NASA Technical Memorandum 101585
DOT/FAA/DS-89/23

A CANDIDATE CONCEPT FOR DISPLAY OF FORWARD-LOOKING WIND SHEAR INFORMATION

David A. Hinton

OCTOBER 1989

NASA
National Aeronautics and Space Administration

Langley Research Center
Hampton, Virginia 23665-5225

U.S. Department of Transportation

Federal Aviation Administration

Summary

A concept is proposed for producing wind shear information displays that would be useful to flight crews for wind shear avoidance and situational awareness. This concept integrates forward-look wind shear information with airplane performance capabilities to predict future airplane energy state as a function of range. The information could be displayed to a crew either in terms of energy height or airspeed deviations. The concept should offer benefits over previously proposed displays of wind velocity or shear strength, since the latter two concepts may require further interpretation by the crew to determine the actual hazard to the airplane. The anticipated benefits of the proposed display information concept are: 1) a wind shear hazard product that scales directly to the performance impact on the airplane and that has intuitive meaning to flight crews, 2) a reduction in flight crew workload by automatic processing of relevant hazard parameters, and 3) a continuous display of predicted airplane energy state if the approach is continued. Such a display may be used to improve pilot situational awareness or improve pilot confidence in wind shear alerts generated by other systems. This paper describes the display concept and provides the algorithms necessary for implementation in a simulation system.

Introduction

Numerous air carrier accidents and incidents have resulted from inadvertent encounters with the atmospheric wind shear associated with "microburst" phenomena, in some cases resulting in heavy loss of life. A microburst is a strong, localized downdraft that strikes the ground, producing winds that diverge radially from the impact point. An airplane penetrating the center of a microburst will initially encounter an increasing headwind, which improves airplane climb angle performance, and will then encounter a strong downdraft and rapidly increasing tailwind. The effects of the downdraft and increasing tailwind may easily exceed the climb and acceleration capabilities of the airplane, causing an unavoidable loss of altitude and airspeed.

This safety hazard is being addressed by the NASA, FAA, and industry in a program to reduce the threat of convective microburst wind shear phenomena to aircraft through hazard characterization, improved wind shear detection and warning, development of recovery guidance, and crew training. Although microburst avoidance is the goal of this research, the ability to reliably predict or detect a microburst in an airplane's flight path, in an operational environment, does not yet exist. Prior

flight deck research has therefore concentrated on recovery from inadvertent wind shear encounters (reference 1).

With the continued development of sensors for measuring wind shear ahead of an airplane (reference 2), research has been initiated into the presentation of this information to the flight crew. Among the issues is the question of what information should be displayed to the crew. Among the concepts that have been proposed for display are: 1) along-path wind components at various distances from the airplane, and 2) the "F-factor" hazard index (reference 1) ahead of the airplane. The first concept is thought to be limited in its usefulness to the crew, in that the hazard of a wind shear to an airplane correlates poorly to the magnitude of a wind change, but is instead related to the spatial gradient of the wind change. It is further constrained in that the horizontal wind is but one of two relevant wind components; the vertical wind contribution must also be accounted for. The second concept, the "F-factor" hazard index, completely describes the impact of the wind shear on airplane performance at any point in the wind shear, but the total hazard of a wind shear event will depend on the persistence of hazardous F-factor values. Very high F-factor values may not be hazardous if the persistence time is low. Additional processing of the F-factor information may be necessary to provide a wind shear display that can be quickly and accurately interpreted by a flight crew during the high workload approach phase of flight. Such a display may be used to improve pilot situational awareness or improve pilot confidence in wind shear alerts generated by other systems. This paper describes a concept for processing the F-factor hazard index and provides the algorithms necessary for implementation in a simulation system.

Symbols

D	Total airplane drag, lbf
E	Total airplane energy, ft-lbf
E_h	Energy height, ft
F	Wind shear F-factor, radians
g	Gravitational acceleration, 32.2 ft/sec^2
G	Deviation from nominal energy height, ft
h	Altitude, ft

h_p	Potential altitude, ft
L	Length of sensor range bin, ft
M	Airplane mass, slugs
N	Nominal energy height change, ft
P	Airplane performance factor, radians
S	Sum of energy height changes, ft
T	Total airplane thrust, lbf
U	Sum of airspeed changes, ft/sec
V	Airspeed, ft/sec
V_g	Ground speed, ft/sec
Vref	Approach airspeed, ft/sec
W	Airplane weight, lb
W_h	Vertical wind speed, ft/sec
W_x	Horizontal wind speed, ft/sec
ΔE_h	Change in energy height, ft
ΔT	Change in time, sec
ΔV	Change in airspeed, ft/sec
α	Wing angle of attack, radians
γ	Inertial flight path angle, radians
γ_a	Air-mass flight path angle, radians
γ_f	Assumed future flight path angle, radians
γ_p	Potential flight path angle, radians
θ	Airplane pitch attitude, radians

The subscript i indicates the value in the (i)th range bin. A dot denotes the derivative with respect to time. Speeds are shown in knots in tables.

Forward-Look Display Concept

The F-factor, described in the section below entitled "Display Information Algorithms", is a function of the rate of change of horizontal wind, downdraft velocity, and airplane airspeed. The F-factor scales directly to airplane performance, in terms of the constant airspeed climb gradient capability of the airplane. For example, an airplane with a 0.14 radian climb gradient capability flying in a wind shear F-factor of 0.10 will only be able to climb at a 0.04 gradient at constant airspeed. A climb gradient of 0.14 can be maintained, however, by slowing the airplane to convert excess kinetic energy to potential energy. Obviously this higher climb gradient can only be maintained for a short time, until a critically low airspeed is reached.

By examining the relationship of airplane performance to the F-factor ahead of the airplane, the rate of change of airplane energy height (total kinetic and potential energy per unit weight) can be determined. If this change rate is then integrated with respect to range, the change in energy height as a function of range can be determined. The predicted energy height change can then be compared to the expected change in energy height, due to the expected loss of altitude while tracking the glide slope, to arrive at a hazard index that is a function of airplane performance, wind shear F-factor strength, and the duration spent in various shear strength regions. Alternatively, the rate of change of airspeed can be determined and integrated to show the crew the airspeed deviation, as a function of range, if the approach were to be continued at an assumed flight path angle and thrust. By changing the sensor scan azimuth, a map-like presentation of the hazard could be generated.

The anticipated benefits of this display concept are: 1) a wind shear hazard product that scales directly to the performance impact on the airplane and that has intuitive meaning to flight crews, 2) a reduction in flight crew workload by automatic processing of relevant hazard parameters, and 3) a continuous display of predicted airplane energy state if the approach is continued.

A limitation of this display concept is that the airplane performance continuously varies with throttle position, therefore the display algorithms must incorporate assumptions about the manipulation of thrust during an approach. This may be a fundamental limitation of any forward-look display concept, since the apparent severity of a wind shear depends on thrust management. In addition to thrust assumptions, flight path angle assumptions must be made for the airspeed deviation calculations. Although energy height change is nearly invariant with flight

path angle, the rate of change of airspeed will depend on the flight path angle flown. Piloted simulations will be needed to verify the operational usefulness of the assumptions made.

Display Information Algorithms

The concepts of airplane energy height and potential flight path angle were discussed in reference 1, and relevant equations are repeated here. The airplane flight path and wind components are related by the coordinate system shown in figure 1.

The airplane total energy is defined as the sum of the air-mass-relative kinetic energy and the inertial potential energy. Air mass kinetic energy is used since airspeed describes the airplane's ability to climb or maintain altitude. Inertial potential energy is likewise used since it is altitude above the ground that is relevant to the recovery. Airplane total energy is then defined as:

$$E = MV^2/2 + Mgh \tag{1}$$

where V is airspeed, M is airplane mass, g is gravitational acceleration, and h is altitude. The specific total energy (E per unit weight), or energy height is:

$$E_h = V^2/(2g) + h \tag{2}$$

The rate of change of E_h is also the potential rate of climb of the airplane, assuming a negligible energy loss when trading airspeed for climb rate, and is:

$$\dot{E}_h = \dot{h}_p = V\dot{V}/g + \dot{h} \tag{3}$$

From reference 1, the inertial flight path angle can be approximated by:

$$\gamma = (T - D)/W - \dot{W}_x/g + W_h/V - \dot{V}/g \tag{4}$$

where T is airplane thrust, D is airplane drag, and W is airplane weight. To simplify the notation, the airplane performance term will be replaced with the variable P.

$$P = (T - D)/W \tag{5}$$

The two wind terms describe the wind shear impact on the climb angle capability of the airplane, in terms of the horizontal shear ($\dot{W}_x$) and vertical wind (W_h), and define the "F-factor".

$$F = \dot{W}_x/g - W_h/V \tag{6}$$

By setting the airspeed rate to zero in equation 4, the potential flight path angle is obtained. Multiplying the potential flight path angle by airplane ground speed produces a small angle approximation to the potential rate of climb. The potential rate of climb is also the rate of change of energy height required for the forward-look display concept.

$$\gamma_p = P - F \tag{7}$$

$$\dot{E}_h = V_g(P - F) \tag{8}$$

Equation 4 also provides the necessary relationships to determine the rate of change of airspeed required to maintain a given flight path angle.

$$\dot{V} = g(P - F - \gamma) \tag{9}$$

To produce the information to be displayed, the quantities described in equations 8 and 9 must be integrated along the range scanned by a forward-look sensor. It is assumed that the sensor can measure the average radial wind component in numerous range "bins" of length L. From these wind measurements the F-factor will be estimated. The absolute change in energy height across any range bin is the rate of change in energy height, given in equation 8, multiplied by the time spent in that range bin. For the purposes of determining time spent in a range bin, it is

assumed that the ground speed is constant while in that bin. The time spent in a bin is then:

$$\Delta T = L/V_g \tag{10}$$

and the change in energy height in the (i)th bin is:

$$\Delta E_{h,i} = \dot{E}_h \Delta T = L(P_i - F_i) \tag{11}$$

Letting S_i be the estimated energy height in bin(i):

$$\begin{aligned} S_i &= \Delta \dot{E}_{h,i} \quad , i = 1 \\ S_i &= S_{i-1} + \Delta \dot{E}_{h,i} \quad , i > 1 \end{aligned} \tag{12}$$

where 1 is the first, or nearest, range bin. The nominal energy height in each bin is found from the gradient of the glide slope:

$$\begin{aligned} N_i &= -0.05L \quad , i = 1 \\ N_i &= N_{i-1} - 0.05L \quad , i > 1 \end{aligned} \tag{13}$$

The hazard is the difference between the nominal and estimated energy height in each bin:

$$G_i = S_i - N_i \tag{14}$$

Likewise, the change in airspeed across the (i)th bin can be expressed by:

$$\Delta V_i = gL(P_i - F_i - \gamma_{f,i})/V_{g,i} \tag{15}$$

where $\gamma_{f,i}$ is an assumed flight path angle target in the (i)th range bin. This will generally be the glide slope gradient. Since the display concept attempts to predict future airspeed deviations if the approach is continued, the assumed flight path angle will be changed to zero when the F-factor exceeds a critical value. This simulates the beginning of a recovery maneuver upon an assumed activation of a reactive alert. The

resultant airspeed deviation in bin(i) is then:

$$U_i = \Delta V_i \quad , i = 1$$
$$U_i = U_{i-1} + \Delta V_i \quad , i > 1 \qquad (16)$$

The calculations above require an estimate of the F-factor from forward-look data. This estimate can be obtained from the wind divergence seen by the forward-look sensor. The relationship is explained in reference 1 and is repeated here:

$$W_h = \frac{-2\partial W_x h}{\partial x} \qquad (17)$$

This estimate is most accurate near the core of the microburst and near the ground. Fortunately, this is also the most hazardous region for an airplane encounter. Obviously, at high altitudes a large downdraft can exist with small horizontal wind gradients and, near the ground at a large distance from the core, a large wind gradient may exist with little or no downdraft. This estimate of W_h will therefore tend to correctly estimate the F-factor in the most hazardous region, overestimate the F-factor near the ground at a distance from the core, and underestimate the F-factor at high altitudes in the core. Additional research is needed to develop improved relationships between horizontal wind gradients and microburst downdrafts, so that more accurate F-factor estimates can be derived from forward-look sensor data.

Forward-Look Display Preliminary Evaluation

A preliminary evaluation of the above algorithms was accomplished in a simple batch simulation of a sensor observing a microburst. The batch simulation permits the range bin size, scan elevation angle, and minimum and maximum scan distances to be varied. In operational use, different sensor scan elevation angles might be used to reduce ground clutter or observe a departure path prior to takeoff. The intensity and location of the microburst relative to the airplane can also be varied. Also, the assumptions made about thrust management can be varied. Three methods of treating thrust are implemented: 1) fix P at the normal approach value of -0.05; 2) vary P to maintain a constant

airspeed but limit the range of P; 3) fix P at -0.05 until the F-factor exceeds a critical limit, then assume maximum go-around thrust. To simulate an autothrottle, equation 9 is used to determine the P value required to maintain a constant airspeed at the desired flight path angle of -0.05. For the airspeed deviation display, the assumed flight path angle is the glide slope gradient in the range bins closest to the airplane. When a range bin is detected where the F-factor exceeds 0.15, remaining bins are processed assuming a zero flight path angle. The result is a prediction of airspeed deviation if the pilot continues the approach until receiving a reactive alert, and then maintains level flight.

In each case, the observation point was placed at an initial altitude and distance from a microburst model, and the display product for each range bin was determined. The observation point was then moved towards the microburst and lowered in altitude by an amount equivalent to 10 seconds of flight on a glide slope. It was assumed that the length of each range bin was 450 feet, and that the sensor scanned from a minimum distance of 1000 feet to a maximum distance of 12000 feet ahead of the airplane. Performance capabilities of a Boeing 737-100 were assumed, and the reference approach speed used was 137 knots. For the purpose of estimating the F-factor, this airspeed is used in all range bins. An additional development of the concept might estimate airspeed in each range bin and use that value to estimate F-factor.

The microburst model (reference 3) represents an axisymmetric stagnation point flow that satisfies mass continuity and includes boundary layer effects near the ground. The boundary layer effects and spatial variation in outflow and downflow closely match real-world observations. The model permits a particular microburst to be simulated by specifying three characteristic parameters: 1) radius of downflow, 2) maximum outflow wind speed, and 3) the altitude at which the maximum outflow occurs. The maximum outflow occurs at a radius 12 percent greater than the radius of downflow. For this effort, the microburst has a maximum outflow of 37 knots at an altitude of 120 feet and at a radius of 2391 feet. The radius of downflow is 2133 feet. Figure 2 shows the outflow and downdraft speed as a function of altitude. The outflow is shown at the maximum outflow radius, and the downdraft is shown at the core. Figure 3 shows the outflow and downdraft speed as a function of radius from the microburst core. The wind speeds are plotted for altitudes of 120 feet and 500 feet.

In each example shown, the hazard was calculated twice in each range bin. The first calculation used an F-factor based on the actual value of the downdraft velocity and the horizontal

wind gradient as supplied by the microburst model. This is the F-factor that would be seen by an airplane in the center of the range bin at the given approach speed. The resulting hazard factor is labeled "Real". The real hazard is always measured along the glide slope, even if the scan elevation angle for the simulated sensor is different from the glide slope. The second calculation used an F-factor based on an estimate of the wind gradient and downdraft, derived using only the horizontal wind magnitude in each bin. The scan elevation angle is used to determine the altitude of each bin for this calculation. The resulting estimate of the hazard factor is labeled "Est". This estimate is representative of information that might be obtained from sensors currently under development.

Preliminary Evaluation Results

The accompanying tables show the results of the display algorithms for both the energy height and airspeed error outputs. The results shown are the numerical outputs, and it is not proposed that this format be used in an actual display. An actual energy height display, for example, may color code ranges where the energy height deviation is between 100 and 200 feet, between 200 and 300 feet, and over 300 feet. Alternatively, a forward-look display could show a map of the F-factor, with superimposed numeric indications of the loss in energy height. An energy height change of 300 feet is equivalent in magnitude to the change in kinetic energy caused by slowing from the approach airspeed to the stick shaker airspeed. The tables show, for each range bin, the distance from the sensor to the center of the range bin, the real and estimated F-factor in that bin, the assumed value of P in that bin (based on the estimated F-factor), and the real and estimated hazard level. Energy height errors are shown in feet, and the sign convention is such that a gain in energy height is shown by positive numbers. Airspeed errors are shown in knots, and positive numbers indicate an increase in airspeed with respect to the nominal approach speed.

Table 1 shows the energy height error for a case where the scan elevation angle was -3 degrees, the initial airplane altitude was 1200 feet above ground level, and the initial distance to the microburst was 22000 feet. This geometry placed the glide slope at an altitude of 100 feet in the core of the microburst. In this run the thrust was fixed for a P value of -0.05. At time zero, the core of the microburst is beyond the range of the sensor, but the performance increase of the leading edge of wind shear is seen. At time = 50 seconds, the core of the microburst is in sensor range, and the performance signature of a microburst can be seen, with a large performance increase

followed by a large loss in energy height. For reasons discussed above, the F-factor estimate exceeds the actual F-factor approaching the core and is less than the actual value in the core itself. This causes the display algorithm to overestimate the performance increase and underestimate the performance decrease. Both the real and estimated change in energy height, from the peak of the increase to the peak of the decrease, is nearly 700 feet. Piloted simulation studies would be required to determine the acceptability and implications of these errors.

At time = 60 seconds, the performance decreasing region of the wind shear is entirely in view of the sensor. Note that the range bin of the greatest displayed hazard does not coincide with the location of the core of the microburst, but is at the last range bin where the F-factor exceeds the performance factor. This is physically correct, since the airplane energy will continue to deteriorate as long as the F-factor is above this value, and the minimum energy state will occur at the end of the wind shear. This phenomena may have operational implications, however, since the pilot may interpret the hazard as being farther from the airplane than it actually is. Piloted simulations will be required to answer this issue.

Another artifact of this output is that the magnitude of the hazard appears to increase as the core is approached. At a time of 60 seconds (at a distance of 8125 feet from the core) the maximum estimated energy height loss is 351 feet. This increases to 683 feet at time = 80 seconds (at a distance of 3500 feet from the core). The actual microburst model is time invariant. This apparent increase in shear strength is due to two related factors: 1) The batch program is not an airplane simulation, but simply moves the observation point forward at each time. The airspeed of the sensor is always assumed to be 137 knots, and predicted energy changes (other than the nominal change in altitude along the glide slope) do not actually occur. For example, the energy increase predicted between the airplane and the core at time = 60 seconds does not occur. 2) As the sensor nears the core, the performance-increasing range bins drop out of the scan. When only performance-decreasing range bins are included in the hazard integration, the predicted loss in energy height at the core becomes more severe. Batch simulations that include an airplane model should more accurately predict the display output during an approach.

Table 2 shows a run beginning with the same initial conditions, but allowing the autothrottle assumption to vary P between -0.07 and 0.05. The lower P value corresponds to an engine-pressure ratio (EPR) of about 1.1 and the higher P value corresponds to an EPR of about 1.56. The maximum value of P that

can be achieved in the approach configuration for the assumed airplane is about 0.14. Examination of the data shows that the effect of the autothrottle assumption is to reduce the magnitude of the displayed hazard and reduce the distance to the microburst where a hazardous level of energy loss is first indicated, since the extra available thrust partially compensates for the effects of the wind shear. In the first case, the distance to the core is about 8000 or 9000 feet when the estimated energy height loss exceeds 300 feet. In the second case, the range is only about 5000 feet when this threshold is exceeded. This effect indicates that assumptions about thrust management must be carefully made to produce a display that displays hazardous shears, yet appears to the crew to provide a correlation between the predicted energy situation and the actual outcome. If thrust is assumed fixed, then the shear will be accurately portrayed, but the pilot may lose confidence in the system since the airplane energy state will remain better than predicted. If thrust is allowed to freely vary, the display may better predict the future energy state, but the full magnitude of the hazard will not be displayed, and the pilot will not know the assumptions being made about future thrust levels. Piloted simulation studies will be required to evaluate operational considerations and better define the optimal thrust assumptions.

Table 3 shows a run with the same initial conditions, but yet another thrust management assumption. This run assumed that P remains fixed at -0.05 until the F-factor exceeds a value of 0.15. At that point a maximum performance recovery effort is assumed, and P is set to 0.14. This assumption greatly reduces the displayed hazard level in the core, and even at a range of 3500 feet from the core the maximum hazard is shown as a 244 foot loss of energy height. A display of low hazard level could be due either to a mild shear and a P value of -0.05, or a severe shear and a P value of 0.14. Since the pilot would be unaware which thrust value is required to achieve the displayed energy state, this thrust management assumption does not appear to be a good candidate for implementation without further pilot aiding information.

Tables 4 and 5 show the effect on the display of altering the scan elevation angle (Table 4) or changing the approach geometry (Table 5). In both cases the thrust is fixed at the normal approach value. In table 4, the scan angle of the forward-look sensor has been raised to zero degrees. The initial conditions are otherwise the same as in example 1. The table column containing the "real" hazard continues to be calculated along the glide slope. The data shows that raising the scan elevation does not appreciably degrade the estimated F-factor and hazard.

The approach geometry was altered in table 5 so that the core of the microburst would be penetrated at an altitude of 400 feet. Comparison of the real and estimated hazard shows that the intensity of the shear is underestimated in the core, due to the higher ratio of downdraft to horizontal divergence at the higher altitude. The display still predicts a hazardous energy state, however, before the distance to the core has decreased to 10000 feet.

Tables 6 through 10 show airspeed error data for the same run conditions as tables 1 through 5, respectively. Display of airspeed error may have the advantage of being more intuitively obvious to pilots than energy height, although a color-coded version of the two displays may look identical. Different colors could be used, for example, to display airspeed losses of 15 to 20 knots, 20 to 25 knots, 25 to 30 knots, and greater than 30 knots. Alternatively, F-factor could be displayed in color-coded format with superimposed labels showing the airspeed loss predicted at various ranges. The data of table 1, where thrust is fixed at a nominal approach value, shows an estimate of a 40 knot increase in airspeed, followed by a large airspeed loss, in the scan taken at time = 50 seconds. The predicted airspeed loss exceeds 30 knots when the range to the core is over 10000 feet (at time = 50 seconds), and grows to over 70 knots when the core is 3500 feet away (at time = 80 seconds).

