NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, D.C. 20594

March 25, 2011

Aircraft Performance Study

I. ACCIDENT

NTSB Number:	ANC10MA068
Description:	Mountainous Tree-Covered Terrain Impact
Location:	Near Aleknagik, Alaska
Date:	August 9, 2010
Time:	1442 Alaska daylight time (ADT)
Aircraft:	de Havilland DHC-3T, N455A
Operator:	General Communication, Incorporated (GCI)

II. VEHICLE PERFORMANCE SPECIALIST

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1.0 INTRODUCTION

On August 9, 2010, about 1442 Alaska daylight time (ADT), a single engine, turbine-powered, amphibious float-equipped de Havilland DHC-3T airplane, N455A, impacted mountainous tree-covered terrain about 10 miles northeast of Aleknagik, Alaska. Of the nine people aboard, the airline transport pilot and four passengers died at the scene, and four passengers sustained serious injuries. The airplane sustained substantial damage. The flight was operated by General Communication, Incorporated (GCI), Anchorage, Alaska, under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91. The flight originated at a GCI-owned remote fishing lodge on the southwest shoreline of Lake Nerka about 1427 and was en route to a remote sport fishing camp on the banks of the Nushagak River, about 52 miles southeast of the GCI lodge. At the time of the accident, marginal visual meteorological conditions were reported at the Dillingham Airport, about 18 miles south of the accident site; however, the weather conditions at the accident site at that time are not known. No flight plan was filed.

Available Sky Connect Global Positioning System (GPS) data were processed and plotted to define discrete N455A flight path constraints for the airplane position, ground track angle, and ground speed as a function of time. Additional flight path constraints were defined by the airplane attitude at terrain impact, derived from a separate evaluation of ground and airplane witness mark evidence. No airplane-based airspeed, acceleration, attitude, flight control input, flight control surface position, or external atmosphere parameters were recorded. However, meteorological, airplane configuration, and DHC-3 aerodynamic data were used to construct a simplified DHC-3T engineering simulation model to estimate the N455A airspeed, attitudes, load factors, and engine thrust/power required as a function of time to match the known accident flight path constraints for eight postulated flight path scenarios.

The Sky Connect GPS data confirm that N455A departed from the GCI lodge at Lake Nerka, climbed and proceeded to the eastern lake shore, turned south, and then generally headed toward the MUKLG waypoint (south of Lake Nerka and west of the Muklung Hills complex) prior to the last Sky Connect GPS data record. The linear ground distance between the last Sky Connect GPS record and the N455A wreckage was about 4.1 nautical miles.

The DHC-3T Otter simplified engineering simulation shows that the airplane had sufficient performance capability to accomplish each postulated flight path scenario within the airplane operating limits (e.g., respecting airspeed, angle of attack, engine thrust, and loading constraints) and applicable constraints imposed by the known factual evidence. None of these scenarios required unusual or exceptional control inputs. Based on the calculated terrain impact angle of attack, airspeed, and flight path angle, control input/maneuvering prior to terrain contact was probable and aerodynamic stall was improbable.

Uncertainties remain about the time of terrain impact, airplane air/ground speed at terrain impact, definitive time correlation between the Sky Connect GPS data and the recorded engine non-volatile memory (NVM) data, extent of airplane maneuvering during the accident flight, and atmospheric conditions (e.g., vertical winds, wind gusts, turbulence, visibility), among others. As a result, none of the scenarios evaluated likely strictly replicate the accident flight and additional plausible aircraft performance scenarios, including variations of the scenarios in this study, can be constructed to satisfy the known factual constraints.

2.0 FACTUAL EVIDENCE

The available factual and supporting evidence used in this study is defined in this section.

2.1 Airplane Drawings and Specifications

Three-view drawings and general specifications for the de Havilland DHC-3T Turbine Otter and de Havilland DHC-3 Otter are included in Attachment 1.

2.2 Airplane Flight Manual (AFM) and AFM Supplement References

For technical reference, cover page copies of the Texas Turbines Conversion, Inc. AFM Supplement TTC-FMS-1, AFM Supplement #5 (AOG Air Support Inc. 400 LB Upgross Kit), AFM Supplement #3 (Wipline Model 8000 Amphibious Floats), and DHC-3 Otter AFM are provided in Attachment 2.

2.3 Airplane Wreckage and Accident Site

The airplane wreckage and accident site location are documented in the Airworthiness Group Chairman's Factual Report. The airplane main wings, fuselage, empennage, engine, propeller, and amphibious floats were all located at the accident site. The airplane was configured with flaps and main gear/float tires found in the retracted position at terrain impact. The Powerplant Group Chairman's Factual Report identified "no pre-existing failures or discrepancies that would preclude normal operation of either the engine or the propeller prior to impact." The airplane wreckage location data documented by two independent GPS devices is shown in Table 1.

Table 1: Accident Site Location

Data Source	Latitude	Longitude	Altitude (feet msl)
Garmin GNS-530 GPS (recovered from the N455A instrument panel)	N59° 19.76’	W158° 22.87’	---
Handheld GPS	N59° 19.754'	W158° 22.809'	900-1000

2.4 Sky Connect GPS Data

The Sky Connect Tracking/Communication System recorded discrete, GPS-based N455A flight path data prior to and during the accident flight. These airplane flight path data were recovered, forwarded to the NTSB, and partially documented in the Operations Group Chairman’s Factual Report, Attachments 3 and 6. The electronic data are filed on the NTSB docket under Airworthiness Submission of Raw Flight Data from Sky Connect. A subset of the accident flight Sky Connect GPS data is listed in Table 2.

Table 2: Sky Connect GPS Data for N455A Accident Flight on 8/9/2010

# / Message Type	UTC[c] (hh:mm:ss)	Ground Speed (knots)	Altitude (m msl)	Ground Track (deg.)	Latitude	Longitude
0 POWER_ON	22:26:33					
1 SCHED[a]	22:27:23	2	18	89	N59° 25’ 45.59”	W158° 50’ 15.60”
2 DEPARTURE	22:29:37	80	51	113	N59° 25’ 33.00”	W158° 49’ 15.00”
3 SCHED	22:32:44	93	328	96	N59° 28’ 24.00”	W158° 40’ 05.40”
4 SCHED	22:35:52	86	237	132	N59° 25’ 49.19”	W158° 32’ 45.00”
5 SCHED	22:38:59	77	281	168	N59° 22’ 14.39”	W158° 29’ 10.80”
6 XML_OVERDUE_ REPORT[b]	22:47:11	0	0	0		

[a] SCHED = position report

[b] XML_OVERDUE_REPORT - Aircraft did not report at 3 minute reporting interval, after 5 minutes of no signal from transceiver, an Overdue Alert is issued.

[c] Coordinated Universal Time (UTC) is 8 hours ahead of Alaska daylight time (22:26:33 UTC = 14:26:33 ADT).

2.5 Weather Data

The Meteorological Factual Report documented the following meteorological aerodrome reports (METARs) from Dillingham Airport (PADL) in Dillingham, Alaska, located about 18 miles to the south-southwest of the accident site at an elevation of 81 feet:

> *At 1422, PADL reported wind from 170° at 10 knots gusting to 17 knots, visibility of 3 miles in light rain with mist, scattered clouds at 800 feet, ceiling overcast at 1,300 feet, temperature 11° Celsius (C), dew point temperature 9°C, altimeter setting 29.57 inches of Mercury. Remarks: lowest cloud layer varying between scattered and broken.*
>
> *At 1455, PADL reported wind from 180° at 12 knots gusting to 23 knots, visibility of 3 miles in light rain with mist, scattered clouds at 600 feet, ceiling overcast at 1,000 feet, temperature 11°C, dew point temperature 9°C, altimeter setting 29.58 inches of Mercury. Remarks: lowest cloud layer varying between scattered and broken.*

Wind speed and direction data used in this study are based on meteorological data collected from a TAMDAR-equipped Saab 340B airplane that arrived at PADL about 95 minutes prior to the accident and departed from PADL about 50 minutes prior to the accident. For convenient reference, the subset of the Meteorological Factual Report that documents the TAMDAR data collected during the Saab 340B descent and ascent paths is included in Attachment 3.

2.6 Weight and Balance

The N455A accident flight weight and balance were calculated based on available N455A maintenance records, estimated fuel and cargo data, and the occupant weight and seating location data provided by the NTSB Survival Factors Specialist. The estimated N455A weight and balance based on the component buildup method is documented in the Operations Group Chairman Factual Report, Attachment 7 – Weight and Balance Data.

At the time of the accident, the airplane maximum takeoff weight (MTOW) was documented to be 8,367 pounds, but was technically 8,000 pounds, as documented in the Airworthiness Group Chairman's Factual Addendum for Weight and Balance. The airplane weight and balance used for the simulation work in this study was 8,034 pounds with a center of gravity location of 28.7 percent mean aerodynamic chord (mac).

2.7 Airspeed Limitations

The DHC-3T Otter airspeed limitations are documented in Attachment 4. The flaps retracted, wings level stall speed at 8,000 pounds is 67 knots calibrated airspeed (KCAS), the design maneuvering speed is 111 KCAS (do not make full/abrupt control movements above this speed), and the maximum operating limit speed is 119 KCAS.

2.8 Engine Data

Subsequent to power application, N455A engine parameters including oil pressure in pounds per square inch (PSI), oil temperature in degrees Celsius (°C), torque in percent (%), and tachometer in percent revolutions per minute (% RPM) were recorded at discrete time intervals, as documented in the Airworthiness Factual Report Addendum 1, Examination of Instrument Gauges. These engine parameter data are presented as a function of estimated time since power application and time relative to the time of assumed terrain impact in Table 3. In addition, the engine tachometer NVM contained a flight time record (time above 96% RPM) of 12 minutes.[1]

Post-accident engine torque gauge bench test data indicated that the displayed torque values could be subject to calibration bias, requiring the calculation of equivalent engine torque gauge input values. At NTSB request, Hartzell Propeller Inc. estimated the expected DHC-3T engine/propeller thrust based on the recorded engine RPM data and, in turn, the displayed and calculated engine input torque values.[2]

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[1] The engine tachometer keeps a running total time of engine RPM at or above 96%. Flight time starts recording when engine RPM is 96% or greater and stops recording and resets to 00.00 when the engine RPM falls below 96%.

[2] The Hartzell Propeller Inc. estimated engine/propeller thrust data are documented in the Airworthiness Factual Report Addendum 1, Examination of Instrument Gauges.

Table 3: N455A Recorded and Recovered Engine Parameters with Time Correlation Estimate

Time Elapsed from Applied Power		Engine Oil Temp.	Engine Oil Pressure	Displayed Engine Torque	Calculated Engine Torque	Engine Tach.	Elapsed Time if Terrain Impact	
							at 18:02	at 19:02
Minutes	Seconds	°C	PSI	%	%	RPM %	Seconds	Seconds
0	0							
1	60							
2	120							
3	180					68.1		
4	240	60	100	12	---			
5	300						101	
5.7	342						143	81
6	360					98.7	161	101
7	420							
8	480	59	106	53	48.3		281	221
9	540					99.5		
10	600							
11	660							
12	720	59	105	48	44.7	96.1	521	461
13	780							
14	840							
15	900					96.1		
16	960	58	105	51	46.9		761	701
17	1020							
18	1080					96.1		
18.03	1082						883	
19	1140							
19.03	1142							883
20	1200							

2.9 Garmin GNS-530 Data

As documented by the NTSB Airworthiness Specialist, the Garmin GNS-530 GPS installed on N455A recorded a total accident flight time above 30 knots ground speed of 13:02 (mm:ss). The GNS-530 GPS did not record N455A flight path data other than the position data presented in Table 1.

2.10 Other Recorded Data

No explicit airplane-based flight records of airplane acceleration, airspeed, attitude, flight control input, flight control surface position, or external atmosphere parameters were identified. No Airport Surveillance Radar (ASR), Air Route Surveillance Radar (ARSR), Automatic Dependent Surveillance-Broadcast (ADS-B), or Air Traffic Communication (ATC) data are known to exist for the accident flight.

2.11 Airplane Aerodynamic Data

At NTSB request, ATLAS Aircraft Technical Liaison and Support (via Viking Air Limited, www.vikingair.com) provided DHC-3 Otter aerodynamic lift and drag coefficient data to support the construction of a simplified engineering simulation model. The aerodynamic lift and drag data were based on engineering reports AEROC 3.2.W.1, "DHC-3 Aerodynamics – Wing," and AEROC 3.2.G.2, "DHC-3 Otter Performance," respectively. Adjustments were made to account for the seaplane configuration equipped with amphibious floats. Mass moment of inertia data were estimated based on exemplar data available in "Airplane Flight Dynamics and Automatic Flight Controls," Part I, Jan Roskam, Roskam Aviation and Engineering Corporation, 1979.

2.12 Constraints and Assumptions

The NTSB Airworthiness Specialist and the Aviation Safety Chief Technical Advisor used airplane and terrain witness mark evidence to estimate the N455A attitude constraints at terrain impact, resulting in a ground track angle of 85 ± 2°, pitch attitude range of 15–18° airplane nose up (ANU), and bank angle range of 25–30° left wing down (LWD). For additional information, see the NTSB Impact Study and Altitude Alerter Operation.

The terrain impact time and associated airplane ground speed were assumed to be 3:07 (mm:ss) after the last Sky Connect GPS data sample and 100 knots, respectively. In general, a smaller assumed terrain impact time window shortens the calculated airplane flight path in three-dimensional space and/or requires the airplane to travel between the known flight path constraints at higher average ground speeds. Similarly, a larger assumed terrain impact time window enables more airplane maneuvering and/or reduces the average ground speeds required to travel between the known flight path constraints.

The airplane simulation wind model was based on available TAMDAR meteorological data (wind speed and direction as a function of altitude) but did not incorporate nonzero vertical winds, horizontal wind gusts, or atmospheric turbulence.

The extent of N455A maneuvering in three-dimensional space between the Sky Connect GPS data points and between the last Sky Connect GPS data point and the accident site is subject to factual uncertainty and therefore assumed to be minimal[3] between the known flight path constraints (with applicable exceptions for the specific scenarios defined below).

3.0 METHOD AND RESULTS

The study methods and results are presented in this section.

3.1 Overview

Available Sky Connect GPS data were processed and plotted to define discrete N455A flight path constraints for the airplane position, ground track angle, and ground speed as a function of time. Additional flight path constraints were defined by the airplane attitude at terrain impact, derived from a separate evaluation of ground and airplane witness mark evidence.

[3] Unexpected, unexplained, complicating, or less conservative maneuvers (e.g., altitude deviation, S-turns, 360° turns, right-hand turns) were purposefully not evaluated. Of these hypothetical maneuvers, only 360° turns were excluded due to available time window aircraft performance constraints.

Meteorological, airplane configuration, and aerodynamic data were used to construct a simplified DHC-3T engineering simulation model to estimate the N455A airspeed, attitudes, load factors, and engine thrust/power required as a function of time to match the known accident flight path constraints for several postulated flight path scenarios.

3.2 Simulation Scenarios

Four flight path scenarios were developed to assess the aircraft performance between the last Sky Connect GPS data sample and the accident site. In addition, two 15° LWD and two 30° LWD mountainous terrain avoidance/escape scenarios were evaluated. In each case the airplane was trimmed during the takeoff climb and flown between Sky Connect GPS data samples 2, 3, 4, and 5 (see Table 2). Subsequent to the last Sky Connect GPS data sample, the airplane ground track was assumed to be defined by one of the following scenarios:

1. Proceed directly to the accident site.
2. Target the MUKLG waypoint stored in the N455A GNS-530 GPS.
3. Target the previous Sky Connect GPS data position for the most easterly southbound N455A flight (flown by the accident pilot) that remained west of the little Muklung hill.
4. Same as Scenario 3, but accomplish a 15° LWD bank angle escape maneuver 100 seconds prior to the assumed time of terrain impact.
5. Same as Scenario 3, but accomplish a 30° LWD bank angle escape maneuver 35 seconds prior to the assumed time of terrain impact.
6. Target the previous Sky Connect GPS data position for the N455A northbound flight (flown by the accident pilot) that proceeded through the narrow pass between the little Muklung hill and the Muklung Hill complex.
7. Same as Scenario 6, but accomplish a 15° LWD bank angle escape maneuver 100 seconds prior to the assumed time of terrain impact.
8. Same as Scenario 6, but accomplish a 30° LWD bank angle escape maneuver 35 seconds prior to the assumed time of terrain impact.

None of the postulated scenarios likely strictly replicate the accident flight. Moreover, due to the sparse sample rate of the Sky Connect GPS data and incomplete constraints at N455A terrain contact, additional, plausible aircraft performance scenarios can be constructed to satisfy the known factual constraints.

Each flight path scenario was evaluated against the constraints defined by the known factual evidence. In addition, the calculated angle of attack, sideslip angle, airspeed, bank angle, pitch attitude, flight path angle, and engine thrust/power required were reviewed to ensure that the respective calculated time history values were reasonable.

3.3 Virtual Radar Track Construction

The specified N455A flight path constraints are airplane position (latitude, longitude, and altitude) and terrain impact attitude (ground track angle, pitch attitude, and bank angle) as a function of time at a sparse sample rate. Each measured data sample was (or, based on the Sky Connect GPS data in Table 2, was assumed to be) separated in time by about 3:07 (mm:ss) minus 0, plus 1 seconds.

The flight path latitude and longitude position data were first converted to coordinates east and north of the accident site (in nautical miles) and fit with a spline curve. The ground track angle constraints were then enforced by imposing virtual flight path position points on either side of each Sky Connect, GNS-530 terrain impact, and optional additional scenario target ground track data point(s), for instance, to target the MUKLG waypoint. The resulting ground track spline curve was subsequently resampled to construct a high frequency east/north position curve. Next an iterative process was used to impose the altitude and ground speed constraints on the resampled ground track data. The resulting three-dimensional space curve together with the TAMDAR wind data were treated like a virtual radar track and processed in a radar trajectory algorithm to estimate airspeed, angle of attack, pitch attitude, bank angle, ground speed, and ground track angle as a function of time (see Section 3.4) below. The calculated ground speed and ground track angle values were compared to the respective N455A flight path constraint values to ensure that these constraints were enforced correctly.

The airplane ground track derived from Sky Connect GPS data for each simulation scenario was plotted to construct the comparison figures in Attachments 5 (conventional two-dimensional data plots with North at the top of the page) and 6 (planform view of virtual radar ground track overlaid on a Google Earth image with North denoted in the upper right-hand corner of the scene).

The Sky Connect GPS data confirm that N455A departed from the GCI lodge at Lake Nerka, climbed and proceeded to the eastern lake shore, turned south, and then generally headed toward the MUKLG waypoint (south of Lake Nerka and west of the Muklung Hills complex) prior to the last Sky Connect GPS data record. The N455A wreckage location is identified by the large red/blue target symbols in Attachment 6. The linear ground distance between the last Sky Connect GPS record and the N455A airplane wreckage was about 4.1 nautical miles (about 25,000 feet).

3.4 Estimated Simulation Model Input Parameters (Speeds, Attitudes, Thrust Required)

The airplane orientation (i.e., bank, pitch, and heading attitudes) and velocity as a function of time were estimated from the three-dimensional position of the airplane (altitude, north, and east parameters) defined by the virtual radar track for each scenario. The airplane orientation estimates were predicated on the following assumptions (which permit the equations of motion to be simplified):[4]

1. The airplane motion is primarily along the longitudinal axis.
2. The sideslip angle is essentially zero: cos(ß) ~ 1 and sin(ß) ~ 0.
3. The angle of attack (AOA) is small enough that the flow remains attached (i.e., the airplane is unstalled) and the input lift and drag characteristics are valid for the flight segment.
4. Aerodynamic and thrust forces along the airplane lateral axis are zero.
5. Thrust forces along the vertical axis are zero (all thrust is along the longitudinal axis).
6. Aerodynamic Mach number effects are negligible.

Calculated results were based on the estimated N455A weight of 8,034 pounds, mid-center of gravity location, flaps retracted, landing gear retracted, engine operating, TAMDAR-based horizontal winds, METAR-based static temperature, and zero vertical winds. Theoretical aerodynamic lift and drag data based on the wing zero lift AOA, zero lift drag coefficient, aspect ratio, taper ratio, and sweep angle were used to estimate the calibrated airspeed, AOA, attitudes, load factors, and engine thrust required for each flight path scenario. In each case, the lift and drag increments due to elevator, aileron, and/or rudder deflection were neglected.

[4] The simplified DHC-3T Otter aerodynamic model may only be representative for a limited portion of the flight envelope and may not be valid for flight segments where the aircraft experienced significant changes in Mach number, angular rates, sideslip angle, or other parameters that have a strong effect on the aerodynamics.

The properties of the atmosphere were determined from the static pressure implied by the altitude data, altimeter setting, sea level pressure, and static temperature information. Ground speed was derived from the GPS position data and wind data were used to derive the airspeeds from the ground speed. Given these data, the heading and vertical flight path angles can be determined.

An iterative method was subsequently used to calculate the AOA, pitch angle, and bank angle. On the first iteration, the pitch angle was set equal to the flight path angle (i.e., the AOA was assumed to be zero) and the bank angle was calculated.[5] The pitch and bank angles were used to calculate the vertical load factor. A new AOA was estimated from the vertical load factor and the airplane lift coefficient data. The updated AOA was then used to update the pitch and bank angles, providing kinematically consistent results. The updated pitch and bank angles were in turn used to update the vertical load factor and AOA estimates.

The final AOA estimate was used with the airplane drag characteristics to calculate the drag, thrust, and horsepower required for the given flight path scenario. The actual power output by the engine can be estimated by dividing the calculated horsepower required by the engine/propeller efficiency.

