NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Washington, D.C. 20594

June 4, 2019

Errata #1 to the Aircraft Performance Memorandum

by John O'Callaghan

ACCIDENT

Location: Oldenburg, IN
Date: December 16, 2017
Time: 20:57 Eastern Daylight Time (EDT) / 01:57 Coordinated Universal Time (UTC)
Aircraft: Cessna T210M, registration N761YZ
NTSB#: CEN18FA053

GROUP

Not Applicable

SUMMARY

On December 16, 2017, at 20:57 eastern standard time, a Cessna T210M airplane, N761YZ, impacted trees and terrain following a loss of engine power near Oldenburg, Indiana. The pilot, pilot-rated passenger, and passenger were fatally injured. The airplane was destroyed by impact forces and a postimpact fire. The airplane was registered to N761YZ LLC and was operated by the pilot as a Title 14 Code of Federal Regulations (CFR) Part 91 personal flight. Dark night visual meteorological conditions prevailed along the route of flight, and the flight was operated on an instrument flight rules (IFR) flight plan. The flight originated from the Columbus Municipal Airport (BAK), Columbus, Indiana, at 2039 and was destined for the Frederick Municipal Airport (FDK), Frederick, Maryland.

A memorandum from John O'Callaghan, NRS-Aircraft Performance, to Tim Sorenson, Investigator in Charge for CEN18FA053, dated February 26, 2018 presents plots of performance data and glide trajectory estimates for the accident airplane. The plots present Automatic Dependent Surveillance – Broadcast (ADS-B) data from N761YZ, performance parameters computed from the ADS-B data, and theoretical zero-thrust glide trajectories based on the best-glide performance data published in the Pilot's Operating Handbook, and a series of assumed heading changes starting from the top of N761YZ's recorded ADS-B climb (the point at which the airplane is assumed to have lost engine power). The time, altitude, location, and content of selected communications between N761YZ and the Cincinnati ATCT LCW position are annotated on several of the plots.

D. DETAILS OF THE INVESTIGATION

The February 26, 2018 memorandum cited above should be corrected as follows:

The EST times quoted and plotted in the memorandum are in error by 1 hour. To correct the times, 1 hour should be subtracted from the times presented in the memorandum. For example, the correct time of the accident is 20:57 EST, vs. the 21:57 EST time presented in the memorandum.

John O'Callaghan
National Resource Specialist – Aircraft Performance
Office of Research and Engineering

National Transportation Safety Board

Memorandum

Date: February 26, 2018

To: Tim Sorensen
Air Safety Investigator, Central Region

From: John O'Callaghan
National Resource Specialist – Aircraft Performance

Subject: Plots of ADS-B data and performance estimates for CEN18FA053

References:
1. Cessna Aircraft Company, *Pilot's Operating Handbook, Turbo Centurion 1978 Model T210M, Revision 1,* issued November 1, 1978
2. Federal Aviation Administration, Cincinnati Air Traffic Control Tower (ATCT), *audio file "NTSB 18-051 LCW 0134-0215.wav," a copy of the recorded communications between Cincinnati ATCT position Local Control West (LCW) and N761YZ*
3. Email from NTSB meteorologist to NTSB Investigator-In-Charge, subject "CEN18FA053 - Oldenburg, IN Weather," dated February 26, 2018

Tim:

Attached please find plots of performance data and glide trajectory estimates for the Cessna Centurion T210M (N761YZ) accident in Oldenberg, IN on December 16, 2017 (CEN18FA053). The plots present Automatic Dependent Surveillance – Broadcast (ADS-B) data from N761YZ, performance parameters computed from the ADS-B data, and theoretical zero-thrust glide trajectories based on the best-glide performance data published in the Pilot's Operating Handbook (POH, Reference 1), and a series of assumed heading changes starting from the top of N761YZ's recorded ADS-B climb (the point at which the airplane is assumed to have lost engine power). The time, altitude, location, and content of selected communications between N761YZ and the Cincinnati ATCT LCW position (as transcribed by me[1] from the recording in Reference 2) are annotated on several of the plots. Because of space limitations, only selected transmissions are depicted on the plots, and the content of these selections are abbreviated; Table 2 on pages 6-7 depicts the full number of communications, and the full content of the selected communications presented in the plots.

[1] For brevity and clarity, my transcription of the recording includes some elements that are not typically part of an official FAA transcription. For example, I use punctuation where I think it is helpful (FAA transcripts do not), and I use numerals to represent numbers rather than spelling out their pronunciation as recorded (e.g., I write "2.5" whereas an official transcript would write "two point five" or "two and a half," depending on the actual pronunciation).

The ADS-B data for the airplane was provided by the Federal Aviation Administration (FAA) and consisted of:

- Time of the ADS-B position message from the airplane in UTC time, at a frequency of 1 report every second (1 Hz);
- Airplane latitude, as determined by the airplane's Global Positioning System (GPS) receiver, recorded to the nearest arc-second (i.e., within an uncertainty of ±0.5 arc-seconds);
- Airplane GPS longitude, recorded to the nearest arc-second;
- Airplane pressure altitude to the nearest 100 feet (i.e., within an uncertainty of ±50 ft.)

Although the ADS-B GPS position of the airplane is provided at a relatively high sample rate (1 Hz) and accuracy (compared to radar data), computing groundspeed from the data directly, without any filtering or other corrections, resulted in unrealistic noisiness or "spikes" in the result. To reduce this spurious noise, the GPS positions were smoothed by de-sampling the data to a frequency of 0.2 Hz and applying a running-average smoothing algorithm. Groundspeed and the other performance parameters presented below were then computed based on this smoothed data.

Similarly, to obtain smooth rate of climb and flight path angle calculations, the recorded pressure altitude was smoothed, while respecting the ±50 ft. uncertainty bounds of the data. In addition, Mean Sea Level (MSL) altitude was computed by adding 166 ft. to the recorded pressure altitude (corresponding to an altimeter setting of 30.10 "Hg, as reported by the 01:55Z METAR from Batesville Airport, Batesville, Indiana (KHLB) (see Reference 3).

The engine-out glide performance was determined based on a simple aerodynamic model of the airplane's lift and drag coefficients (C_L and C_D, respectively), computed using the best glide speed and glide ratio published in Reference 1, and textbook methods. The glide calculations were performed at two assumed airspeeds: the best glide speed noted in Reference 1 (85 KCAS), and a representative value of the actual airspeed flown during the airplane's descent, as computed from the ADS-B data and assumed winds (105 KCAS; the wind assumptions are described below).

A precise airplane weight for the flight was not available, so per our previous correspondence the maximum gross weight of 3800 lb. was used for the calculations. This assumption results in the maximum rate of descent and minimum computed glide time; lighter weights would result in lower rates of descent and longer glide times. The glide ratio (distance travelled per unit of altitude lost) is a function of the lift over drag ratio of the airplane, and is independent of weight.

