world.				
21:16:26.4 **MC1**	I usually can't hit dispatch 'til you get over that ridge there with the towers.				
21:16:29.8 **Pilot**	yeah it it hit (them).				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:16:32.4 **MC1**	did it?				
21:16:33.3 **Pilot**	hit the repeater - yeah.				
21:16:35.6 **Pilot**	we'll just head to St. Joe [St. Joseph, Wisconsin] and then we'll go north. that'll still kinda cut us through that big cell stay - south of it. I wanna get behind that line before it extends down south this way.				
21:16:48.9 **MC1**	why don't we just climb to like twenty thousand and go over it. [joking.]				
21:16:51.9 **Pilot**	yeah we can do that and get the # beat out us. [Spoken in a joking tone.]				
21:16:54.1 **ALL**	[Sound of chuckling by the entire crew.]				
				21:17:00 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:17:12.6 **Pilot**	might be hittin' Merrill on the way home for fuel too. [Sound of quick laugh.]				
21:17:15.1 **MC1/MC2**	[Sound of quick laugh.]				
21:17:17.7 **MC2**	well wouldn't be the first time.				
21:17:48.6 **Pilot**	pretty good off the nose - uh - you can see what's making that lightning right there that's cloud's towering way up off the nose - I don't see much - way up there - couple here and there.				
				21:17:55 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
21:18:00.3 **MC2**	you got it.				
		21:18:11.5 **Pilot-RDO**	Spirit Base - Spirit Two - Custer.		
		21:18:18.5 **SpiritBase-RDO**	Spirit Two on Custer - go ahead.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
		21:18:23.9 **Pilot-RDO**	yeah just be advised we're gunna be uh goin' west around this line of storms - so uh if you got us on the sat [satellite] tracker you may see us swingin' out to the west here.		
		21:18:37.7 **SpiritBase-RDO**	copy that Spirit Two I now see that you guys are goin' a little bit west of your normal path - do you have (lift) time from Madison airport?		
				21:18:45 **IMAGE**	[The pilot turned on the map light. The pilot was utilizing his NVGs. It did not appear that the pilot was also wearing the clear face shield on his helmet. The pilot appeared to stow his left glove. The pilot's now ungloved left hand was visible. The pilot picked up a clipboard and read the lift off time from MSN. The pilot appeared to be wearing the provided four-point helicopter restraint system, including the shoulder harness portion of the restraint system.]
		21:18:48.1 **Pilot-RDO**	yes. stand by.		
		21:18:55.6 **Pilot-RDO**	yeah uh we were off uh twenty-one-four.		
				21:19:00 **IMAGE**	[The pilot turned off the map light. Then the pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
		21:19:00.4 **SpiritBase-RDO**	copy that twenty-one-oh-four lifted from Madison I have * (your) numbers. Thank you safe flight and I'll keep an eye on the tracking for ya.		
		21:19:09.2 **Pilot-RDO**	yeah right now it's uh gunna have to head way south of Marshfield [Marshfield, Wisconsin] behind that southern cell.		
		21:19:22.9 **SpiritBase-RDO**	ookay copy that. just keep me posted if anything changes. twenty-one-nineteen.		
21:19:31.7 **Pilot**	bout the only red in there is that # lightning right there off our right.				
21:19:41.5 **MC1/MC2**	[Non-aviation related conversation between MC1 and MC2. The pilot reacted to one portion of the conversation with a few words. Conversation ended at 21:31:18.8.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				21:23:55 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:25:08 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:26:50 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:27:21 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:28:45 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:30:00 **IMAGE**	[The video recording playback was unavailable and froze on an image until 21:35:27. Audio was still available.]
21:31:18.8 **MC1/MC2**	[Non-aviation conversation ended at 21:31:18.8. Duration 11m37.3s]				
21:31:21.1 **MC1**	gettin' a little windy now eh?				
21:31:23.1 **Pilot**	yeah we're just on the leading edge of that - front'				
21:31:26.1 **MC1/Pilot**	[Brief conversation about flying near a cow pasture and pilot made a quick reference to a cell				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
	on the right of the helicopter's flight path. Conversation ended at 21:31:32.7.]				
21:31:32.7 **MC1/Pilot**	[Brief conversation ended at 21:31:32.7. Duration 6m9s.]				
21:31:34.3 **Pilot**	naw we're behind it now - we got about a thirty knot headwind but-- once we cut through this front -- well uh - the front's actually south of us built up on the backside of it.				
21:31:48.4 **MC2**	we're gunna stop for fuel aren't we?				
21:31:50.6 **Pilot**	naw I think we'll be good.				
21:31:54.7 **Pilot**	nahh uhh we really didn't go that far outta the way. another maybe fifteen twenty miles to the west - which still keeps us pretty in line.				
