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Future Enhancements to Ground-Based Microburst Detection.

M. Matthews, S. Campbell,
and T. Dasey,
Massachusetts Institute of Technology

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"FUTURE ENHANCEMENTS TO GROUND BASED MICROBURST DETECTION"*

Steven D. Campbell, Michael P. Matthews and Timothy J. Dasey

Lincoln Laboratory
Massachusetts Institute of Technology
Lexington, Massachusetts
Telephone: 617/981–3386, E–mail: sdc@ll.mit.edu

This talk will present the results of the Cockpit Weather Information (CWI) program at M.I.T. Lincoln Laboratory. The CWI program has been funded through NASA Langley Research Center by the joint NASA/FAA Integrated Airborne Wind Shear program for the past four years. During this time, over 120 microburst penetrations by research aircraft have been conducted under Terminal Doppler Weather Radar (TDWR) testbed radar surveillance at Orlando, FL. The results of these in–situ measurements have been compared with ground–based detection methods.

Several valuable insights were gained from this research activity. First, it was found that the current TDWR microburst shapes do not permit accurate characterization of microburst hazard in terms of the F factor hazard index, because they are based on loss value rather than shear. Second, it was found that the horizontal component of the F factor can be accurately estimated from shear, provided compensation is made for the dependence of outflow strength on altitude. Third, it was found that a simple continuity assumption for estimating the vertical component of the F factor yielded poor results. However, further research has shown that downdraft strength is correlated with features aloft detected by the TDWR radar scan strategy.

The outcome of the CWI program is to move from the loss–based wind shear detection algorithm used in the TDWR to a shear–based detection scheme as proposed in the Integrated Terminal Weather System (ITWS). The ITWS Microburst Detection algorithm being developed at Lincoln Laboratory uses a one kilometer radial shearmap to find regions of shear at various thresholds related to F factor hazard. The ITWS runway alerting strategy is planned to incorporate altitude compensation for outflow strength estimates. Finally, work is currently in progress to incorporate outputs from the ITWS Downdraft Detection algorithm to estimate the vertical F factor component.

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References:

1. Bowles, R. L.: "Reducing Windshear Risk Through Airborne Systems Technology", 17th Congress on the Aeronautical Sciences, Stockholm, Sweden, Sep. 9–14, 1990

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FUTURE ENHANCEMENTS TO GROUND BASED MICROBURST DETECTION

STEVEN D. CAMPBELL, MICHAEL P. MATTHEWS, AND TIMOTHY J. DASEY
MIT LINCOLN LABORATORY

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- **CWI PROGRAM OVERVIEW**
- **ESTIMATION OF F FACTOR FROM TDWR**
- **NEW MICROBURST DETECTION ALGORITHM**
- **SUMMARY**

CWI PROGRAM OVERVIEW

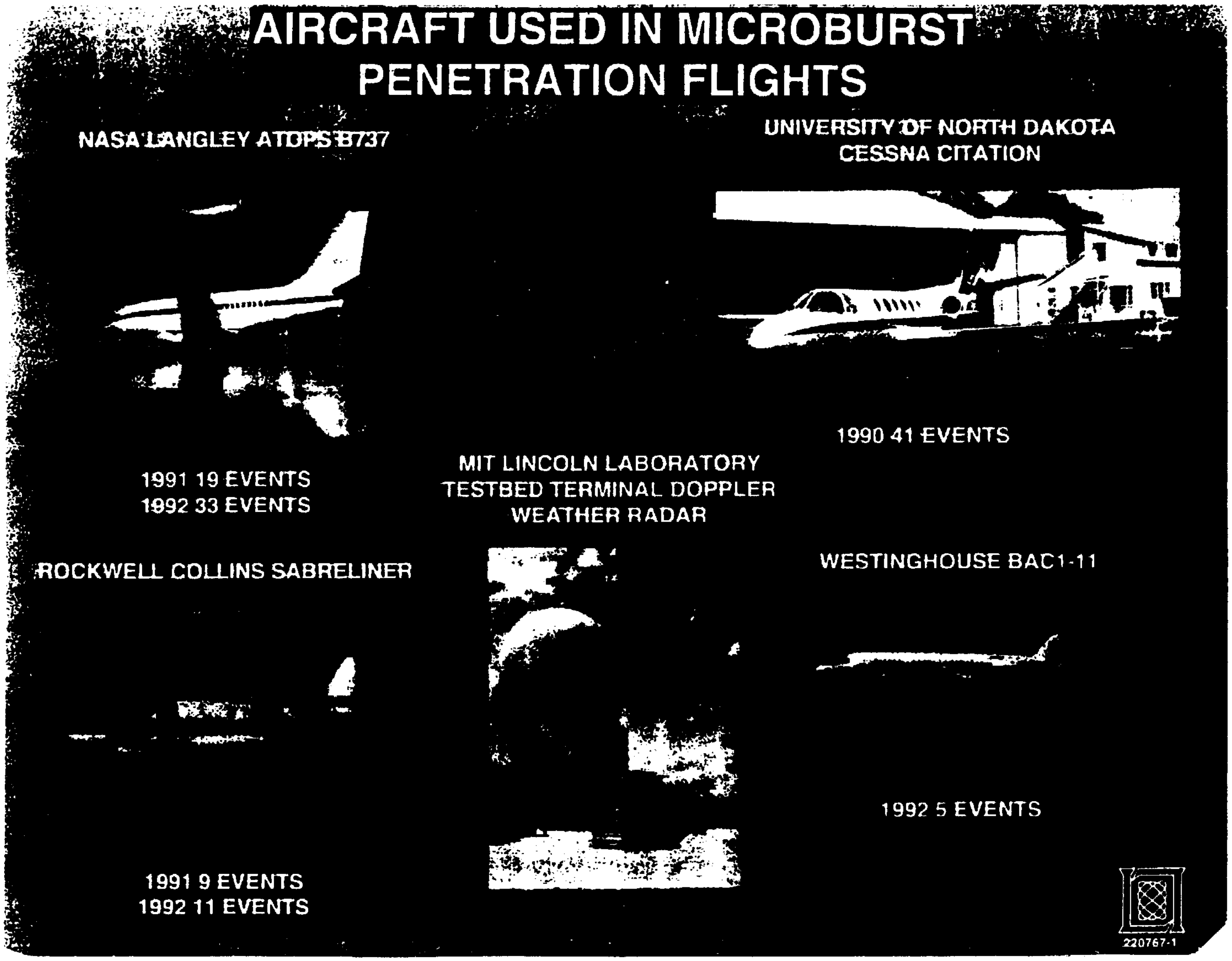
TWO MAIN OBJECTIVES OF CWI PROGRAM:

