CIWS Cockpit Weather Demonstration

Steve Campbell

M.I.T. Lincoln Laboratory

Outline

- Motivation
- Weather-Huffman Data Compression
- System Design
- Airborne Display
- Results
- Summary

Air Traffic Delays Are Increasing As Traffic Recovers from September 11th

ATC GRIDLOCK

2 Aug 99

Airlines Pin Passenger Unrest on ATC Delays

JAMES T. McKENNA/WASHINGTON

Carriers say they suffer along with their customers, and want taxes cut if air traffic problems persist

Top U.S. airline executives are launching a counterattack in the fight over passenger rights, charging that an inept and inefficient air traffic control system is to blame for worsening flight delays that infuriate travelers and cost airlines billions of dollars in wasted fuel and crew time.

Continental Airlines' chairman and chief executive, Gordon Bethune, opened the counterattack on July 27, charging in a speech to the Aero Club here that this

gress that delays and airspace conge are reaching a critical point (see p. The Air Transport Assn. is demanding the Transportation Dept. report d caused by the FAA's management of in its monthly reports on airline on-performance (*AW&ST* July 26, p. 6

LATE LAST MONTH, UNITED Airlines' chairman and CEO, James Goodwin a group of business officials in Chi that ATC delays cost that airline $1 million each month in added expense

Continental claims flight delays at Newark International Airport alone cost the carrier $100 million last year and that delays are worsening this year.

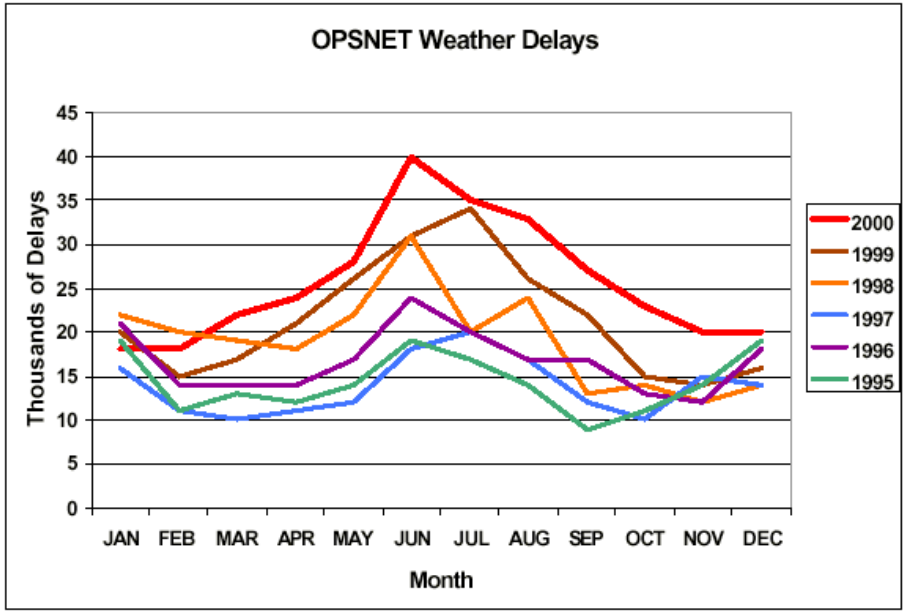
ATC Del Rile Car

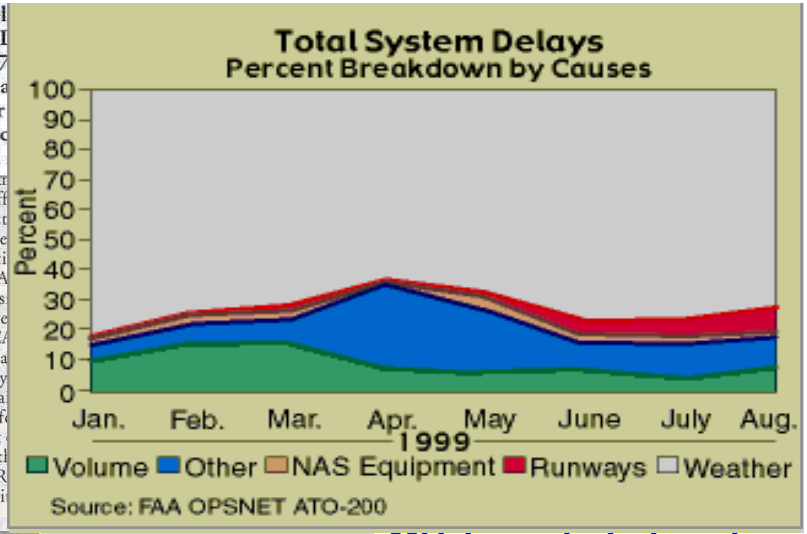
Seattle

The U.S. Air Tra titioned the Trans break out air traffi future airline on-tin accurately reflect the

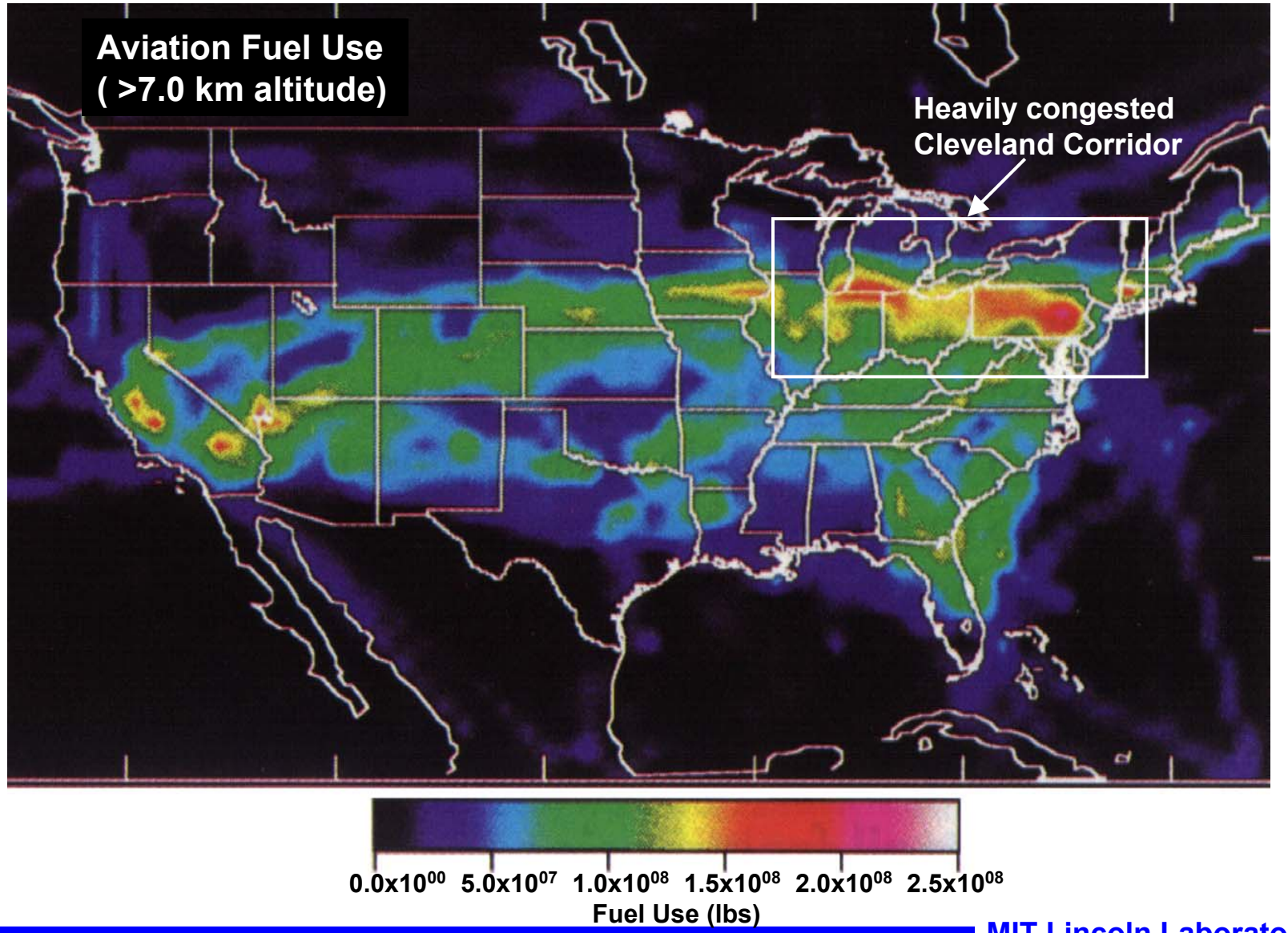
The filing, which Transportation Dep monthly Air Travel ostensibly is to hel compare airline on-time and rel formance. The Transportation I compiled the report since 1987 lay figures are not categorized a many are the fault of the carrier many a problem with air traffic ATA said. Washington-based

Second, the managers ar employees of the air traff system continue to batt with each other. Manage are bitter over substanti pay raises the National A Traffic Controllers Ass won late last year in its ne contract, as well as NATCA greater influence with Ga vey and with the ATC sy tem. Controllers compla of the FAA's disregard f them in the development ATC upgrades, such as th Standard Terminal Area R placement System, and in dealing wi workplace issues.