The large airspeed loss is almost equal to the actual wind change magnitude in the microburst (74 knots) and is the result of assumed level flight through the microburst core (after the F-factor exceeds 0.15) at approach thrust. In this respect, the assumptions made about flight path angle and thrust are not compatible. Also, an airplane could obviously not remain airborne while 70 knots below approach speed. This analysis considers only energy tradeoffs, and does not include airplane stall dynamics or predict a flight path. It is believed, however, that this does not diminish the usefulness of the display, since an indication that 70 knots airspeed loss would be needed to maintain an acceptable trajectory would be adequate grounds for avoidance of the weather phenomena. The assumptions in this example predict a much larger airspeed loss than would be experienced in an actual approach. At the other extreme, allowing an autothrottle to use maximum thrust and assuming a constant 3 degree descent angle could greatly reduce the displayed hazard, possibly leading the crew into a situation where a descent is needed to maintain airspeed at full thrust. Additional analysis and piloted simulations are necessary to develop the appropriate thrust and flight path angle assumptions.

The remaining tables, 7 through 10, use the same variations in thrust assumptions and approach geometry as were used for tables 2 through 5 for the energy height display. These tables show the same error trends and thrust effects that were discussed for the energy height display, and will not be individually discussed.

In addition to the display cases shown in this report, additional analysis should be conducted to predict the display information generated from other wind shear models, including gust front and temperature inversion shears and turbulence.

Concluding Remarks

A candidate concept is presented for producing hazard display information that would be useful to flight crews for wind shear avoidance and situational awareness. This concept integrates forward-look wind shear information with airplane performance capabilities to predict future airplane energy state as a function of range, subject to assumptions about future thrust levels and flight path angle. The information could be displayed to a crew either in terms of energy height or airspeed deviations. The concept attempts to inform the crew of the energy consequences of continuing an approach. The display concept should offer benefits over previously proposed displays of wind velocity or F-factor, since the latter two display concepts may require further interpretation by the crew to determine the actual hazard to the airplane.

A preliminary evaluation of the display algorithms was made, using an analytical microburst model. This analysis indicates that the display concept is valid, but that further analysis and piloted simulations are necessary to address numerous issues. The most important issues are the assumptions made in the display algorithms about future thrust values and flight path angle. If thrust is assumed fixed at the approach value, the airplane may perform better than predicted by the display, possibly reducing pilot confidence in the display. If thrust is assumed to freely vary, the threat may be underestimated, and the crew may fly into a wind shear that could prevent the airplane from maintaining level flight at full thrust. Another issue is the fact that the area of greatest displayed hazard is not in the core of the microburst, but at the far side of the microburst. This presentation reflects the fact that airplane energy state will be minimum in that region, but it may lead the pilot into believing that the microburst is farther away than it actually is.

Other issues to be addressed are fundamental to all forward-look display concepts. One question is whether to display only performance-decreasing shears, or to also show areas of performance increase. With forward-look systems, display of a performance-increasing shear region may improve pilot confidence in the system, since pilots may penetrate that region and see the correlation between actual and predicted performance. Situational awareness may also be improved by display of performance increasing regions, since microbursts will likely show different hazard "signatures" than other types of shear, such as temperature inversions. Another fundamental need is the ability to accurately estimate F-factor without direct knowledge of vertical wind components.

Batch simulations, incorporating airplane performance models and piloted simulations will be necessary to explore the dynamics of the display and its usefulness to flight crews. The display should also be evaluated with additional wind models, including turbulence and temperature inversion effects.

References

1. Hinton, David A.: Flight-Management Strategies for Escape From Microburst Encounters, NASA TM-4057, 1988.

2. Wind Shear Detection, Forward-Looking Sensor Technology; NASA CP-10004, DOT/FAA/PS-87/2, 1987.

3. Oseguera, Rosa M. and Bowles, Roland L.: A Simple, Analytic 3-Dimensional Downburst Model Based on Boundry Layer Stagnation Flow, NASA TM-100632, 1988.

Table 1 - Energy Height Display Data with Fixed-Thrust Assumption

Initial altitude = 1200 feet
Distance to microburst = 22000 feet
Reference airspeed = 137 knots
Scan elevation = -0.050
Scan bin length = 450 feet
Scan range is from 1000 to 12000 feet
Perf ratio fixed at -0.050

Altitude = 1200
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.005	-0.006	-0.050	2.1	2.5
2	1675	-0.005	-0.006	-0.050	4.4	5.1
3	2125	-0.005	-0.006	-0.050	6.7	7.7
4	2575	-0.005	-0.006	-0.050	9.1	10.4
5	3025	-0.006	-0.006	-0.050	11.6	13.3
6	3475	-0.006	-0.006	-0.050	14.2	16.1
7	3925	-0.006	-0.007	-0.050	17.0	19.1
8	4375	-0.006	-0.007	-0.050	19.8	22.2
9	4825	-0.007	-0.007	-0.050	22.8	25.3
10	5275	-0.007	-0.007	-0.050	25.8	28.6
11	5725	-0.007	-0.007	-0.050	29.0	31.9
12	6175	-0.007	-0.008	-0.050	32.4	35.3
13	6625	-0.008	-0.008	-0.050	35.9	38.8
14	7075	-0.008	-0.008	-0.050	39.5	42.4
15	7525	-0.008	-0.008	-0.050	43.2	46.1
16	7975	-0.009	-0.008	-0.050	47.2	50.0
17	8425	-0.009	-0.009	-0.050	51.2	53.9
18	8875	-0.009	-0.009	-0.050	55.5	57.9
19	9325	-0.010	-0.009	-0.050	59.9	62.0
20	9775	-0.010	-0.009	-0.050	64.5	66.3
21	10225	-0.011	-0.010	-0.050	69.3	70.6
22	10675	-0.011	-0.010	-0.050	74.3	75.1
23	11125	-0.012	-0.010	-0.050	79.4	79.6

Table 1 - Continued.

Altitude = 1084
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.006	-0.006	-0.050	2.6	2.9
2	1675	-0.006	-0.007	-0.050	5.4	5.9
3	2125	-0.006	-0.007	-0.050	8.2	9.0
4	2575	-0.007	-0.007	-0.050	11.2	12.1
5	3025	-0.007	-0.007	-0.050	14.3	15.4
6	3475	-0.007	-0.007	-0.050	17.5	18.7
7	3925	-0.007	-0.008	-0.050	20.9	22.1
8	4375	-0.008	-0.008	-0.050	24.4	25.7
9	4825	-0.008	-0.008	-0.050	28.0	29.3
10	5275	-0.008	-0.008	-0.050	31.8	33.0
11	5725	-0.009	-0.009	-0.050	35.7	36.8
12	6175	-0.009	-0.009	-0.050	39.8	40.8
13	6625	-0.009	-0.009	-0.050	44.1	44.8
14	7075	-0.010	-0.009	-0.050	48.6	49.0
15	7525	-0.010	-0.009	-0.050	53.2	53.2
16	7975	-0.011	-0.010	-0.050	58.0	57.6
17	8425	-0.011	-0.010	-0.050	63.0	62.0
18	8875	-0.012	-0.010	-0.050	68.2	66.6
19	9325	-0.012	-0.013	-0.050	73.6	72.3
20	9775	-0.013	-0.023	-0.050	79.3	82.9
21	10225	-0.014	-0.026	-0.050	85.7	94.5
22	10675	-0.016	-0.029	-0.050	92.8	107.4
23	11125	-0.018	-0.032	-0.050	100.8	121.6

Altitude = 969
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.007	-0.007	-0.050	3.2	3.4
2	1675	-0.007	-0.008	-0.050	6.6	6.8
3	2125	-0.008	-0.008	-0.050	10.1	10.3
4	2575	-0.008	-0.008	-0.050	13.8	14.0
5	3025	-0.008	-0.008	-0.050	17.6	17.7

Table 1 - Continued.

6	3475	-0.009	-0.009	-0.050	21.6	21.6
7	3925	-0.009	-0.009	-0.050	25.7	25.5
8	4375	-0.010	-0.009	-0.050	30.0	29.6
9	4825	-0.010	-0.009	-0.050	34.4	33.7
10	5275	-0.010	-0.009	-0.050	39.1	38.0
11	5725	-0.011	-0.010	-0.050	43.9	42.3
12	6175	-0.011	-0.010	-0.050	49.0	46.8
13	6625	-0.012	-0.010	-0.050	54.2	51.4
14	7075	-0.012	-0.014	-0.050	59.6	57.9
15	7525	-0.013	-0.024	-0.050	65.4	68.6
16	7975	-0.014	-0.026	-0.050	71.9	80.4
17	8425	-0.016	-0.029	-0.050	79.1	93.4
18	8875	-0.018	-0.032	-0.050	87.3	107.9
19	9325	-0.020	-0.036	-0.050	96.4	124.0
20	9775	-0.023	-0.040	-0.050	106.8	142.0
21	10225	-0.026	-0.045	-0.050	118.7	162.3
22	10675	-0.030	-0.051	-0.050	132.2	185.3
23	11125	-0.035	-0.058	-0.050	147.8	211.6

Altitude = 853
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.009	-0.009	-0.050	4.0	3.9
2	1675	-0.009	-0.009	-0.050	8.1	7.8
3	2125	-0.010	-0.009	-0.050	12.4	11.9
4	2575	-0.010	-0.009	-0.050	16.9	16.0
5	3025	-0.010	-0.010	-0.050	21.6	20.3
6	3475	-0.011	-0.010	-0.050	26.5	24.7
7	3925	-0.011	-0.010	-0.050	31.5	29.2
8	4375	-0.012	-0.010	-0.050	36.8	33.8
9	4825	-0.012	-0.016	-0.050	42.3	41.1
10	5275	-0.013	-0.024	-0.050	48.2	51.9
11	5725	-0.015	-0.027	-0.050	54.7	63.9
12	6175	-0.016	-0.029	-0.050	62.1	77.1
13	6625	-0.018	-0.033	-0.050	70.3	91.8
14	7075	-0.021	-0.036	-0.050	79.7	108.1
15	7525	-0.024	-0.041	-0.050	90.2	126.4
16	7975	-0.027	-0.046	-0.050	102.3	147.1
17	8425	-0.031	-0.052	-0.050	116.1	170.5
18	8875	-0.035	-0.059	-0.050	132.1	197.2

Table 1 - Continued.

19	9325	-0.041	-0.068	-0.050	150.5	227.8
20	9775	-0.047	-0.078	-0.050	171.9	262.7
21	10225	-0.054	-0.088	-0.050	196.3	302.1
22	10675	-0.061	-0.096	-0.050	223.7	345.4
23	11125	-0.065	-0.100	-0.050	252.7	390.4

Altitude = 737
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.011	-0.010	-0.050	4.9	4.4
2	1675	-0.011	-0.010	-0.050	10.0	8.9
3	2125	-0.012	-0.010	-0.050	15.3	13.5
4	2575	-0.012	-0.018	-0.050	20.8	21.6
5	3025	-0.013	-0.024	-0.050	26.8	32.6
6	3475	-0.015	-0.027	-0.050	33.4	44.7
7	3925	-0.017	-0.030	-0.050	40.9	58.1
8	4375	-0.019	-0.033	-0.050	49.3	73.0
9	4825	-0.021	-0.037	-0.050	58.8	89.6
10	5275	-0.024	-0.041	-0.050	69.5	108.2
11	5725	-0.027	-0.047	-0.050	81.8	129.2
12	6175	-0.031	-0.053	-0.050	95.9	153.1
13	6625	-0.036	-0.060	-0.050	112.2	180.3
14	7075	-0.042	-0.069	-0.050	131.0	211.4
15	7525	-0.048	-0.079	-0.050	152.8	247.0
16	7975	-0.055	-0.089	-0.050	177.7	287.0
17	8425	-0.062	-0.097	-0.050	205.4	330.7
18	8875	-0.065	-0.100	-0.050	234.5	375.6
19	9325	-0.061	-0.092	-0.050	262.0	416.9
20	9775	-0.047	-0.067	-0.050	283.0	447.3
21	10225	-0.016	-0.022	-0.050	290.3	457.1
22	10675	0.033	0.046	-0.050	275.7	436.6
23	11125	0.100	0.131	-0.050	230.6	377.6

Table 1 - Continued.

Altitude = 622
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.015	-0.027	-0.050	6.8	12.3
2	1675	-0.017	-0.030	-0.050	14.4	25.9
3	2125	-0.019	-0.034	-0.050	22.9	41.0
4	2575	-0.021	-0.037	-0.050	32.5	57.8
5	3025	-0.024	-0.042	-0.050	43.5	76.8
6	3475	-0.028	-0.048	-0.050	56.0	98.2
7	3925	-0.032	-0.054	-0.050	70.4	122.5
8	4375	-0.037	-0.062	-0.050	87.0	150.2
9	4825	-0.043	-0.070	-0.050	106.2	181.9
10	5275	-0.049	-0.080	-0.050	128.4	218.0
11	5725	-0.056	-0.090	-0.050	153.8	258.6
12	6175	-0.062	-0.098	-0.050	181.7	302.7
13	6625	-0.065	-0.099	-0.050	210.9	347.5
14	7075	-0.060	-0.090	-0.050	237.8	387.8
15	7525	-0.043	-0.062	-0.050	257.4	415.9
16	7975	-0.011	-0.014	-0.050	262.1	422.1
17	8425	0.041	0.057	-0.050	243.8	396.6
18	8875	0.111	0.144	-0.050	193.9	331.9
19	9325	0.195	0.238	-0.050	106.2	225.0
20	9775	0.281	0.317	-0.050	-20.3	82.1
21	10225	0.344	0.352	-0.050	-175.1	-76.4
22	10675	0.344	0.302	-0.050	-329.9	-212.3
23	11125	0.239	0.133	-0.050	-437.6	-272.2

Altitude = 506
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.028	-0.048	-0.050	12.8	21.8
2	1675	-0.033	-0.055	-0.050	27.4	46.5
3	2125	-0.038	-0.063	-0.050	44.4	74.7
4	2575	-0.044	-0.072	-0.050	64.0	107.0
5	3025	-0.050	-0.082	-0.050	86.6	143.8

Table 1 - Continued.

6	3475	-0.057	-0.092	-0.050	112.4	185.0
7	3925	-0.063	-0.099	-0.050	140.6	229.4
8	4375	-0.065	-0.099	-0.050	169.7	273.9
9	4825	-0.058	-0.087	-0.050	196.0	313.0
10	5275	-0.040	-0.057	-0.050	213.9	338.7
11	5725	-0.005	-0.005	-0.050	216.0	341.0
12	6175	0.049	0.068	-0.050	193.7	310.5
13	6625	0.122	0.157	-0.050	138.9	239.9
14	7075	0.207	0.250	-0.050	45.7	127.4
15	7525	0.292	0.326	-0.050	-85.8	-19.2
16	7975	0.349	0.351	-0.050	-242.7	-177.3
17	8425	0.336	0.286	-0.050	-394.1	-306.0
18	8875	0.215	0.100	-0.050	-490.9	-350.9
19	9325	-0.029	-0.206	-0.050	-477.8	-258.2
20	9775	-0.362	-0.581	-0.050	-314.8	3.1
21	10225	-0.693	-0.918	-0.050	-3.1	416.2

Altitude = 391
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.058	-0.093	-0.050	26.1	41.7
2	1675	-0.063	-0.099	-0.050	54.7	86.4
3	2125	-0.064	-0.098	-0.050	83.6	130.5
4	2575	-0.057	-0.084	-0.050	109.1	168.3
5	3025	-0.036	-0.051	-0.050	125.3	191.3
6	3475	0.002	0.004	-0.050	124.5	189.7
7	3925	0.058	0.079	-0.050	98.2	153.9
8	4375	0.133	0.170	-0.050	38.3	77.4
9	4825	0.220	0.262	-0.050	-60.5	-40.6
10	5275	0.302	0.333	-0.050	-196.6	-190.6
11	5725	0.352	0.349	-0.050	-355.1	-347.4
12	6175	0.327	0.268	-0.050	-502.1	-467.9
13	6625	0.188	0.064	-0.050	-586.8	-496.6
14	7075	-0.072	-0.256	-0.050	-554.6	-381.5
15	7525	-0.411	-0.633	-0.050	-369.6	-96.7
16	7975	-0.730	-0.953	-0.050	-41.0	332.0

Table 1 - Concluded.

Altitude = 275
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.008	0.013	-0.050	-3.8	-5.9
2	1675	0.068	0.091	-0.050	-34.4	-47.0
3	2125	0.145	0.183	-0.050	-99.4	-129.4
4	2575	0.232	0.274	-0.050	-203.7	-252.7
5	3025	0.312	0.340	-0.050	-344.2	-405.6
6	3475	0.354	0.344	-0.050	-503.6	-560.3
7	3925	0.315	0.247	-0.050	-645.3	-671.5
8	4375	0.159	0.025	-0.050	-716.9	-683.0
9	4825	-0.116	-0.307	-0.050	-664.9	-545.0
10	5275	-0.460	-0.684	-0.050	-458.0	-237.1
11	5725	-0.764	-0.983	-0.050	-114.1	205.2

Altitude = 159
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.355	0.337	-0.050	-159.6	-151.8
2	1675	0.301	0.224	-0.050	-294.9	-252.6
3	2125	0.127	-0.015	-0.050	-352.2	-245.8
4	2575	-0.161	-0.359	-0.050	-279.7	-84.4
5	3025	-0.508	-0.734	-0.050	-51.3	245.9
6	3475	-0.794	-1.007	-0.050	306.0	699.1

Table 2 - Energy Height Display Data with Autothrottle Assumption

Initial altitude = 1200
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = -0.050
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Autothrottle used from -0.070 to 0.050 perf ratio

Altitude = 1200
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.005	-0.006	-0.056	0.0	0.0
2	1675	-0.005	-0.006	-0.056	0.0	0.0
3	2125	-0.005	-0.006	-0.056	0.0	0.0
4	2575	-0.005	-0.006	-0.056	0.0	0.0
5	3025	-0.006	-0.006	-0.056	0.0	0.0
6	3475	-0.006	-0.006	-0.056	0.0	0.0
7	3925	-0.006	-0.007	-0.057	0.0	0.0
8	4375	-0.006	-0.007	-0.057	0.0	0.0
9	4825	-0.007	-0.007	-0.057	0.0	0.0
10	5275	-0.007	-0.007	-0.057	0.0	0.0
11	5725	-0.007	-0.007	-0.057	0.0	0.0
12	6175	-0.007	-0.008	-0.058	0.0	0.0
13	6625	-0.008	-0.008	-0.058	0.0	0.0
14	7075	-0.008	-0.008	-0.058	0.0	0.0
15	7525	-0.008	-0.008	-0.058	0.0	0.0
16	7975	-0.009	-0.008	-0.058	0.0	0.0
17	8425	-0.009	-0.009	-0.059	0.0	0.0
18	8875	-0.009	-0.009	-0.059	0.0	0.0
19	9325	-0.010	-0.009	-0.059	0.0	0.0
20	9775	-0.010	-0.009	-0.059	0.0	0.0
21	10225	-0.011	-0.010	-0.060	0.0	0.0
22	10675	-0.011	-0.010	-0.060	0.0	0.0
23	11125	-0.012	-0.010	-0.060	0.0	0.0

Table 2 - Continued.

Altitude = 1084
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.006	-0.006	-0.056	0.0	0.0
2	1675	-0.006	-0.007	-0.057	0.0	0.0
3	2125	-0.006	-0.007	-0.057	0.0	0.0
4	2575	-0.007	-0.007	-0.057	0.0	0.0
5	3025	-0.007	-0.007	-0.057	0.0	0.0
6	3475	-0.007	-0.007	-0.057	0.0	0.0
7	3925	-0.007	-0.008	-0.058	0.0	0.0
8	4375	-0.008	-0.008	-0.058	0.0	0.0
9	4825	-0.008	-0.008	-0.058	0.0	0.0
10	5275	-0.008	-0.008	-0.058	0.0	0.0
11	5725	-0.009	-0.009	-0.059	0.0	0.0
12	6175	-0.009	-0.009	-0.059	0.0	0.0
13	6625	-0.009	-0.009	-0.059	0.0	0.0
14	7075	-0.010	-0.009	-0.059	0.0	0.0
15	7525	-0.010	-0.009	-0.059	0.0	0.0
16	7975	-0.011	-0.010	-0.060	0.0	0.0
17	8425	-0.011	-0.010	-0.060	0.0	0.0
18	8875	-0.012	-0.010	-0.060	0.0	0.0
19	9325	-0.012	-0.013	-0.063	0.0	0.0
20	9775	-0.013	-0.023	-0.070	0.0	1.6
21	10225	-0.014	-0.026	-0.070	0.0	4.2
22	10675	-0.016	-0.029	-0.070	0.0	8.0
23	11125	-0.018	-0.032	-0.070	0.0	13.3

Altitude = 969
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.007	-0.007	-0.057	0.0	0.0
2	1675	-0.007	-0.008	-0.058	0.0	0.0
3	2125	-0.008	-0.008	-0.058	0.0	0.0
4	2575	-0.008	-0.008	-0.058	0.0	0.0
5	3025	-0.008	-0.008	-0.058	0.0	0.0

Table 2 - Continued.

6	3475	-0.009	-0.009	-0.059	0.0	0.0
7	3925	-0.009	-0.009	-0.059	0.0	0.0
8	4375	-0.010	-0.009	-0.059	0.0	0.0
9	4825	-0.010	-0.009	-0.059	0.0	0.0
10	5275	-0.010	-0.009	-0.059	0.0	0.0
11	5725	-0.011	-0.010	-0.060	0.0	0.0
12	6175	-0.011	-0.010	-0.060	0.0	0.0
13	6625	-0.012	-0.010	-0.060	0.0	0.0
14	7075	-0.012	-0.014	-0.064	0.0	0.0
15	7525	-0.013	-0.024	-0.070	0.0	1.7
16	7975	-0.014	-0.026	-0.070	0.0	4.5
17	8425	-0.016	-0.029	-0.070	0.0	8.5
18	8875	-0.018	-0.032	-0.070	0.0	13.9
19	9325	-0.020	-0.036	-0.070	0.2	21.1
20	9775	-0.023	-0.040	-0.070	1.6	30.1
21	10225	-0.026	-0.045	-0.070	4.4	41.4
22	10675	-0.030	-0.051	-0.070	9.0	55.4
23	11125	-0.035	-0.058	-0.070	15.6	72.6

Altitude = 853
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.009	-0.009	-0.059	0.0	0.0
2	1675	-0.009	-0.009	-0.059	0.0	0.0
3	2125	-0.010	-0.009	-0.059	0.0	0.0
4	2575	-0.010	-0.009	-0.059	0.0	0.0
5	3025	-0.010	-0.010	-0.060	0.0	0.0
6	3475	-0.011	-0.010	-0.060	0.0	0.0
7	3925	-0.011	-0.010	-0.060	0.0	0.0
8	4375	-0.012	-0.010	-0.060	0.0	0.0
9	4825	-0.012	-0.016	-0.066	0.0	0.0
10	5275	-0.013	-0.024	-0.070	0.0	1.8
11	5725	-0.015	-0.027	-0.070	0.0	4.8
12	6175	-0.016	-0.029	-0.070	0.0	9.0
13	6625	-0.018	-0.033	-0.070	0.0	14.7
14	7075	-0.021	-0.036	-0.070	0.3	22.0
15	7525	-0.024	-0.041	-0.070	1.9	31.3
16	7975	-0.027	-0.046	-0.070	5.0	43.0
17	8425	-0.031	-0.052	-0.070	9.8	57.4
18	8875	-0.035	-0.059	-0.070	16.7	75.1

Table 2 - Continued.

