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A Microburst Prediction Algorithm for the FAA Integrated Terminal Weather System*

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ABSTRACT

Lincoln Laboratory is developing a prototype of the Federal Aviation Administration (FAA) Integrated Terminal Weather System (ITWS) to provide improved aviation weather information in the terminal area by integrating data and products from various FAA and National Weather Service (NWS) sensors and weather information systems. The ITWS Microburst Prediction product is intended to provide an additional margin of safety for pilots in avoiding microburst wind shear hazards (Fig. 1). The product is envisioned for use by traffic managers, supervisors, controllers, and pilots (directly via datalink). Our objective is to accurately predict the onset of microburst wind shear several minutes in advance.

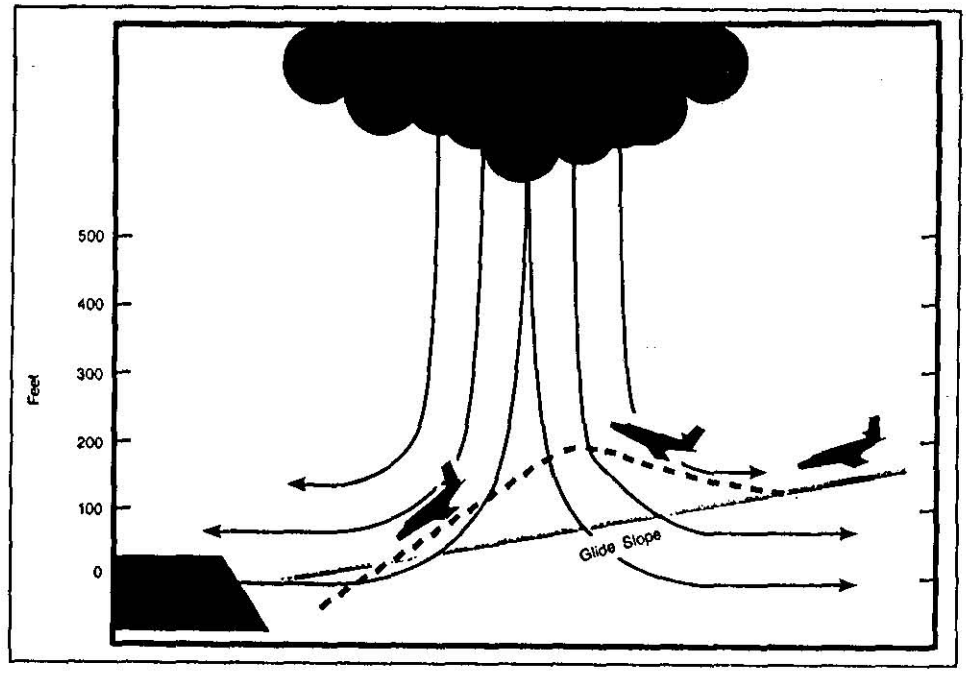

Figure 1. Example of an aircraft encounter with a microburst. The spreading winds from a strong downdraft form the microburst outflow. A penetrating aircraft first experiences an increase in head wind, followed rapidly by a downdraft, and finally a tail wind. The loss in altitude across the event may result in ground impact.

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The approach we have chosen in developing the ITWS Microburst Prediction algorithm emphasizes fundamental physical principles of thunderstorm evolution and downdraft development, incorporating heuristic and/or statistical methods as needed for refinement. Image processing and data fusion techniques are used to produce an "interest" image (Delanoy *et al.*, 1991, 1992) that reveals developing downdrafts. We use Doppler radar data to identify regions of growing thunderstorms and probable regions of downdraft, and combine these with measures of the ambient temperature structure (height of the freezing level, lapse rate in the lower atmosphere; Wolfson 1990), total lightning flash rate, and storm motion to predict the microburst location, timing, and outflow strength. There is also a simple feedback system based on the results of the Microburst Detection algorithm that desensitizes prediction thresholds if false predictions are being reported.

The following slides describe the preliminary ITWS Microburst Prediction algorithm design, and show examples of feature detector, and the algorithm output on one test case. Results from off–line testing on 17 days of data from Orlando are also presented.

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Delanoy, R.L., J.G. Verly, and D.E. Dudgeon, 1992: Functional templates and their application to 3–D object recognition. *IEEE International Conference on Acoustics, Speech and Signal Processing*, San Francisco, March 23–26, pp. III–141–144.