3.5 DHC-3T Simplified Engineering Simulation

The previously estimated airplane position, velocity, and orientation (i.e., bank, pitch, and heading attitudes) were subsequently used to define the airplane simulation model initial trim conditions and math pilot targets as a function of time. For each flight path scenario, the DHC-3T simulation airplane was trimmed at the same initial condition (between Sky Connect GPS data samples 2 and 3 in Table 2) and math pilots (closed-loop feedback controllers)[6] were used to track the target east/north and altitude position (defined by the virtual radar track), estimated pitch attitude, and estimated bank angle, respectively.

The calculated simulation parameter results are plotted in Attachment 7, Figures A7.1-8 as a function of elapsed time (seconds) and Coordinated Universal Time (UTC in HH:MM:SS format).[7] Ordered top to bottom, each figure presents calculated time history data for altitude, calibrated airspeed, ground speed, engine thrust required, longitudinal load factor, normal load factor, AOA, pitch attitude, flight path angle, sideslip angle, bank angle, lateral load factor, true heading, ground track angle, and horizontal and vertical wind speed components. The known flight path constraints are depicted by the blue line/square symbols for applicable parameters.

Calculated simulation parameter values at terrain impact are summarized in Table 4 for flight path scenarios 1–3 and 6. The derived terrain impact attitude defines a bank angle constraint of 25–30° LWD (negative bank angle), pitch attitude of 15–18° ANU, and ground track angle of 85 ± 2°. Flight path scenarios 1–3 and 6 satisfy each of these terrain impact constraints.

The simulation data in Attachment 7 indicate that the airspeed during the assumed cruise segment (between Sky Connect GPS data samples 3 and 5) ranged from 88 to 98 KCAS.

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[5] The pitch angle estimate along with the rate of change of heading is used to calculate the roll angle.

[6] Math pilot target tracking errors can be minimized by adjusting the appropriate proportional, integral, and/or derivative (PID) controller gains, providing a better target signal, or a combination of these strategies.

[7] The relationship between the elapsed time plotted in Attachment 7 and Coordinated Universal Time is 696.0 seconds equals 2238:59.0 UTC.

The calculated airspeed varied between 80 and 105 KCAS among terrain impact scenarios 1–3 and 6 for the assumed 3-minute, 7-second period between the last Sky Connect GPS data sample and the accident site. The calculated bank angle in the eight simulation scenarios did not exceed a magnitude of about 30°. The estimated AOA ranged between 2.5° and 8.5° among the various scenarios. The estimated flight path angle ranged from -3° to 10° for scenarios 1–3 and 6 but narrowed to -1° to 2° for the terrain avoidance/escape scenarios (4–5 and 7–8).

Table 4: Simulation Scenario Summary at Terrain Impact

Flight Path Scenario	Bank Angle	Pitch Attitude	Angle of Attack	Flight Path Angle	Ground Track Angle	Ground Speed
	Degrees	Degrees	Degrees	Degrees	Degrees	Knots
1	-29.0	16.4	6.8	9.5	85.0	98.8
2	-29.9	16.5	6.8	9.5	85.5	98.5
3	-29.1	16.7	6.7	9.8	85.2	98.3
6	-29.0	16.6	7.0	9.5	85.5	98.1

The number of turns and maneuvers actually executed during the various discrete flight path segments defined by the Sky Connect and GNS-530 GPS data cannot be fully quantified. However, the calculated parameters for each simulation scenario provide no indication of any maneuvers that exceeded the DHC-3T Otter stall or maximum operating airspeed limits.

The calculated simulation thrust data required for scenarios 1–3 and 6 are compared to the estimated NVM-based engine/propeller thrust as a function of true airspeed in knots (KTAS) in Attachment 8. The calculated simulation thrust data for the four scenarios at times overlap the two families of constant engine torque curves.[8] However, the calculated simulation thrust required for the assumed cruise portion of the N455A flight between Sky Connect GPS data samples 3 and 5 is about 10 percent lower than the engine/propeller thrust estimated by Hartzell Propeller Inc.

A trailing wingman view of the calculated N455A airplane position en route between the last Sky Connect GPS data record and the accident site is included in Attachment 9 for scenarios 1–3 and 6. No attempt was made to reconstruct the visibility, lighting, terrain color, or terrain texture observed during the accident flight.

4.0 SUMMARY

Available Sky Connect GPS data were processed and plotted to define discrete N455A flight path constraints for the airplane position, ground track angle, and ground speed as a function of time. Additional flight path constraints were defined by the airplane attitude at terrain impact, derived from a separate evaluation of ground and airplane witness mark evidence. No airplane-based acceleration, airspeed, attitude, flight control input, flight control surface position, or external atmosphere parameters were recorded. However, meteorological, airplane configuration (i.e., flaps, weight, center of gravity), and aerodynamic data were used to construct a simplified DHC-3T engineering simulation model to estimate the N455A

[8] One family of constant torque curves represents the displayed engine torque gauge NVM data. The other family of constant torque curves depicts the thrust corresponding to the calculated engine torque gauge input, including suspected gauge calibration bias.

airspeed, attitudes, load factors, and engine thrust/power required as a function of time to match the known accident flight path constraints.

Four flight path scenarios were developed to evaluate the aircraft performance between the last Sky Connect GPS sample and the accident site. In addition, two 15° LWD and two 30° LWD mountainous terrain avoidance/escape scenarios were evaluated. Each flight path scenario satisfied all applicable constraints imposed by the known factual evidence. The DHC-3T Otter has sufficient performance capability to accomplish each defined scenario within the airplane operating limits (e.g., respecting airspeed, angle of attack, engine thrust, and loading constraints). Moreover, none of these flight path scenarios required unusual or exceptional control inputs.

The accident position and ground track angle constraints can be satisfied relatively easily in the absence of pitch attitude and bank angle constraints. The addition of terrain impact pitch attitude and bank angle constraints (derived from airplane crush damage and ground witness marks), narrows the flight path solution set, making dynamic control inputs/maneuvering prior to terrain contact probable and aerodynamic stall improbable (based on the calculated terrain impact angle of attack, airspeed, and flight path angle).

Although the DHC-3T Otter had adequate performance capability to match the known flight path constraints for multiple postulated yet plausible scenarios, uncertainties remain about the time of terrain impact, airplane air/ground speed at terrain impact, definitive time correlation between the Sky Connect GPS data and the recorded engine NVM parameters, extent of airplane maneuvering during the accident flight,[9] and atmospheric conditions (e.g., vertical winds, wind gusts, turbulence, visibility), among others. As a result, none of the scenarios evaluated likely strictly replicate the accident flight and additional plausible aircraft performance scenarios, including variations of the scenarios in this study, can be constructed to satisfy the known factual constraints. From a strict aircraft performance perspective, none of the simulation scenarios that reach the accident site is clearly more probable or compelling than another.

5.0 ATTACHMENTS

Attachment 1: 3-View Drawings and General Specifications

Attachment 2: DHC-3T AFM and Supplement References

Attachment 3: TAMDAR-based Wind Data (excerpted from Meteorological Factual Report)

Attachment 4: Airspeed Limitations

Attachment 5: Calculated Ground Track

Attachment 6: Simulation Scenario Targets and Flight Paths

Attachment 7: Simulation Results & Factual Constraints

Attachment 8: Estimated Thrust Comparison

Attachment 9: Accident Site Approach Views

[9] This study cannot exclude limited control inputs, no control inputs, or intentional control inputs (for example, an S-turn with altitude variation) for the period of time between the last Sky Connect GPS data sample and the probable maneuvering inputs shortly before terrain impact.

Attachment 1: Drawings & General Specifications

DHC-3T Turbine Otter

DHC-3 Otter

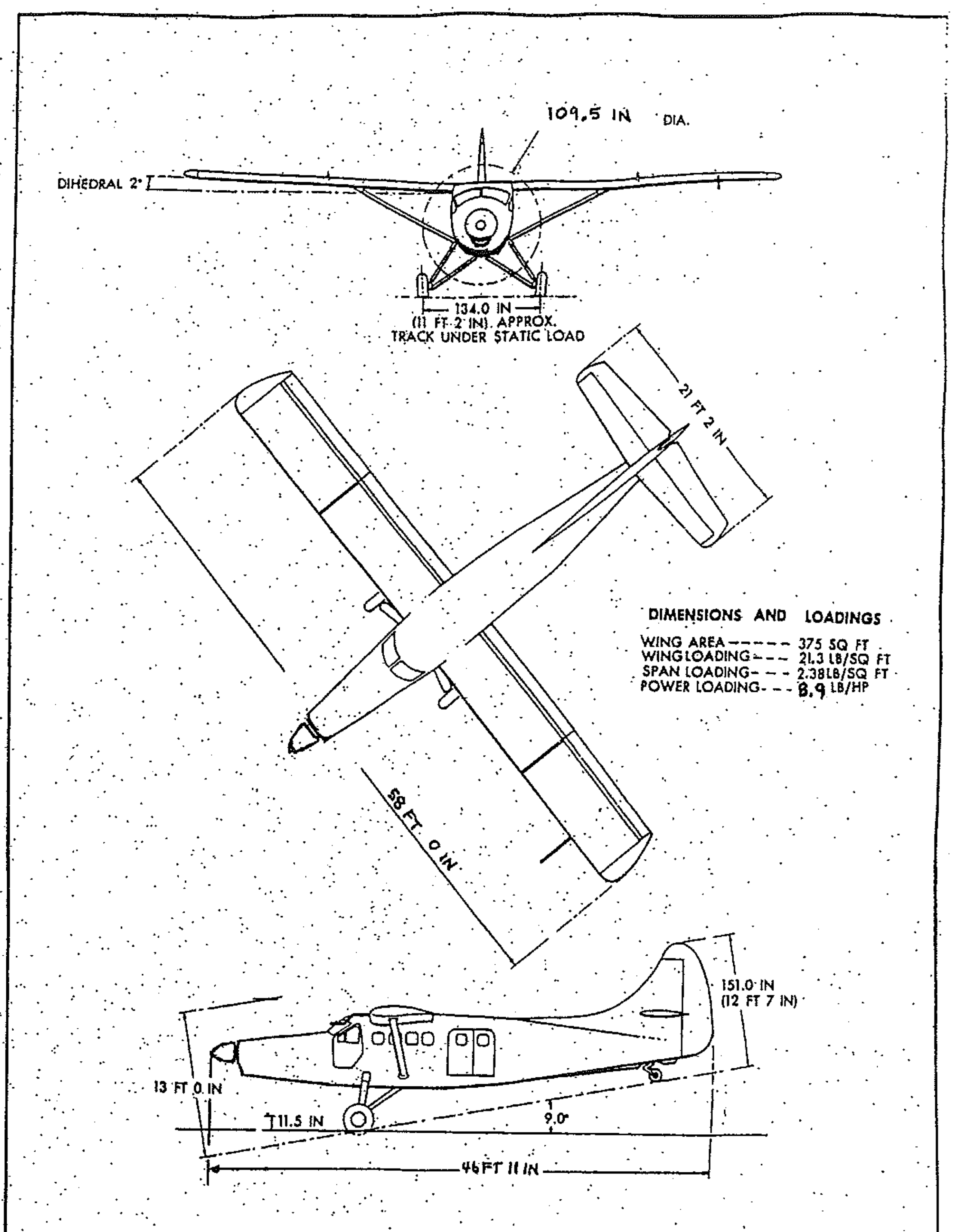


Figure 1-1, Three-view dimensional diagram: Landplane

DESCRIPTION

The DHC "Otter" airplane is an all-metal, high wing monoplane powered by a single Honeywell (Garrett) TPE331-10 engine driving a Hartzell constant speed, full-feathering, reversing propeller. The aircraft has been designed to carry a pilot and from six to fifteen passengers. It may also be used for liaison duties, ambulance and rescue operations, forestry, border and coastal patrols, spraying, dusting, skydiving, aerial surveying, photographic operations, or cargo transportation. The aircraft is divided through partitions into a cockpit, a cabin and a baggage compartment. An optional bleed-air heater may be installed.

DIMENSIONS

General overall dimensions of the airplane are:

Length	46 feet, 11 inches
Wing Span	58 feet, 0 inches
Height	12 feet, 6.6 inches

MAXIMUM WEIGHT

Maximum takeoff weight	8000 pounds.
Maximum landing weight	8000 pounds.

ENGINE

Manufacturer:	Honeywell (Garrett)
Model:	TPE331-10 or TPE331-12JR
Horsepower:	Flat rated to 900 shp at 1591 rpm.

PROPELLER

Manufacturer:	Hartzell Propeller
Model:	HC-B4TN-5NL/LT10890N
Blades:	4
Diameter:	109.5"
Type:	Constant-speed, Full-feathering, Reversing, Counter-weighted, and Hydraulically actuated.
Pitch Range:	measured at the 42" blade station

Feathered........................ +81.2°
Reverse.......................... -12°

FUEL

Recommended Fuel:	Jet A
Emergency Fuels:	See LIMITATIONS Section.

ENGINE OIL

Recommended Engine Oil:	See LIMITATIONS Section.
Total Oil Capacity:	8 U.S. quarts

SEAPLANE COMPATIBILITY

This conversion is compatible with the following approved float installations:

STRAIGHT FLOATS

Model	Length	Width	Installed Weight	Float Displacement	Otter Max Allowable Weight	Approval
EDO 7170	24'8"	10'6"	800 lbs.	7170 lbs.	7967 lbs.	TC A-815
EDO 7490	25'4.5"	11'0"	850 lbs.	7490 lbs.	8000-*8367 lbs.	TC A-815
EDO 7850	26'2"	12'0"	900 lbs.	7850 lbs.	8000-*8367 lbs.	U.S. STC SA678NW or CDN STC SA01-127
Intaero 8100	26'6"	12'0"	1204 lbs.	8100 lbs.	8000-*8367 lbs.	LSTC O-LSA01-475/D
Wipline 8000	27'6"	12'0"	1211 lbs.	7842 lbs.	8000-*8367 lbs.	U.S. STC SA331CH

AMPHIBIOUS FLOATS

Model	Length	Width	Installed Weight	Displacement	Otter Max Allowable Weight	Approval
EDO 7490	25'4.5"	10'6"	1369 lbs.	7200 lbs.	8000 lbs.	TC A-815
Wipline 8000	27'6"	12'0"	1504 lbs.	7570 lbs.	8000-*8367 lbs.	U.S. STC SA331CH

* with the Baron STC gross weight increase installed per STC SA00438NY.

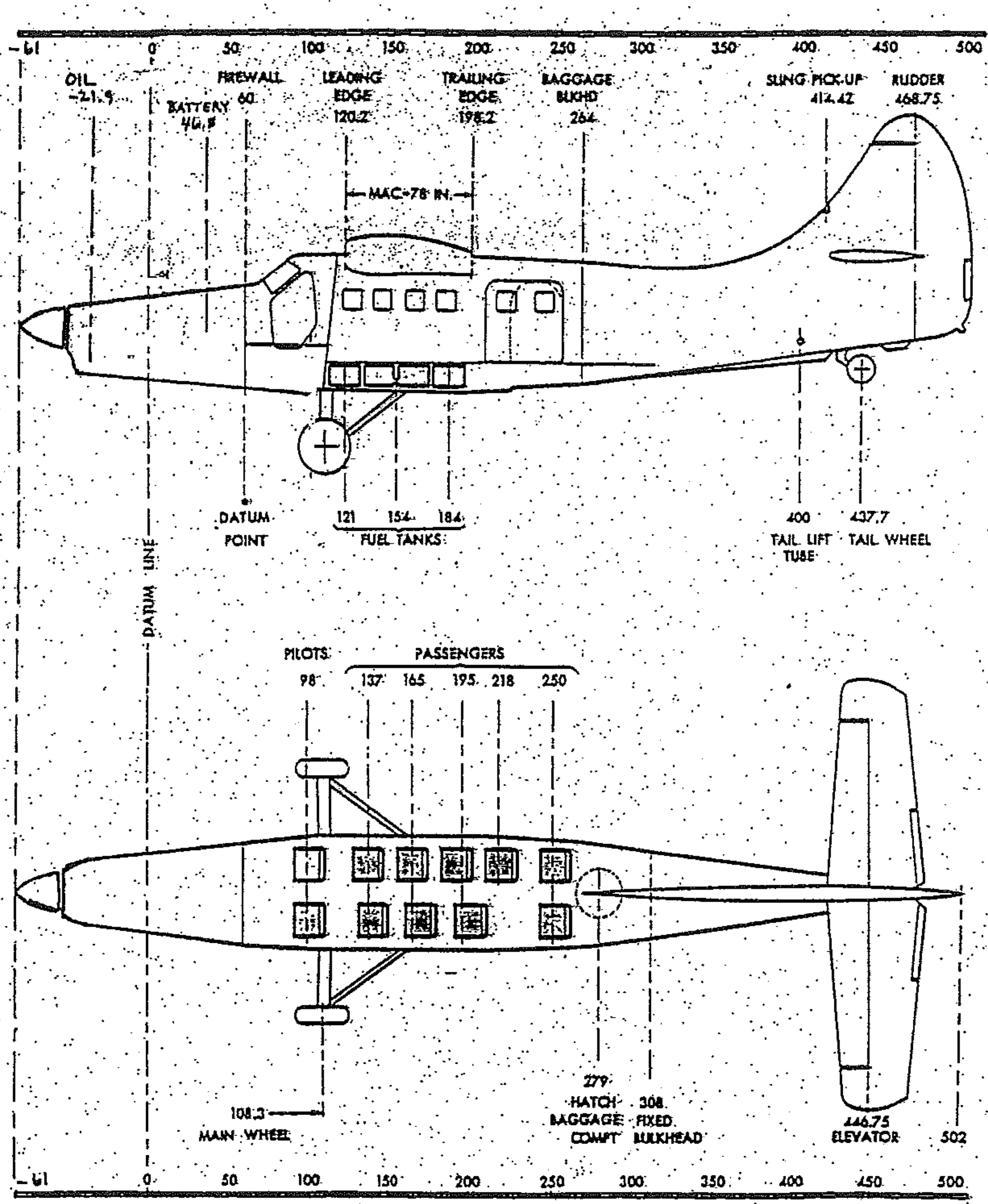


Figure 6-1, Balance Diagram

BASIC WEIGHT OF AIRCRAFT ....LB *

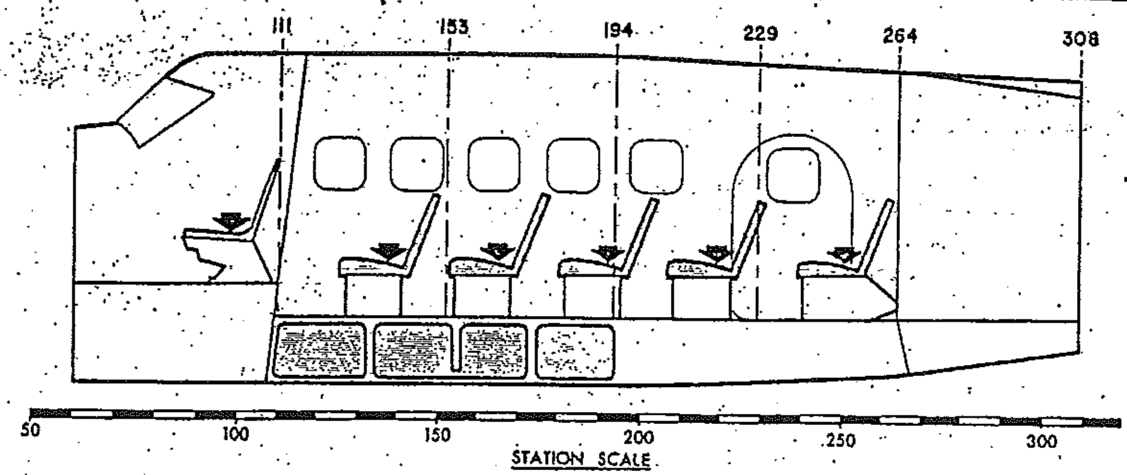
BASIC MOMENT .... *

STD: WEIGHT OF PILOT(S) OR PASSENGER(S). 170 LB

* (INSERT ACTUAL WEIGHT AND BASIC MOMENT GIVEN IN WEIGHT AND BALANCE REPORT TO BE FOUND IN ENVELOPE ON INSIDE OF REAR COVER)

MEAN ARM IN INS.	98	137	165	195	218	250	279
MOMENT/100	170	235	285	330	371	425	SEE BELOW

FREIGHT COMPT. NO.	D-1	D-2	D-3	D-4	E	SEE FREIGHT MOMENT TABLE



1) ADD TO BASIC WEIGHT AND TO BASIC MOMENT:
- A) PILOT(S) AND PASSENGER(S)
- B) FREIGHT AND BAGGAGE
- C) FUEL AND OIL

} WEIGHTS AND MOMENTS

2). MAKE SURE:
- A) TAKE-OFF WEIGHT IS LESS THAN MAX ALL-UP WT
- B) TOTAL MOMENT VALUE IS WITHIN SAFE MOMENTS LIMITS
- C) AVAILABLE TAKE-OFF DISTANCE PERMITS TAKE-OFF AT THIS WEIGHT

3) ADDITIONAL INFORMATION:

FREIGHT MOMENT TABLE
BALANCE DIAGRAM
FLOOR LOAD DISTRIBUTION DIAGRAM

OIL
CAP. 9 U.S. QTS

LBS.	ARM	MOM/100
14.0	-21.9	-306.6
1.8	9	16.2

BAGGAGE COMPARTMENT
ARM = 279 INS.

