



Date: February 28, 2025

To: Joshua Young, Office of Aviation Safety

From: John O'Callaghan, Office of Research and Engineering

Subject: Airplane performance plots for ERA24FA136

Joshua:

This memorandum transmits plots of Automatic Dependent Surveillance - Broadcast (ADS-B) flight path and airplane performance information for the IAI Westwind Astra (N1125A) accident in Hot Springs, Virginia, on March 10, 2024 (ERA24FA136). The plots present ADS-B data from N1125A, and additional performance parameters computed from these data. The airplane impacted terrain about 300 ft. from the runway threshold while conducting the ILS approach to runway 25 at Ingalls Field Airport (KHSP) in Hot Springs.

Description of ADS-B data

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

- Time of the ADS-B messages in Universal Coordinated Time (UTC), at a frequency of approximately 1 report every second (1 Hz).
- Latitude, as determined by the airplane's Global Navigation Satellite System (GNSS) receiver, recorded to the nearest hundredth of an arc-second.
- GNSS longitude, recorded to the nearest hundredth of an arc-second.
- GNSS altitude, recorded to the nearest 25 feet (i.e., within an uncertainty of ± 12.5 ft.). The GNSS altitude is the height above the WGS84 ellipsoid. Altitude above mean sea level (MSL) is obtained by subtracting the height of the geoid above the ellipsoid from the GNSS height. In this case, MSL altitude = GNSS altitude + 107 ft. (at KHSP, the geoid is 107 ft. below the ellipsoid).
- Pressure altitude to the nearest 25 feet.

- Avionics-reported¹ GPS-based north and east velocities recorded to the nearest knot.
- Avionics-reported barometric-based rate of climb recorded to the nearest foot per second.

Additional performance parameters computed from the ADS-B data – such as the Euler angles (pitch, roll, and heading) – depend on the ground speed, and will reflect any “noise” in that parameter. Although the ADS-B GNSS position of the airplane is provided at a relatively high sample rate (1 Hz) and accuracy (compared to radar data), computing ground speed from the data directly, without any filtering or other corrections, results in unrealistic noisiness or “spikes” in the result.

The north and east components of the ADS-B recorded ground speed are themselves filtered by the airplane’s avionics prior to broadcast over the ADS-B system, and are consequently very smooth. However, in this case they still exhibit unrealistic “spikes” or “noise” at particular times (see Figure 5). To address this noise, the recorded ground speed components are curve-fit using a cubic spline smoothing algorithm. The curve fit velocity components are then integrated over time to obtain the airplane north and east coordinates relative to the KHSP runway threshold. Using the integrated north and east positions in the performance calculations ensures that smooth velocities and other performance parameters result from taking the time-derivatives of the positions. As shown in Figure 1, the resulting flight track (labeled “Integrated ADS-B ground speeds”) matches the recorded flight track well.² This integrated flight track is used in the computation of additional performance parameters.

A similar approach is used to determine the altitude used for additional performance calculations. Figure 2 plots the ADS-B geometric and pressure altitudes vs. time as the blue and black dot symbols. The red line labeled “Integration of corrected ADS-B vertical speed” is the true altitude computed by integrating a cubic spline curve-fit of the ADS-B recorded vertical speed, and then correcting the result for non-standard temperature and pressure. This integrated altitude is used along with the integrated flight track to compute additional performance parameters.

Additional performance parameters computed from ADS-B data

The position of an airplane as a function of time defines its velocity and acceleration vectors. In coordinated flight, these vectors lie almost entirely in the plane defined by

¹ Here “avionics-reported” indicates that the recorded speed values were computed by the airplane’s avionics and broadcast over the ADS-B system, as opposed to being computed on the ground using the GNSS latitude and longitude coordinates broadcast by the airplane.

² Several Figures in this memorandum have “a” and “b” versions, which present the same information but at different scales, or with different background images. When the text refers to a Figure with two or more versions without specifying the version, all versions are meant to be included in the reference.

the airplane's longitudinal and vertical axes. Furthermore, any change in the *direction* of the velocity vector is produced by a change in the lift vector, either by increasing the magnitude of the lift (as in a pull-up), or by changing the direction of the lift (as in a banked turn). The lift vector also acts entirely in the aircraft's longitudinal-vertical plane, and is a function of the angle between the aircraft longitudinal axis and the velocity vector (the angle of attack, α). These facts allow the equations of motion to be simplified to the point that a solution for the airplane orientation can be found given additional information about the wind and the airplane. Specifically, the wind speed and direction, as well as the airplane weight and lift coefficient (C_L) as a function of α , are required to compute the Euler angles.

Winds aloft from a High Resolution Rapid Refresh (HRRR) atmosphere model for 15:00 EDT near the accident site, provided by an NTSB meteorologist, are used in the performance calculations (see Figure 4). A weight of 16,012 lb. is assumed based on the landing weight specified in the flight plan provided during the investigation.

The lift curve (C_L vs. α) for the airplane depends on the flap setting. Cockpit Voice Recorder (CVR) information indicates that the flaps were extended incrementally at various points during the approach. The applicable lift curve, which affects the pitch angle (θ) and α calculations, would have changed at these points accordingly. A rigorous calculation of θ and α during the approach would therefore require accounting for the changing lift curve characteristics as the flaps were extended. However, since the airspeeds during the approach were sufficiently high that concerns about an aerodynamic stall are not a factor in this accident (see Figure 5), θ and α during the approach are not of primary interest, and consequently are not computed or presented here.

Results

The ADS-B data and results of the performance calculations are presented in Figures 1-8. Figure 1 presents a birds-eye view of the flight path of the airplane, over a simple map background. The position of the airplane is presented as north and east coordinates from the KHSP runway 25 threshold. The altitude labels in these Figures are the ADS-B geometric altitude in feet above mean sea level (MSL). The integration of the curve-fit ADS-B speeds is shown as the red line. The locations of the KHSP ILS RWY25 localizer beams are depicted by the blue dash / dash-dot lines.

Figure 2 plots the ADS-B altitudes vs. time. The geometric altitude is depicted by the black dots, the pressure altitude is depicted by the blue dots, and the curve fit of the integrated vertical speed is depicted as the red line. The indicated altitudes corresponding to the ADS-B recorded pressure altitude corrected for altimeter settings of 29.65 "Hg (the current altimeter setting reported by the AWOS) and 29.81 "Hg (the last altimeter setting provided to the flight crew by ATC) are also shown.

Figure 3 shows a profile view of the flight path as it approached KHSP runway 25. The x-axis in this plot is the KHSP runway 25 x-coordinate. The runway axis system is centered at the runway threshold, and the x-axis extends down the runway centerline towards the departure end of the runway. The y-axis is at right angles to the x-axis and points to the right of the centerline. In Figure 3, the airplane's calibrated airspeed is depicted by the red labels next to the time / speed callout symbols, and the location of the KHSP ILS RWY25 glideslope beams are depicted by the blue dash / dash-dot lines. The terrain underlying the airplane is depicted by the brown-shaded area.

Figure 4 plots the wind direction, wind velocity, and static air temperature vs. altitude from the 15:00 EDT HRRR model obtained from the NTSB meteorologist.

Figure 5 plots several airplane speeds, including ground speed, true airspeed, calibrated airspeed, and vertical speed (rate of climb). The ground speed and vertical speed recorded in the ADS-B data are depicted by the black dots. The ground speed obtained from the curve-fit of the ADS-B velocity components is depicted as the black line in the top plot of the Figure. The true and calibrated airspeeds computed using the ground speed from the curve-fit combined with the winds aloft from the HRRR model are depicted by the red and blue lines, respectively. The vertical speed obtained by taking the time derivative of the computed true altitude is depicted by the red line in the bottom plot of Figure 5 labeled "smoothed & corrected vertical speed."

Figure 6 presents the speeds and rate of climb vs. the KHSP runway 25 x-coordinate.

The top plot of Figure 7 presents the height of the airplane above the terrain, obtained by subtracting the terrain elevation from the airplane's true altitude. The rate of climb relative to the terrain, which is the time derivative of the height above the terrain, is shown in the bottom plot of Figure 7. Note that near the end of the flight, the combination of the rising terrain and descent of the airplane made the rate of descent relative to the terrain peak at 8,000 feet/minute.

Figure 8 presents the Euler angle calculations. As noted above, the θ and α during the approach are not of primary interest, and only the flight path angles relative to the Earth and relative to the airmass are presented. The difference between them is due to the wind. The roll angle oscillation at the end of the flight, peaking at about 22° left and then reversing to 10° right, reflects the oscillations in the flight path and track and heading angles. The strong winds at the time resulted in a relatively high drift angle (between 10° and 13° left, i.e., nose right of track).

Please let me know if you have any questions about the contents of this memorandum.