The glide calculations consisted of computing the airplane's path over the ground as it descended without engine power from the starting point of the calculation (the maximum altitude recorded in the ADS-B data) to the elevation of the accident site (900 ft. MSL). To determine the glide range of the airplane in different directions from the starting point, a series of assumed heading changes[2] were evaluated, as listed in Table 1. The heading changes are evaluated by assuming the airplane rolls into a 30° roll angle immediately at the start of the scenario, using roll rate of 10°/s. The airplane rolls out of the turn at approximately 10°/s to end up on the new, target heading, and

[2] Actually, the calculations evaluate a series of ground track (as opposed to heading) changes; in other than calm winds, the ground track changes will differ slightly from heading changes. For simplicity of discussion, however, these ground track changes are referred to here as "heading changes."

maintains that heading until descending to the accident elevation. The effects of the roll angle on the airplane's glide performance during the turns are accounted for in the calculations.

Heading Change #	Heading Change (degrees)
1	-180
2	-135
3	-90
4	-45
5	0
6	45
7	90
8	135
9	180

Table 1. Heading changes assumed for the series of glide calculations.

The glide calculation results are shown in Figure 1. The glide range in different directions is affected strongly by the winds; the prevailing winds were west / southwesterly, and so the glide range to the east is greater than the glide range to the west. The assumed wind direction and speed as a function of altitude are shown in Figure 2, and are taken from the High Resolution Rapid Refresh (HRRR) model sounding over Batesville at 02:00 UTC (22:00 EST), as provided in Reference 3.

Figure 1 shows the glide range for the airplane starting at 21:52:00 EST, around the time it started to descend from about 7600 ft. MSL (and presumably the time that the engine failure reported by the pilot occurred). The plot is shown over a VFR terminal chart background.

The actual airplane trajectory recorded by the ADS-B data is depicted by the thickest line in Figure 1. The glide trajectories at the best glide speed (85 KCAS) are depicted by the medium-thickness lines; and the glide trajectories at an airspeed of 105 KCAS are depicted by the thinnest lines. For the T201M, the glide ratio (relative to the air) at 105 KCAS should be about 8% less than the glide ratio at 85 KCAS (1.44 nm per 1000 ft. altitude, vs. 1.56 nm per 1000 ft. altitude). The color of the lines depicts the altitude at each point, as shown in the legend.

The crash site coordinates plotted in Figures 1 are based on an aerial picture of the site, overlaid in the *Google Earth* computer program:

39° 22' 20.64" N, 085° 14' 52.74" W, elevation 902 ft.

The Figure 1 coordinates of the crash site are: east = 0.48 nm, north = 2.24 nm.

Plan views of the recorded and smoothed ADS-B data are shown in Figures 3a (with a grid background) and 3b (with a *Google Earth* image background). As in Figure 1, the altitude of the airplane is shown by the color of the thick line depicting the recorded ADS-B track. Figures 3a and 3b are annotated with selected communications between N761YZ and the LCW controller; the time and altitude corresponding to these communications are also shown in the plots. As noted earlier, the content of the communications presented in the plots is abbreviated; see Table 2 on pages 6-7 for the full number and content of the communications.

Altitude vs. time and altitude vs. distance for both the recorded ADS-B data and the glide performance calculations (with zero heading change) are shown in Figures 4 and 5, respectively. These plots show the reduction in glide time and distance resulting from flying at 105 KCAS instead of the optimal glide speed of 85 KCAS. Figure 4 includes vertical lines labeled with selected ATC communications; the intersections of these lines with the x-axis of the plot indicate the times at which the communications were recorded.

Figure 6 shows the speed, rate of climb, and glide ratio for N761YZ during its descent, as computed from the smoothed ADS-B data and the winds aloft shown in Figure 2. During most of the descent (until about 21:56:40, or about 2300 ft. MSL), the glide ratio relative to the ground is greater than that relative to the air, because the airplane is generally flying with a tailwind component. After about 21:56:40 the airplane has a headwind component. Note that in general the computed glide ratio relative to the air oscillates around the best glide ratio cited in Reference 1 (1.56 nm per 1000 ft. of altitude). Between 21:53:40 and 21:54:25, the airplane is slowing from about 110 KCAS to 95 KCAS, and the glide ratio is significantly higher than 1.56 as a result of trading kinetic for potential energy (airspeed for altitude, or a reduction in the rate of descent).

At other times, the oscillations in the glide ratio calculation are the result of the oscillations in rate of climb and flight path angle (γ), and are much larger than the 8% difference between the glide ratio at 105 KCAS and 85 KCAS that theoretically would be observed during a steady glide. Consequently, the expected degradation in the glide ratio resulting from flying faster than the optimal 85 KCAS is hidden in the oscillations in the data, and is of less consequence than the observation that the airplane glide performance was consistent with that published in Reference 1. In any case, the computed glide ratio is sensitive to the assumed winds aloft. If the tailwind were greater than that implied by the winds shown in Figure 2, then for the same groundspeed the airspeed would be smaller, and glide ratio relative to the air would also be smaller. Uncertainty in the winds is probably the greatest factor affecting the accuracy of the glide calculations.

Figure 7 shows plots of lift C_L vs. C_D for both the aerodynamic model based on the Reference 1 best-glide data, and for the values computed from the ADS-B data and assumed winds. The bottom of Figure 7 presents a plot of horsepower required vs. time. These plots indicate that:

- The scatter in the computed C_D reflects the oscillations in the computed rate of climb (see Figure 6), which directly affect the flight path angle γ (plotted in Figure 8) and the C_D calculation ($C_D = -C_L \gamma$). Although the scatter in C_D is generally about the modeled values of C_D, the calculation is not reliable because the equation is only valid for a steady glide, and the computed rate of descent is almost never steady.

- In general, the horsepower required during the descent oscillates around zero, indicating that the assumed lift and drag model is consistent with a zero-power descent. After about 21:56:05, the computed required horsepower is mostly negative horsepower, indicating that in this area, additional drag is required beyond the assumed C_L vs. C_D model to fly the smoothed ADS-B trajectory with the winds shown in Figure 2.

The negative horsepower required after 21:56:05 can be the result of a greater than assumed headwind in this part of the flight (a very plausible explanation), and / or an airplane configuration that differs from the optimal (unlikely, because per our previous correspondence, evidence in wreckage indicates that the gear and flaps were up at the time of impact).

Finally, Figure 8 presents several flight angles computed from the smoothed ADS-B data and assumed winds, including the pitch angle, flight path angles relative to the air and to the ground, roll and drift angles, and heading and ground track angles. These calculations assume:

- A lift-curve (C_L vs. angle of attack (α)) equivalent to that of a Cessna 182P (data for which was obtained from Textron Aviation during a previous investigation)
- Turns are coordinated (lateral load factor and sideslip angle = 0)

As noted above, the contents of ATC communications shown in Figures 1-4 are abbreviated. The full number and content of these communications based on my transcription of Reference 2 is presented in Table 2 on pages 6-7.

If you have any questions about the data shown in the plots or the calculations, please let me know.