WEIGHT	MOM/100
50	140
100	279
150	419
200	558
250	698
300	837
350	977
400	1116
450	1256
500	1395
550	1535
600	1674
650	1814

FUEL FRONT TANK
CAP. 62 US GALS. ARM= 121 INS.

GALS.	LBS.	MOM/100
10	67	81.1
20	134	162.1
30	201	243.2
40	268	324.3
50	335	405.4
62	415.4	502.6

FUEL CENTRE TANK
CAP. 102 US GALS. ARM= 154 INS.

GALS.	LBS.	MOM/100
10	67	103.2
20	134	206.4
30	201	309.5
40	268	412.7
50	335	515.9
60	402	619.1
70	469	722.3
80	536	825.4
102	683.4	~~[illegible]~~ 1052.4

FUEL REAR TANK
CAP. 51 US GALS. ARM= 184 INS.

GALS.	LBS.	MOM/100
10	67	123.3
20	134	246.6
30	201	369.8
40	268	493.1
51	341.7	628.7

Figure 6-2, Operational Loads Diagram

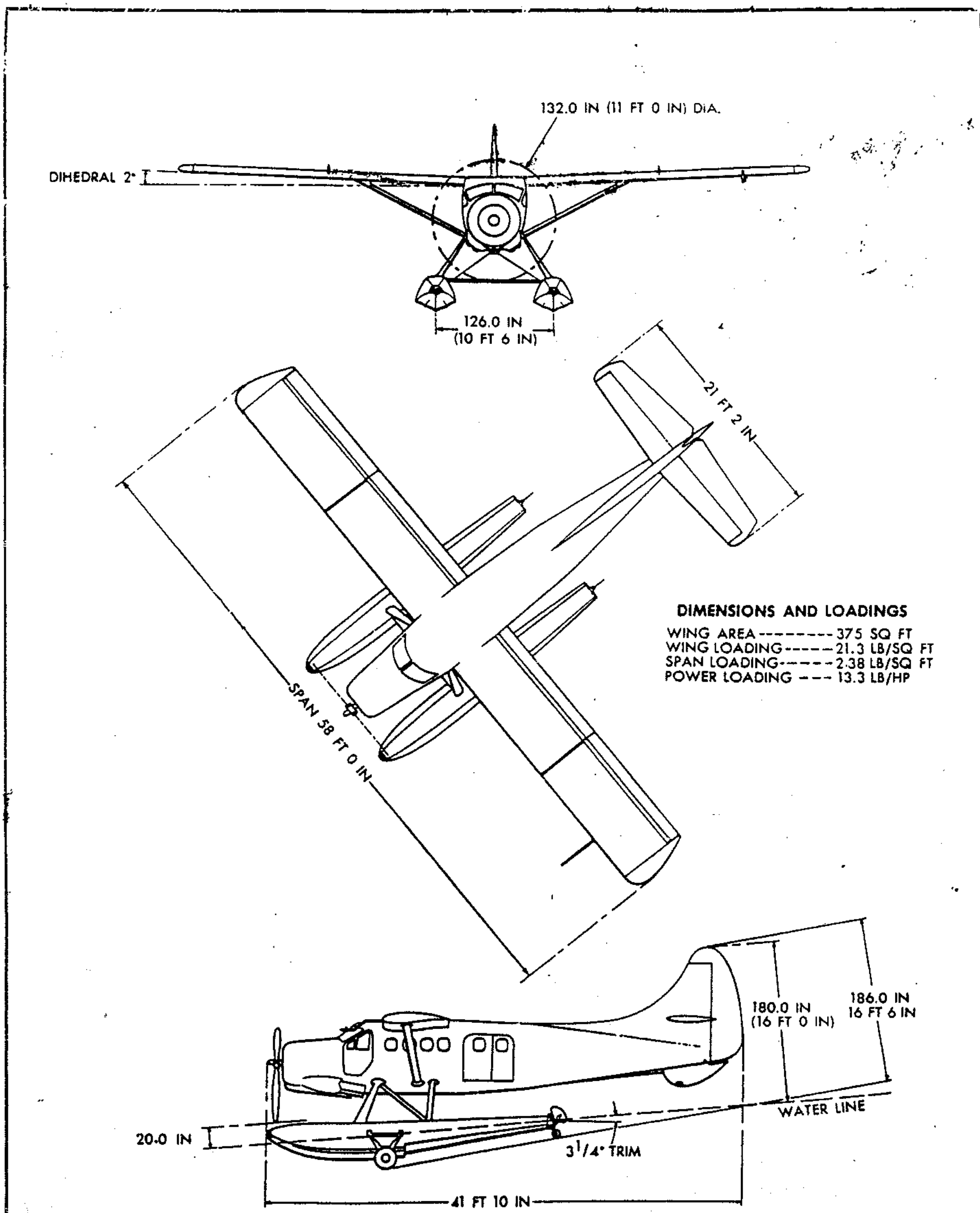


FIG. 1-1 THREE VIEW DIMENSIONAL DIAGRAM: SEAPLANE

CHAPTER I

DESCRIPTION OF AIRCRAFT

1.1 GENERAL

The DHC-3 "OTTER" airplane is an all-metal, high wing monoplane powered by a single Pratt and Whitney "Wasp" engine driving a Hamilton Standard constant-speed propeller. The aircraft has been designed to carry a pilot and from six to eleven passengers. It may also be used for liaison duties, ambulance and rescue operations, for forestry, border and coast patrols, for spraying, dusting, aerial surveying and for photographic operations or cargo transportation. The non retractable landing gear may be replaced by a twin floats installation, an amphibious floats installation, a ski installation, or by a combination wheel-ski installation.

Through partitions the aircraft is divided into a cockpit, a cabin and a baggage compartment.

1.2 DIMENSIONS. General over-all dimensions of the airplane are:

Length	41 feet,	10 inches
Wing Span	58 feet,	0 inches
Height (to top of rudder tailwheel on ground)	12 feet,	6.6 inches
Sea plane (From Water line)	16	6"

1.3 GROSS WEIGHT. The maximum gross weight of the aircraft is 8000 pounds for the landplane and amphibian, 7967 lb for the seaplane.

1.4 ENGINE

The airplane is powered by a Pratt and Whitney "Wasp" R-1340, model S1H1-G or S3H1-G geared nine cylinder, air-cooled, radial, supercharged engine rated at 600 BHP. The two engine models are similar in every respect with the exception of the super-charger ratio which is 12:1 for the S1H1 engine, 10:1 for the S3H1 engine, resulting in rated altitudes of 6,200 feet and 3,000 feet respectively.

The supercharger is of the direct-connected, engine driven centrifugal type and is not under the control of the pilot.

1.4.1 EXHAUST AUGMENTOR TUBES. The two exhaust augmentor tubes on both sides of the fuselage, just below the cockpit doors, (marked "NO STEP") are a special design feature of the aircraft.

In these four exhaust augmentor tubes, the exhaust gases produce suction strong enough to pull cooling air around the engine and from behind the engine accessories compartment while at the same time providing a measurable amount of thrust in cruising flight. The engine is thus effectively cooled during steep climbs when the forward air speed is low and engine output near its maximum.

Attachment 2: DHC-3T AFM and Supplement References

Texas Turbine Conversions, Inc.

DeHavilland DHC-3ST Otter

Airplane Flight Manual Supplement

TTC-FMS-1

for

Turbine Engine Conversion

and

Optional Bleed-air Heater

Applicable to:

Aircraft Registration No: N455A

Aircraft Serial No. 206

This supplement is FAA approved and must be attached to the FAA-approved Airplane Flight Manual when the aircraft has been modified by the installation of a Honeywell TPE-331 engine in accordance with S.T.C. SA09866SC. The information contained in this document supplements or supersedes the Airplane Flight Manual only in those areas listed herein. For limitations, procedures, and performance not contained in this supplement, consult the Airplane Flight Manual.

Approved By: [redacted]

S. Frances Cox, Manager
Special Certification Office, ASW-190
Federal Aviation Administration
Fort Worth, Texas 76193-0190

Dated: May 5, 2001

[redacted]

AOG AIR SUPPORT INC.
P.O BOX 2340 STN. R
KELOWNA, BC
V1X 6A5

CUFFS P/N 850-SC-100
SN 70230001

DOT APPROVED
AIRPLANE FLIGHT MANUAL SUPPLEMENT # 5
to
FAA APPROVED FLIGHT MANUAL SUPPLEMENT REPORT 041288
for
SERV-AERO TURBO OTTER
with
ANY APPROVED FLOAT UP TO 7850 SIZE
OR
WITH A MINIMUM BUOYANCY
OF 7530 POUNDS
AT MAX. GROSS WEIGHT OF 8367 LBS.

STA # SA 95-32
STC # SA 00438NY

REG # ___ S/N

This supplement must be attached to the Serv-Aero Turbo Otter FAA Approved Airplane Flight Manual Supplement Report 041288 when the Serv-Aero Turbo Otter is modified by the installation of AOG Air Support Inc. 400 LB Upgross Kit, with or without the Baron/Stol Kit also installed (STA SA 94-114 OR FAA STC SA 00287NY).

The information contained herein supplements or supersedes the information in the FAA approved Airplane Flight Manual Supplement Report 041288 and/or the basic DHC-3 Otter Flight Manual only in the areas listed herein. For LIMITATIONS, PROCEDURES and PERFORMANCE information not contained in this supplement, consult Serv-Aero Turbo Otter FAA Approved Airplane Flight Manual Supplement Report 041288 and/or the basic DHC-3 Otter Flight Manual. Compliance with section I OPERATING LIMITATIONS is mandatory.

DOT APPROVED: [redacted]
NAME: J.H. NEHERA
TITLE: REGIONAL MANAGER AIRCRAFT CERTIFICATION
PACIFIC REGION

N455A
206

DATE OF APPROVAL: July 28, 2000

REVISION: " C"
REVISION DATE: JULY 28, 2000
DOT APPROVED

Wipaire, Inc.
8520 River Road
Inver Grove Heights, MN 55076
Phone 612-451-1205
Fax 612-451-1786

FAA APPROVED

FLIGHT MANUAL SUPPLEMENT 3

FOR

AMPHIBIAN FLOATPLANE OPERATION

OF THE DE HAVILLAND DHC-3 OTTER

AT A GROSS WEIGHT OF 8000 POUNDS

WITH

WIPLINE MODEL 8000 AMPHIBIOUS FLOATS

REG. NO. N455A

SER. NO. 206

This Supplement must be attached to the deHavilland Flight Manual when the airplane is modified by the installation of Wipline Model 8000 Amphibious floats in accordance with STC SA 331CH. The information contained herein supplements or supersedes the basic manual only in those areas listed. For limitations, procedures and performance information not contained in this Supplement, consult the basic deHavilland Flight Manual.

FAA APPROVED: [redacted]
for Carl F. Mittag, Manager,
Flight Test Branch
Chicago Aircraft Certification Office
Federal Aviation Administration
Des Plaines, IL

Date: APR 24 1995

Xtra Copy Flt Manual DHC-3 Otter

TABLE OF CONTENTS

Revised 1 March 1966

Attachment 3: TAMDAR-based Wind Data

The wind speed and direction data used in the aircraft performance study were based on the enclosed meteorological data, excerpted from pages 12 and 13 of the NTSB Meteorological Factual Report.

3.0.3 TAMDAR Aircraft

Meteorological data[7] from a TAMDAR[8]-equipped commercial aircraft flying in and out of PADL near the time of the accident is presented in tables 1 and 2. These data originated from a PenAir Saab 340B aircraft (registration number N365PX), and its flight path and data reporting points are depicted in Figure 5. Data retrieved from below 3,000 feet from the TAMDAR sensor on this aircraft is presented here, which includes time and position information, Global Positioning System (GPS) altitude, temperature and moisture retrievals, as well as wind direction and magnitudes. The data from this aircraft have been quality controlled.

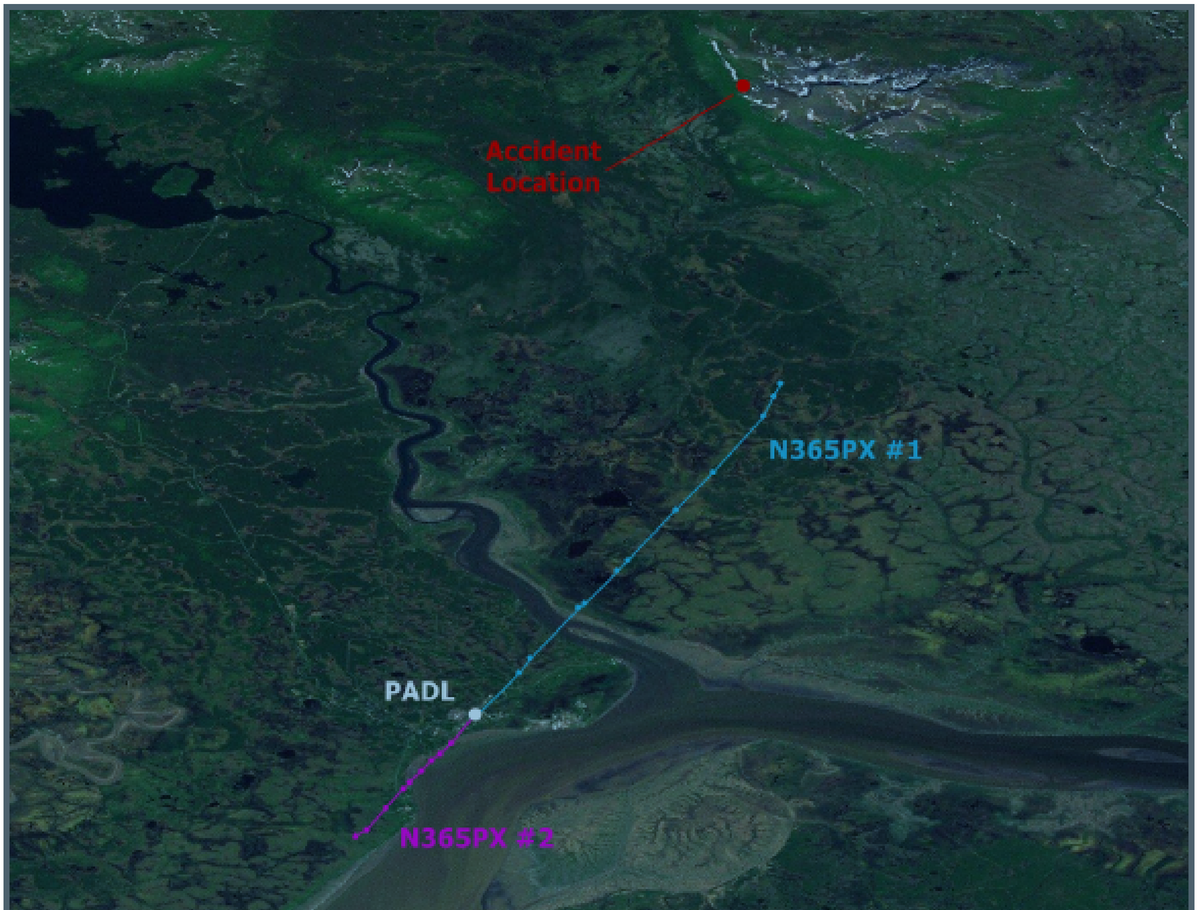


Figure 5 – Flight paths for the TAMDAR-equipped PenAir Saab 340B aircraft near PADL on August 9, 2010.

[7] The TAMDAR data presented in this report was provided courtesy of Dr. Neil Jacobs at AirDat, LLC, in Morrisville, North Carolina, USA.

[8] The Tropospheric Airborne Meteorological Data Reporting (TAMDAR) sensor collects atmospheric observations via a multi-function in-situ sensor on aircraft. These observations include humidity, pressure, temperature, winds aloft, icing, and turbulence, along with the corresponding location, time, and altitude from built-in GPS, and are relayed via satellite in real-time to a ground-based network operations center.

N365PX arrived at PADL (flight #1) at 1308, approximately 95 minutes prior to the accident time. On approach to PADL below 3,000 feet, N365PX experienced wind magnitudes between 16-28 knots, with wind directions ranging between 174° and 211°. The atmosphere below 3,000 feet was saturated with relative humidity retrievals consistently reaching 100 percent and temperatures remained above 0°C. During N365PX's ascent from PADL (flight #2), approximately 40 minutes following its arrival and 55 minutes prior to the accident time, the aircraft experienced wind magnitudes between 22 and 26 knots and wind directions between 200°-218° through 3,000 feet. The atmosphere remained close to saturation with relative humidity values greater than 93% through 3,000 feet. N365PX's arrival and departure routes were not identical.

Time(Z)	Altitude(ft.)	Temp(°C)	RH(%)	Wind Dir.	Wind Speed(kts)	Latitude	Longitude
2104:16	2,950	3.5	100.0	211°	28	59.196	-158.365
2104:25	2,750	4.1	100.0	169°	21	59.190	-158.368
2104:35	2,570	4.8	100.0	174°	21	59.181	-158.373
2105:13	2,130	5.3	100.0	190°	22	59.155	-158.396
2105:40	1,900	6.0	100.0	197°	22	59.138	-158.413
2106:24	1,560	6.3	100.0	199°	23	59.115	-158.435
2106:35	1,340	7.0	100.0	202°	21	59.110	-158.440
2107:08	900	7.9	100.0	200°	21	59.095	-158.455
2107:12	820	8.5	100.0	198°	20	59.093	-158.458
2108:02	430	8.9	100.0	197°	19	59.070	-158.480
2108:13	330	9.6	100.0	200°	16	59.063	-158.485

Table 1 – TAMDAR data collected from N365PX flight #1 on descent into PADL on August 9, 2010. Altitude is GPS altitude in feet with a margin of error of 20-30 feet. Flight path is depicted in figure 5.

Time(Z)	Altitude(ft.)	Temp(°C)	RH(%)	Wind Dir.	Wind Speed(kts)	Latitude	Longitude
2149:45	670	10.5	97.5	201°	22	59.031	-158.516
2149:53	910	9.8	97.5	201°	22	59.026	-158.521
2149:59	1,090	9.1	98.5	200°	24	59.023	-158.525
2150:07	1,340	8.8	98.0	207°	25	59.018	-158.530
2150:19	1,710	8.5	93.5	209°	26	59.013	-158.535
2150:23	1,850	7.8	96.0	212°	26	59.010	-158.538
2150:39	2,270	7.0	95.5	216°	25	59.001	-158.546
2150:54	2,650	6.3	97.0	218°	26	58.991	-158.555
2151:02	2,870	5.5	98.0	215°	26	58.988	-158.560

Table 2 – TAMDAR data collected from N365PX flight #2 on ascent out of PADL on August 9, 2010. Altitude is GPS altitude in feet with a margin of error of 20-30 feet. Flight path is depicted in figure 5.

Attachment 4: Airspeed Limitations

CHAPTER IV OPERATING LIMITS

GENERAL REMARKS

The aircraft must be operated according to the following limitations and instructions.

AIRSPEED LIMITS (MPH)	IAS	CAS
SEAPLANE		
MAXIMUM OPERATING LIMIT SPEED, Vmo	133	137
MANEUVERING SPEED, Va	124	128
MAXIMUM FLAP EXTENDED SPEED, Vfe	91	95

FLOATS: This modification is approved for floats which includes the following categories or models.

A/ EDO 7850 floats,

B/ EDO 7170 floats with AOG Air Support Inc 22 aft Extension per STA SF 95-1

C/ EDO 7490 floats that have had an approved conversion to remove the amphibious gear, or installation of approved flotation elements (meeting a minimum buoyancy of 7530 lbs).

D/ WHIPLINE model 8000 seaplane or amphibious float installed in accordance with FAA STC SA331CH.

E/ OR any other approved float installation with a minimum buoyancy of 7530 pounds.

GROSS WEIGHT

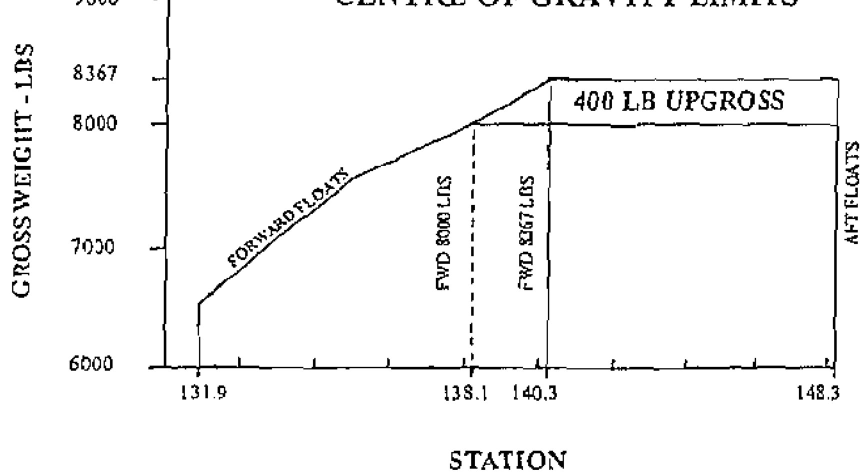
Maximum take-off and landing weight: 8367 lbs.

NOTE: TAKE-OFF & LANDING WEIGHTS FOR WIPLINE 8000 FLOATS

Max Take-off weight: Wheels 8367 lbs.
: Water 8367 lbs.
Max Landing weight: Wheels 8000 lbs.
: Water 8367 lbs.

N455A
206

CENTRE OF GRAVITY LIMITS



REVISION: " C"
REVISION DATE: JULY 28, 2000
DOT APPROVED

PERFORMANCE AT 8000 LB GROSS WEIGHT.

The aircraft performance meets or exceeds that of the original aircraft. Refer to the original DeHavilland DHC-3 Otter Flight Manual for determining performance.