21:32:05.4 **Pilot/MC1**	[Conversation regarding a previous dispatch in which the helicopter had to divert around				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
	weather. Conversation was primarily led by the pilot, with some responses from MC1.]				
		21:34:19.6 **Pilot-RDO**	Spirit Base - Spirit Two.		
		21:34:25.5 **SpiritBase-RDO**	Spirit Two go ahead.		
		21:34:28.5 **Pilot-RDO**	yeah uh we're in behind that line no so uhhh we're just headed uhhh direct north to the base.		
		21:34:39.3 **SpiritBase-RDO**	* uh clear of the storms heading directly north to base. time now twenty-one-thirty-four thank you.		
21:34:47.6 **MC1/MC2**	[Non-aviation related conversation between MC1 and MC2. The pilot's voice was never heard. Conversation ended at 21:43:36.5 when audio information became unavailable.]				
				21:35:27 **IMAGE**	[Image playback returned. Cockpit lighting conditions were the same as previously described.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				21:36:43 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
21:43:36.9 **CAM**	[Dropout of audio in this area. No audio information was available. Audio Returned at 21:43:47.5. Duration of missing audio segment was 10.6s.]				
21:43:47.5 **MC1/MC2**	[Non-aviation related conversation between MC1 and MC2 picked up when audio information returned. The pilot's voice was never heard. Conversation ended at 21:43:57.5.]				
21:43:57.5 **MC1/MC2**	[Non-aviation related conversation ended at 21:43:57.5. Duration 10.0s.]				
21:43:57.5 **?**	[Sound of congested cough. The pilot did not exhibit any movement consistent with a cough.]				
21:43:58.7 **MC1/MC2**	[Non-aviation related conversation between MC1 and MC2. The pilot's voice was				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
	never heard. Conversation ended at 21:55:46.5.]				
				21:44:45 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet. The pilot performed this action twice, quickly.]
				21:45:00 **IMAGE**	[Image playback became sporadic and playback was not smooth. For the majority of this area, image playback could be considered unavailable. During moments when image playback momentarily returned, events potentially pertinent to the accident flight were transcribed. Smooth playback returned at 21:51:50.]
				21:46:10 **IMAGE**	[Image playback returned quickly and showed the pilot had made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:47:40 **IMAGE**	[Image playback returned quickly and showed the pilot had made a quick motion of his left arm in the vicinity of his helmet.]
				21:51:50 **IMAGE**	[Image playback returned to a smooth playback rate. Cockpit lighting conditions were the same as previously described.]
				21:52:26 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:52:48 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:53:52 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
21:55:46.5 **MC1/MC2**	[Non-aviation related conversation ended at 21:55:46.5. Duration 11m47.8s.]				
21:55:47.4 **MC1/MC2**	[Brief non-aviation related conversation between MC1 and MC2. The pilot chimed in briefly, "what's that?" when he inquired about the new topic of conversation. Conversation ended at 21:56:19.9.]				
21:56:19.9 **MC1/MC2**	[Brief non-aviation conversation ended at 21:56:19.9. Duration 32.5s.]				
21:56:31.5 **MC1/MC2**	[Non-aviation related conversation between MC1 and MC2. The pilot's voice was never heard. Conversation ended at 22:00:21.6.]				
				21:56:36 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				21:57:29 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				21:58:47 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:00:21.6 **MC1/MC2**	[Non-aviation related conversation ended at 22:00:21.6. Duration 3m50.1s]				
22:00:21.6 **?**	[Sound of cough. The pilot did not exhibit any movement consistent with a cough.]				
22:00:42.5 **MC2**	I could go to sleep.				
22:00:45.7 **Pilot**	yeah that'd be nice huh.				
22:00:47.0 **MC2**	yeah.				
22:00:48.4 **MC2**	been up since three thirty this morning.				
				22:00:49 **IMAGE**	[The pilot adjusted himself and appeared to flex his glutes while seated, then returned to a sitting position as seen previously.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
22:00:53.7 **MC2**	wasn't able to get a nap in today because uh # meeting -- and our botched P-R.				
				22:01:00 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:01:04.2 **MC1**	what'd ya botch?				
22:01:05.5 **MC2**	well we didn't botch it they botched it because they tried landing us in a parking lot that was -- normally would be alright but there was a great big ass eight foot snowbank in the one end of it and we needed clearance to land.				
				22:01:12 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:01:19.4 **Pilot?**	that'll happen.				
22:01:21.3 **MC1?**	where was that at?				
22:01:22.2 **MC2**	Lac Du Flambeau um Casino.				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
22:01:30.6 **MC1/MC2**	[Brief conversation between MC1 and MC2 about Lac Du Flambeau area. Conversation ended at 22:01:58.2.]				
