Choosing Colors for Work-Centered Support Systems for Command and Control Using a Visual Search Task

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Introduction

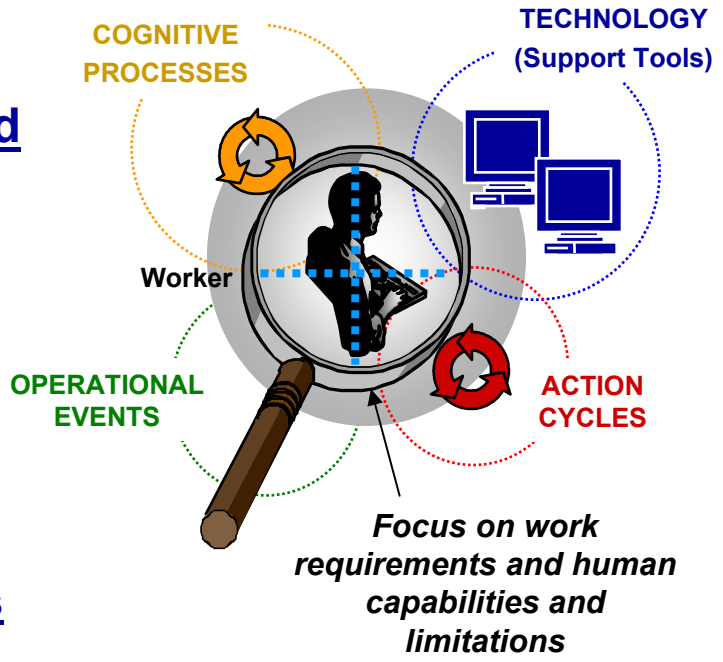
- Complexity of displays has increased with availability of new technology
  - Information technology
  - Ease of color display
- Human factors guidelines
  - Hard to keep pace with rapidly increasing technology
  - Complex displays particularly challenging

Work-Centered Support Systems

- Replace “Windows-based” desktop with arrangement more suited to work needs
- Incorporates intelligent technology to retrieve data and automate functions where it makes sense to do so
- Continuous and work-specific display of status information
- Detailed, work-specific information easily accessed

Work-Centered Support System Technology Summary

- New human-computer interface technology
- Highly efficient support for work as practiced
- Uses:
  - Cognitive work & task analyses
  - Cognitive-based design techniques
  - Intelligent agents

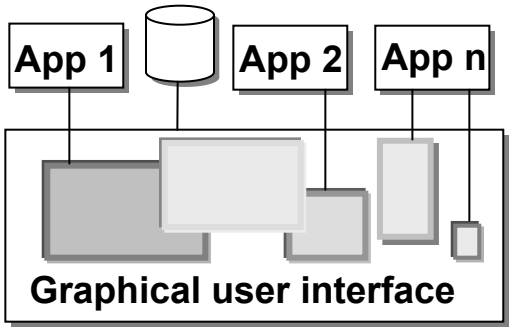


- Provides:
  - Cognitively compatible, "actionable" displays
  - Rapid user adaptation to unanticipated events
  - Agents to automatically monitor, retrieve & fuse information
  - ➢ *User remains focused on "core" work activities, NOT "overhead" activities of data monitoring, retrieval & fusion*

- Provides:
  - *Proactive problem identification*
  - *Better, faster decisions/work actions*
  - *Reduced training and operating costs*

Historical Perspective: User Interface as Work Support System

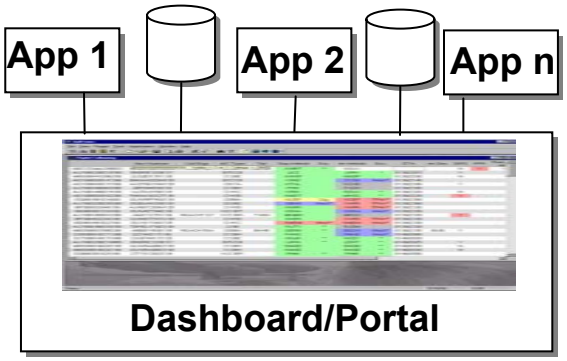
Traditional



Stove-piped data

- UI as a desktop
  - -- One window per application
  - -- High procedural cost
  - -- High cognitive burden

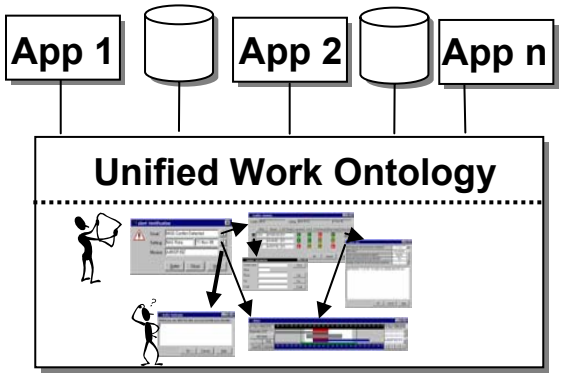
Modern



Integrated data

- UI as a portal
  - -- Data-centric
  - -- Moderate procedural cost
  - -- High cognitive burden

Future



Work objects

- UI as a work aiding system
  - -- Single organizing framework
  - -- Work-centered aiding collaboration; decision making; product development; work management
  - -- Low procedural cost
  - -- Low cognitive burden

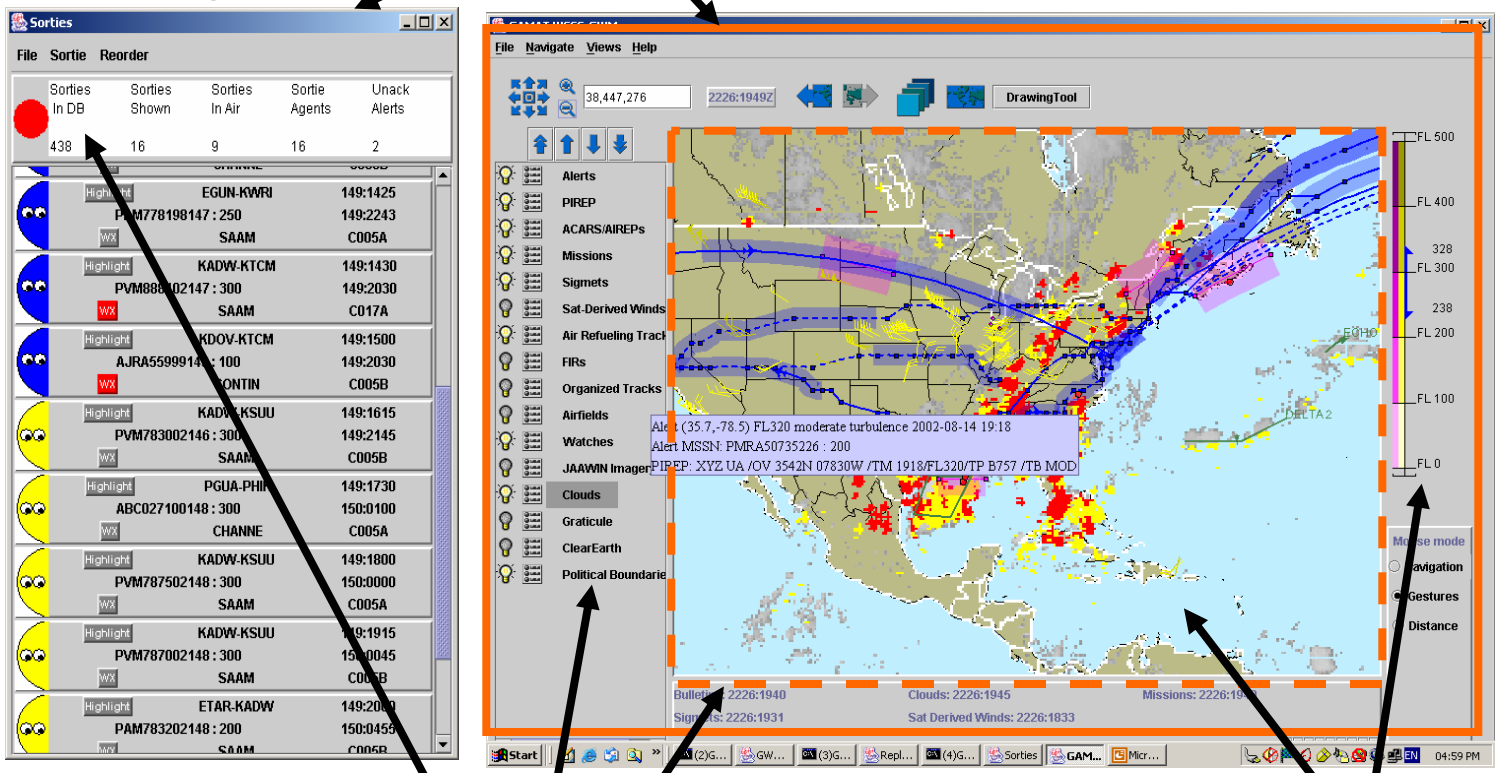
Next generation User Interface technology

Work-Centered Design Principles

(1) Work-context space/panel (work management)

(2) Context space coordination

(1) Work-context space/panel (decision support & product development)