NOTE

Use of the Bleed-air Heater System can degrade the climb performance as much as 100 ft/min. The resulting climb performance still meets or exceeds that of the original aircraft. A torque loss of up to 8% can be seen with the bleed-air heater full open versus closed for the same takeoff EGT.

CRUISE POWER SETTINGS.

For turbine engine aircraft, the best fuel efficiency (relative to fuel consumption vs. horsepower) is usually the maximum turbine temperature allowable at the given engine inlet temperature. This is not possible with the engine installed, because the pilot can easily exceed the airframe speed limits. Therefore, it is recommended to set the power lever to the highest allowable speed for the conditions within the operating envelope and reduce the engine speed (with the condition lever) to 96%. The lower engine speed will reduce fuel consumption and the engine noise level.

FLIGHT CHARACTERISTICS.

The flight characteristics are very similar to the original aircraft although the p-factor is opposite to the original due the counter-clockwise rotation of the engine and propeller.

STALL SPEEDS

1. Airspeeds shown are in mph-calibrated airspeed.
2. Power set at zero thrust.
3. Maximum altitude loss during any stall is 350 feet.
4. Stall characteristics are conventional.

CAUTION

When demonstrating stalls with power on and flaps extended, full rudder deflection may be reached before aircraft stalls. Recovery must be initiated prior to full rudder deflection.

Weight	Flap	Angle of Bank			
(lbs)	Position	0°	20°	40°	60°
8,000	Up	77	79	88	109
	Climb	57	59	65	81
	Landing	52	54	59	74
7,500	Up	75	77	85	105
	Climb	55	57	63	78
	Landing	50	52	58	71
7,000	Up	72	74	82	102
	Climb	53	55	61	76
	Landing	49	50	56	69
6,500	Up	70	72	80	99
	Climb	52	53	59	73
	Landing	47	49	54	67
6,000	Up	68	70	77	96
	Climb	50	52	57	71
	Landing	46	47	52	65

SECTION 2

LIMITATIONS

INTRODUCTION

Except as shown in this section, the operating limitations are the same as those for the basic deHavilland seaplane. The limitations in this section apply only to operations of the Otter when it is equipped with Wipline Model 8000 floats.

WARNING!

The limitations included in this section have been approved by the Federal Aviation Administration. Observance of these operating limitations is required by Federal Aviation Regulations.

Weight Limitations

Maximum Takeoff and Landing Weight - 8000 pounds (with dual stall strips installed per Item 104, TC Data Sheet.)

Center of Gravity Limitations

Center of Gravity Range:
Forward: 131.9 inches (15% MAC) aft of datum at 6600 pounds or less, with straight line variation to 135.8 inches (20% MAC) aft of datum at 7600 pounds to 139.0 inches (24.1% MAC) aft of datum at 8000 pounds.

Aft: 148.3 inches (36.0% MAC) aft of datum at all weights up to 8000 pounds.

Airspeed Limitations

Maneuvering Speed - 8000 pounds - 126 mph IAS

FAA APPROVED APR 2 4 1995

SECTION 5

PERFORMANCE INFORMATION

INTRODUCTION

In general, the performance information shown in the deHavilland Flight Manual is applicable to this aircraft, particularly at weights of 8000 pounds or less. Data which is the same for this configuration is not repeated, and the basic deHavilland manual should be consulted.

Airspeed Calibration

Conditions:
Power for Level Flight or MCP
8000 Pounds
Speeds in Miles per Hour

Flaps Up

IAS	70	80	90	100	110	120	130	140	150	160
CAS	76	85	94	103	113	123	134	144	155	165

Flaps Takeoff

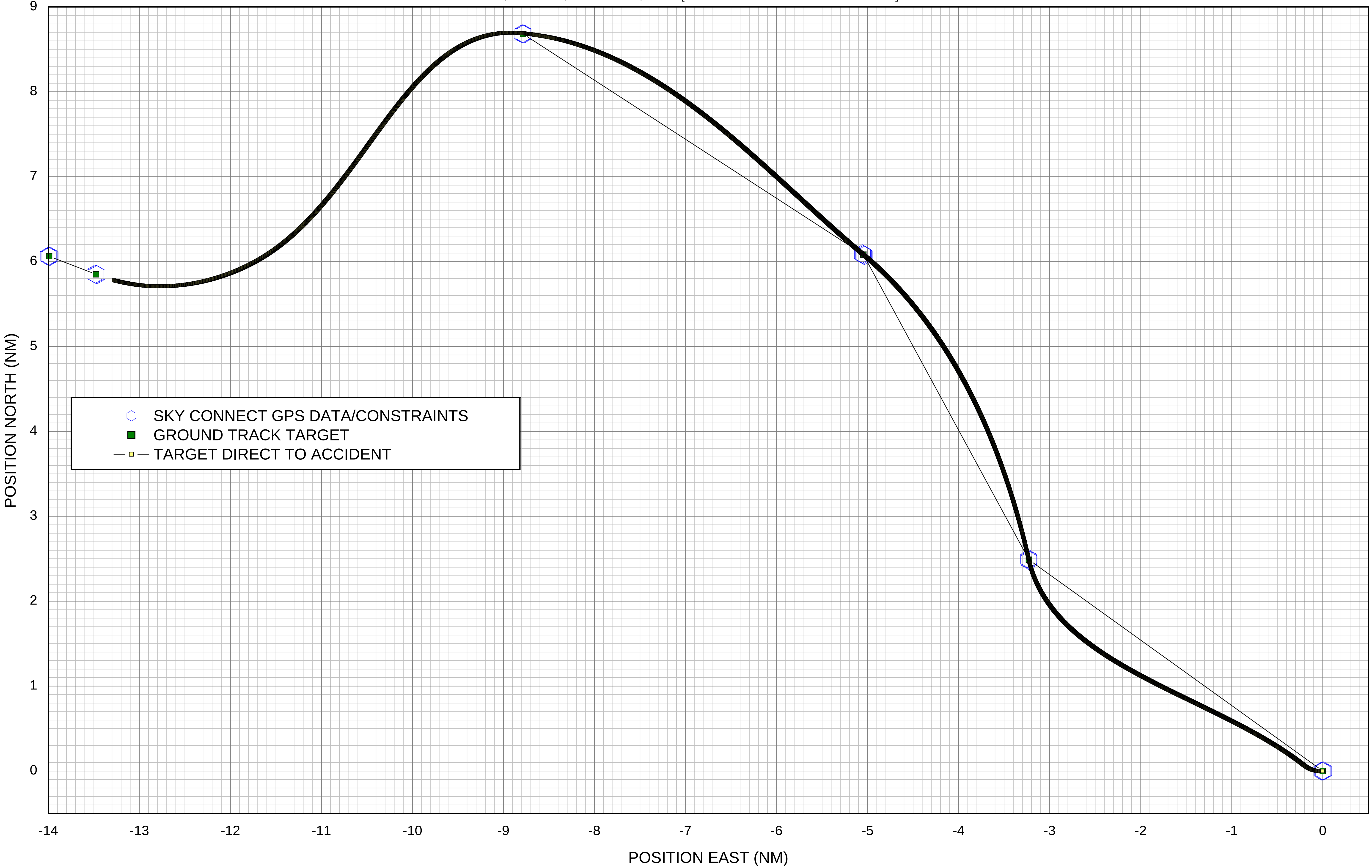
IAS	50	60	70	80	90
CAS	55	64	74	84	94

Flaps Landing

IAS	45	50	60	70	80	90
CAS	51	55	64	74	84	94

Attachment 5: Calculated Ground Track

Figure A5.1: de HAVILLAND DHC-3T (N455A) CALCULATED GROUND TRACK POSITION [Accident location is 0. nm east, 0. nm north]
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [BASED ON TAMDAR WIND DATA]



NATIONAL TRANSPORTATION SAFETY BOARD

Figure A5.2: de HAVILLAND DHC-3T (N455A) CALCULATED GROUND TRACK POSITION [Accident location is 0. nm east, 0. nm north]

MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [BASED ON TAMDAR WIND DATA]

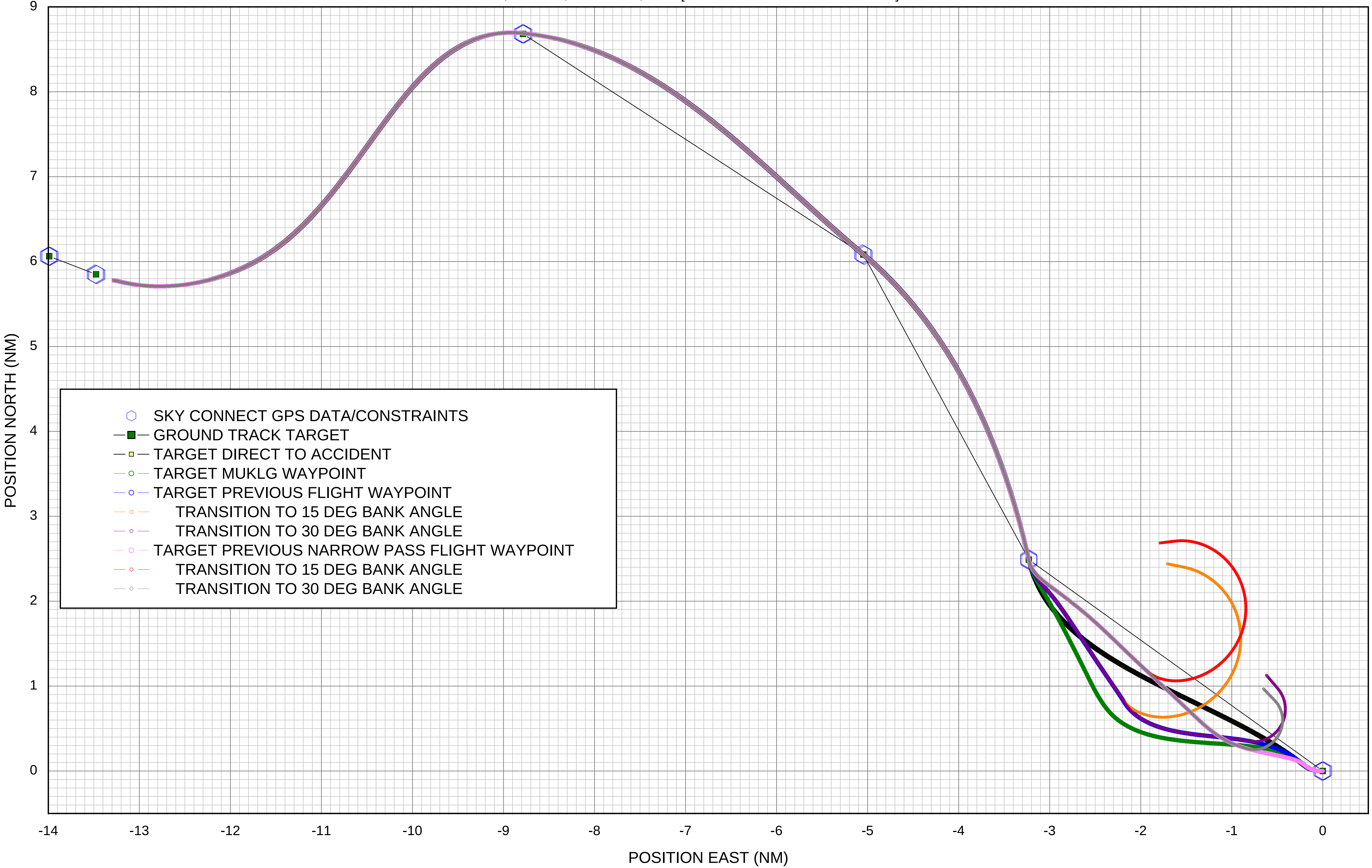
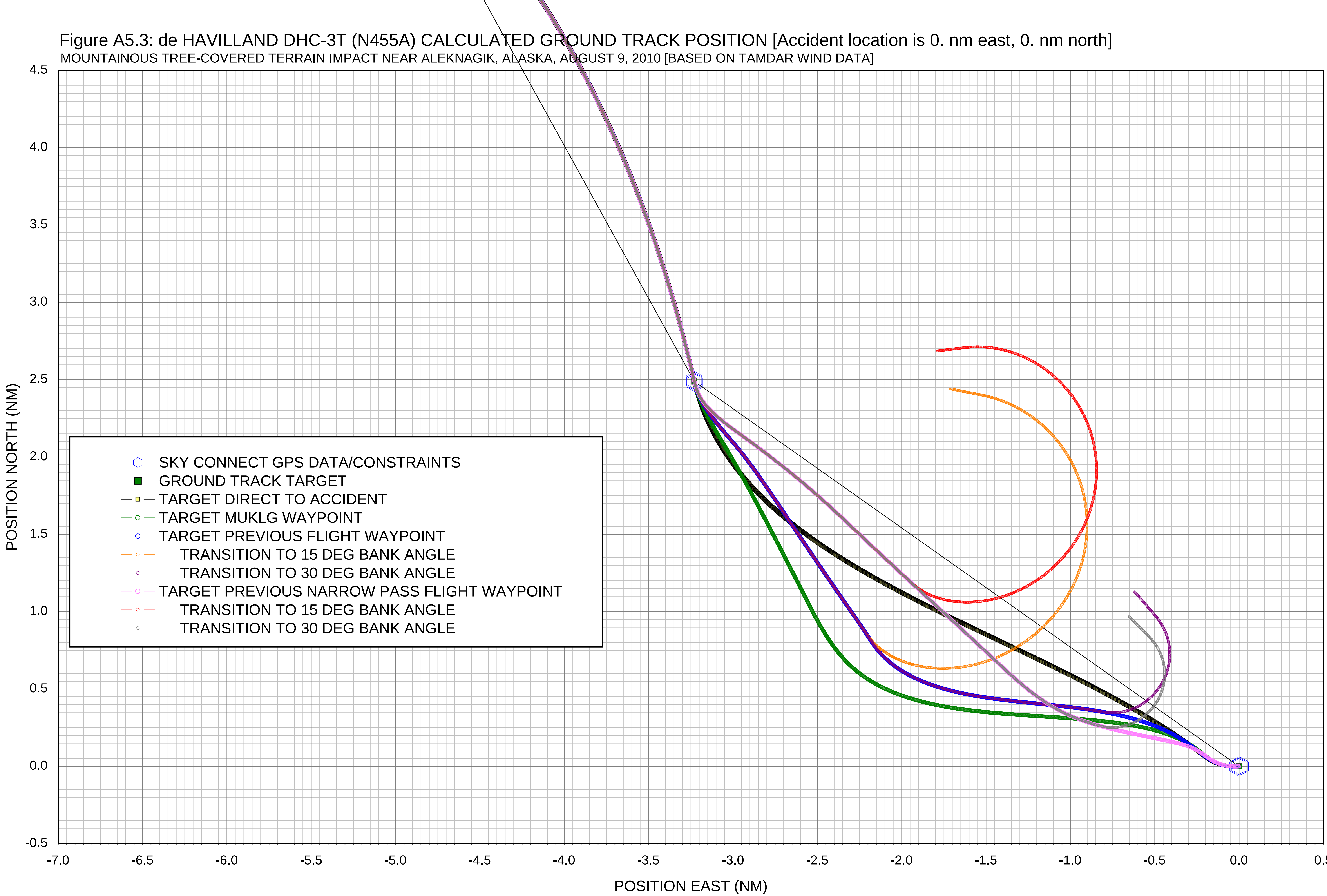


Figure A5.3: de HAVILLAND DHC-3T (N455A) CALCULATED GROUND TRACK POSITION [Accident location is 0. nm east, 0. nm north]

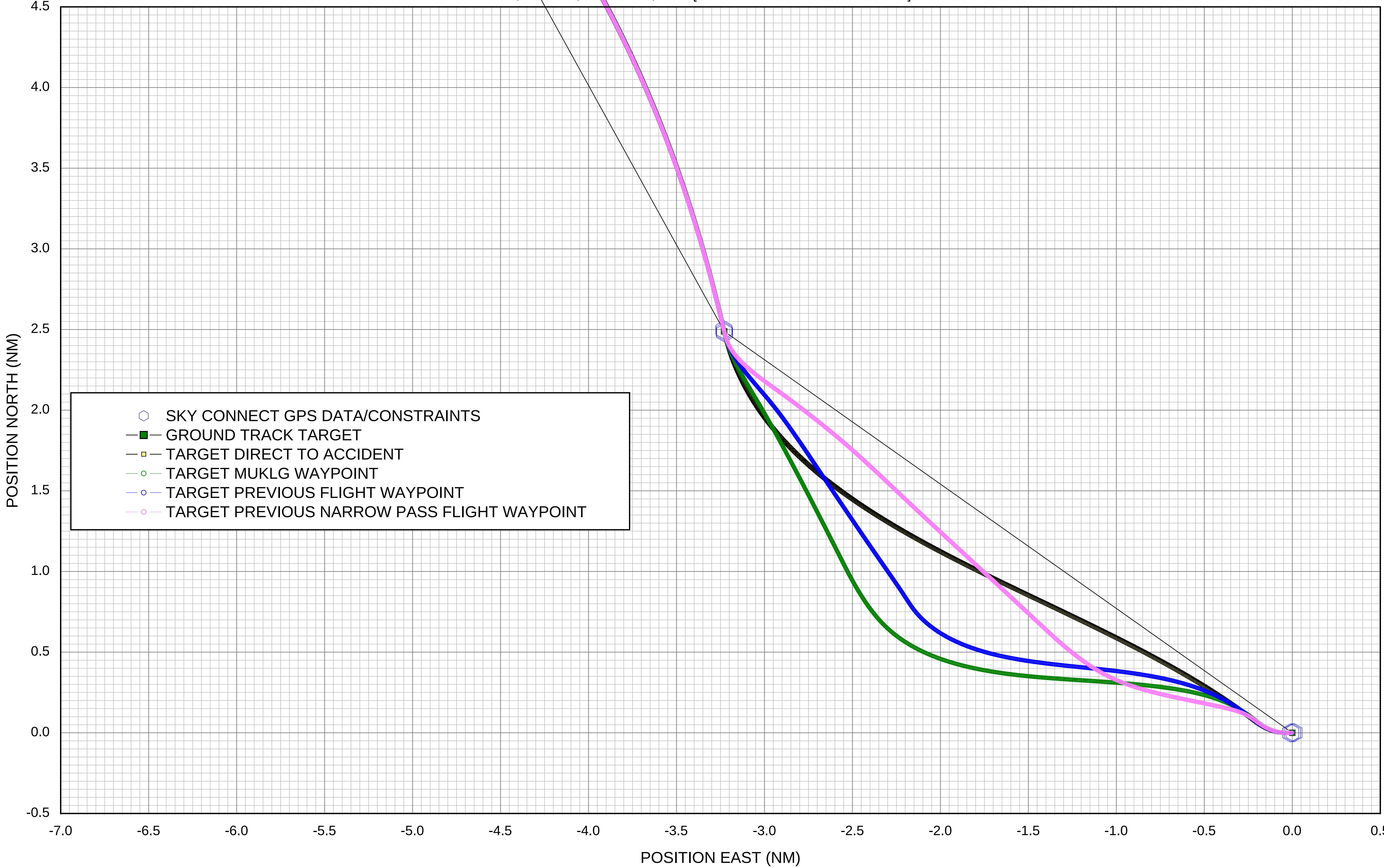
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [BASED ON TAMDAR WIND DATA]



NATIONAL TRANSPORTATION SAFETY BOARD

Figure A5.4: de HAVILLAND DHC-3T (N455A) CALCULATED GROUND TRACK POSITION [Accident location is 0. nm east, 0. nm north]

MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [BASED ON TAMDAR WIND DATA]



NATIONAL TRANSPORTATION SAFETY BOARD

Figure A5.5: de HAVILLAND DHC-3T (N455A) CALCULATED GROUND TRACK POSITION [Accident location is 0. nm east, 0. nm north]

MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [BASED ON TAMDAR WIND DATA]