				22:01:32 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:01:58.2 **MC1/MC2**	[Brief conversation ended at 22:01:58.2. Duration 27.4s]				
				22:02:07 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:02:12.8 **MC1/MC2**	[Non-aviation related conversation between MC1 and MC2. The pilot's voice was never heard. Conversation ended at 22:04:01.9.]				
				22:03:05 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:03:29 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:04:01.9 **MC1/MC2**	[Non-aviation related conversation ended at 22:04:01.9. Duration 1m49.1s.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				22:04:17 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
		22:04:34.7 **Pilot-RDO**	Central Wisconsin helicopter one-two-seven lima november.		
22:04:49.5 **MC1**	they're not there after ten. what time is it?				
22:04:51.7 **Pilot**	uhh just missed 'em huh.				
22:05:00.4 **MC1**	what time is it?				
22:05:01.8 **Pilot**	like ten oh one.				
22:05:02.9 **MC1**	yeah yeah they shut down at ten.				
22:05:07.6 **MC1**	yeah they're sittin' there walkin' out the door goin' '# you lima november.'				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
		22:05:08.3 **CWN-AWOS**	[Incomplete AWOS transmission potentially from Central Wisconsin Airport.]		
		22:05:19.3 **Pilot-RDO**	uh Central Wisconsin traffic Spirit Two helicopter is nine southwest of the airport transitioning northbound one thousand nine hundred. uh -- Central Wisconsin traffic.		
22:05:51.1 **MC2**	ugh @Pilot it's gunna be like last summer where every time you and I worked together --				
22:05:54.3 **Pilot**	ughh [Sound of sigh] Minneapolis.				
22:05:56.4 **MC2**	Minneapolis # Milwaukee				
22:05:56.9 **Pilot**	Minneapolis - Milwaukee				
22:05:59.9 **?**	[Sound of cough. The pilot did not exhibit any movement consistent with a cough.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
22:06:01.6 **MC1**	I dodged that Milwaukee bullet about six times before I finally # got it.				
22:06:04.7 **Pilot**	yeah.				
22:06:12.6 **MC2**	yeaaup nothing but long runs. (right) I - I even said earlier today - I told @AnotherCompanyPilot 'it's a good day to fly to Madison.' sure as # here we are.				
				22:06:22 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:06:22.9 **ALL**	[Conversation about previous medical dispatch missions. All three crew members participated in the conversation. Conversation ended at 22:10:24.0.]				
				22:08:04 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:10:24.0 **ALL**	[Conversation ended at 22:10:24.0. Duration 4m01.1s.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
22:10:25.4 **MC1/MC2/ Pilot**	[Non-aviation related conversation. All three crew members participated in the conversation. Conversation ended at 22:11:13.6.]				
				22:10:44 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:10:55 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:11:13.6 **MC1/MC2/ Pilot**	[Non-aviation related conversation ended at 22:11:13.6. Duration 48.2s.]				
22:11:14.3 **?**	[Sound of yawn.]				
22:11:15.1 **ALL**	[Non-aviation related conversation. All three crew members participated in the conversation. Conversation ended at 22:11:29.4]				
22:11:29.4 **ALL**	[Non-aviation related conversation. Conversation ended at 22:11:29.4. Duration 13.3s.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
22:11:30.9 **MC1/MC2/ Pilot**	[Non-aviation related conversation. All three crew members participated in the conversation. The pilot related a story from his childhood about the topic of conversation. Conversation ended at 22:15:08.4.]				
				22:14:17 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:15:08.4 **MC1/MC2/ Pilot**	[Non-aviation related conversation ended at 22:15:08.4. Duration 3m37.5s.]				
22:15:08.9 **MC2**	that isn't Irma [Irma, Wisconsin] here is it?				
22:15:10.1 **Pilot**	oh no it's Rib Mountain [Rib Mountain, Wisconsin].				
22:15:10.2 **MC1**	it's Rib Mountain.				
22:15:13.7 **Pilot**	big ol' tower at our right.				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
22:15:15.2 **MC1?**	yup.				
22:15:18.0 **MC1?**	tally. [tally-ho]				
22:15:20.8 **MC1/MC2**	[Non-aviation related conversation primarily between MC1 and MC2. The pilot participated minimally in the beginning of the conversation and then again, shortly, near the end of the conversation when the topic being discussed became related to an event that occurred near his home. Conversation ended at 22:29:39.7. The pilot was last heard at 22:29:20.5. The pilot was not heard for the remainder of the audio recording. The audio recording lasted another 14 minutes and 3.3 seconds.]				
				22:15:36 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:16:20 **IMAGE**	[The pilot adjusted his legs slightly.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				22:17:35 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:18:21 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:19:02 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:19:38 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:20:07 **IMAGE**	[The pilot adjusted his position and appeared to flex his glutes while seated, then returned to a sitting position as seen previously.]