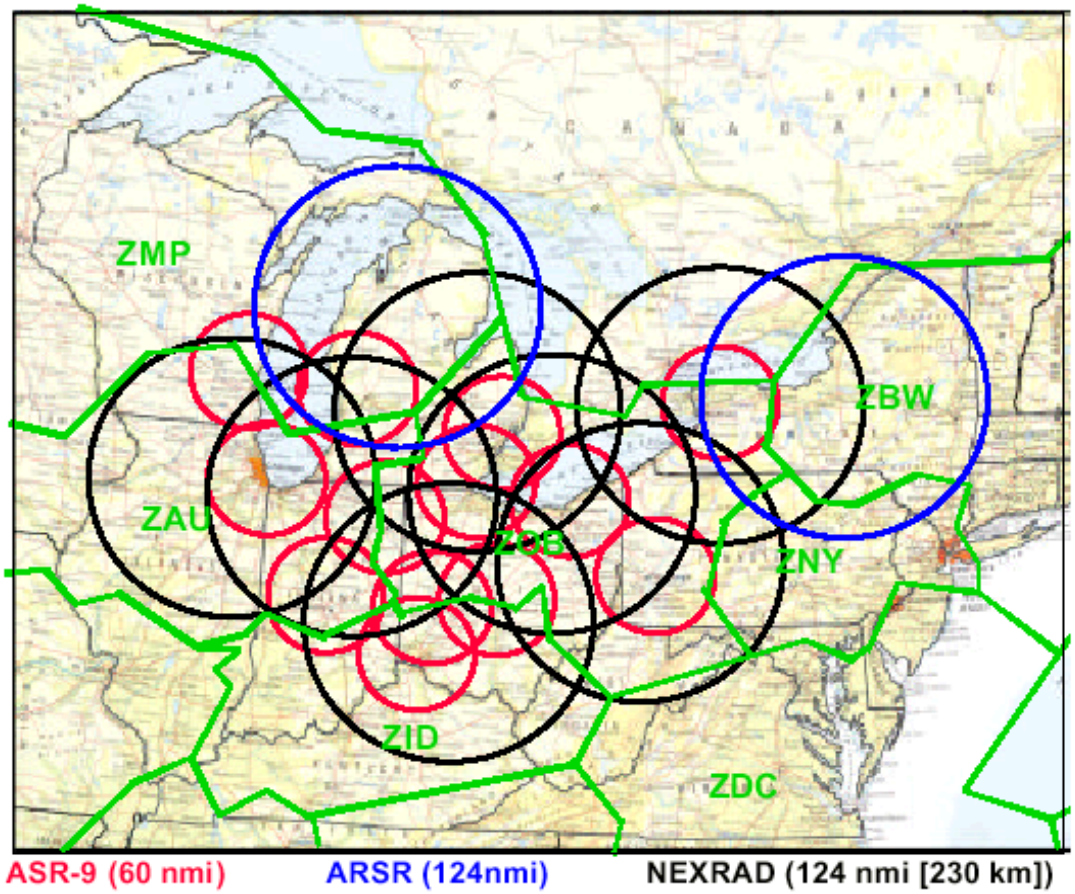


Much Delay Occurs in "Cleveland Corridor"



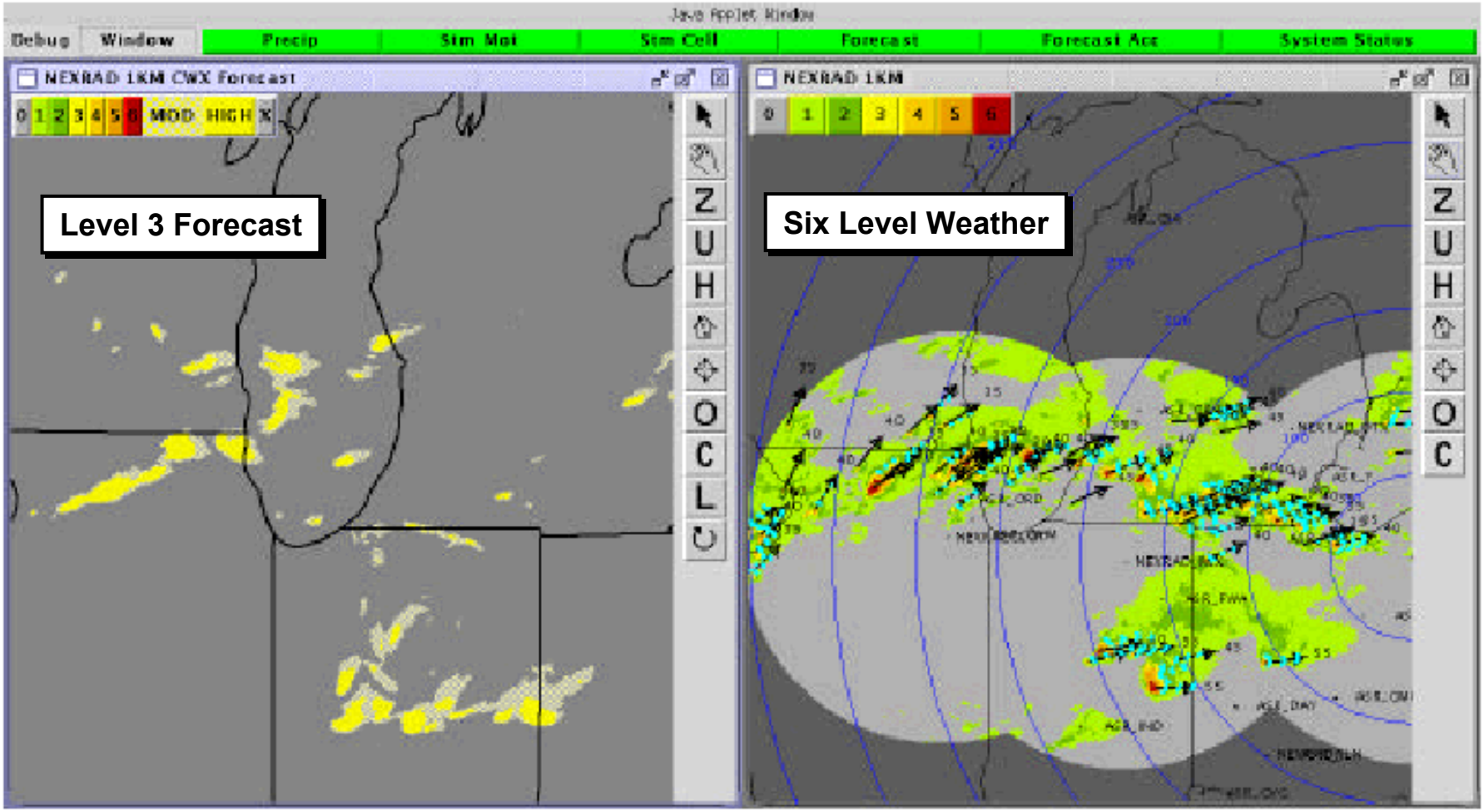
Source: *Bulletin of the American Meteorological Society*, Vol. 78, No. 9, September 1997, p.1887.

Corridor Integrated Weather System (CIWS)
(FAA sponsored program)



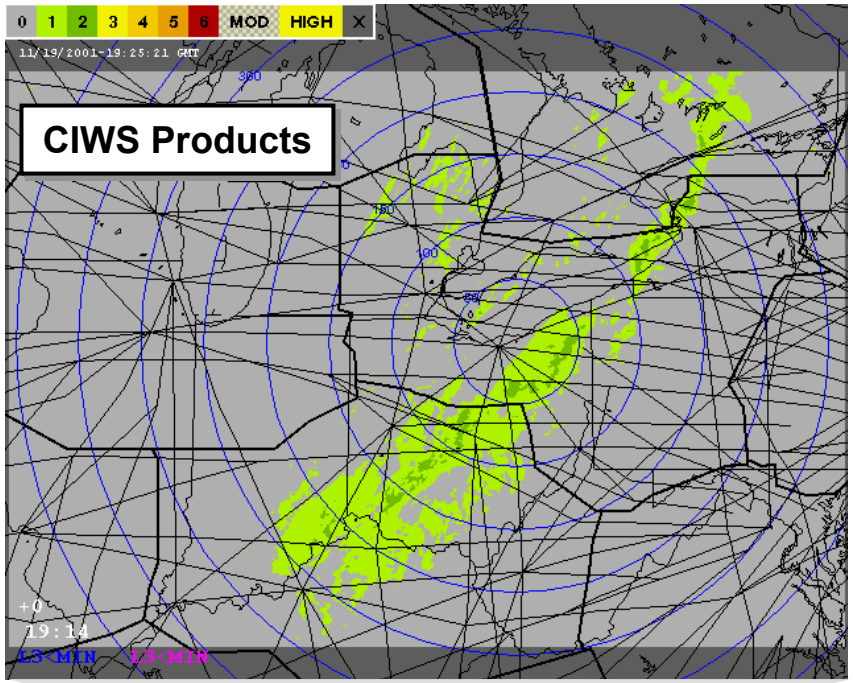
Integrates multiple weather sensors to provide regional precipitation, precipitation forecast and other products to facilitate air traffic flow.