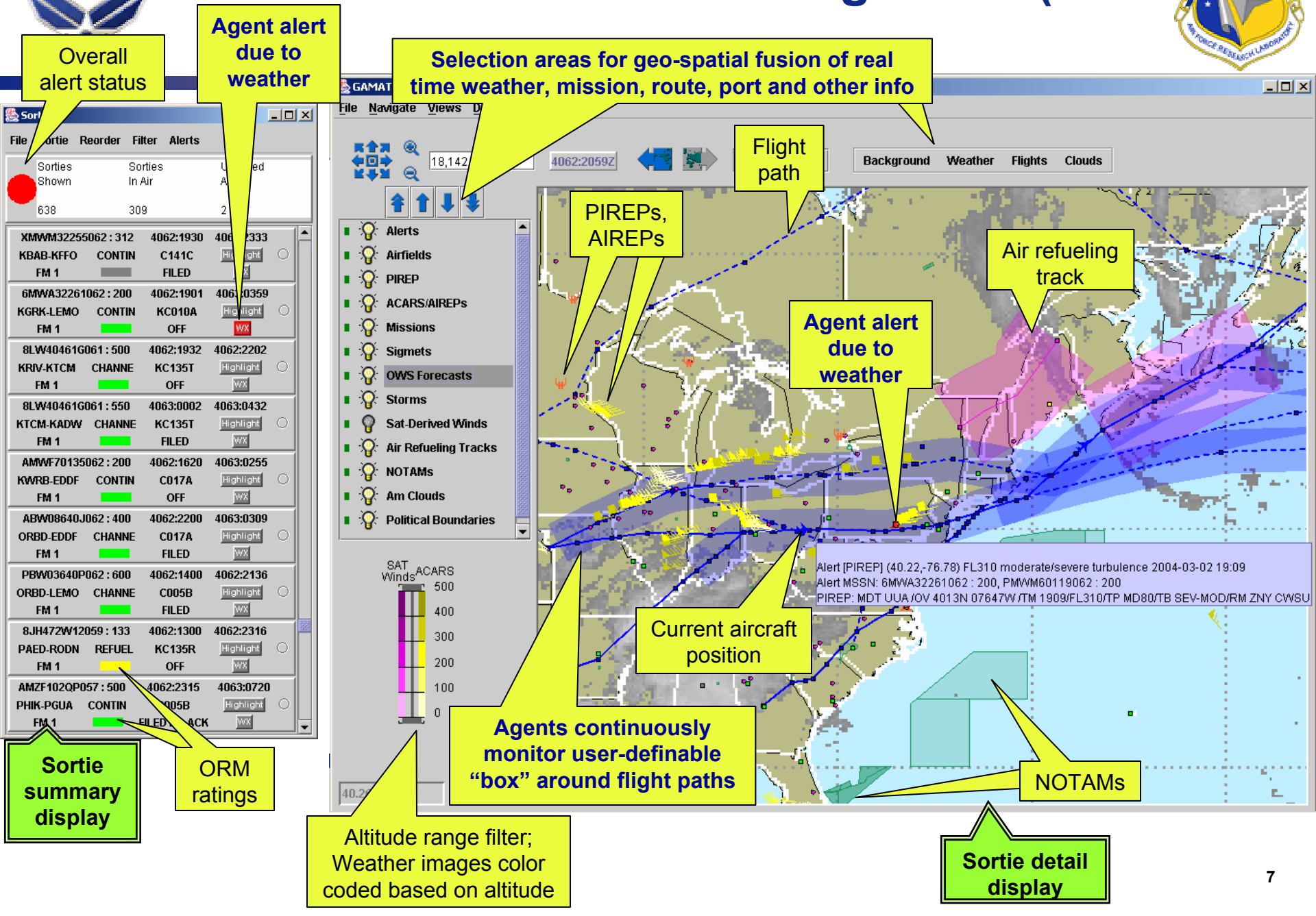
(3) Problem – Vantage – Frame

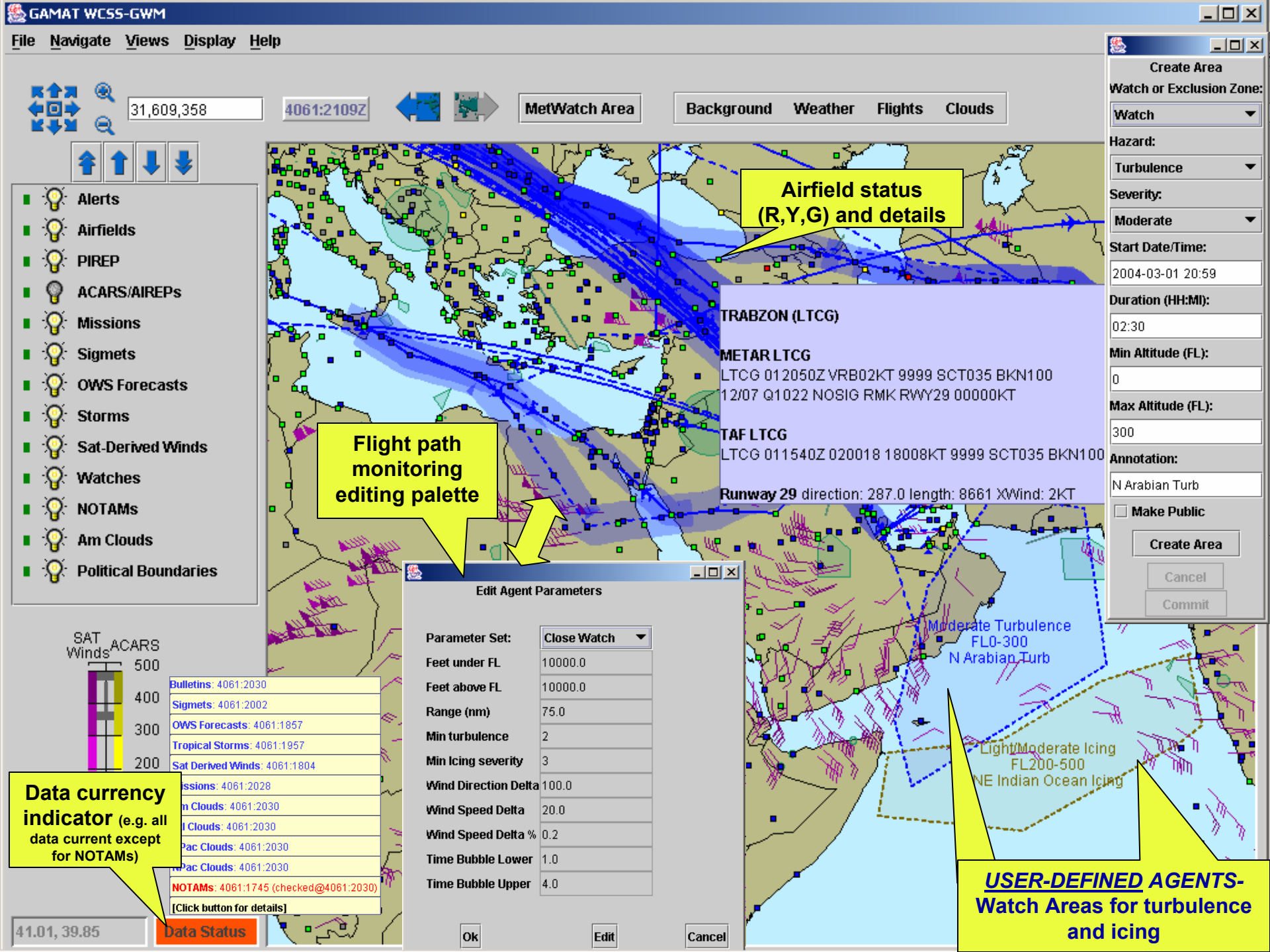
(4) Central - Peripheral

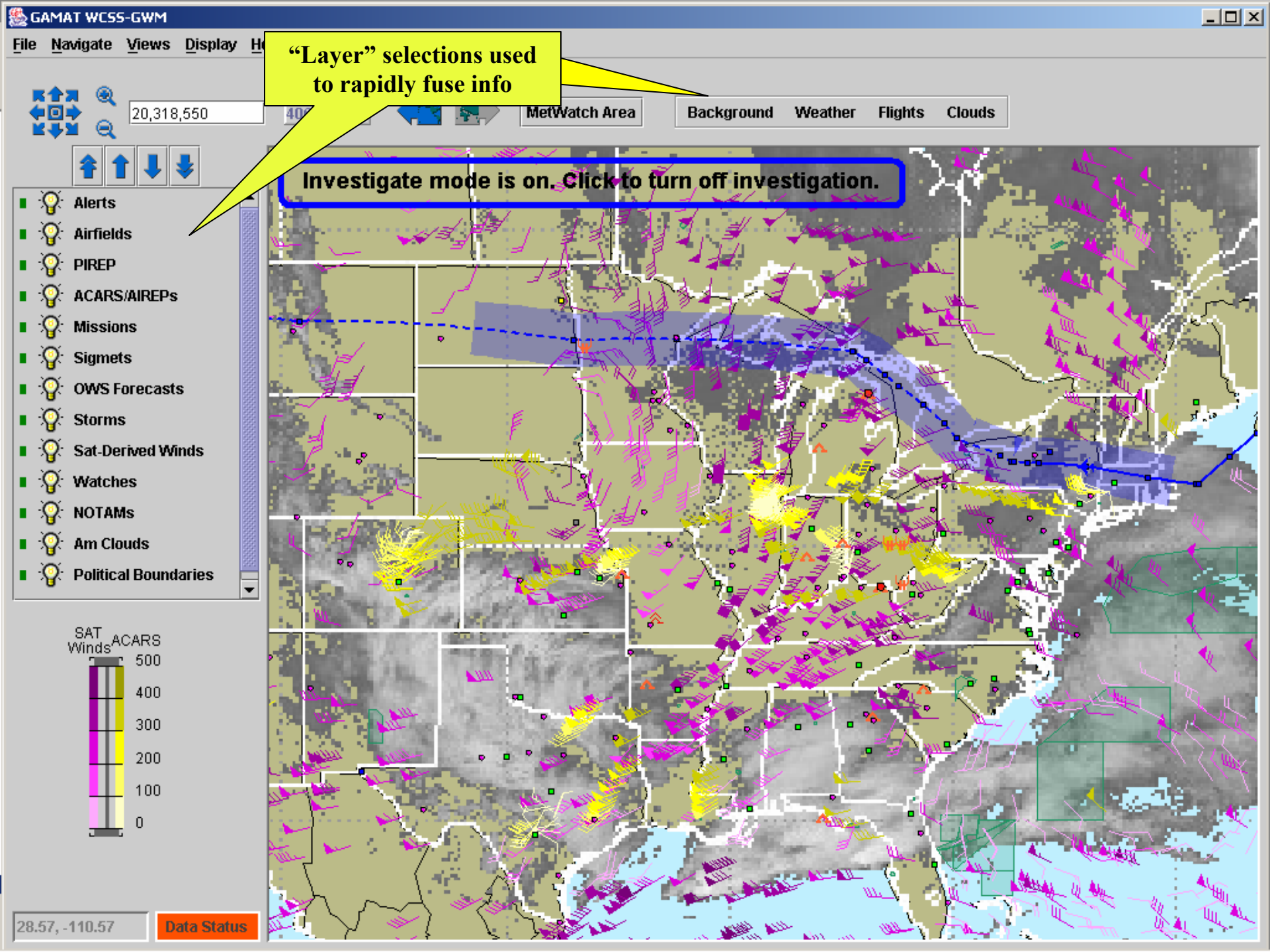
(5) Joint aiding throughout

(6) First person principle (Work ontology) throughout

WCSS- Global Weather Management (GWM)




GAMAT WCSS-GWM
File Navigate Views Display Help
31,609,358
4061:2109Z
MetWatch Area
Background Weather Flights Clouds
Alerts
Airfields
PIREP
ACARS/AIREPs
Missions
Sigmets
OWS Forecasts
Storms
Sat-Derived Winds
Watches
NOTAMs
Am Clouds
Political Boundaries
Airfield status (R,Y,G) and details
TRABZON (LTCG)
METAR LTCG
LTCG 012050Z VRB02KT 9999 SCT035 BKN100
12/07 Q1022 NOSIG RMK RWY29 00000KT
TAF LTCG
LTCG 011540Z 020018 18008KT 9999 SCT035 BKN100
Runway 29 direction: 287.0 length: 8661 XWind: 2KT
Flight path monitoring editing palette
Edit Agent Parameters
Parameter Set: Close Watch
Feet under FL 10000.0
Feet above FL 10000.0
Range (nm) 75.0
Min turbulence 2
Min Icing severity 3
Wind Direction Delta 100.0
Wind Speed Delta 20.0
Wind Speed Delta % 0.2
Time Bubble Lower 1.0
Time Bubble Upper 4.0
Ok
Edit
Cancel
Create Area
Watch or Exclusion Zone:
Watch
Hazard:
Turbulence
Severity:
Moderate
Start Date/Time:
2004-03-01 20:59
Duration (HH:MI):
02:30