Regards,

John O'Callaghan

EST Time	Full transcription text	Plotted text
21:52:06	Ah, Indianapolis, Indianapolis, Indianapolis center, um … 76 [stepped on / unreadable]	[N761YZ] Indianapolis …
21:52:14	Indianapolis Center, Centurion 751YZ, 761YZ, ah we're having an emergency, um …	
21:52:30	Mayday, Mayday, Mayday , 761YZ, over, over	[N761YZ] Mayday …
21:52:35	N761YZ Cincinnati	
21:52:38	… having a partial engine failure we need to get down right now - I show KHLB 3.6 miles please confirm please confirm	
21:52:48	N1YZ Hillenbrand airport is off your left and 4 miles - the airport is listed as closed, but that's the closest airport to you	[LCW] HLB closest but closed
21:53:05	N1YZ I understand you have an engine failure and you're going to go to Hillenbrand airport, is that correct?	
21:53:11	How do we turn the lights on? Do you know anything about this airport?	[N761YZ] lights?
21:53:14	Yeah it is a private airport for Batesville, Indiana, ah I can get the ah frequency for the lights but I'm not sure if they're workin' the airport is listed as closed	
21:53:23	We're we're not going to make it, we're not going to make it, ah but it's 2.3 miles, that's all we have, that's all we have	[N761YZ] that's all we have
21:53:30	OK the airport is ahead and to your left 9 to 10 o'clock and 3 miles that's the closest airport sir	
21:53:40	It's a 18-36 runway, if you turn due north now you'll be lined up for 36 but you're a little high for 36	
21:53:49	That doesn't matter we can circle turning to 360 right now	[N761YZ] turning to 360
21:53:52	Yeah go north right now y- you're about a mile south of the Hillenbrand airport	
21:53:56	We've gotta get the lights on, gotta get the lights on	[N761YZ] gotta get the lights on
21:54:19	I'm looking up for you right now sir I'm trying to figure out the frequency to turn the lights on	
21:54:23	We're not going to make this, we gotta be able to see, we gotta be able to see	[N761YZ] we gotta be able to see
21:54:52	Center is there anything else you can do for us can you direct me	[N761YZ] can you direct me
21:54:55	OK you're you're right over the Hillenbrand airport sir you're directly over it the the CTAF frequency is 122.72 and you can try that for the lights	
21:55:21	N1YZ I'm showin' two frequencies 122.72 is the CTAF see if that can turn on the lights sir	[LCW] 122.72 is the CTAF
21:55:44	N1YZ I'm shown' you now northbound north of Hillenbrand suggest you turn southbound now for the runw- for the airport	[LCW] suggest turn southbound

Table 2 (p. 1 of 2). Full number and contents of transcribed ATC communications, and corresponding abbreviated number and contents of communications as plotted in Figures 1-4.

EST Time	Content	Plotted text
21:55:56	We're going to need something we're going to need something right now	[N761YZ] we need something right now
21:55:59	N1YZ turn southbound right now for Hillenbrand airport y- you're now north of the airport about 3 miles I ca- I- the only frequency I'm showing is 122.72 it's a private airport I don't know the frequency to turn the lights on I'm trying to find something for ya	
21:56:20	All I'm showin' that the airport is closed all I'm showin' sir is the closest airport ah is a 18-36 runway and it's 5950 feet	[LCW] closed airport closest
21:56:42	N1YZ you're 2 miles northeast of Hillenbrand airport now suggest you tur- you need to go southwest sir	
21:56:51	I'm southwest now sir I do not -	[N761YZ] I'm southwest now
21:56:56	It's about your 2 to 3 it's your 2 o'clock sir it's at your 2 o'clock and 2.5 miles	
21:57:01	[sound of 4 microphone clicks]	[?] [sound of 4 clicks]
21:57:04	The unicom is 122.72 …	
21:57:07	… that may turn the lights on	

Table 2 (p. 2 of 2). Full number and contents of transcribed ATC communications, and corresponding abbreviated number and contents of communications as plotted in Figures 1-4.

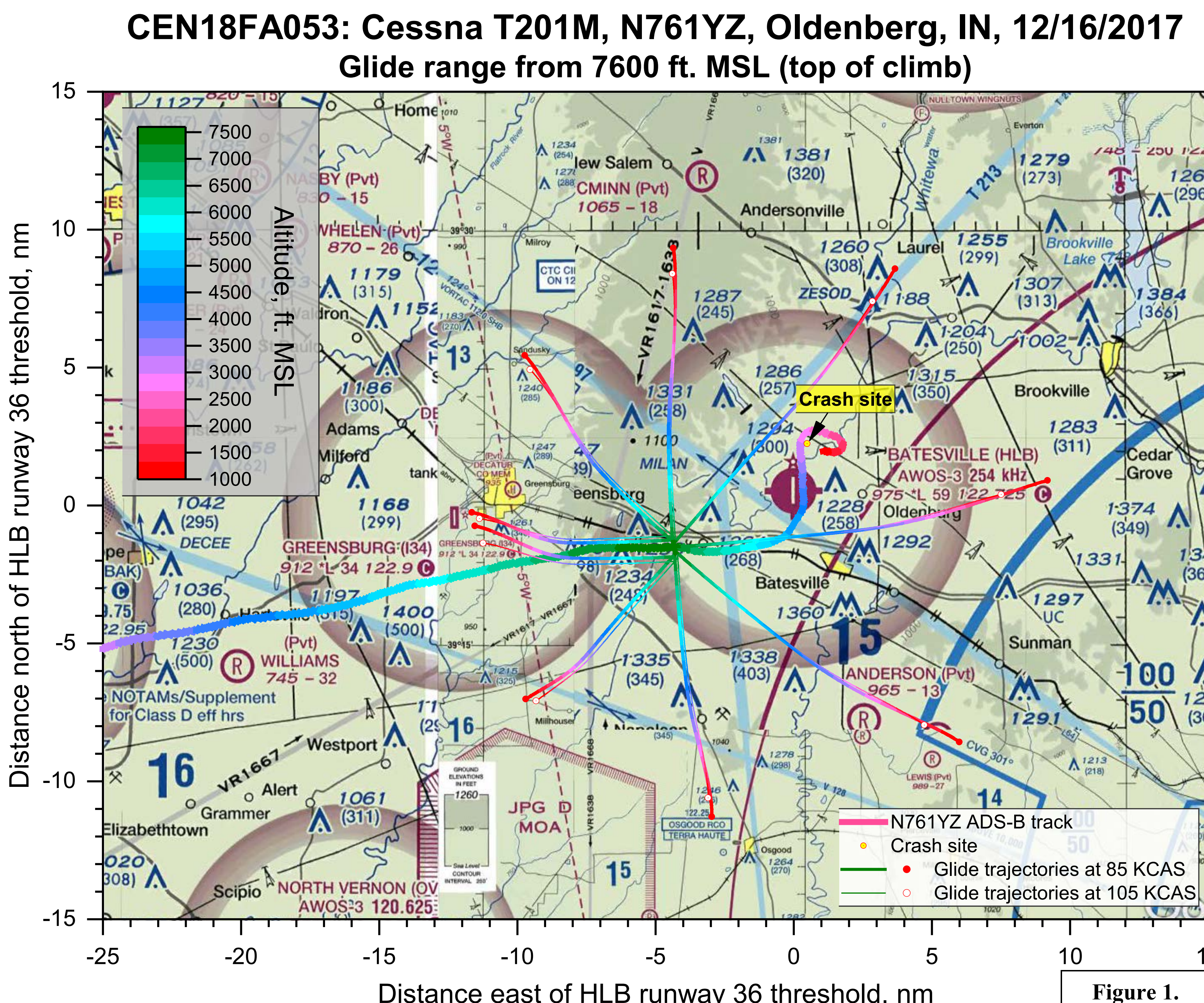

CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017
Glide range from 7600 ft. MSL (top of climb)
Altitude, ft. MSL
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
Crash site
N761YZ ADS-B track
Crash site
Glide trajectories at 85 KCAS
Glide trajectories at 105 KCAS
Distance north of HLB runway 36 threshold, nm
Distance east of HLB runway 36 threshold, nm
15
10
5
0
-5
-10
-15
-25
-20
-15
-10
-5
0
5
10
15

Figure 1.