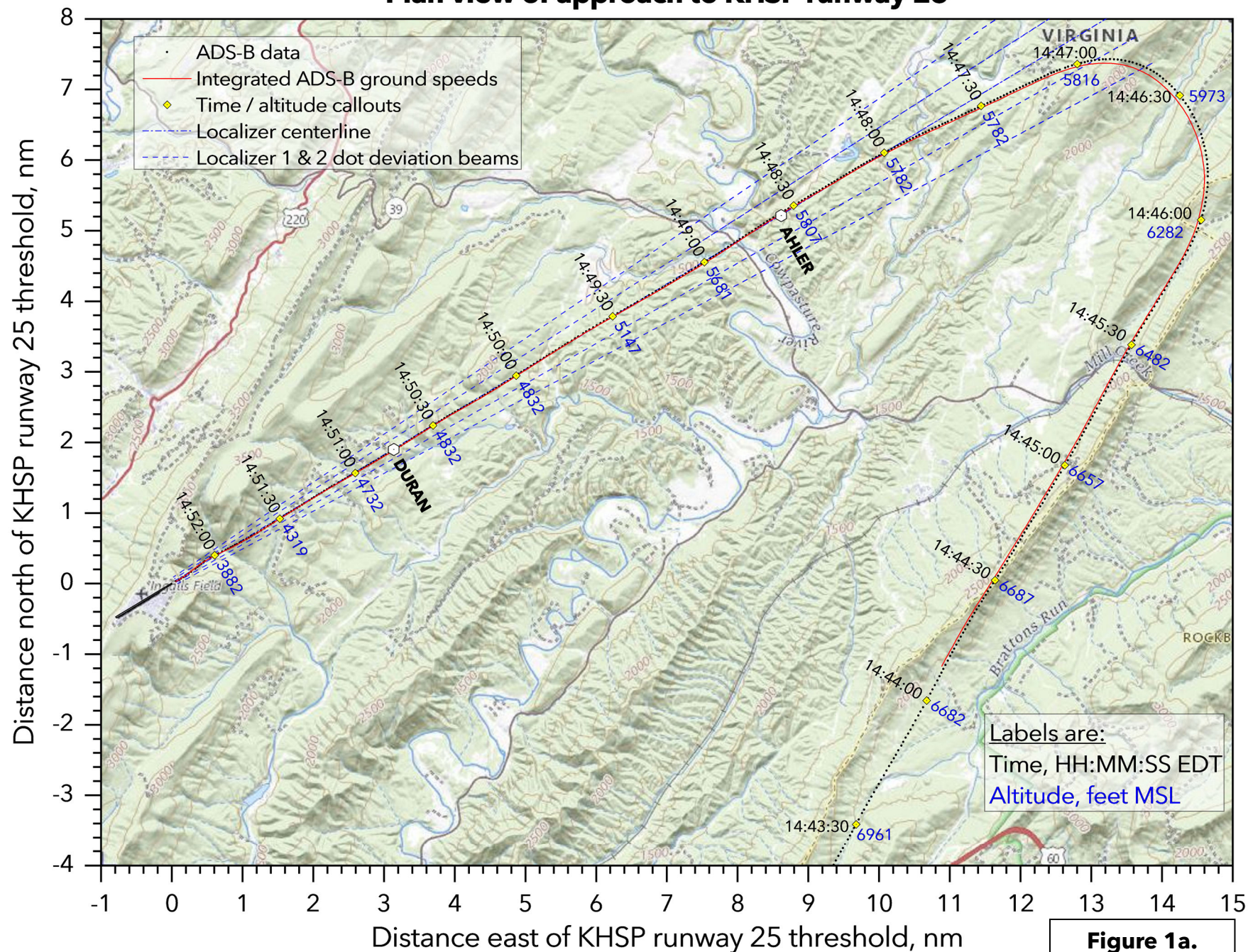
Regards,

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Plan view of approach to KHSP runway 25



Plan view of approach to KHSP runway 25 (detail)

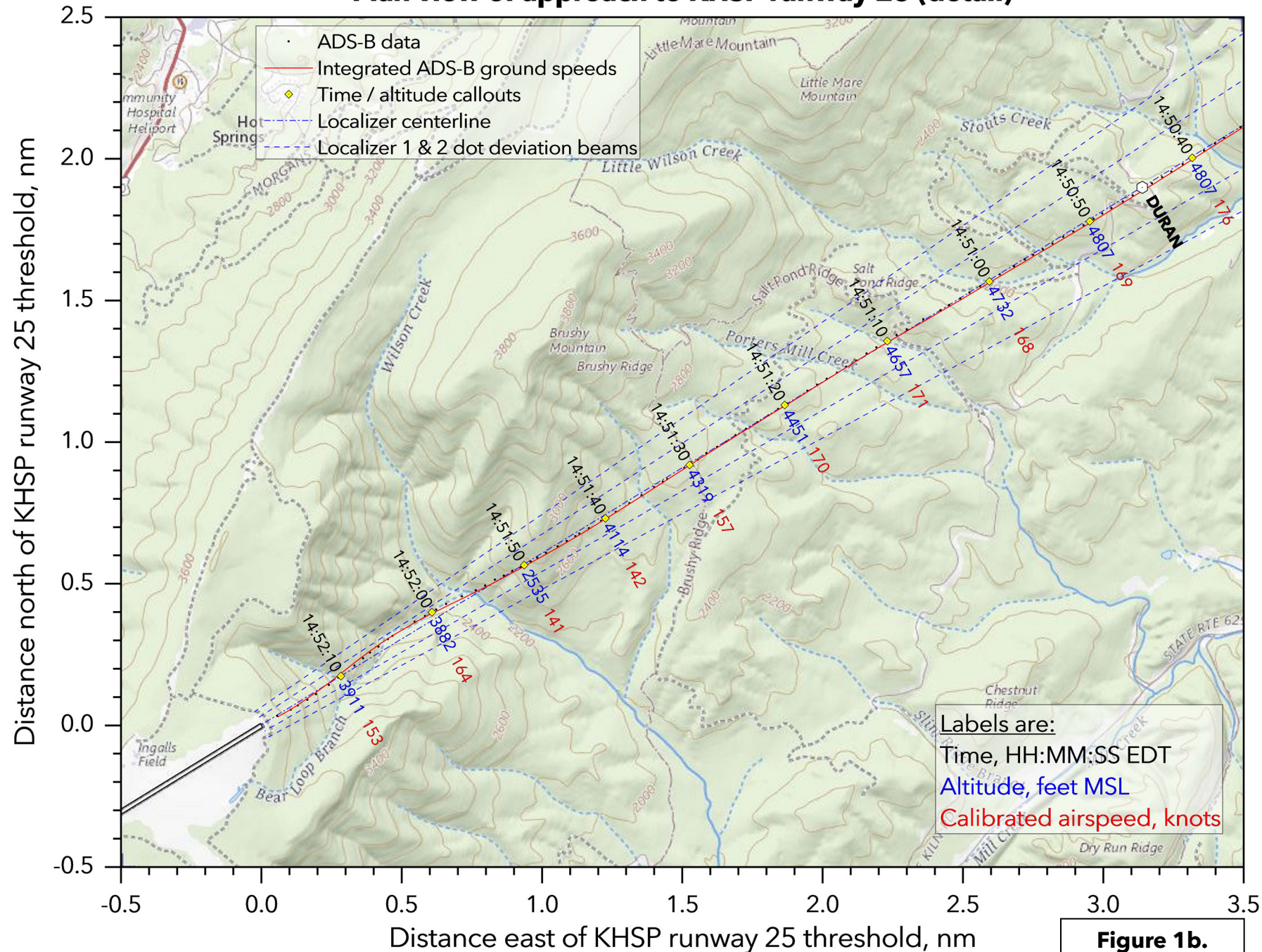


Figure 1b.

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Altitude vs. time during approach to KHSP runway 25