19	9325	-0.041	-0.068	-0.070	26.2	96.7
20	9775	-0.047	-0.078	-0.070	38.5	122.6
21	10225	-0.054	-0.088	-0.070	54.0	153.0
22	10675	-0.061	-0.096	-0.070	72.3	187.3
23	11125	-0.065	-0.100	-0.070	92.4	223.3

Altitude = 737
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.011	-0.010	-0.060	0.0	0.0
2	1675	-0.011	-0.010	-0.060	0.0	0.0
3	2125	-0.012	-0.010	-0.060	0.0	0.0
4	2575	-0.012	-0.018	-0.068	0.0	0.0
5	3025	-0.013	-0.024	-0.070	0.0	2.0
6	3475	-0.015	-0.027	-0.070	0.0	5.1
7	3925	-0.017	-0.030	-0.070	0.0	9.5
8	4375	-0.019	-0.033	-0.070	0.0	15.4
9	4825	-0.021	-0.037	-0.070	0.5	23.0
10	5275	-0.024	-0.041	-0.070	2.3	32.6
11	5725	-0.027	-0.047	-0.070	5.5	44.6
12	6175	-0.031	-0.053	-0.070	10.6	59.5
13	6625	-0.036	-0.060	-0.070	17.9	77.7
14	7075	-0.042	-0.069	-0.070	27.8	99.8
15	7525	-0.048	-0.079	-0.070	40.5	126.3
16	7975	-0.055	-0.089	-0.070	56.4	157.4
17	8425	-0.062	-0.097	-0.070	75.1	192.1
18	8875	-0.065	-0.100	-0.070	95.2	228.0
19	9325	-0.061	-0.092	-0.070	113.8	260.3
20	9775	-0.047	-0.067	-0.070	125.7	281.6
21	10225	-0.016	-0.022	-0.070	125.7	282.5
22	10675	0.033	0.046	-0.004	125.7	282.5
23	11125	0.100	0.131	0.050	125.7	268.5

Table 2 - Continued.

Altitude = 622
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.015	-0.027	-0.070	0.0	3.3
2	1675	-0.017	-0.030	-0.070	0.0	7.9
3	2125	-0.019	-0.034	-0.070	0.0	14.0
4	2575	-0.021	-0.037	-0.070	0.7	21.8
5	3025	-0.024	-0.042	-0.070	2.6	31.8
6	3475	-0.028	-0.048	-0.070	6.1	44.2
7	3925	-0.032	-0.054	-0.070	11.5	59.5
8	4375	-0.037	-0.062	-0.070	19.1	78.2
9	4825	-0.043	-0.070	-0.070	29.3	100.9
10	5275	-0.049	-0.080	-0.070	42.5	128.0
11	5725	-0.056	-0.090	-0.070	58.9	159.6
12	6175	-0.062	-0.098	-0.070	77.9	194.7
13	6625	-0.065	-0.099	-0.070	98.0	230.5
14	7075	-0.060	-0.090	-0.070	115.9	261.8
15	7525	-0.043	-0.062	-0.070	126.5	280.9
16	7975	-0.011	-0.014	-0.064	126.5	280.9
17	8425	0.041	0.057	0.007	126.5	280.9
18	8875	0.111	0.144	0.050	121.6	261.1
19	9325	0.195	0.238	0.050	78.9	199.2
20	9775	0.281	0.317	0.050	-2.7	101.4
21	10225	0.344	0.352	0.050	-112.5	-12.1
22	10675	0.344	0.302	0.050	-222.2	-103.0
23	11125	0.239	0.133	0.050	-284.9	-118.0

Altitude = 506
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.028	-0.048	-0.070	3.8	12.8
2	1675	-0.033	-0.055	-0.070	9.4	28.5
3	2125	-0.038	-0.063	-0.070	17.4	47.7
4	2575	-0.044	-0.072	-0.070	28.0	71.0
5	3025	-0.050	-0.082	-0.070	41.6	98.8

Table 2 - Continued.

6	3475	-0.057	-0.092	-0.070	58.4	131.0
7	3925	-0.063	-0.099	-0.070	77.6	166.4
8	4375	-0.065	-0.099	-0.070	97.7	201.9
9	4825	-0.058	-0.087	-0.070	115.0	232.0
10	5275	-0.040	-0.057	-0.070	123.9	248.7
11	5725	-0.005	-0.005	-0.055	123.9	248.7
12	6175	0.049	0.068	0.018	123.9	248.7
13	6625	0.122	0.157	0.050	114.1	223.1
14	7075	0.207	0.250	0.050	65.9	155.6
15	7525	0.292	0.326	0.050	-20.6	53.9
16	7975	0.349	0.351	0.050	-132.5	-59.2
17	8425	0.336	0.286	0.050	-238.9	-142.9
18	8875	0.215	0.100	0.050	-290.7	-142.9
19	9325	-0.029	-0.206	-0.070	-286.6	-59.2
20	9775	-0.362	-0.581	-0.070	-132.6	193.1
21	10225	-0.693	-0.918	-0.070	170.1	597.2

Altitude = 391
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.058	-0.093	-0.070	17.1	32.7
2	1675	-0.063	-0.099	-0.070	36.7	68.4
3	2125	-0.064	-0.098	-0.070	56.6	103.5
4	2575	-0.057	-0.084	-0.070	73.1	132.3
5	3025	-0.036	-0.051	-0.070	80.3	146.3
6	3475	0.002	0.004	-0.046	80.3	146.3
7	3925	0.058	0.079	0.029	80.3	146.3
8	4375	0.133	0.170	0.050	65.4	114.8
9	4825	0.220	0.262	0.050	11.7	41.8
10	5275	0.302	0.333	0.050	-79.5	-63.1
11	5725	0.352	0.349	0.050	-192.9	-175.0
12	6175	0.327	0.268	0.050	-295.0	-250.5
13	6625	0.188	0.064	0.014	-334.7	-250.5
14	7075	-0.072	-0.256	-0.070	-311.5	-144.4
15	7525	-0.411	-0.633	-0.070	-135.5	131.4
16	7975	-0.730	-0.953	-0.070	184.1	551.1

Table 2 - Concluded.

Altitude = 275
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.008	0.013	-0.037	0.0	0.0
2	1675	0.068	0.091	0.041	0.0	0.0
3	2125	0.145	0.183	0.050	-20.1	-37.4
4	2575	0.232	0.274	0.050	-79.4	-115.7
5	3025	0.312	0.340	0.050	-174.9	-223.6
6	3475	0.354	0.344	0.050	-289.3	-333.3
7	3925	0.315	0.247	0.050	-386.0	-399.5
8	4375	0.159	0.025	-0.025	-412.5	-399.5
9	4825	-0.116	-0.307	-0.070	-369.5	-270.5
10	5275	-0.460	-0.684	-0.070	-171.6	28.4
11	5725	-0.764	-0.983	-0.070	163.3	461.6

Altitude = 159
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.355	0.337	0.050	-114.6	-106.8
2	1675	0.301	0.224	0.050	-204.9	-162.6
3	2125	0.127	-0.015	-0.065	-217.2	-162.6
4	2575	-0.161	-0.359	-0.070	-153.7	-10.2
5	3025	-0.508	-0.734	-0.070	65.7	311.2
6	3475	-0.794	-1.007	-0.070	414.0	755.4

Table 3 - Energy Height Display Data with Go-around Thrust Assumption

Initial altitude = 1200
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = -0.050
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Perf ratio fixed at -0.05 till F > 0.15 then perf ratio = 0.140

Altitude = 1200
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.005	-0.006	-0.050	2.1	2.5
2	1675	-0.005	-0.006	-0.050	4.4	5.1
3	2125	-0.005	-0.006	-0.050	6.7	7.7
4	2575	-0.005	-0.006	-0.050	9.1	10.4
5	3025	-0.006	-0.006	-0.050	11.6	13.3
6	3475	-0.006	-0.006	-0.050	14.2	16.1
7	3925	-0.006	-0.007	-0.050	17.0	19.1
8	4375	-0.006	-0.007	-0.050	19.8	22.2
9	4825	-0.007	-0.007	-0.050	22.8	25.3
10	5275	-0.007	-0.007	-0.050	25.8	28.6
11	5725	-0.007	-0.007	-0.050	29.0	31.9
12	6175	-0.007	-0.008	-0.050	32.4	35.3
13	6625	-0.008	-0.008	-0.050	35.9	38.8
14	7075	-0.008	-0.008	-0.050	39.5	42.4
15	7525	-0.008	-0.008	-0.050	43.2	46.1
16	7975	-0.009	-0.008	-0.050	47.2	50.0
17	8425	-0.009	-0.009	-0.050	51.2	53.9
18	8875	-0.009	-0.009	-0.050	55.5	57.9
19	9325	-0.010	-0.009	-0.050	59.9	62.0
20	9775	-0.010	-0.009	-0.050	64.5	66.3
21	10225	-0.011	-0.010	-0.050	69.3	70.6
22	10675	-0.011	-0.010	-0.050	74.3	75.1
23	11125	-0.012	-0.010	-0.050	79.4	79.6

Table 3 - Continued.

Altitude = 1084
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.006	-0.006	-0.050	2.6	2.9
2	1675	-0.006	-0.007	-0.050	5.4	5.9
3	2125	-0.006	-0.007	-0.050	8.2	9.0
4	2575	-0.007	-0.007	-0.050	11.2	12.1
5	3025	-0.007	-0.007	-0.050	14.3	15.4
6	3475	-0.007	-0.007	-0.050	17.5	18.7
7	3925	-0.007	-0.008	-0.050	20.9	22.1
8	4375	-0.008	-0.008	-0.050	24.4	25.7
9	4825	-0.008	-0.008	-0.050	28.0	29.3
10	5275	-0.008	-0.008	-0.050	31.8	33.0
11	5725	-0.009	-0.009	-0.050	35.7	36.8
12	6175	-0.009	-0.009	-0.050	39.8	40.8
13	6625	-0.009	-0.009	-0.050	44.1	44.8
14	7075	-0.010	-0.009	-0.050	48.6	49.0
15	7525	-0.010	-0.009	-0.050	53.2	53.2
16	7975	-0.011	-0.010	-0.050	58.0	57.6
17	8425	-0.011	-0.010	-0.050	63.0	62.0
18	8875	-0.012	-0.010	-0.050	68.2	66.6
19	9325	-0.012	-0.013	-0.050	73.6	72.3
20	9775	-0.013	-0.023	-0.050	79.3	82.9
21	10225	-0.014	-0.026	-0.050	85.7	94.5
22	10675	-0.016	-0.029	-0.050	92.8	107.4
23	11125	-0.018	-0.032	-0.050	100.8	121.6

Altitude = 969
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.007	-0.007	-0.050	3.2	3.4
2	1675	-0.007	-0.008	-0.050	6.6	6.8
3	2125	-0.008	-0.008	-0.050	10.1	10.3
4	2575	-0.008	-0.008	-0.050	13.8	14.0
5	3025	-0.008	-0.008	-0.050	17.6	17.7

Table 3 - Continued.

6	3475	-0.009	-0.009	-0.050	21.6	21.6
7	3925	-0.009	-0.009	-0.050	25.7	25.5
8	4375	-0.010	-0.009	-0.050	30.0	29.6
9	4825	-0.010	-0.009	-0.050	34.4	33.7
10	5275	-0.010	-0.009	-0.050	39.1	38.0
11	5725	-0.011	-0.010	-0.050	43.9	42.3
12	6175	-0.011	-0.010	-0.050	49.0	46.8
13	6625	-0.012	-0.010	-0.050	54.2	51.4
14	7075	-0.012	-0.014	-0.050	59.6	57.9
15	7525	-0.013	-0.024	-0.050	65.4	68.6
16	7975	-0.014	-0.026	-0.050	71.9	80.4
17	8425	-0.016	-0.029	-0.050	79.1	93.4
18	8875	-0.018	-0.032	-0.050	87.3	107.9
19	9325	-0.020	-0.036	-0.050	96.4	124.0
20	9775	-0.023	-0.040	-0.050	106.8	142.0
21	10225	-0.026	-0.045	-0.050	118.7	162.3
22	10675	-0.030	-0.051	-0.050	132.2	185.3
23	11125	-0.035	-0.058	-0.050	147.8	211.6

Altitude = 853
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.009	-0.009	-0.050	4.0	3.9
2	1675	-0.009	-0.009	-0.050	8.1	7.8
3	2125	-0.010	-0.009	-0.050	12.4	11.9
4	2575	-0.010	-0.009	-0.050	16.9	16.0
5	3025	-0.010	-0.010	-0.050	21.6	20.3
6	3475	-0.011	-0.010	-0.050	26.5	24.7
7	3925	-0.011	-0.010	-0.050	31.5	29.2
8	4375	-0.012	-0.010	-0.050	36.8	33.8
9	4825	-0.012	-0.016	-0.050	42.3	41.1
10	5275	-0.013	-0.024	-0.050	48.2	51.9
11	5725	-0.015	-0.027	-0.050	54.7	63.9
12	6175	-0.016	-0.029	-0.050	62.1	77.1
13	6625	-0.018	-0.033	-0.050	70.3	91.8
14	7075	-0.021	-0.036	-0.050	79.7	108.1
15	7525	-0.024	-0.041	-0.050	90.2	126.4
16	7975	-0.027	-0.046	-0.050	102.3	147.1
17	8425	-0.031	-0.052	-0.050	116.1	170.5

Table 3 - Continued.

18	8875	-0.035	-0.059	-0.050	132.1	197.2
19	9325	-0.041	-0.068	-0.050	150.5	227.8
20	9775	-0.047	-0.078	-0.050	171.9	262.7
21	10225	-0.054	-0.088	-0.050	196.3	302.1
22	10675	-0.061	-0.096	-0.050	223.7	345.4
23	11125	-0.065	-0.100	-0.050	252.7	390.4

Altitude = 737
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.011	-0.010	-0.050	4.9	4.4
2	1675	-0.011	-0.010	-0.050	10.0	8.9
3	2125	-0.012	-0.010	-0.050	15.3	13.5
4	2575	-0.012	-0.018	-0.050	20.8	21.6
5	3025	-0.013	-0.024	-0.050	26.8	32.6
6	3475	-0.015	-0.027	-0.050	33.4	44.7
7	3925	-0.017	-0.030	-0.050	40.9	58.1
8	4375	-0.019	-0.033	-0.050	49.3	73.0
9	4825	-0.021	-0.037	-0.050	58.8	89.6
10	5275	-0.024	-0.041	-0.050	69.5	108.2
11	5725	-0.027	-0.047	-0.050	81.8	129.2
12	6175	-0.031	-0.053	-0.050	95.9	153.1
13	6625	-0.036	-0.060	-0.050	112.2	180.3
14	7075	-0.042	-0.069	-0.050	131.0	211.4
15	7525	-0.048	-0.079	-0.050	152.8	247.0
16	7975	-0.055	-0.089	-0.050	177.7	287.0
17	8425	-0.062	-0.097	-0.050	205.4	330.7
18	8875	-0.065	-0.100	-0.050	234.5	375.6
19	9325	-0.061	-0.092	-0.050	262.0	416.9
20	9775	-0.047	-0.067	-0.050	283.0	447.3
21	10225	-0.016	-0.022	-0.050	290.3	457.1
22	10675	0.033	0.046	-0.050	275.7	436.6
23	11125	0.100	0.131	-0.050	230.6	377.6

Table 3 - Continued.

Altitude = 622
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.015	-0.027	-0.050	6.8	12.3
2	1675	-0.017	-0.030	-0.050	14.4	25.9
3	2125	-0.019	-0.034	-0.050	22.9	41.0
4	2575	-0.021	-0.037	-0.050	32.5	57.8
5	3025	-0.024	-0.042	-0.050	43.5	76.8
6	3475	-0.028	-0.048	-0.050	56.0	98.2
7	3925	-0.032	-0.054	-0.050	70.4	122.5
8	4375	-0.037	-0.062	-0.050	87.0	150.2
9	4825	-0.043	-0.070	-0.050	106.2	181.9
10	5275	-0.049	-0.080	-0.050	128.4	218.0
11	5725	-0.056	-0.090	-0.050	153.8	258.6
12	6175	-0.062	-0.098	-0.050	181.7	302.7
13	6625	-0.065	-0.099	-0.050	210.9	347.5
14	7075	-0.060	-0.090	-0.050	237.8	387.8
15	7525	-0.043	-0.062	-0.050	257.4	415.9
16	7975	-0.011	-0.014	-0.050	262.1	422.1
17	8425	0.041	0.057	-0.050	243.8	396.6
18	8875	0.111	0.144	-0.050	193.9	331.9
19	9325	0.195	0.238	0.140	191.7	310.5
20	9775	0.281	0.317	0.140	150.7	253.1
21	10225	0.344	0.352	0.140	81.4	180.1
22	10675	0.344	0.302	0.140	12.1	129.7
23	11125	0.239	0.133	0.140	-10.1	155.3

Altitude = 506
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.028	-0.048	-0.050	12.8	21.8
2	1675	-0.033	-0.055	-0.050	27.4	46.5
3	2125	-0.038	-0.063	-0.050	44.4	74.7
4	2575	-0.044	-0.072	-0.050	64.0	107.0

Table 3 - Continued.

5	3025	-0.050	-0.082	-0.050	86.6	143.8
6	3475	-0.057	-0.092	-0.050	112.4	185.0
7	3925	-0.063	-0.099	-0.050	140.6	229.4
8	4375	-0.065	-0.099	-0.050	169.7	273.9
9	4825	-0.058	-0.087	-0.050	196.0	313.0
10	5275	-0.040	-0.057	-0.050	213.9	338.7
11	5725	-0.005	-0.005	-0.050	216.0	341.0
12	6175	0.049	0.068	-0.050	193.7	310.5
13	6625	0.122	0.157	0.140	138.9	325.4
14	7075	0.207	0.250	0.140	131.2	298.4
15	7525	0.292	0.326	0.140	85.2	237.3
16	7975	0.349	0.351	0.140	13.8	164.7
17	8425	0.336	0.286	0.140	-52.1	121.5
18	8875	0.215	0.100	0.140	-63.4	162.1
19	9325	-0.029	-0.206	0.140	35.2	340.3
20	9775	-0.362	-0.581	0.140	283.7	687.1
21	10225	-0.693	-0.918	0.140	680.9	1185.7

Altitude = 391
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.058	-0.093	-0.050	26.1	41.7
2	1675	-0.063	-0.099	-0.050	54.7	86.4
3	2125	-0.064	-0.098	-0.050	83.6	130.5
4	2575	-0.057	-0.084	-0.050	109.1	168.3
5	3025	-0.036	-0.051	-0.050	125.3	191.3
6	3475	0.002	0.004	-0.050	124.5	189.7
7	3925	0.058	0.079	-0.050	98.2	153.9
8	4375	0.133	0.170	0.140	38.3	162.9
9	4825	0.220	0.262	0.140	25.0	130.4
10	5275	0.302	0.333	0.140	-25.6	65.9
11	5725	0.352	0.349	0.140	-98.6	-5.4
12	6175	0.327	0.268	0.140	-160.1	-40.4
13	6625	0.188	0.064	0.140	-159.3	16.4
14	7075	-0.072	-0.256	0.140	-41.6	217.0
15	7525	-0.411	-0.633	0.140	228.9	587.3
16	7975	-0.730	-0.953	0.140	643.0	1101.5

Table 3 - Concluded.

Altitude = 275
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.008	0.013	-0.050	-3.8	-5.9
2	1675	0.068	0.091	-0.050	-34.4	-47.0
3	2125	0.145	0.183	0.140	-99.4	-43.9
4	2575	0.232	0.274	0.140	-118.2	-81.7
5	3025	0.312	0.340	0.140	-173.2	-149.1
6	3475	0.354	0.344	0.140	-247.1	-218.3
7	3925	0.315	0.247	0.140	-303.3	-244.0
8	4375	0.159	0.025	0.140	-289.4	-170.0
9	4825	-0.116	-0.307	0.140	-151.9	53.5
10	5275	-0.460	-0.684	0.140	140.5	446.9
11	5725	-0.764	-0.983	0.140	569.9	974.7

Altitude = 159
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.355	0.337	0.140	-74.1	-66.3
2	1675	0.301	0.224	0.140	-123.9	-81.6
3	2125	0.127	-0.015	0.140	-95.7	10.7
4	2575	-0.161	-0.359	0.140	62.3	257.6
5	3025	-0.508	-0.734	0.140	376.2	673.4
6	3475	-0.794	-1.007	0.140	819.0	1212.1

Table 4 - Energy Height Display Data with Zero-Elevation Scan Assumption

Initial altitude = 1200
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = 0.000
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Perf ratio fixed at -0.050

Altitude = 1200
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.005	0.000	-0.050	2.1	0.0
2	1675	-0.005	0.000	-0.050	4.4	0.0
3	2125	-0.005	0.000	-0.050	6.7	0.0
4	2575	-0.005	0.000	-0.050	9.1	0.0
5	3025	-0.006	0.000	-0.050	11.6	0.0
6	3475	-0.006	0.000	-0.050	14.2	0.0
7	3925	-0.006	0.000	-0.050	17.0	0.0
8	4375	-0.006	0.000	-0.050	19.8	0.0
9	4825	-0.007	0.000	-0.050	22.8	0.0
10	5275	-0.007	0.000	-0.050	25.8	0.0
11	5725	-0.007	0.000	-0.050	29.0	0.0
12	6175	-0.007	0.000	-0.050	32.4	0.0
13	6625	-0.008	0.000	-0.050	35.9	0.0
14	7075	-0.008	0.000	-0.050	39.5	0.0
15	7525	-0.008	0.000	-0.050	43.2	0.0
16	7975	-0.009	0.000	-0.050	47.2	0.0
17	8425	-0.009	0.000	-0.050	51.2	0.0
18	8875	-0.009	0.000	-0.050	55.5	0.0
19	9325	-0.010	0.000	-0.050	59.9	0.0
20	9775	-0.010	0.000	-0.050	64.5	0.0
21	10225	-0.011	0.000	-0.050	69.3	0.0
22	10675	-0.011	0.000	-0.050	74.3	0.0
23	11125	-0.012	0.000	-0.050	79.4	0.0

Table 4 - Continued.