1) PROVIDE SUPPORT FOR MICROBURST PENETRATIONS IN ORLANDO

- DATA LINKED TDWR MICROBURST SHAPES TO THE COCKPIT
- PROVIDED VERBAL COMMUNICATIONS ABOUT WEATHER

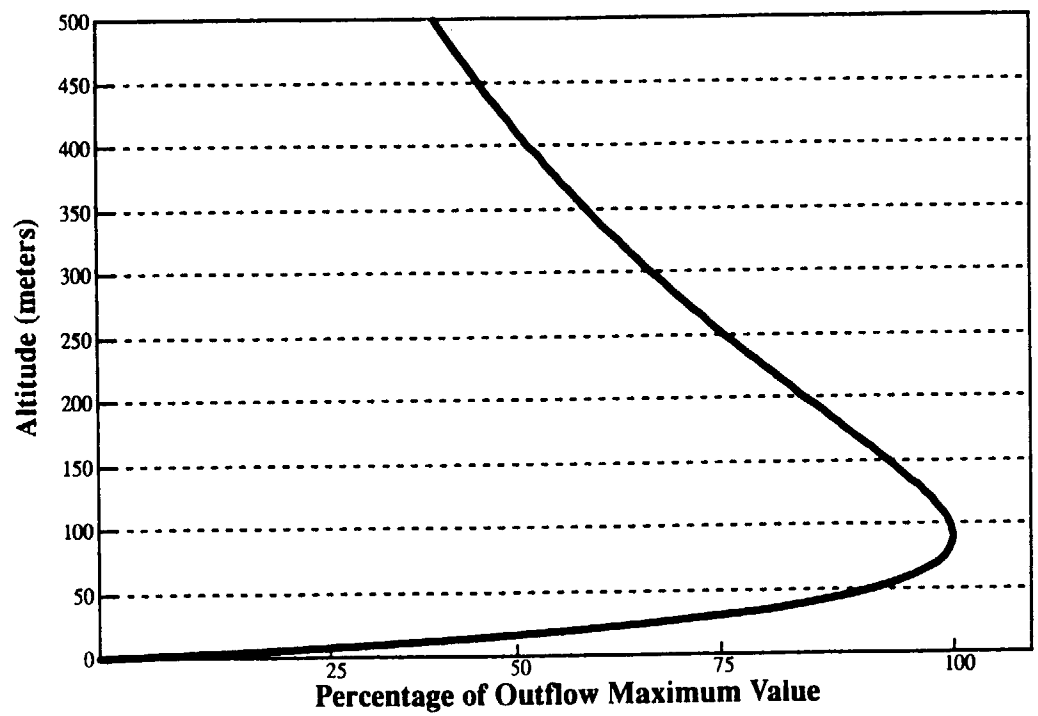
2) COMPUTE THE F FACTOR FROM GROUND BASED DOPPLER RADAR

- OVER 120 MICROBURST PENETRATIONS IN DATABASE
- USED NASA/LINCOLN KNOWLEDGE TO ESTIMATE F FACTOR

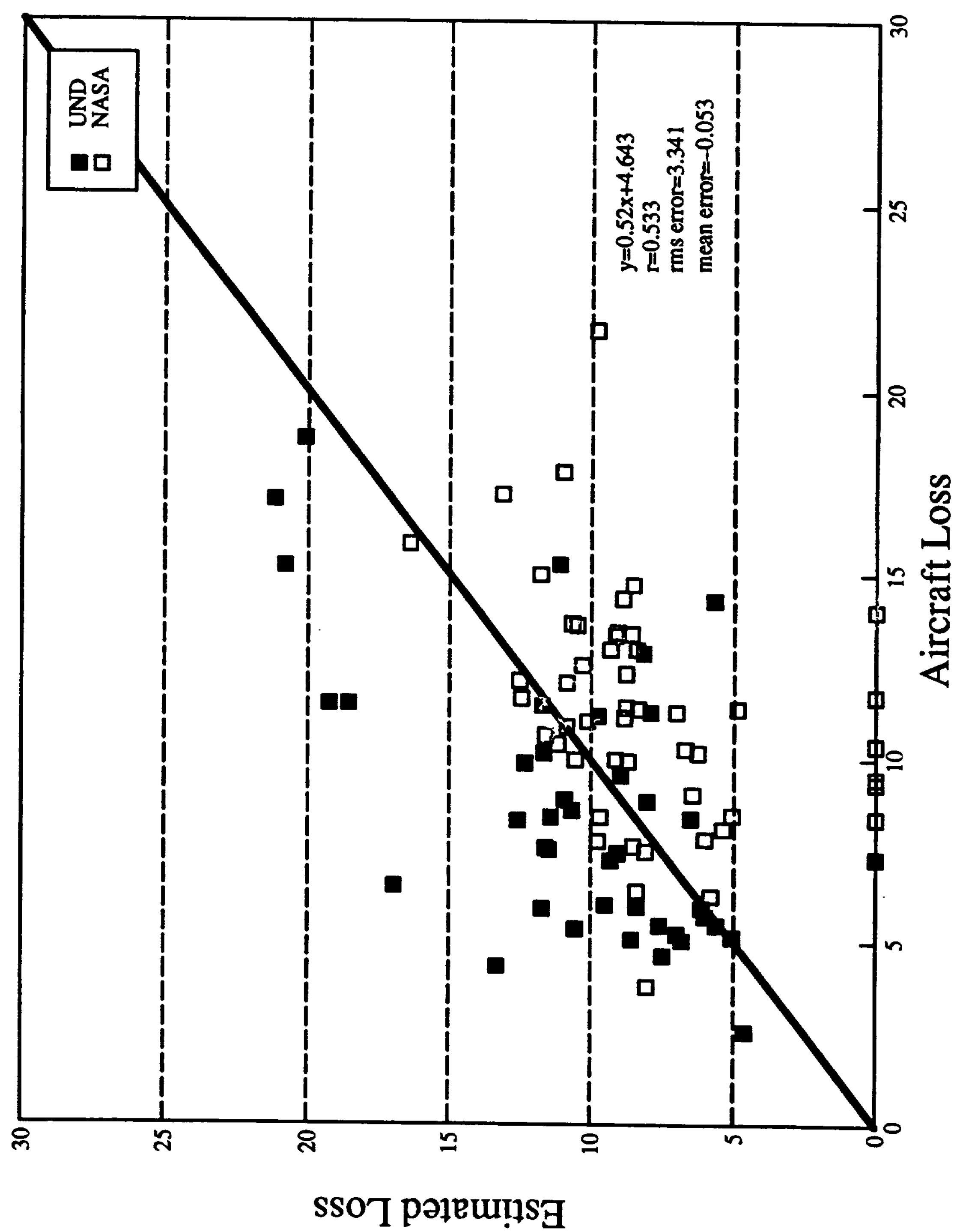

AIRCRAFT USED IN MICROBURST
PENETRATION FLIGHTS
NASA LANGLEY ATOPS B737
1991 19 EVENTS
1992 33 EVENTS
UNIVERSITY OF NORTH DAKOTA
CESSNA CITATION
1990 41 EVENTS
MIT LINCOLN LABORATORY
TESTBED TERMINAL DOPPLER
WEATHER RADAR
ROCKWELL COLLINS SABRELINER
1991 9 EVENTS
1992 11 EVENTS
WESTINGHOUSE BAC1-11
1992 5 EVENTS
220767-1