				22:20:29 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:20:52 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:21:03 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:21:23 **IMAGE**	[The pilot scratched his left knee with his left hand.]
				22:21:40 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:22:18 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				22:23:13 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:23:29 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:23:37 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:23:52 **IMAGE**	[The pilot adjusted himself and appeared to flex his glutes while seated, then returned to a sitting position with his feet now flat on the floor.]
				22:24:21 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:24:24 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:24:51 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:25:14 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:25:49 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:26:28 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:27:08 **IMAGE**	[The pilot flexed his left hand, made a quick motion in the vicinity of his helmet and adjust his seating position

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
					slightly. The pilot's feet still appeared to be flat on the floor.]
				22:27:27 **IMAGE**	[The pilot scratched his left knee with his left hand.]
				22:27:44 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:28:08 **IMAGE**	[The pilot flexed his left leg.]
				22:28:15 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:28:23 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:29:08 **IMAGE**	[The pilot flexed his lower legs.]
				22:29:17 **IMAGE**	[The pilot flexed his lower legs.]
				22:29:22 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
22:29:39.7 **MC1/MC2**	[Non-aviation related conversation ended at 22:29:39.7. Duration 14m18.9s.]				
22:29:41.3 **MC1/MC2**	[Non-aviation related conversation between MC1 and MC2. The pilot's voice was				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
	never heard. Conversation ended at 22:30:03.1.]				
				22:29:48 **IMAGE**	[The pilot flexed his lower legs and then made a quick motion of his left arm in the vicinity of his helmet. The action was a bit longer in duration that previous similar actions.]
22:30:03.1 **MC1/MC2**	[Non-aviation related conversation ended at 22:30:03.1. Duration 21.7s.]				
22:30:05.9 **?**	[Sound of groan. The pilot did not exhibit any movement consistent with a groan.]				
22:30:07.5 **MC1/MC2**	[Non-aviation related conversation between MC1 and MC2. The pilot's voice was never heard. The conversation is continued below, transcribed verbatim.]				
				22:30:38 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of his helmet and flexed his leg.]
				22:30:51 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:31:16 **IMAGE**	[The pilot flexed his lower legs.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				22:31:37 **IMAGE**	[The pilot moved his left hand quickly near the left side of his head, then his chin. Around the same time, the pilot flexed his legs.]
				22:31:55 **IMAGE**	[The pilot changed his grip on the cyclic and used his left hand to temporarily hold the cyclic. The action was brief.]
				22:32:27 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:32:36 **IMAGE**	[The pilot flexed his lower legs.]
				22:32:43 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:33:10 **IMAGE**	[The pilot flexed his lower legs.]
				22:33:19 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:33:57 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:34:00 **IMAGE**	[Image playback became sporadic and playback was not smooth. For the majority of this area, image playback could be considered unavailable. During moments when image playback momentarily returned, events potentially pertinent to the accident flight were transcribed. Smooth playback returned at 22:41:00.]
				22:34:55 **IMAGE**	[The pilot flexed his lower legs.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				22:35:13 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:35:22 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:37:10 **IMAGE**	[The pilot flexed his lower legs then made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:37:25 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:39:22 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:40:42 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:41:00 **IMAGE**	[Image playback returned fully. The pilot was flexing his legs.]
				22:41:25 **IMAGE**	[The pilot made a quick motion of his left arm in the vicinity of the left side of his helmet.]
				22:41:40 **IMAGE**	[The pilot changed his grip slightly on the cyclic and had temporarily placed his left hand on the cyclic grip while he was still resting his right hand on the grip.]
				22:41:50 **IMAGE**	[The pilot scratched his knee with his left hand.]
22:42:31.3 **MC1**	a guy that he - he hunts with us - or you know he's pretty good friends with my - my buddy there				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
	- umm - up in Iron River [Iron River, Wisconsin] there - they went out shootin' - came home there he - whatever reason uhhh had one in the chamber - it was just a three eighty - you know he had the clip out they were cleanin' the gun --				
				22:42:42 **IMAGE**	[The pilot scratched his left knee with his left hand.]
22:42:52.1 **MC2**	yeah.				
22:42:52.5 **MC1**	and sooomehow - one way or the other - he shot - and it shot through his hand and hit his damn girlfriend in the chest and killed her.				
22:43:00.3 **MC2**	ooof.				