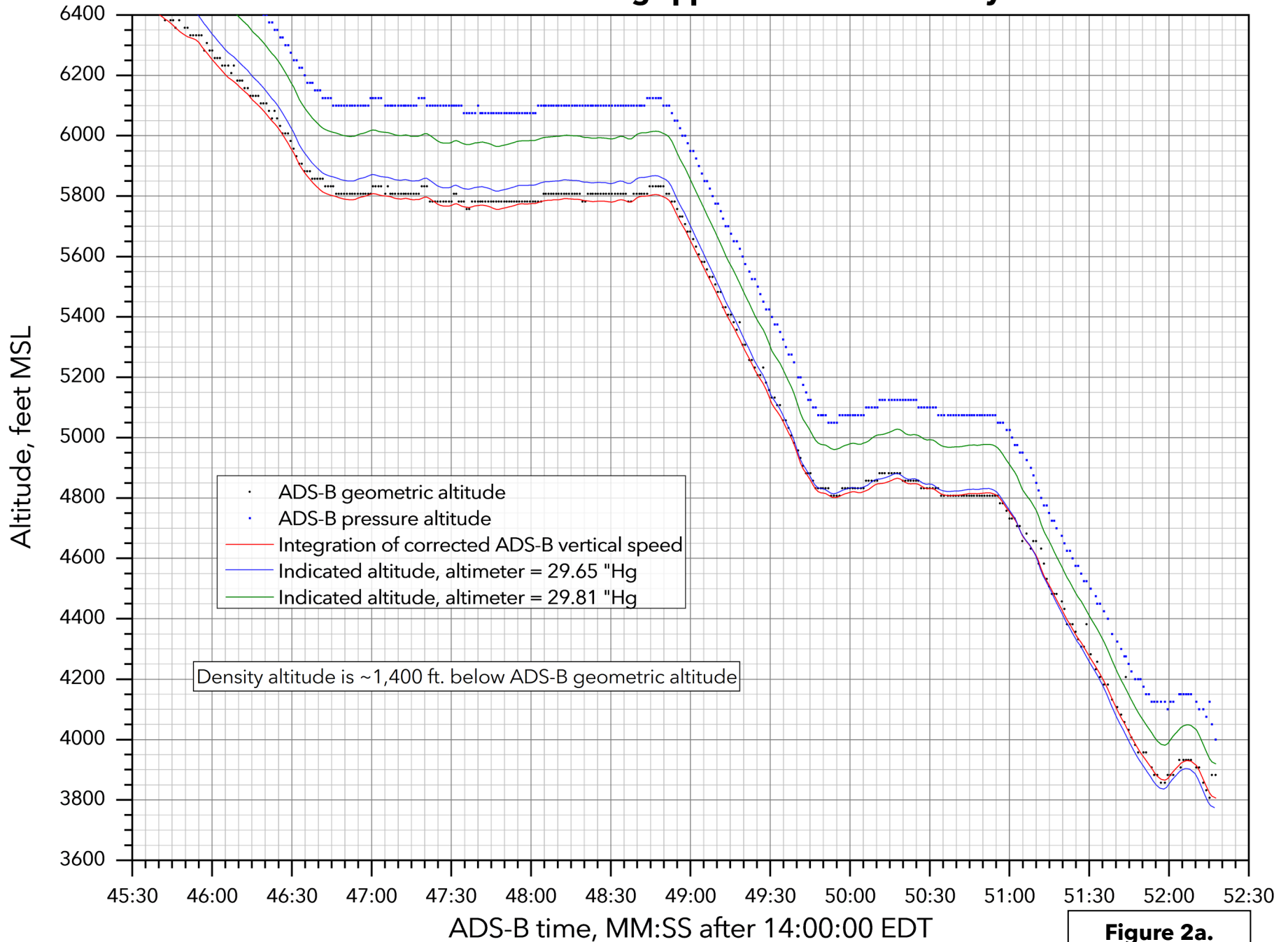
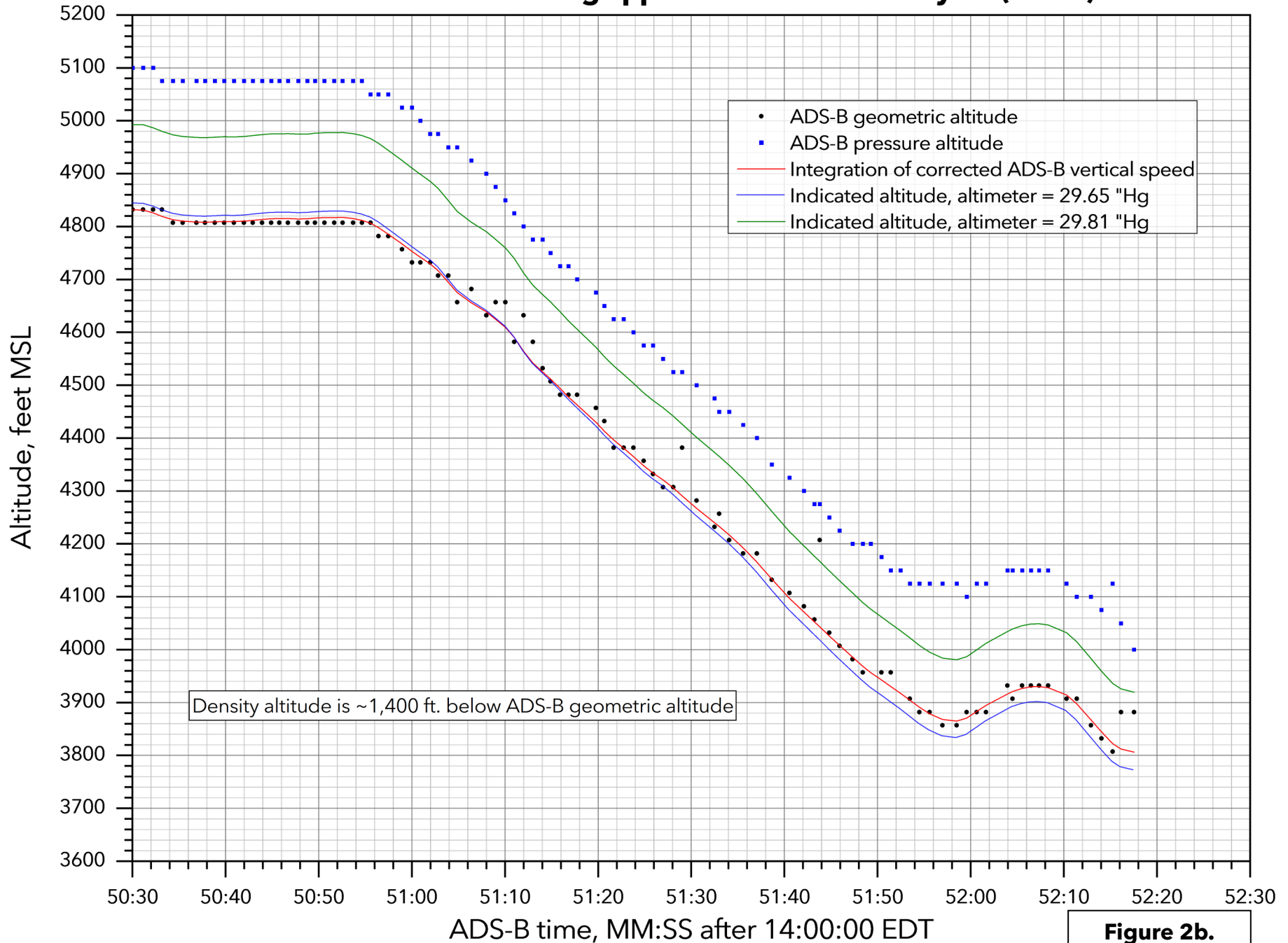


Figure 2a.

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Altitude vs. time during approach to KHSP runway 25 (detail)