Altitude = 1084
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.006	0.000	-0.050	2.6	0.0
2	1675	-0.006	0.000	-0.050	5.4	0.0
3	2125	-0.006	0.000	-0.050	8.2	0.0
4	2575	-0.007	0.000	-0.050	11.2	0.0
5	3025	-0.007	0.000	-0.050	14.3	0.0
6	3475	-0.007	0.000	-0.050	17.5	0.0
7	3925	-0.007	0.000	-0.050	20.9	0.0
8	4375	-0.008	0.000	-0.050	24.4	0.0
9	4825	-0.008	0.000	-0.050	28.0	0.0
10	5275	-0.008	0.000	-0.050	31.8	0.0
11	5725	-0.009	0.000	-0.050	35.7	0.0
12	6175	-0.009	0.000	-0.050	39.8	0.0
13	6625	-0.009	0.000	-0.050	44.1	0.0
14	7075	-0.010	0.000	-0.050	48.6	0.0
15	7525	-0.010	0.000	-0.050	53.2	0.0
16	7975	-0.011	0.000	-0.050	58.0	0.0
17	8425	-0.011	0.000	-0.050	63.0	0.0
18	8875	-0.012	0.000	-0.050	68.2	0.0
19	9325	-0.012	-0.001	-0.050	73.6	0.6
20	9775	-0.013	-0.007	-0.050	79.3	3.6
21	10225	-0.014	-0.007	-0.050	85.7	7.0
22	10675	-0.016	-0.008	-0.050	92.8	10.7
23	11125	-0.018	-0.009	-0.050	100.8	14.8

Altitude = 969
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.007	0.000	-0.050	3.2	0.0
2	1675	-0.007	0.000	-0.050	6.6	0.0
3	2125	-0.008	0.000	-0.050	10.1	0.0
4	2575	-0.008	0.000	-0.050	13.8	0.0

Table 4 - Continued.

5	3025	-0.008	0.000	-0.050	17.6	0.0
6	3475	-0.009	0.000	-0.050	21.6	0.0
7	3925	-0.009	0.000	-0.050	25.7	0.0
8	4375	-0.010	0.000	-0.050	30.0	0.0
9	4825	-0.010	0.000	-0.050	34.4	0.0
10	5275	-0.010	0.000	-0.050	39.1	0.0
11	5725	-0.011	0.000	-0.050	43.9	0.0
12	6175	-0.011	0.000	-0.050	49.0	0.0
13	6625	-0.012	0.000	-0.050	54.2	0.0
14	7075	-0.012	-0.002	-0.050	59.6	1.1
15	7525	-0.013	-0.008	-0.050	65.4	4.7
16	7975	-0.014	-0.009	-0.050	71.9	8.7
17	8425	-0.016	-0.010	-0.050	79.1	13.0
18	8875	-0.018	-0.011	-0.050	87.3	17.9
19	9325	-0.020	-0.012	-0.050	96.4	23.3
20	9775	-0.023	-0.014	-0.050	106.8	29.4
21	10225	-0.026	-0.015	-0.050	118.7	36.3
22	10675	-0.030	-0.018	-0.050	132.2	44.1
23	11125	-0.035	-0.020	-0.050	147.8	53.2

Altitude = 853
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.009	0.000	-0.050	4.0	0.0
2	1675	-0.009	0.000	-0.050	8.1	0.0
3	2125	-0.010	0.000	-0.050	12.4	0.0
4	2575	-0.010	0.000	-0.050	16.9	0.0
5	3025	-0.010	0.000	-0.050	21.6	0.0
6	3475	-0.011	0.000	-0.050	26.5	0.0
7	3925	-0.011	0.000	-0.050	31.5	0.0
8	4375	-0.012	0.000	-0.050	36.8	0.0
9	4825	-0.012	-0.004	-0.050	42.3	1.8
10	5275	-0.013	-0.009	-0.050	48.2	6.0
11	5725	-0.015	-0.010	-0.050	54.7	10.6
12	6175	-0.016	-0.011	-0.050	62.1	15.7
13	6625	-0.018	-0.013	-0.050	70.3	21.4
14	7075	-0.021	-0.014	-0.050	79.7	27.8
15	7525	-0.024	-0.016	-0.050	90.2	34.9
16	7975	-0.027	-0.018	-0.050	102.3	43.0

Table 4 - Continued.

17	8425	-0.031	-0.021	-0.050	116.1	52.2
18	8875	-0.035	-0.024	-0.050	132.1	62.8
19	9325	-0.041	-0.027	-0.050	150.5	75.1
20	9775	-0.047	-0.031	-0.050	171.9	89.2
21	10225	-0.054	-0.036	-0.050	196.3	105.3
22	10675	-0.061	-0.039	-0.050	223.7	122.8
23	11125	-0.065	-0.040	-0.050	252.7	140.7

Altitude = 737
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.011	0.000	-0.050	4.9	0.0
2	1675	-0.011	0.000	-0.050	10.0	0.0
3	2125	-0.012	0.000	-0.050	15.3	0.0
4	2575	-0.012	-0.006	-0.050	20.8	2.8
5	3025	-0.013	-0.011	-0.050	26.8	7.6
6	3475	-0.015	-0.012	-0.050	33.4	13.0
7	3925	-0.017	-0.013	-0.050	40.9	18.9
8	4375	-0.019	-0.015	-0.050	49.3	25.5
9	4825	-0.021	-0.016	-0.050	58.8	32.9
10	5275	-0.024	-0.018	-0.050	69.5	41.2
11	5725	-0.027	-0.021	-0.050	81.8	50.6
12	6175	-0.031	-0.024	-0.050	95.9	61.4
13	6625	-0.036	-0.028	-0.050	112.2	73.8
14	7075	-0.042	-0.032	-0.050	131.0	88.1
15	7525	-0.048	-0.037	-0.050	152.8	104.5
16	7975	-0.055	-0.041	-0.050	177.7	123.1
17	8425	-0.062	-0.045	-0.050	205.4	143.2
18	8875	-0.065	-0.045	-0.050	234.5	163.5
19	9325	-0.061	-0.038	-0.050	262.0	180.8
20	9775	-0.047	-0.022	-0.050	283.0	190.6
21	10225	-0.016	0.008	-0.050	290.3	187.2
22	10675	0.033	0.050	-0.050	275.7	164.6
23	11125	0.100	0.101	-0.050	230.6	118.9

Table 4 - Continued.

Altitude = 622
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.015	-0.014	-0.050	6.8	6.2
2	1675	-0.017	-0.015	-0.050	14.4	13.0
3	2125	-0.019	-0.017	-0.050	22.9	20.6
4	2575	-0.021	-0.019	-0.050	32.5	29.1
5	3025	-0.024	-0.021	-0.050	43.5	38.8
6	3475	-0.028	-0.024	-0.050	56.0	49.7
7	3925	-0.032	-0.028	-0.050	70.4	62.1
8	4375	-0.037	-0.032	-0.050	87.0	76.5
9	4825	-0.043	-0.037	-0.050	106.2	93.0
10	5275	-0.049	-0.042	-0.050	128.4	111.9
11	5725	-0.056	-0.047	-0.050	153.8	133.2
12	6175	-0.062	-0.051	-0.050	181.7	156.2
13	6625	-0.065	-0.050	-0.050	210.9	178.7
14	7075	-0.060	-0.042	-0.050	237.8	197.4
15	7525	-0.043	-0.021	-0.050	257.4	206.8
16	7975	-0.011	0.014	-0.050	262.1	200.3
17	8425	0.041	0.064	-0.050	243.8	171.5
18	8875	0.111	0.123	-0.050	193.9	116.3
19	9325	0.195	0.181	-0.050	106.2	34.9
20	9775	0.281	0.226	-0.050	-20.3	-66.8
21	10225	0.344	0.246	-0.050	-175.1	-177.3
22	10675	0.344	0.234	-0.050	-329.9	-282.6
23	11125	0.239	0.193	-0.050	-437.6	-369.5

Altitude = 506
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.028	-0.028	-0.050	12.8	12.5
2	1675	-0.033	-0.032	-0.050	27.4	26.8
3	2125	-0.038	-0.036	-0.050	44.4	43.2
4	2575	-0.044	-0.042	-0.050	64.0	62.1

Table 4 - Continued.

5	3025	-0.050	-0.048	-0.050	86.6	83.7
6	3475	-0.057	-0.054	-0.050	112.4	107.8
7	3925	-0.063	-0.057	-0.050	140.6	133.5
8	4375	-0.065	-0.055	-0.050	169.7	158.4
9	4825	-0.058	-0.044	-0.050	196.0	178.1
10	5275	-0.040	-0.019	-0.050	213.9	186.6
11	5725	-0.005	0.023	-0.050	216.0	176.3
12	6175	0.049	0.080	-0.050	193.7	140.4
13	6625	0.122	0.146	-0.050	138.9	74.7
14	7075	0.207	0.211	-0.050	45.7	-20.1
15	7525	0.292	0.259	-0.050	-85.8	-136.8
16	7975	0.349	0.279	-0.050	-242.7	-262.5
17	8425	0.336	0.263	-0.050	-394.1	-380.7
18	8875	0.215	0.213	-0.050	-490.9	-476.8
19	9325	-0.029	0.144	-0.050	-477.8	-541.4
20	9775	-0.362	0.070	-0.050	-314.8	-573.0
21	10225	-0.693	0.008	-0.050	-3.1	-576.8

Altitude = 391
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.058	-0.060	-0.050	26.1	26.9
2	1675	-0.063	-0.063	-0.050	54.7	55.2
3	2125	-0.064	-0.059	-0.050	83.6	82.0
4	2575	-0.057	-0.045	-0.050	109.1	102.3
5	3025	-0.036	-0.015	-0.050	125.3	109.2
6	3475	0.002	0.033	-0.050	124.5	94.5
7	3925	0.058	0.097	-0.050	98.2	51.0
8	4375	0.133	0.170	-0.050	38.3	-25.6
9	4825	0.220	0.242	-0.050	-60.5	-134.3
10	5275	0.302	0.294	-0.050	-196.6	-266.8
11	5725	0.352	0.314	-0.050	-355.1	-408.3
12	6175	0.327	0.293	-0.050	-502.1	-540.3
13	6625	0.188	0.235	-0.050	-586.8	-646.0
14	7075	-0.072	0.154	-0.050	-554.6	-715.2
15	7525	-0.411	0.070	-0.050	-369.6	-746.9
16	7975	-0.730	0.001	-0.050	-41.0	-747.5

Table 4 - Concluded.

Altitude = 275
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.008	0.043	-0.050	-3.8	-19.3
2	1675	0.068	0.113	-0.050	-34.4	-70.3
3	2125	0.145	0.194	-0.050	-99.4	-157.4
4	2575	0.232	0.271	-0.050	-203.7	-279.4
5	3025	0.312	0.329	-0.050	-344.2	-427.5
6	3475	0.354	0.350	-0.050	-503.6	-585.1
7	3925	0.315	0.325	-0.050	-645.3	-731.2
8	4375	0.159	0.257	-0.050	-716.9	-846.6
9	4825	-0.116	0.163	-0.050	-664.9	-920.2
10	5275	-0.460	0.069	-0.050	-458.0	-951.3
11	5725	-0.764	-0.008	-0.050	-114.1	-947.9

Altitude = 159
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.355	0.375	-0.050	-159.6	-168.8
2	1675	0.301	0.346	-0.050	-294.9	-324.7
3	2125	0.127	0.270	-0.050	-352.2	-446.4
4	2575	-0.161	0.167	-0.050	-279.7	-521.6
5	3025	-0.508	0.064	-0.050	-51.3	-550.4
6	3475	-0.794	-0.018	-0.050	306.0	-542.2

Table 5 - Energy Height Display Data with Higher Altitude Pass Through Microburst

Initial altitude = 1500
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = -0.050
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Perf ratio fixed at -0.050

Altitude = 1500
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.003	-0.004	-0.050	1.2	1.7
2	1675	-0.003	-0.004	-0.050	2.5	3.4
3	2125	-0.003	-0.004	-0.050	3.9	5.2
4	2575	-0.003	-0.004	-0.050	5.3	7.0
5	3025	-0.003	-0.004	-0.050	6.8	8.9
6	3475	-0.003	-0.004	-0.050	8.3	10.8
7	3925	-0.004	-0.004	-0.050	9.9	12.8
8	4375	-0.004	-0.005	-0.050	11.5	14.9
9	4825	-0.004	-0.005	-0.050	13.2	17.0
10	5275	-0.004	-0.005	-0.050	15.0	19.2
11	5725	-0.004	-0.005	-0.050	16.9	21.5
12	6175	-0.004	-0.005	-0.050	18.8	23.8
13	6625	-0.005	-0.005	-0.050	20.9	26.2
14	7075	-0.005	-0.005	-0.050	23.0	28.7
15	7525	-0.005	-0.006	-0.050	25.2	31.2
16	7975	-0.005	-0.006	-0.050	27.5	33.9
17	8425	-0.005	-0.006	-0.050	29.8	36.6
18	8875	-0.006	-0.006	-0.050	32.3	39.3
19	9325	-0.006	-0.006	-0.050	34.9	42.2
20	9775	-0.006	-0.007	-0.050	37.6	45.1
21	10225	-0.006	-0.007	-0.050	40.4	48.2
22	10675	-0.006	-0.007	-0.050	43.3	51.3
23	11125	-0.007	-0.007	-0.050	46.4	54.5

Table 5 - Continued.

Altitude = 1384
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.003	-0.004	-0.050	1.5	2.0
2	1675	-0.004	-0.004	-0.050	3.1	4.0
3	2125	-0.004	-0.005	-0.050	4.8	6.0
4	2575	-0.004	-0.005	-0.050	6.5	8.2
5	3025	-0.004	-0.005	-0.050	8.3	10.4
6	3475	-0.004	-0.005	-0.050	10.2	12.7
7	3925	-0.004	-0.005	-0.050	12.2	15.0
8	4375	-0.005	-0.005	-0.050	14.2	17.4
9	4825	-0.005	-0.006	-0.050	16.3	19.9
10	5275	-0.005	-0.006	-0.050	18.5	22.5
11	5725	-0.005	-0.006	-0.050	20.8	25.1
12	6175	-0.005	-0.006	-0.050	23.2	27.8
13	6625	-0.006	-0.006	-0.050	25.7	30.6
14	7075	-0.006	-0.006	-0.050	28.3	33.5
15	7525	-0.006	-0.007	-0.050	31.0	36.4
16	7975	-0.006	-0.007	-0.050	33.8	39.5
17	8425	-0.007	-0.007	-0.050	36.8	42.6
18	8875	-0.007	-0.007	-0.050	39.8	45.8
19	9325	-0.007	-0.009	-0.050	43.0	49.8
20	9775	-0.007	-0.017	-0.050	46.4	57.3
21	10225	-0.008	-0.018	-0.050	50.1	65.6
22	10675	-0.009	-0.020	-0.050	54.3	74.7
23	11125	-0.010	-0.023	-0.050	59.0	84.9

Altitude = 1269
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.004	-0.005	-0.050	1.9	2.3
2	1675	-0.004	-0.005	-0.050	3.9	4.6
3	2125	-0.005	-0.005	-0.050	5.9	7.1
4	2575	-0.005	-0.006	-0.050	8.0	9.5
5	3025	-0.005	-0.006	-0.050	10.3	12.1
6	3475	-0.005	-0.006	-0.050	12.6	14.8
7	3925	-0.005	-0.006	-0.050	15.0	17.5

Table 5 - Continued.

8	4375	-0.006	-0.006	-0.050	17.5	20.3
9	4825	-0.006	-0.006	-0.050	20.1	23.2
10	5275	-0.006	-0.007	-0.050	22.8	26.1
11	5725	-0.006	-0.007	-0.050	25.7	29.2
12	6175	-0.007	-0.007	-0.050	28.6	32.3
13	6625	-0.007	-0.007	-0.050	31.7	35.6
14	7075	-0.007	-0.010	-0.050	34.9	40.1
15	7525	-0.008	-0.017	-0.050	38.3	47.7
16	7975	-0.008	-0.019	-0.050	42.1	56.1
17	8425	-0.009	-0.021	-0.050	46.4	65.4
18	8875	-0.011	-0.023	-0.050	51.2	75.8
19	9325	-0.012	-0.026	-0.050	56.6	87.4
20	9775	-0.014	-0.029	-0.050	62.8	100.5
21	10225	-0.016	-0.033	-0.050	69.8	115.3
22	10675	-0.018	-0.038	-0.050	78.0	132.2
23	11125	-0.021	-0.043	-0.050	87.4	151.7

Altitude = 1153
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.005	-0.006	-0.050	2.3	2.7
2	1675	-0.005	-0.006	-0.050	4.8	5.4
3	2125	-0.006	-0.006	-0.050	7.3	8.2
4	2575	-0.006	-0.006	-0.050	9.9	11.1
5	3025	-0.006	-0.007	-0.050	12.6	14.1
6	3475	-0.006	-0.007	-0.050	15.5	17.1
7	3925	-0.007	-0.007	-0.050	18.5	20.3
8	4375	-0.007	-0.007	-0.050	21.5	23.5
9	4825	-0.007	-0.011	-0.050	24.8	28.7
10	5275	-0.008	-0.017	-0.050	28.2	36.4
11	5725	-0.009	-0.019	-0.050	32.1	44.8
12	6175	-0.010	-0.021	-0.050	36.4	54.3
13	6625	-0.011	-0.023	-0.050	41.3	64.8
14	7075	-0.012	-0.026	-0.050	46.8	76.6
15	7525	-0.014	-0.030	-0.050	53.1	89.9
16	7975	-0.016	-0.034	-0.050	60.3	105.1
17	8425	-0.018	-0.038	-0.050	68.6	122.3
18	8875	-0.021	-0.044	-0.050	78.2	142.2
19	9325	-0.025	-0.051	-0.050	89.4	165.1
20	9775	-0.029	-0.059	-0.050	102.3	191.6
21	10225	-0.033	-0.067	-0.050	117.1	221.9
22	10675	-0.036	-0.075	-0.050	133.5	255.7
23	11125	-0.037	-0.080	-0.050	150.3	291.6

Table 5 - Continued.

Altitude = 1037
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.006	-0.007	-0.050	2.9	3.1
2	1675	-0.007	-0.007	-0.050	5.8	6.2
3	2125	-0.007	-0.007	-0.050	9.0	9.5
4	2575	-0.007	-0.013	-0.050	12.2	15.2
5	3025	-0.008	-0.017	-0.050	15.7	23.0
6	3475	-0.009	-0.019	-0.050	19.6	31.6
7	3925	-0.010	-0.021	-0.050	24.0	41.2
8	4375	-0.011	-0.024	-0.050	29.0	51.9
9	4825	-0.013	-0.027	-0.050	34.6	63.9
10	5275	-0.014	-0.030	-0.050	41.0	77.4
11	5725	-0.016	-0.034	-0.050	48.4	92.8
12	6175	-0.019	-0.039	-0.050	56.8	110.4
13	6625	-0.022	-0.045	-0.050	66.6	130.6
14	7075	-0.025	-0.052	-0.050	78.0	154.0
15	7525	-0.029	-0.060	-0.050	91.2	181.0
16	7975	-0.033	-0.069	-0.050	106.3	211.9
17	8425	-0.037	-0.076	-0.050	122.8	246.1
18	8875	-0.037	-0.080	-0.050	139.5	282.1
19	9325	-0.032	-0.076	-0.050	153.7	316.2
20	9775	-0.016	-0.058	-0.050	160.8	342.3
21	10225	0.014	-0.023	-0.050	154.5	352.5
22	10675	0.061	0.033	-0.050	127.2	337.7
23	11125	0.123	0.105	-0.050	72.0	290.6

Altitude = 922
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.009	-0.019	-0.050	4.0	8.7
2	1675	-0.010	-0.022	-0.050	8.5	18.5
3	2125	-0.011	-0.024	-0.050	13.5	29.3
4	2575	-0.013	-0.027	-0.050	19.2	41.5
5	3025	-0.015	-0.031	-0.050	25.8	55.3
6	3475	-0.017	-0.035	-0.050	33.3	71.0
7	3925	-0.019	-0.040	-0.050	41.9	88.9

Table 5 - Continued.

8	4375	-0.022	-0.046	-0.050	51.9	109.6
9	4825	-0.026	-0.053	-0.050	63.5	133.4
10	5275	-0.030	-0.061	-0.050	77.0	161.0
11	5725	-0.034	-0.070	-0.050	92.3	192.3
12	6175	-0.037	-0.077	-0.050	108.9	227.0
13	6625	-0.037	-0.080	-0.050	125.5	262.9
14	7075	-0.030	-0.074	-0.050	139.0	296.3
15	7525	-0.013	-0.054	-0.050	144.7	320.8
16	7975	0.020	-0.016	-0.050	135.9	328.0
17	8425	0.068	0.042	-0.050	105.1	309.1
18	8875	0.132	0.116	-0.050	45.6	257.1
19	9325	0.205	0.195	-0.050	-46.4	169.3
20	9775	0.275	0.266	-0.050	-170.0	49.4
21	10225	0.328	0.314	-0.050	-317.6	-91.7
22	10675	0.351	0.324	-0.050	-475.5	-237.6
23	11125	0.335	0.294	-0.050	-626.2	-369.8

Altitude = 806
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.017	-0.035	-0.050	7.6	16.0
2	1675	-0.020	-0.041	-0.050	16.4	34.2
3	2125	-0.023	-0.047	-0.050	26.7	55.3
4	2575	-0.026	-0.054	-0.050	38.5	79.7
5	3025	-0.030	-0.062	-0.050	52.2	107.7
6	3475	-0.034	-0.071	-0.050	67.8	139.6
7	3925	-0.037	-0.078	-0.050	84.5	174.6
8	4375	-0.036	-0.080	-0.050	100.9	210.5
9	4825	-0.028	-0.072	-0.050	113.6	243.0
10	5275	-0.009	-0.050	-0.050	117.7	265.6
11	5725	0.025	-0.009	-0.050	106.3	269.7
12	6175	0.076	0.051	-0.050	71.9	246.6
13	6625	0.142	0.127	-0.050	8.1	189.7
14	7075	0.215	0.206	-0.050	-88.6	97.0
15	7525	0.283	0.275	-0.050	-216.1	-26.6
16	7975	0.333	0.318	-0.050	-366.1	-169.5
17	8425	0.351	0.322	-0.050	-524.0	-314.6
18	8875	0.330	0.287	-0.050	-672.3	-443.5
19	9325	0.272	0.219	-0.050	-794.9	-542.1
20	9775	0.194	0.138	-0.050	-882.2	-604.0
21	10225	0.112	0.061	-0.050	-932.8	-631.5
22	10675	0.044	0.002	-0.050	-952.5	-632.4
23	11125	-0.004	-0.035	-0.050	-950.7	-616.6

Table 5 - Continued.

