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From Science to Solutions

Procedures for Off-Nominal Cases: Three Closely Spaced Parallel Runway Operations

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Agenda

- Background
- Approach
- Focus of the study
- Results
- Conclusions
- Future Research

Motivation

- Potential capacity gains from third runway 750 ft apart especially because it could be added within the existing foot print of the airport
- No previous research on procedures for three parallel runways 750 ft and their impact on workload and situation awareness

Previous Research

Concept	No. of runways	Runway Separation	Researcher / Research area
Triple at Hartsfield, Atlanta	3	1000ft/ 4000ft	Variations on simultaneous approaches Gladstone (2000) Mitre
Multiple Parallel Approach Program- (MPAP)	3	4000 ft and 5300 ft	Breakout maneuvers on three runways Magyarits & Ozmore, 2002 FAA
SOIA/ MPAP	2/3	≥ 750 ft	Non-Transgression Zone (for breakout maneuvers)

Focus of Study

- Investigate procedures, roles and responsibilities for off-nominal situations that require a breakout maneuver for simultaneous approaches to three parallel runways 750 ft apart.
 - Feasibility of the procedures
 - Impact of procedures on workload and/or situation awareness levels

Independent Variables

- Nominal vs. breakout
- Cause of breakout:
 - Aircraft deviation (blunder)
 - Crosswind blowing wake towards the trailing aircraft
- Location of breakout:
 - Above 500 ft
 - Between 200 ft and 500 ft
- Relative position of the simulator
 - Center
 - Trailing

Experimental Procedure

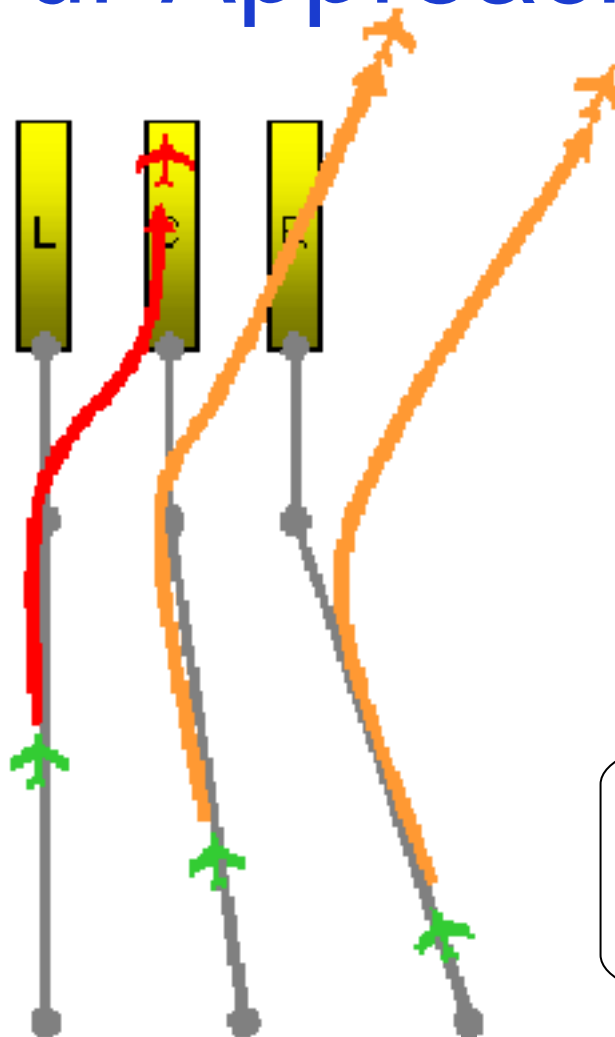
- Advanced Concepts Flight Simulator:
 - digital, audio, and video data collection
 - Six degree motion
 - Performance similar to Boeing 757
 - Side stick control
- 8 days of data collection - 8 participants
- Total runs = 24 per participant.
- Each run was 10-15 min long followed with questionnaires and debriefs.
- All runs had visibility of 2 nm at 400 ft.