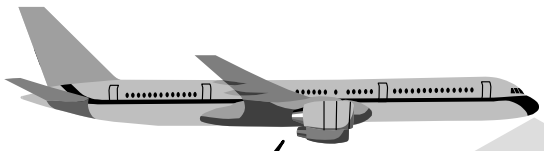
CIWS Regional Convective Weather Forecast



- Six level weather: -30 min, -15 min and current
- Level 3 Forecast: +15, +30, +45 & +60 min (mod & high probability)

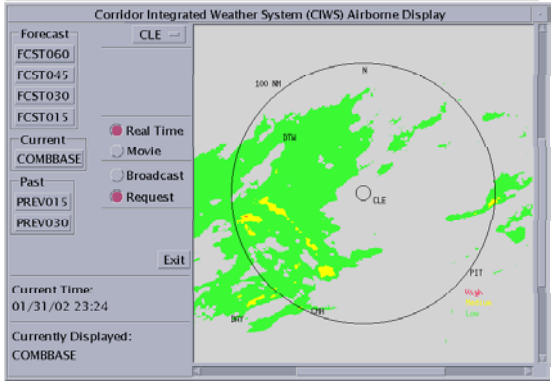
CIWS Cockpit Weather Display Demonstration
(NASA Glenn WINCOMM)





Aircraft
NASA 757

Display
PC Laptop



Weather Products
Regional Precipitation Mosaic
Convective Weather Forecast

Tailoring & Compression → **Generic Data Link**

Tailoring for cockpit display
Weather-Huffman encoding

VDL-2
SATCOMM

Phase I: Ground-based demo at NASA Glenn

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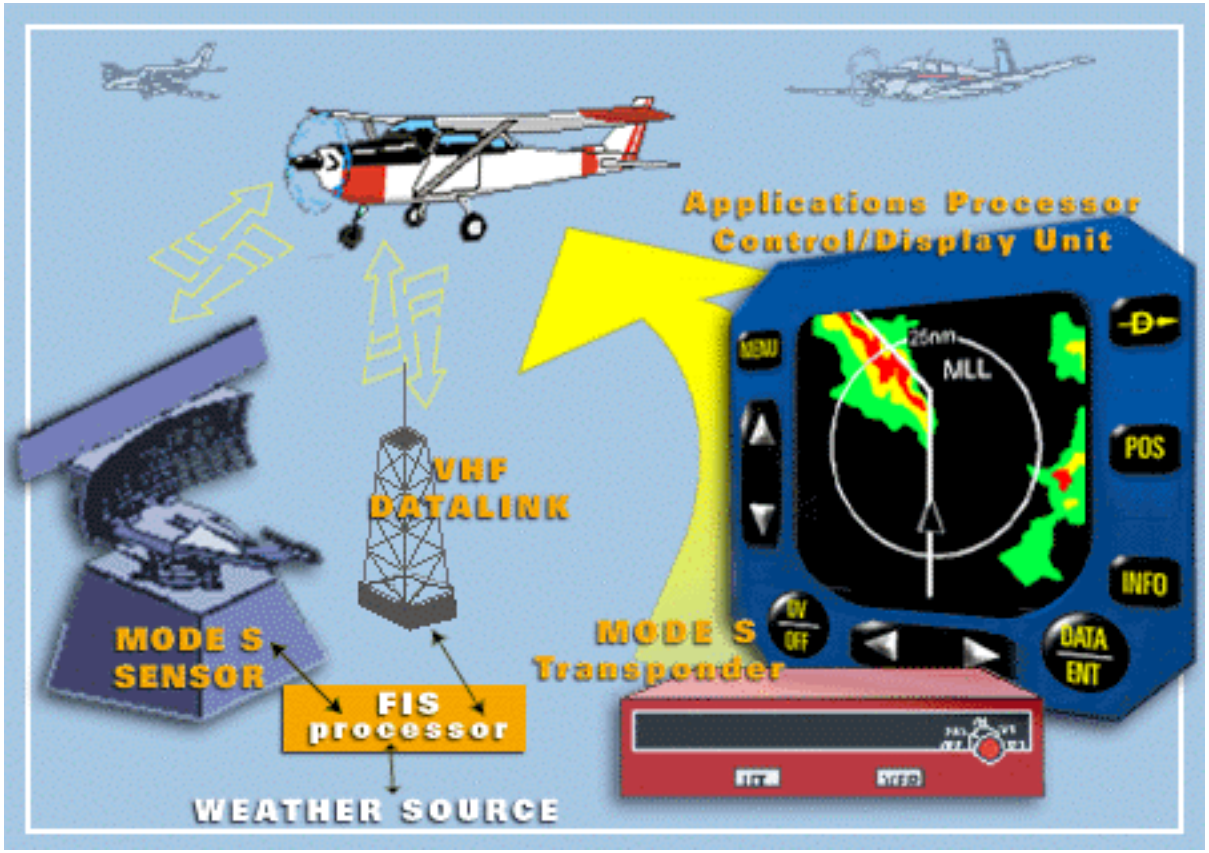
Graphical Weather Service (GWS)

Precip Map:
Composite
NEXRAD
(2 nm)
every 5 or
15 minutes

Centered on
VOR or airport
with range of
25, 50, 100
or 200nm



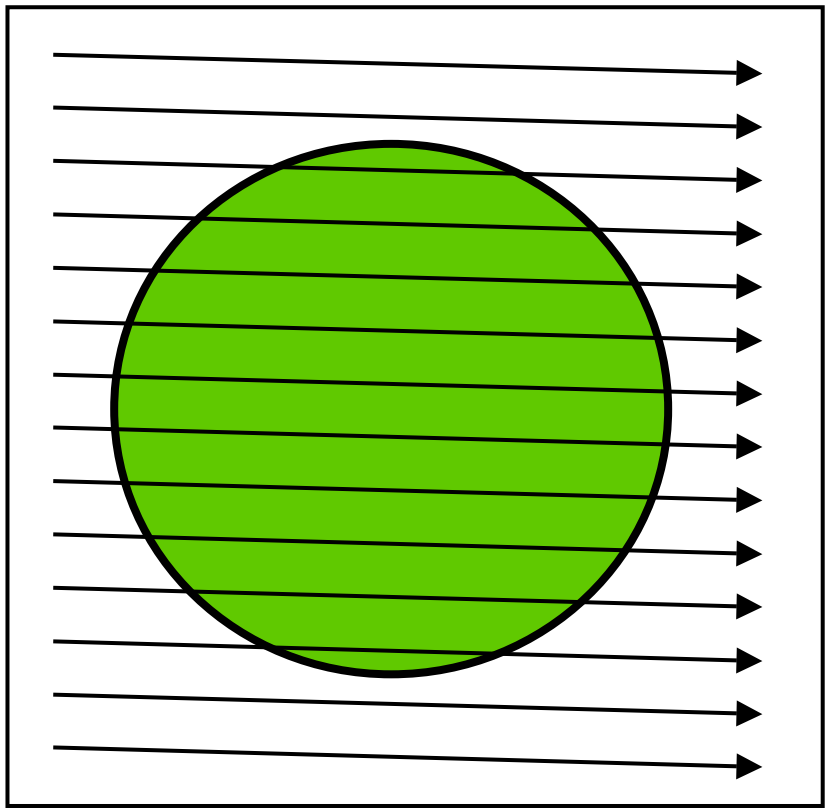
Text Weather:
METAR
TAF

Graphical weather
encoding scheme
compatible with
VHF data link &
satellite broadcast

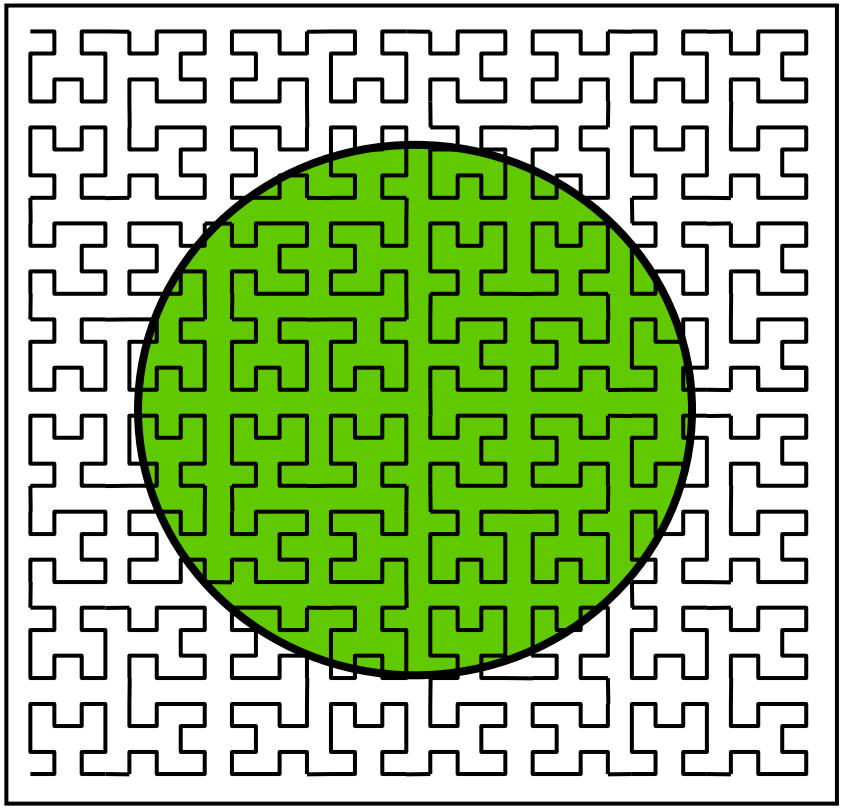
- Weather-Huffman encoding scheme developed at Lincoln
  - Achieves highly efficient compression with acceptable fidelity
  - Flight tested with GA user organizations & being licensed to industry