Altitude = 691
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	-0.035	-0.072	-0.050	15.7	32.4
2	1675	-0.037	-0.078	-0.050	32.6	67.6
3	2125	-0.036	-0.079	-0.050	48.6	103.4
4	2575	-0.026	-0.070	-0.050	60.5	135.0
5	3025	-0.005	-0.046	-0.050	62.9	155.6
6	3475	0.031	-0.002	-0.050	48.8	156.4
7	3925	0.085	0.061	-0.050	10.6	128.9
8	4375	0.152	0.138	-0.050	-57.7	66.9
9	4825	0.225	0.216	-0.050	-158.9	-30.5
10	5275	0.292	0.283	-0.050	-290.2	-157.6
11	5725	0.338	0.321	-0.050	-442.2	-301.9
12	6175	0.350	0.320	-0.050	-600.0	-445.8
13	6625	0.324	0.279	-0.050	-745.5	-571.2
14	7075	0.262	0.208	-0.050	-863.6	-664.8
15	7525	0.182	0.126	-0.050	-945.6	-721.7
16	7975	0.102	0.052	-0.050	-991.5	-744.9
17	8425	0.036	-0.004	-0.050	-1007.7	-742.9
18	8875	-0.009	-0.039	-0.050	-1003.5	-725.5
19	9325	-0.035	-0.055	-0.050	-987.8	-700.7
20	9775	-0.046	-0.060	-0.050	-967.1	-673.8
21	10225	-0.050	-0.060	-0.050	-944.8	-646.8
22	10675	-0.050	-0.059	-0.050	-922.2	-620.2
23	11125	-0.052	-0.062	-0.050	-899.0	-592.4

Altitude = 575
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.038	0.006	-0.050	-17.0	-2.6
2	1675	0.093	0.071	-0.050	-59.1	-34.7
3	2125	0.162	0.149	-0.050	-131.9	-101.6
4	2575	0.235	0.227	-0.050	-237.6	-203.6
5	3025	0.300	0.290	-0.050	-372.5	-334.1
6	3475	0.342	0.323	-0.050	-526.3	-479.5
7	3925	0.349	0.316	-0.050	-683.4	-621.8

Table 5 - Continued.

8	4375	0.317	0.270	-0.050	-826.0	-743.4
9	4825	0.252	0.197	-0.050	-939.4	-832.0
10	5275	0.171	0.115	-0.050	-1016.2	-883.8
11	5725	0.092	0.043	-0.050	-1057.4	-903.0
12	6175	0.028	-0.010	-0.050	-1070.2	-898.3
13	6625	-0.014	-0.042	-0.050	-1064.0	-879.4
14	7075	-0.037	-0.056	-0.050	-1047.3	-854.1
15	7525	-0.047	-0.060	-0.050	-1026.1	-827.1
16	7975	-0.050	-0.060	-0.050	-1003.8	-800.2
17	8425	-0.050	-0.059	-0.050	-981.2	-773.5
18	8875	-0.052	-0.063	-0.050	-957.7	-745.3
19	9325	-0.058	-0.072	-0.050	-931.5	-712.9
20	9775	-0.072	-0.091	-0.050	-899.2	-672.1
21	10225	-0.095	-0.123	-0.050	-856.3	-616.9
22	10675	-0.135	-0.174	-0.050	-795.8	-538.7
23	11125	-0.196	-0.250	-0.050	-707.8	-426.1

Altitude = 459
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.345	0.325	-0.050	-155.3	-146.0
2	1675	0.347	0.312	-0.050	-311.5	-286.5
3	2125	0.309	0.261	-0.050	-450.7	-404.1
4	2575	0.241	0.186	-0.050	-559.3	-487.6
5	3025	0.159	0.104	-0.050	-630.9	-534.5
6	3475	0.082	0.034	-0.050	-667.7	-549.7
7	3925	0.021	-0.016	-0.050	-677.2	-542.5
8	4375	-0.018	-0.045	-0.050	-669.0	-522.4
9	4825	-0.039	-0.057	-0.050	-651.4	-496.6
10	5275	-0.048	-0.060	-0.050	-630.0	-469.5
11	5725	-0.050	-0.060	-0.050	-607.6	-442.7
12	6175	-0.050	-0.060	-0.050	-584.9	-415.9
13	6625	-0.053	-0.063	-0.050	-561.2	-387.4
14	7075	-0.060	-0.074	-0.050	-534.4	-354.1
15	7525	-0.074	-0.094	-0.050	-501.0	-311.6
16	7975	-0.100	-0.129	-0.050	-456.1	-253.8
17	8425	-0.142	-0.183	-0.050	-392.4	-171.6
18	8875	-0.206	-0.263	-0.050	-299.6	-53.2
19	9325	-0.300	-0.376	-0.050	-164.8	116.0

Table 5 - Concluded.

Altitude = 344
Distance flown = 23126
Range to core = -1126
Time = 100

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-Eh Error	Est-Eh Error
1	1225	0.072	0.026	-0.050	-32.4	-11.5
2	1675	0.015	-0.021	-0.050	-39.0	-2.0
3	2125	-0.022	-0.047	-0.050	-29.1	19.3
4	2575	-0.041	-0.058	-0.050	-10.6	45.5
5	3025	-0.048	-0.060	-0.050	11.1	72.6
6	3475	-0.050	-0.059	-0.050	33.5	99.3
7	3925	-0.050	-0.060	-0.050	56.2	126.2
8	4375	-0.053	-0.064	-0.050	80.2	155.2
9	4825	-0.061	-0.076	-0.050	107.7	189.5
10	5275	-0.077	-0.098	-0.050	142.4	233.6
11	5725	-0.104	-0.135	-0.050	189.4	294.2
12	6175	-0.149	-0.192	-0.050	256.5	380.7
13	6625	-0.217	-0.277	-0.050	354.2	505.3
14	7075	-0.315	-0.394	-0.050	496.0	682.6

Table 6 - Airspeed Deviation Display Data with Fixed-Thrust Assumption

Initial altitude = 1200
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = -0.050
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Perf ratio fixed at -0.050

Altitude = 1200
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.005	-0.006	-0.050	0.2	0.2
2	1675	-0.005	-0.006	-0.050	0.4	0.4
3	2125	-0.005	-0.006	-0.050	0.6	0.6
4	2575	-0.005	-0.006	-0.050	0.8	0.9
5	3025	-0.006	-0.006	-0.050	1.0	1.1
6	3475	-0.006	-0.006	-0.050	1.2	1.4
7	3925	-0.006	-0.007	-0.050	1.4	1.6
8	4375	-0.006	-0.007	-0.050	1.7	1.9
9	4825	-0.007	-0.007	-0.050	1.9	2.1
10	5275	-0.007	-0.007	-0.050	2.2	2.4
11	5725	-0.007	-0.007	-0.050	2.4	2.7
12	6175	-0.007	-0.008	-0.050	2.7	3.0
13	6625	-0.008	-0.008	-0.050	3.0	3.3
14	7075	-0.008	-0.008	-0.050	3.3	3.6
15	7525	-0.008	-0.008	-0.050	3.6	3.9
16	7975	-0.009	-0.008	-0.050	4.0	4.2
17	8425	-0.009	-0.009	-0.050	4.3	4.5
18	8875	-0.009	-0.009	-0.050	4.7	4.9
19	9325	-0.010	-0.009	-0.050	5.1	5.2
20	9775	-0.010	-0.009	-0.050	5.5	5.6
21	10225	-0.011	-0.010	-0.050	5.9	6.0
22	10675	-0.011	-0.010	-0.050	6.3	6.4
23	11125	-0.012	-0.010	-0.050	6.7	6.7

Table 6 - Continued.

Altitude = 1084
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.006	-0.006	-0.050	0.2	0.2
2	1675	-0.006	-0.007	-0.050	0.5	0.5
3	2125	-0.006	-0.007	-0.050	0.7	0.8
4	2575	-0.007	-0.007	-0.050	0.9	1.0
5	3025	-0.007	-0.007	-0.050	1.2	1.3
6	3475	-0.007	-0.007	-0.050	1.5	1.6
7	3925	-0.007	-0.008	-0.050	1.8	1.9
8	4375	-0.008	-0.008	-0.050	2.1	2.2
9	4825	-0.008	-0.008	-0.050	2.4	2.5
10	5275	-0.008	-0.008	-0.050	2.7	2.8
11	5725	-0.009	-0.009	-0.050	3.0	3.1
12	6175	-0.009	-0.009	-0.050	3.4	3.4
13	6625	-0.009	-0.009	-0.050	3.7	3.8
14	7075	-0.010	-0.009	-0.050	4.1	4.1
15	7525	-0.010	-0.009	-0.050	4.5	4.5
16	7975	-0.011	-0.010	-0.050	4.9	4.9
17	8425	-0.011	-0.010	-0.050	5.3	5.3
18	8875	-0.012	-0.010	-0.050	5.8	5.7
19	9325	-0.012	-0.013	-0.050	6.3	6.1
20	9775	-0.013	-0.023	-0.050	6.7	7.1
21	10225	-0.014	-0.026	-0.050	7.3	8.1
22	10675	-0.016	-0.029	-0.050	7.9	9.2
23	11125	-0.018	-0.032	-0.050	8.6	10.4

Altitude = 969
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.007	-0.007	-0.050	0.3	0.3
2	1675	-0.007	-0.008	-0.050	0.6	0.6
3	2125	-0.008	-0.008	-0.050	0.9	0.9
4	2575	-0.008	-0.008	-0.050	1.2	1.2
5	3025	-0.008	-0.008	-0.050	1.5	1.5
6	3475	-0.009	-0.009	-0.050	1.8	1.8

Table 6 - Continued.

7	3925	-0.009	-0.009	-0.050	2.2	2.2
8	4375	-0.010	-0.009	-0.050	2.5	2.5
9	4825	-0.010	-0.009	-0.050	2.9	2.9
10	5275	-0.010	-0.009	-0.050	3.3	3.2
11	5725	-0.011	-0.010	-0.050	3.7	3.6
12	6175	-0.011	-0.010	-0.050	4.2	4.0
13	6625	-0.012	-0.010	-0.050	4.6	4.4
14	7075	-0.012	-0.014	-0.050	5.1	4.9
15	7525	-0.013	-0.024	-0.050	5.6	5.9
16	7975	-0.014	-0.026	-0.050	6.1	6.9
17	8425	-0.016	-0.029	-0.050	6.8	8.0
18	8875	-0.018	-0.032	-0.050	7.5	9.3
19	9325	-0.020	-0.036	-0.050	8.3	10.7
20	9775	-0.023	-0.040	-0.050	9.2	12.3
21	10225	-0.026	-0.045	-0.050	10.3	14.1
22	10675	-0.030	-0.051	-0.050	11.5	16.2
23	11125	-0.035	-0.058	-0.050	12.9	18.5

Altitude = 853
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.009	-0.009	-0.050	0.3	0.3
2	1675	-0.009	-0.009	-0.050	0.7	0.7
3	2125	-0.010	-0.009	-0.050	1.1	1.0
4	2575	-0.010	-0.009	-0.050	1.4	1.4
5	3025	-0.010	-0.010	-0.050	1.8	1.7
6	3475	-0.011	-0.010	-0.050	2.3	2.1
7	3925	-0.011	-0.010	-0.050	2.7	2.5
8	4375	-0.012	-0.010	-0.050	3.1	2.9
9	4825	-0.012	-0.016	-0.050	3.6	3.5
10	5275	-0.013	-0.024	-0.050	4.1	4.4
11	5725	-0.015	-0.027	-0.050	4.7	5.5
12	6175	-0.016	-0.029	-0.050	5.3	6.6
13	6625	-0.018	-0.033	-0.050	6.0	7.9
14	7075	-0.021	-0.036	-0.050	6.9	9.3
15	7525	-0.024	-0.041	-0.050	7.8	11.0
16	7975	-0.027	-0.046	-0.050	8.9	12.8
17	8425	-0.031	-0.052	-0.050	10.1	14.9
18	8875	-0.035	-0.059	-0.050	11.6	17.3
19	9325	-0.041	-0.068	-0.050	13.3	20.2

Table 6 - Continued.

20	9775	-0.047	-0.078	-0.050	15.3	23.4
21	10225	-0.054	-0.088	-0.050	17.6	27.2
22	10675	-0.061	-0.096	-0.050	20.3	31.4
23	11125	-0.065	-0.100	-0.050	23.2	35.9

Altitude = 737
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.011	-0.010	-0.050	0.4	0.4
2	1675	-0.011	-0.010	-0.050	0.9	0.8
3	2125	-0.012	-0.010	-0.050	1.3	1.2
4	2575	-0.012	-0.018	-0.050	1.8	1.9
5	3025	-0.013	-0.024	-0.050	2.3	2.8
6	3475	-0.015	-0.027	-0.050	2.9	3.8
7	3925	-0.017	-0.030	-0.050	3.5	5.0
8	4375	-0.019	-0.033	-0.050	4.3	6.3
9	4825	-0.021	-0.037	-0.050	5.1	7.8
10	5275	-0.024	-0.041	-0.050	6.0	9.4
11	5725	-0.027	-0.047	-0.050	7.1	11.3
12	6175	-0.031	-0.053	-0.050	8.4	13.5
13	6625	-0.036	-0.060	-0.050	9.9	15.9
14	7075	-0.042	-0.069	-0.050	11.6	18.8
15	7525	-0.048	-0.079	-0.050	13.7	22.1
16	7975	-0.055	-0.089	-0.050	16.1	26.0
17	8425	-0.062	-0.097	-0.050	18.8	30.2
18	8875	-0.065	-0.100	-0.050	21.7	34.7
19	9325	-0.061	-0.092	-0.050	24.5	39.0
20	9775	-0.047	-0.067	-0.050	26.7	42.2
21	10225	-0.016	-0.022	-0.050	27.5	43.3
22	10675	0.033	0.046	-0.050	25.9	41.0
23	11125	0.100	0.131	-0.050	21.1	34.7

Table 6 - Continued.

Altitude = 622
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.015	-0.027	-0.050	0.6	1.1
2	1675	-0.017	-0.030	-0.050	1.2	2.2
3	2125	-0.019	-0.034	-0.050	2.0	3.6
4	2575	-0.021	-0.037	-0.050	2.8	5.1
5	3025	-0.024	-0.042	-0.050	3.8	6.7
6	3475	-0.028	-0.048	-0.050	4.9	8.6
7	3925	-0.032	-0.054	-0.050	6.2	10.8
8	4375	-0.037	-0.062	-0.050	7.7	13.4
9	4825	-0.043	-0.070	-0.050	9.5	16.3
10	5275	-0.049	-0.080	-0.050	11.6	19.7
11	5725	-0.056	-0.090	-0.050	14.0	23.6
12	6175	-0.062	-0.098	-0.050	16.8	27.9
13	6625	-0.065	-0.099	-0.050	19.7	32.4
14	7075	-0.060	-0.090	-0.050	22.5	36.6
15	7525	-0.043	-0.062	-0.050	24.6	39.6
16	7975	-0.011	-0.014	-0.050	25.1	40.2
17	8425	0.041	0.057	-0.050	23.1	37.5
18	8875	0.111	0.144	-0.050	17.8	30.5
19	9325	0.195	0.238	-0.050	6.5	17.4
20	9775	0.281	0.317	-0.050	-7.5	1.8
21	10225	0.344	0.352	-0.050	-22.8	-13.8
22	10675	0.344	0.302	-0.050	-36.8	-26.3
23	11125	0.239	0.133	-0.050	-46.4	-32.4

Altitude = 506
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.028	-0.048	-0.050	1.1	1.9
2	1675	-0.033	-0.055	-0.050	2.5	4.2
3	2125	-0.038	-0.063	-0.050	4.0	6.8
4	2575	-0.044	-0.072	-0.050	5.8	9.8

Table 6 - Continued.

5	3025	-0.050	-0.082	-0.050	8.0	13.2
6	3475	-0.057	-0.092	-0.050	10.4	17.2
7	3925	-0.063	-0.099	-0.050	13.2	21.5
8	4375	-0.065	-0.099	-0.050	16.2	26.0
9	4825	-0.058	-0.087	-0.050	18.9	30.1
10	5275	-0.040	-0.057	-0.050	20.8	32.9
11	5725	-0.005	-0.005	-0.050	21.0	33.1
12	6175	0.049	0.068	-0.050	18.6	29.8
13	6625	0.122	0.157	-0.050	12.8	19.9
14	7075	0.207	0.250	-0.050	1.1	6.3
15	7525	0.292	0.326	-0.050	-13.2	-9.5
16	7975	0.349	0.351	-0.050	-28.5	-24.8
17	8425	0.336	0.286	-0.050	-42.1	-36.6
18	8875	0.215	0.100	-0.050	-50.8	-41.6
19	9325	-0.029	-0.206	-0.050	-51.5	-36.5
20	9775	-0.362	-0.581	-0.050	-41.0	-18.6
21	10225	-0.693	-0.918	-0.050	-16.1	15.0

Altitude = 391
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.058	-0.093	-0.050	2.5	4.0
2	1675	-0.063	-0.099	-0.050	5.3	8.4
3	2125	-0.064	-0.098	-0.050	8.3	12.9
4	2575	-0.057	-0.084	-0.050	10.9	16.8
5	3025	-0.036	-0.051	-0.050	12.7	19.3
6	3475	0.002	0.004	-0.050	12.6	19.1
7	3925	0.058	0.079	-0.050	9.7	15.2
8	4375	0.133	0.170	-0.050	3.4	4.8
9	4825	0.220	0.262	-0.050	-8.7	-9.3
10	5275	0.302	0.333	-0.050	-23.3	-25.1
11	5725	0.352	0.349	-0.050	-38.5	-40.2
12	6175	0.327	0.268	-0.050	-51.6	-51.2
13	6625	0.188	0.064	-0.050	-59.4	-55.0
14	7075	-0.072	-0.256	-0.050	-58.7	-48.3
15	7525	-0.411	-0.633	-0.050	-46.4	-28.4
16	7975	-0.730	-0.953	-0.050	-19.3	7.6

Table 6 - Concluded.

Altitude = 275
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.008	0.013	-0.050	-0.4	-0.6
2	1675	0.068	0.091	-0.050	-3.7	-5.1
3	2125	0.145	0.183	-0.050	-10.6	-16.1
4	2575	0.232	0.274	-0.050	-23.1	-30.5
5	3025	0.312	0.340	-0.050	-37.9	-46.5
6	3475	0.354	0.344	-0.050	-53.0	-61.2
7	3925	0.315	0.247	-0.050	-65.5	-71.4
8	4375	0.159	0.025	-0.050	-72.4	-73.9
9	4825	-0.116	-0.307	-0.050	-70.2	-65.5
10	5275	-0.460	-0.684	-0.050	-56.0	-43.5
11	5725	-0.764	-0.983	-0.050	-26.6	-5.1

Altitude = 159
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.355	0.337	-0.050	-14.9	-14.3
2	1675	0.301	0.224	-0.050	-26.9	-23.6
3	2125	0.127	-0.015	-0.050	-32.6	-24.7
4	2575	-0.161	-0.359	-0.050	-29.0	-14.7
5	3025	-0.508	-0.734	-0.050	-12.9	9.4
6	3475	-0.794	-1.007	-0.050	19.0	50.4

Table 7 - Airspeed Deviation Display Data with Autothrottle Assumption

Initial altitude = 1200
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = -0.050
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Autothrottle used from -0.070 to 0.050 perf ratio

Altitude = 1200
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.005	-0.006	-0.056	0.0	0.0
2	1675	-0.005	-0.006	-0.056	0.0	0.0
3	2125	-0.005	-0.006	-0.056	0.0	0.0
4	2575	-0.005	-0.006	-0.056	0.0	0.0
5	3025	-0.006	-0.006	-0.056	0.0	0.0
6	3475	-0.006	-0.006	-0.056	0.0	0.0
7	3925	-0.006	-0.007	-0.057	0.0	0.0
8	4375	-0.006	-0.007	-0.057	0.0	0.0
9	4825	-0.007	-0.007	-0.057	0.0	0.0
10	5275	-0.007	-0.007	-0.057	0.0	0.0
11	5725	-0.007	-0.007	-0.057	0.0	0.0
12	6175	-0.007	-0.008	-0.058	0.0	0.0
13	6625	-0.008	-0.008	-0.058	0.0	0.0
14	7075	-0.008	-0.008	-0.058	0.0	0.0
15	7525	-0.008	-0.008	-0.058	0.0	0.0
16	7975	-0.009	-0.008	-0.058	0.0	0.0
17	8425	-0.009	-0.009	-0.059	0.0	0.0
18	8875	-0.009	-0.009	-0.059	0.0	0.0
19	9325	-0.010	-0.009	-0.059	0.0	0.0
20	9775	-0.010	-0.009	-0.059	0.0	0.0
21	10225	-0.011	-0.010	-0.060	0.0	0.0
22	10675	-0.011	-0.010	-0.060	0.0	0.0
23	11125	-0.012	-0.010	-0.060	0.0	0.0

Table 7 - Continued.