22:43:02.1 **MC1**	ohhh he - he uh - he actually - he wasn't gettin' in any trouble necessarily - like the - the girl's parents didn't wanna press any charges or anything you know - he's - he's a good guy.				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				22:43:10 **IMAGE**	[At this time, the rotorcraft was operating normally. The artificial horizon showed level flight, the altimeter read 2,280 MSL, the vertical speed indicator was masked by glare, the heading indicator appeared to be around due north, turn-slip instrument showed wings level and the ball was slightly to the left of center, airspeed indicator read about 126 knots. The T4 gauge read about 700 degrees C (within the green arc), delta Ng read minus 5% RPM (within the green arc), the torque gauge read about 90% (within the green arc), fuel gauge read about 20%, fuel pressure read about 0.8 bar, oil pressure read as 4 bar (within the green arc), engine oil temperature indicated 70 degrees C, Volt meter was about 28 volts (within the green arc), Amperage read about 0 amps. Rotor RPM gauge read within the upper limit of the green arc. Annunciator lights on the main caution and warning panel were all extinguished. The condition of annunciator lights on the auxiliary caution and warning indicators and switches, although they could not be conclusively distinguished, remained unchanged since the beginning of flight. The visible Garmin 430 navigator was on the CDI page. A display field potentially showing the distance to an unknown programmed waypoint appeared to be about 6 nautical miles. The pilot was sitting in the pilot's seat, generally as noted previously. His left foot appeared flat on the floor, his right knee indicated his right foot would have been either flat on the floor or slightly splayed to the right. The pilot's left hand was resting on his upper left thigh. The pilot's right hand was holding the base of the cyclic grip. The pilot's right forearm was resting on his upper right thigh area.]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
22:43:13.9 **MC2**	yeap.				
22:43:14.3 **MC1**	well-uh - it was obviously an accident.				
				23:43:14.8 **IMAGE**	[The artificial horizon began showing a slowly developing right bank from straight and level flight. The altimeter now displayed 2,300 MSL.]
				22:43:14.8	[The artificial horizon began showing a slowly developing right bank from straight and level flight. The altimeter displayed 2,300 MSL.]
				22:43:15.8 **IMAGE**	[The pilot's right forearm started moving in unison with the cyclic to the right. The pilot's right hand was still gripping the base of the cyclic. It was unclear if this was an input from the pilot, or a result of the right roll which had developed as noted above. The rate of roll to the right appeared to increase slightly. The artificial horizon indicator showed between 10 and 15 degrees of right bank. Between 43:15.75 and 43:20.00 the rate of roll to the right appeared to increase rapidly. The pilot's upper body and forearm, which was still gripped at the base of the cyclic, appeared to move in unison with the increased rate of the right roll.]
22:43:18.1 **MC2**	What are we doin'? what are we doin'? [Sound of elevated voice.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
22:43:19.2 **MC2**	ohhh # [strained voice.]				
				22:43:20.0 **IMAGE**	[The movement of the pilot's right forearm, the cyclic stick and the pilot's right leg all moved to the right. The pilot's head had moved slightly forward and to the right and the pilot's head became out of frame to the right. At this time, the artificial horizon indicator indicated a right bank well beyond 90 degrees to the right. The pilot's left hand was still resting on his upper left thigh, in the position seen previously. Rotor RPM indicated near the top of the green arc, the turn coordinator was full deflection left, the ball appeared near center and the heading indicator had swung in the direction of a right turn. The airspeed indicator read about 126 knots. The torque gauge swung into the yellow arc (high torque value), the delta Ng % RPM gauge was reading zero. All other instruments indicated values as noted previously at 22:43:10.]
22:43:20.5 **MC2?**	WHAT? [Shouted.]			22:43:20.5 **IMAGE**	[The pilot's head came back into frame and moved across the image to the left. The pilot's right hand was still gripped near the base of the cyclic, and the pilot's left hand was still resting on his upper left thigh as noted previously.]
				22:43:21.0 **IMAGE**	[The artificial horizon indicator showed an inverted indication. The torque gauge had moved beyond the range of the red line (a higher value).]
22:43:21.1 **MC2**	@Pilot. [Shouted.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				22:43:21.5 **IMAGE**	[The ELT light came on and the pilot's head and upper body continued to swing through the image frame to the left.]
22:43:22.0 **MC1**	@Pilot. [Shouted.]			22:43:22.0 **IMAGE**	[The pilot's head continued to move to the left of the frame, the entire instrument panel was obscured from view.]
22:43:22.0 **CAM**	[sound similar to high rotor RPM horn.]				
				22:43:22.8 **IMAGE**	[The pilot's head and upper body had moved across the instrument panel to the left. There was no observed response from the pilot consistent with the crew members shouting his name. The instrument panel was back in view. The artificial horizon indicator exhibited a continued right roll (now displaying around a 270 degree right roll), but still in a nose down pitch attitude. The turn slip indicator had gone full deflection right and the ball had moved almost full deflection left. The rotor RPM gauge had moved above the green arc into a high rotor RPM caution range. The torque gauge had decreased to a mid-green arc range. The T4 gauge had reduced slightly from previously noted. The airspeed indicator now displayed around 98 knots, the altimeter displayed 1,900 feet MSL.]