HILBERT SCAN STRATEGY

RASTER Scan

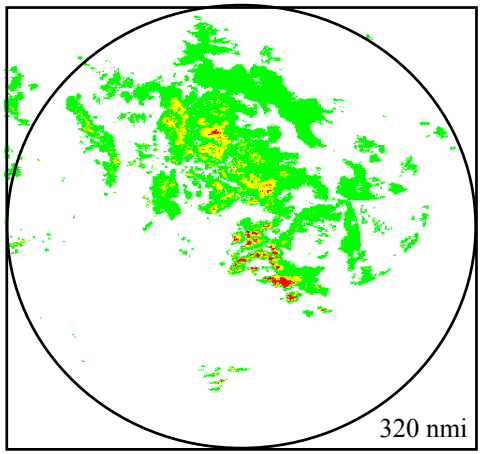


HILBERT Scan

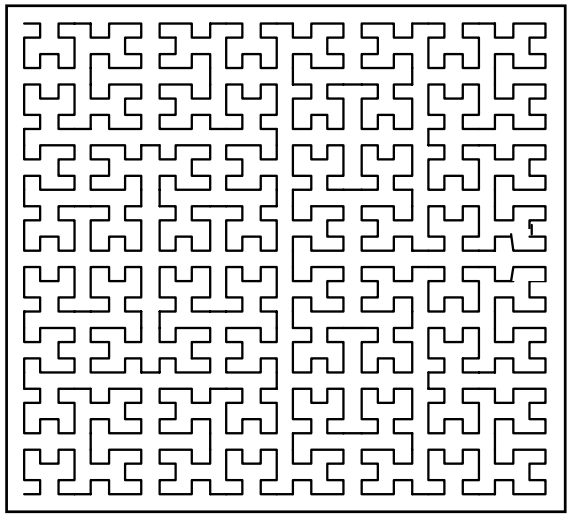


Hilbert scan tends to produce long runs for regions (ideal for weather)