Altitude = 1084
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.006	-0.006	-0.056	0.0	0.0
2	1675	-0.006	-0.007	-0.057	0.0	0.0
3	2125	-0.006	-0.007	-0.057	0.0	0.0
4	2575	-0.007	-0.007	-0.057	0.0	0.0
5	3025	-0.007	-0.007	-0.057	0.0	0.0
6	3475	-0.007	-0.007	-0.057	0.0	0.0
7	3925	-0.007	-0.008	-0.058	0.0	0.0
8	4375	-0.008	-0.008	-0.058	0.0	0.0
9	4825	-0.008	-0.008	-0.058	0.0	0.0
10	5275	-0.008	-0.008	-0.058	0.0	0.0
11	5725	-0.009	-0.009	-0.059	0.0	0.0
12	6175	-0.009	-0.009	-0.059	0.0	0.0
13	6625	-0.009	-0.009	-0.059	0.0	0.0
14	7075	-0.010	-0.009	-0.059	0.0	0.0
15	7525	-0.010	-0.009	-0.059	0.0	0.0
16	7975	-0.011	-0.010	-0.060	0.0	0.0
17	8425	-0.011	-0.010	-0.060	0.0	0.0
18	8875	-0.012	-0.010	-0.060	0.0	0.0
19	9325	-0.012	-0.013	-0.063	0.0	0.0
20	9775	-0.013	-0.023	-0.070	0.0	0.1
21	10225	-0.014	-0.026	-0.070	0.0	0.4
22	10675	-0.016	-0.029	-0.070	0.0	0.7
23	11125	-0.018	-0.032	-0.070	0.0	1.2

Altitude = 969
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.007	-0.007	-0.057	0.0	0.0
2	1675	-0.007	-0.008	-0.058	0.0	0.0
3	2125	-0.008	-0.008	-0.058	0.0	0.0
4	2575	-0.008	-0.008	-0.058	0.0	0.0
5	3025	-0.008	-0.008	-0.058	0.0	0.0

Table 7 - Continued.

6	3475	-0.009	-0.009	-0.059	0.0	0.0
7	3925	-0.009	-0.009	-0.059	0.0	0.0
8	4375	-0.010	-0.009	-0.059	0.0	0.0
9	4825	-0.010	-0.009	-0.059	0.0	0.0
10	5275	-0.010	-0.009	-0.059	0.0	0.0
11	5725	-0.011	-0.010	-0.060	0.0	0.0
12	6175	-0.011	-0.010	-0.060	0.0	0.0
13	6625	-0.012	-0.010	-0.060	0.0	0.0
14	7075	-0.012	-0.014	-0.064	0.0	0.0
15	7525	-0.013	-0.024	-0.070	0.0	0.1
16	7975	-0.014	-0.026	-0.070	0.0	0.4
17	8425	-0.016	-0.029	-0.070	0.0	0.7
18	8875	-0.018	-0.032	-0.070	0.0	1.2
19	9325	-0.020	-0.036	-0.070	0.0	1.8
20	9775	-0.023	-0.040	-0.070	0.1	2.6
21	10225	-0.026	-0.045	-0.070	0.4	3.6
22	10675	-0.030	-0.051	-0.070	0.8	4.9
23	11125	-0.035	-0.058	-0.070	1.4	6.5

Altitude = 853
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.009	-0.009	-0.059	0.0	0.0
2	1675	-0.009	-0.009	-0.059	0.0	0.0
3	2125	-0.010	-0.009	-0.059	0.0	0.0
4	2575	-0.010	-0.009	-0.059	0.0	0.0
5	3025	-0.010	-0.010	-0.060	0.0	0.0
6	3475	-0.011	-0.010	-0.060	0.0	0.0
7	3925	-0.011	-0.010	-0.060	0.0	0.0
8	4375	-0.012	-0.010	-0.060	0.0	0.0
9	4825	-0.012	-0.016	-0.066	0.0	0.0
10	5275	-0.013	-0.024	-0.070	0.0	0.2
11	5725	-0.015	-0.027	-0.070	0.0	0.4
12	6175	-0.016	-0.029	-0.070	0.0	0.8
13	6625	-0.018	-0.033	-0.070	0.0	1.3
14	7075	-0.021	-0.036	-0.070	0.0	1.9
15	7525	-0.024	-0.041	-0.070	0.2	2.7
16	7975	-0.027	-0.046	-0.070	0.4	3.8
17	8425	-0.031	-0.052	-0.070	0.9	5.1
18	8875	-0.035	-0.059	-0.070	1.5	6.7

Table 7 - Continued.

19	9325	-0.041	-0.068	-0.070	2.4	8.7
20	9775	-0.047	-0.078	-0.070	3.5	11.1
21	10225	-0.054	-0.088	-0.070	5.0	14.0
22	10675	-0.061	-0.096	-0.070	6.8	17.3
23	11125	-0.065	-0.100	-0.070	8.8	20.9

Altitude = 737
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.011	-0.010	-0.060	0.0	0.0
2	1675	-0.011	-0.010	-0.060	0.0	0.0
3	2125	-0.012	-0.010	-0.060	0.0	0.0
4	2575	-0.012	-0.018	-0.068	0.0	0.0
5	3025	-0.013	-0.024	-0.070	0.0	0.2
6	3475	-0.015	-0.027	-0.070	0.0	0.4
7	3925	-0.017	-0.030	-0.070	0.0	0.8
8	4375	-0.019	-0.033	-0.070	0.0	1.3
9	4825	-0.021	-0.037	-0.070	0.0	2.0
10	5275	-0.024	-0.041	-0.070	0.2	2.9
11	5725	-0.027	-0.047	-0.070	0.5	3.9
12	6175	-0.031	-0.053	-0.070	1.0	5.3
13	6625	-0.036	-0.060	-0.070	1.6	6.9
14	7075	-0.042	-0.069	-0.070	2.5	9.0
15	7525	-0.048	-0.079	-0.070	3.7	11.5
16	7975	-0.055	-0.089	-0.070	5.2	14.4
17	8425	-0.062	-0.097	-0.070	7.1	17.8
18	8875	-0.065	-0.100	-0.070	9.1	21.4
19	9325	-0.061	-0.092	-0.070	11.0	24.7
20	9775	-0.047	-0.067	-0.070	12.3	27.0
21	10225	-0.016	-0.022	-0.070	12.3	27.1
22	10675	0.033	0.046	-0.004	12.3	27.1
23	11125	0.100	0.131	0.050	12.3	25.6

Table 7 - Continued.

Altitude = 622
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.015	-0.027	-0.070	0.0	0.3
2	1675	-0.017	-0.030	-0.070	0.0	0.7
3	2125	-0.019	-0.034	-0.070	0.0	1.2
4	2575	-0.021	-0.037	-0.070	0.1	1.9
5	3025	-0.024	-0.042	-0.070	0.2	2.8
6	3475	-0.028	-0.048	-0.070	0.5	3.9
7	3925	-0.032	-0.054	-0.070	1.0	5.3
8	4375	-0.037	-0.062	-0.070	1.7	7.0
9	4825	-0.043	-0.070	-0.070	2.7	9.1
10	5275	-0.049	-0.080	-0.070	3.9	11.6
11	5725	-0.056	-0.090	-0.070	5.5	14.7
12	6175	-0.062	-0.098	-0.070	7.3	18.1
13	6625	-0.065	-0.099	-0.070	9.4	21.7
14	7075	-0.060	-0.090	-0.070	11.2	24.9
15	7525	-0.043	-0.062	-0.070	12.3	27.0
16	7975	-0.011	-0.014	-0.064	12.3	27.0
17	8425	0.041	0.057	0.007	12.3	27.0
18	8875	0.111	0.144	0.050	11.8	24.9
19	9325	0.195	0.238	0.050	5.2	16.3
20	9775	0.281	0.317	0.050	-4.6	4.9
21	10225	0.344	0.352	0.050	-16.0	-6.8
22	10675	0.344	0.302	0.050	-26.4	-15.7
23	11125	0.239	0.133	0.050	-32.7	-18.5

Altitude = 506
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.028	-0.048	-0.070	0.3	1.1
2	1675	-0.033	-0.055	-0.070	0.8	2.6
3	2125	-0.038	-0.063	-0.070	1.6	4.3
4	2575	-0.044	-0.072	-0.070	2.6	6.5
5	3025	-0.050	-0.082	-0.070	3.8	9.1

Table 7 - Continued.

6	3475	-0.057	-0.092	-0.070	5.5	12.2
7	3925	-0.063	-0.099	-0.070	7.3	15.7
8	4375	-0.065	-0.099	-0.070	9.4	19.3
9	4825	-0.058	-0.087	-0.070	11.2	22.4
10	5275	-0.040	-0.057	-0.070	12.1	24.2
11	5725	-0.005	-0.005	-0.055	12.1	24.2
12	6175	0.049	0.068	0.018	12.1	24.2
13	6625	0.122	0.157	0.050	11.1	19.0
14	7075	0.207	0.250	0.050	3.9	10.0
15	7525	0.292	0.326	0.050	-6.2	-1.6
16	7975	0.349	0.351	0.050	-17.6	-13.1
17	8425	0.336	0.286	0.050	-27.7	-21.4
18	8875	0.215	0.100	0.050	-33.1	-23.1
19	9325	-0.029	-0.206	-0.070	-34.5	-18.6
20	9775	-0.362	-0.581	-0.070	-24.6	-1.4
21	10225	-0.693	-0.918	-0.070	-0.5	31.4

Altitude = 391
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.058	-0.093	-0.070	1.7	3.2
2	1675	-0.063	-0.099	-0.070	3.6	6.7
3	2125	-0.064	-0.098	-0.070	5.6	10.2
4	2575	-0.057	-0.084	-0.070	7.3	13.2
5	3025	-0.036	-0.051	-0.070	8.1	14.7
6	3475	0.002	0.004	-0.046	8.1	14.7
7	3925	0.058	0.079	0.029	8.1	14.7
8	4375	0.133	0.170	0.050	6.5	9.0
9	4825	0.220	0.262	0.050	-1.1	-0.5
10	5275	0.302	0.333	0.050	-11.5	-12.2
11	5725	0.352	0.349	0.050	-23.0	-23.5
12	6175	0.327	0.268	0.050	-32.6	-31.1
13	6625	0.188	0.064	0.014	-37.1	-32.7
14	7075	-0.072	-0.256	-0.070	-37.1	-26.7
15	7525	-0.411	-0.633	-0.070	-25.4	-7.5
16	7975	-0.730	-0.953	-0.070	0.9	27.7

Table 7 - Concluded.

Altitude = 275
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.008	0.013	-0.037	0.0	0.0
2	1675	0.068	0.091	0.041	0.0	0.0
3	2125	0.145	0.183	0.050	-2.1	-6.3
4	2575	0.232	0.274	0.050	-10.2	-16.3
5	3025	0.312	0.340	0.050	-20.9	-28.1
6	3475	0.354	0.344	0.050	-32.3	-39.1
7	3925	0.315	0.247	0.050	-41.4	-45.8
8	4375	0.159	0.025	-0.025	-44.9	-47.5
9	4825	-0.116	-0.307	-0.070	-43.5	-39.8
10	5275	-0.460	-0.684	-0.070	-30.0	-18.5
11	5725	-0.764	-0.983	-0.070	-1.3	19.1

Altitude = 159
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.355	0.337	0.050	-11.2	-10.6
2	1675	0.301	0.224	0.050	-19.8	-16.5
3	2125	0.127	-0.015	-0.065	-22.3	-18.1
4	2575	-0.161	-0.359	-0.070	-19.3	-8.7
5	3025	-0.508	-0.734	-0.070	-3.9	14.7
6	3475	-0.794	-1.007	-0.070	27.1	54.8

Table 8 - Airspeed Deviation Display Data with Go-around Thrust Assumption

Initial altitude = 1200
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = -0.050
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Perf ratio fixed at -0.05 till F > 0.15 then perf ratio = 0.140

Altitude = 1200
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.005	-0.006	-0.050	0.2	0.2
2	1675	-0.005	-0.006	-0.050	0.4	0.4
3	2125	-0.005	-0.006	-0.050	0.6	0.6
4	2575	-0.005	-0.006	-0.050	0.8	0.9
5	3025	-0.006	-0.006	-0.050	1.0	1.1
6	3475	-0.006	-0.006	-0.050	1.2	1.4
7	3925	-0.006	-0.007	-0.050	1.4	1.6
8	4375	-0.006	-0.007	-0.050	1.7	1.9
9	4825	-0.007	-0.007	-0.050	1.9	2.1
10	5275	-0.007	-0.007	-0.050	2.2	2.4
11	5725	-0.007	-0.007	-0.050	2.4	2.7
12	6175	-0.007	-0.008	-0.050	2.7	3.0
13	6625	-0.008	-0.008	-0.050	3.0	3.3
14	7075	-0.008	-0.008	-0.050	3.3	3.6
15	7525	-0.008	-0.008	-0.050	3.6	3.9
16	7975	-0.009	-0.008	-0.050	4.0	4.2
17	8425	-0.009	-0.009	-0.050	4.3	4.5
18	8875	-0.009	-0.009	-0.050	4.7	4.9
19	9325	-0.010	-0.009	-0.050	5.1	5.2
20	9775	-0.010	-0.009	-0.050	5.5	5.6
21	10225	-0.011	-0.010	-0.050	5.9	6.0
22	10675	-0.011	-0.010	-0.050	6.3	6.4
23	11125	-0.012	-0.010	-0.050	6.7	6.7

Table 8 - Continued.

Altitude = 1084
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.006	-0.006	-0.050	0.2	0.2
2	1675	-0.006	-0.007	-0.050	0.5	0.5
3	2125	-0.006	-0.007	-0.050	0.7	0.8
4	2575	-0.007	-0.007	-0.050	0.9	1.0
5	3025	-0.007	-0.007	-0.050	1.2	1.3
6	3475	-0.007	-0.007	-0.050	1.5	1.6
7	3925	-0.007	-0.008	-0.050	1.8	1.9
8	4375	-0.008	-0.008	-0.050	2.1	2.2
9	4825	-0.008	-0.008	-0.050	2.4	2.5
10	5275	-0.008	-0.008	-0.050	2.7	2.8
11	5725	-0.009	-0.009	-0.050	3.0	3.1
12	6175	-0.009	-0.009	-0.050	3.4	3.4
13	6625	-0.009	-0.009	-0.050	3.7	3.8
14	7075	-0.010	-0.009	-0.050	4.1	4.1
15	7525	-0.010	-0.009	-0.050	4.5	4.5
16	7975	-0.011	-0.010	-0.050	4.9	4.9
17	8425	-0.011	-0.010	-0.050	5.3	5.3
18	8875	-0.012	-0.010	-0.050	5.8	5.7
19	9325	-0.012	-0.013	-0.050	6.3	6.1
20	9775	-0.013	-0.023	-0.050	6.7	7.1
21	10225	-0.014	-0.026	-0.050	7.3	8.1
22	10675	-0.016	-0.029	-0.050	7.9	9.2
23	11125	-0.018	-0.032	-0.050	8.6	10.4

Altitude = 969
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.007	-0.007	-0.050	0.3	0.3
2	1675	-0.007	-0.008	-0.050	0.6	0.6
3	2125	-0.008	-0.008	-0.050	0.9	0.9
4	2575	-0.008	-0.008	-0.050	1.2	1.2
5	3025	-0.008	-0.008	-0.050	1.5	1.5

Table 8 - Continued.

6	3475	-0.009	-0.009	-0.050	1.8	1.8
7	3925	-0.009	-0.009	-0.050	2.2	2.2
8	4375	-0.010	-0.009	-0.050	2.5	2.5
9	4825	-0.010	-0.009	-0.050	2.9	2.9
10	5275	-0.010	-0.009	-0.050	3.3	3.2
11	5725	-0.011	-0.010	-0.050	3.7	3.6
12	6175	-0.011	-0.010	-0.050	4.2	4.0
13	6625	-0.012	-0.010	-0.050	4.6	4.4
14	7075	-0.012	-0.014	-0.050	5.1	4.9
15	7525	-0.013	-0.024	-0.050	5.6	5.9
16	7975	-0.014	-0.026	-0.050	6.1	6.9
17	8425	-0.016	-0.029	-0.050	6.8	8.0
18	8875	-0.018	-0.032	-0.050	7.5	9.3
19	9325	-0.020	-0.036	-0.050	8.3	10.7
20	9775	-0.023	-0.040	-0.050	9.2	12.3
21	10225	-0.026	-0.045	-0.050	10.3	14.1
22	10675	-0.030	-0.051	-0.050	11.5	16.2
23	11125	-0.035	-0.058	-0.050	12.9	18.5

Altitude = 853
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.009	-0.009	-0.050	0.3	0.3
2	1675	-0.009	-0.009	-0.050	0.7	0.7
3	2125	-0.010	-0.009	-0.050	1.1	1.0
4	2575	-0.010	-0.009	-0.050	1.4	1.4
5	3025	-0.010	-0.010	-0.050	1.8	1.7
6	3475	-0.011	-0.010	-0.050	2.3	2.1
7	3925	-0.011	-0.010	-0.050	2.7	2.5
8	4375	-0.012	-0.010	-0.050	3.1	2.9
9	4825	-0.012	-0.016	-0.050	3.6	3.5
10	5275	-0.013	-0.024	-0.050	4.1	4.4
11	5725	-0.015	-0.027	-0.050	4.7	5.5
12	6175	-0.016	-0.029	-0.050	5.3	6.6
13	6625	-0.018	-0.033	-0.050	6.0	7.9
14	7075	-0.021	-0.036	-0.050	6.9	9.3
15	7525	-0.024	-0.041	-0.050	7.8	11.0
16	7975	-0.027	-0.046	-0.050	8.9	12.8
17	8425	-0.031	-0.052	-0.050	10.1	14.9
18	8875	-0.035	-0.059	-0.050	11.6	17.3

Table 8 - Continued.

19	9325	-0.041	-0.068	-0.050	13.3	20.2
20	9775	-0.047	-0.078	-0.050	15.3	23.4
21	10225	-0.054	-0.088	-0.050	17.6	27.2
22	10675	-0.061	-0.096	-0.050	20.3	31.4
23	11125	-0.065	-0.100	-0.050	23.2	35.9

Altitude = 737
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.011	-0.010	-0.050	0.4	0.4
2	1675	-0.011	-0.010	-0.050	0.9	0.8
3	2125	-0.012	-0.010	-0.050	1.3	1.2
4	2575	-0.012	-0.018	-0.050	1.8	1.9
5	3025	-0.013	-0.024	-0.050	2.3	2.8
6	3475	-0.015	-0.027	-0.050	2.9	3.8
7	3925	-0.017	-0.030	-0.050	3.5	5.0
8	4375	-0.019	-0.033	-0.050	4.3	6.3
9	4825	-0.021	-0.037	-0.050	5.1	7.8
10	5275	-0.024	-0.041	-0.050	6.0	9.4
11	5725	-0.027	-0.047	-0.050	7.1	11.3
12	6175	-0.031	-0.053	-0.050	8.4	13.5
13	6625	-0.036	-0.060	-0.050	9.9	15.9
14	7075	-0.042	-0.069	-0.050	11.6	18.8
15	7525	-0.048	-0.079	-0.050	13.7	22.1
16	7975	-0.055	-0.089	-0.050	16.1	26.0
17	8425	-0.062	-0.097	-0.050	18.8	30.2
18	8875	-0.065	-0.100	-0.050	21.7	34.7
19	9325	-0.061	-0.092	-0.050	24.5	39.0
20	9775	-0.047	-0.067	-0.050	26.7	42.2
21	10225	-0.016	-0.022	-0.050	27.5	43.3
22	10675	0.033	0.046	-0.050	25.9	41.0
23	11125	0.100	0.131	-0.050	21.1	34.7

Table 8 - Continued.

Altitude = 622
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.015	-0.027	-0.050	0.6	1.1
2	1675	-0.017	-0.030	-0.050	1.2	2.2
3	2125	-0.019	-0.034	-0.050	2.0	3.6
4	2575	-0.021	-0.037	-0.050	2.8	5.1
5	3025	-0.024	-0.042	-0.050	3.8	6.7
6	3475	-0.028	-0.048	-0.050	4.9	8.6
7	3925	-0.032	-0.054	-0.050	6.2	10.8
8	4375	-0.037	-0.062	-0.050	7.7	13.4
9	4825	-0.043	-0.070	-0.050	9.5	16.3
10	5275	-0.049	-0.080	-0.050	11.6	19.7
11	5725	-0.056	-0.090	-0.050	14.0	23.6
12	6175	-0.062	-0.098	-0.050	16.8	27.9
13	6625	-0.065	-0.099	-0.050	19.7	32.4
14	7075	-0.060	-0.090	-0.050	22.5	36.6
15	7525	-0.043	-0.062	-0.050	24.6	39.6
16	7975	-0.011	-0.014	-0.050	25.1	40.2
17	8425	0.041	0.057	-0.050	23.1	37.5
18	8875	0.111	0.144	-0.050	17.8	30.5
19	9325	0.195	0.238	0.140	15.2	26.1
20	9775	0.281	0.317	0.140	9.3	18.5
21	10225	0.344	0.352	0.140	1.4	10.3
22	10675	0.344	0.302	0.140	-5.9	4.6
23	11125	0.239	0.133	0.140	-9.2	4.8

Altitude = 506
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.028	-0.048	-0.050	1.1	1.9
2	1675	-0.033	-0.055	-0.050	2.5	4.2
3	2125	-0.038	-0.063	-0.050	4.0	6.8
4	2575	-0.044	-0.072	-0.050	5.8	9.8

Table 8 - Continued.

5	3025	-0.050	-0.082	-0.050	8.0	13.2
6	3475	-0.057	-0.092	-0.050	10.4	17.2
7	3925	-0.063	-0.099	-0.050	13.2	21.5
8	4375	-0.065	-0.099	-0.050	16.2	26.0
9	4825	-0.058	-0.087	-0.050	18.9	30.1
10	5275	-0.040	-0.057	-0.050	20.8	32.9
11	5725	-0.005	-0.005	-0.050	21.0	33.1
12	6175	0.049	0.068	-0.050	18.6	29.8
13	6625	0.122	0.157	0.140	12.8	29.0
14	7075	0.207	0.250	0.140	9.7	24.0
15	7525	0.292	0.326	0.140	3.3	16.2
16	7975	0.349	0.351	0.140	-4.6	8.1
17	8425	0.336	0.286	0.140	-11.5	3.0
18	8875	0.215	0.100	0.140	-14.0	4.3
19	9325	-0.029	-0.206	0.140	-8.5	15.5
20	9775	-0.362	-0.581	0.140	8.4	39.8
21	10225	-0.693	-0.918	0.140	40.6	80.8

Altitude = 391
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.058	-0.093	-0.050	2.5	4.0
2	1675	-0.063	-0.099	-0.050	5.3	8.4
3	2125	-0.064	-0.098	-0.050	8.3	12.9
4	2575	-0.057	-0.084	-0.050	10.9	16.8
5	3025	-0.036	-0.051	-0.050	12.7	19.3
6	3475	0.002	0.004	-0.050	12.6	19.1
7	3925	0.058	0.079	-0.050	9.7	15.2
8	4375	0.133	0.170	0.140	3.4	13.8
9	4825	0.220	0.262	0.140	-0.2	8.3
10	5275	0.302	0.333	0.140	-6.9	0.3
11	5725	0.352	0.349	0.140	-14.9	-7.6
12	6175	0.327	0.268	0.140	-21.4	-12.0
13	6625	0.188	0.064	0.140	-23.0	-9.5
14	7075	-0.072	-0.256	0.140	-16.1	3.3
15	7525	-0.411	-0.633	0.140	2.7	29.8
16	7975	-0.730	-0.953	0.140	37.4	73.3

Table 8 - Concluded.