Profile view of approach to KHSP runway 25

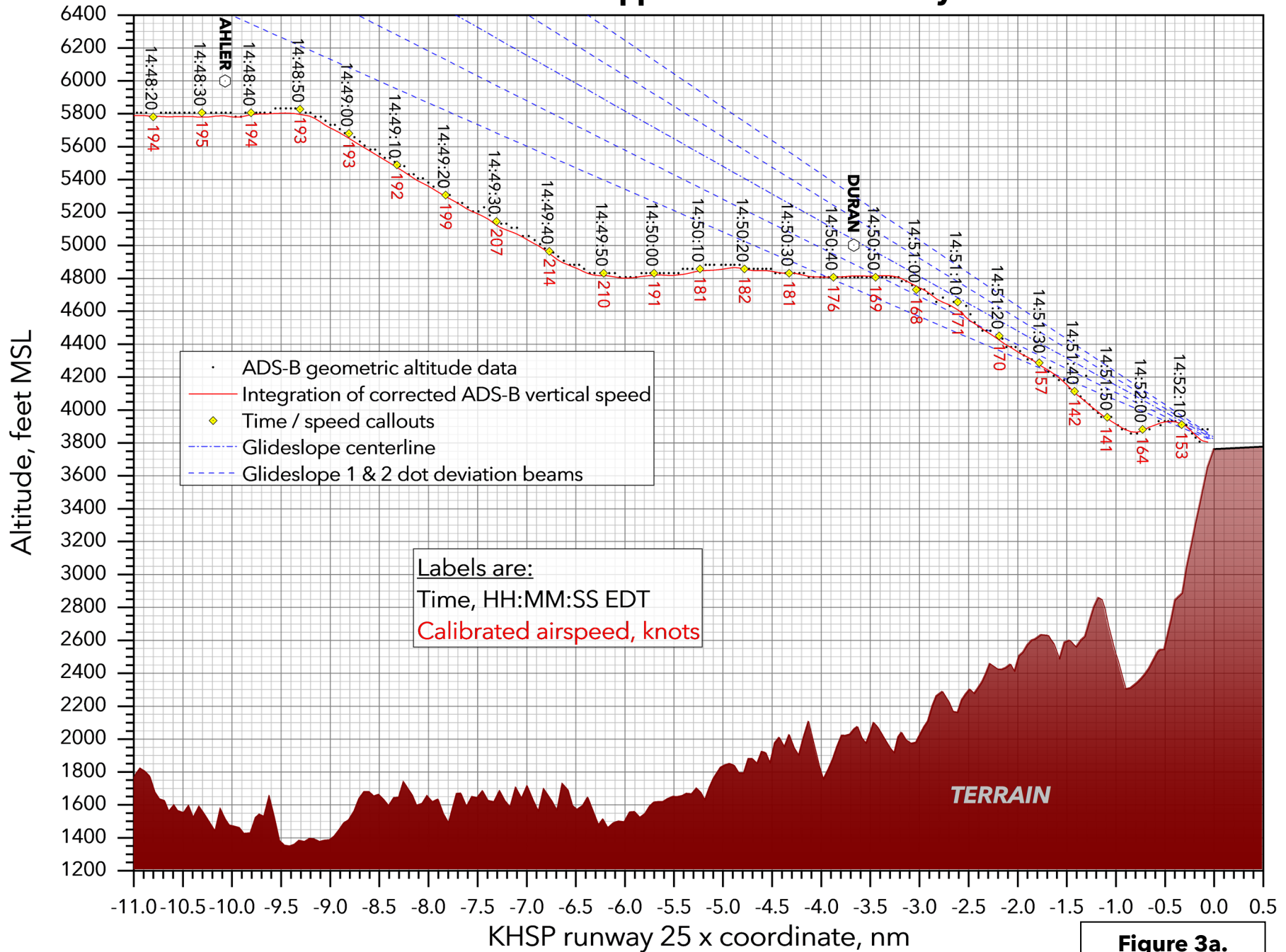
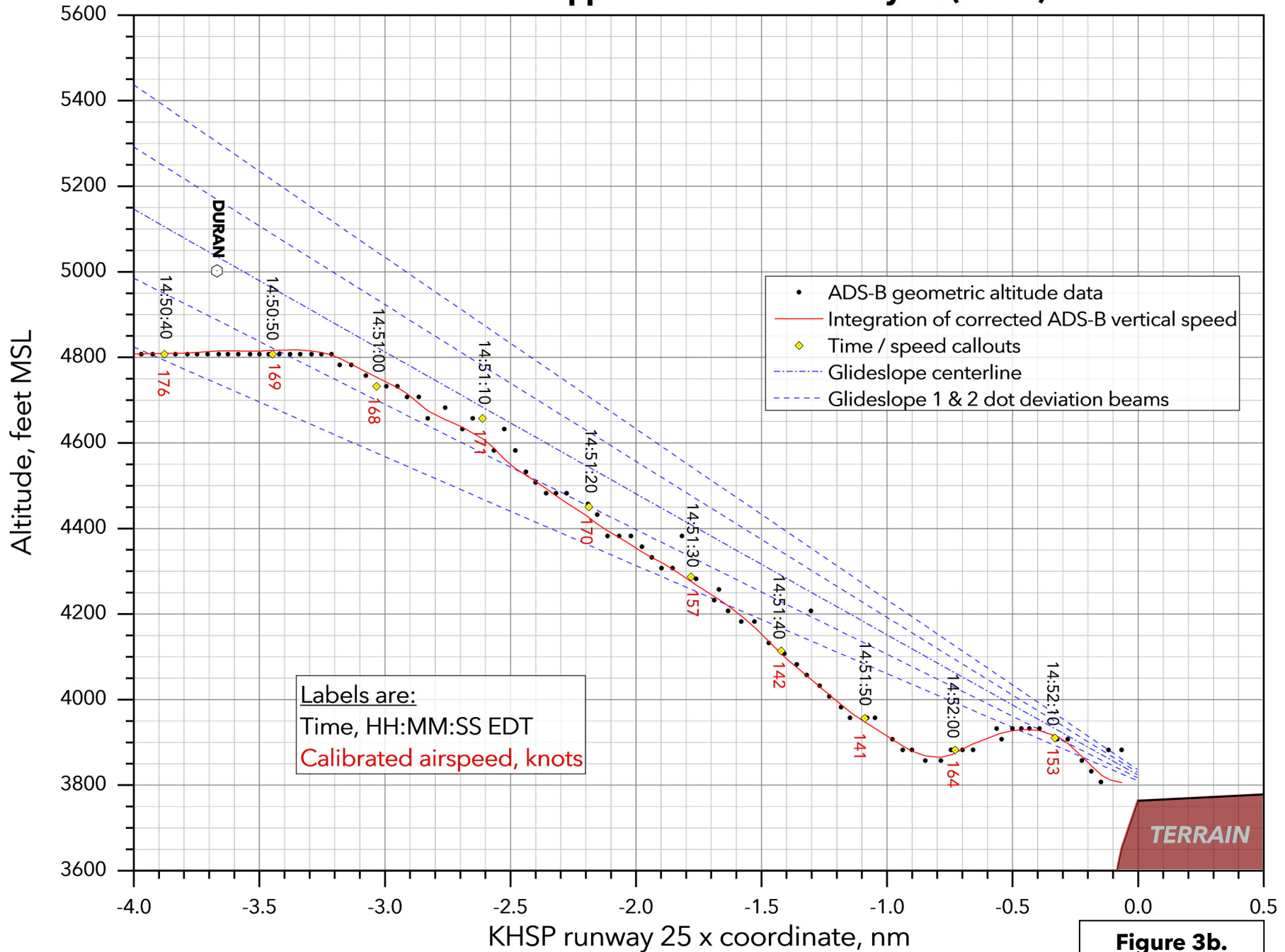


Figure 3a.

Profile view of approach to KHSP runway 25 (detail)



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Winds aloft from 15:00 EDT HRRR model