ESTIMATION OF F FACTOR FROM TDWR

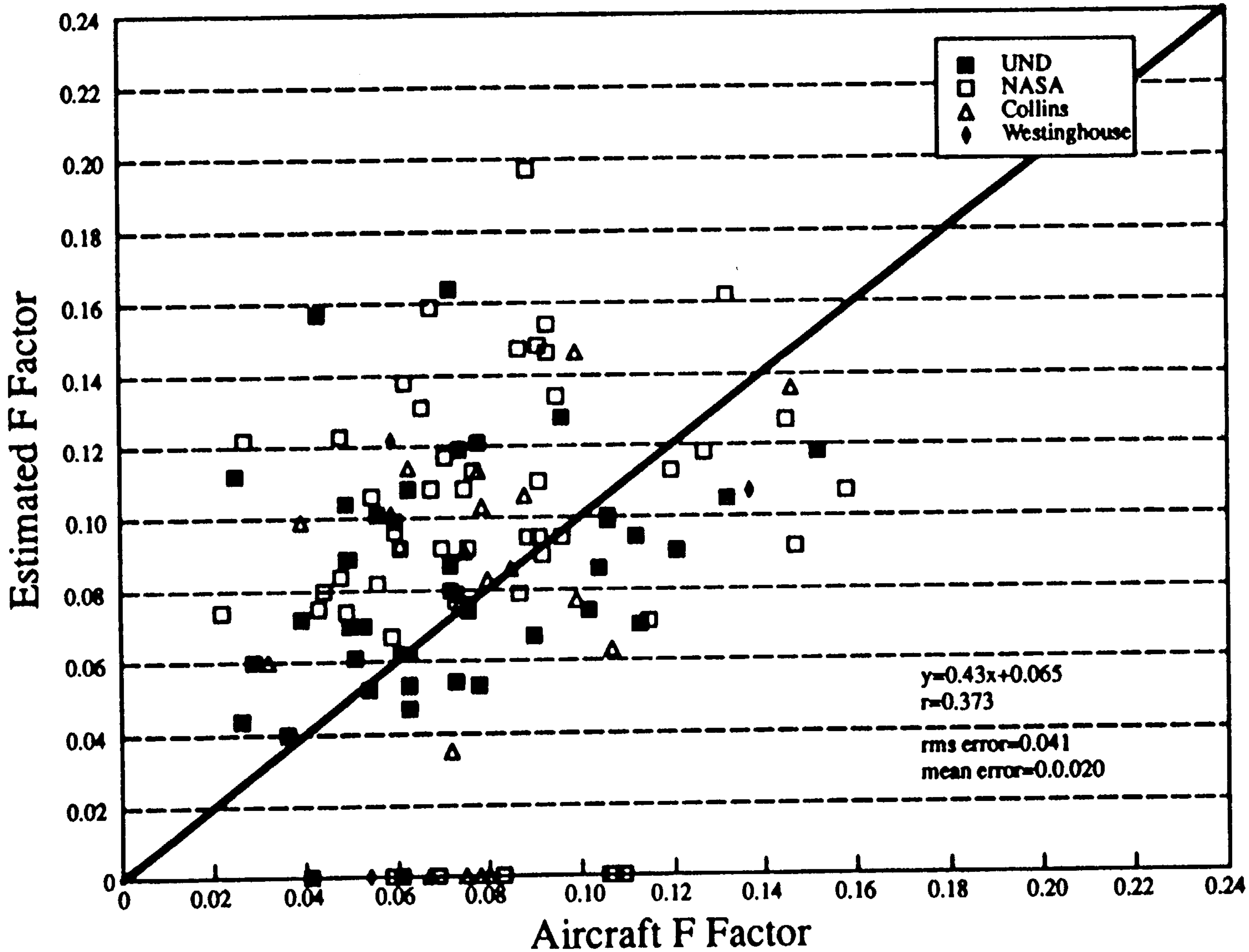
- MASS CONTINUITY ASSUMPTION FOR VERTICAL COMPONENT
- MUST COMPENSATE FOR ALTITUDE DIFFERENCES



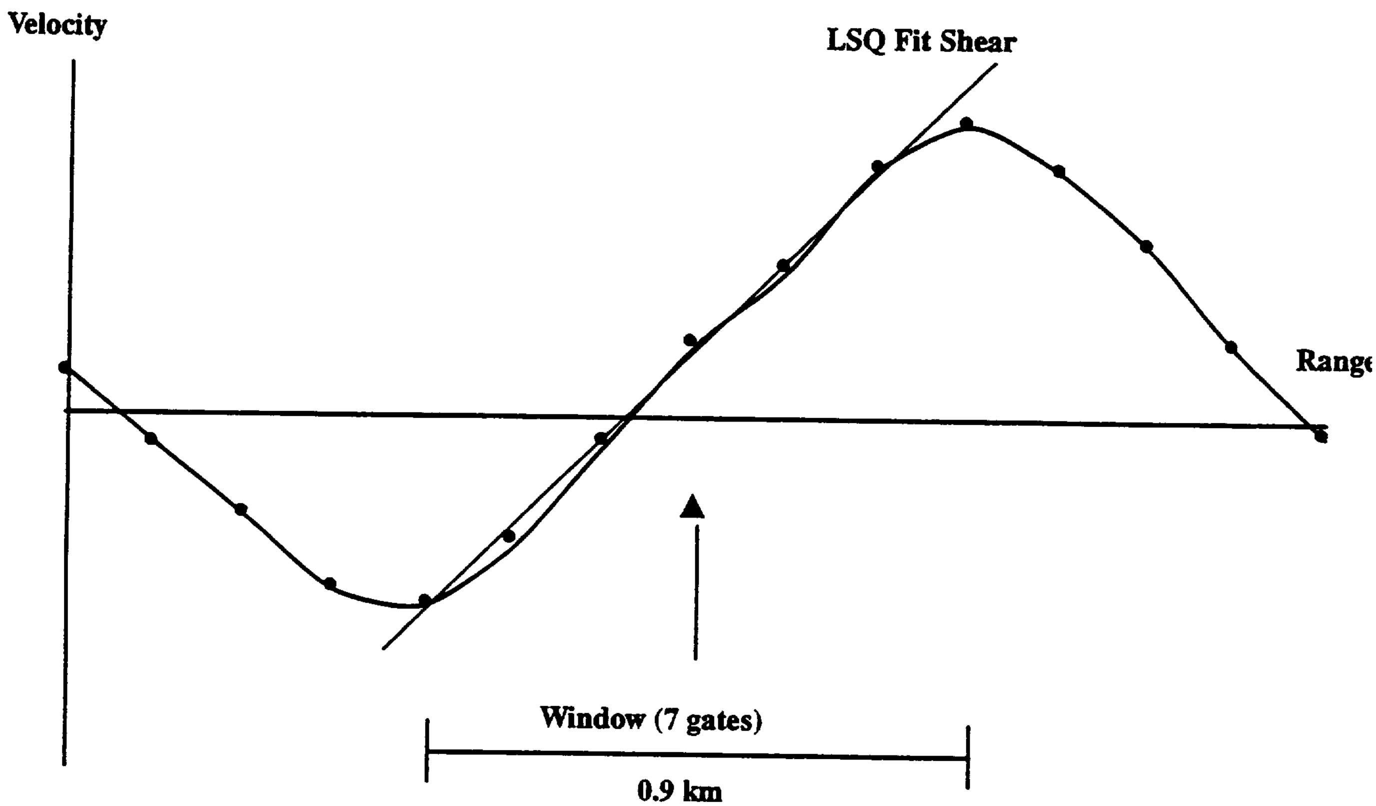
TDWR vs. Aircraft Loss using Osegura/Bowles Model Correction