Altitude = 275
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.008	0.013	-0.050	-0.4	-0.6
2	1675	0.068	0.091	-0.050	-3.7	-5.1
3	2125	0.145	0.183	0.140	-10.6	-7.1
4	2575	0.232	0.274	0.140	-14.7	-13.1
5	3025	0.312	0.340	0.140	-21.7	-21.3
6	3475	0.354	0.344	0.140	-29.7	-28.9
7	3925	0.315	0.247	0.140	-35.7	-32.6
8	4375	0.159	0.025	0.140	-36.3	-28.8
9	4825	-0.116	-0.307	0.140	-28.0	-14.3
10	5275	-0.460	-0.684	0.140	-7.2	14.3
11	5725	-0.764	-0.983	0.140	30.1	60.6

Altitude = 159
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.355	0.337	0.140	-7.9	-7.3
2	1675	0.301	0.224	0.140	-13.4	-10.1
3	2125	0.127	-0.015	0.140	-13.0	-5.1
4	2575	-0.161	-0.359	0.140	-3.1	11.2
5	3025	-0.508	-0.734	0.140	19.7	42.0
6	3475	-0.794	-1.007	0.140	59.7	91.1

Table 9 - Airspeed Deviation Display Data with Zero-Elevation Scan Assumption

Initial altitude = 1200
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = 0.000
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Perf ratio fixed at -0.050

Altitude = 1200
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.005	0.000	-0.050	0.2	0.0
2	1675	-0.005	0.000	-0.050	0.4	0.0
3	2125	-0.005	0.000	-0.050	0.6	0.0
4	2575	-0.005	0.000	-0.050	0.8	0.0
5	3025	-0.006	0.000	-0.050	1.0	0.0
6	3475	-0.006	0.000	-0.050	1.2	0.0
7	3925	-0.006	0.000	-0.050	1.4	0.0
8	4375	-0.006	0.000	-0.050	1.7	0.0
9	4825	-0.007	0.000	-0.050	1.9	0.0
10	5275	-0.007	0.000	-0.050	2.2	0.0
11	5725	-0.007	0.000	-0.050	2.4	0.0
12	6175	-0.007	0.000	-0.050	2.7	0.0
13	6625	-0.008	0.000	-0.050	3.0	0.0
14	7075	-0.008	0.000	-0.050	3.3	0.0
15	7525	-0.008	0.000	-0.050	3.6	0.0
16	7975	-0.009	0.000	-0.050	4.0	0.0
17	8425	-0.009	0.000	-0.050	4.3	0.0
18	8875	-0.009	0.000	-0.050	4.7	0.0
19	9325	-0.010	0.000	-0.050	5.1	0.0
20	9775	-0.010	0.000	-0.050	5.5	0.0
21	10225	-0.011	0.000	-0.050	5.9	0.0
22	10675	-0.011	0.000	-0.050	6.3	0.0
23	11125	-0.012	0.000	-0.050	6.7	0.0

Table 9 - Continued.

Altitude = 1084
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.006	0.000	-0.050	0.2	0.0
2	1675	-0.006	0.000	-0.050	0.5	0.0
3	2125	-0.006	0.000	-0.050	0.7	0.0
4	2575	-0.007	0.000	-0.050	0.9	0.0
5	3025	-0.007	0.000	-0.050	1.2	0.0
6	3475	-0.007	0.000	-0.050	1.5	0.0
7	3925	-0.007	0.000	-0.050	1.8	0.0
8	4375	-0.008	0.000	-0.050	2.1	0.0
9	4825	-0.008	0.000	-0.050	2.4	0.0
10	5275	-0.008	0.000	-0.050	2.7	0.0
11	5725	-0.009	0.000	-0.050	3.0	0.0
12	6175	-0.009	0.000	-0.050	3.4	0.0
13	6625	-0.009	0.000	-0.050	3.7	0.0
14	7075	-0.010	0.000	-0.050	4.1	0.0
15	7525	-0.010	0.000	-0.050	4.5	0.0
16	7975	-0.011	0.000	-0.050	4.9	0.0
17	8425	-0.011	0.000	-0.050	5.3	0.0
18	8875	-0.012	0.000	-0.050	5.8	0.0
19	9325	-0.012	-0.001	-0.050	6.3	0.0
20	9775	-0.013	-0.007	-0.050	6.7	0.3
21	10225	-0.014	-0.007	-0.050	7.3	0.6
22	10675	-0.016	-0.008	-0.050	7.9	0.9
23	11125	-0.018	-0.009	-0.050	8.6	1.2

Altitude = 969
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.007	0.000	-0.050	0.3	0.0
2	1675	-0.007	0.000	-0.050	0.6	0.0
3	2125	-0.008	0.000	-0.050	0.9	0.0
4	2575	-0.008	0.000	-0.050	1.2	0.0

Table 9 - Continued.

5	3025	-0.008	0.000	-0.050	1.5	0.0
6	3475	-0.009	0.000	-0.050	1.8	0.0
7	3925	-0.009	0.000	-0.050	2.2	0.0
8	4375	-0.010	0.000	-0.050	2.5	0.0
9	4825	-0.010	0.000	-0.050	2.9	0.0
10	5275	-0.010	0.000	-0.050	3.3	0.0
11	5725	-0.011	0.000	-0.050	3.7	0.0
12	6175	-0.011	0.000	-0.050	4.2	0.0
13	6625	-0.012	0.000	-0.050	4.6	0.0
14	7075	-0.012	-0.002	-0.050	5.1	0.1
15	7525	-0.013	-0.008	-0.050	5.6	0.4
16	7975	-0.014	-0.009	-0.050	6.1	0.7
17	8425	-0.016	-0.010	-0.050	6.8	1.1
18	8875	-0.018	-0.011	-0.050	7.5	1.5
19	9325	-0.020	-0.012	-0.050	8.3	2.0
20	9775	-0.023	-0.014	-0.050	9.2	2.5
21	10225	-0.026	-0.015	-0.050	10.3	3.1
22	10675	-0.030	-0.018	-0.050	11.5	3.7
23	11125	-0.035	-0.020	-0.050	12.9	4.5

Altitude = 853
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.009	0.000	-0.050	0.3	0.0
2	1675	-0.009	0.000	-0.050	0.7	0.0
3	2125	-0.010	0.000	-0.050	1.1	0.0
4	2575	-0.010	0.000	-0.050	1.4	0.0
5	3025	-0.010	0.000	-0.050	1.8	0.0
6	3475	-0.011	0.000	-0.050	2.3	0.0
7	3925	-0.011	0.000	-0.050	2.7	0.0
8	4375	-0.012	0.000	-0.050	3.1	0.0
9	4825	-0.012	-0.004	-0.050	3.6	0.2
10	5275	-0.013	-0.009	-0.050	4.1	0.5
11	5725	-0.015	-0.010	-0.050	4.7	0.9
12	6175	-0.016	-0.011	-0.050	5.3	1.3
13	6625	-0.018	-0.013	-0.050	6.0	1.8
14	7075	-0.021	-0.014	-0.050	6.9	2.4
15	7525	-0.024	-0.016	-0.050	7.8	3.0
16	7975	-0.027	-0.018	-0.050	8.9	3.7

Table 9 - Continued.

17	8425	-0.031	-0.021	-0.050	10.1	4.5
18	8875	-0.035	-0.024	-0.050	11.6	5.4
19	9325	-0.041	-0.027	-0.050	13.3	6.4
20	9775	-0.047	-0.031	-0.050	15.3	7.7
21	10225	-0.054	-0.036	-0.050	17.6	9.0
22	10675	-0.061	-0.039	-0.050	20.3	10.6
23	11125	-0.065	-0.040	-0.050	23.2	12.2

Altitude = 737
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.011	0.000	-0.050	0.4	0.0
2	1675	-0.011	0.000	-0.050	0.9	0.0
3	2125	-0.012	0.000	-0.050	1.3	0.0
4	2575	-0.012	-0.006	-0.050	1.8	0.2
5	3025	-0.013	-0.011	-0.050	2.3	0.6
6	3475	-0.015	-0.012	-0.050	2.9	1.1
7	3925	-0.017	-0.013	-0.050	3.5	1.6
8	4375	-0.019	-0.015	-0.050	4.3	2.2
9	4825	-0.021	-0.016	-0.050	5.1	2.8
10	5275	-0.024	-0.018	-0.050	6.0	3.5
11	5725	-0.027	-0.021	-0.050	7.1	4.3
12	6175	-0.031	-0.024	-0.050	8.4	5.3
13	6625	-0.036	-0.028	-0.050	9.9	6.4
14	7075	-0.042	-0.032	-0.050	11.6	7.6
15	7525	-0.048	-0.037	-0.050	13.7	9.0
16	7975	-0.055	-0.041	-0.050	16.1	10.7
17	8425	-0.062	-0.045	-0.050	18.8	12.5
18	8875	-0.065	-0.045	-0.050	21.7	14.3
19	9325	-0.061	-0.038	-0.050	24.5	15.8
20	9775	-0.047	-0.022	-0.050	26.7	16.7
21	10225	-0.016	0.008	-0.050	27.5	16.4
22	10675	0.033	0.050	-0.050	25.9	14.4
23	11125	0.100	0.101	-0.050	21.1	10.3

Table 9 - Continued.

Altitude = 622
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.015	-0.014	-0.050	0.6	0.5
2	1675	-0.017	-0.015	-0.050	1.2	1.1
3	2125	-0.019	-0.017	-0.050	2.0	1.8
4	2575	-0.021	-0.019	-0.050	2.8	2.5
5	3025	-0.024	-0.021	-0.050	3.8	3.4
6	3475	-0.028	-0.024	-0.050	4.9	4.3
7	3925	-0.032	-0.028	-0.050	6.2	5.4
8	4375	-0.037	-0.032	-0.050	7.7	6.7
9	4825	-0.043	-0.037	-0.050	9.5	8.1
10	5275	-0.049	-0.042	-0.050	11.6	9.8
11	5725	-0.056	-0.047	-0.050	14.0	11.7
12	6175	-0.062	-0.051	-0.050	16.8	13.8
13	6625	-0.065	-0.050	-0.050	19.7	15.9
14	7075	-0.060	-0.042	-0.050	22.5	17.6
15	7525	-0.043	-0.021	-0.050	24.6	18.5
16	7975	-0.011	0.014	-0.050	25.1	17.9
17	8425	0.041	0.064	-0.050	23.1	15.2
18	8875	0.111	0.123	-0.050	17.8	10.1
19	9325	0.195	0.181	-0.050	6.5	0.8
20	9775	0.281	0.226	-0.050	-7.5	-10.1
21	10225	0.344	0.246	-0.050	-22.8	-21.3
22	10675	0.344	0.234	-0.050	-36.8	-31.6
23	11125	0.239	0.193	-0.050	-46.4	-40.1

Altitude = 506
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.028	-0.028	-0.050	1.1	1.1
2	1675	-0.033	-0.032	-0.050	2.5	2.4
3	2125	-0.038	-0.036	-0.050	4.0	3.9
4	2575	-0.044	-0.042	-0.050	5.8	5.6

Table 9 - Continued.

5	3025	-0.050	-0.048	-0.050	8.0	7.5
6	3475	-0.057	-0.054	-0.050	10.4	9.8
7	3925	-0.063	-0.057	-0.050	13.2	12.1
8	4375	-0.065	-0.055	-0.050	16.2	14.5
9	4825	-0.058	-0.044	-0.050	18.9	16.4
10	5275	-0.040	-0.019	-0.050	20.8	17.2
11	5725	-0.005	0.023	-0.050	21.0	16.2
12	6175	0.049	0.080	-0.050	18.6	12.7
13	6625	0.122	0.146	-0.050	12.8	6.5
14	7075	0.207	0.211	-0.050	1.1	-4.2
15	7525	0.292	0.259	-0.050	-13.2	-16.4
16	7975	0.349	0.279	-0.050	-28.5	-28.9
17	8425	0.336	0.263	-0.050	-42.1	-40.1
18	8875	0.215	0.213	-0.050	-50.8	-49.2
19	9325	-0.029	0.144	-0.050	-51.5	-55.7
20	9775	-0.362	0.070	-0.050	-41.0	-59.6
21	10225	-0.693	0.008	-0.050	-16.1	-61.5

Altitude = 391
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.058	-0.060	-0.050	2.5	2.6
2	1675	-0.063	-0.063	-0.050	5.3	5.3
3	2125	-0.064	-0.059	-0.050	8.3	7.9
4	2575	-0.057	-0.045	-0.050	10.9	9.9
5	3025	-0.036	-0.015	-0.050	12.7	10.6
6	3475	0.002	0.033	-0.050	12.6	9.1
7	3925	0.058	0.097	-0.050	9.7	4.8
8	4375	0.133	0.170	-0.050	3.4	-4.9
9	4825	0.220	0.242	-0.050	-8.7	-17.1
10	5275	0.302	0.294	-0.050	-23.3	-30.8
11	5725	0.352	0.314	-0.050	-38.5	-44.5
12	6175	0.327	0.293	-0.050	-51.6	-56.7
13	6625	0.188	0.235	-0.050	-59.4	-66.3
14	7075	-0.072	0.154	-0.050	-58.7	-73.0
15	7525	-0.411	0.070	-0.050	-46.4	-76.8
16	7975	-0.730	0.001	-0.050	-19.3	-78.4

Table 9 - Concluded.

Altitude = 275
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.008	0.043	-0.050	-0.4	-2.0
2	1675	0.068	0.113	-0.050	-3.7	-7.4
3	2125	0.145	0.194	-0.050	-10.6	-18.4
4	2575	0.232	0.271	-0.050	-23.1	-32.2
5	3025	0.312	0.329	-0.050	-37.9	-47.4
6	3475	0.354	0.350	-0.050	-53.0	-62.3
7	3925	0.315	0.325	-0.050	-65.5	-75.4
8	4375	0.159	0.257	-0.050	-72.4	-85.4
9	4825	-0.116	0.163	-0.050	-70.2	-92.2
10	5275	-0.460	0.069	-0.050	-56.0	-95.8
11	5725	-0.764	-0.008	-0.050	-26.6	-97.1

Altitude = 159
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.355	0.375	-0.050	-14.9	-15.7
2	1675	0.301	0.346	-0.050	-26.9	-29.1
3	2125	0.127	0.270	-0.050	-32.6	-39.3
4	2575	-0.161	0.167	-0.050	-29.0	-46.0
5	3025	-0.508	0.064	-0.050	-12.9	-49.3
6	3475	-0.794	-0.018	-0.050	19.0	-50.3

Table 10 - Airspeed Deviation Display Data with Higher Altitude Pass Through Microburst

Initial altitude = 1500
Distance to microburst = 22000
Reference airspeed = 137
Scan elevation (radians) = -0.050
Scan bin length (feet) = 450
Scan range is from 1000 to 12000 feet
Perf ratio fixed at -0.050

Altitude = 1500
Distance flown = 0
Range to core = 22000
Time = 0

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.003	-0.004	-0.050	0.1	0.1
2	1675	-0.003	-0.004	-0.050	0.2	0.3
3	2125	-0.003	-0.004	-0.050	0.3	0.4
4	2575	-0.003	-0.004	-0.050	0.4	0.6
5	3025	-0.003	-0.004	-0.050	0.6	0.7
6	3475	-0.003	-0.004	-0.050	0.7	0.9
7	3925	-0.004	-0.004	-0.050	0.8	1.1
8	4375	-0.004	-0.005	-0.050	1.0	1.2
9	4825	-0.004	-0.005	-0.050	1.1	1.4
10	5275	-0.004	-0.005	-0.050	1.3	1.6
11	5725	-0.004	-0.005	-0.050	1.4	1.8
12	6175	-0.004	-0.005	-0.050	1.6	2.0
13	6625	-0.005	-0.005	-0.050	1.7	2.2
14	7075	-0.005	-0.005	-0.050	1.9	2.4
15	7525	-0.005	-0.006	-0.050	2.1	2.6
16	7975	-0.005	-0.006	-0.050	2.3	2.8
17	8425	-0.005	-0.006	-0.050	2.5	3.1
18	8875	-0.006	-0.006	-0.050	2.7	3.3
19	9325	-0.006	-0.006	-0.050	2.9	3.5
20	9775	-0.006	-0.007	-0.050	3.1	3.8
21	10225	-0.006	-0.007	-0.050	3.4	4.0
22	10675	-0.006	-0.007	-0.050	3.6	4.3
23	11125	-0.007	-0.007	-0.050	3.9	4.6

Table 10 - Continued.

Altitude = 1384
Distance flown = 2313
Range to core = 19687
Time = 10

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.003	-0.004	-0.050	0.1	0.2
2	1675	-0.004	-0.004	-0.050	0.3	0.3
3	2125	-0.004	-0.005	-0.050	0.4	0.5
4	2575	-0.004	-0.005	-0.050	0.5	0.7
5	3025	-0.004	-0.005	-0.050	0.7	0.9
6	3475	-0.004	-0.005	-0.050	0.9	1.1
7	3925	-0.004	-0.005	-0.050	1.0	1.3
8	4375	-0.005	-0.005	-0.050	1.2	1.5
9	4825	-0.005	-0.006	-0.050	1.4	1.7
10	5275	-0.005	-0.006	-0.050	1.5	1.9
11	5725	-0.005	-0.006	-0.050	1.7	2.1
12	6175	-0.005	-0.006	-0.050	1.9	2.3
13	6625	-0.006	-0.006	-0.050	2.2	2.6
14	7075	-0.006	-0.006	-0.050	2.4	2.8
15	7525	-0.006	-0.007	-0.050	2.6	3.1
16	7975	-0.006	-0.007	-0.050	2.8	3.3
17	8425	-0.007	-0.007	-0.050	3.1	3.6
18	8875	-0.007	-0.007	-0.050	3.3	3.8
19	9325	-0.007	-0.009	-0.050	3.6	4.2
20	9775	-0.007	-0.017	-0.050	3.9	4.8
21	10225	-0.008	-0.018	-0.050	4.2	5.5
22	10675	-0.009	-0.020	-0.050	4.6	6.3
23	11125	-0.010	-0.023	-0.050	5.0	7.2

Altitude = 1269
Distance flown = 4625
Range to core = 17375
Time = 20

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.004	-0.005	-0.050	0.2	0.2
2	1675	-0.004	-0.005	-0.050	0.3	0.4
3	2125	-0.005	-0.005	-0.050	0.5	0.6
4	2575	-0.005	-0.006	-0.050	0.7	0.8
5	3025	-0.005	-0.006	-0.050	0.9	1.0
6	3475	-0.005	-0.006	-0.050	1.1	1.2
7	3925	-0.005	-0.006	-0.050	1.3	1.5

Table 10 - Continued.

8	4375	-0.006	-0.006	-0.050	1.5	1.7
9	4825	-0.006	-0.006	-0.050	1.7	1.9
10	5275	-0.006	-0.007	-0.050	1.9	2.2
11	5725	-0.006	-0.007	-0.050	2.2	2.4
12	6175	-0.007	-0.007	-0.050	2.4	2.7
13	6625	-0.007	-0.007	-0.050	2.7	3.0
14	7075	-0.007	-0.010	-0.050	2.9	3.4
15	7525	-0.008	-0.017	-0.050	3.2	4.0
16	7975	-0.008	-0.019	-0.050	3.5	4.7
17	8425	-0.009	-0.021	-0.050	3.9	5.5
18	8875	-0.011	-0.023	-0.050	4.3	6.4
19	9325	-0.012	-0.026	-0.050	4.8	7.4
20	9775	-0.014	-0.029	-0.050	5.3	8.5
21	10225	-0.016	-0.033	-0.050	5.9	9.8
22	10675	-0.018	-0.038	-0.050	6.6	11.3
23	11125	-0.021	-0.043	-0.050	7.4	13.0

Altitude = 1153
Distance flown = 6938
Range to core = 15062
Time = 30

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.005	-0.006	-0.050	0.2	0.2
2	1675	-0.005	-0.006	-0.050	0.4	0.5
3	2125	-0.006	-0.006	-0.050	0.6	0.7
4	2575	-0.006	-0.006	-0.050	0.8	0.9
5	3025	-0.006	-0.007	-0.050	1.1	1.2
6	3475	-0.006	-0.007	-0.050	1.3	1.4
7	3925	-0.007	-0.007	-0.050	1.6	1.7
8	4375	-0.007	-0.007	-0.050	1.8	2.0
9	4825	-0.007	-0.011	-0.050	2.1	2.4
10	5275	-0.008	-0.017	-0.050	2.4	3.1
11	5725	-0.009	-0.019	-0.050	2.7	3.8
12	6175	-0.010	-0.021	-0.050	3.1	4.6
13	6625	-0.011	-0.023	-0.050	3.5	5.5
14	7075	-0.012	-0.026	-0.050	4.0	6.5
15	7525	-0.014	-0.030	-0.050	4.5	7.6
16	7975	-0.016	-0.034	-0.050	5.1	8.9
17	8425	-0.018	-0.038	-0.050	5.8	10.4
18	8875	-0.021	-0.044	-0.050	6.7	12.2
19	9325	-0.025	-0.051	-0.050	7.7	14.2
20	9775	-0.029	-0.059	-0.050	8.8	16.5
21	10225	-0.033	-0.067	-0.050	10.1	19.2
22	10675	-0.036	-0.075	-0.050	11.6	22.3
23	11125	-0.037	-0.080	-0.050	13.1	25.6

Table 10 - Continued.