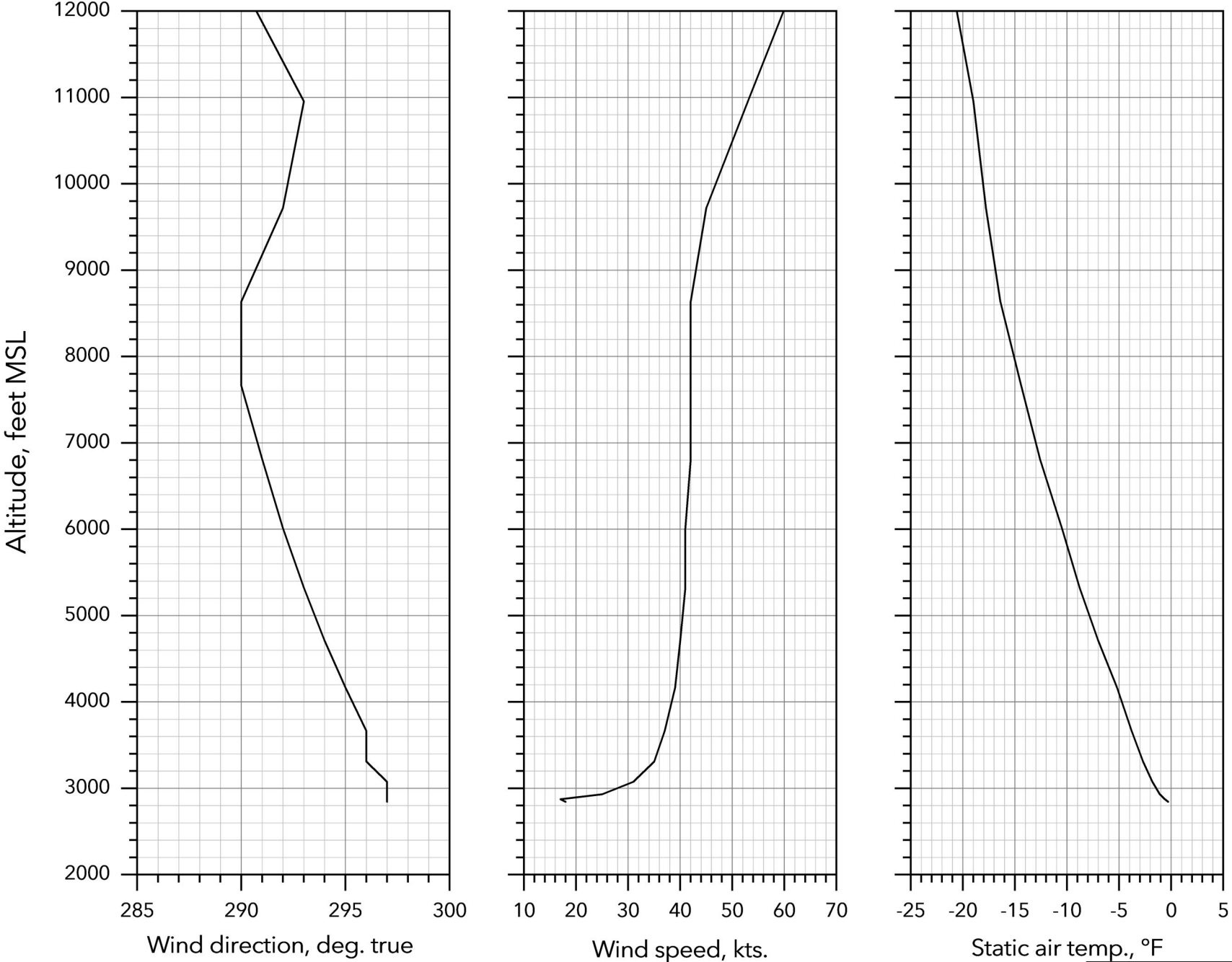
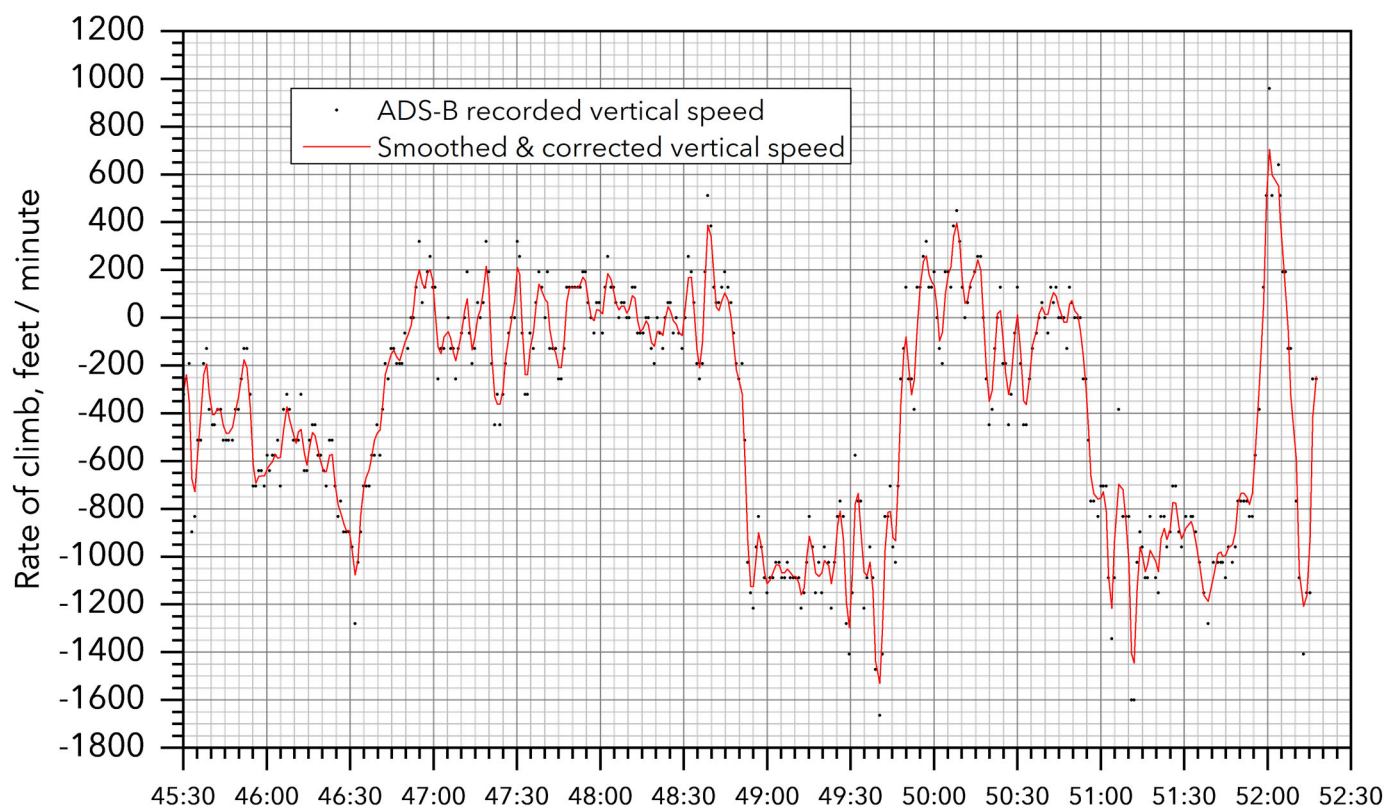
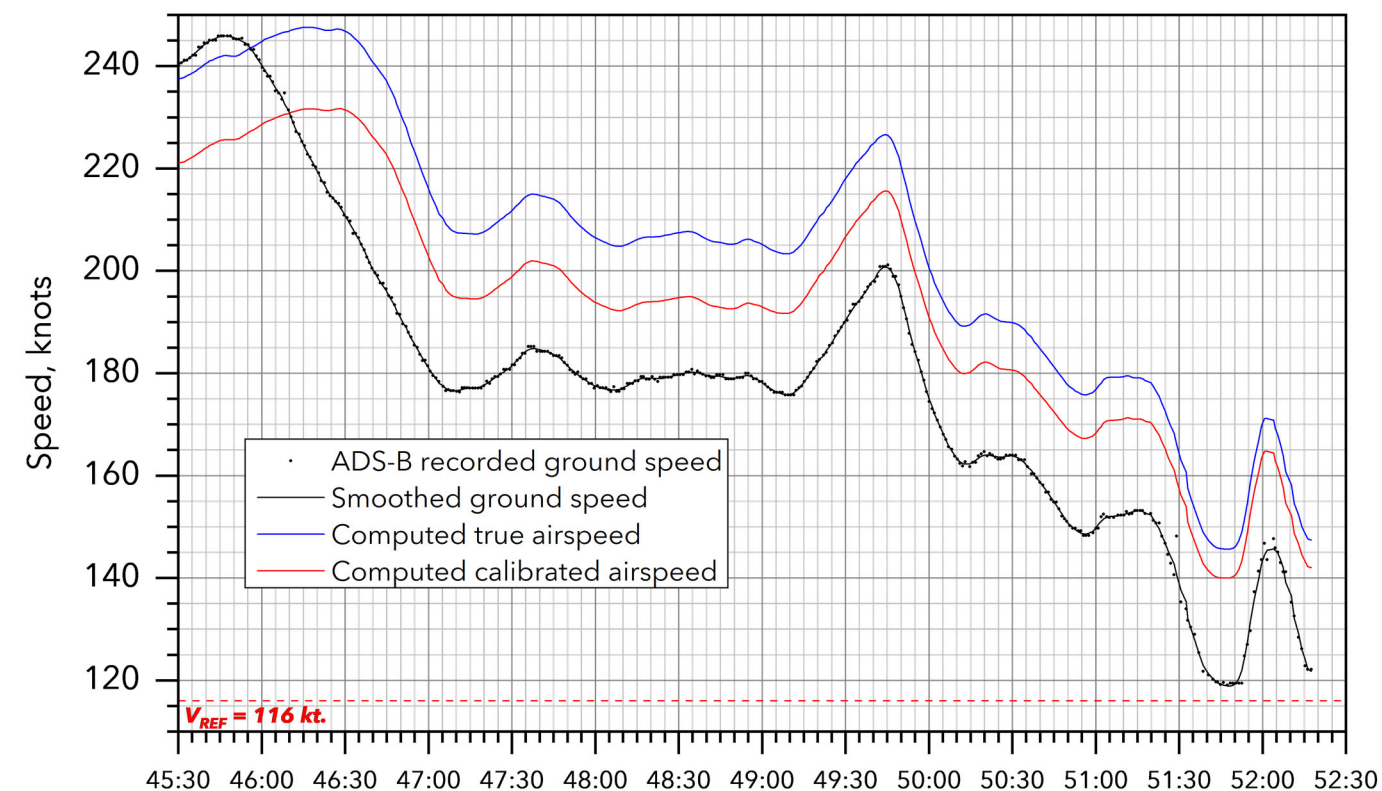


Figure 4.