22:43:23.2 **?**	[sound of grunt.]				
22:43:23.2 **MC1?/MC 2?**	@Pilot [Shouted loudly.]				

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication	Time and Source	Image Recording Comments
				22:43:23.5 **IMAGE**	[Last frame displayed from the manufacturer's software. The next two frames discussed below were recovered forensically.]
22:43:23.8 **AUDIO**	[End of recorded audio data.]			22:43:23.8 **IMAGE**	[In the remaining two frames, the pilot's head and upper body had started moving back toward the right of the frame. The pilot's head and upper body once again obscured most of the instrument panel. The airspeed indicator displayed around 70 knots. The artificial horizon showed a 90 degree left bank and a nose down attitude. The altimeter read about 1,825 feet MSL. No other information was recovered from the Appareo device and the recording ended before impact occurred. The time associated with the last recovered image frame was 22:43:24.]
				22:43:24 **IMAGE**	[End of forensically recovered video data.]

END OF TRANSCRIPT
END OF RECORDING

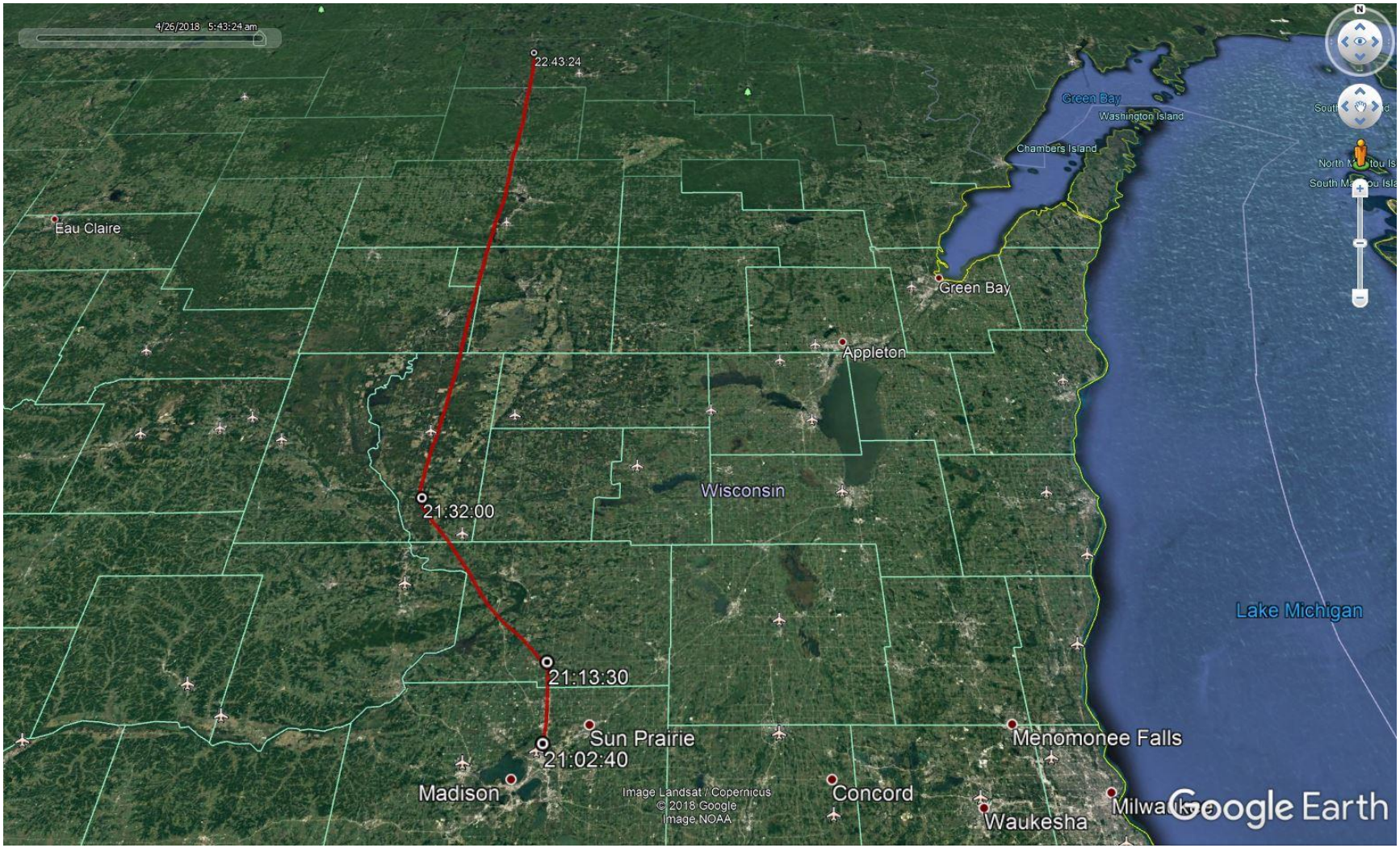

Figure 5. A Google Earth overlaying showing recorded GPS data for the entire accident flight.