Our Approach

Runways 750 ft apart

DGPS*, ADS-B**, winds on a/c assumed



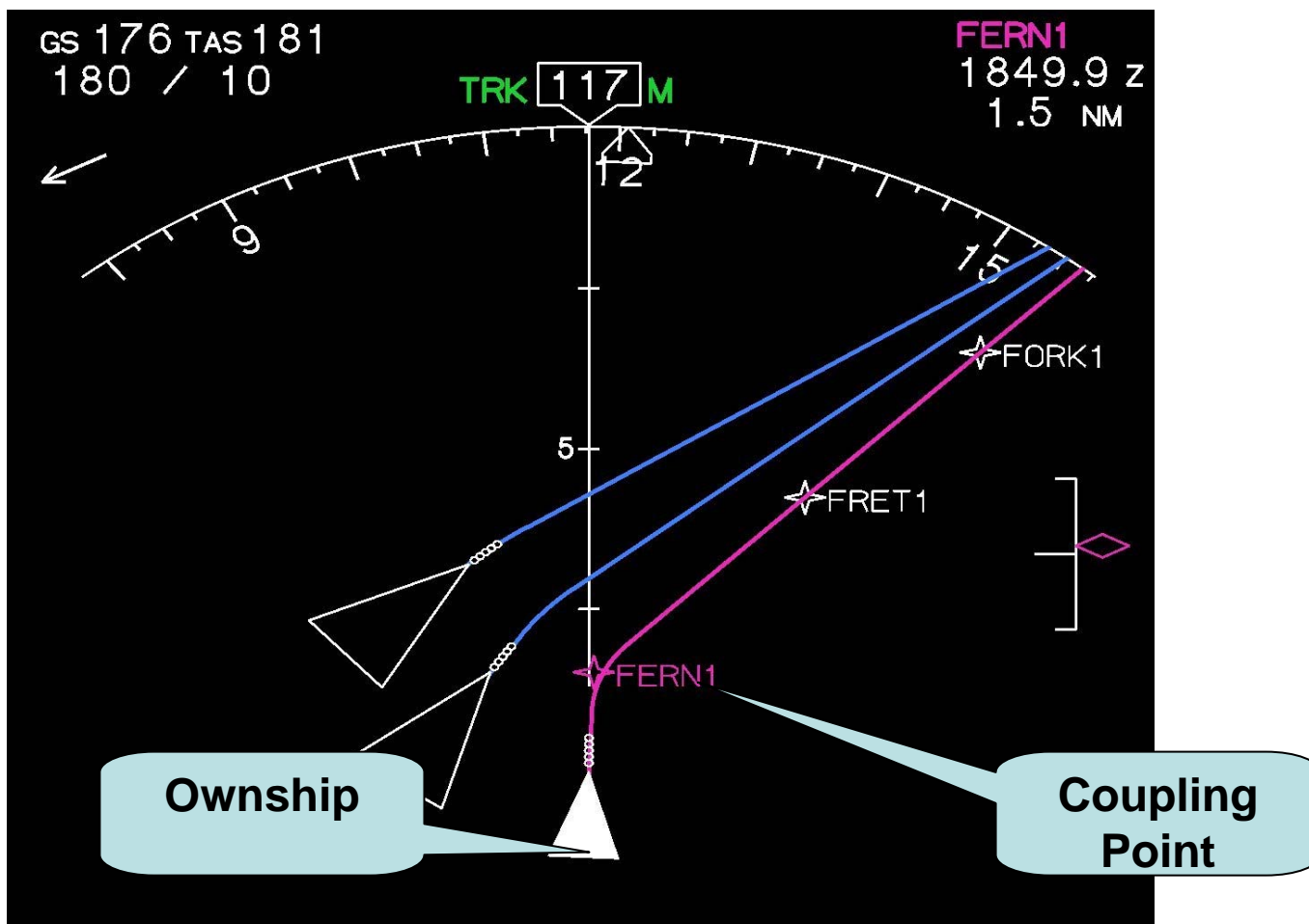
Dynamic S-trajectories adaptive and displayed in real time

S trajectory parallels 1.5 nmi for center a/c and at 3 nmi for the trailing aircraft

*Differential Global Positioning System
 **Automatic Dependent Surveillance System