Min Altitude (FL):
0
Max Altitude (FL):
300
Annotation:
N Arabian Turb
Make Public
Create Area
Cancel
Commit
SAT Winds
ACARS
500
400
300
200
Bulletins: 4061:2030
Sigmets: 4061:2002
OWS Forecasts: 4061:1857
Tropical Storms: 4061:1957
Sat Derived Winds: 4061:1804
NOTAMs: 4061:1745 (checked@4061:2030)
[Click button for details]
Data currency indicator (e.g. all data current except for NOTAMs)
41.01, 39.85
Data Status
Moderate Turbulence
FL0-300
N Arabian Turb
Light/Moderate Icing
FL200-500
NE Indian Ocean Icing
USER-DEFINED AGENTS-
Watch Areas for turbulence and icing


GAMAT WCSS-GWM
File
Navigate
Views
Display
"Layer" selections used to rapidly fuse info
20,318,550
MetWatch Area
Background
Weather
Flights
Clouds
Investigate mode is on. Click to turn off investigation.
Alerts
Airfields
PIREP
ACARS/AIREPs
Missions
Sigmets
OWS Forecasts
Storms
Sat-Derived Winds
Watches
NOTAMs
Am Clouds
Political Boundaries
SAT Winds
ACARS
500
400
300
200
100
0
28.57, -110.57
Data Status

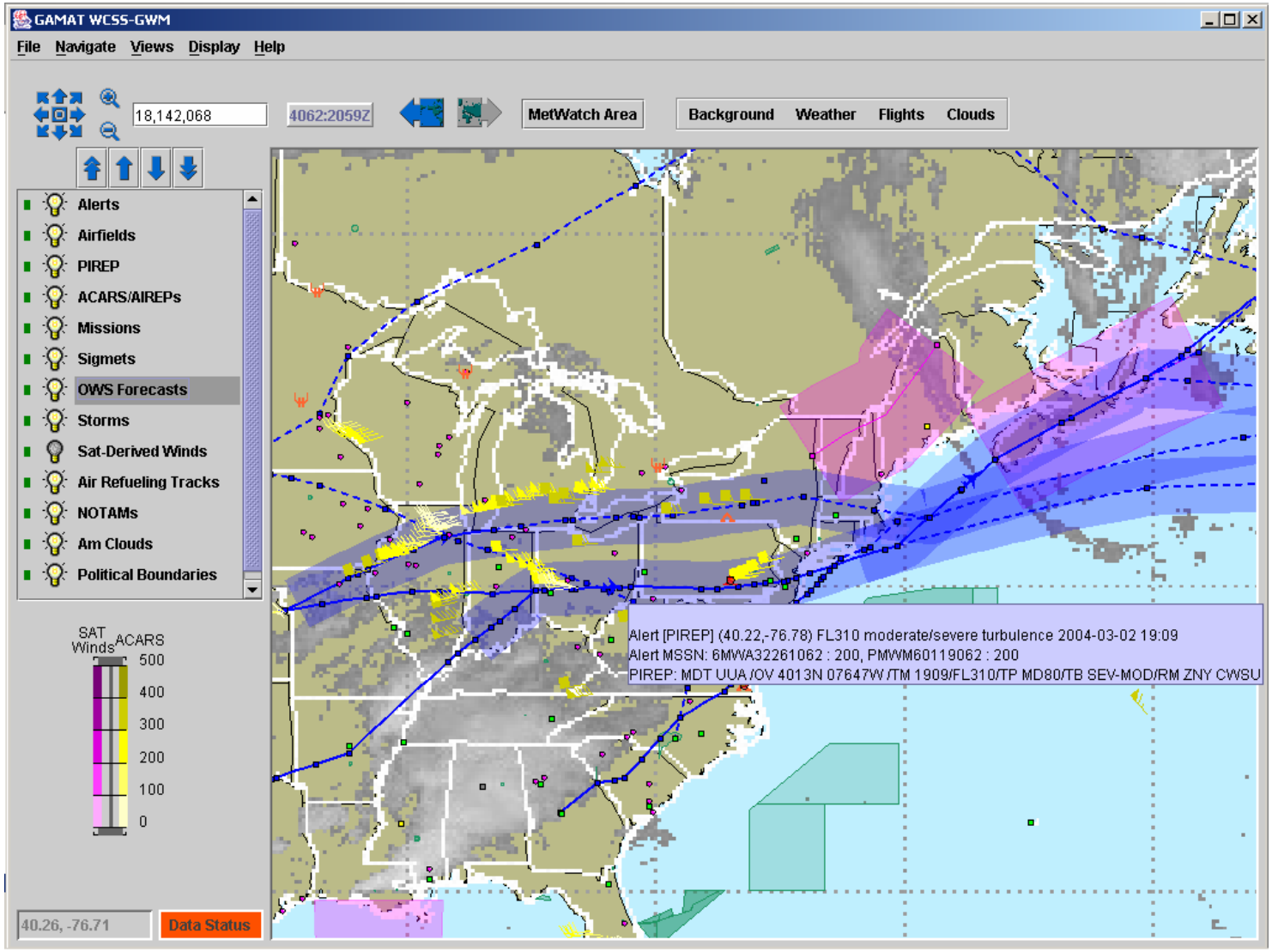
Display Color Guidelines
(Helander, 1987)

- Limit use of color to 10 or less
- Reserve color use for drawing attention or means of quickly categorizing data
- Reserve red, green, & yellow for warning, safe, and caution, respectively

