Coordination Between Sectors In Shared Airspace Operations

Bonny Parke, Eric Chevalley, Paul Lee, Faisal Omar, Joshua M. Kraut, Kari Gonter, Abhay Borade, Conrad Gabriel, Nancy Bienert, Cindy Lin, Hyo-Sang Yoo, & Daphne Rein-Weston
San Jose State University Research Foundation/NASA Ames, Moffett Field, CA

Everett Palmer, NASA Ames Research Center, Moffett Field, CA

Outline

- Problem
- Background
  - 3 types of relevant coordination
- Method of addressing problem
  - Human-in-the-Loop simulation
- Results
- Conclusions

Problem

- Shared airspace operations
  - Aircraft share same airspace *temporally*
  - E.g., departures fly through gaps in arrival flows
    - Shown to be a more efficient use of crowded terminal airspace [1,2]
- Problem: How coordinate a departure flying through arrival sectors?

Background

- Typical operations
  - Controllers have responsibility for all aircraft within their sectors
    - If need to cut aircraft through corner of another controller's sector
      - Can hand-off aircraft, transfer communication
      - BUT next controller has to do the same almost immediately
- OR can use one of three types of coordination for controlling aircraft in another controller's airspace
  - 1) Point-outs
  - 2) Look-and-go
  - 3) Prearranged Coordination Procedures (P-ACP)

1) Point-outs—FAA Definition

- *Point-outs*
  - "A physical or automated action taken by a controller *to transfer the radar identification of an aircraft* to another controller if the aircraft will or may enter the airspace or protected airspace of another controller *and radio communications will not be transferred*."

1) Point-outs: FAA Requirements

- The *transferring* controller must
  - Receive verbal or automated approval from receiving controller
  - Let the receiving controller know of any changes in flight path
  - Comply with any restrictions from receiving controller
  - Be responsible for next handoff and transfer of radio communication

1) Point-outs: FAA Requirements

- The *receiving* controller must
  - Make sure position of aircraft and data block are correct
  - *Be responsible for separation between point out aircraft and other aircraft for which he/she has separation responsibility*
  - Issue any restrictions necessary (ahead of time) to provide separation from other aircraft in their sector

1) Automated Point-out and Meaning

Automated

- A flashes (in yellow) aircraft's data tag onto B's radar scope
- B flashes (in yellow) relevant traffic to A's scope
- A accepts point-out of traffic. Data tag stops flashing but remains yellow
- B accepts original point-out. Data-tag stops flashing but remains yellow.

Meaning

- A: "Can I take aircraft through your airspace?"
- B: "I have traffic you'll have to watch out for."
- A: "I see that and accept responsibility for avoiding it."
- B: "Okay, point-out approved."

1) Problems with Point-outs in the Field (ASRS* Reports)

- High traffic
  - A controller in a busy sector receives many point outs and "often is responsible for separation of 2 aircraft when he is talking to neither one."
- Airspace
  - "I don't know how to discourage the . . . lack of point outs.. . .Our airspace . . . has a lot of cutouts and different altitudes for each section. It should be a goal . . . to simplify the airspace."

*Aviation Safety Reporting System

1) Problems with Point-outs in the Field (cont.)

- Training
  - "Suggest X facility gets regular training for Point Outs. It appears that they interpret Point Outs as permission to enter [our] facility's airspace, but are unaware that they are responsible for separation of affected aircraft"
    - Actually, reporter's facility (not X) IS responsible for separation of affected aircraft

1) Problems with Point-outs in the Field (Cont.)