Procedure / Scenario

Navigational Display

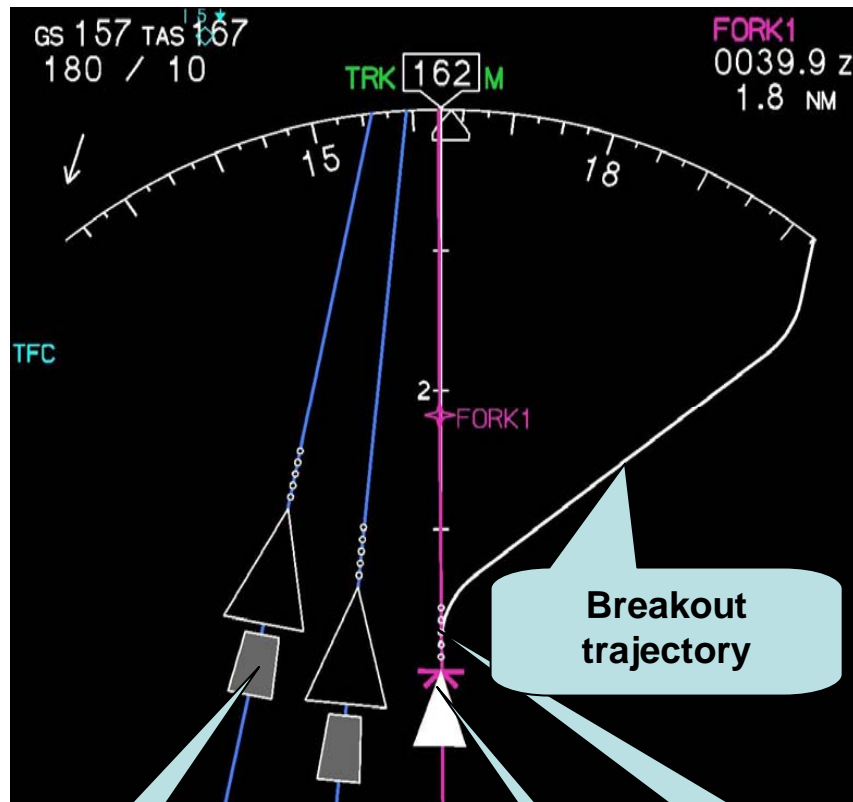


Displays for Breakout Procedure

Normal conditions



Primary Flight Display



Navigation Display

wake

LSI

wake

Breakout trajectory

Predictor Dots

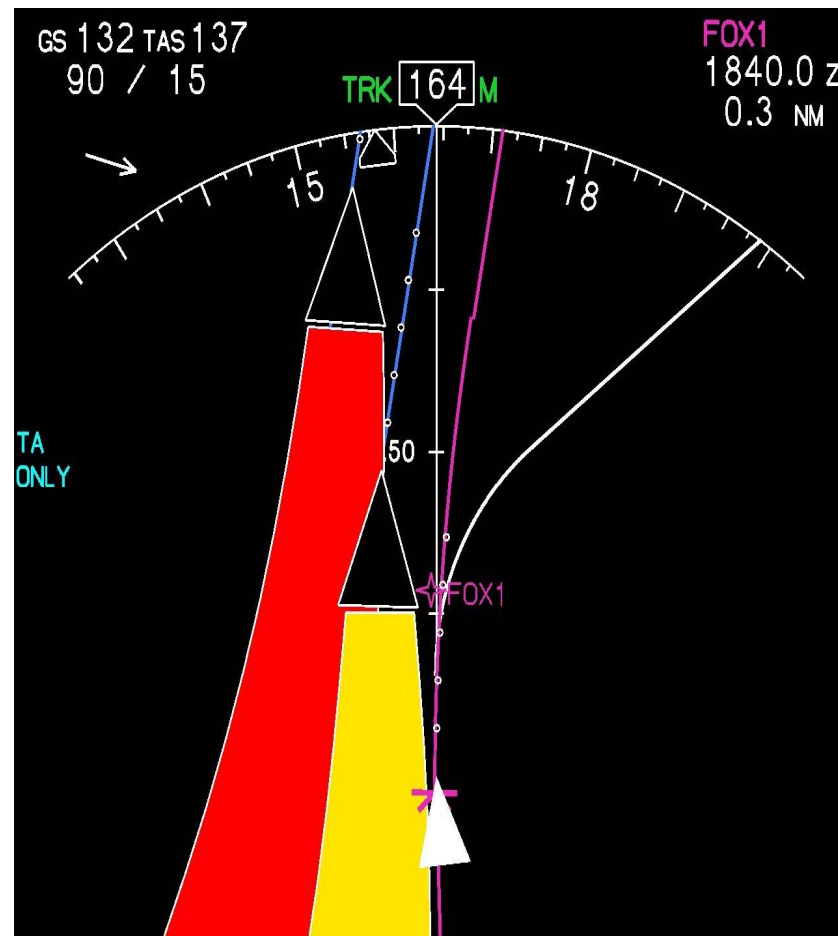
LSI

Breakout Procedures and Displays

Wake drifting towards follower



Leader's wake drifted
by one wing span



Follower's center of
gravity in leader's wake

Breakout Procedures & Displays

Aircraft Blunder



Leader deviates 60 ft towards follower



Leader deviates 120 ft towards follower

Breakout Maneuvers

Altitude	Bank Angle
> 500 ft	30 deg