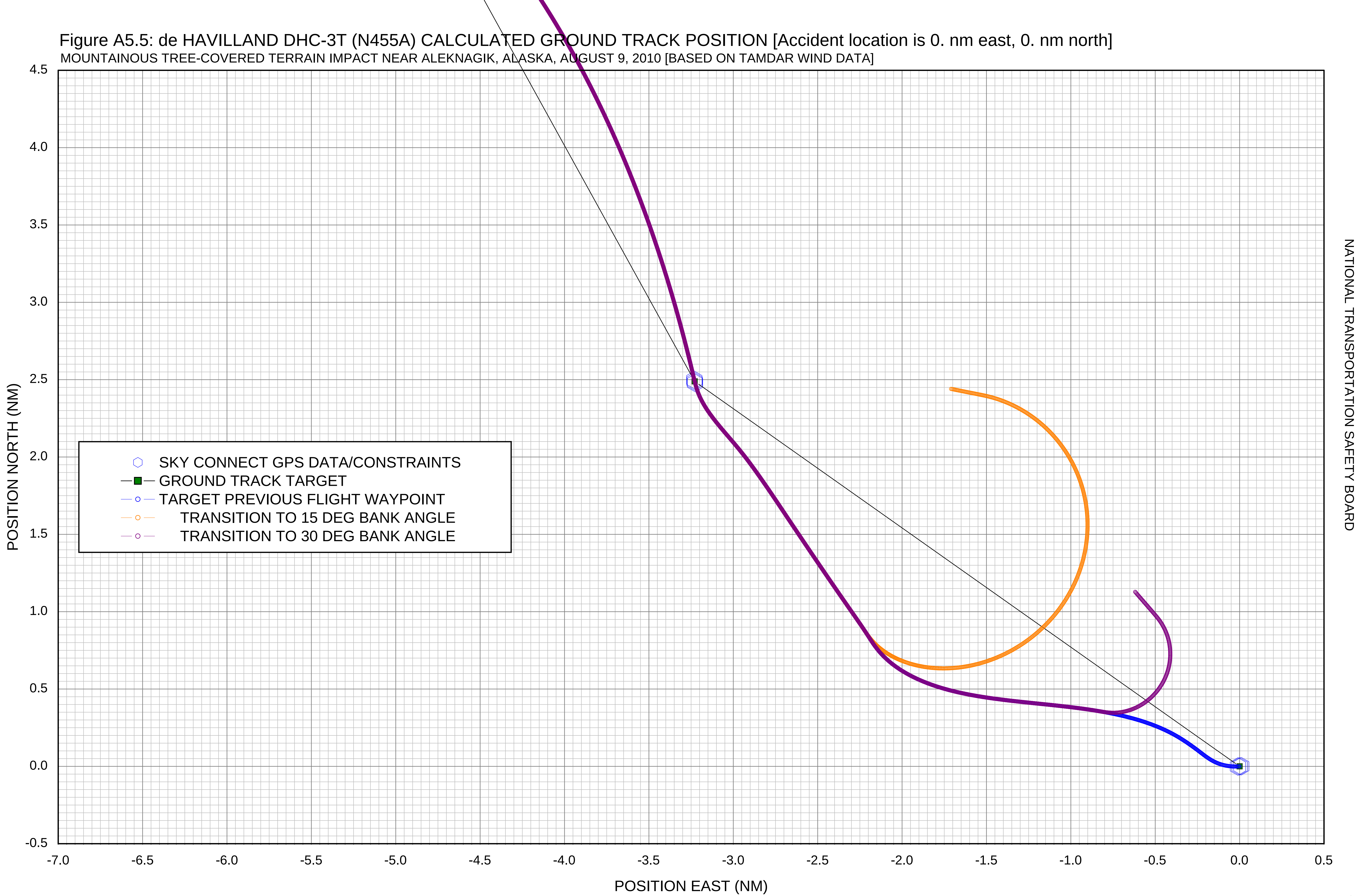
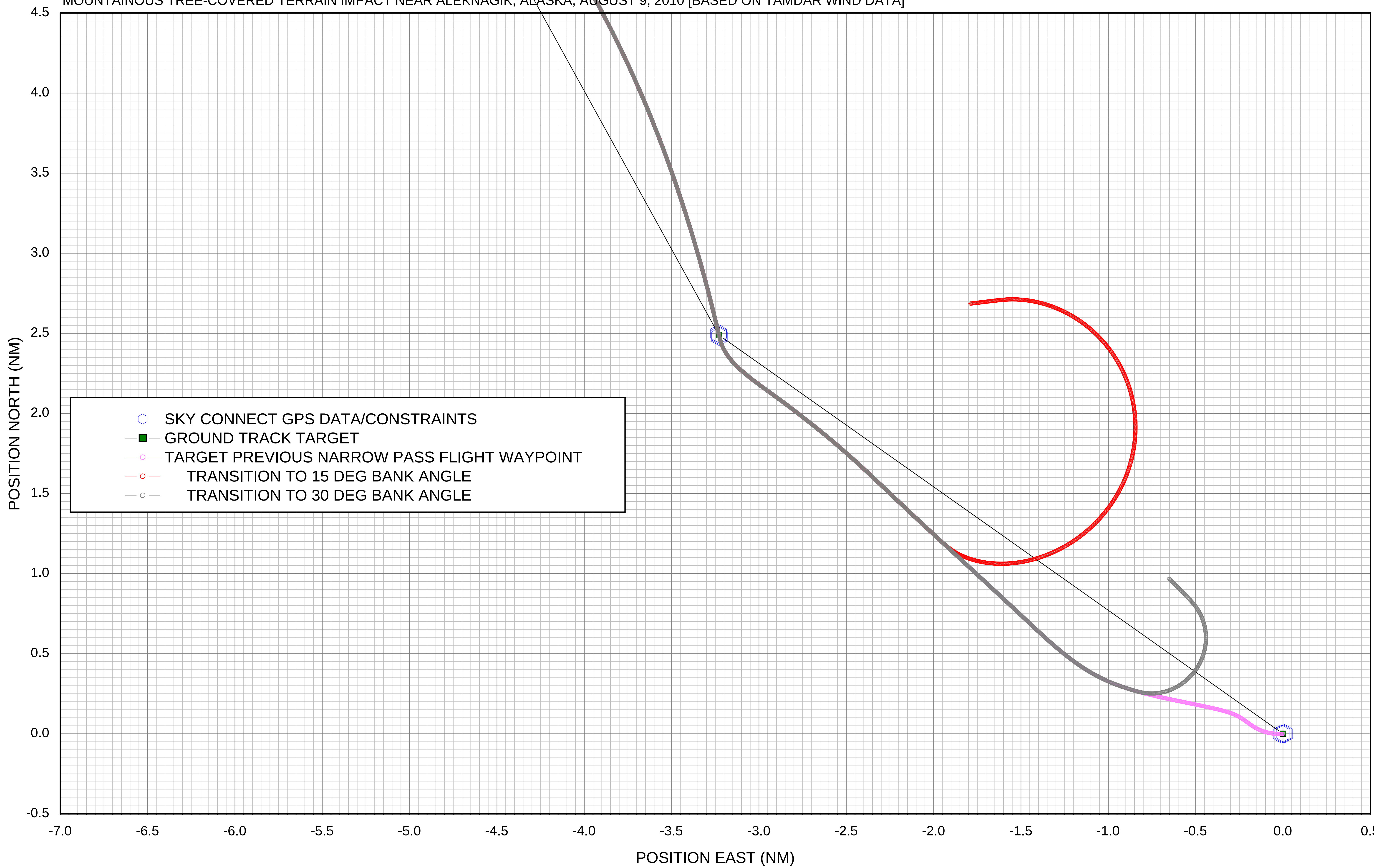


Figure A5.6: de HAVILLAND DHC-3T (N455A) CALCULATED GROUND TRACK POSITION [Accident location is 0. nm east, 0. nm north]
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [BASED ON TAMDAR WIND DATA]



NATIONAL TRANSPORTATION SAFETY BOARD

Attachment 6: Simulation Scenario Targets & Flight Paths

Figure A6.1: N455A simulation scenario 1 (target DIRECT to accident site).

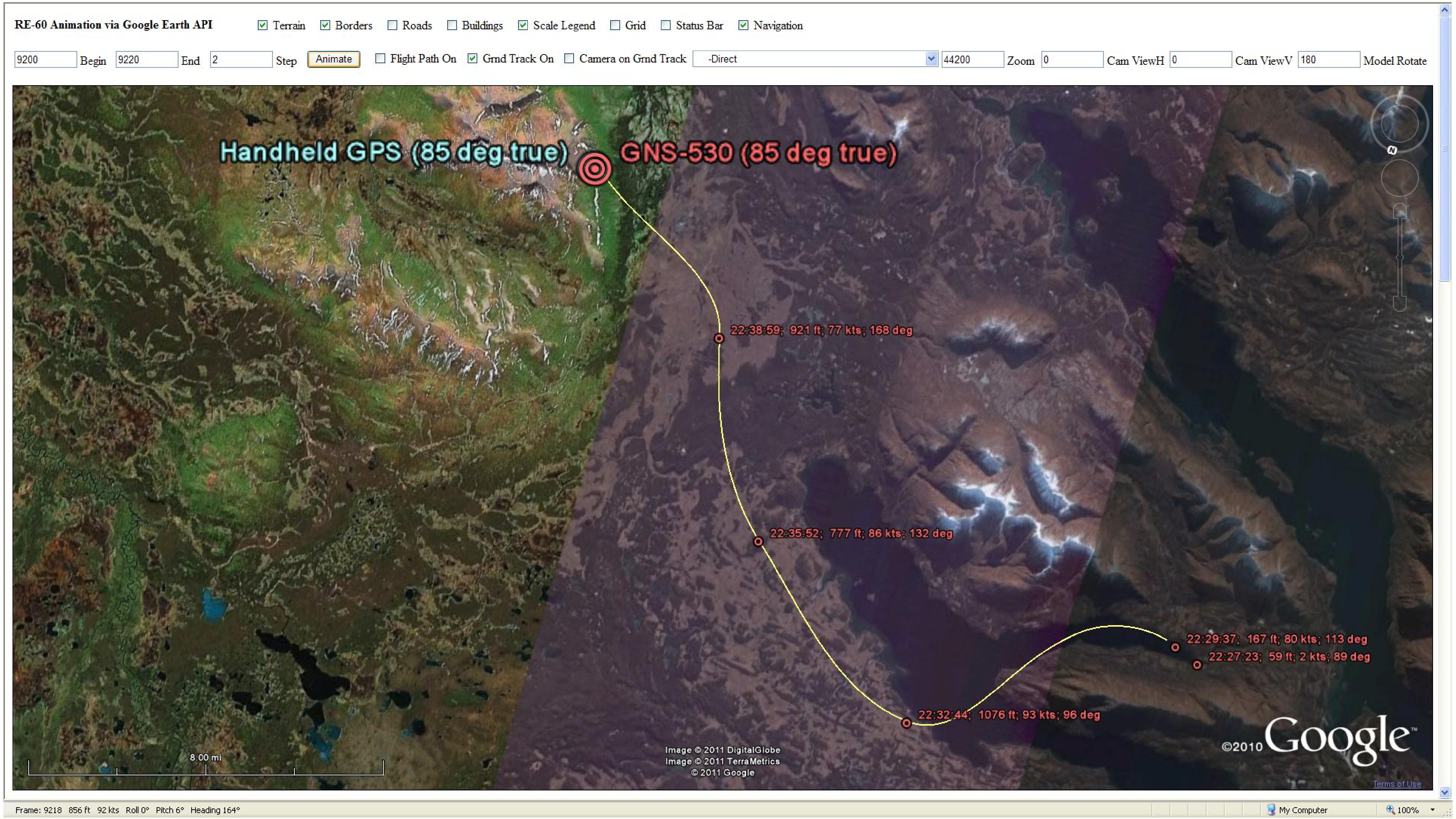


Figure A6.2: N455A simulation scenario 2 (target MUKLG).

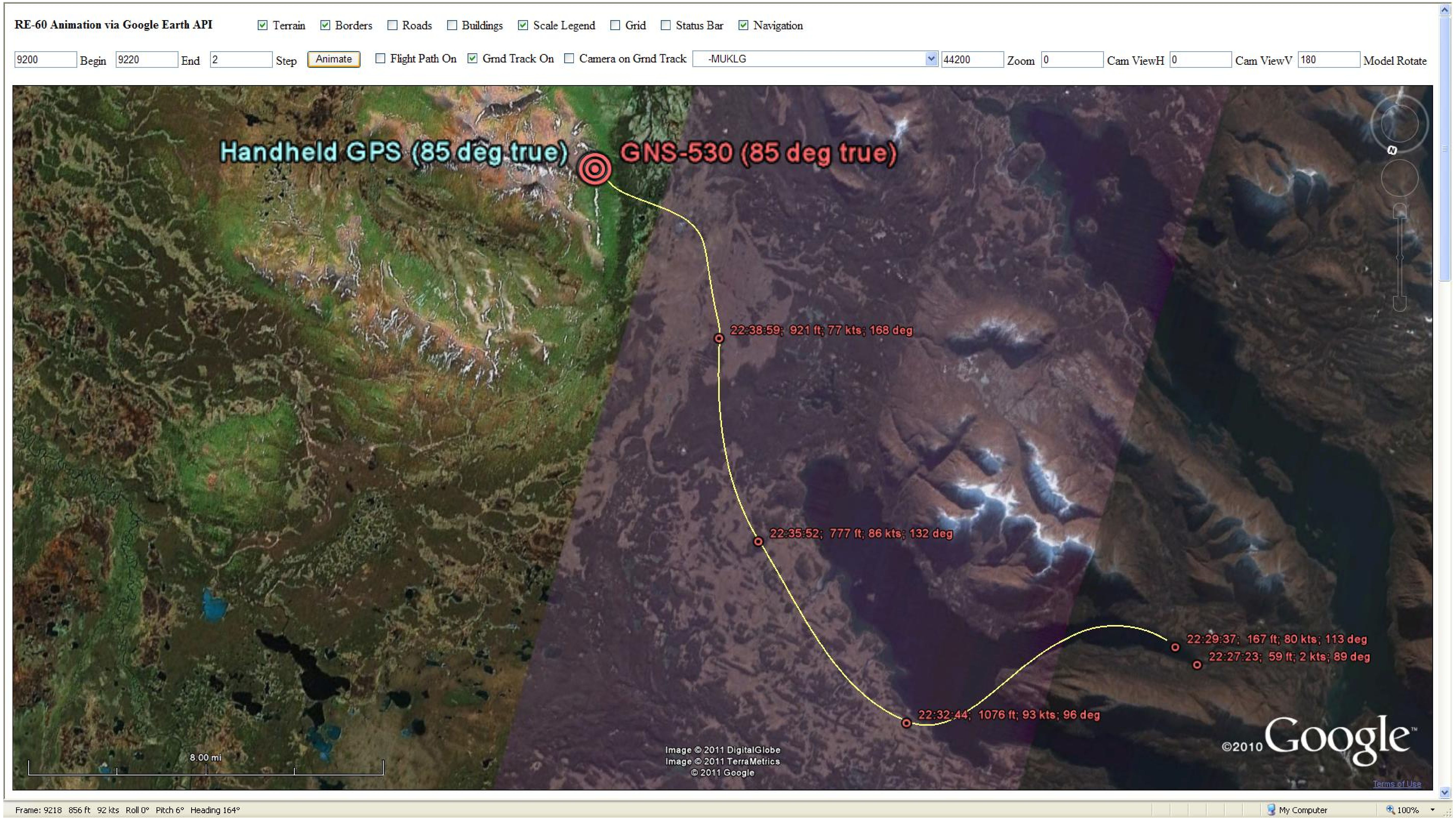


Figure A6.3: N455A simulation scenario 3 (target PREVIOUS FLIGHT waypoint).

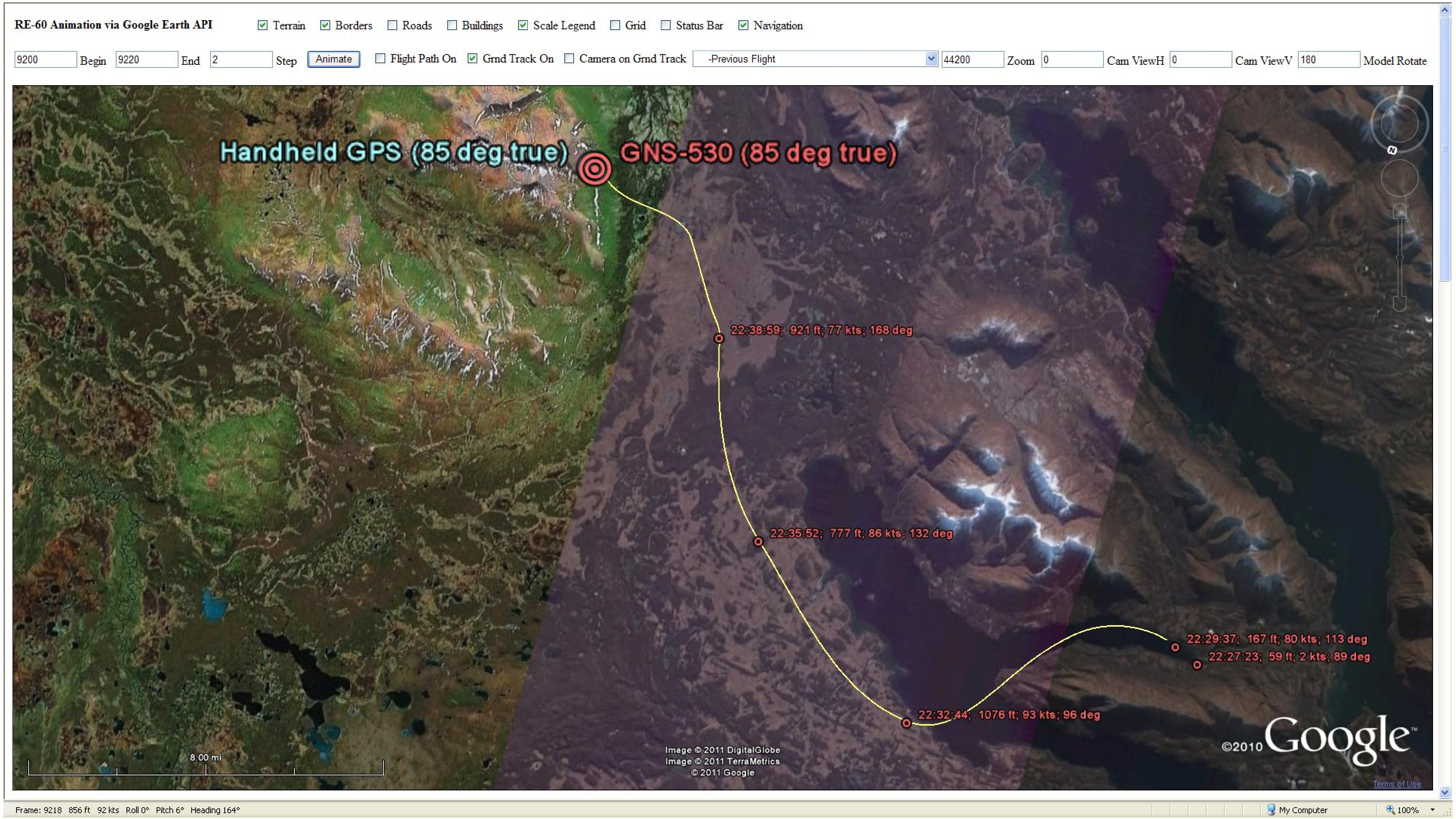


Figure A6.4: N455A simulation scenario 4 (target PREVIOUS FLIGHT waypoint followed by 15° LWD escape maneuver).

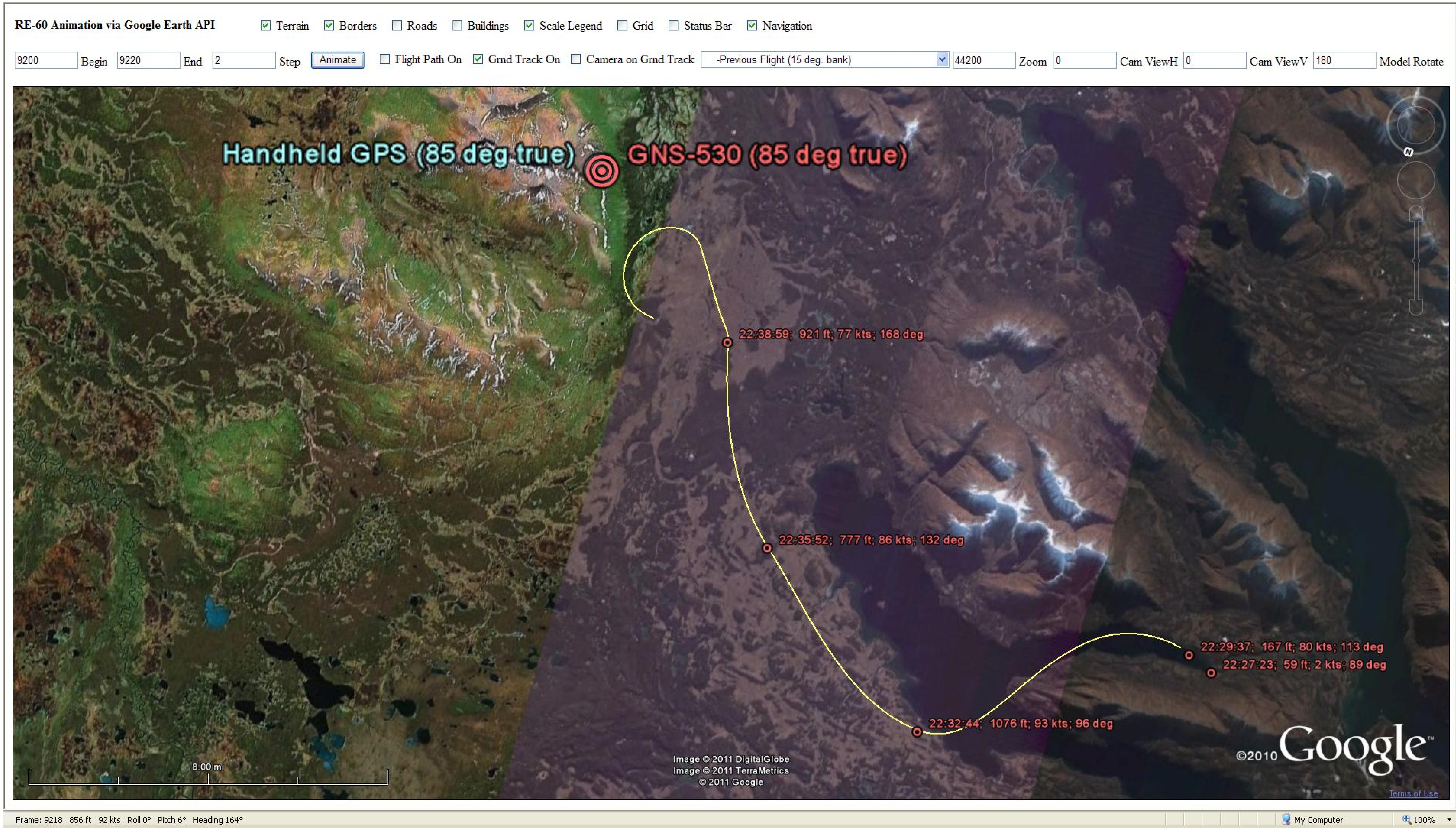


Figure A6.5: N455A simulation scenario 5 (target PREVIOUS FLIGHT waypoint followed by 30° LWD escape maneuver).