Altitude = 1037
Distance flown = 9250
Range to core = 12750
Time = 40

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.006	-0.007	-0.050	0.2	0.3
2	1675	-0.007	-0.007	-0.050	0.5	0.5
3	2125	-0.007	-0.007	-0.050	0.8	0.8
4	2575	-0.007	-0.013	-0.050	1.0	1.3
5	3025	-0.008	-0.017	-0.050	1.3	1.9
6	3475	-0.009	-0.019	-0.050	1.7	2.7
7	3925	-0.010	-0.021	-0.050	2.0	3.5
8	4375	-0.011	-0.024	-0.050	2.5	4.4
9	4825	-0.013	-0.027	-0.050	2.9	5.4
10	5275	-0.014	-0.030	-0.050	3.5	6.6
11	5725	-0.016	-0.034	-0.050	4.1	7.9
12	6175	-0.019	-0.039	-0.050	4.9	9.4
13	6625	-0.022	-0.045	-0.050	5.7	11.2
14	7075	-0.025	-0.052	-0.050	6.7	13.3
15	7525	-0.029	-0.060	-0.050	7.9	15.7
16	7975	-0.033	-0.069	-0.050	9.2	18.4
17	8425	-0.037	-0.076	-0.050	10.7	21.5
18	8875	-0.037	-0.080	-0.050	12.3	24.8
19	9325	-0.032	-0.076	-0.050	13.6	28.0
20	9775	-0.016	-0.058	-0.050	14.3	30.5
21	10225	0.014	-0.023	-0.050	13.7	31.5
22	10675	0.061	0.033	-0.050	11.0	30.0
23	11125	0.123	0.105	-0.050	5.8	25.5

Altitude = 922
Distance flown = 11563
Range to core = 10437
Time = 50

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.009	-0.019	-0.050	0.3	0.7
2	1675	-0.010	-0.022	-0.050	0.7	1.6
3	2125	-0.011	-0.024	-0.050	1.2	2.5
4	2575	-0.013	-0.027	-0.050	1.6	3.5
5	3025	-0.015	-0.031	-0.050	2.2	4.7
6	3475	-0.017	-0.035	-0.050	2.8	6.1
7	3925	-0.019	-0.040	-0.050	3.6	7.6

Table 10 - Continued.

8	4375	-0.022	-0.046	-0.050	4.5	9.4
9	4825	-0.026	-0.053	-0.050	5.5	11.5
10	5275	-0.030	-0.061	-0.050	6.7	14.0
11	5725	-0.034	-0.070	-0.050	8.1	16.8
12	6175	-0.037	-0.077	-0.050	9.6	19.9
13	6625	-0.037	-0.080	-0.050	11.1	23.3
14	7075	-0.030	-0.074	-0.050	12.4	26.4
15	7525	-0.013	-0.054	-0.050	12.9	28.7
16	7975	0.020	-0.016	-0.050	12.1	29.4
17	8425	0.068	0.042	-0.050	9.1	27.6
18	8875	0.132	0.116	-0.050	3.4	22.6
19	9325	0.205	0.195	-0.050	-7.2	12.3
20	9775	0.275	0.266	-0.050	-20.3	-0.4
21	10225	0.328	0.314	-0.050	-34.7	-14.2
22	10675	0.351	0.324	-0.050	-49.1	-27.7
23	11125	0.335	0.294	-0.050	-62.2	-39.4

Altitude = 806
Distance flown = 13875
Range to core = 8125
Time = 60

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.017	-0.035	-0.050	0.7	1.4
2	1675	-0.020	-0.041	-0.050	1.4	3.0
3	2125	-0.023	-0.047	-0.050	2.3	4.8
4	2575	-0.026	-0.054	-0.050	3.4	7.0
5	3025	-0.030	-0.062	-0.050	4.6	9.4
6	3475	-0.034	-0.071	-0.050	6.0	12.3
7	3925	-0.037	-0.078	-0.050	7.5	15.5
8	4375	-0.036	-0.080	-0.050	9.0	18.8
9	4825	-0.028	-0.072	-0.050	10.2	21.9
10	5275	-0.009	-0.050	-0.050	10.6	24.0
11	5725	0.025	-0.009	-0.050	9.5	24.4
12	6175	0.076	0.051	-0.050	6.2	22.2
13	6625	0.142	0.127	-0.050	0.1	16.8
14	7075	0.215	0.206	-0.050	-10.9	6.1
15	7525	0.283	0.275	-0.050	-24.2	-6.9
16	7975	0.333	0.318	-0.050	-38.7	-20.8
17	8425	0.351	0.322	-0.050	-53.1	-34.1
18	8875	0.330	0.287	-0.050	-65.9	-45.5
19	9325	0.272	0.219	-0.050	-76.3	-54.2
20	9775	0.194	0.138	-0.050	-83.9	-60.0
21	10225	0.112	0.061	-0.050	-88.9	-63.4
22	10675	0.044	0.002	-0.050	-91.8	-65.0
23	11125	-0.004	-0.035	-0.050	-93.2	-65.5

Table 10 - Continued.

Altitude = 691
Distance flown = 16188
Range to core = 5812
Time = 70

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	-0.035	-0.072	-0.050	1.4	2.9
2	1675	-0.037	-0.078	-0.050	2.9	6.1
3	2125	-0.036	-0.079	-0.050	4.4	9.4
4	2575	-0.026	-0.070	-0.050	5.6	12.4
5	3025	-0.005	-0.046	-0.050	5.8	14.4
6	3475	0.031	-0.002	-0.050	4.4	14.4
7	3925	0.085	0.061	-0.050	0.8	11.8
8	4375	0.152	0.138	-0.050	-7.9	5.9
9	4825	0.225	0.216	-0.050	-19.3	-5.1
10	5275	0.292	0.283	-0.050	-3?.8	-18.3
11	5725	0.338	0.321	-0.050	-47.4	-32.2
12	6175	0.350	0.320	-0.050	-61.6	-45.3
13	6625	0.324	0.279	-0.050	-74.1	-56.4
14	7075	0.262	0.208	-0.050	-84.2	-64.7
15	7525	0.182	0.126	-0.050	-91.4	-70.2
16	7975	0.102	0.052	-0.050	-96.1	-73.3
17	8425	0.036	-0.004	-0.050	-98.7	-74.7
18	8875	-0.009	-0.039	-0.050	-99.9	-75.0
19	9325	-0.035	-0.055	-0.050	-100.4	-74.9
20	9775	-0.046	-0.060	-0.050	-100.5	-74.6
21	10225	-0.050	-0.060	-0.050	-100.5	-74.2
22	10675	-0.050	-0.059	-0.050	-100.5	-74.0
23	11125	-0.052	-0.062	-0.050	-100.4	-73.6

Altitude = 575
Distance flown = 18500
Range to core = 3500
Time = 80

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.038	0.006	-0.050	-1.6	-0.3
2	1675	0.093	0.071	-0.050	-5.7	-3.3
3	2125	0.162	0.149	-0.050	-14.7	-9.7
4	2575	0.235	0.227	-0.050	-26.4	-21.1
5	3025	0.300	0.290	-0.050	-40.2	-34.5
6	3475	0.342	0.323	-0.050	-54.8	-48.3
7	3925	0.349	0.316	-0.050	-68.8	-61.2

Table 10 - Continued.

8	4375	0.317	0.270	-0.050	-81.1	-71.9
9	4825	0.252	0.197	-0.050	-90.7	-79.8
10	5275	0.171	0.115	-0.050	-97.6	-84.9
11	5725	0.092	0.043	-0.050	-101.9	-87.8
12	6175	0.028	-0.010	-0.050	-104.3	-89.0
13	6625	-0.014	-0.042	-0.050	-105.4	-89.2
14	7075	-0.037	-0.056	-0.050	-105.8	-89.0
15	7525	-0.047	-0.060	-0.050	-105.9	-88.7
16	7975	-0.050	-0.060	-0.050	-105.9	-88.4
17	8425	-0.050	-0.059	-0.050	-105.9	-88.1
18	8875	-0.052	-0.063	-0.050	-105.8	-87.7
19	9325	-0.058	-0.072	-0.050	-105.6	-87.0
20	9775	-0.072	-0.091	-0.050	-104.9	-85.7
21	10225	-0.095	-0.123	-0.050	-103.4	-83.3
22	10675	-0.135	-0.174	-0.050	-100.5	-79.1
23	11125	-0.196	-0.250	-0.050	-95.3	-72.0

Altitude = 459
Distance flown = 20813
Range to core = 1187
Time = 90

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.345	0.325	-0.050	-14.6	-13.8
2	1675	0.347	0.312	-0.050	-28.4	-26.5
3	2125	0.309	0.261	-0.050	-40.4	-36.8
4	2575	0.241	0.186	-0.050	-49.6	-44.3
5	3025	0.159	0.104	-0.050	-56.1	-49.1
6	3475	0.082	0.034	-0.050	-60.1	-51.6
7	3925	0.021	-0.016	-0.050	-62.3	-52.7
8	4375	-0.018	-0.045	-0.050	-63.3	-52.8
9	4825	-0.039	-0.057	-0.050	-63.6	-52.6
10	5275	-0.048	-0.060	-0.050	-63.7	-52.3
11	5725	-0.050	-0.060	-0.050	-63.7	-52.0
12	6175	-0.050	-0.060	-0.050	-63.7	-51.7
13	6625	-0.053	-0.063	-0.050	-63.6	-51.2
14	7075	-0.060	-0.074	-0.050	-63.3	-50.5
15	7525	-0.074	-0.094	-0.050	-62.5	-49.0
16	7975	-0.100	-0.129	-0.050	-60.8	-46.4
17	8425	-0.142	-0.183	-0.050	-57.7	-41.9
18	8875	-0.206	-0.263	-0.050	-52.1	-34.3
19	9325	-0.300	-0.376	-0.050	-42.7	-21.9

Table 10 - Concluded.

Altitude = 344
Distance flown = 23126
Range to core = -1126
Time = 100

Bin #	Distance to bin center	Real-F	Est-F	(T-D)/W	Real-V Error	Est-V Error
1	1225	0.072	0.026	-0.050	-2.2	-0.8
2	1675	0.015	-0.021	-0.050	-2.6	-0.1
3	2125	-0.022	-0.047	-0.050	-2.0	1.3
4	2575	-0.041	-0.058	-0.050	-0.7	3.1
5	3025	-0.048	-0.060	-0.050	0.8	5.0
6	3475	-0.050	-0.059	-0.050	2.3	6.8
7	3925	-0.050	-0.060	-0.050	3.9	8.7
8	4375	-0.053	-0.064	-0.050	5.6	10.8
9	4825	-0.061	-0.076	-0.050	7.6	13.2
10	5275	-0.077	-0.098	-0.050	10.1	16.4
11	5725	-0.104	-0.135	-0.050	13.6	20.9
12	6175	-0.149	-0.192	-0.050	18.7	27.5
13	6625	-0.217	-0.277	-0.050	26.5	37.4
14	7075	-0.315	-0.394	-0.050	38.6	52.6

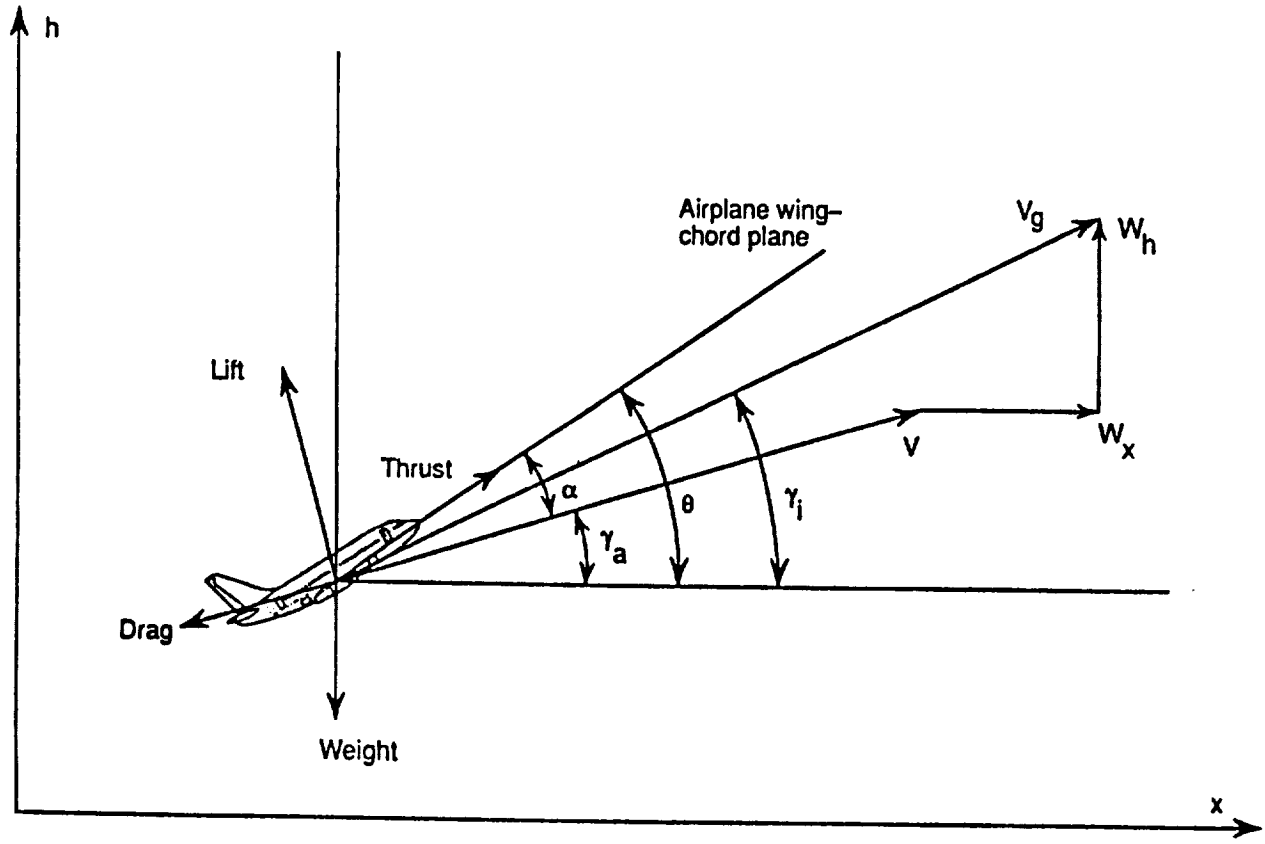

Figure 1. Flight path and wind coordinate system.

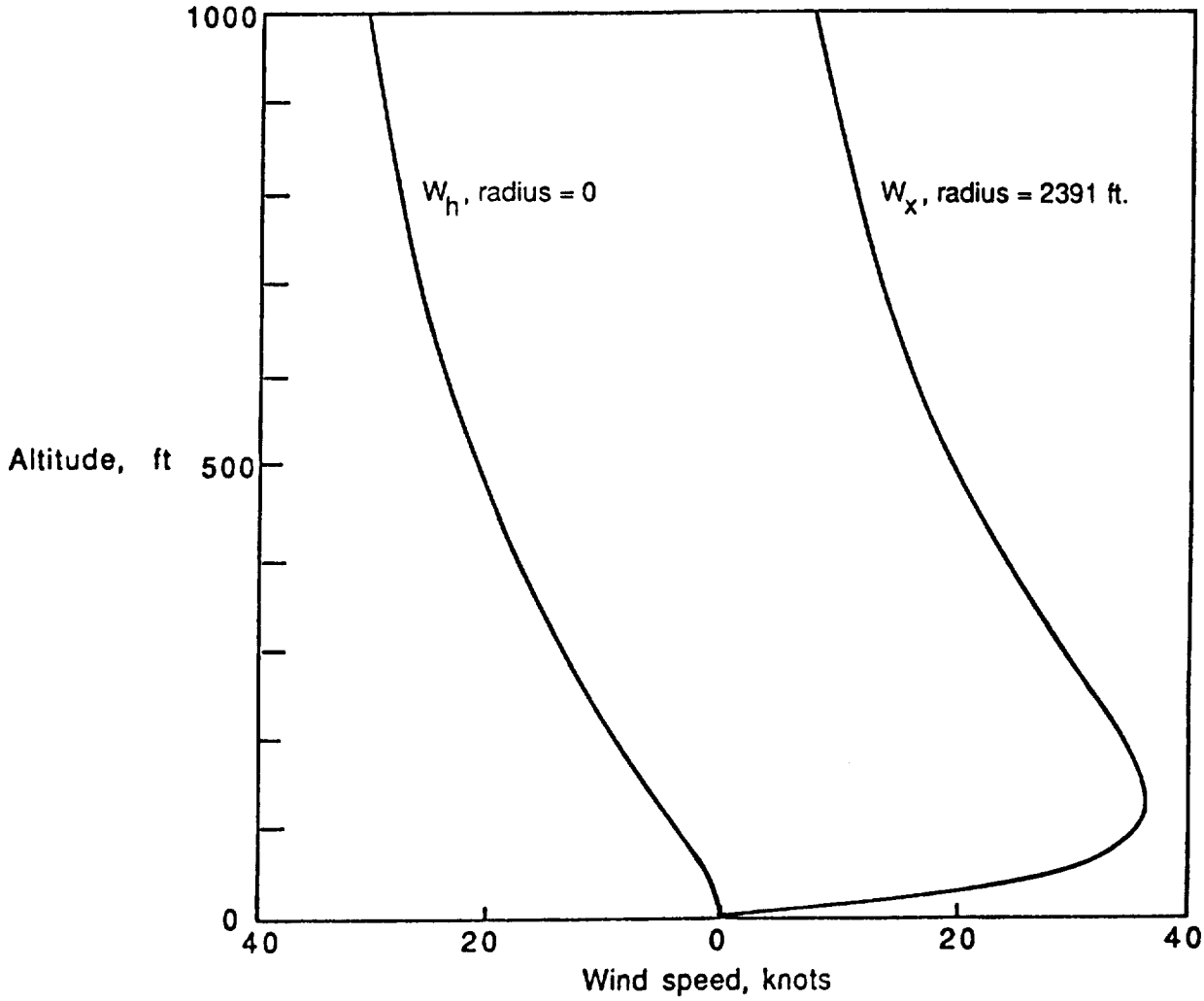

Figure 2. Microburst model altitude profiles.

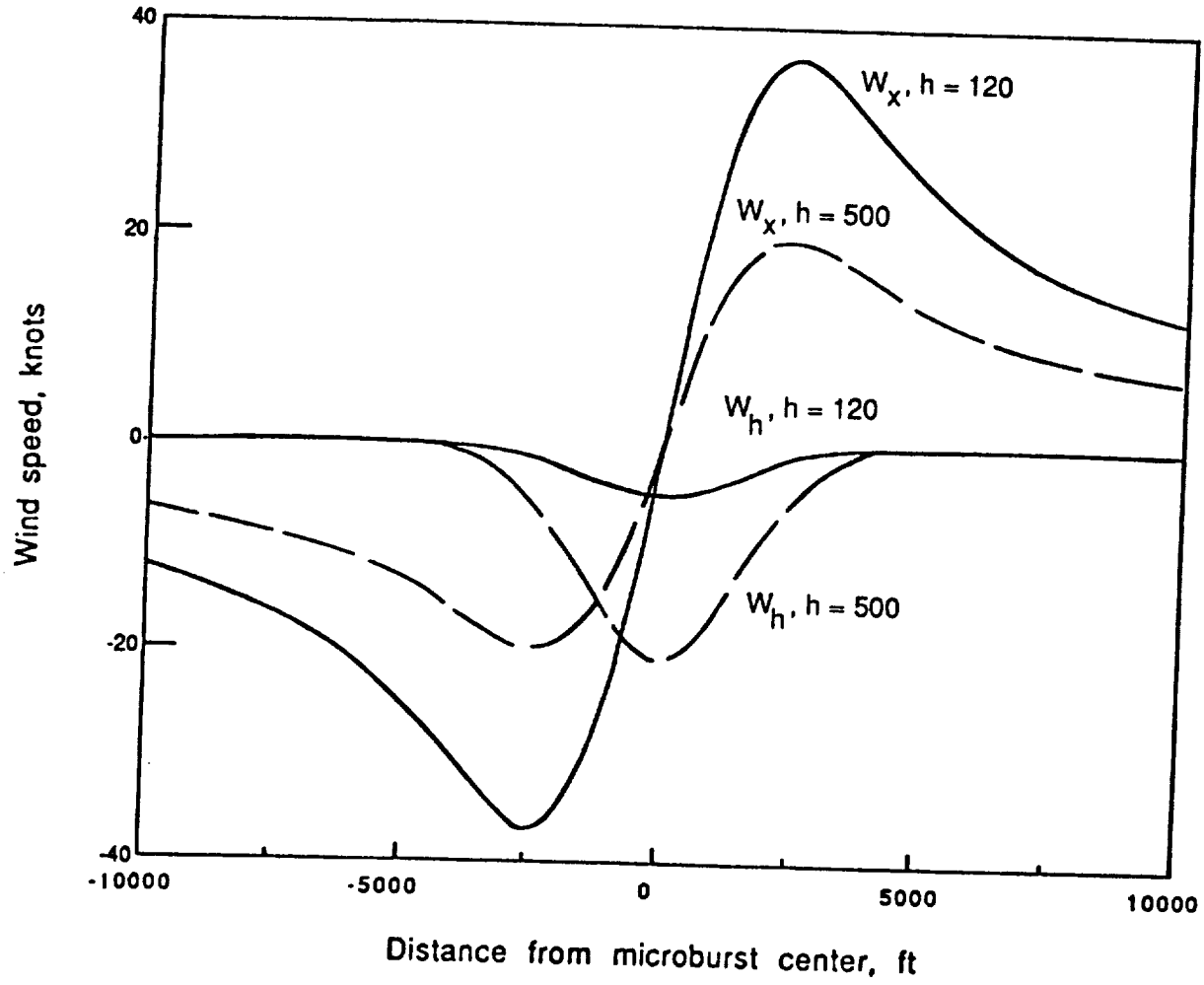

Figure 3. Radial and vertical wind components of microburst model.

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-101585 DOT/FAA/DS-89/23		

4. Title and Subtitle	5. Report Date
A Candidate Concept for Display of Forward-Looking Wind Shear Information	October 1989
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
David A. Hinton	
	10. Work Unit No.
	505-66-41-42

9. Performing Organization Name and Address	11. Contract or Grant No.
NASA Langley Research Center Hampton, VA 23665-5225	
	13. Type of Report and Period Covered
	Technical Memorandum

12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, DC 20546	

15. Supplementary Notes

16. Abstract

A concept is proposed which integrates forward-look wind shear information with airplane performance capabilities to predict future airplane energy state as a function of range. The information could be displayed to a crew either in terms of energy height or airspeed deviations. The anticipated benefits of the proposed display information concept are: 1) a wind shear hazard product that scales directly to the performance impact on the airplane and that has intuitive meaning to flight crews, 2) a reduction in flight crew workload by automatic processing of relevant hazard parameters, and 3) a continuous display of predicted airplane energy state if the approach is continued. Such a display may be used to improve pilot situational awareness or improve pilot confidence in wind shear alerts generated by other systems. This paper describes the display concept and provides the algorithms necessary for implementation in a simulation system.

17. Key Words (Suggested by Author(s))		18. Distribution Statement
microburst	radar	Unclassified - Unlimited Subject Category 06
downburst	lidar	
wind shear	forward-look sensing	
situational displays	weather	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	91	A05