Weather-Huffman Encoding



Input Weather Image

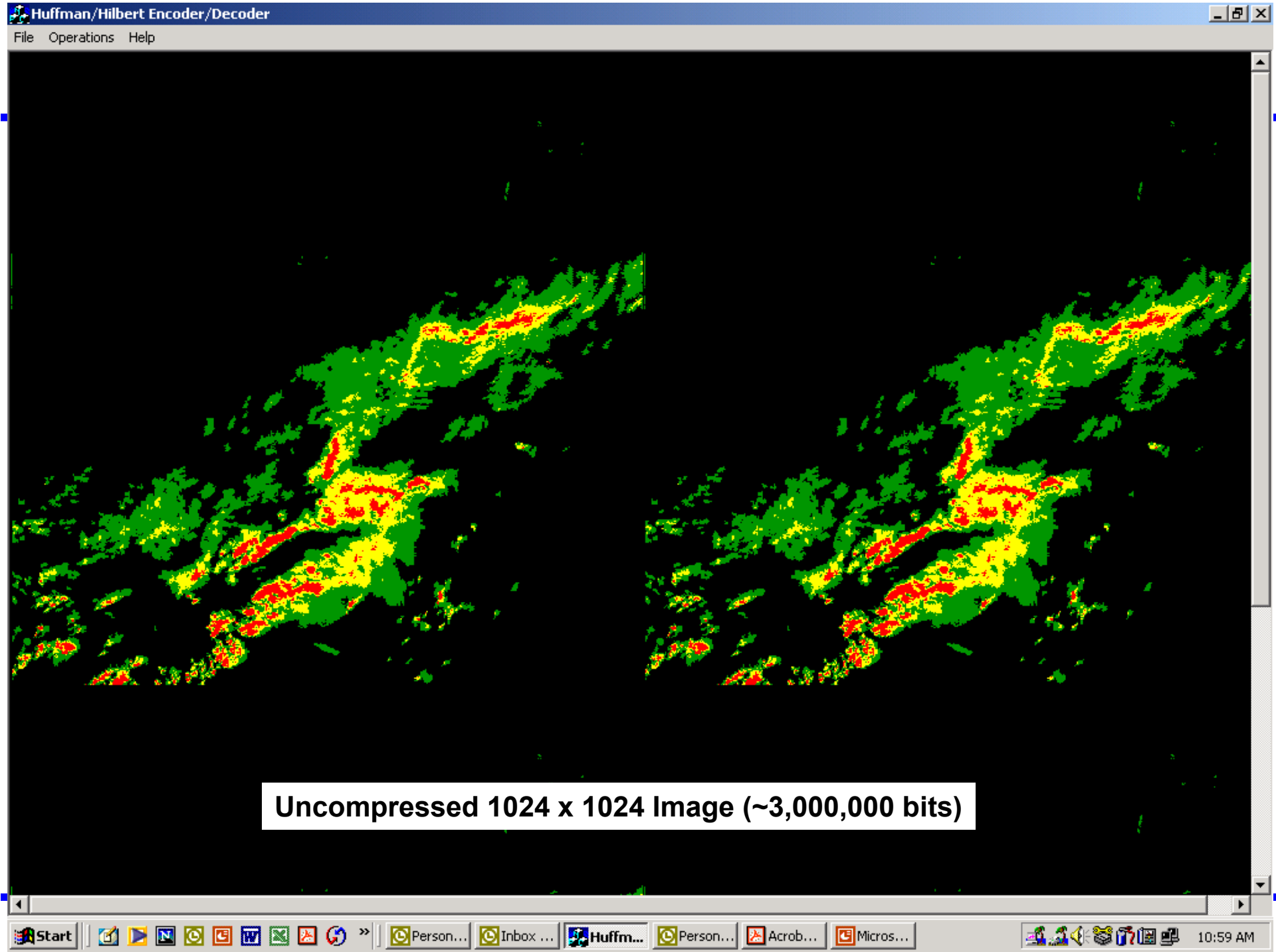


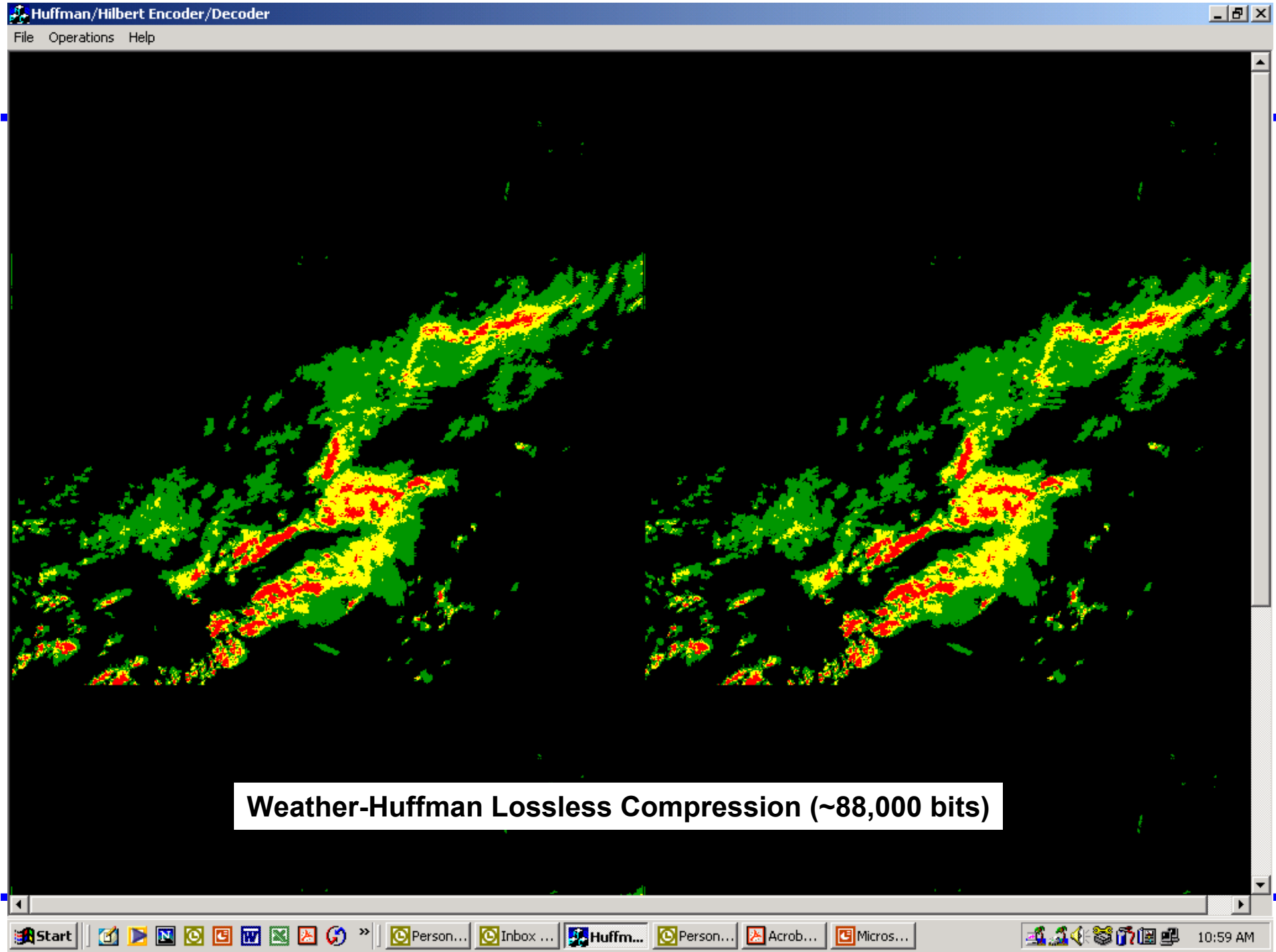
Hilbert Scan Pattern

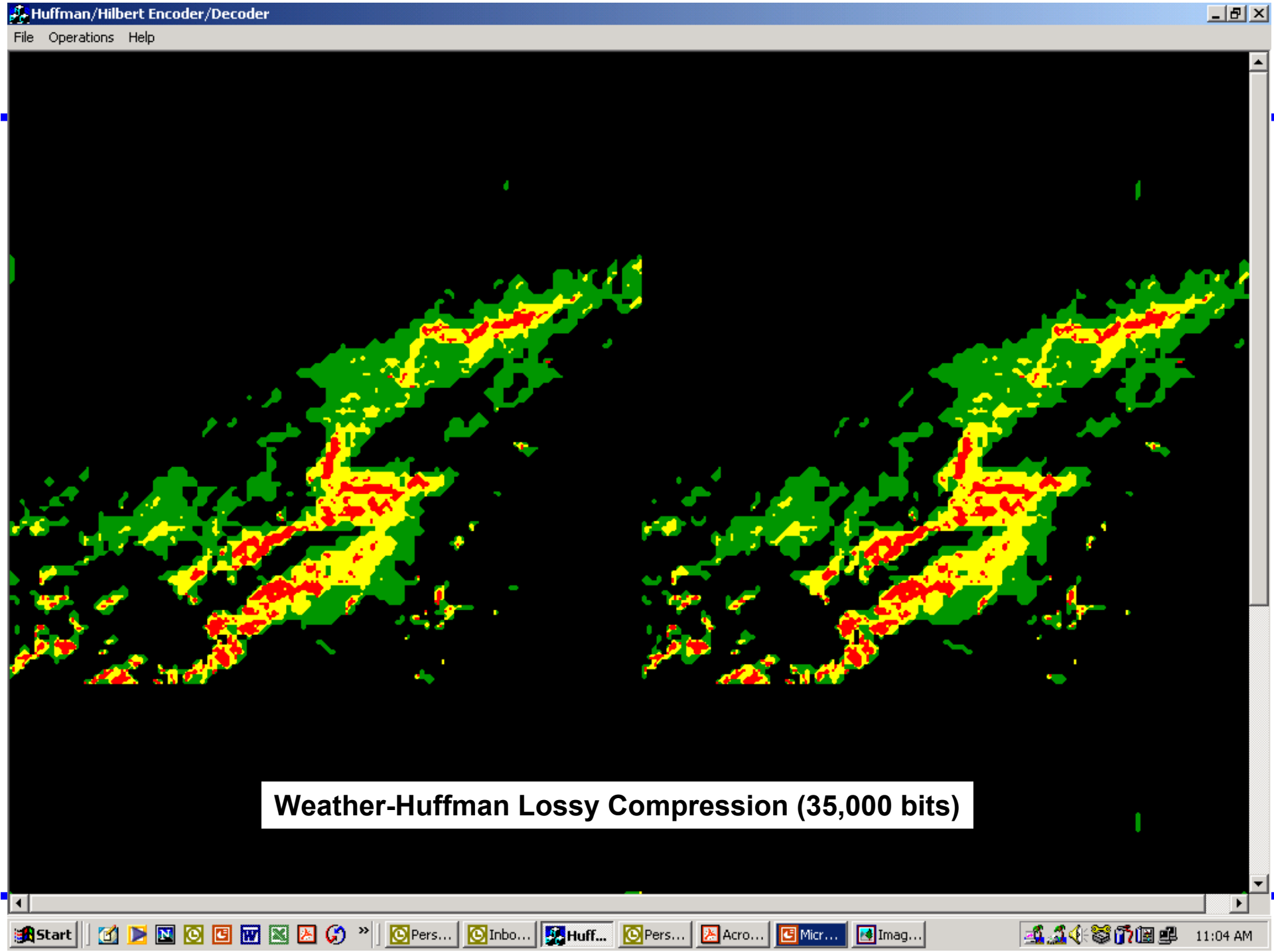
Find runlengths for each weather level

Calculate Huffman codes → Iteratively filter & resample to meet bit limit → Output compressed image

Encoding can be lossless or lossy (depending on bit limit)


Huffman/Hilbert Encoder/Decoder
File Operations Help
Uncompressed 1024 x 1024 Image (~3,000,000 bits)
Start
Person...
Inbox ...
Huffm...
Person...
Acrob...
Micros...
10:59 AM


Huffman/Hilbert Encoder/Decoder
File Operations Help
Weather-Huffman Lossless Compression (~88,000 bits)
Start
Person...
Inbox ...
Huffm...
Person...
Acrob...
Micros...
10:59 AM


Huffman/Hilbert Encoder/Decoder
File Operations Help
Weather-Huffman Lossy Compression (35,000 bits)
Start
Pers...
Inbo...
Huff...
Pers...
Acro...
Micr...
Imag...
11:04 AM

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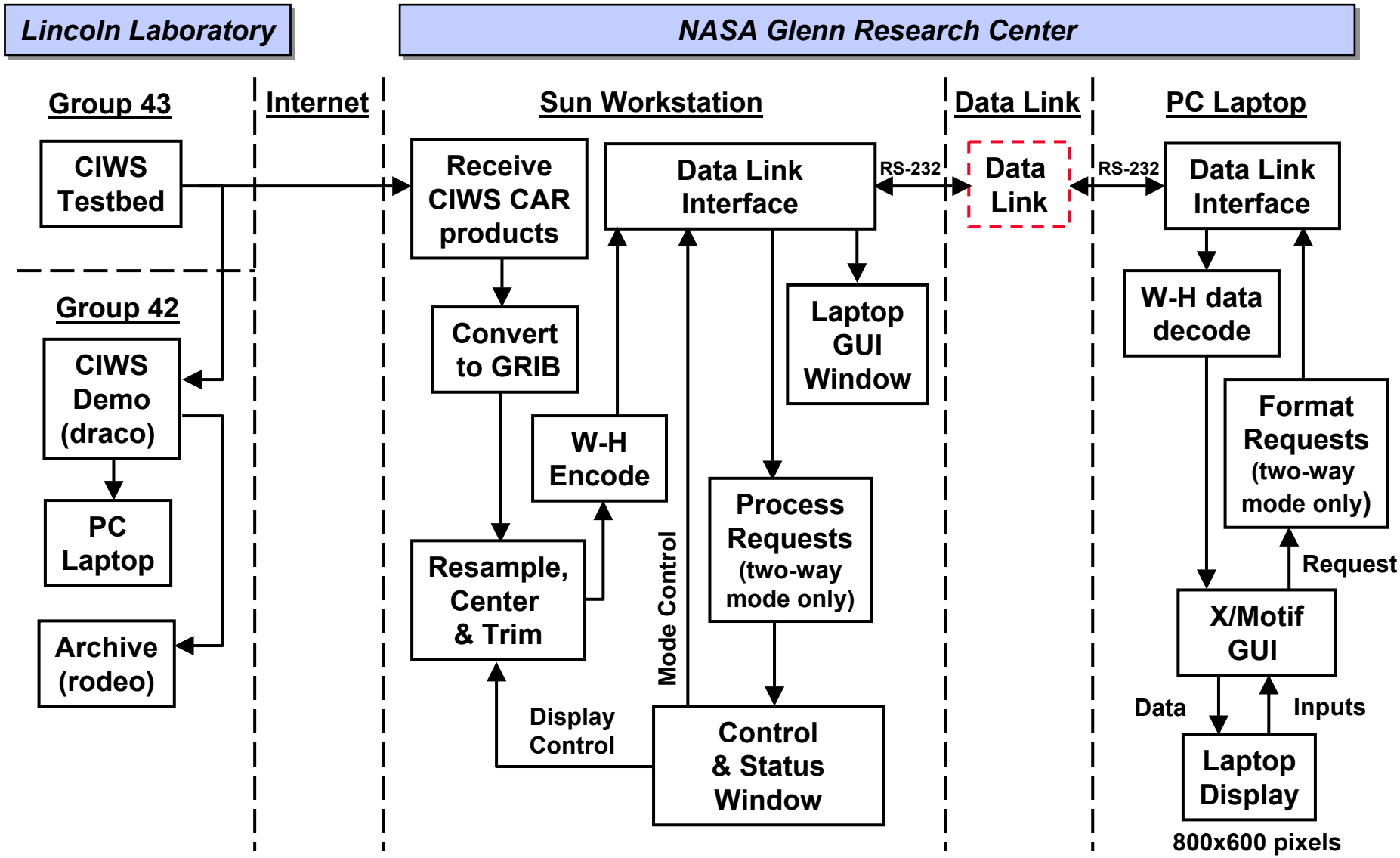
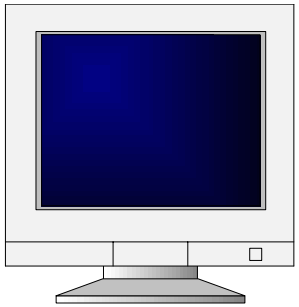
System Block Diagram