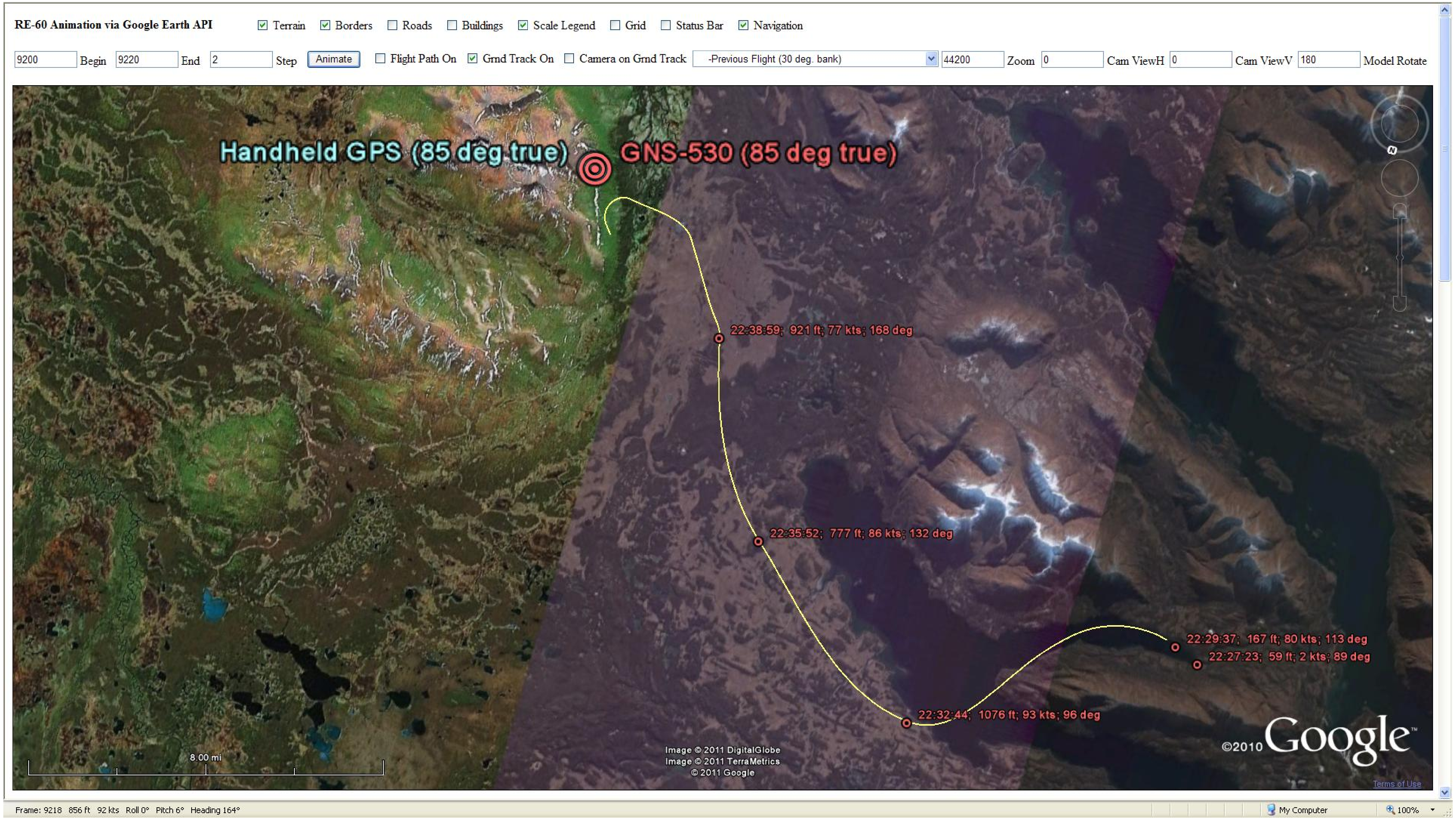


Figure A6.6: N455A simulation scenario 6 (target PREVIOUS PASS waypoint).

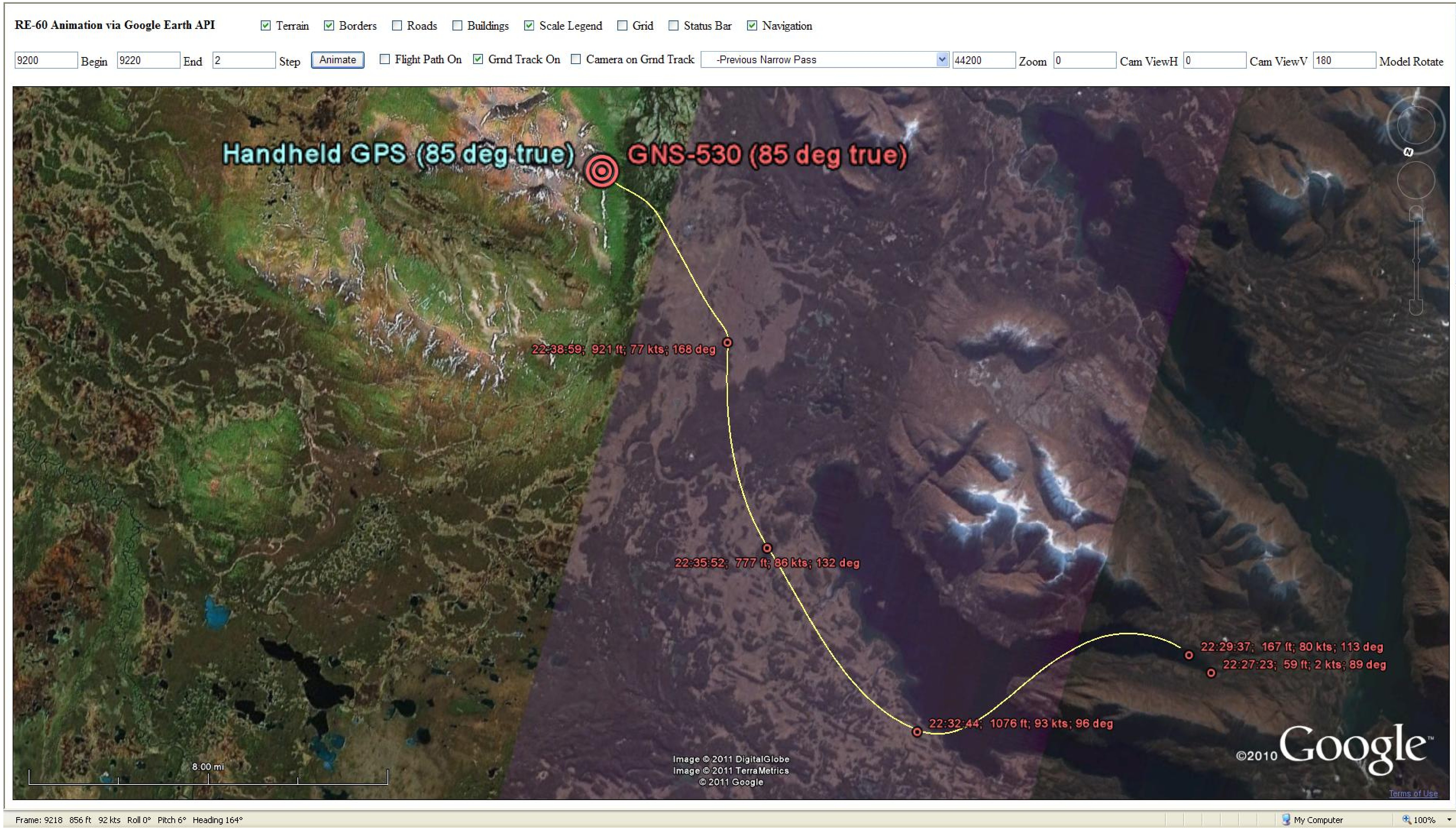


Figure A6.7: N455A simulation scenario 7 (target PREVIOUS PASS waypoint followed by 15° LWD escape maneuver).

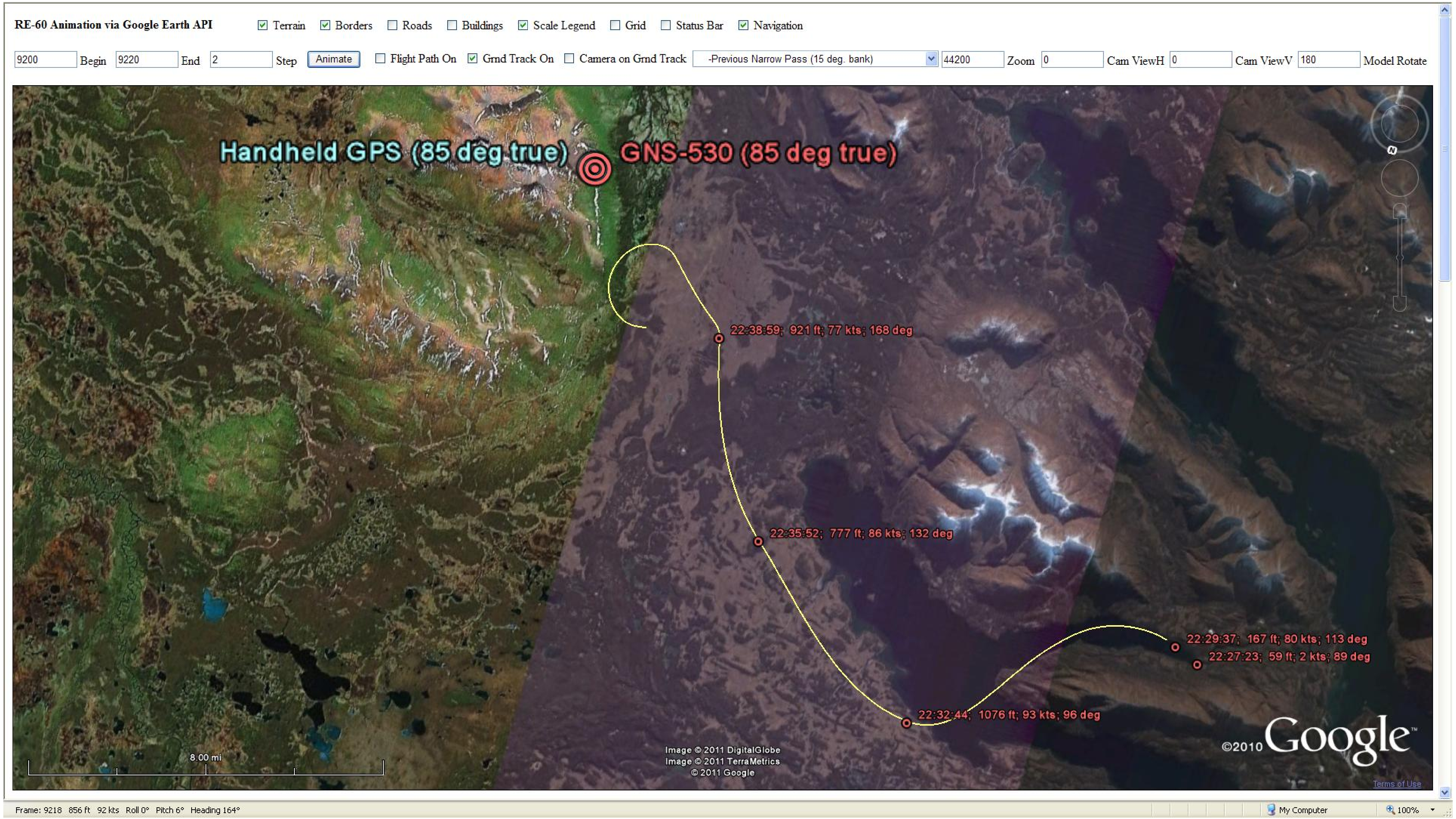
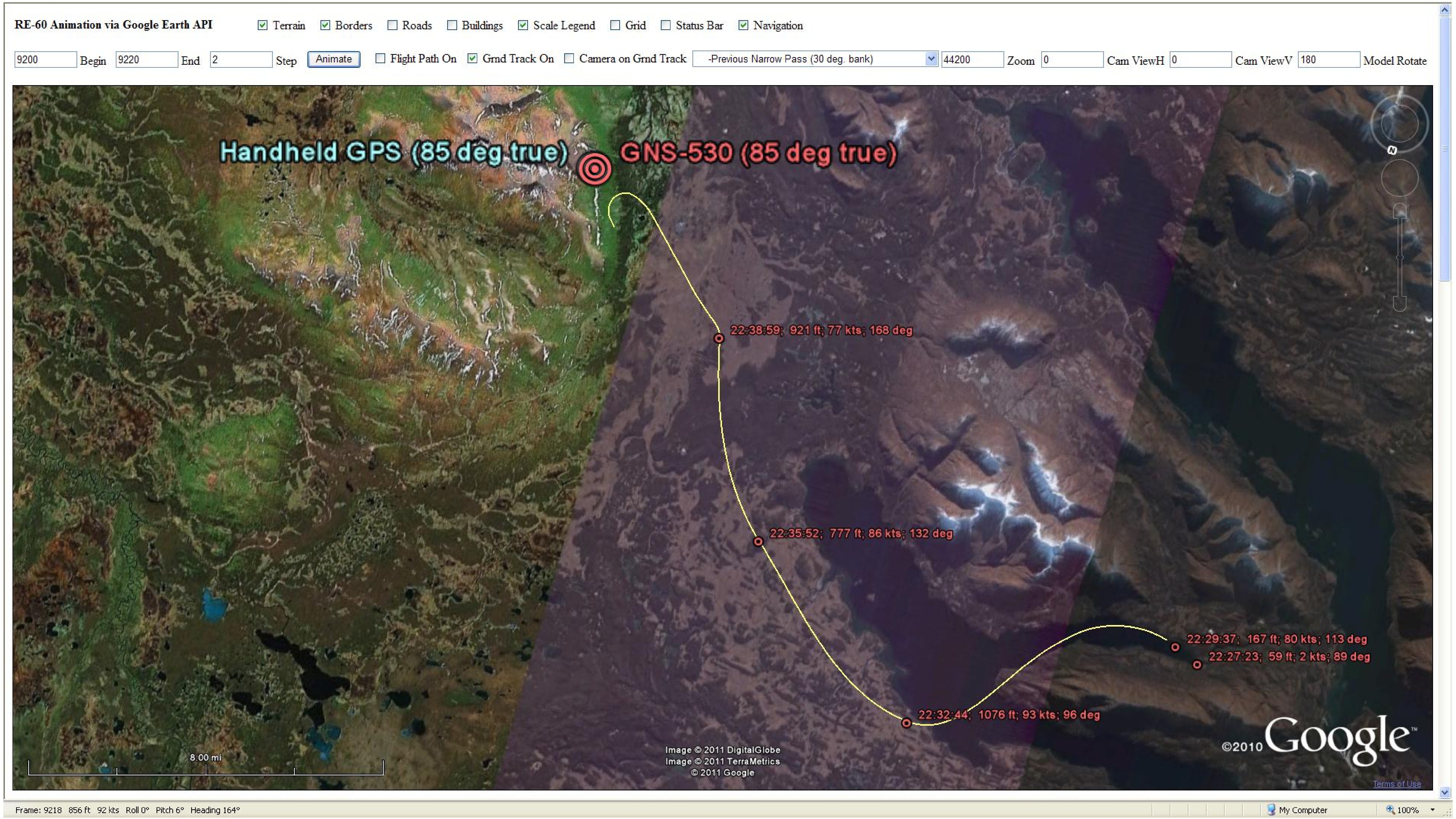


Figure A6.8: N455A simulation scenario 8 (target PREVIOUS PASS waypoint followed by 30° LWD escape maneuver).



Attachment 7: Simulation Results & Factual Constraints

Figure A7.1: de HAVILLAND DHC-3T (N455A) SIMULATION (ALTITUDE, POSITION, GROUND SPEED, TRACK ANGLE, PITCH, & ROLL CONSTRAINTS)
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [TARGET DIRECT; TAMDAR WINDS]

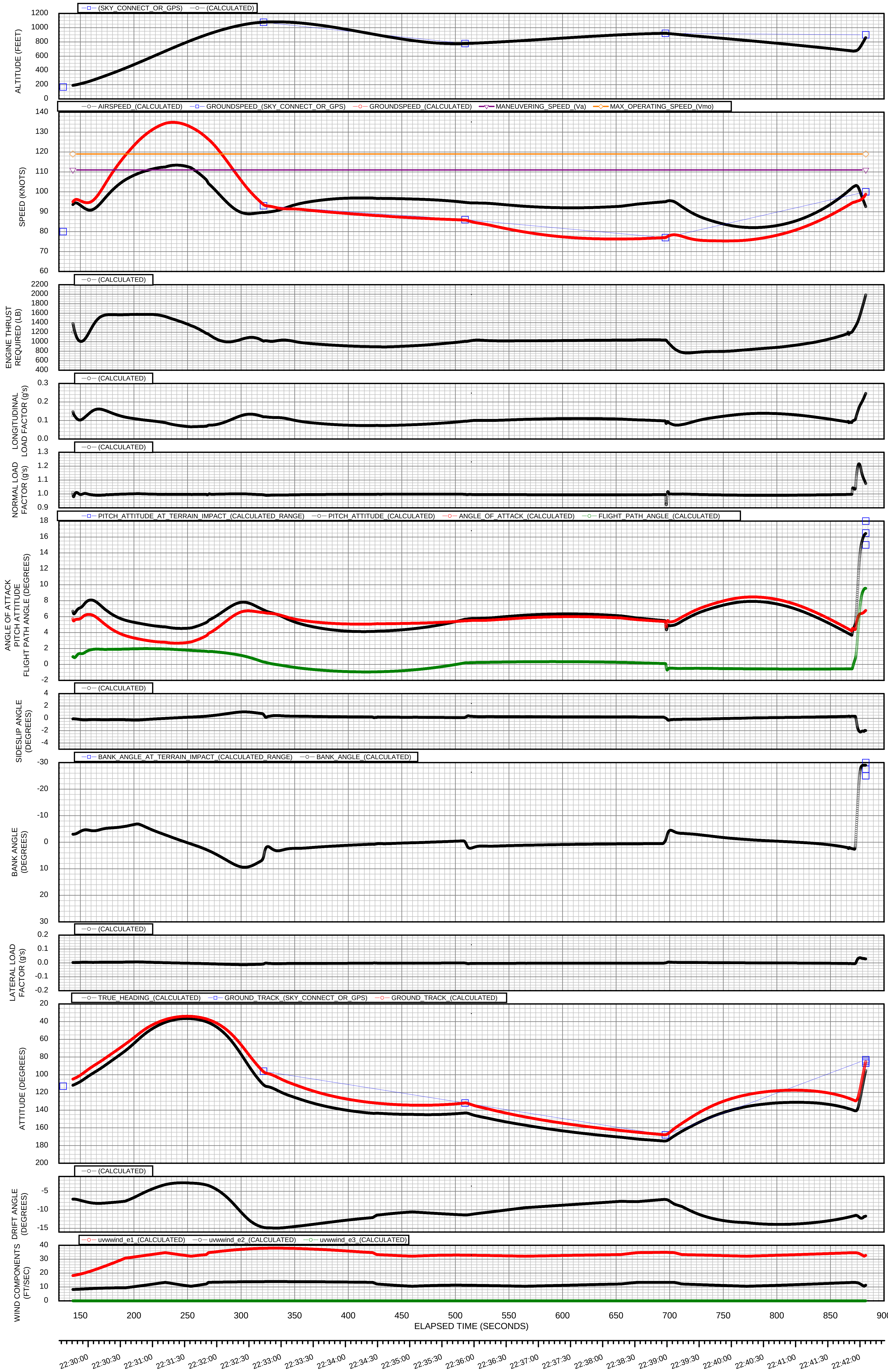


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Figure A7.2: de HAVILLAND DHC-3T (N455A) SIMULATION (ALTITUDE, POSITION, GROUND SPEED, TRACK ANGLE, PITCH, & ROLL CONSTRAINTS)
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [TARGET MUKLG; TAMDAR WINDS]