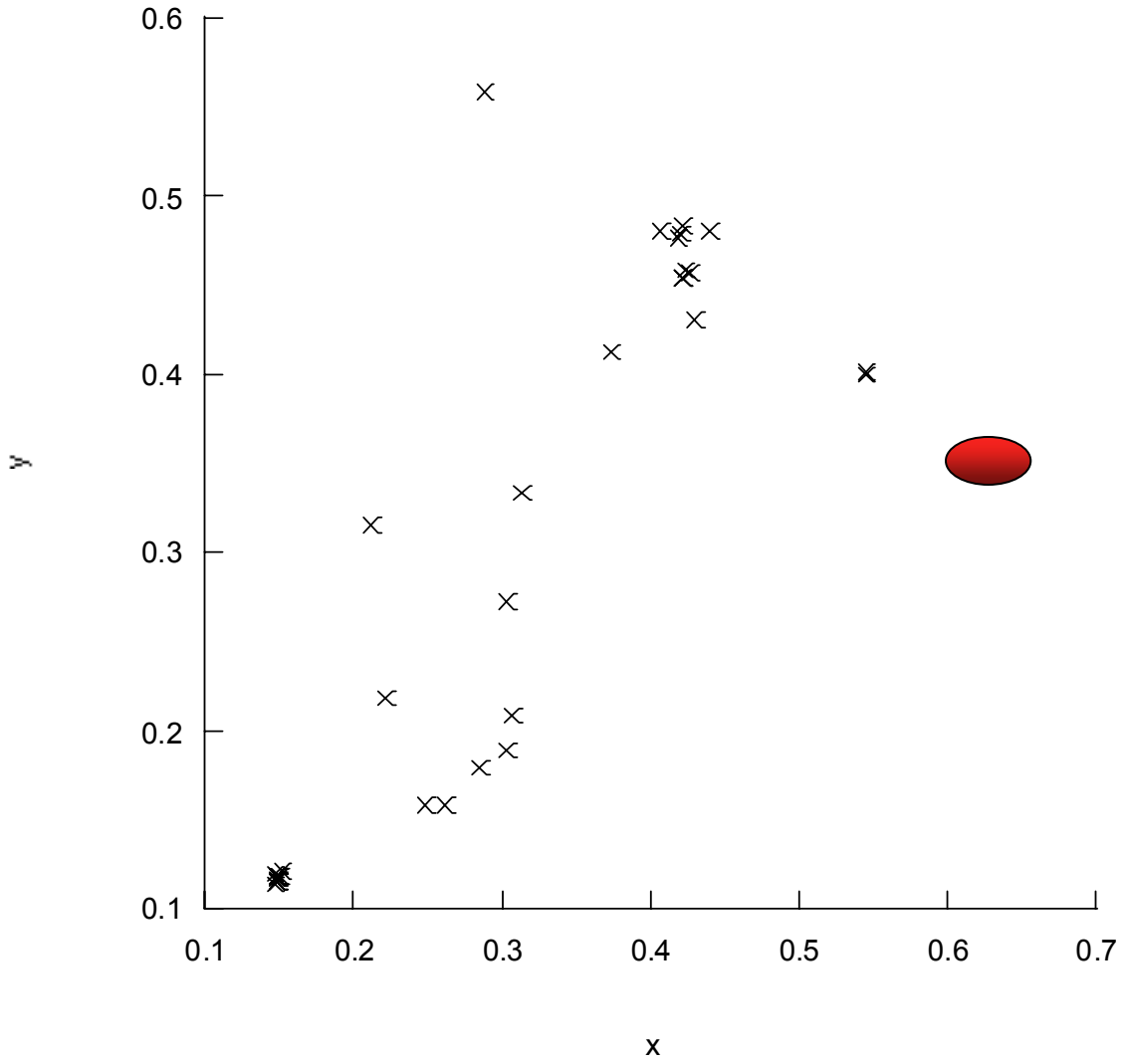
Display Color Guidelines
(DoD, 1989)

- Emergency – flashing red
- Alert – red
- Marginal or caution – yellow
- Satisfactory – green
- Advisory may be blue
- May use color to differentiate between classes of information BUT must not conflict with above color use

The GWM Map Display



GWM Colors

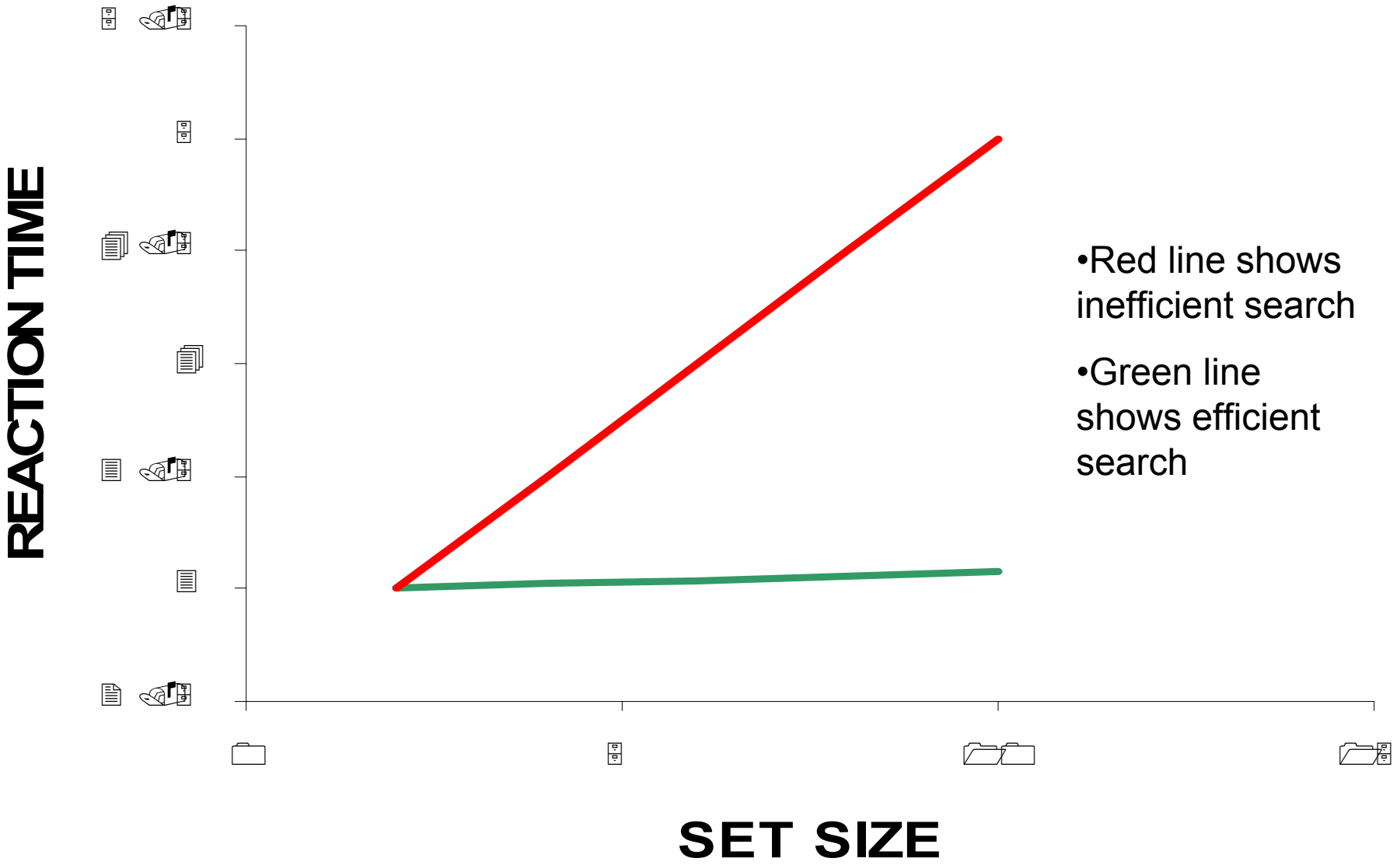


“No matter how intelligent the choice of information, no matter how ingenious the encoding . . . the graph is a failure if the visual decoding fails.” (Cleveland, 1985)

Display Element Criteria Levels

- **Visibility**
- **Discriminability**
- **Conspicuity**

Efficient Search



- Red line shows inefficient search
- Green line shows efficient search

Research Goals of this Pilot Work

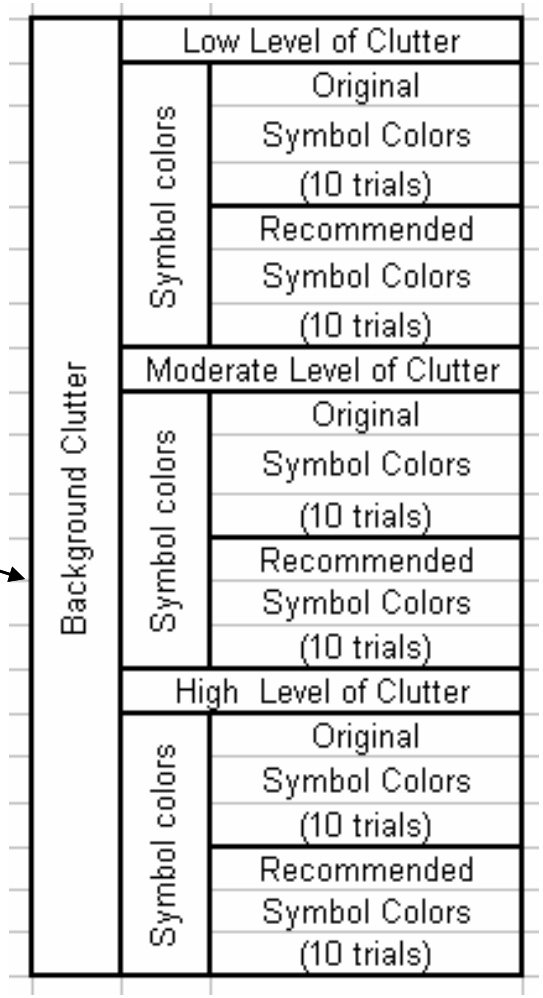
- Combine basic methodology with applied display to demonstrate usefulness for designing and evaluating display coding
- Compare expected outcomes to results of using this methodology
- Verify expected effects of changing the GWM display color scheme
- Collect pilot data for future research testing use of transparency as a visual feature
- Recommend color sets to test in future evaluation