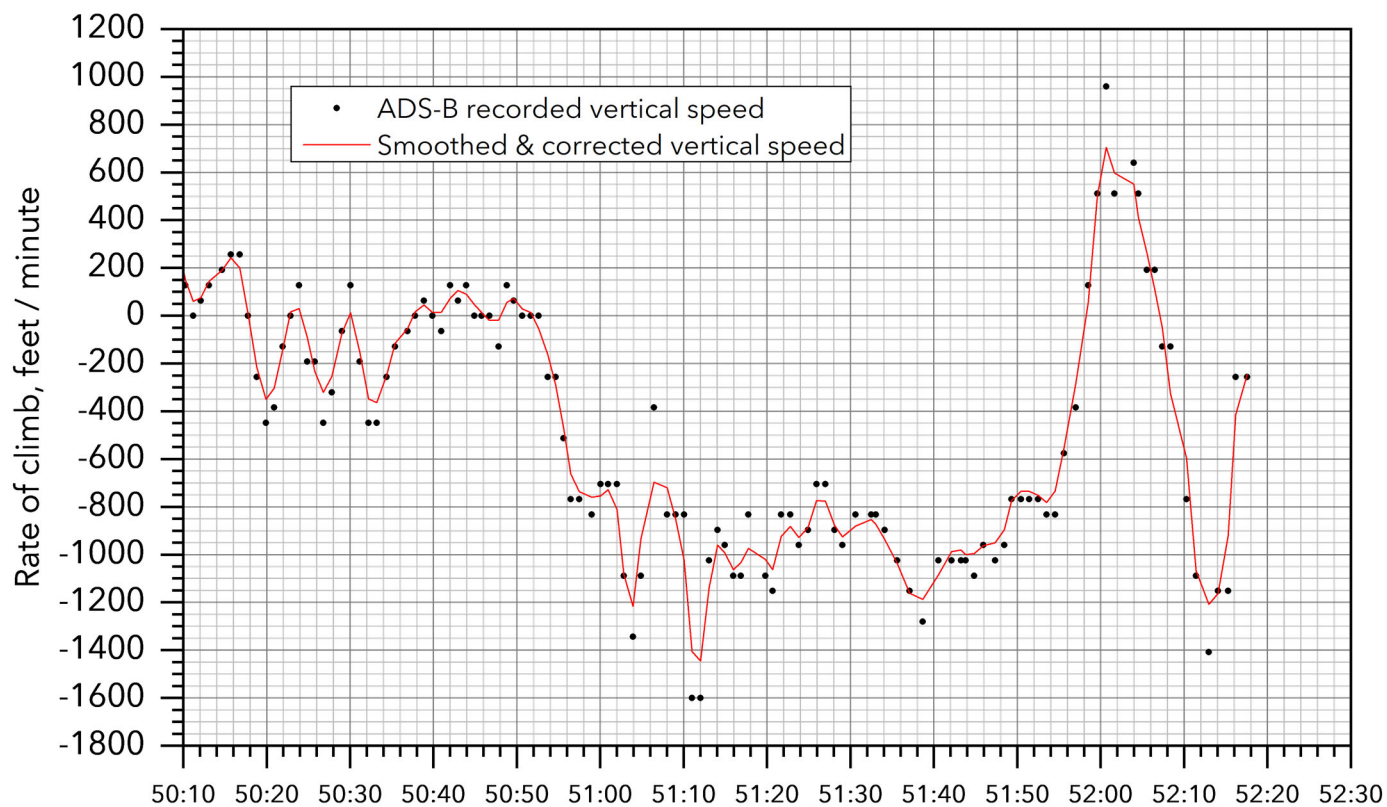
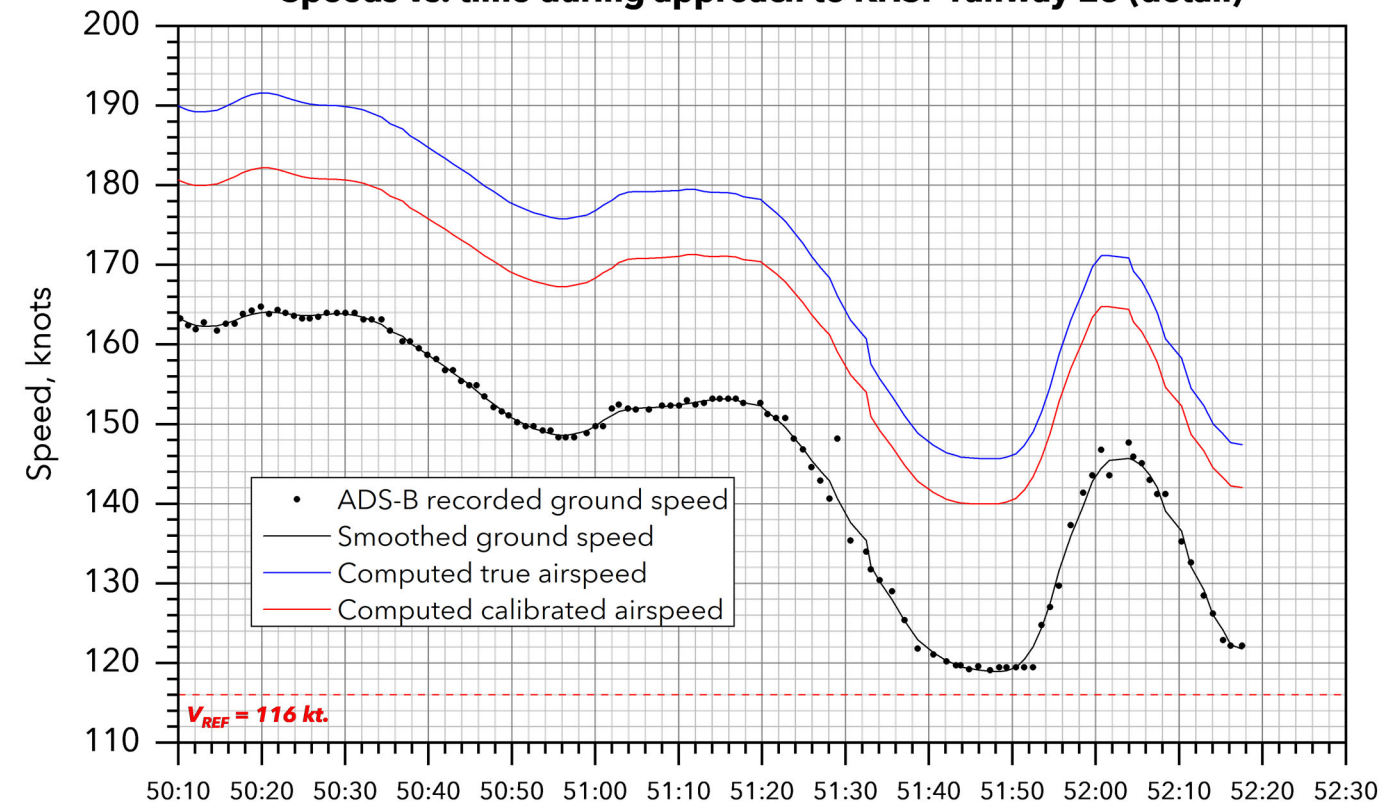
ERA24FA136: IAI Astra, N1125A, Hot Springs, VA 03/10/2024**Speeds vs. time during approach to KHSP runway 25**

ADS-B time, MM:SS after 14:00:00 EDT

Figure 5a.

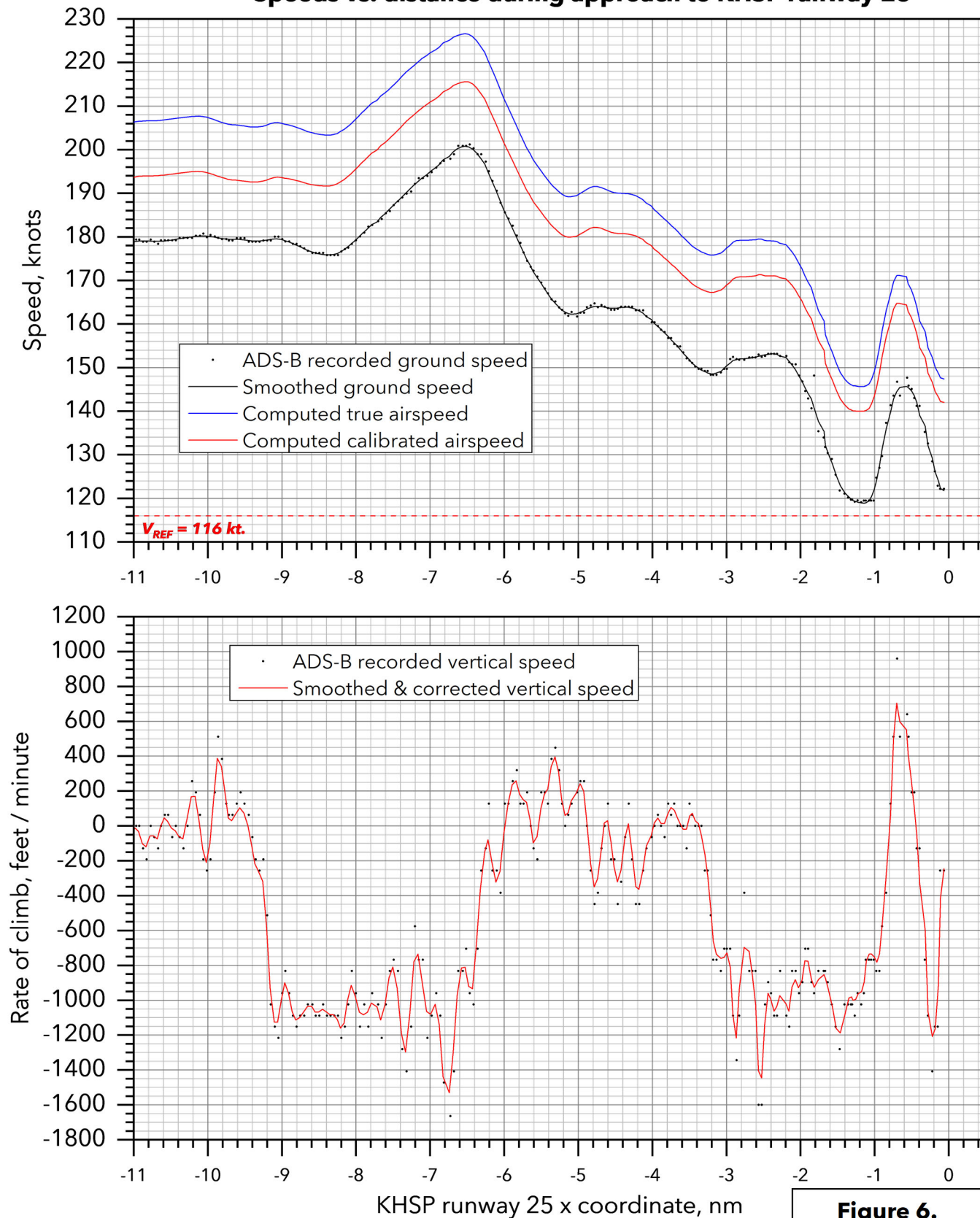
ERA24FA136: IAI Astra, N1125A, Hot Springs, VA 03/10/2024