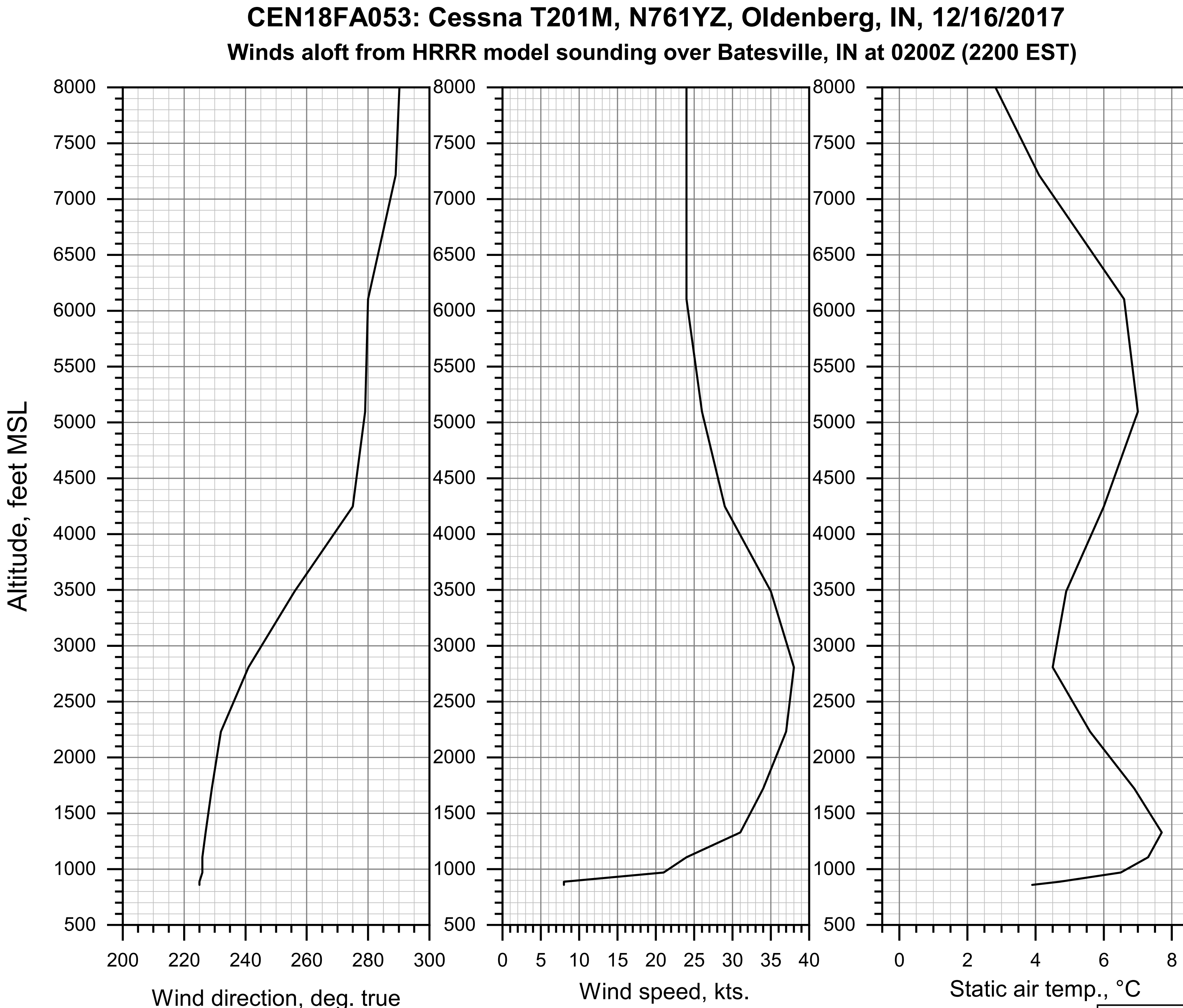

CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017
Winds aloft from HRRR model sounding over Batesville, IN at 0200Z (2200 EST)
Altitude, feet MSL
Wind direction, deg. true
Wind speed, kts.
Static air temp., °C

Figure 2.