Experimental Design

Block

Background color		Experimental Design	
original		Set size 2 (2 repetitions)	Set size 6 (2 repetitions)
		Set size 18 (2 repetitions)	Set size 54 (2 repetitions)
recommended		Set size 2 (2 repetitions)	Set size 6 (2 repetitions)
		Set size 18 (2 repetitions)	Set size 54 (2 repetitions)

Trials within each block

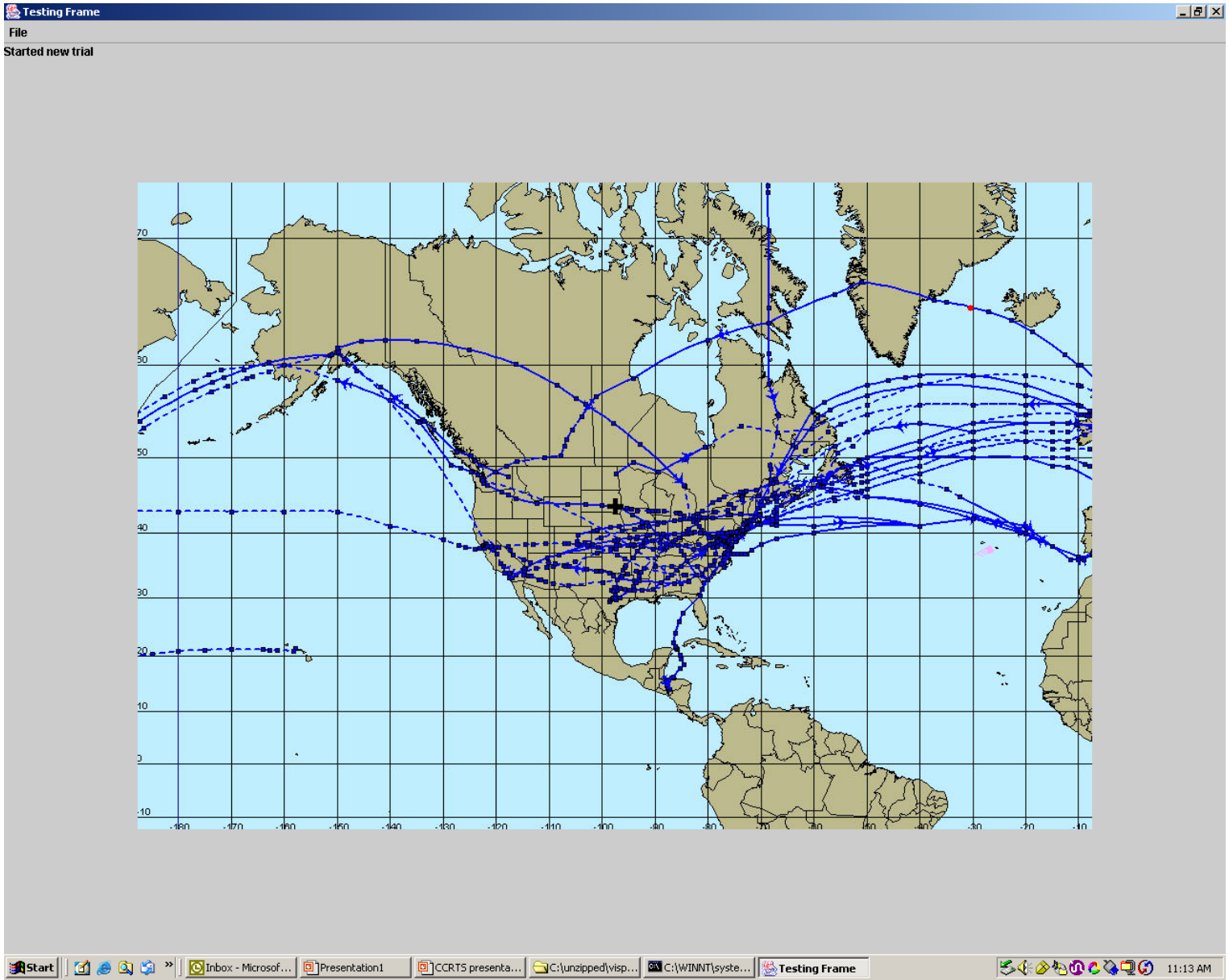


Note: Paper (page 9) reports 8 blocks instead of 16 completed & set size of 3 rather than 2.

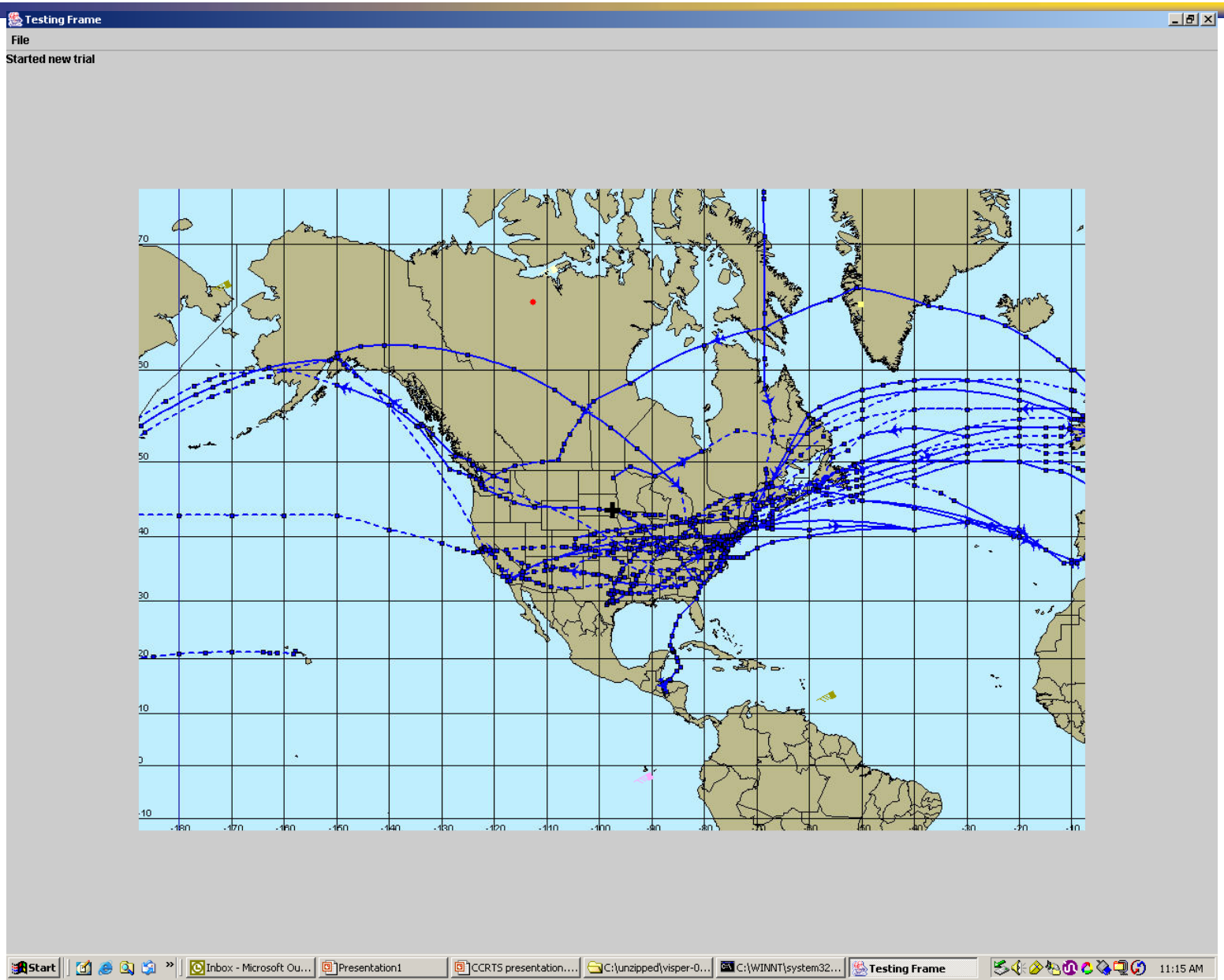
Method

- Participant
  - Female, age 46, normal color vision
- Apparatus
  - Dell PC with flat panel display
  - Stimuli generated by JAVA / JYTHON program
  - Office setting
- Procedure
  - Fixation cross presented at the center of the display background
  - Mouse click to signal “ready”
  - Target and distractors appear
  - Press “enter” or mouse click when target is found
  - Target and distractors disappear (background remains)
  - Position cursor over the quadrant where the target had been – mouse click
  - Next background appears with fixation cross