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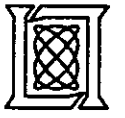
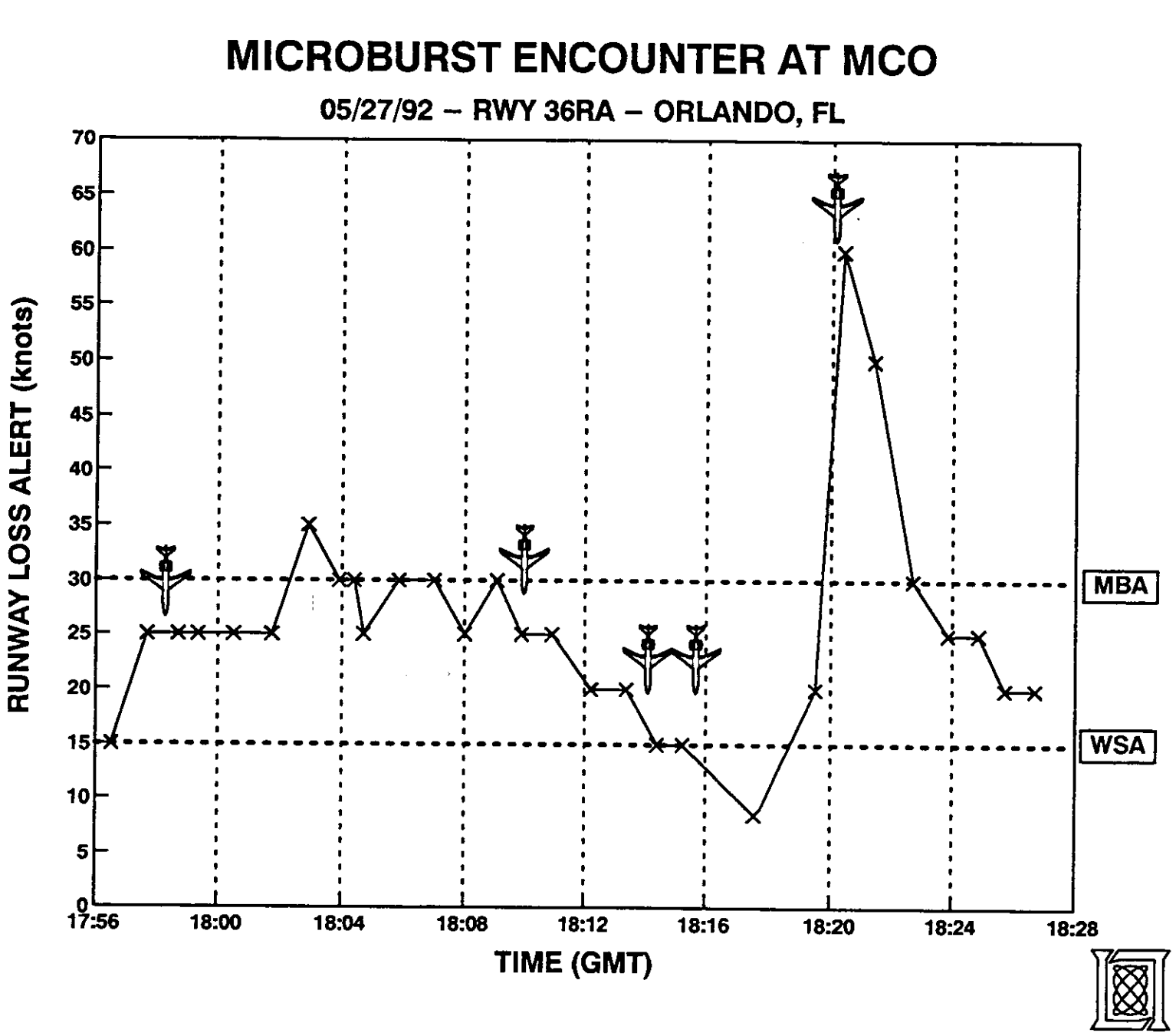
ITWS MICROBURST PREDICTION ALGORITHM