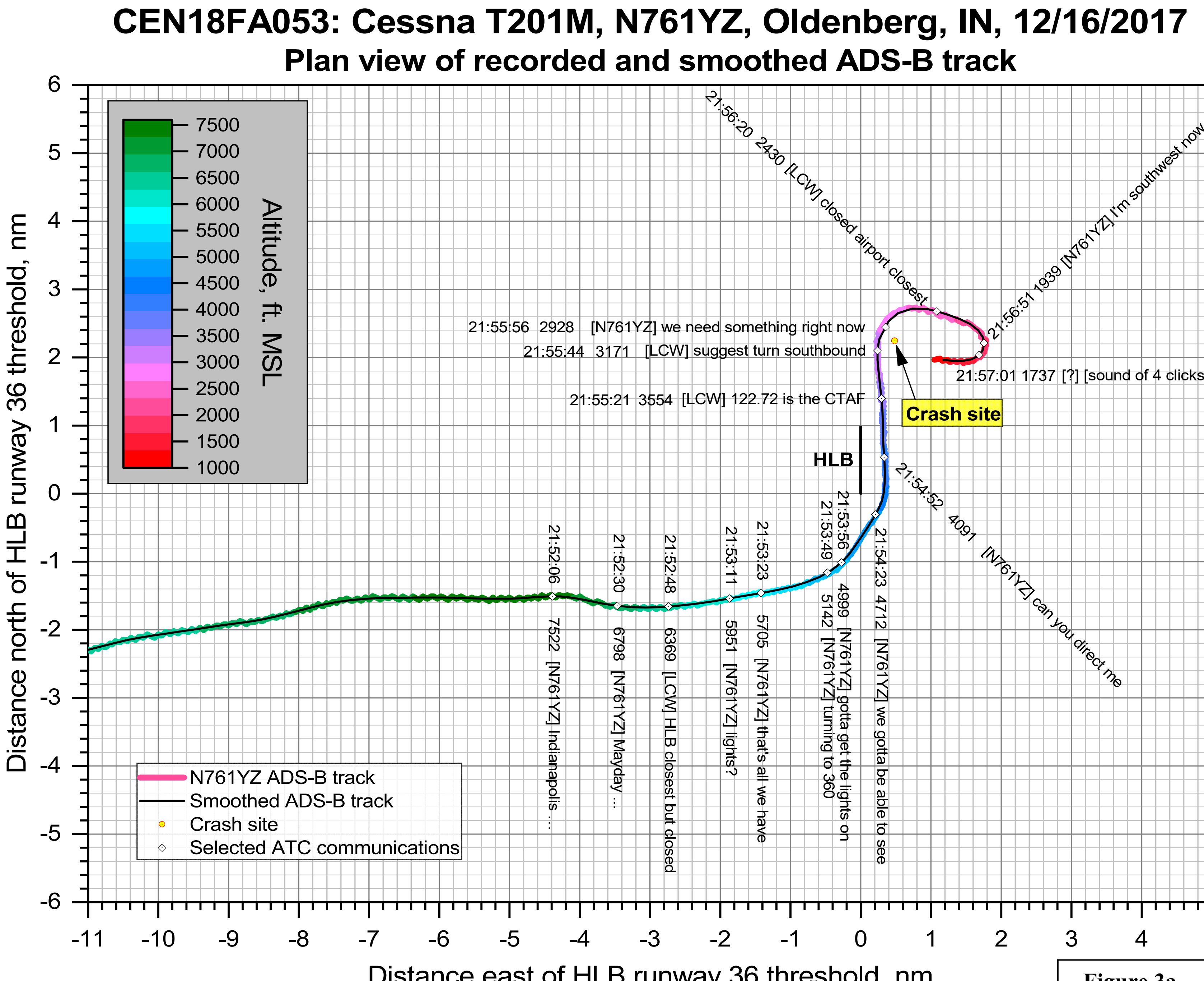

CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017
Plan view of recorded and smoothed ADS-B track
Altitude, ft. MSL
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
Distance north of HLB runway 36 threshold, nm
Distance east of HLB runway 36 threshold, nm
HLB
Crash site
21:52:06 7522 [N761YZ] Indianapolis . . .
21:52:30 6798 [N761YZ] Mayday . . .
21:52:48 6369 [LCW] HLB closest but closed
21:53:11 5951 [N761YZ] lights?
21:53:23 5705 [N761YZ] that's all we have
21:53:49 5142 [N761YZ] turning to 360
21:53:56 4999 [N761YZ] gotta get the lights on
21:54:23 4712 [N761YZ] we gotta be able to see
21:54:52 4091 [N761YZ] can you direct me
21:55:21 3554 [LCW] 122.72 is the CTAF
21:55:44 3171 [LCW] suggest turn southbound
21:55:56 2928 [N761YZ] we need something right now
21:56:20 2430 [LCW] closed airport closest
21:56:51 1939 [N761YZ] I'm southwest now
21:57:01 1737 [?] [sound of 4 clicks]
N761YZ ADS-B track
Smoothed ADS-B track
Crash site
Selected ATC communications

Figure 3a.

CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017
Plan view of recorded and smoothed ADS-B track

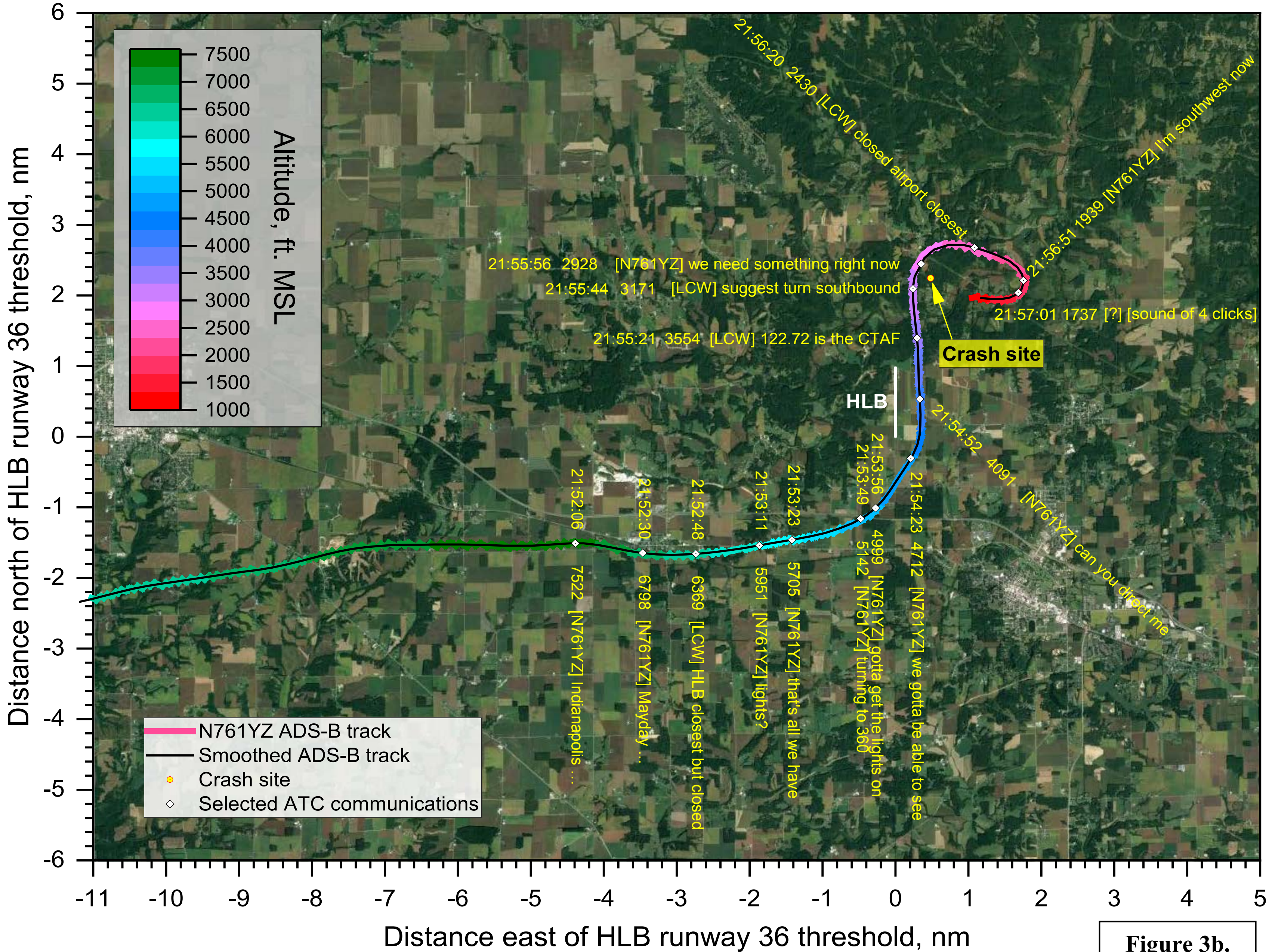


Figure 3b.