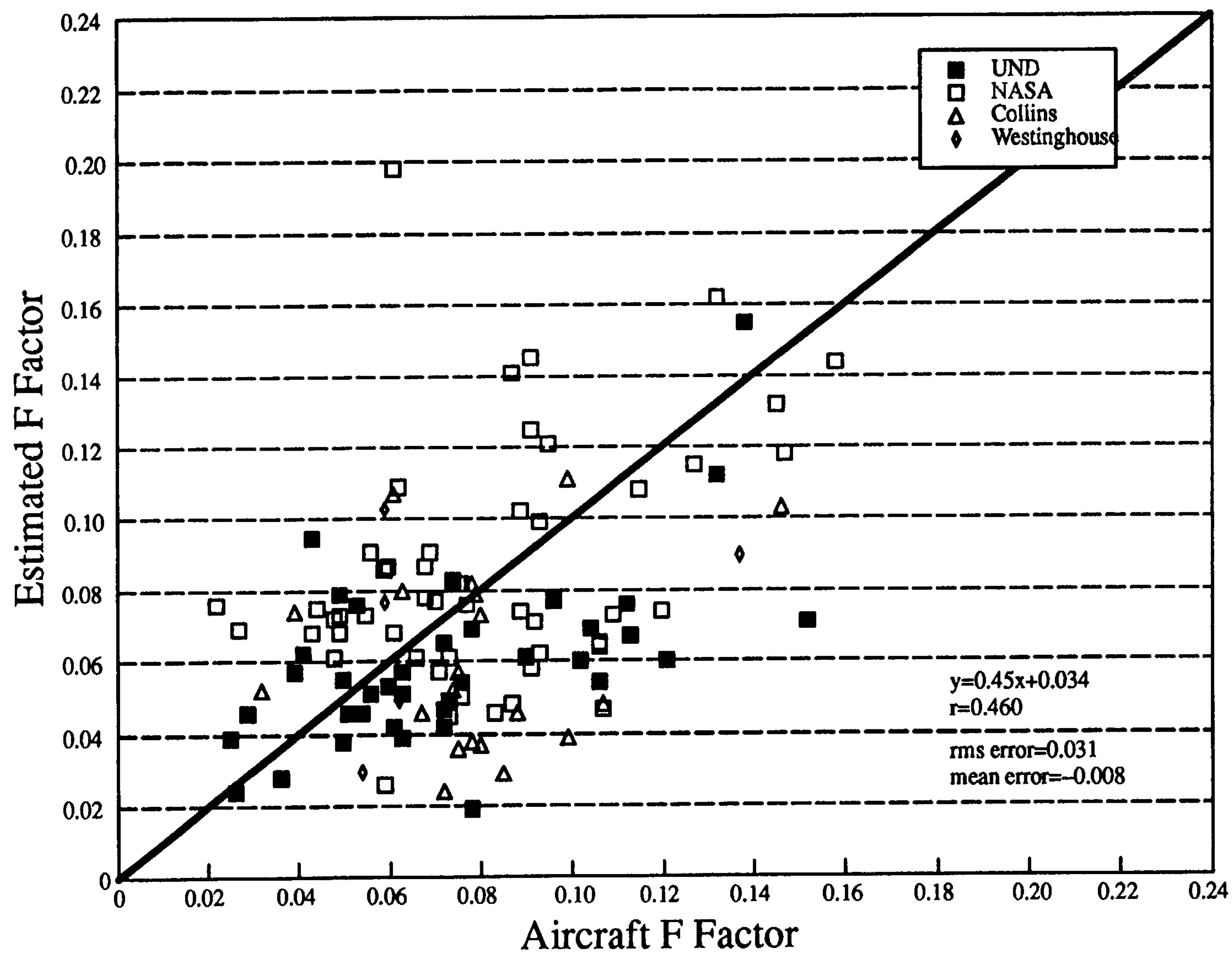
TDWR Shape vs. Aircraft Total F Factor using Osegura/Bowles Model Correction