MARILYN WOLFSON DICK DELANOY BARBARA FORMAN
BOB HALLOWELL MARGO PAWLAK PETER SMITH

- ALGORITHMIC APPROACH
- OVERVIEW OF ALGORITHM
- OPERATIONAL CONCEPT
- PERFORMANCE EVALUATION
- FUTURE PLANS



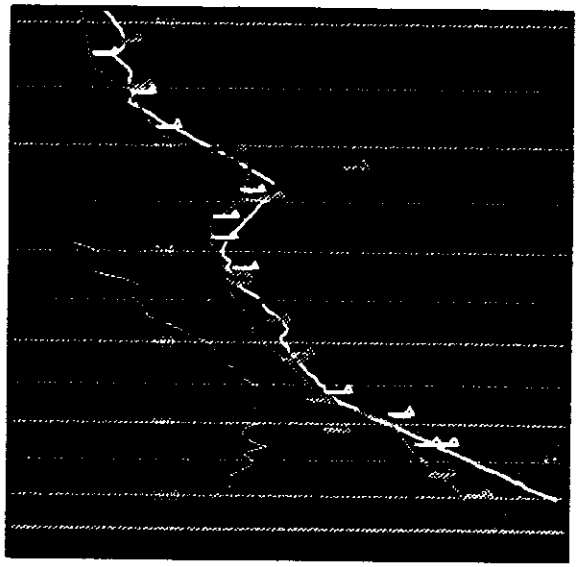

MICROBURST ENCOUNTER AT MCO
05/27/92 – RWY 36RA – ORLANDO, FL
RUNWAY LOSS ALERT (knots)
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
MBA
WSA
17:56
18:00
18:04
18:08
18:12
18:16
18:20
18:24
18:28
TIME (GMT)

OVERVIEW OF MICROBURST PREDICTION ALGORITHM

VERTICAL ACCELERATION OF DOWNDRAFT = EVAPORATION + MELTING + WATER LOADING + PRESSURE FORCES

[RELATE TO OUTFLOW VIA CONTINUITY]