NASA Glenn Demo Setup

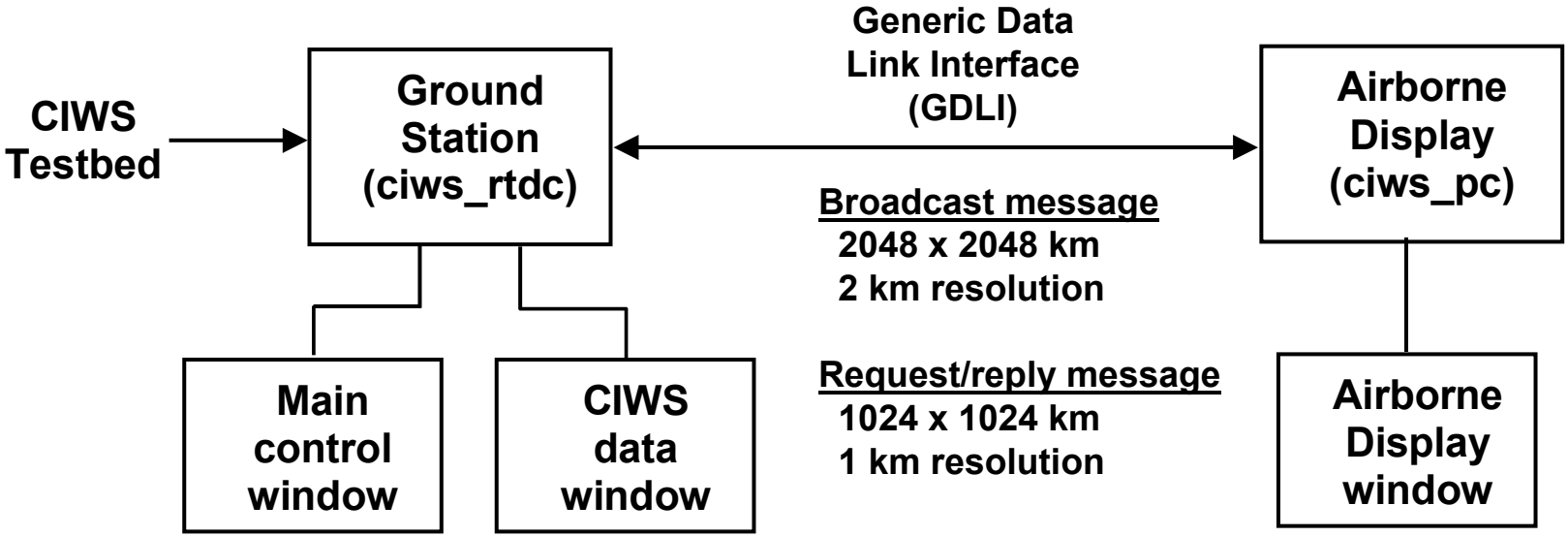
Ground Station



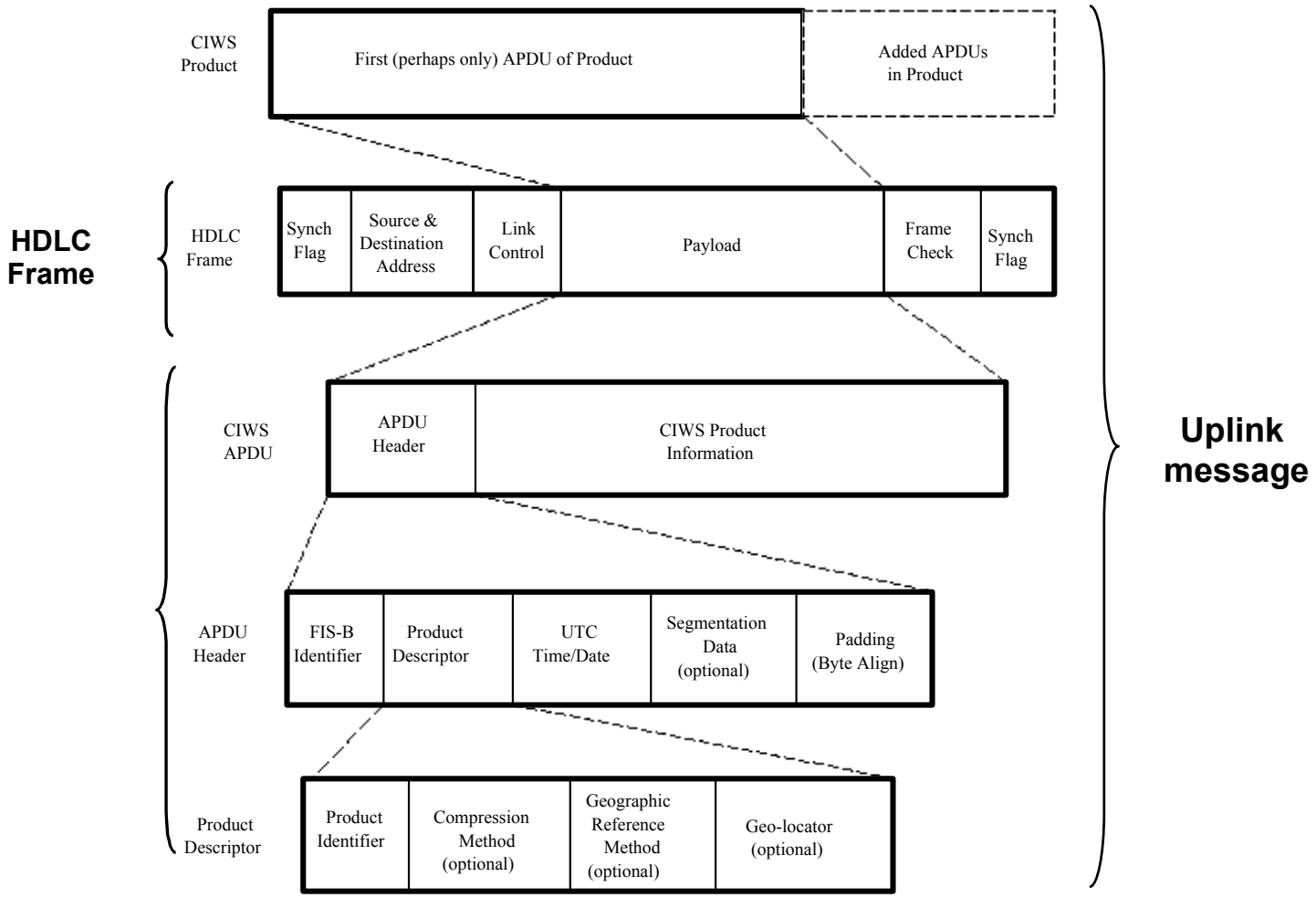
Sunblade 100 Unix Workstation

Airborne Display

Kontron FW5000 PC Laptop



Generic Data Link Interface (GDLI)



Designed to support both broadcast and request/reply data links.