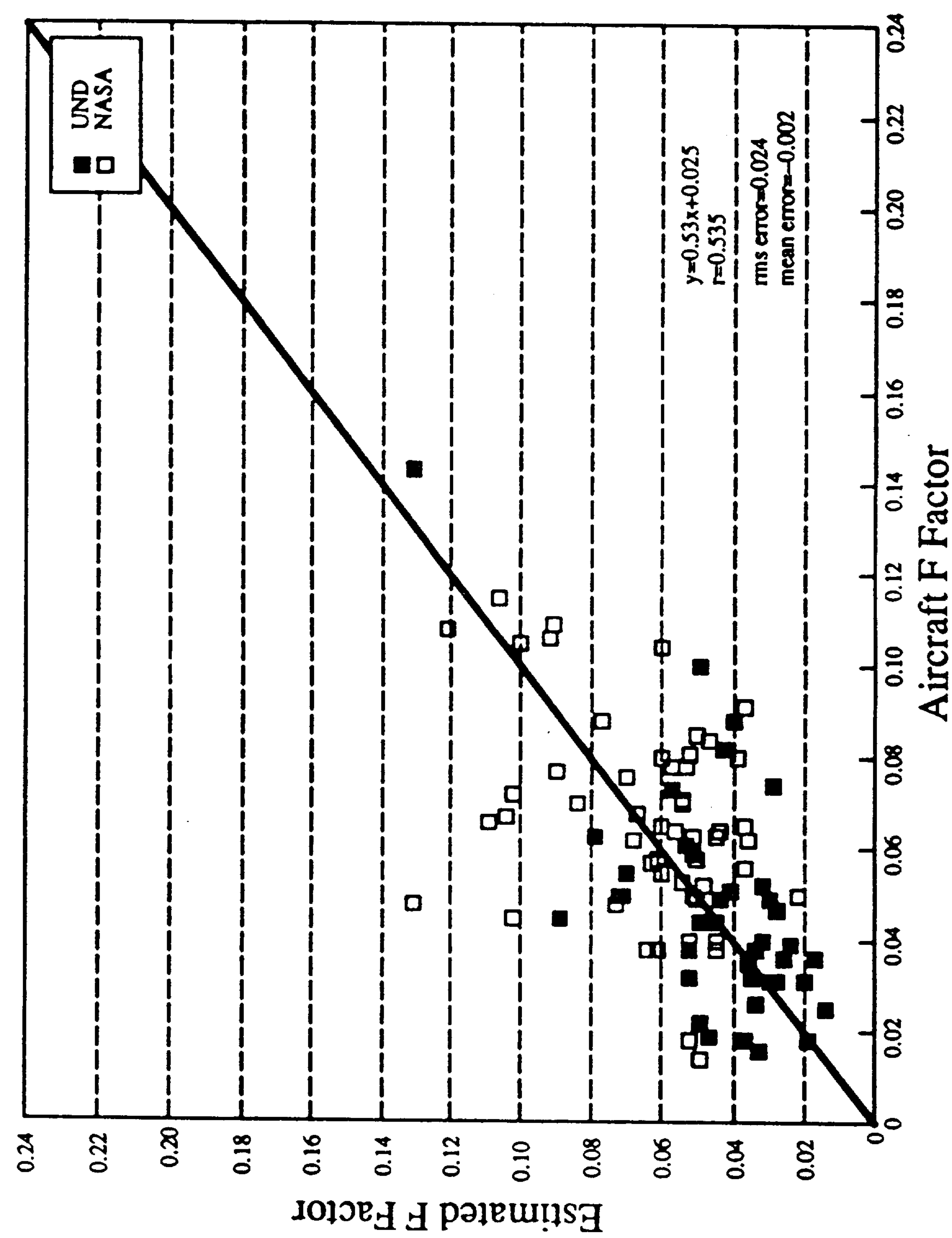
SHEAR COMPUTATION USING LEAST–SQUARES FIT

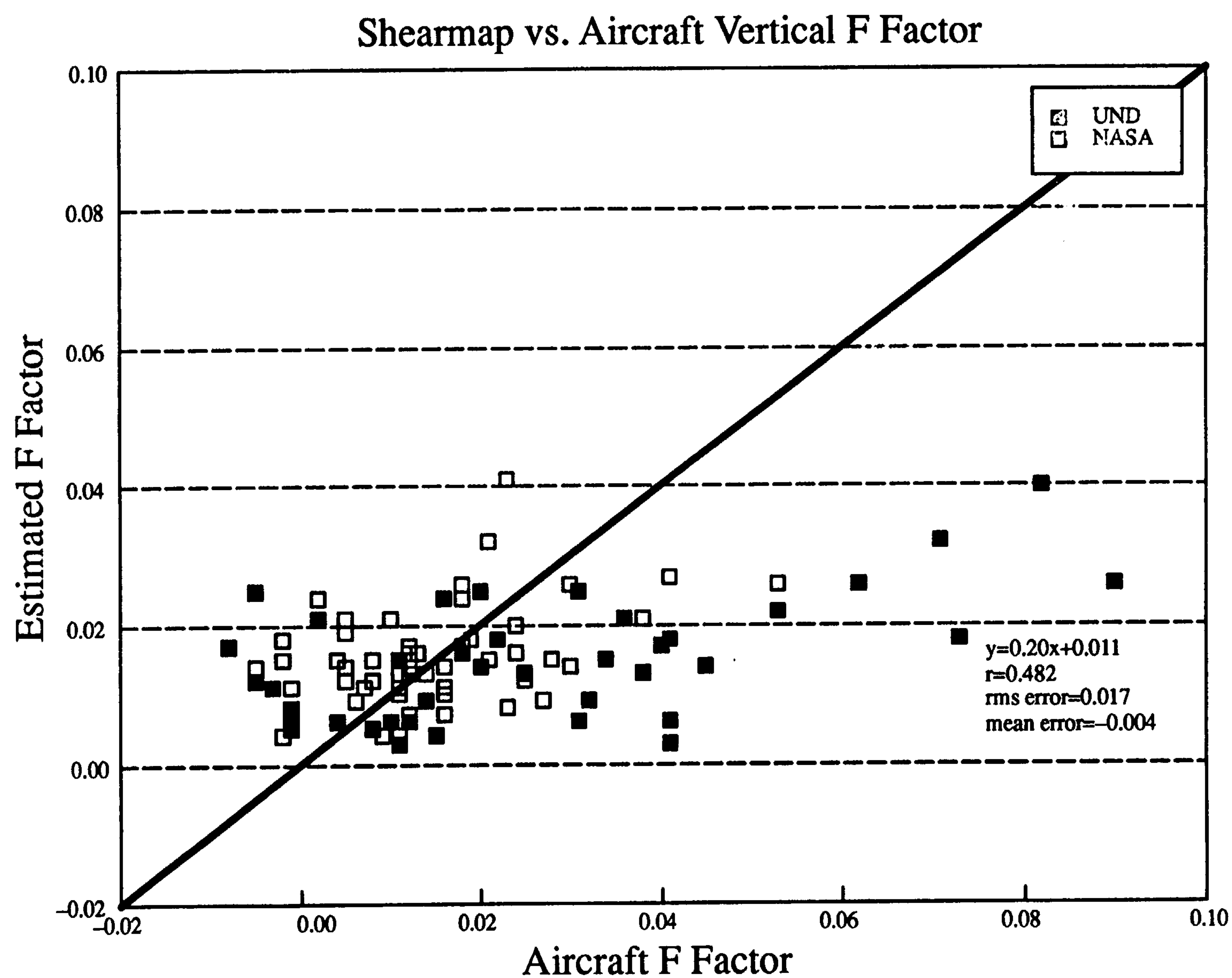


Shearmap vs. Aircraft Total F Factor using Osegura/Bowles Model Correction



Shearmap vs. Aircraft Horizontal F Factor using Osegura/Bowles Model Correction





Shearmap vs. Aircraft Vertical F Factor
UND
NASA
y=0.20x+0.011
r=0.482
rms error=0.017
mean error=-0.004
Estimated F Factor
Aircraft F Factor
0.10
0.08
0.06
0.04
0.02
0.00
-0.02

ESTIMATION OF F FACTOR FROM TDWR

- ERROR IN VERTICAL F FACTOR ESTIMATION

Error in Vertical F Factor Estimation	Reflectivity Core and Convergence	Reflectivity Core	No Features
$Fe < -0.010$	6	2	0
$-0.010 < Fe < -0.005$	3	3	2
$-0.005 < Fe < 0.005$	5	2	11
$0.005 < Fe < 0.010$	0	4	4
$0.010 < Fe$	0	0	10