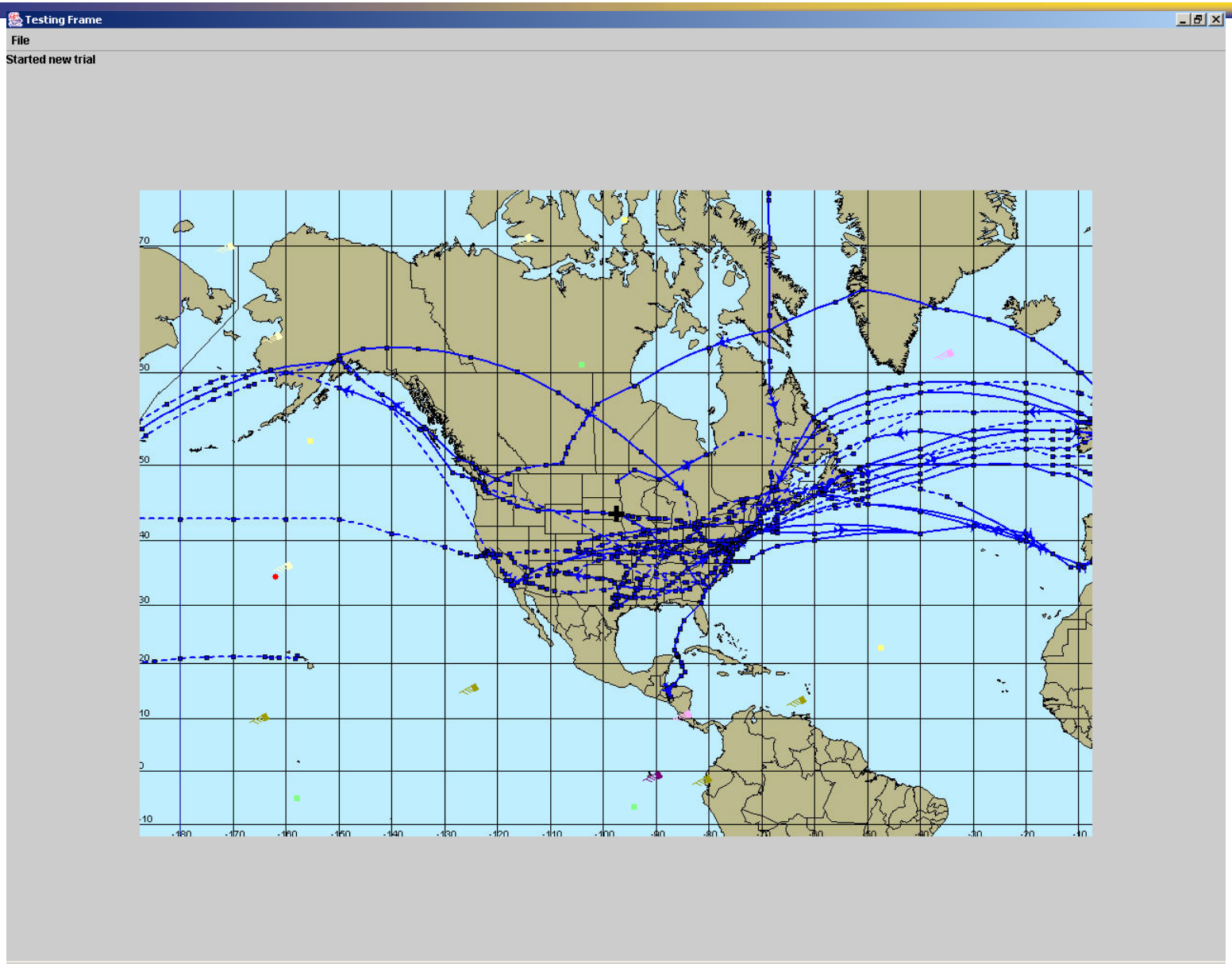
Set Size 2


Testing Frame
File
Started new trial
Start
Inbox - Microsof...
Presentation1
CCRTS presenta...
C:\unzipped\visp...
C:\WINNT\syste...
Testing Frame
11:13 AM

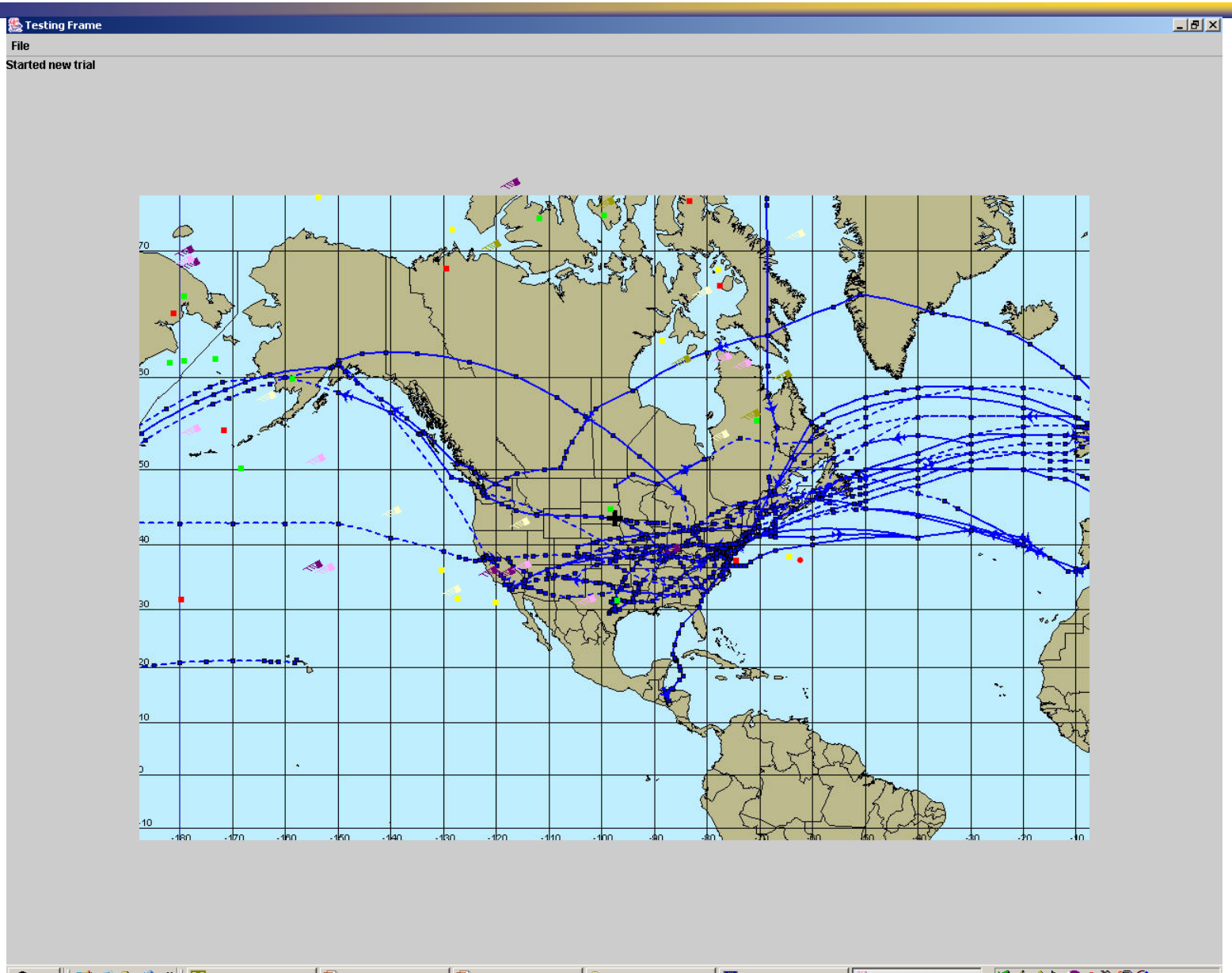
Set Size 6


Testing Frame
File
Started new trial
70
50
40
30
20
10
0
-10
-180
-170
-160
-150
-140
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
Start
Inbox - Microsoft Ou...
Presentation1
CCRTS presentation....
C:\unzipped\visper-0...
C:\WINNT\system32...
Testing Frame
11:15 AM