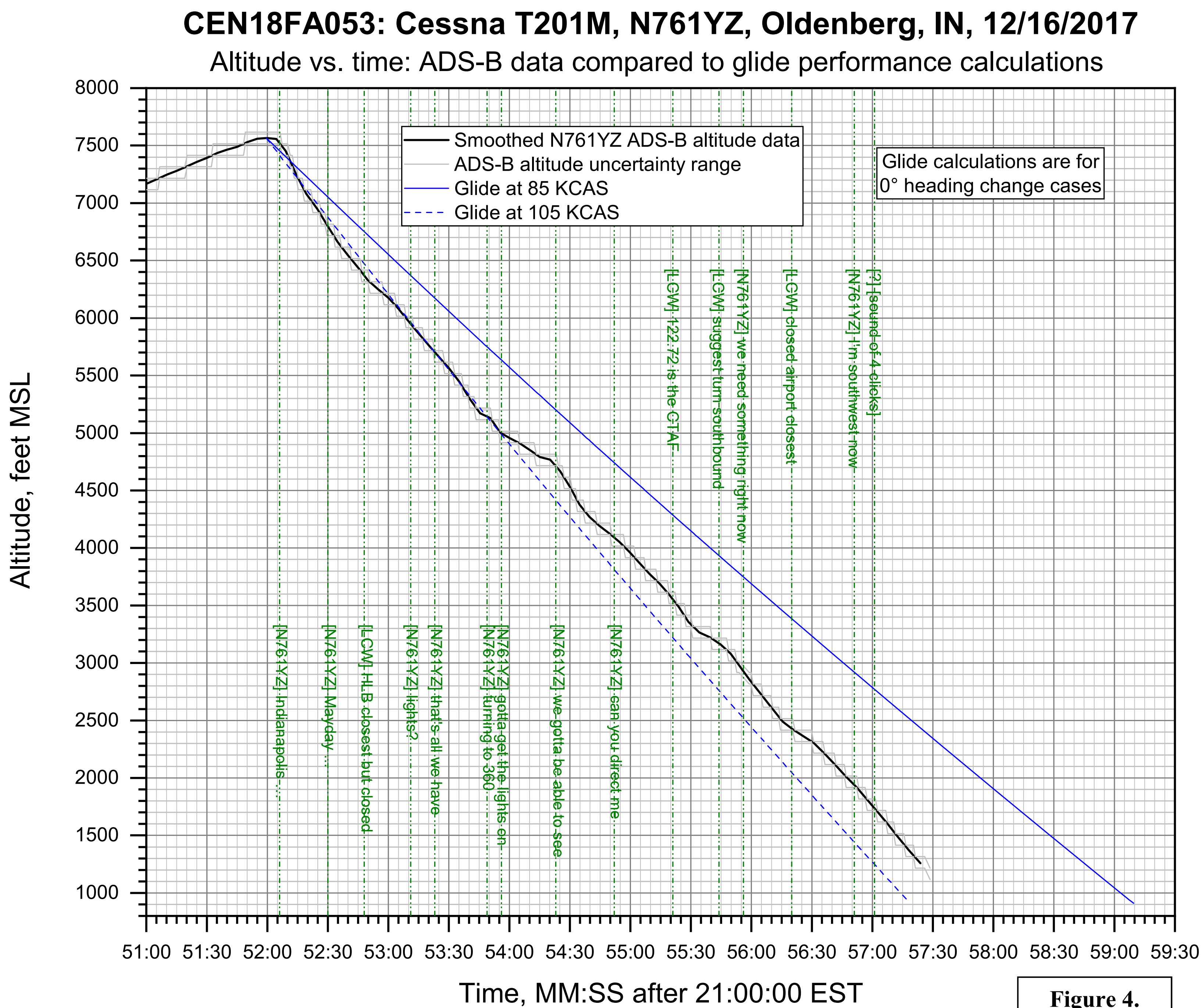
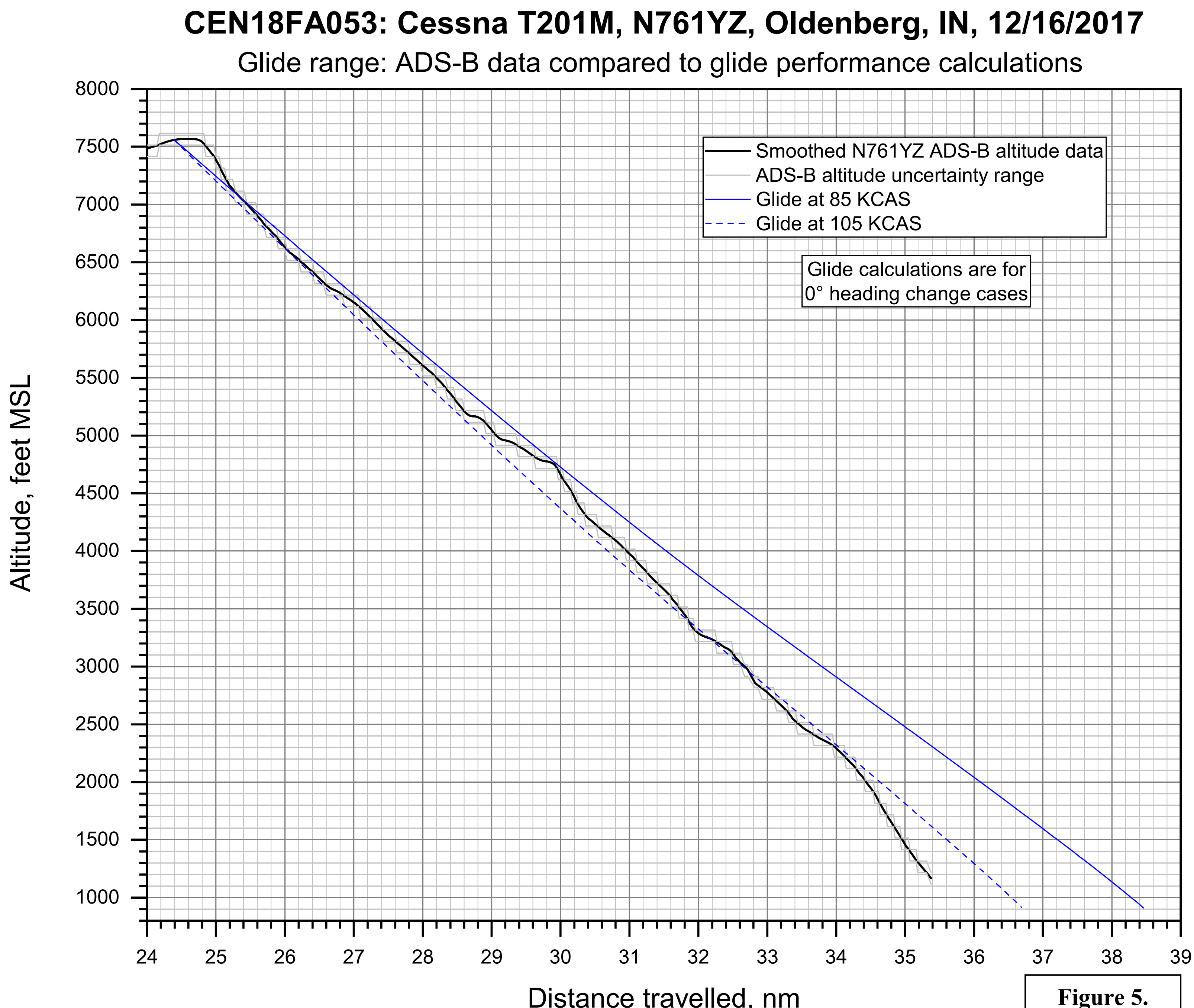

CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017
Altitude vs. time: ADS-B data compared to glide performance calculations
Smoothed N761YZ ADS-B altitude data
ADS-B altitude uncertainty range
Glide at 85 KCAS
Glide at 105 KCAS
Glide calculations are for 0° heading change cases
Altitude, feet MSL
Time, MM:SS after 21:00:00 EST
[N761YZ] indianapolis ...
[N761YZ] Mayday ...
[LCW] HLB closest but closed
[N761YZ] lights?
[N761YZ] that's all we have
[N761YZ] turning to 360
[N761YZ] gotta get the lights on
[N761YZ] we gotta be able to see
[N761YZ] can you direct me
[LCW] 122.72 is the CTAF
[LCW] suggest turn southbound
[N761YZ] we need something right now
[LCW] closed airport closest
[N761YZ] I'm southwest now
[?] [sound of 4 clicks]
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
51:00
51:30
52:00
52:30
53:00
53:30
54:00
54:30
55:00
55:30
56:00
56:30
57:00
57:30
58:00
58:30
59:00
59:30

Figure 4.



CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017
Glide range: ADS-B data compared to glide performance calculations
Smoothed N761YZ ADS-B altitude data
ADS-B altitude uncertainty range
Glide at 85 KCAS
Glide at 105 KCAS
Glide calculations are for 0° heading change cases
Altitude, feet MSL
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
Distance travelled, nm

Figure 5.

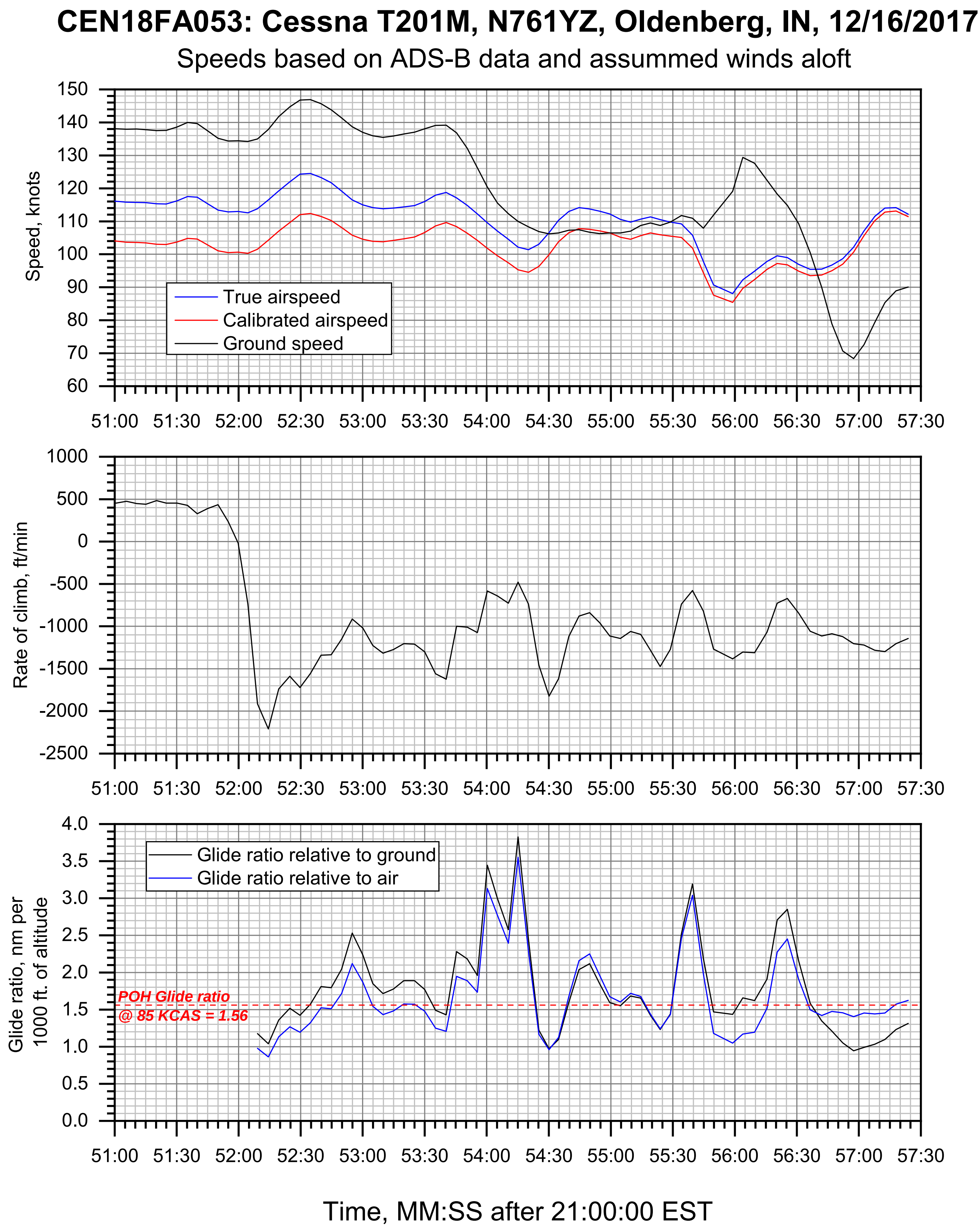

CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017
Speeds based on ADS-B data and assummed winds aloft
Speed, knots
150
140
130
120
110
100
90
80
70
60
True airspeed
Calibrated airspeed
Ground speed
51:00
51:30
52:00
52:30
53:00
53:30
54:00
54:30
55:00
55:30
56:00
56:30
57:00
57:30
Rate of climb, ft/min
1000
500
0
-500
-1000
-1500
-2000
-2500
Glide ratio, nm per 1000 ft. of altitude
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Glide ratio relative to ground
Glide ratio relative to air
POH Glide ratio
@ 85 KCAS = 1.56
Time, MM:SS after 21:00:00 EST

Figure 6.

CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017

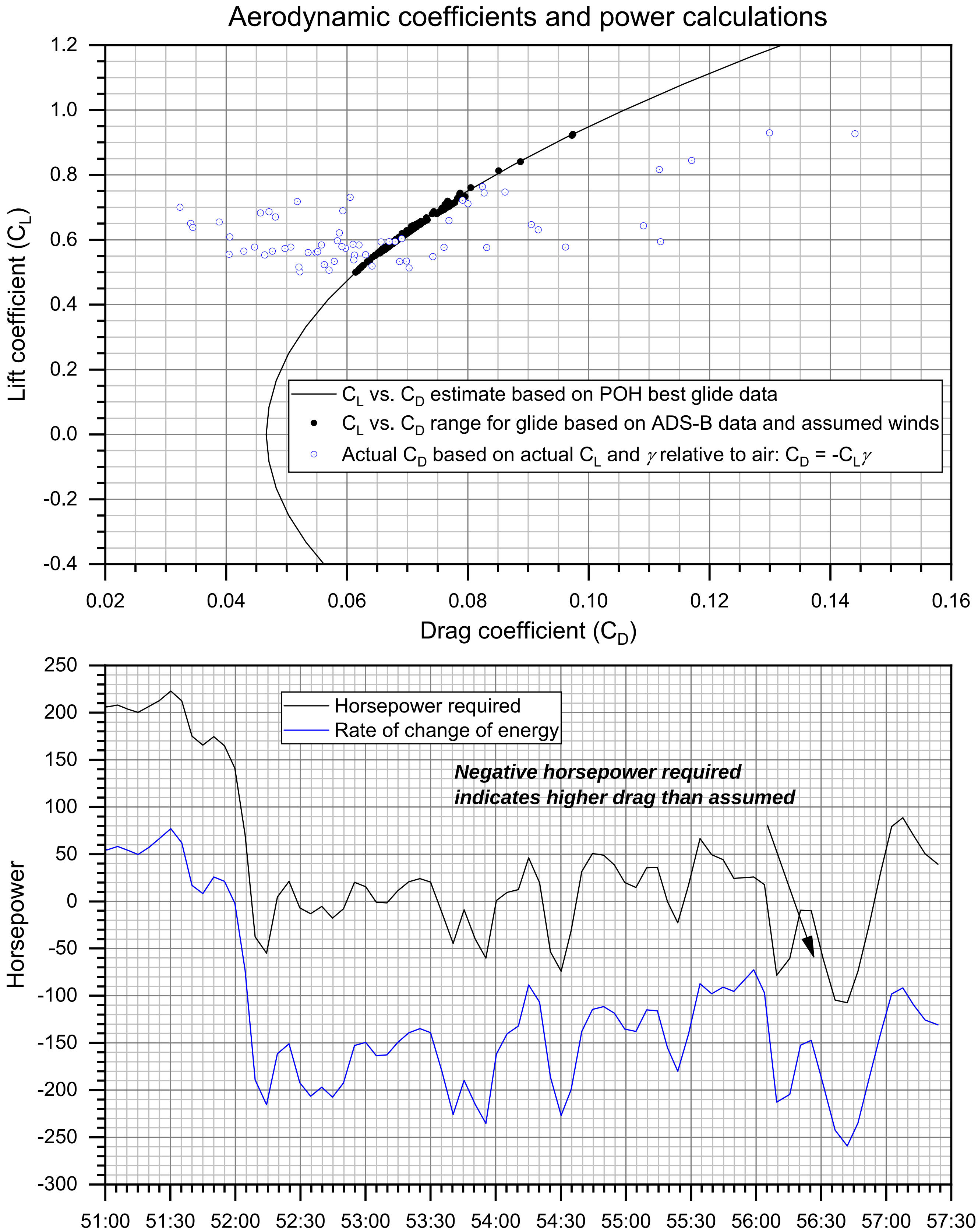
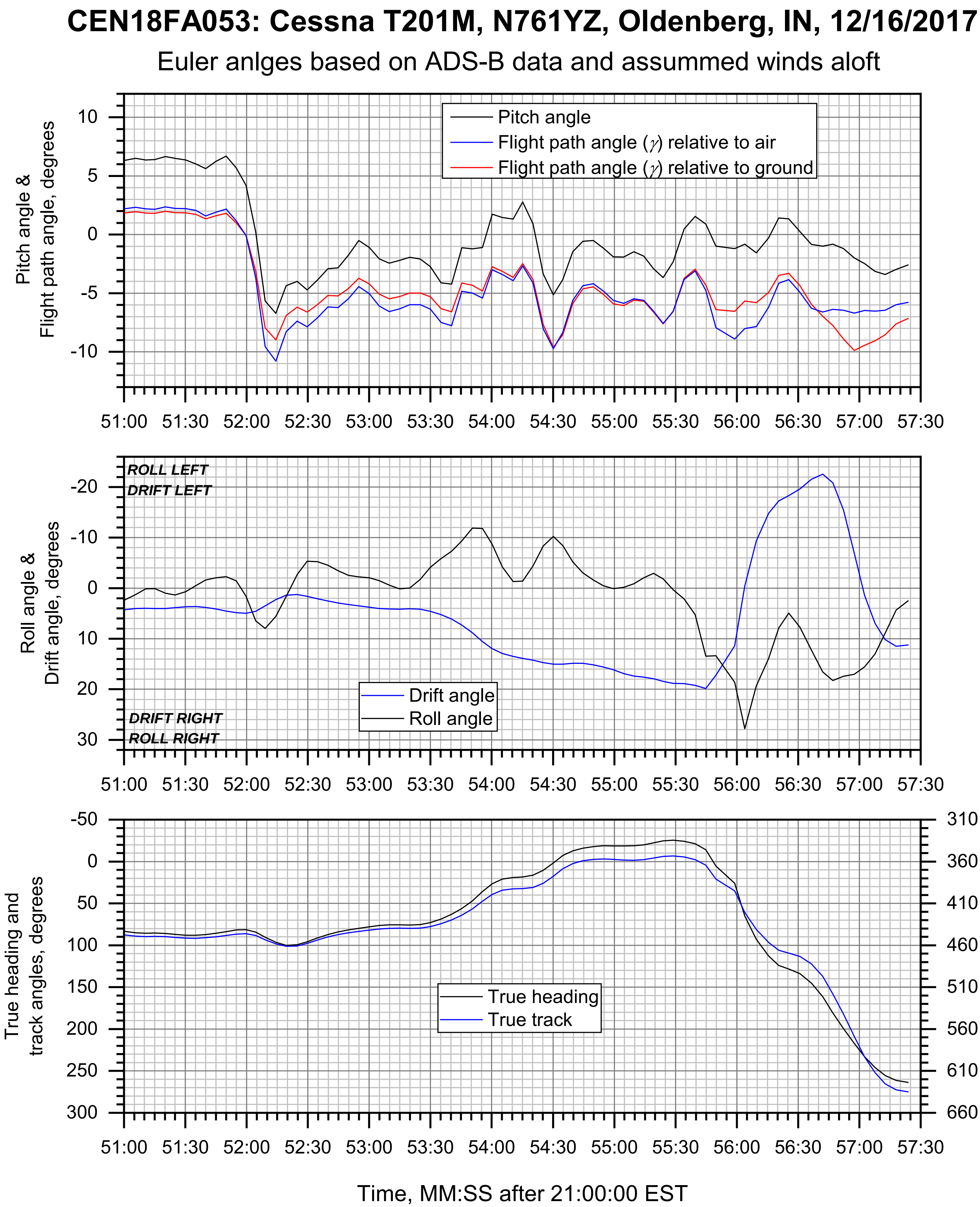


Figure 7.



CEN18FA053: Cessna T201M, N761YZ, Oldenberg, IN, 12/16/2017
Euler anlges based on ADS-B data and assummed winds aloft
Pitch angle
Flight path angle (γ) relative to air
Flight path angle (γ) relative to ground
Pitch angle & Flight path angle, degrees
ROLL LEFT
DRIFT LEFT
DRIFT RIGHT
ROLL RIGHT
Drift angle
Roll angle
Roll angle & Drift angle, degrees
True heading
True track
True heading and track angles, degrees
51:00 51:30 52:00 52:30 53:00 53:30 54:00 54:30 55:00 55:30 56:00 56:30 57:00 57:30
Time, MM:SS after 21:00:00 EST

Figure 8.