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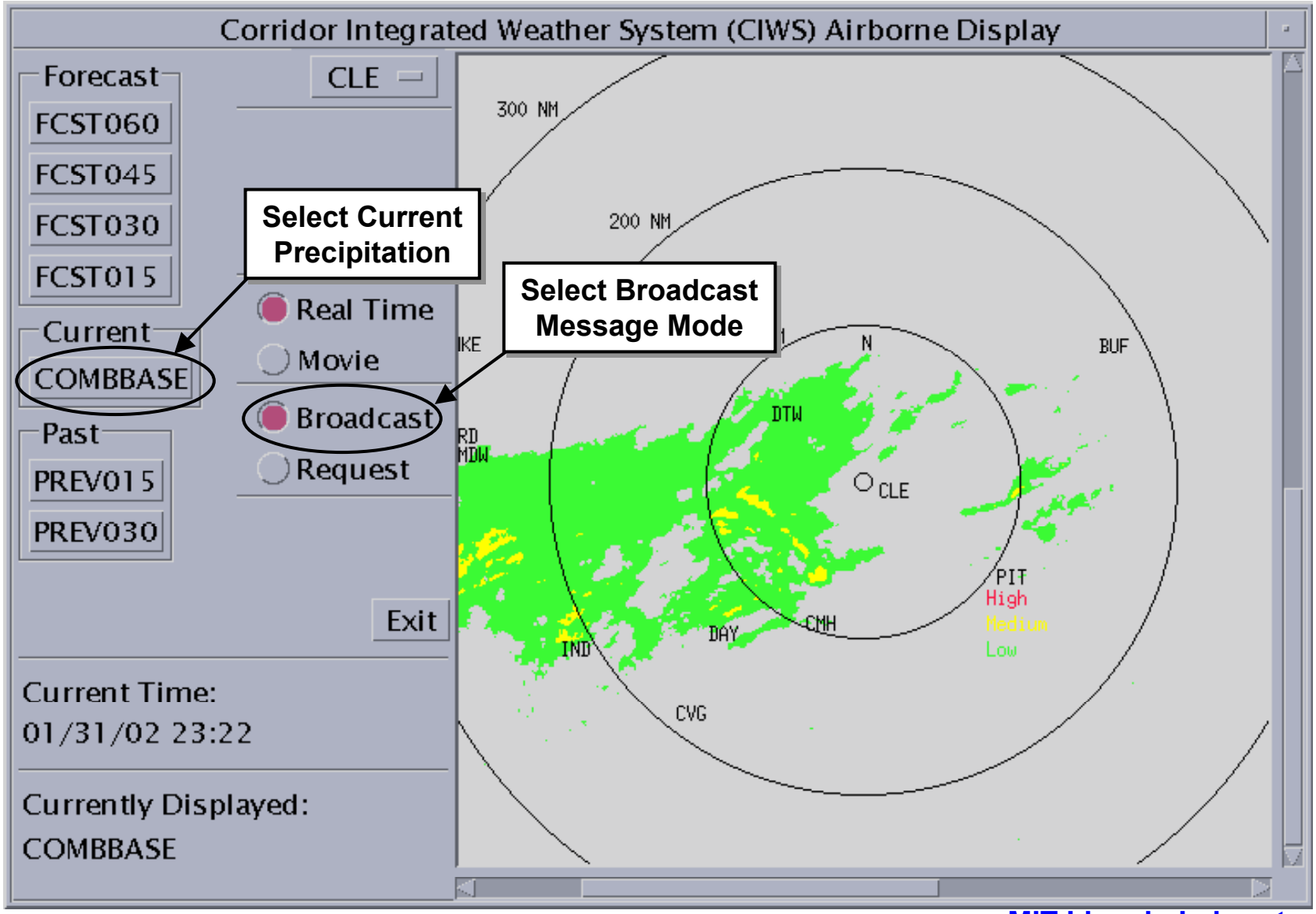
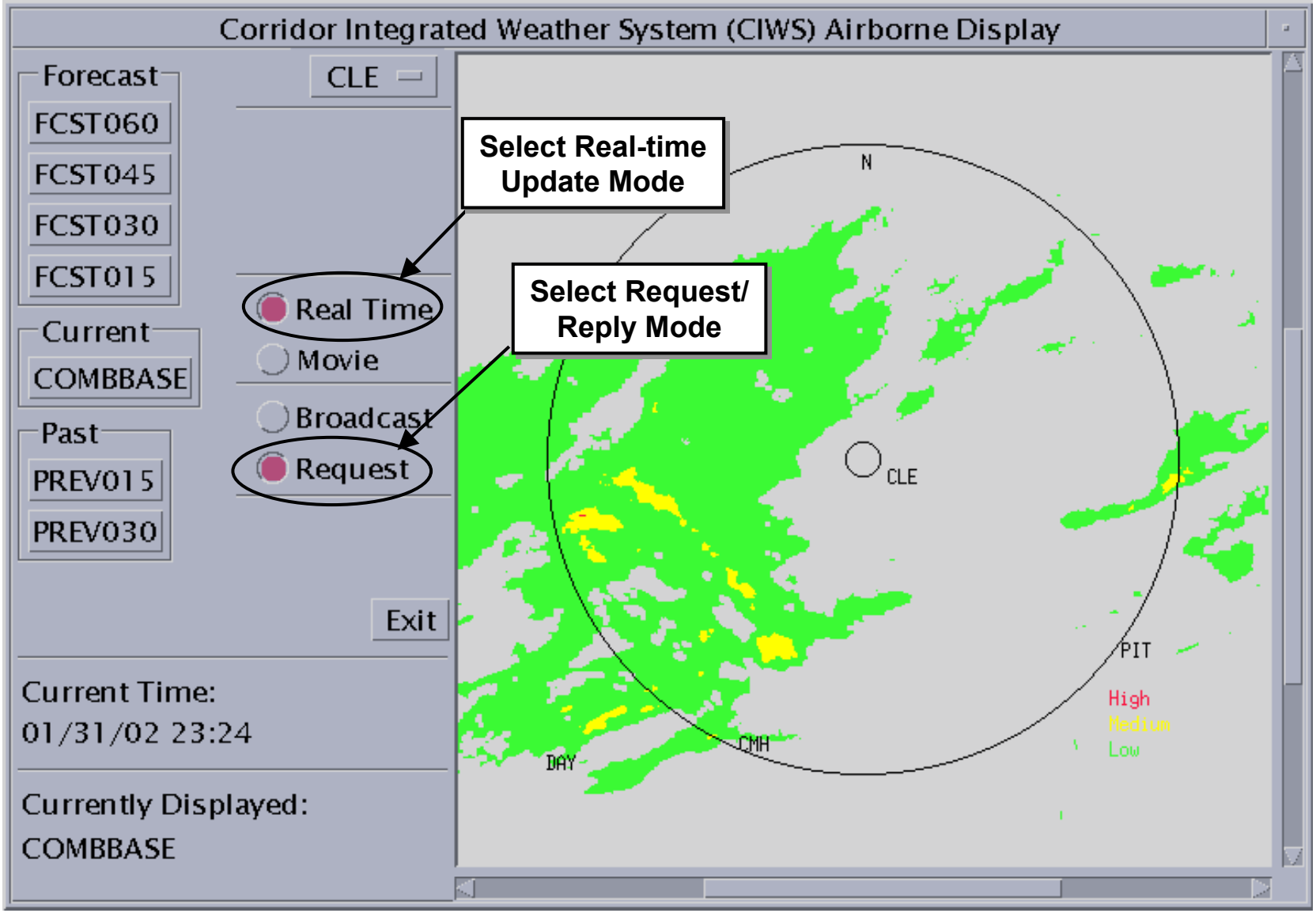
Broadcast Message (2km resolution)



Request/Reply Message (1km resolution)



Precipitation Forecast

Corridor Integrated Weather System (CIWS) Airborne Display

Forecast
FCST060
FCST045
FCST030
FCST015

Current
COMBBASE

Past
PREV015
PREV030

CLE

Real Time
Movie
Broadcast
Request

Exit

Current Time:
01/31/02 23:47

Currently Displayed:
FCST015

Select 15 minute Precip. Forecast

Moderate Probability of Level 3+ Weather in 15 minutes

N
100 NM
DTW
CLE
PIT
CMH
DAY
High
Medium
Low

Airport Selection Options

Corridor Integrated Weather System (CIWS) Airborne Display

Forecast
FCST060
FCST045
FCST030
FCST015

Current
COMBBASE

Past
PREV015
PREV030

IND

Real Time
Movie
Broadcast
Request

Exit

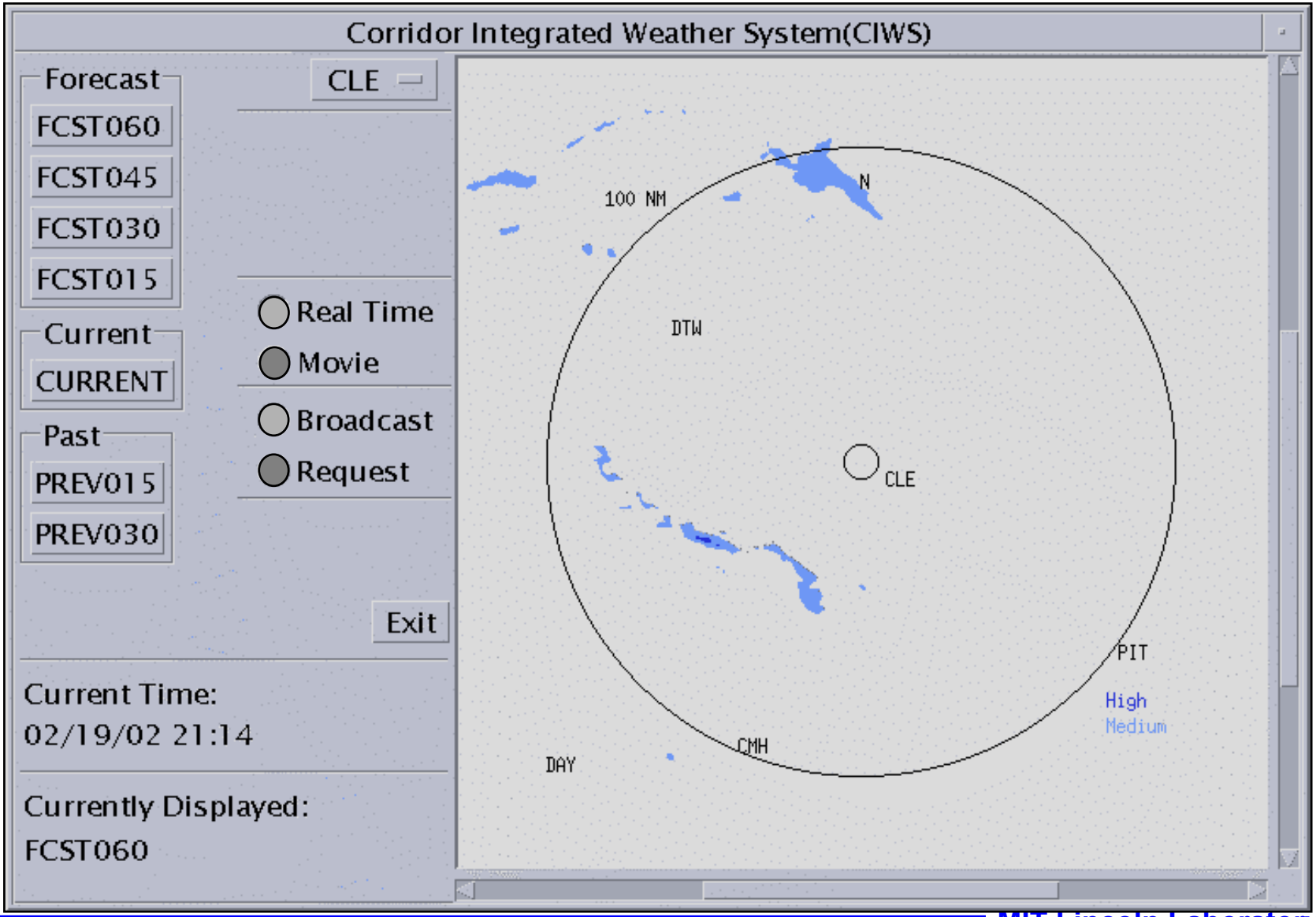
Current Time:
01/31/02 23:49

Currently Displayed:
COMBBASE

Airport	Code
Cleveland, OH	CLE
Buffalo, NY	BUF
Columbus, OH	CMH
Cincinnati, OH	CVG
Dayton, OH	DAY
Detroit, MI	DTW
Indianapolis, IN	IND
Chicago Midway	MDW
Milwaukee, WI	MKE
Chicago O'Hare	ORD
Pittsburgh, PA	PIT