200- 500 ft	10 deg

Relative Position	Heading change
Center	20 deg
Trailing	40 deg

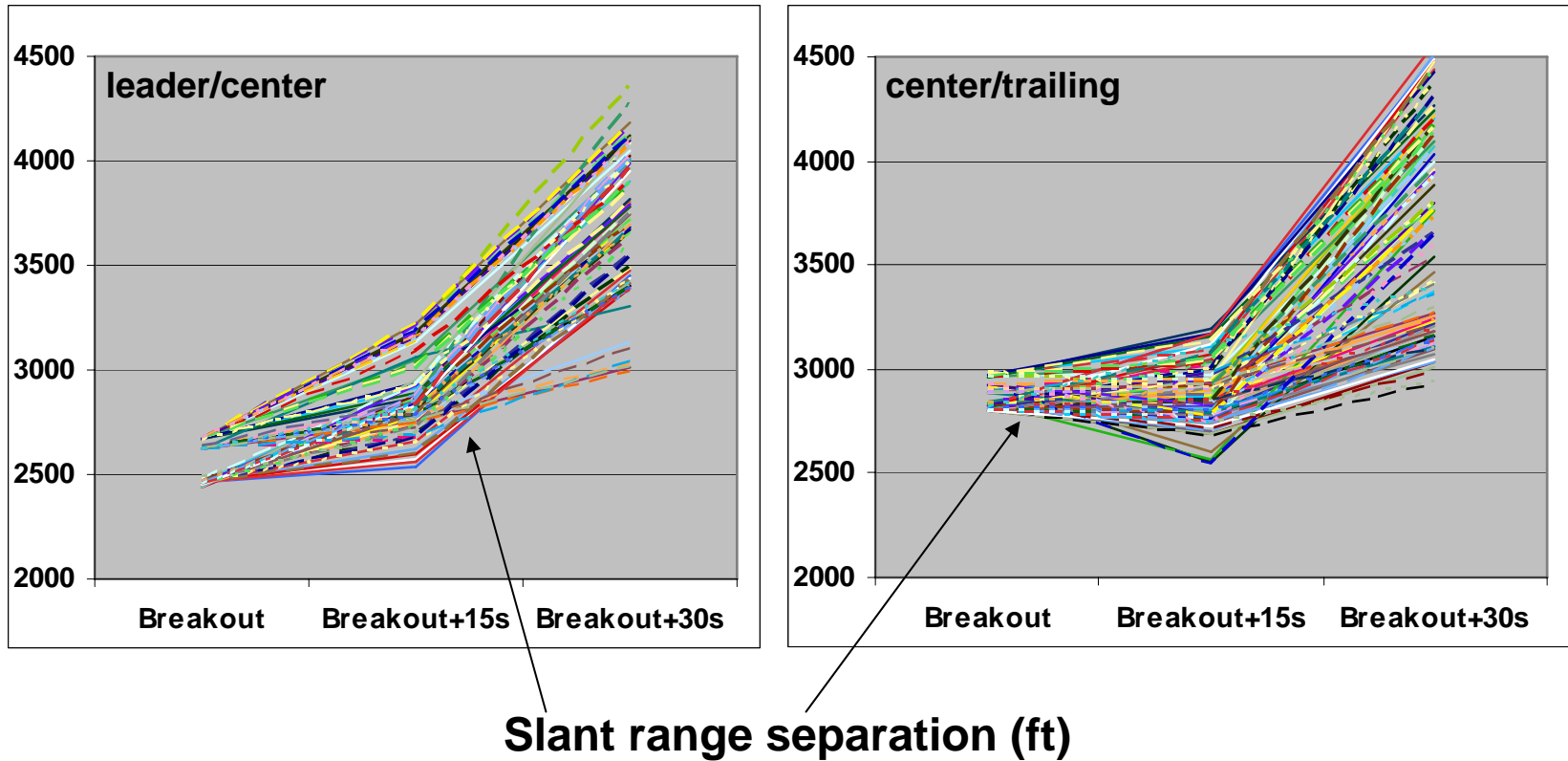
Dependent Variables

- Aircraft separation during breakout
- Accuracy of breakout maneuver
- Subjective data:
 - Workload
 - Situation awareness
 - Acceptability of procedures

Aircraft Separation During Breakout

- Three-way repeated measures analysis of variance
- Dependent variables:
 - Slant range between
 1. leader / center aircraft
 2. center / trailing aircraft
- Independent variables:
 - Cause of breakout
 - Location of breakout (low / high altitude)
 - Relative position of the simulator (center / trailing)