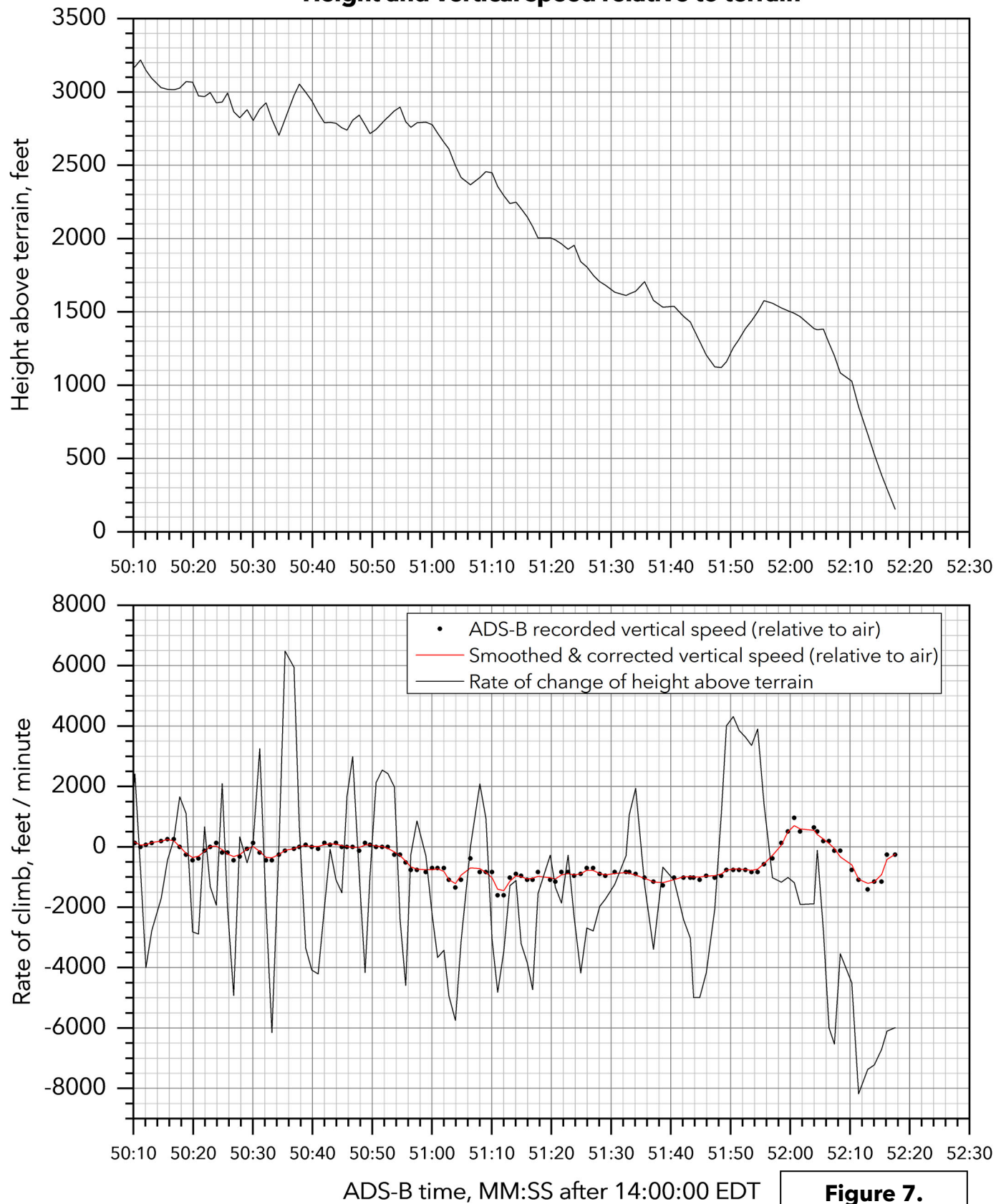
Speeds vs. time during approach to KHSP runway 25 (detail)



ADS-B time, MM:SS after 14:00:00 EDT

Figure 5b.

ERA24FA136: IAI Astra, N1125A, Hot Springs, VA 03/10/2024**Speeds vs. distance during approach to KHSP runway 25****Figure 6.**

ERA24FA136: IAI Astra, N1125A, Hot Springs, VA 03/10/2024**Height and vertical speed relative to terrain****Figure 7.**

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Flight angles vs. time during approach to KHSP runway 25