ESTIMATION OF SOUNDING PARAMETERS

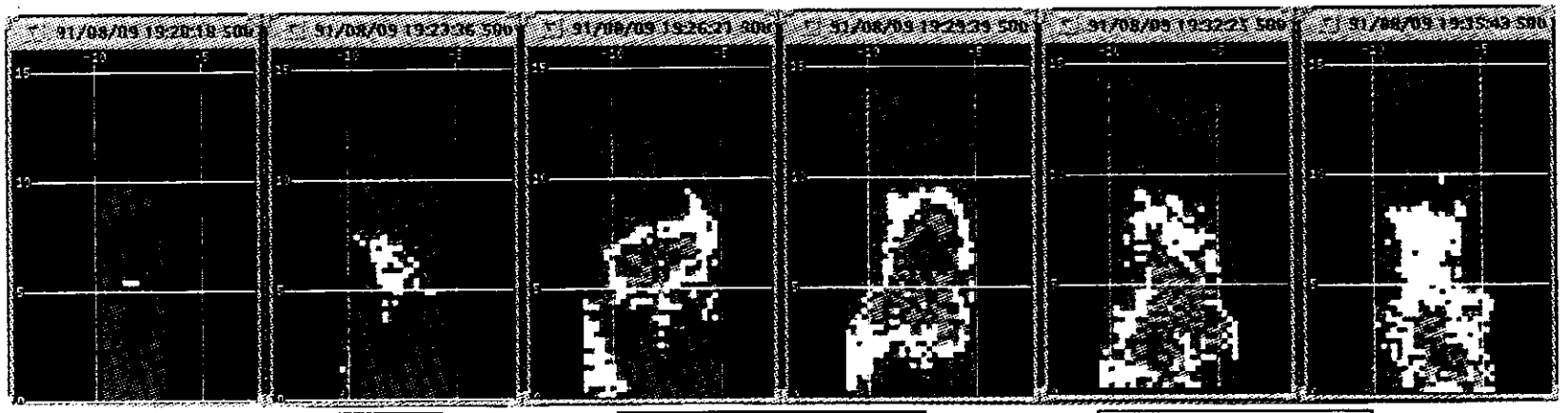


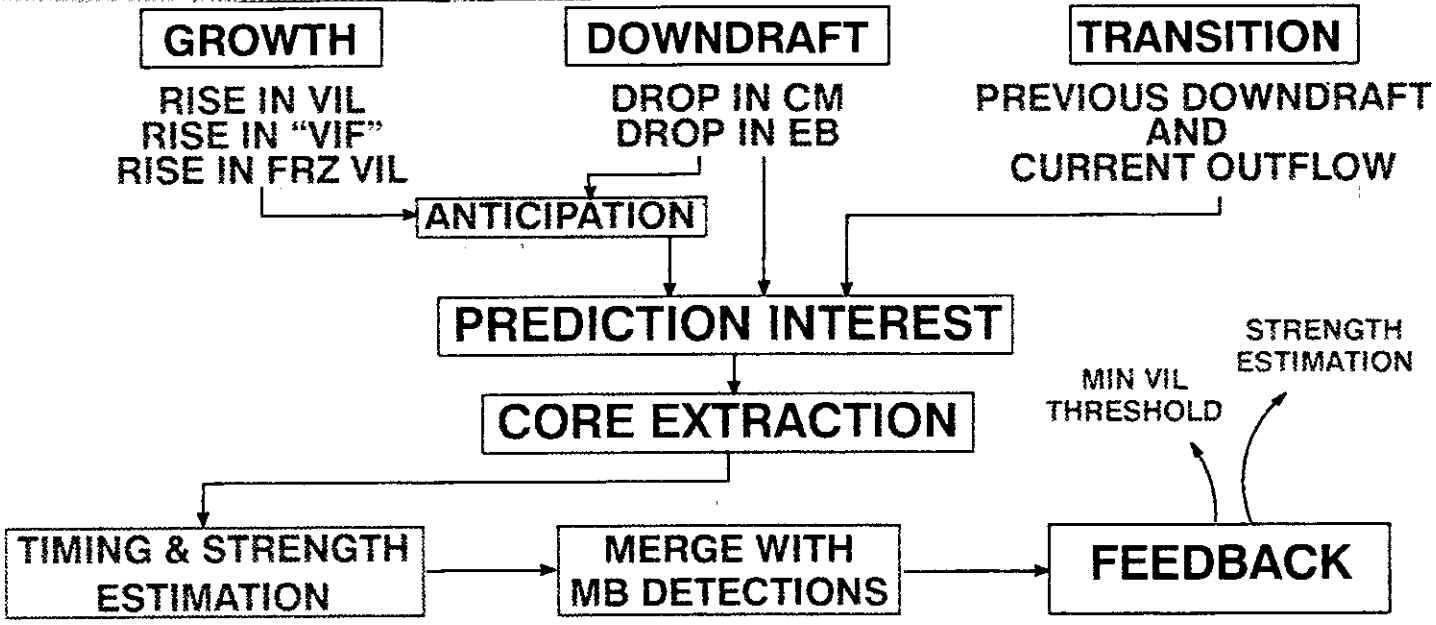
- USE MDCRS & ASOS & SA TEMPERATURE DATA
- DERIVE TIME & SPACE WEIGHTED PROFILE
- COMPUTE MEAN LAPSE RATE & FREEZING LEVEL

DETECTION OF STORM GROWTH & DOWNDRAFT DEVELOPMENT

- LOOK FOR GROWTH (e.g., INCREASE IN VIL)
- LOOK FOR DOWNDRAFT (e.g., DROP IN CENTER OF MASS)
- ESTIMATE OUTFLOW STRENGTH USING SOUNDING
- ESTIMATE TIMING OF MICROBURST ONSET
- MAKE PREDICTIONS (MERGE W/ DETECTIONS FOR DISPLAY)
- RUN FEEDBACK (COMPARE DETECTIONS & PREDICTIONS)