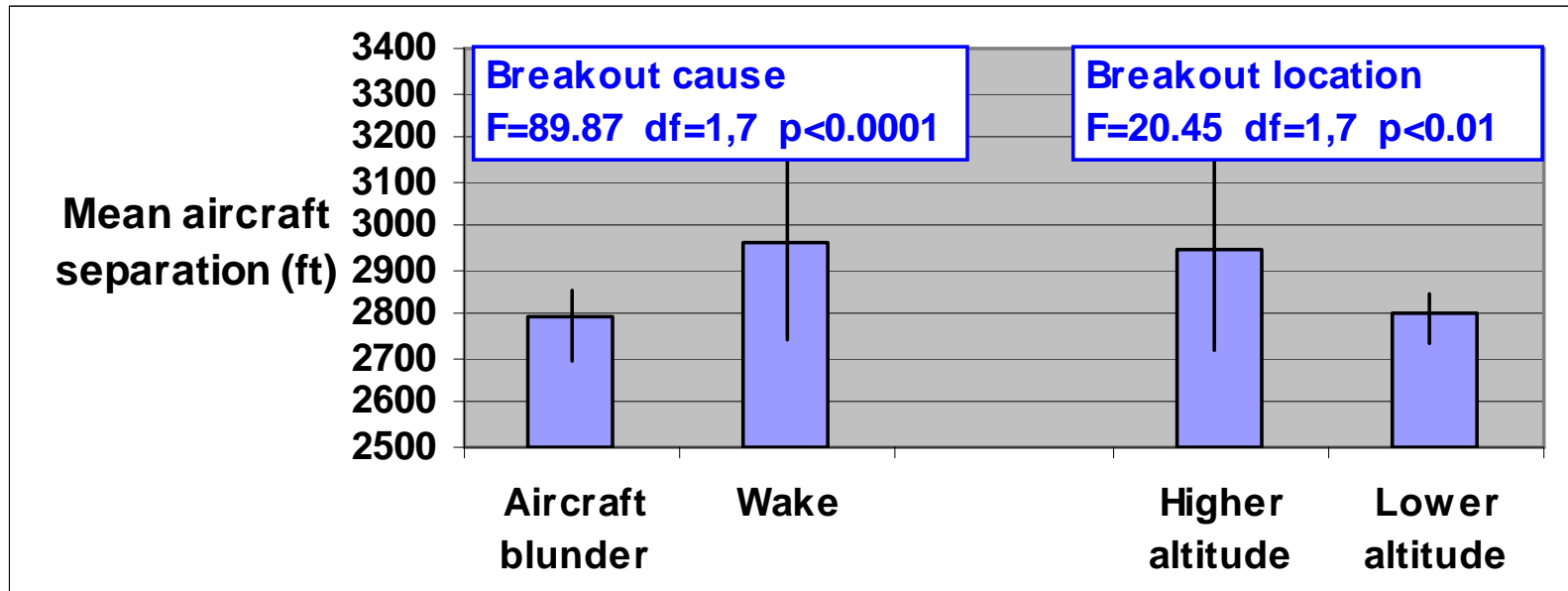
Aircraft Separation During Breakout



- No single instance of slant range separation less than 2400 ft
- Breakout aircraft separation always well above the