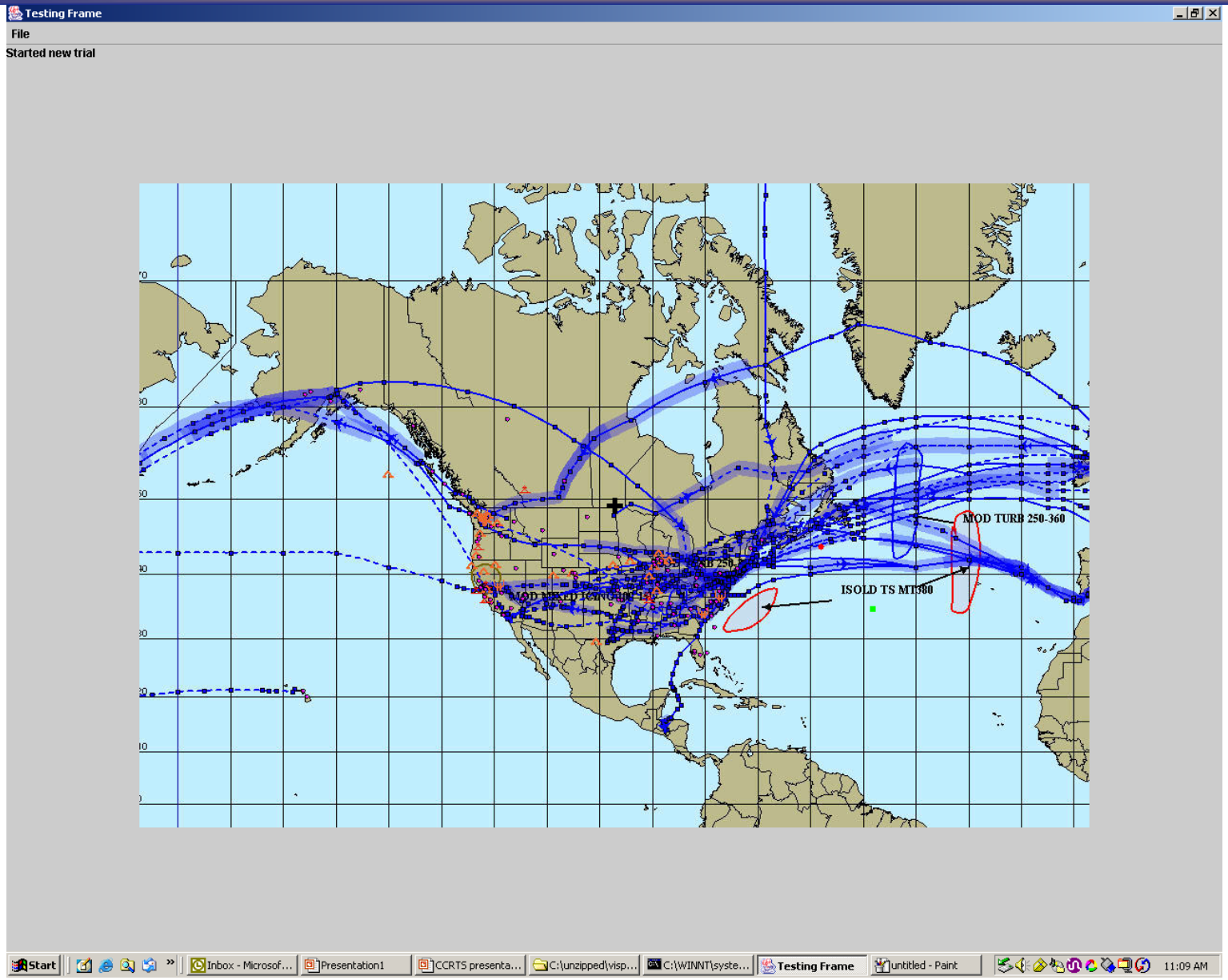
Set Size 18


Testing Frame
File
Started new trial
70
50
40
30
20
10
0
-10
-180
-170
-160
-150
-140
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
Start
Inbox - Microsoft Ou...
Presentation1
CCRTS presentation....
C:\unzipped\visper-0...
C:\WINNT\system32...
Testing Frame
11:16 AM

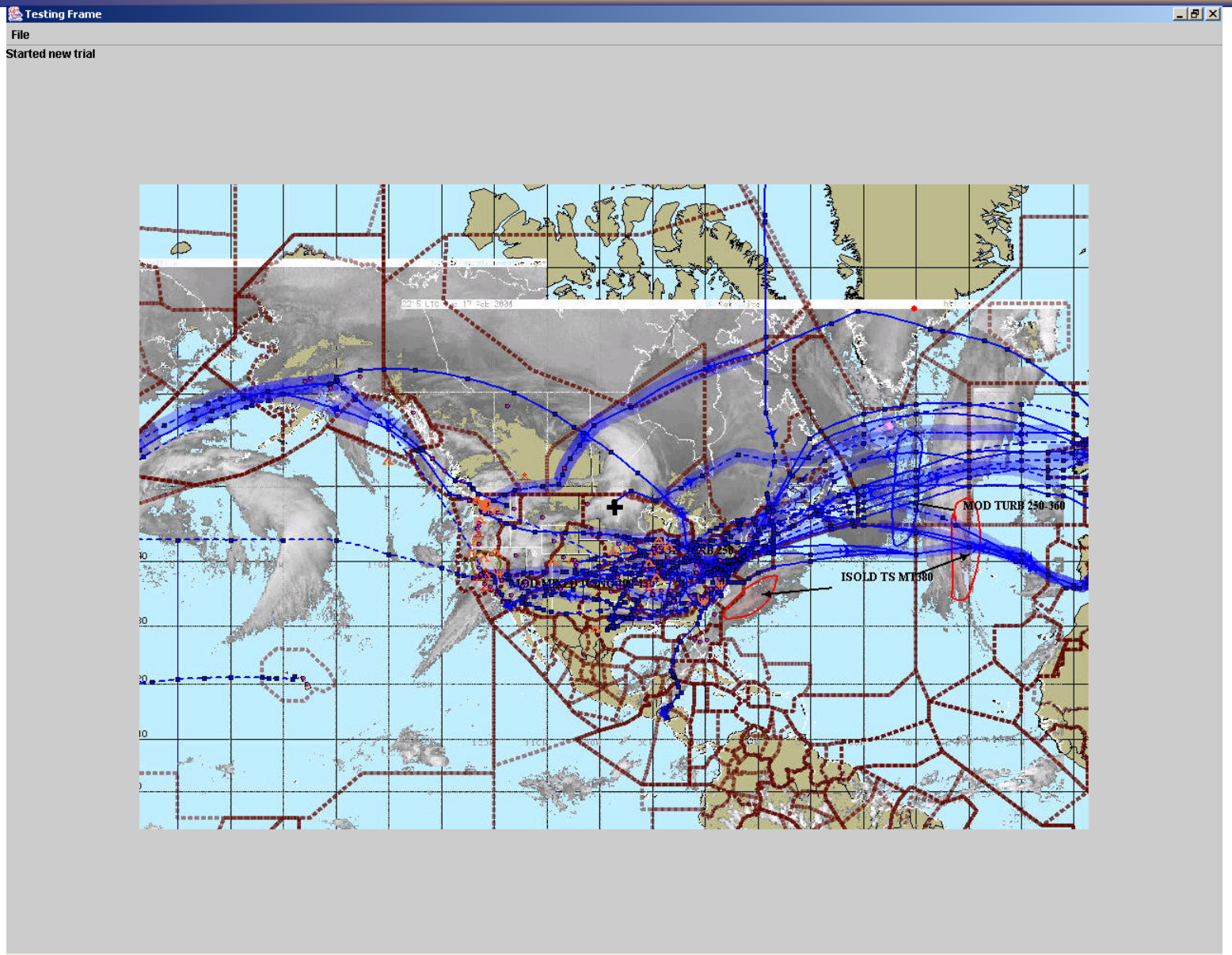
Set Size 54


Testing Frame
File
Started new trial
Start
Inbox - Microsoft Ou...
Presentation1
CCRTS presentation....
C:\unzipped\visper-0...
C:\WINNT\system32...
Testing Frame
11:14 AM