- 1981 review of ASRS reports on point-outs [3]:
  - Point out approval means controller sees aircraft, but control is not coordinated & intentions of aircraft frequently unknown
  - Need facility directives that define coordinated operations with point-outs

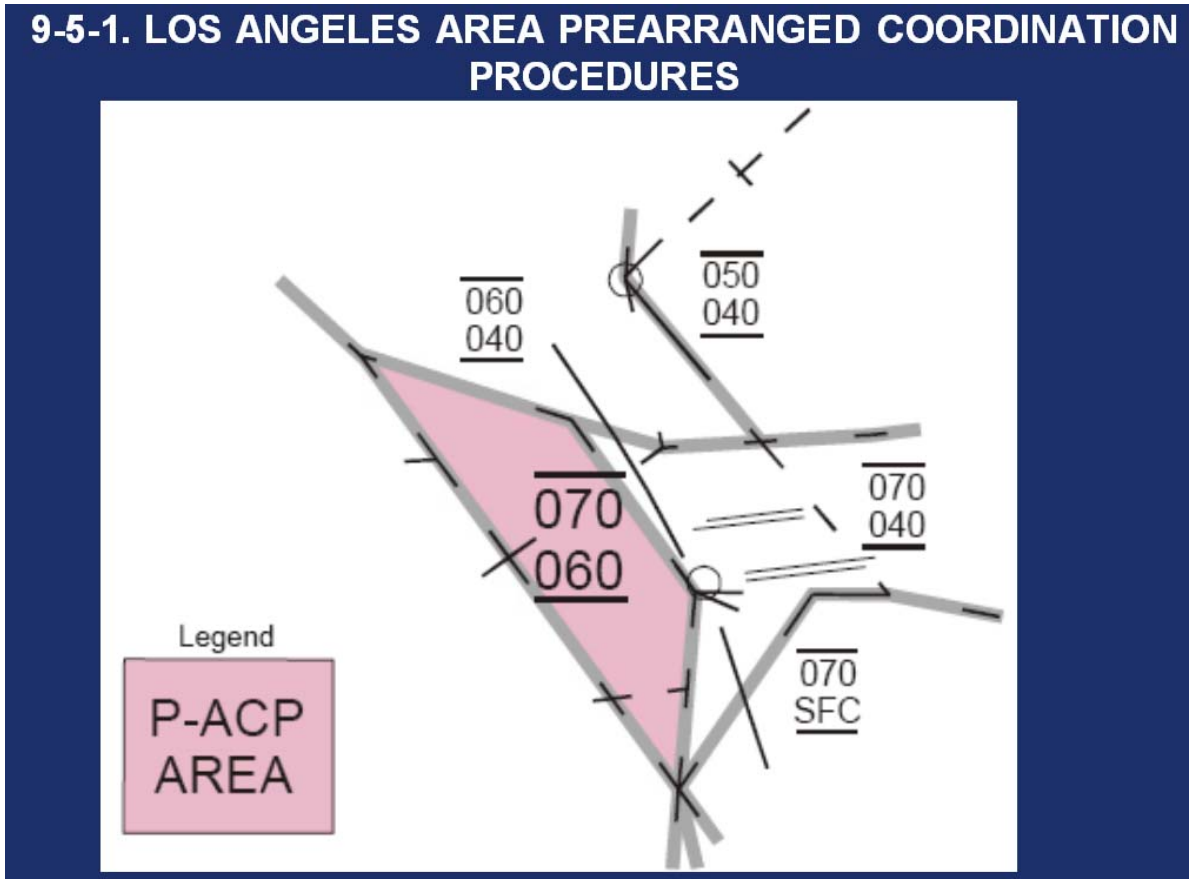
2) "Look-and-Go"

- Not an FAA-approved procedure
- Has been used in US airspace
  - "A controller quick-looks the airspace being controlled by another, and if he observes no traffic pertinent to his plan, he clears the aircraft he is controlling into the adjacent airspace" [3]
- Many incidents and accidents caused by this procedure
- "In reality, no coordination [takes] place." [3]

3) Pre-Arranged Coordination Procedure (P-ACP)

- FAA:
  - "*A facility's standardized procedure* that describes the process by which one controller may allow an aircraft to penetrate or transit another controller's airspace in a way that assures standard separation *without individual coordination* for each aircraft"
  - P-ACP and its development must include
    - Consideration of airspace redesign instead
    - Negotiation of requirements locally
    - Thorough training
    - What to do when cannot implement P-ACP
    - Which positions involved
    - What responsibilities involved
    - Stating that two positions can't penetrate each other's airspace at the same time
    - Stating that requesting controller must display data block info. to other controller
    - Indicating if dealing with a 757
    - What to do when equipment breaks down