threshold value specified in an FAA study (Magyaritis & Ozmore, 2002)

Aircraft Separation During Breakout

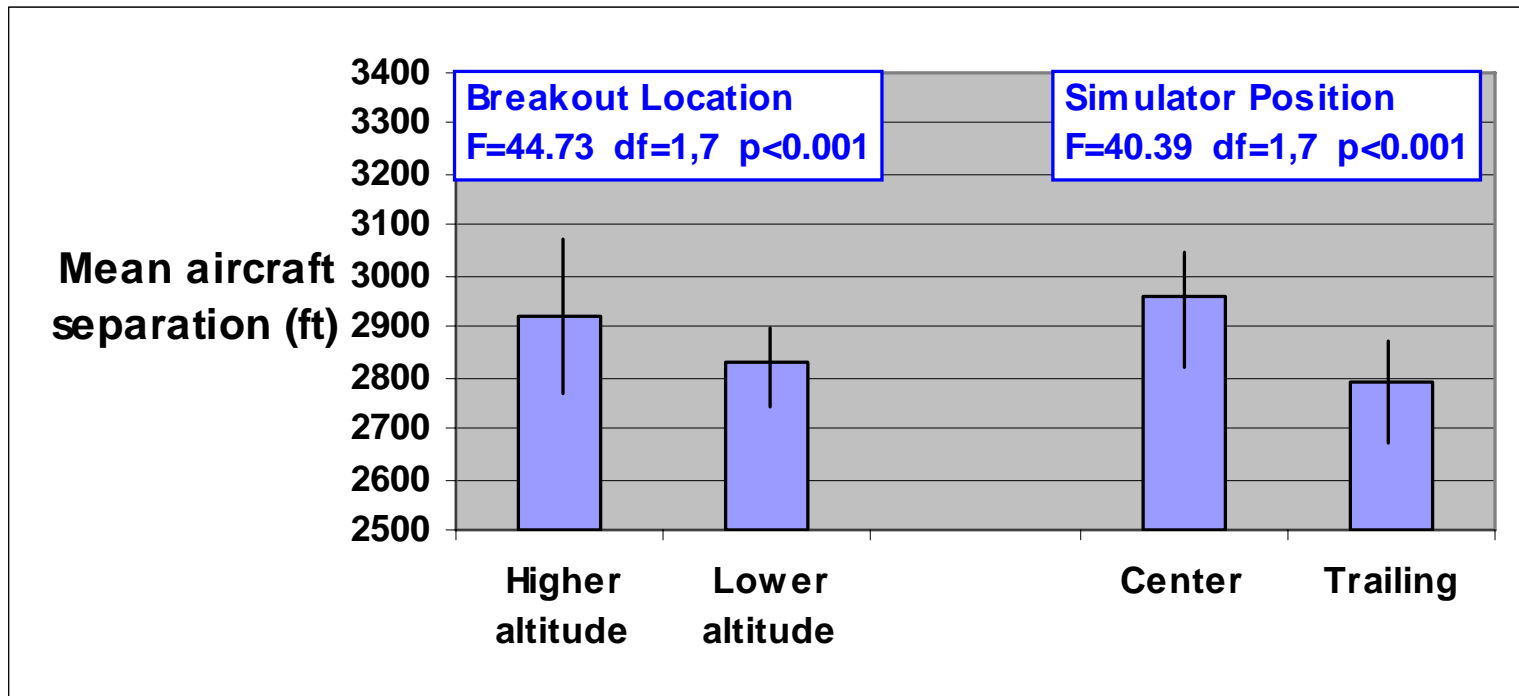
- **Leader / Center** Separation 15s past breakout