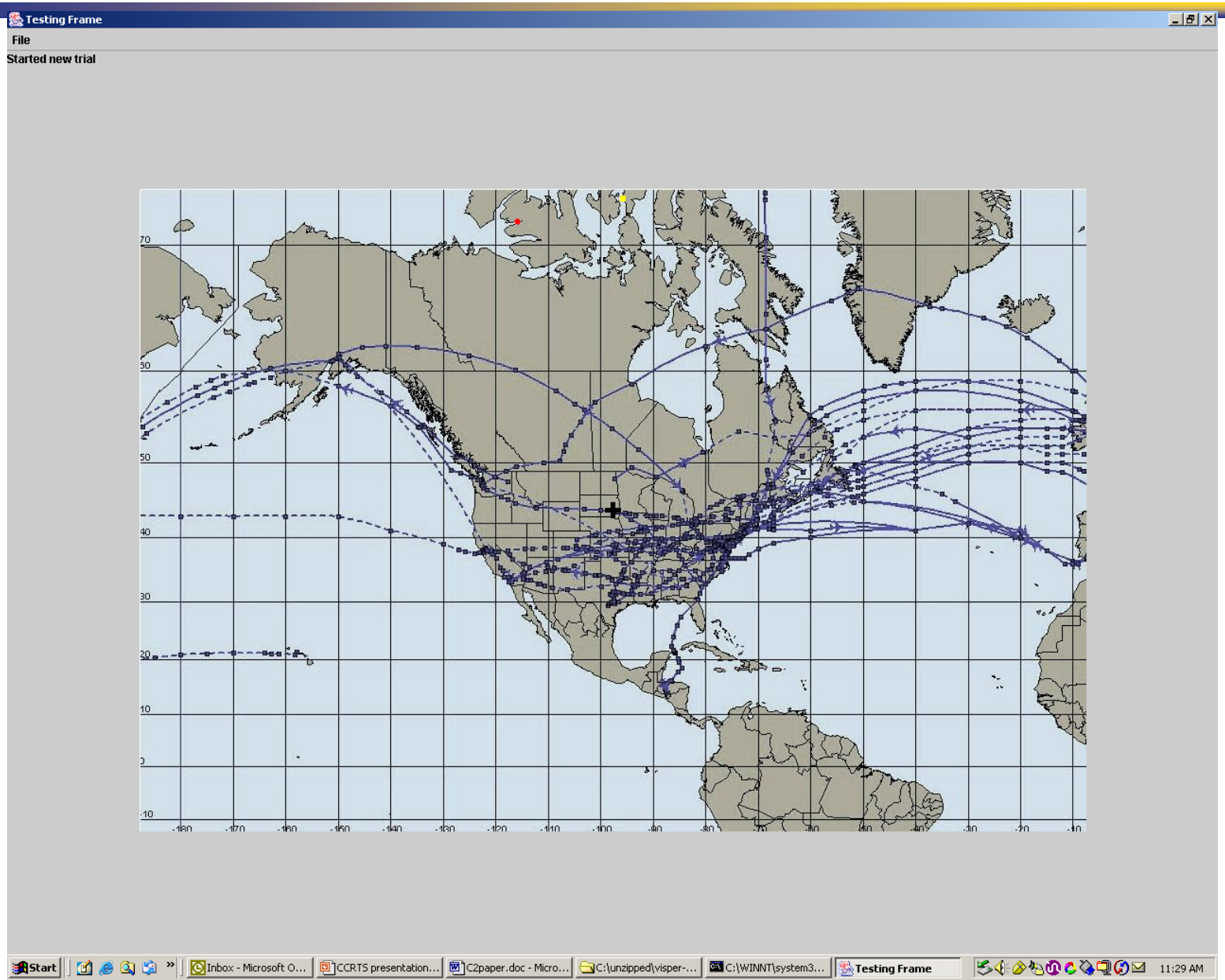
Moderate Clutter



High Clutter



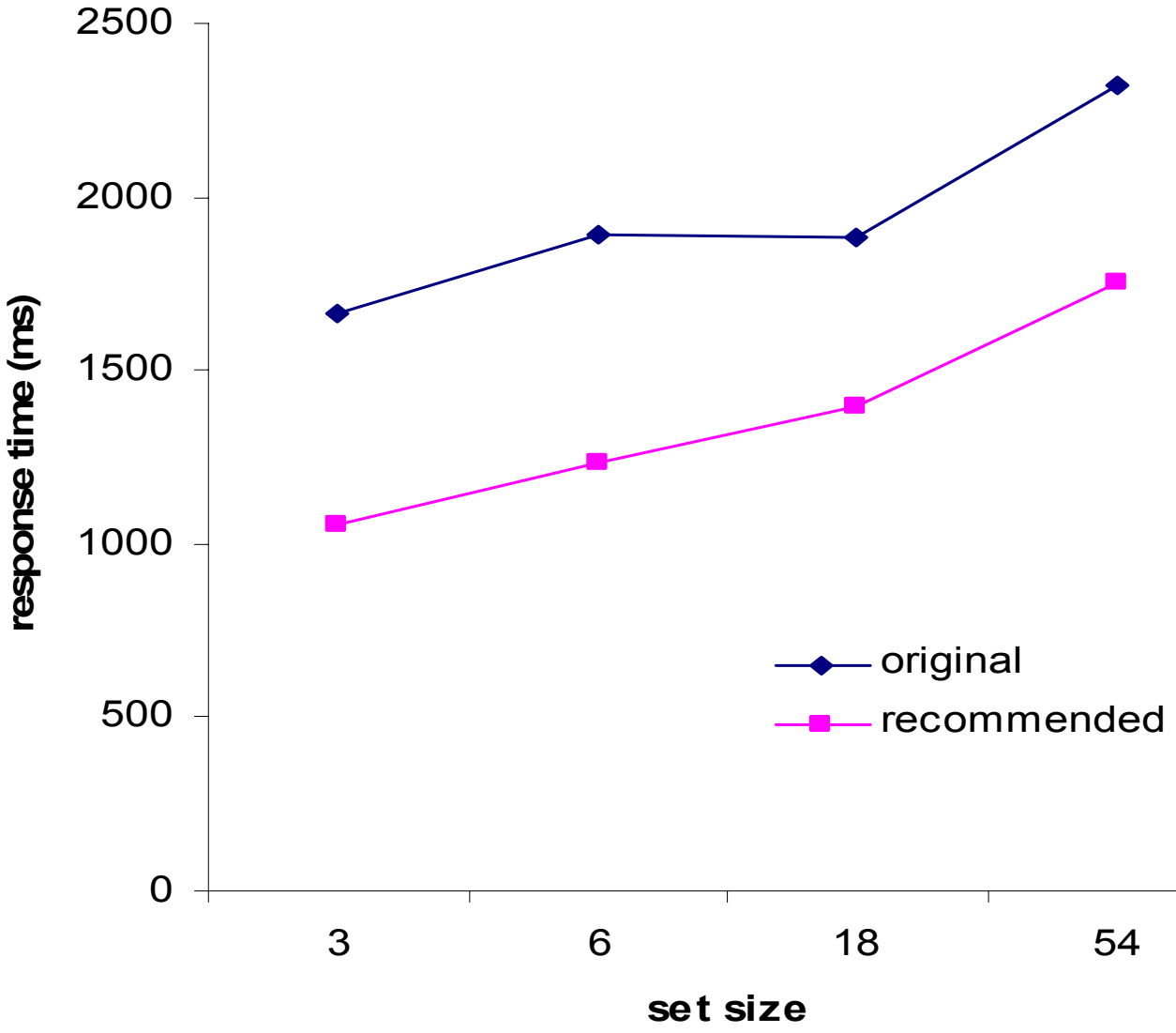
De-saturated Background



Results

- No effect of distractor symbol color
- Set size effect, $F(3, 29) = 5.9$, $p < 0.05$
- Effect of Clutter, $F(2, 39) = 7.1$, $p < 0.05$
- **Effect of de-saturation of background, $F(1, 119) = 24.6$, $p < 0.05$**

Background Color



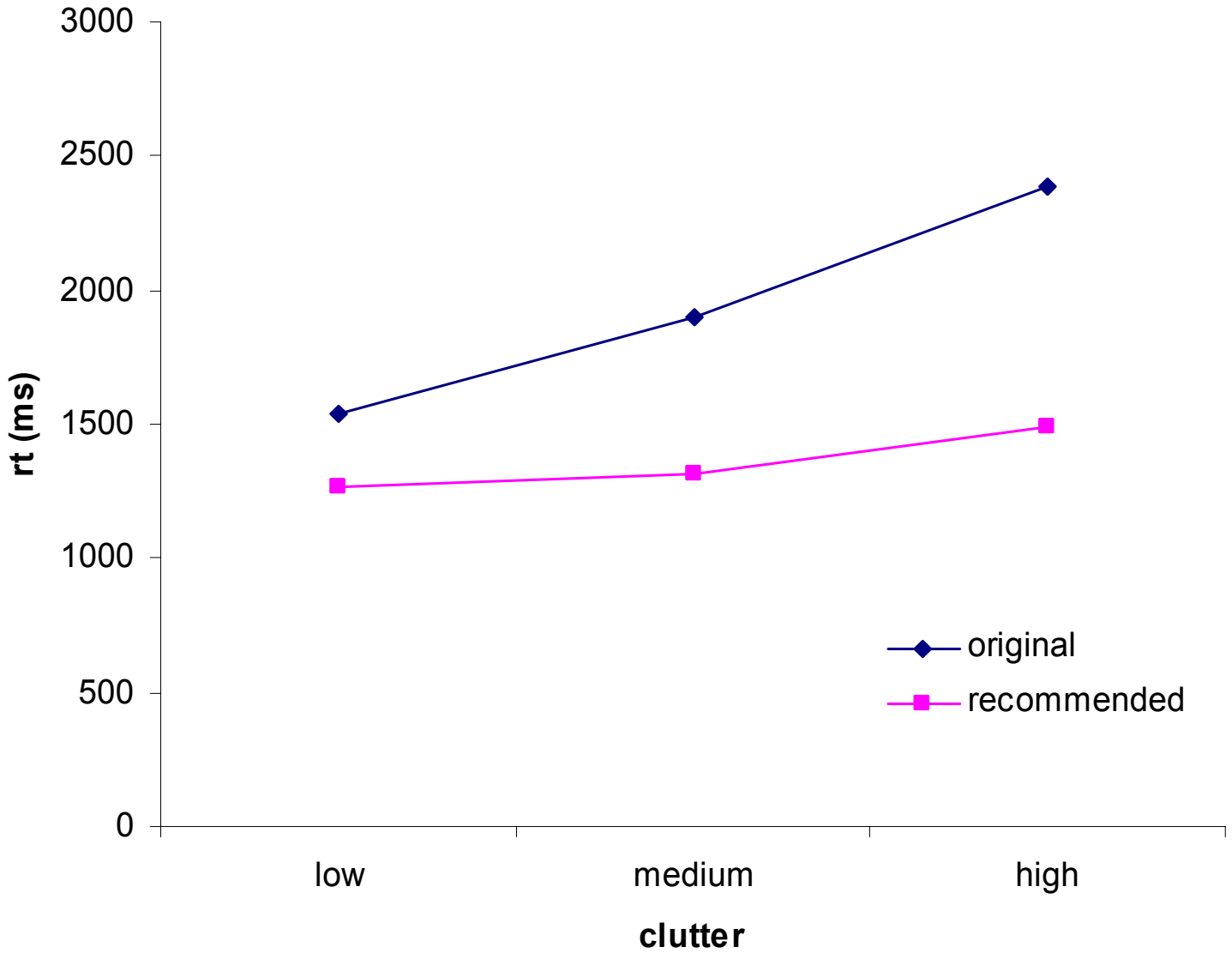
Background

F(1, 119) = 24.6,
p < 0.05

Set Size

F(3, 29) = 5.9,
p < 0.05

Background Color



Background

F(1, 59) = 24.6,
p < 0.05

Clutter

F(2, 39) = 7.1,
p < 0.05

Discussion

- Search task felt to be effective method of testing color sets in this type of display
- Verified that background color de-saturation was effective in speeding search for target
- Method was sensitive to set size effects and effects of clutter
- Selected task for future research with color sets and transparency

Future Research

- **TRANSPARENCY**
  - **Perceptual phenomenon**
  - **Factors leading to / improving the perception of transparency much studied**
  - **Perception of transparency as a visual feature not studied**
- **MORE COLOR SETS**

??? QUESTIONS ???