3) Example of P-ACP: Southern California TRACON (SCT)



3) Example of P-ACP Coordination Procedures

- When LAX is in the West configuration, "
  - **(1)** The Manhattan controller may apply P-ACP within the depicted boundaries of Laker airspace [shown in Figure 1 above].
  - **(2)** Prior to using P-ACP, the Manhattan and Laker controllers shall Quick Look each other or ensure Full Data Blocks are auto displayed to both sectors within P-ACP airspace.
  - **(3)** Manhattan may enter P-ACP airspace with aircraft that depart Los Angeles International Runways 25L/R, or 24L/R.
  - **(4)** The Manhattan controller shall be responsible for maintaining approved separation between aircraft under their control and all traffic in the P-ACP airspace"

3) Problems with P-ACP in the Field (ASRS Reports)

- Design
  - "The new prearranged coordination procedures [at my facility] are incorrect, flawed, and not safe. There are no restrictions with regards to altitudes, headings, or separation responsibility.. . . This type of prearranged coordination is essentially a sanctioned form of "look and go" . . .Need to be rewritten by someone who has knowledge and experience."
- Training
  - '"Once again our facility misapplied prearranged coordination procedures, except this time it led to a loss of separation. . . It is basically jungle rules at times. . . . Specialists are not taught to remain in their airspace and misapply prearranged coordination procedures all the time. . . "
- Workload
  - "I still remain certain that there is an increased workload placed upon the RADAR Approach/Departure Controller, all over the interpretation of 'Pre-arranged Coordination'"

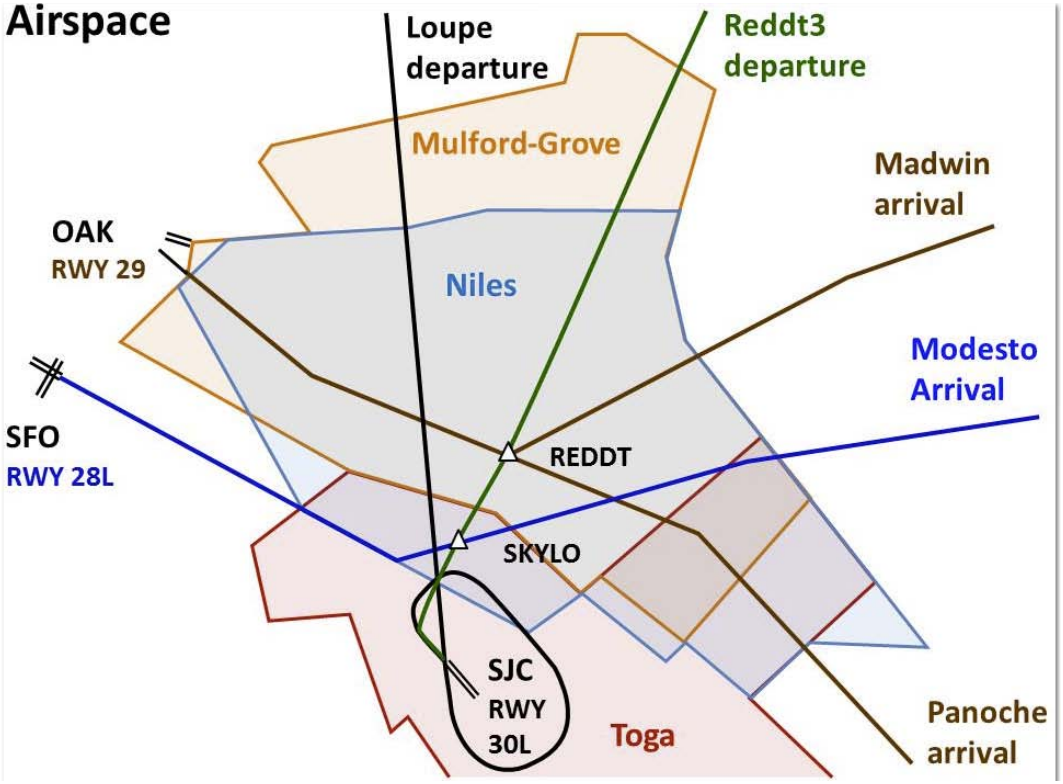
Goal of Study

- Determine which type of coordination in shared airspace operations is
  - Safe
  - Efficient
  - Low workload
- Compare
  - Point-outs (edge in safety?)
  - P-ACP (edge in efficiency?)
  - ~~Look-and-go~~ (Unsafe)
- Design & train procedures well