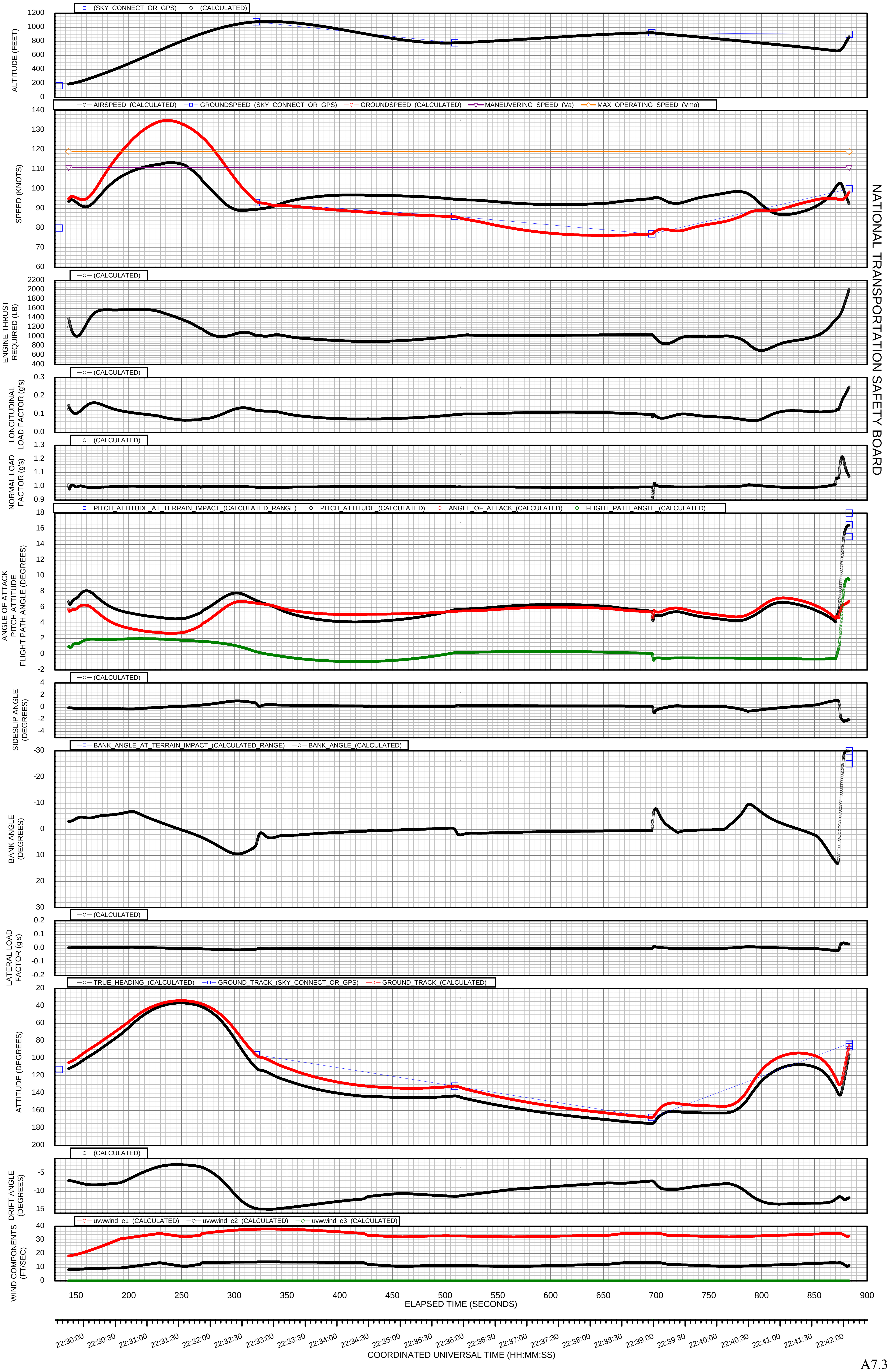

Figure A7.3: de HAVILLAND DHC-3T (N455A) SIMULATION (ALTITUDE, POSITION, GROUND SPEED, TRACK ANGLE, PITCH, & ROLL CONSTRAINTS)
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [TARGET PREV_FLIGHT; TAMDAR WINDS]

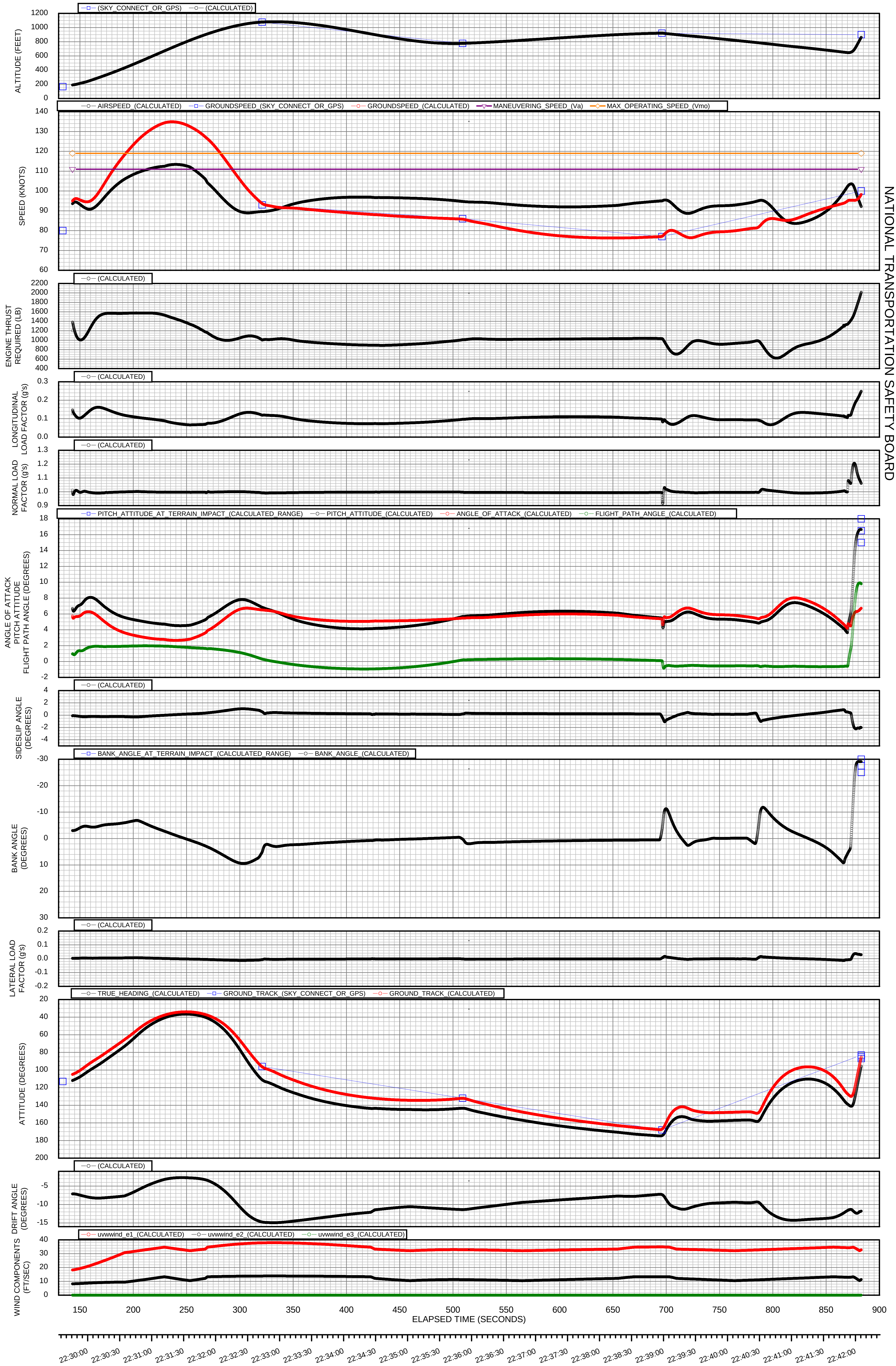

Figure A7.4: de HAVILLAND DHC-3T (N455A) SIMULATION (ALTITUDE, POSITION, GROUND SPEED, TRACK ANGLE, PITCH, & ROLL CONSTRAINTS)
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [TARGET PREV_FLIGHT_BANK_15; TAMDAR WINDS]

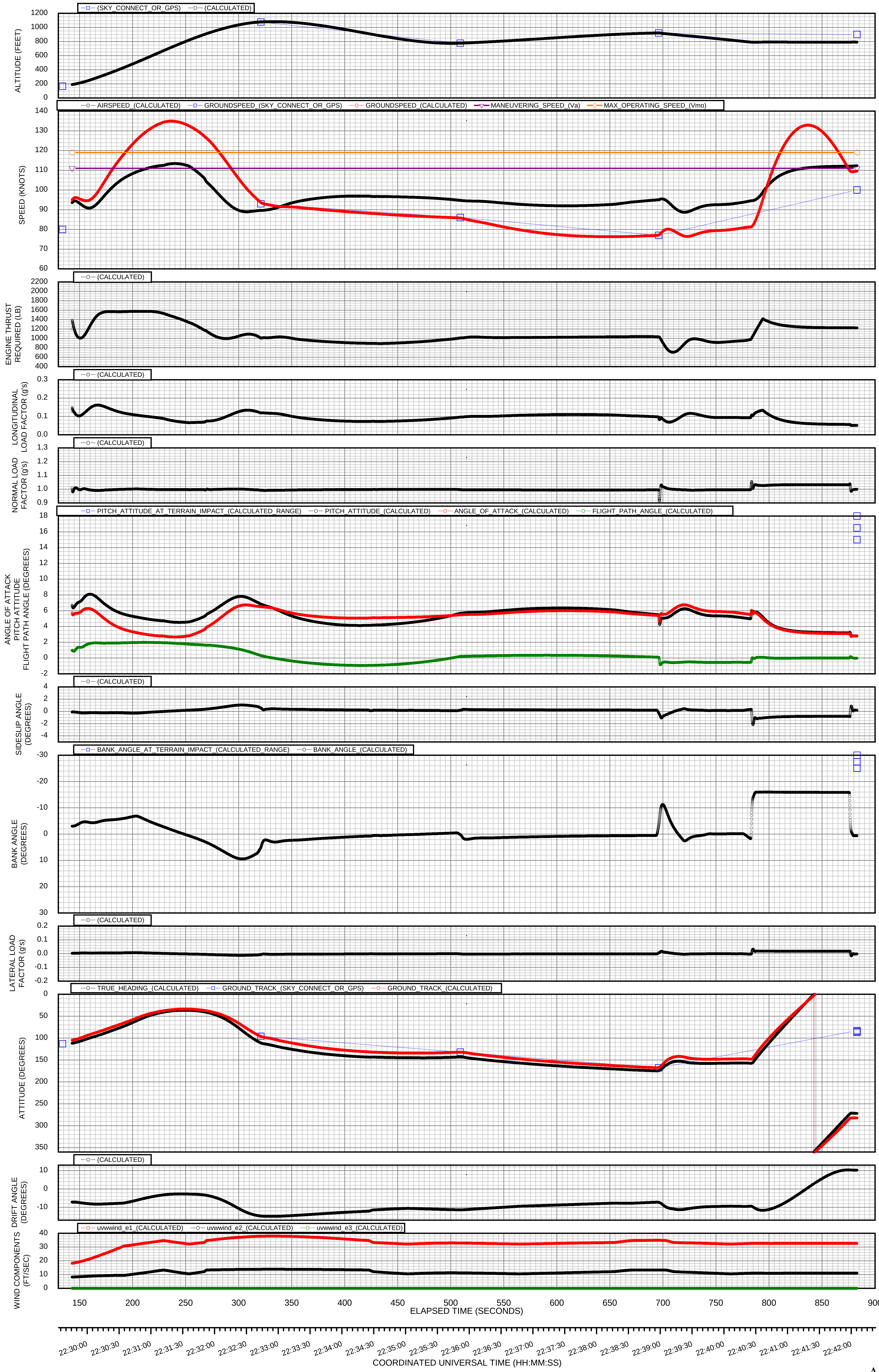

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Figure A7.5: de HAVILLAND DHC-3T (N455A) SIMULATION (ALTITUDE, POSITION, GROUND SPEED, TRACK ANGLE, PITCH, & ROLL CONSTRAINTS)
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [TARGET PREV_FLIGHT_BANK_30; TAMDAR WINDS]

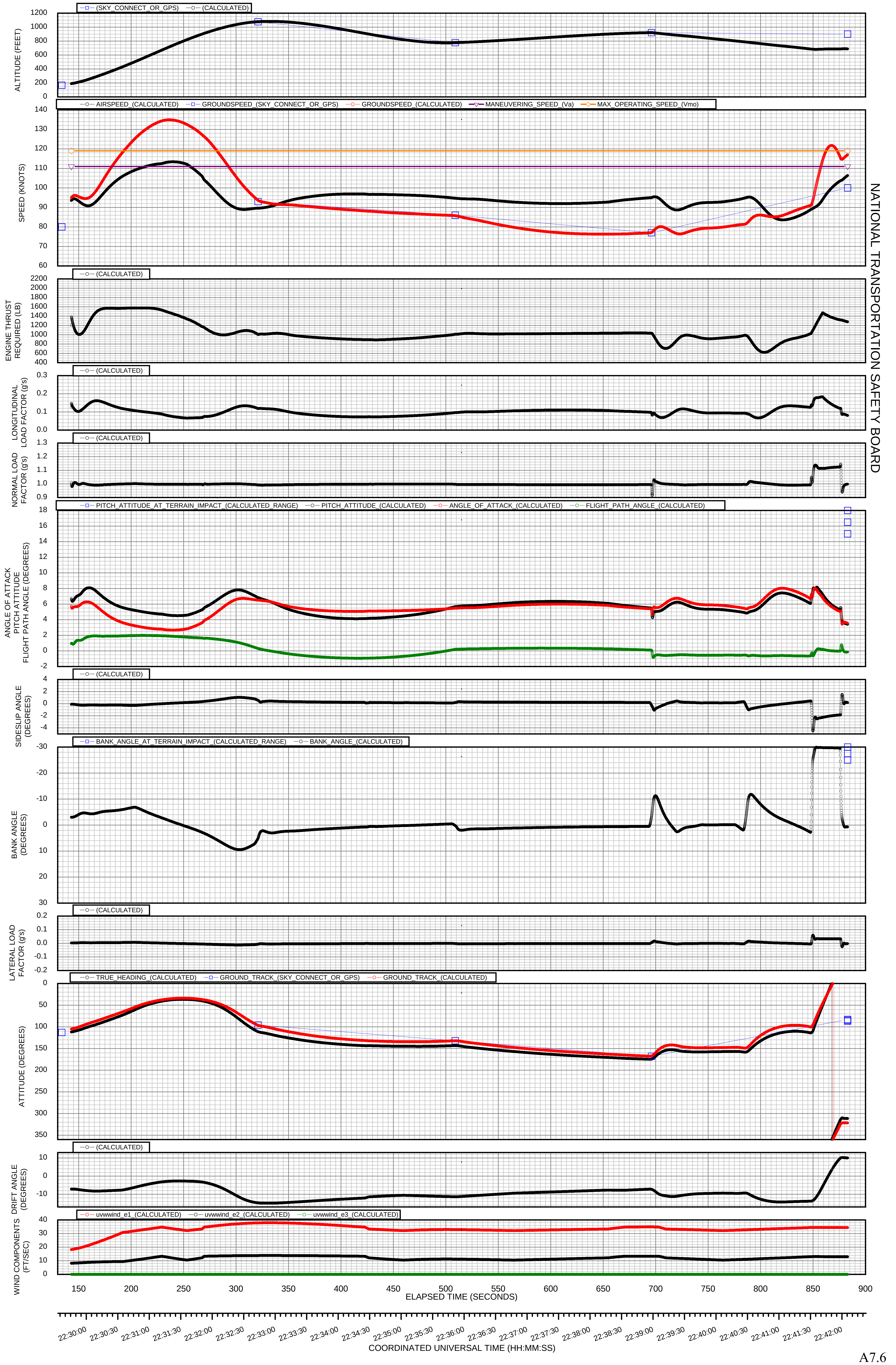

Figure A7.6: de HAVILLAND DHC-3T (N455A) SIMULATION (ALTITUDE, POSITION, GROUND SPEED, TRACK ANGLE, PITCH, & ROLL CONSTRAINTS)
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [TARGET PREV_PASS; TAMDAR WINDS]

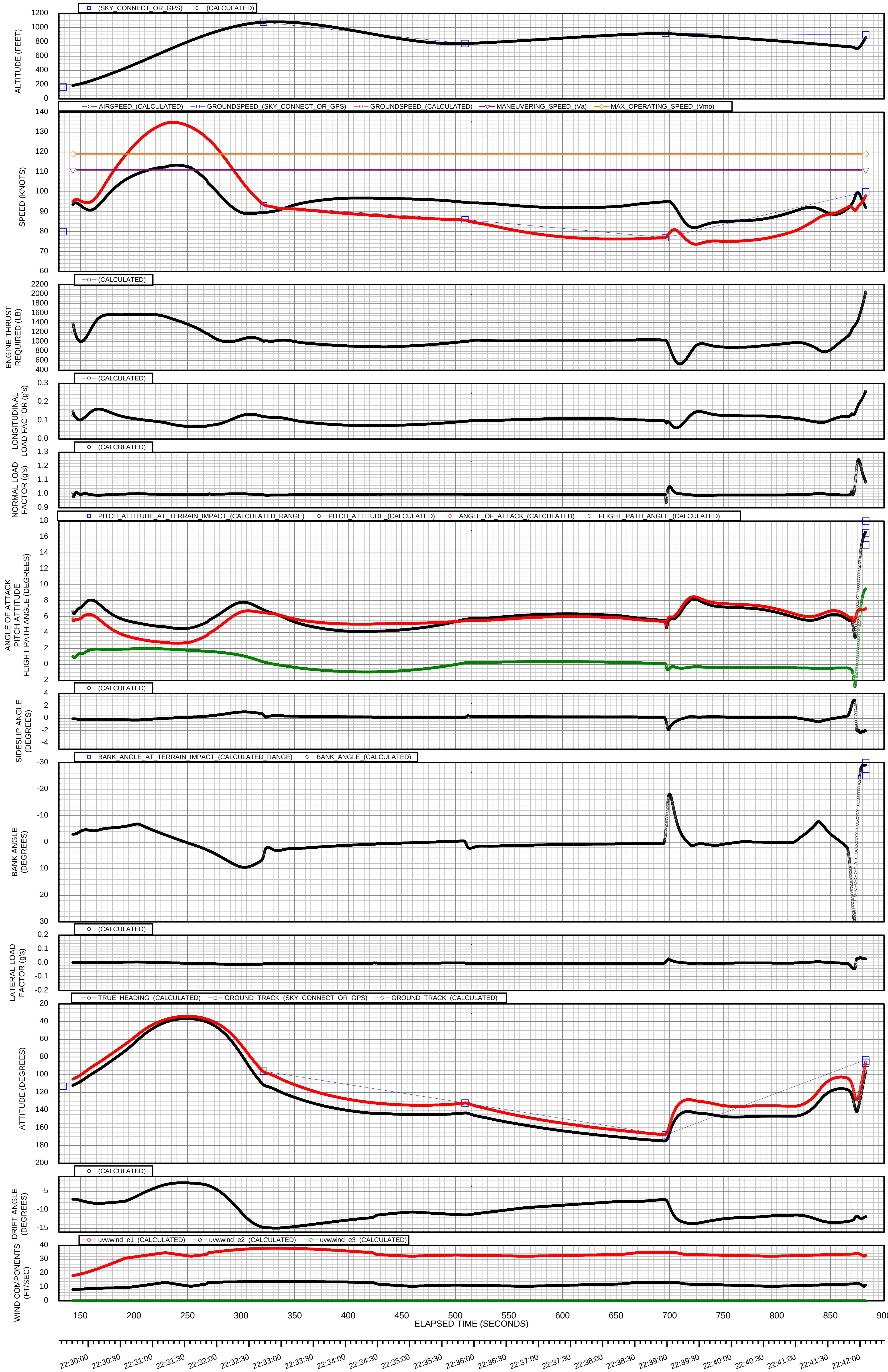

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Figure A7.7: de HAVILLAND DHC-3T (N455A) SIMULATION (ALTITUDE, POSITION, GROUND SPEED, TRACK ANGLE, PITCH, & ROLL CONSTRAINTS)
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [TARGET PREV_PASS_BANK_15; TAMDAR WINDS]