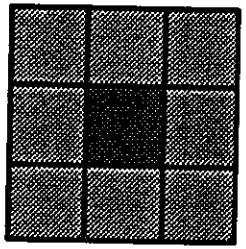
MICROBURST PREDICTION ALGORITHM OVERVIEW

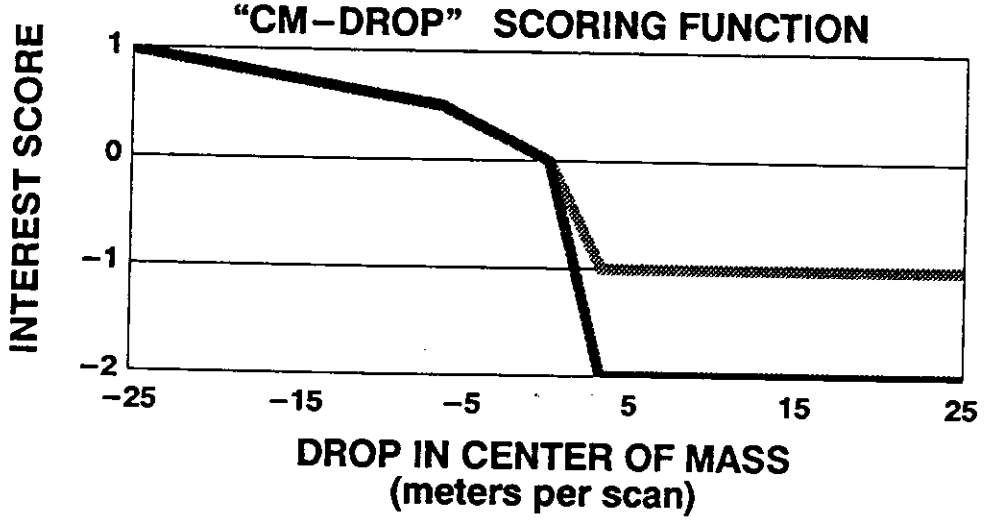




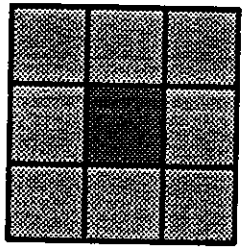
"CM–DROP–AT–VIL" FEATURE DETECTOR

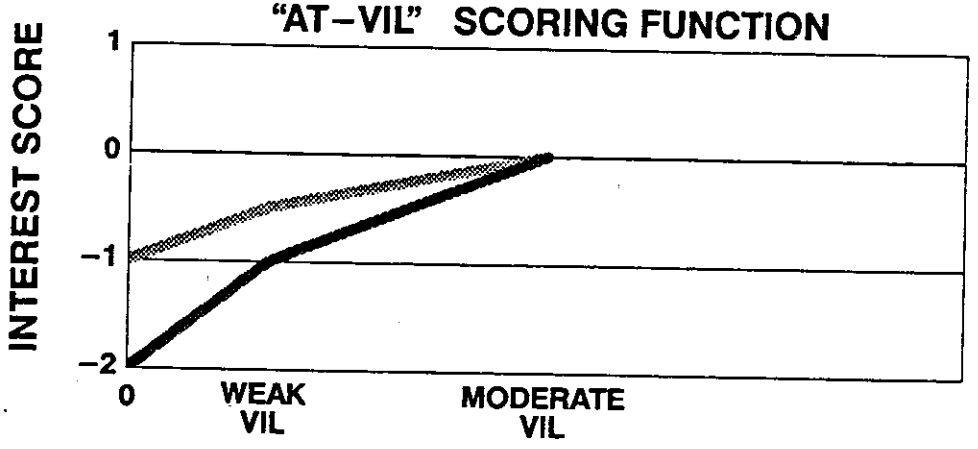
KERNEL

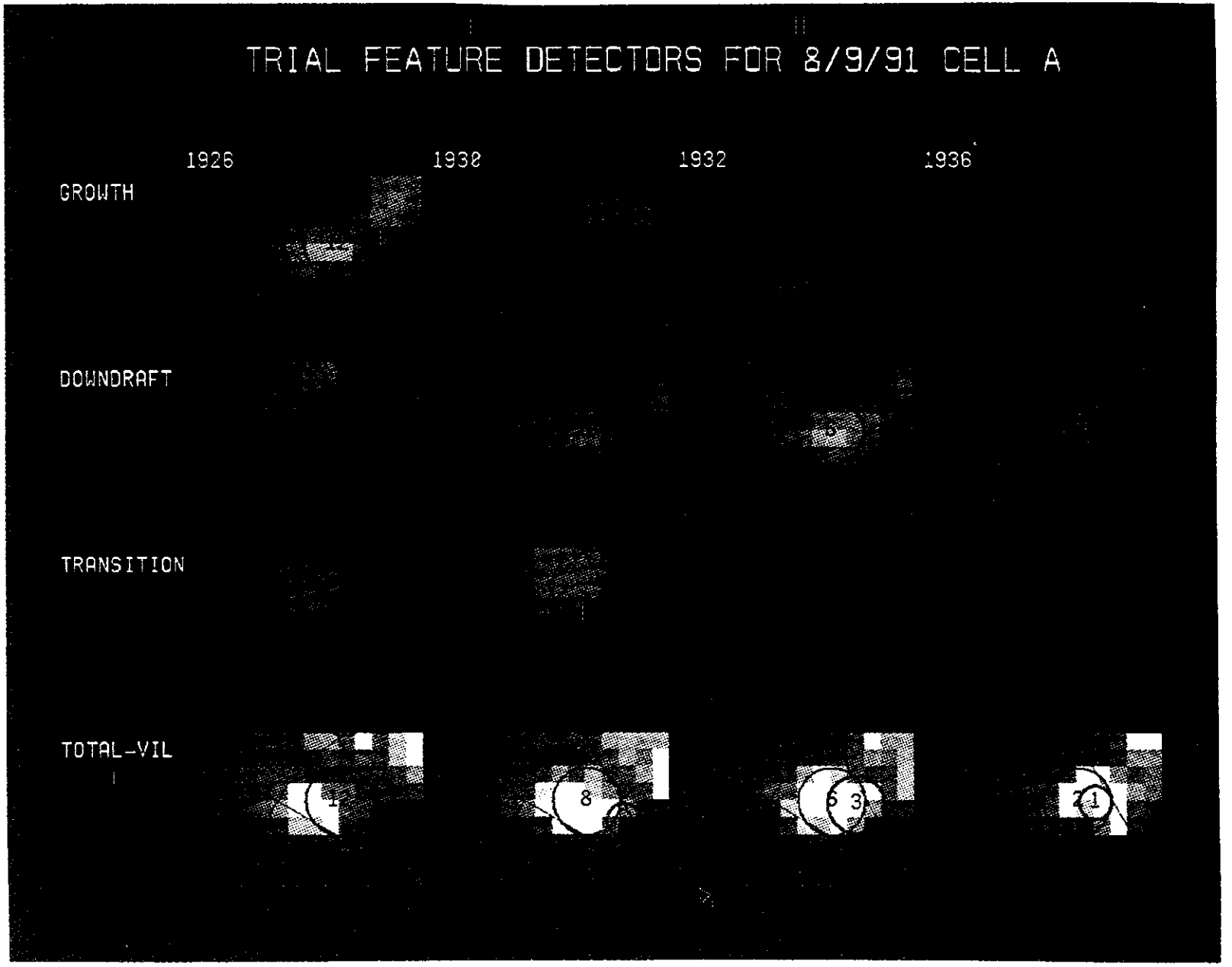




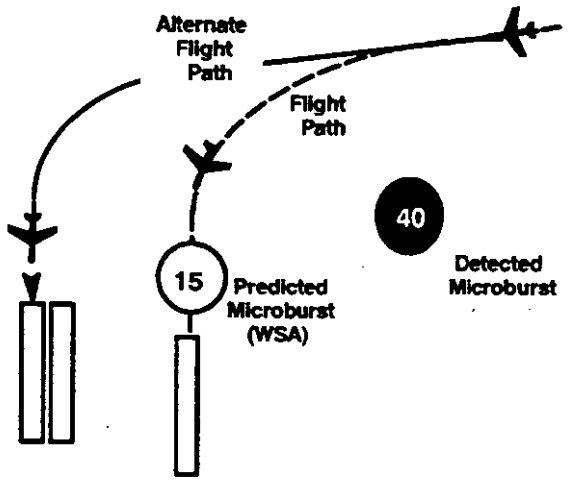
KERNEL






TRIAL FEATURE DETECTORS FOR 8/9/91 CELL A
1926
1930
1932
1936
GROWTH
DOWNDRAFT
TRANSITION
TOTAL-VIL
1
8
6
3
2
1

OPERATIONAL CONCEPT



- PROVIDES SAFETY MARGIN (2–5+ min LEAD TIME)
- DIRECTLY USED BY CONTROLLERS, SUPERVISORS
- LOW PROBABILITY OF FALSE ALARM REQUIRED
- PRODUCT DELINEATES DOWNDRAFTS

ITWS MICROBURST PREDICTION ALGORITHM PERFORMANCE EVALUATION

	POP	PFA
WSA & MBA	56.3	3.1
MBA ONLY	33.0	0

17 ORLANDO DAYS – 266 WSA – 112 MBA – 1845 MINUTES

POP = PROB. OF PREDICTION
PFA = PROB. OF FALSE ALARM

SUMMARY

- DEVELOPED PHYSICALLY–BASED MICROBURST PREDICTION ALGORITHM
- NEW APPLICATION FOR SKETCH IMAGE PROCESSING SYSTEM
- IMPROVEMENTS IN PERFORMANCE POSSIBLE

FUTURE PLANS

- REAL–TIME SYSTEM INTEGRATION IN PROGRESS
- ITWS "DEMONSTRATION/VALIDATION" IN 1994
  - MEMPHIS IN MAY & JUNE
  - ORLANDO IN JULY & AUGUST