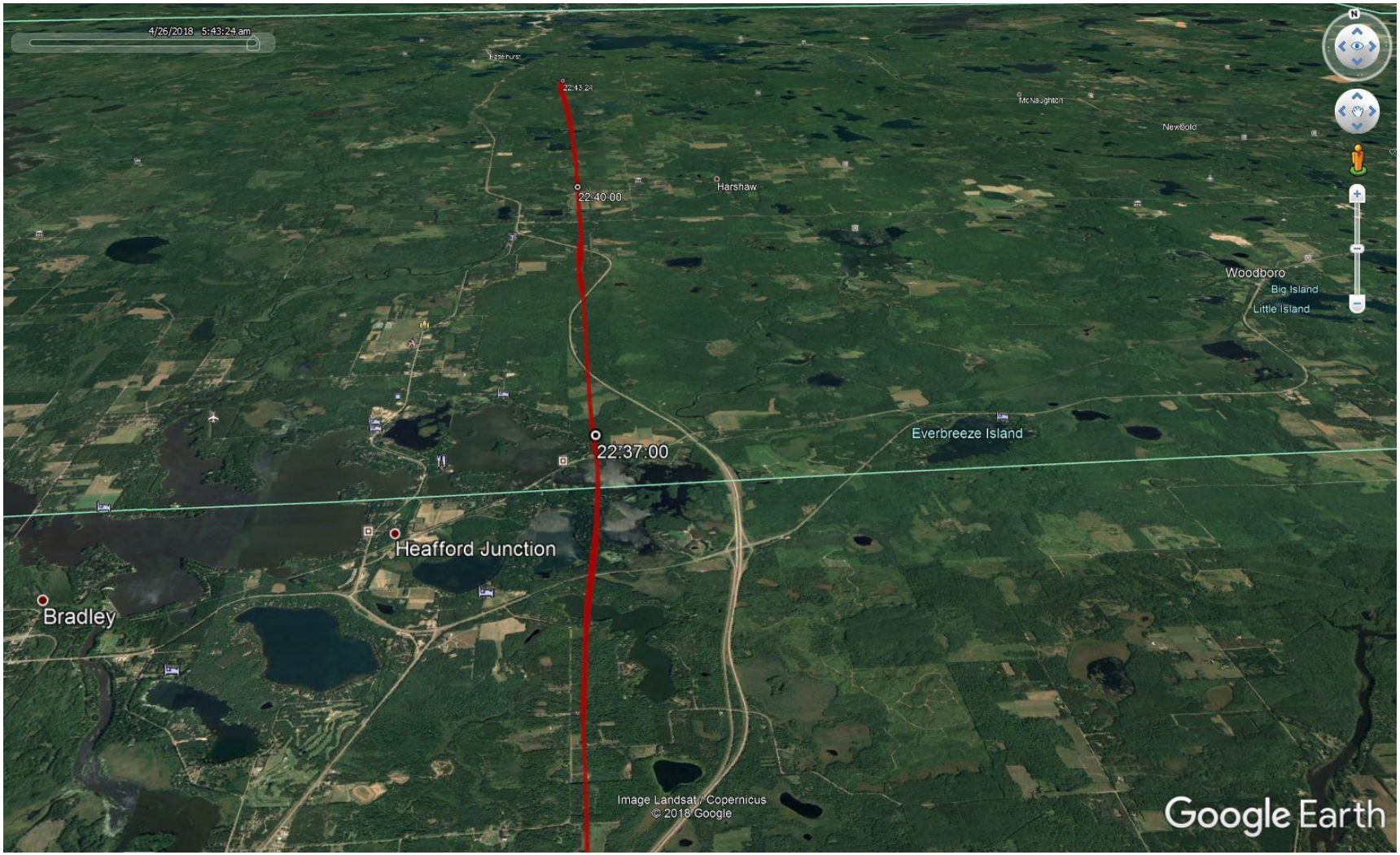

Figure 6. A Google Earth overlaying showing recorded GPS data for the last six minutes of flight.