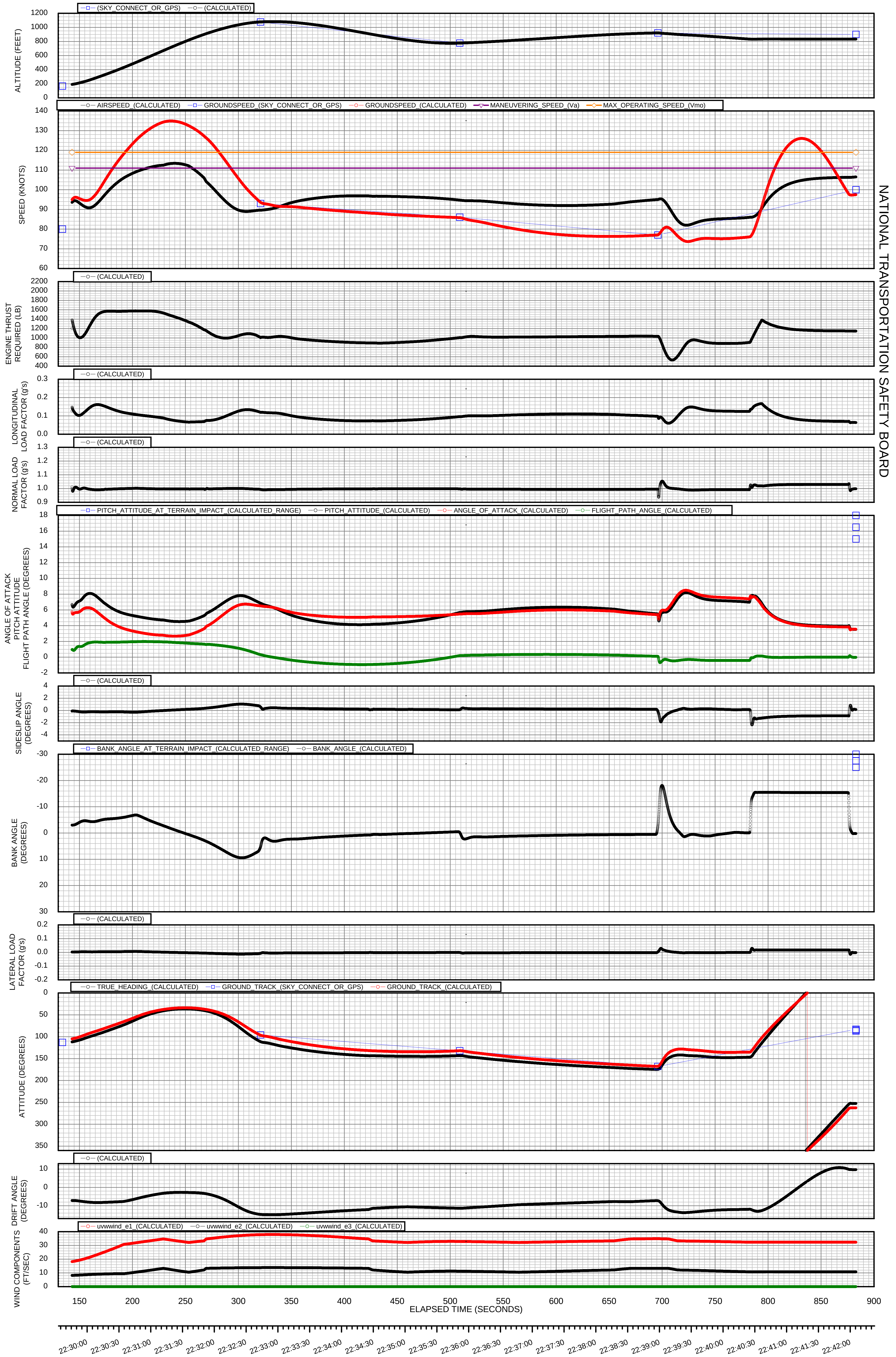
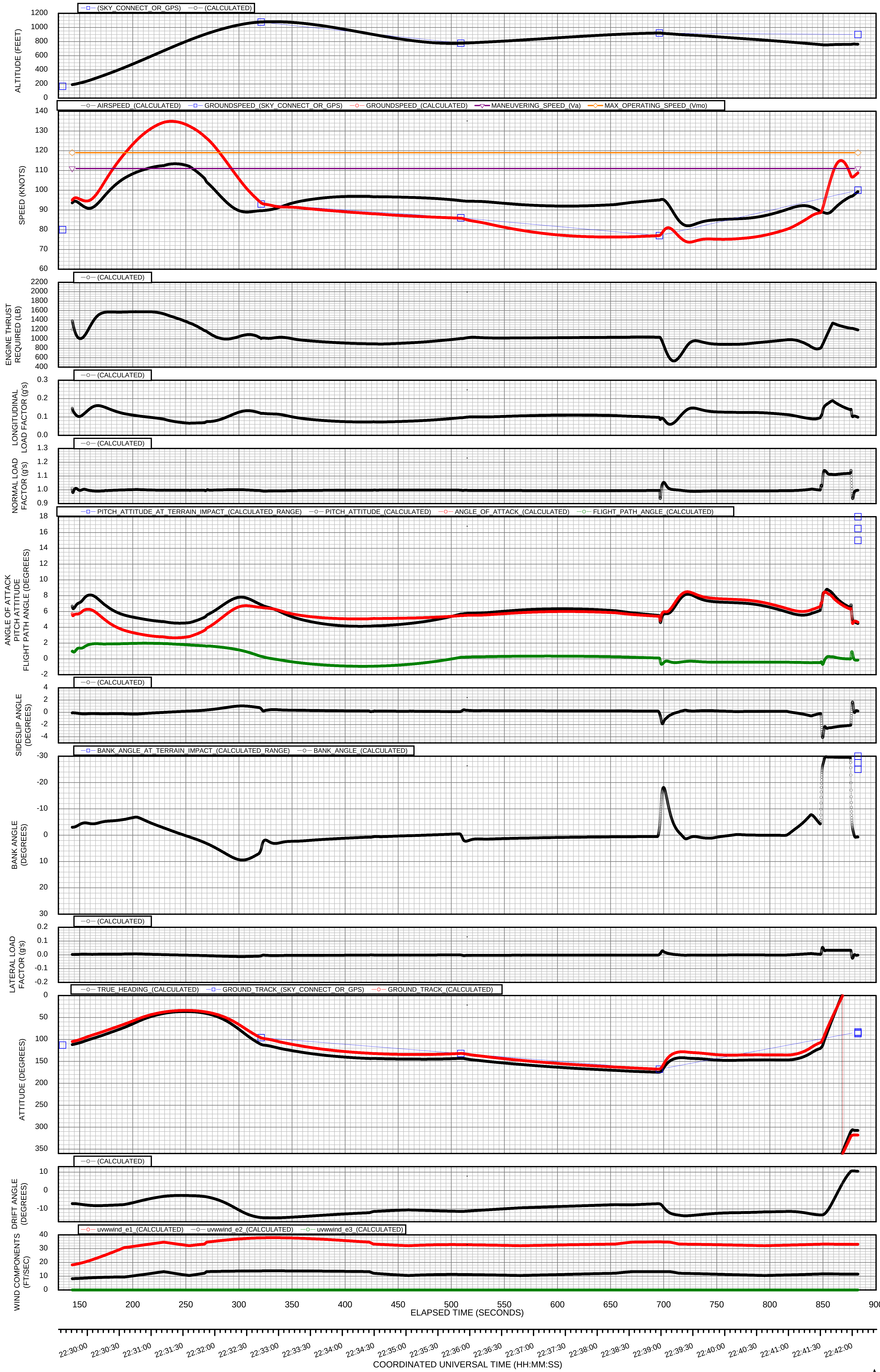


Figure A7.8: de HAVILLAND DHC-3T (N455A) SIMULATION (ALTITUDE, POSITION, GROUND SPEED, TRACK ANGLE, PITCH, & ROLL CONSTRAINTS)
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [TARGET PREV_PASS_BANK_30; TAMDAR WINDS]



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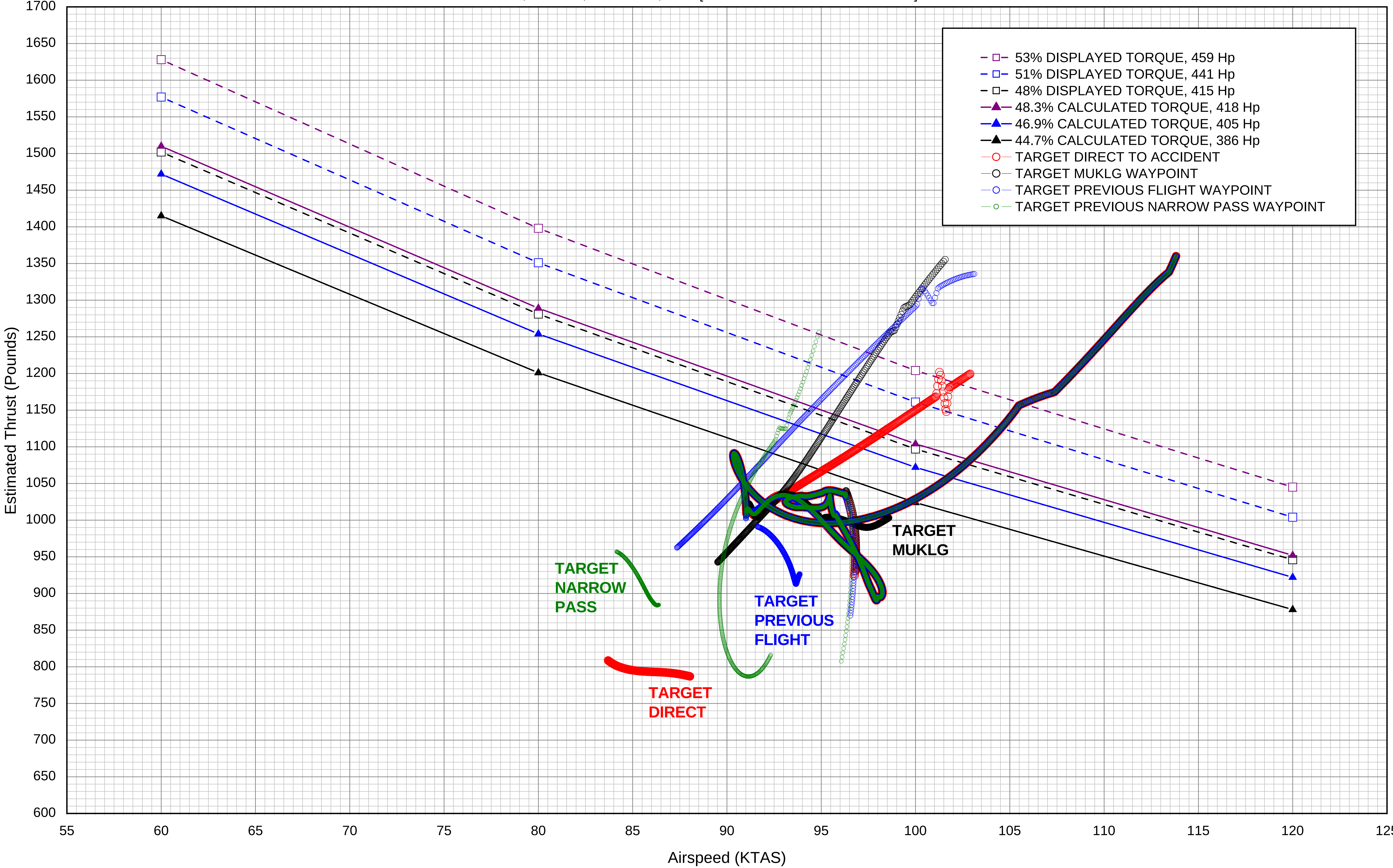
Attachment 8: Estimated Thrust Comparison

Figure A8.1: de HAVILLAND DHC-3T (N455A) ESTIMATED THRUST AS A FUNCTION OF TRUE AIRSPEED
MOUNTAINOUS TREE-COVERED TERRAIN IMPACT NEAR ALEKNAGIK, ALASKA, AUGUST 9, 2010 [BASED ON TAMDAR WIND DATA]



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Attachment 9: Accident Site Approach Views

Figure A9.1: N455A simulation scenario 1 (target DIRECT to accident site).

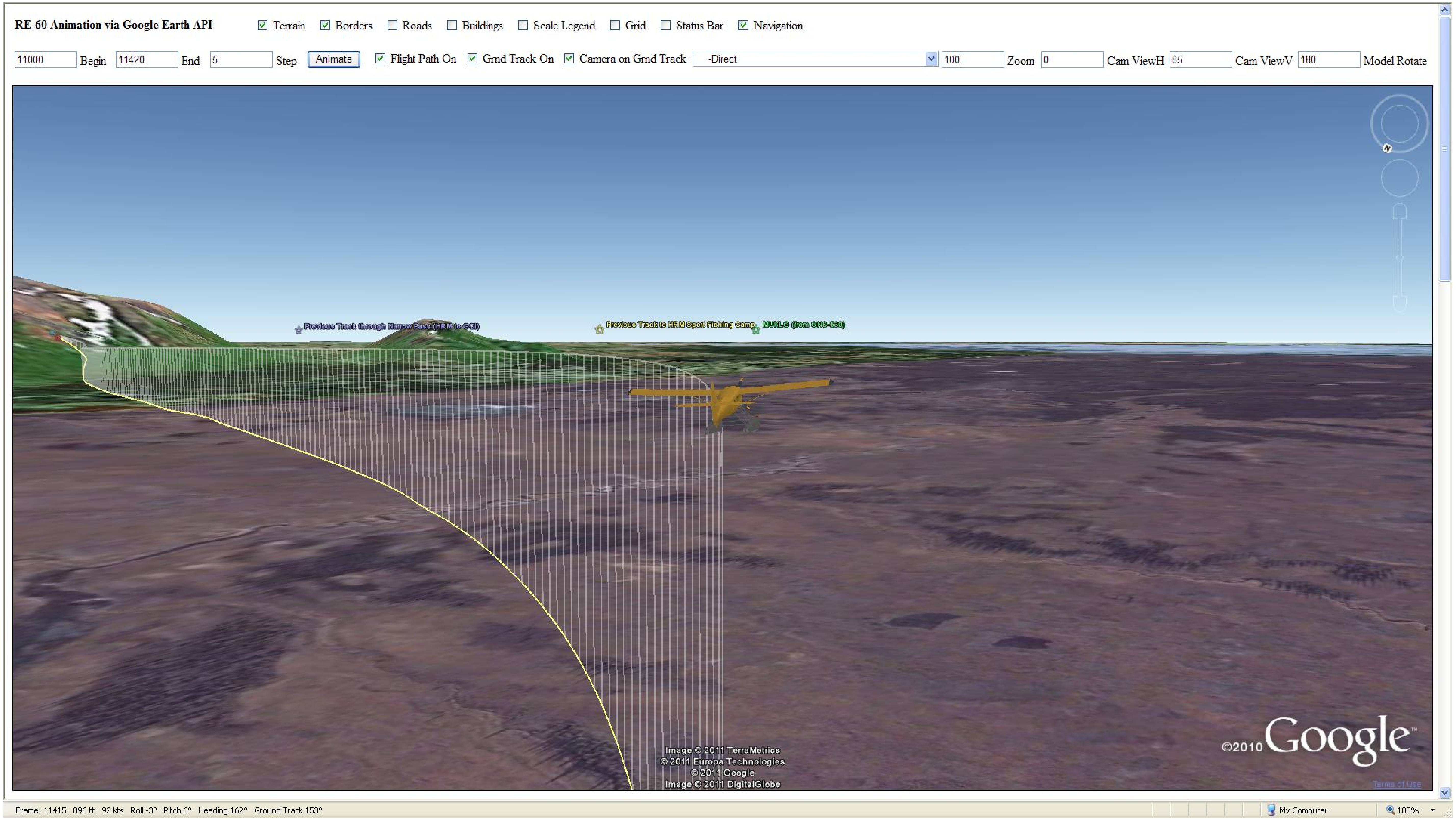

Figure A9.2: N455A simulation scenario 2 (target MUKLG).

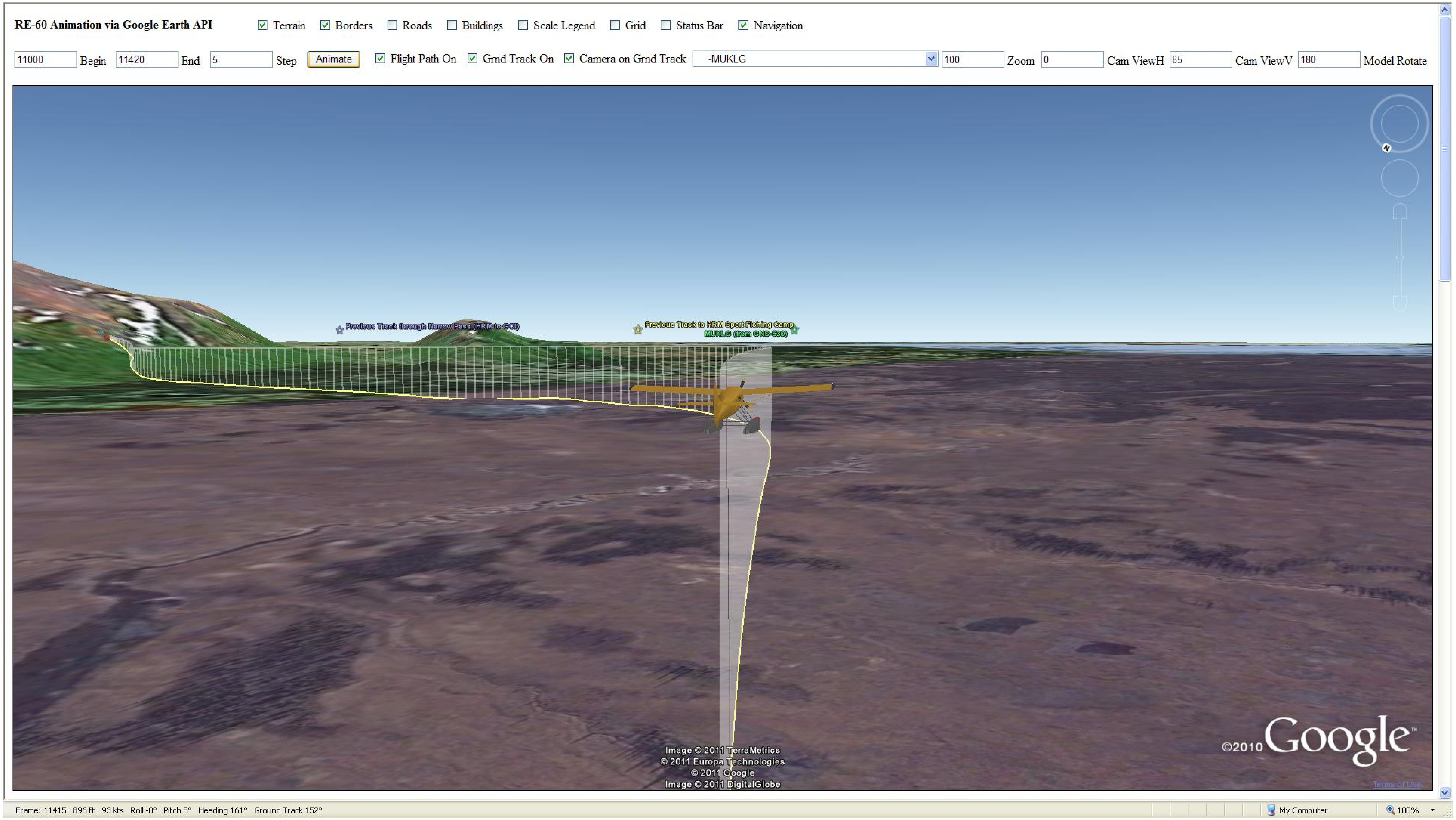

Figure A9.3: N455A simulation scenario 3 (target PREVIOUS FLIGHT waypoint).

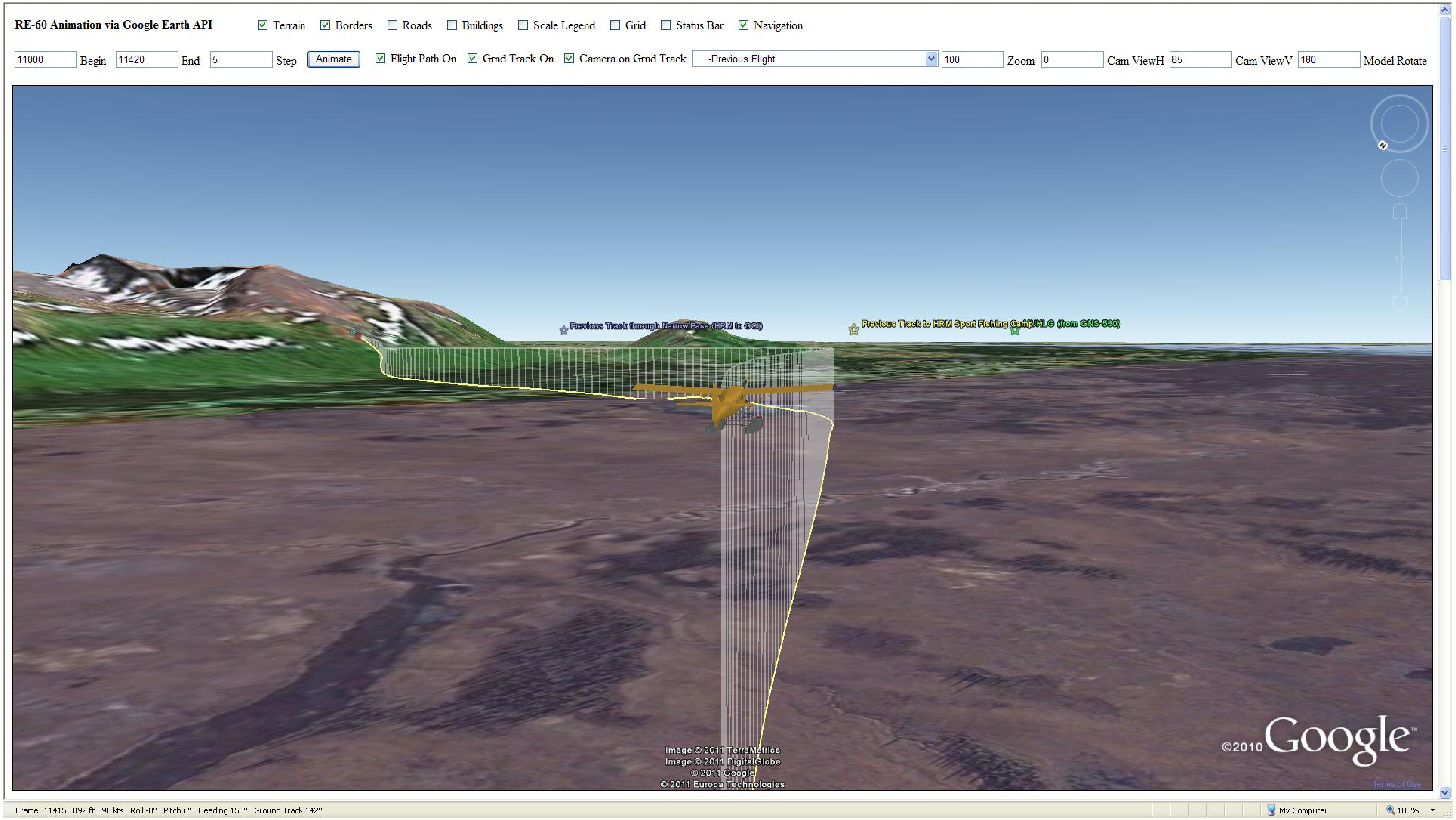

Figure A9.4: N455A simulation scenario 6 (target PREVIOUS PASS waypoint).