- Pilot participants indicated that the uncertainty of wake characteristics prompted faster responses
- Higher altitude breakout reflect different post breakout geometries between aircraft

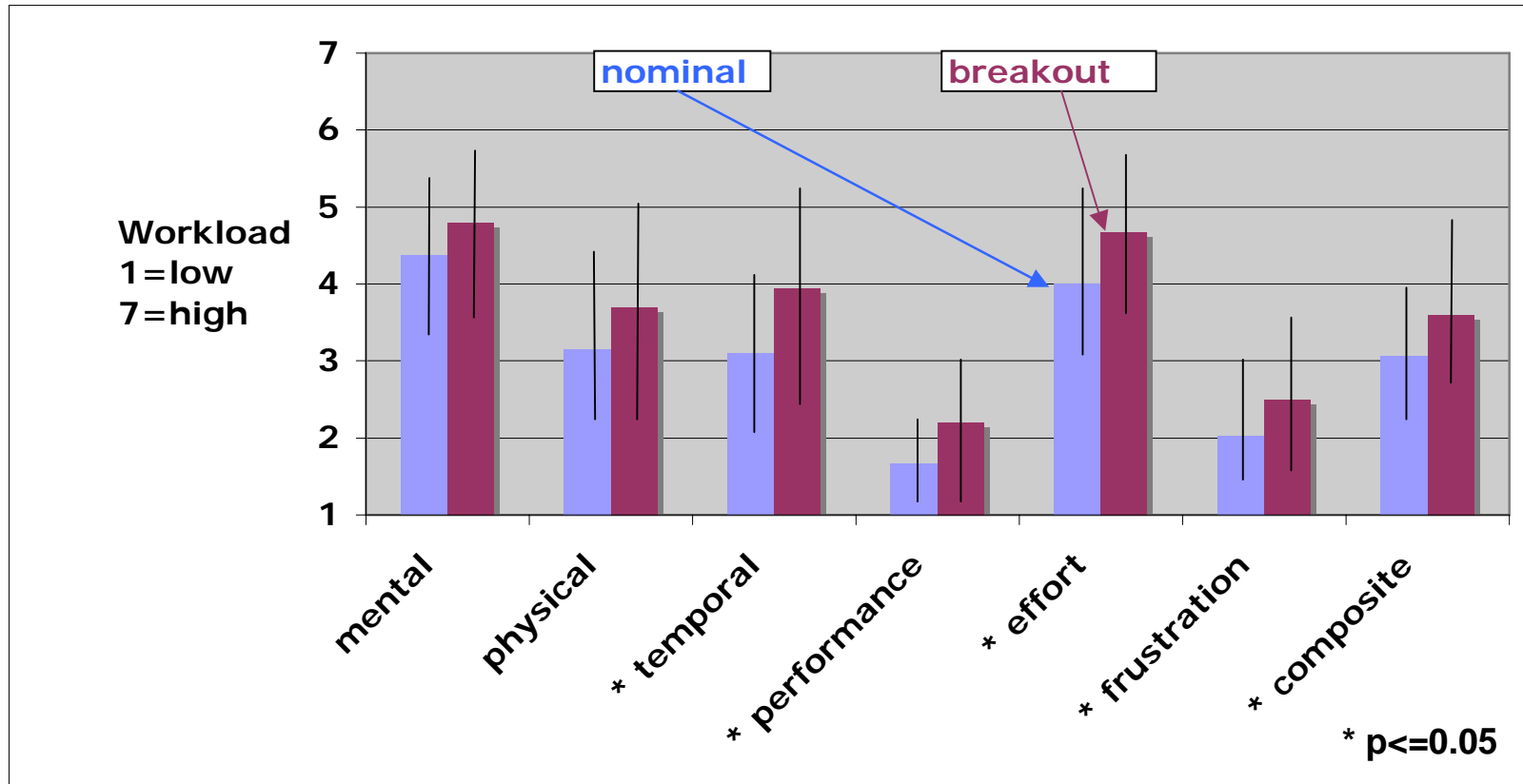
Aircraft Separation During Breakout

- Center / Trailing Separation 15s past breakout



Pilots indicated that the center aircraft needs to maintain separation with two other aircraft