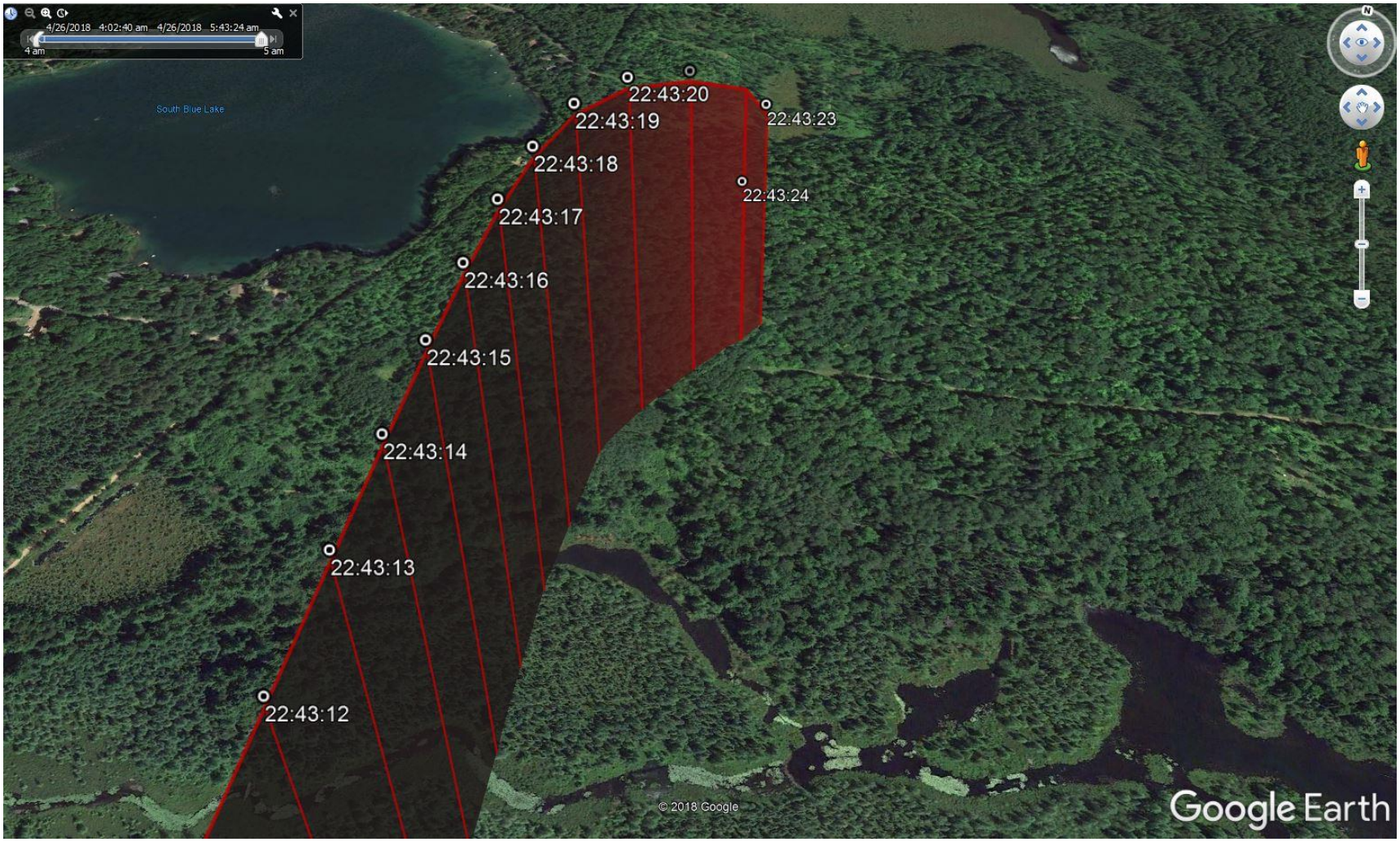

Figure 7. A Google Earth overlaying showing recorded GPS data for the final moments of the accident flight.

APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameters and table A-2 describes the unit abbreviations used in this report.

Table A-1. Verified and provided parameters.

Parameter Name	Parameter Description
Latitude	Latitude
Longitude	Longitude
Elevation	Altitude
GroundSpeed	Groundspeed
VerticalSpeed	Vertical Speed
Course	Ground Track
Heading	Heading
Pitch	Pitch
Roll	Roll
RollRate	Roll Rate
YawRate	Yaw Rate
NormalAccel	Normal Acceleration
LateralAccel	Lateral Acceleration
Slip	Slip/Skid Indication
TurnRate	Turn Rate
NormalField	Magnetic Field (Z Direction)
LongitudinalField	Magnetic Field (X Direction)
LateralField	Magnetic Field (Y Direction)
Fix	Fix Quality
HAcc	Horizontal Fix Accuracy
VAcc	Vertical Fix Accuracy

Table A-2. Unit abbreviations.

Units Abbreviation	Description
Degrees	degrees
Degrees/Sec	degrees per second
G's	g
Gauss	gauss
2D	two-dimensional fix
3D	three-dimensional fix
DGPS	differential GPS fix
Millimeters	millimeters