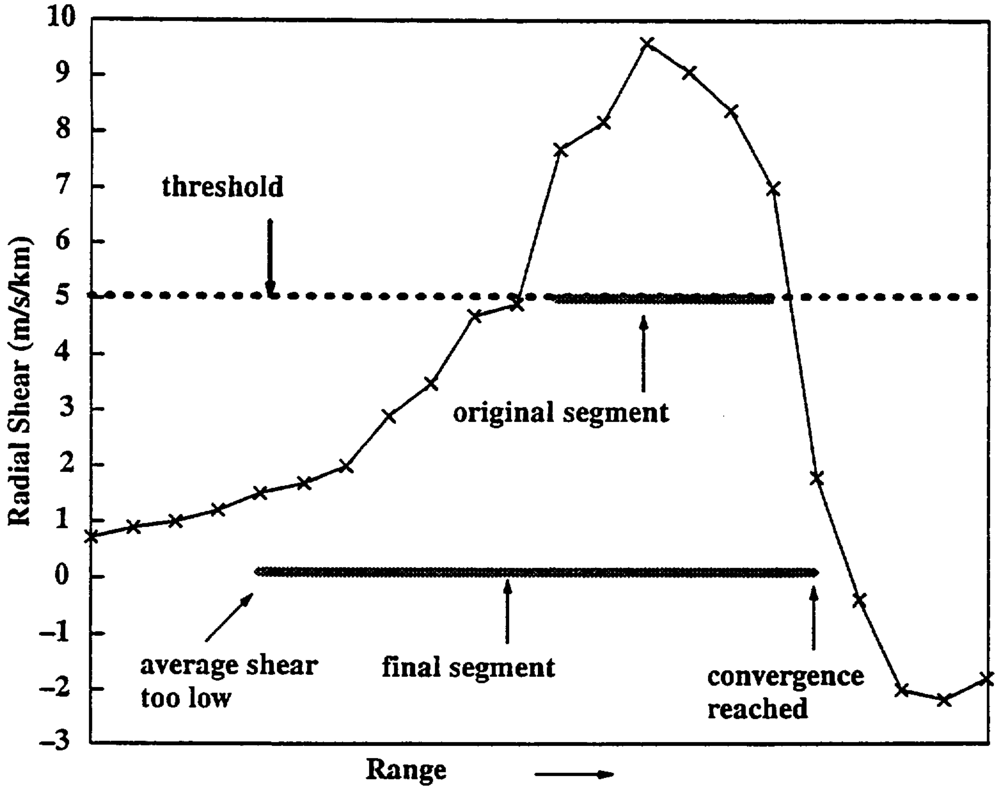
NEW MICROBURST DETECTION ALGORITHM

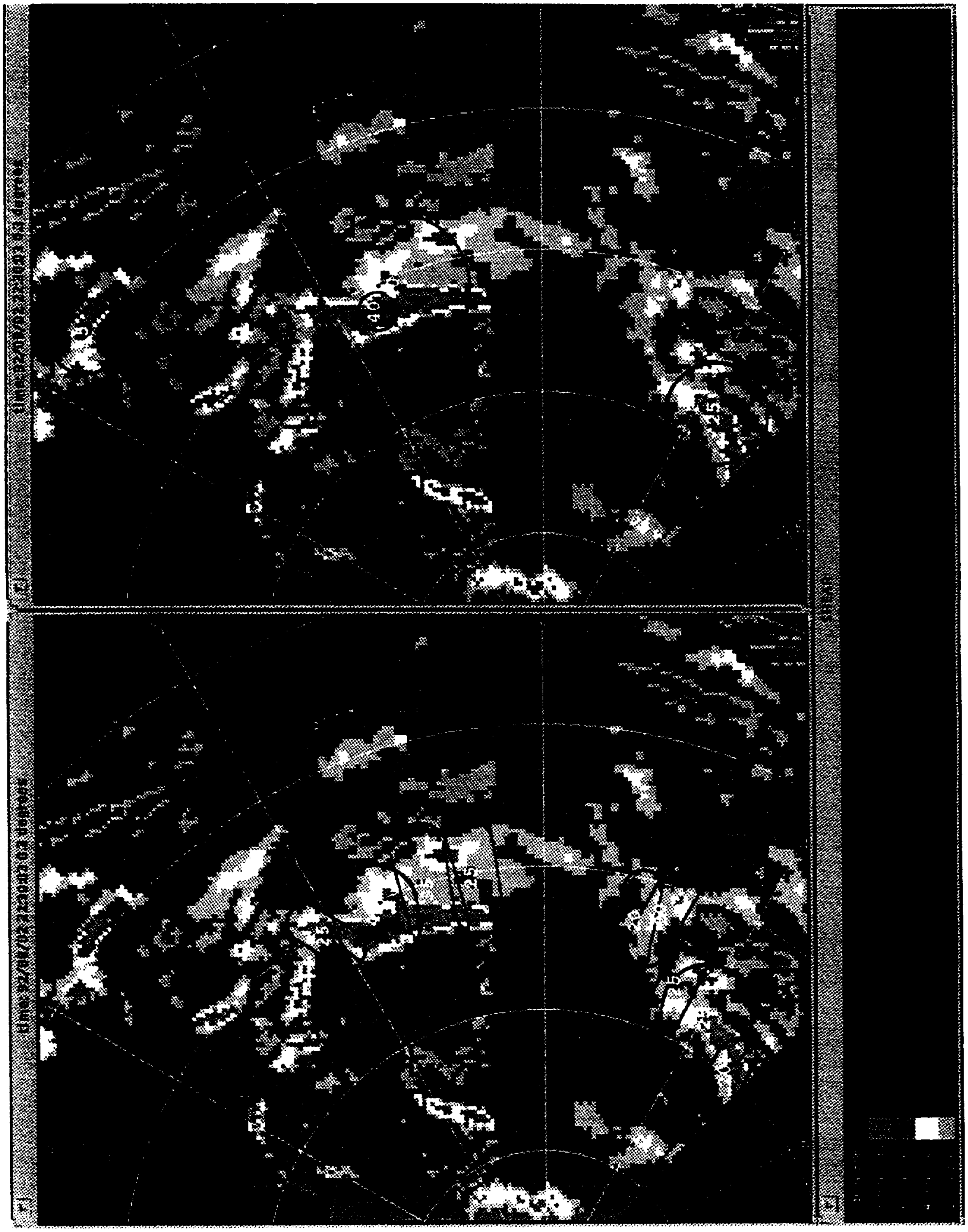
- MOTIVATIONS FOR ITWS MICROBURST DETECTION
  - ASSIST IN PROVIDING CONSISTENT WARNINGS AND TERMINOLOGY WITH AIRBORNE WIND SHEAR DETECTION SYSTEMS
  - APPLY RECENT KNOWLEDGE OF AIRCRAFT HAZARD FROM INSTRUMENTED FLIGHT PENETRATIONS
  - CONSISTENT INPUT FOR MICROBURST TREND

ALERT COMPARISON

TDWR	AIRBORNE
ALERTS BASED ON HEADWIND TO TAILWIND WIND CHANGES	ALERTS BASED ON ENERGY LOSS RATE (F–FACTOR)
TWO ALERT LEVELS: "WIND SHEAR ALERT (WSA)" FOR EXPECTED LOSS BETWEEN 15 AND 30 KNOTS "MICROBURST ALERT (MBA)" FOR EXPECTED LOSS > 30 KNOTS	ONE ALERT LEVEL: "WIND SHEAR WITH LOSS ALERT" FOR F–FACTOR > 0.105
TEXT BASED ALERT	GRAPHICAL ALERT
FLIGHT PATH INTENSITY PROVIDED	NO INTENSITY PROVIDED

SEGMENT FORMATION





CONCLUSIONS

- TDWR MICROBURST ALGORITHM
  - – ACCURATELY REPORTS THE LOSS
  - – OVERESTIMATES F FACTOR HAZARD
- NASA LANGELY DEVELOPED SHEARMAP
  - – PROVIDES A BETTER ESTIMATE OF HAZARD
  - – MUST CORRECT FOR ALTITUDE
  - – NEED TO IMPROVE VERTICAL F FACTOR ESTIMATION
- ITWS MICROBURST ALGORITHM
  - – USES AIRBORNE WIND SHEAR PROGRAM TECHNOLOGY
  - – PROVED A BETTER ESTIMATE OF F FACTOR