Weather Display Scroll Bars

Movie Loop Capability



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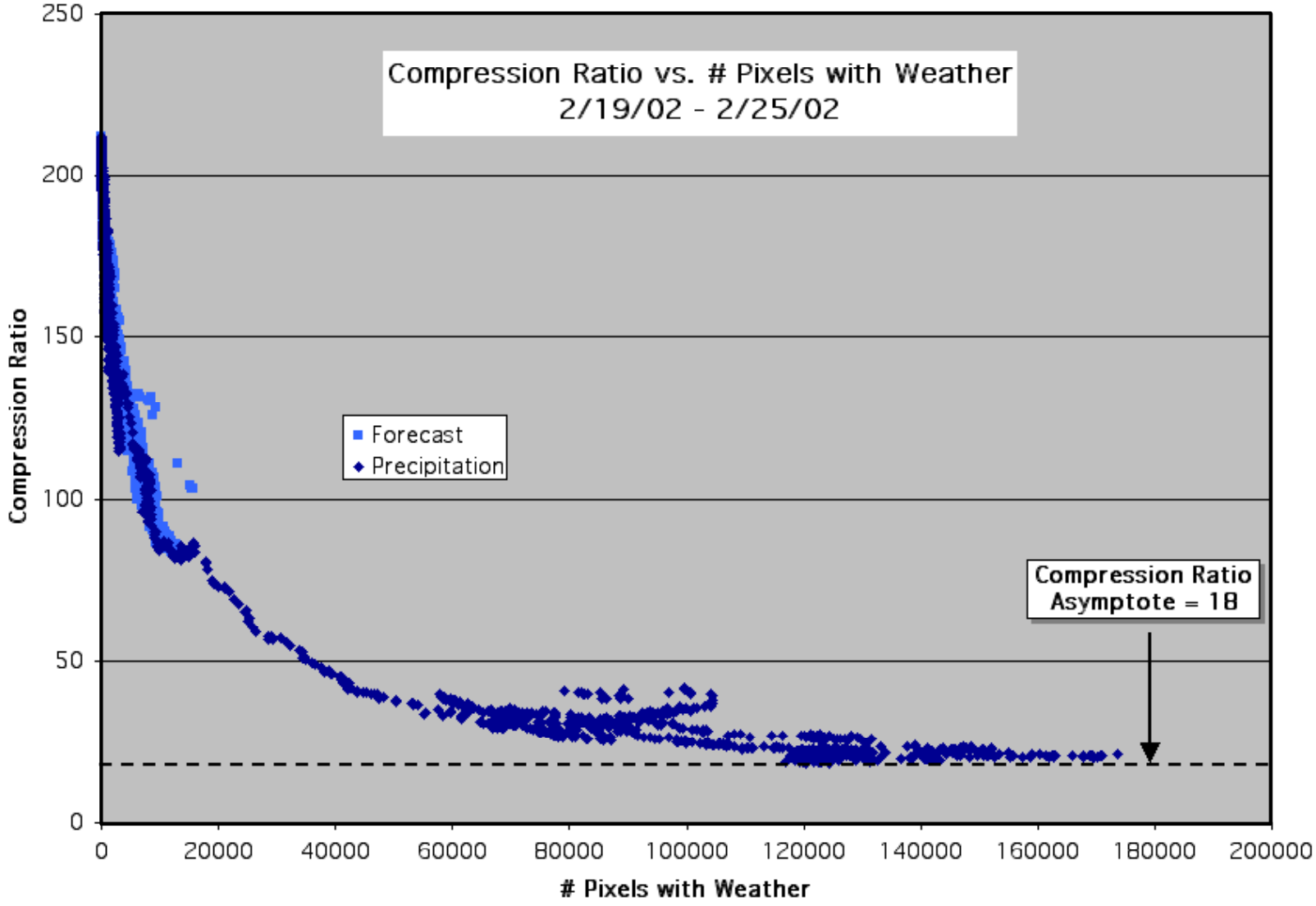
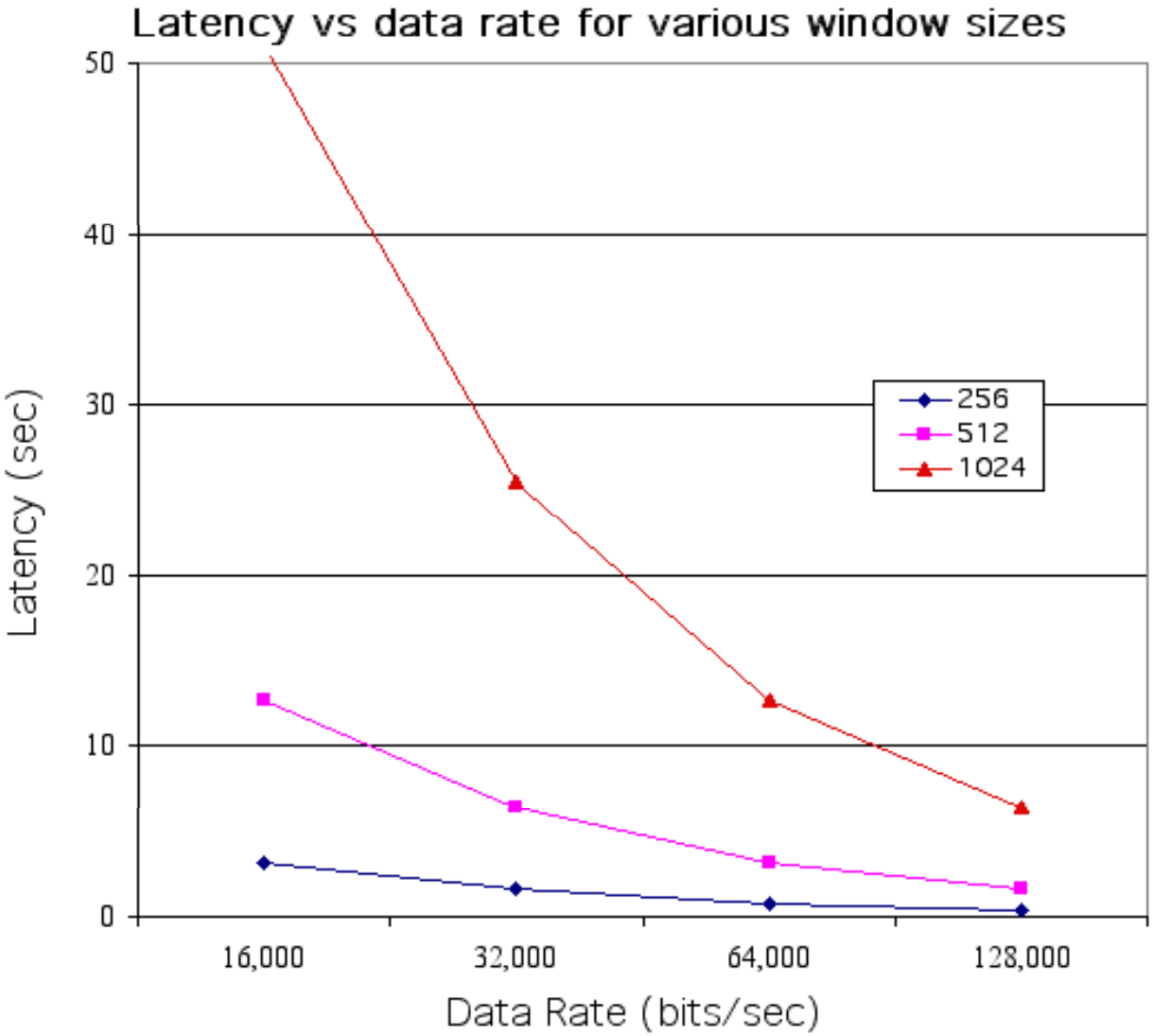
Lossless Compression Results



Latency vs. Data Rate



Summary

- CIWS testbed provides regional precipitation & convective weather forecast products for high-traffic “Cleveland Corridor”
- Providing CIWS products to aircraft would aid pilot awareness of current & forecasted weather to improve safety & reduce delays
- Weather-Huffman compression technique works well on CIWS precipitation & forecast products (>18:1 lossless compression)
- Generic interface developed to transparently support broadcast & request/reply data links
- Airborne display developed for ruggedized laptop PC using X/Motif.
- Next phase: install in test aircraft with VDL-2 and/or SATCOMM