Pilot Workload: NASA Task Load Index



- Higher overall workload in breakout runs
- Off-nominal conditions require the safe maneuvering of the aircraft following breakout, rather than implementing normal approach procedures

Pilot Situation Awareness

- Dependent variables from Situation Awareness Rating Technique (SART)
 - Ten subscales combined into 3 broader categories

Demands of the situation

- instability, variability, complexity

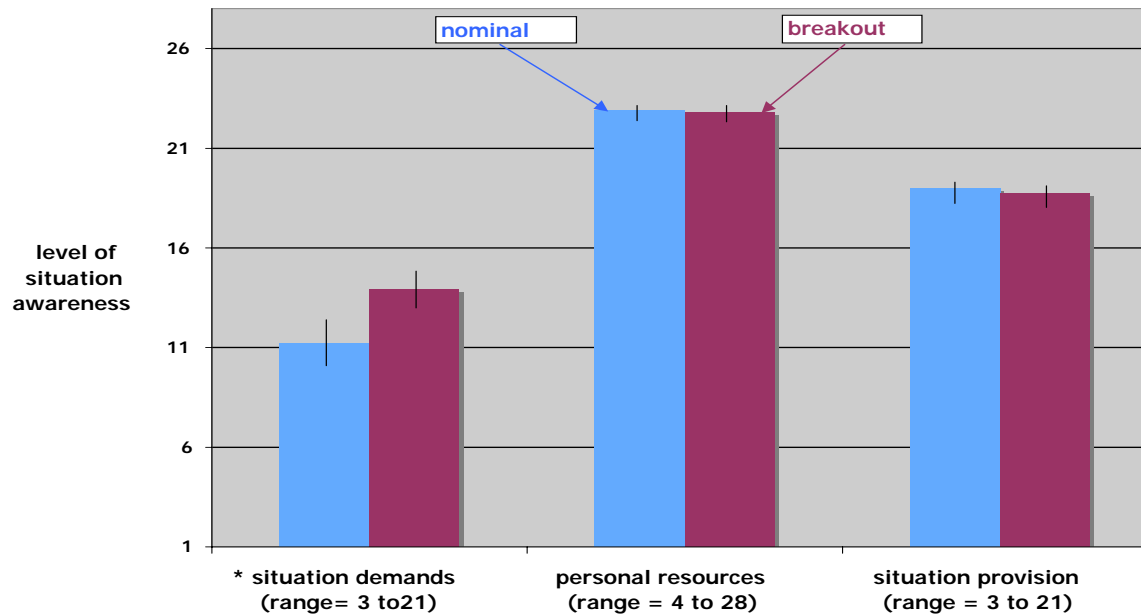
Personal resources

- alertness, spare mental capacity, concentration, division of attention

Situation provision

- information quantity, information quality, familiarity

Pilot Situation Awareness (SART)



- Higher overall situation demands in breakout runs ($F=25.46$, $df=2,6$, $p\leq 0.01$)
- Situation instability, variability, complexity: consistent with workload results
- Non-significant results for situation provision indicate that information and procedures provided was adequate for both nominal and off-nominal cases

Pilot Discussion / Feedback

Feedback on Procedures

- Some maneuvers were aggressive
- Trust in automation could be an issue
- Automate breakout maneuvers

User Interface Feedback

- Pilots wanted the system to automatically set the field of view of the navigation displays so that all three aircraft were always visible
- Information provided via the displays was considered simple, clear and unambiguous

Conclusions

Feasibility of breakout procedures was tested using three very closely spaced parallel runways

- Aircraft separation was maintained well above 2400 ft during breakout across all conditions
- Similar levels of situation awareness between nominal and breakout runs indicate adequacy of information and procedures
- While workload was higher in breakout flights, it still remained manageable across all conditions

Future Work

- Auto pilot versus manual breakout procedures
- Evaluation of the role of air traffic control
- Evaluation of post-breakout maneuvers back into the arrival flow
- Evaluation of the integration of our concept with terminal and surface operations



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Questions?