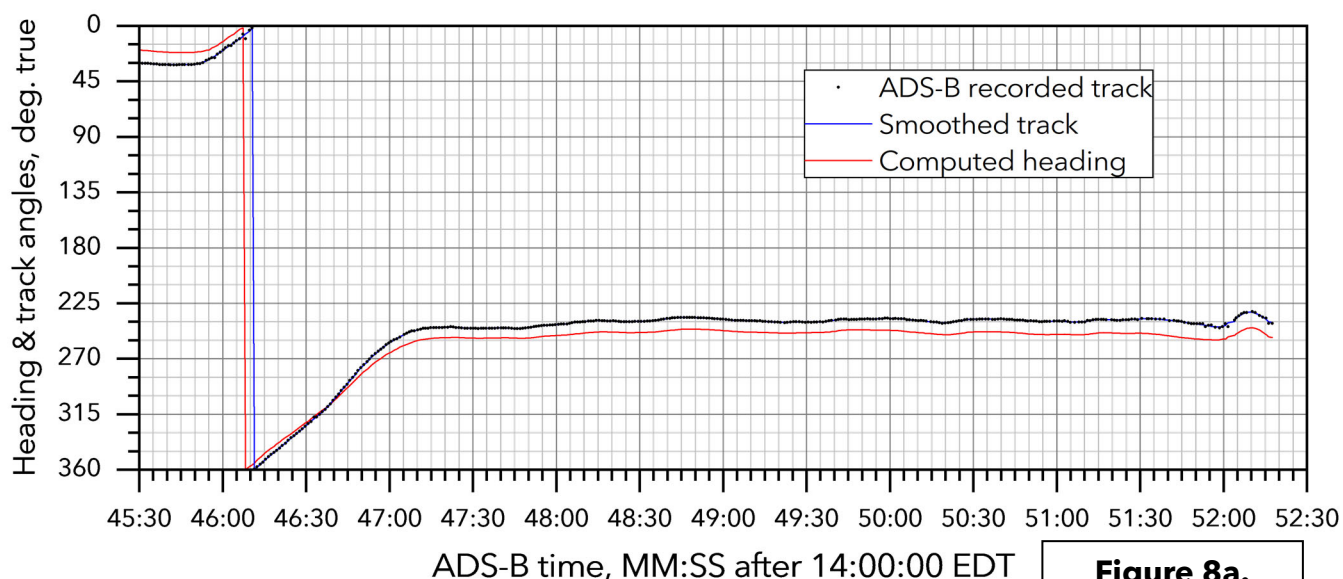
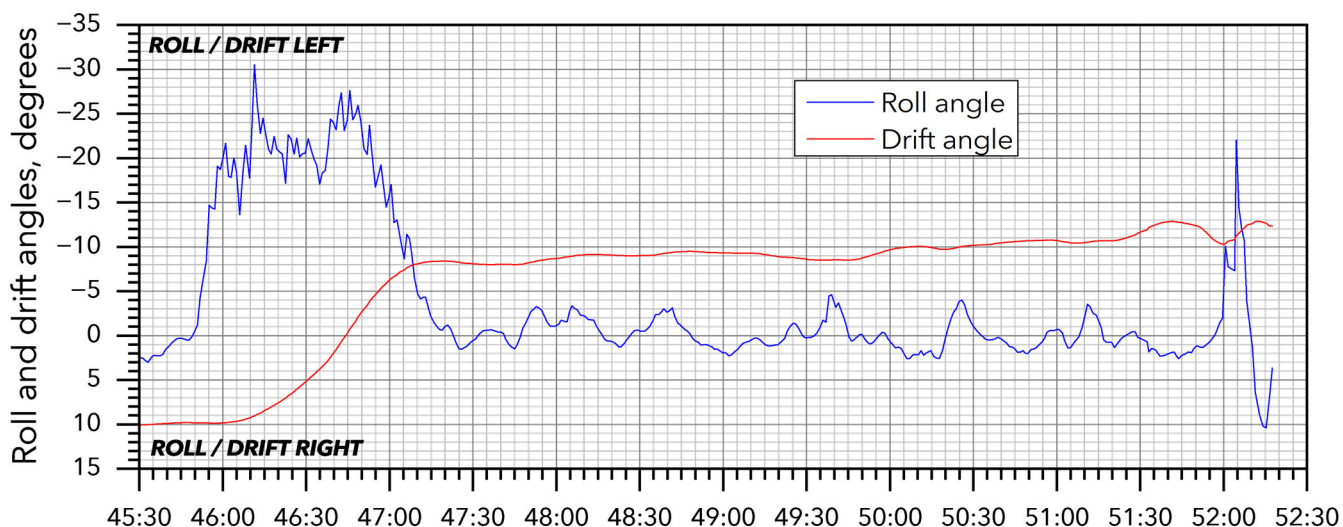
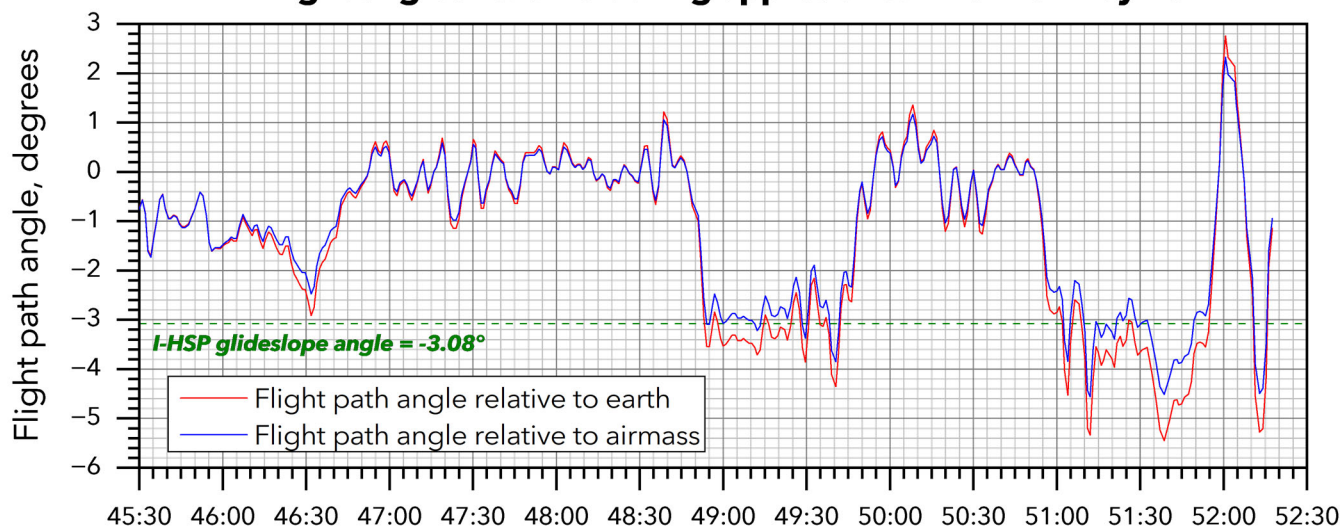
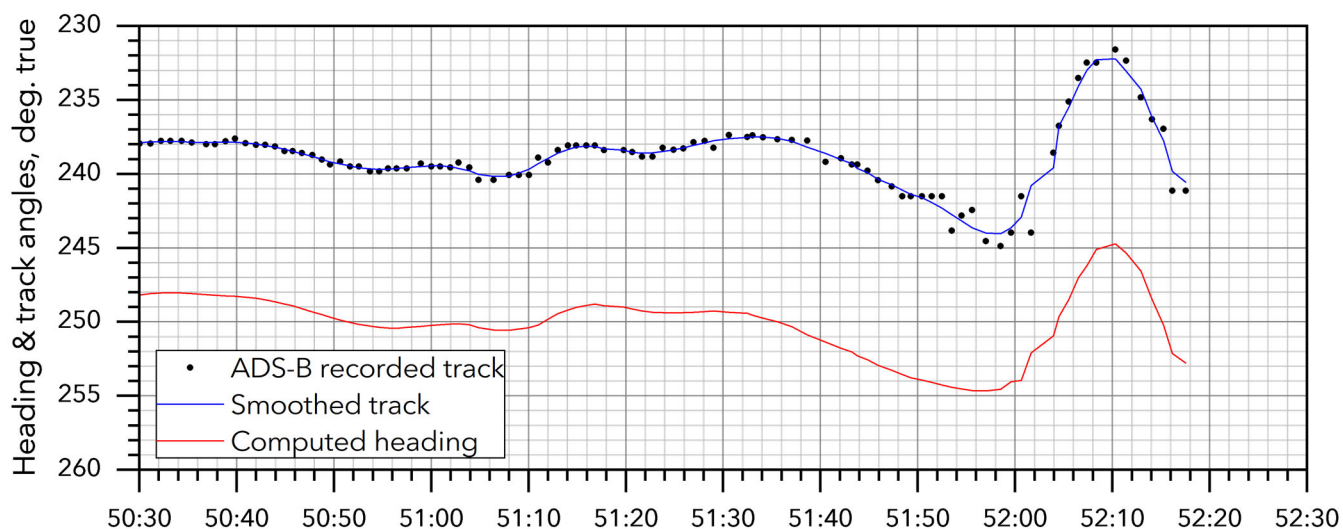
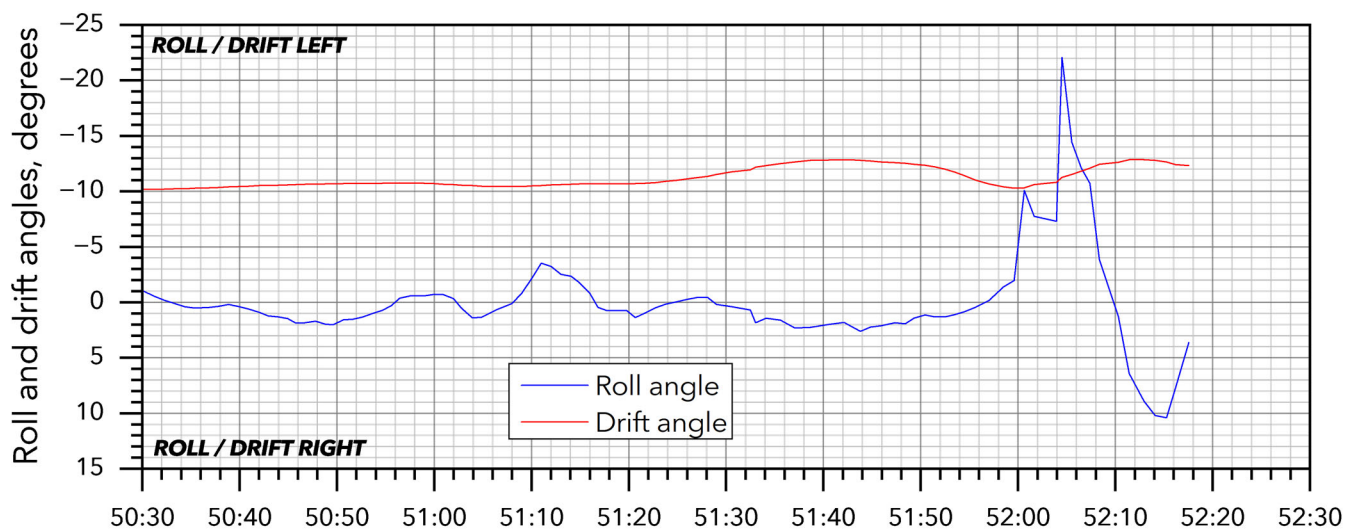
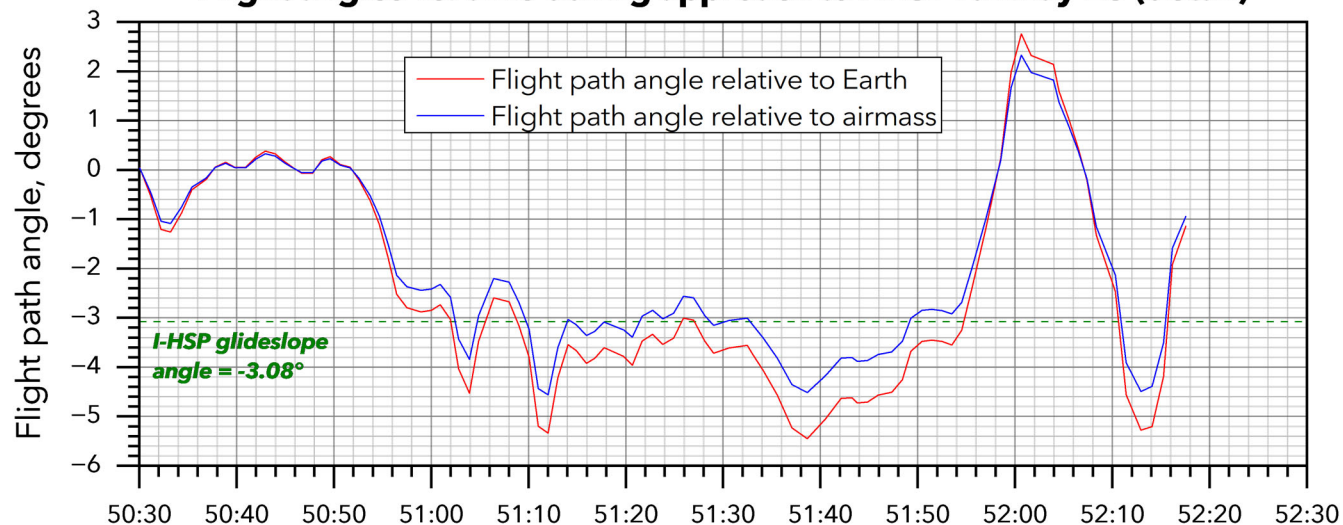


Figure 8a.

ERA24FA136: IAI Astra, N1125A, Hot Springs, VA 03/10/2024

Flight angles vs. time during approach to KHSP runway 25 (detail)



ADS-B time, MM:SS after 14:00:00 EDT

Figure 8b.