Method—HITL

- Three experienced retired controllers rotated through 3 arrival positions in simulated airspace in Northern California TRACON (near SJC, SFO, and OAK)
  - Mulford
    - Two OAK arrival streams
    - SJC departures flying through his and (possibly) Niles' arrival airspace—*therefore coordinated with Niles*
  - Niles
    - SFO arrival stream
    - *Coordinated with Mulford on SJC departures*
  - Sunol
    - Fed arrival streams to both Mulford and Niles

Simulated Airspace



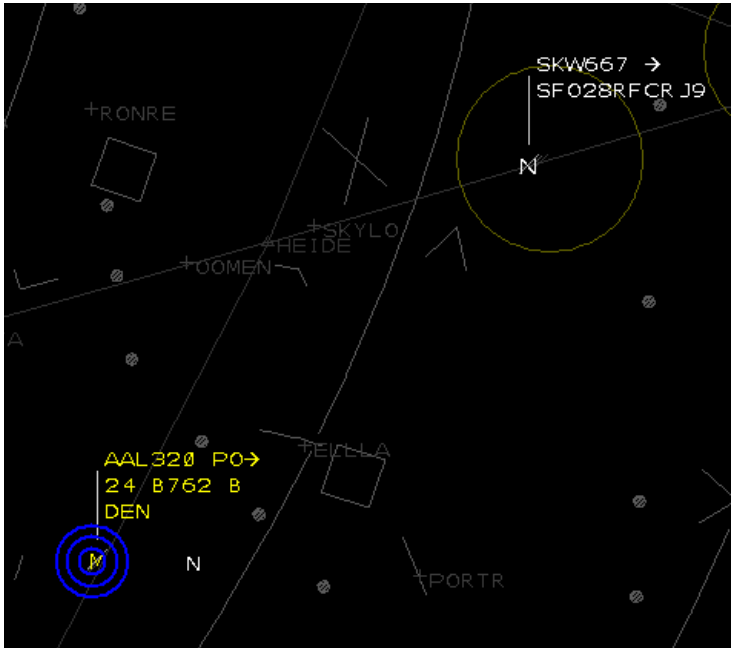
Experimental Design

- 18 one-hour runs
- 4 full days
- Preceded by training runs
- 2 coordination types; 3 tools; 3 scenarios
  - Tools described elsewhere in conference [4]
  - Scenarios based on actual traffic

Run #	Coordination	Tool Set #	Scenario #
1	Pointout	1	3
2	Pointout	2	2
3	Pointout	3	1
4	PACP	1	3
5	PACP	2	1
6	PACP	3	2
7	Pointout	2	1
8	Pointout	1	2
9	Pointout	3	3
10	PACP	2	2
11	PACP	1	1
12	PACP	3	3
13	Pointout	3	2
14	Pointout	2	3
15	Pointout	1	1
16	PACP	2	3
17	PACP	3	1
18	PACP	1	2

Apparatus

- Automated point-out function available in emulated STARS* display using MACS** software
- On right, Niles is accepting a point-out (flashing yellow) on AAL320 from Mulford
  - (Blue indicates click recorded for research purposes)
- Data tag of point-outs remain yellow



*Standard Terminal Automation Replacement System

** Multi Aircraft Control System

Point-out Coordination for Study

- Mulford had to point out *each* Reddt3 departure to Niles
  - (Even though departure could stay on safe route in Mulford's airspace below 5,000')
- Reddt3 departures had to stay on route
- With point-out approval from Niles, Mulford could climb Reddt3 departures up to 11,000' through Niles' airspace

Prearranged Coordination Procedure (P-ACP) for Study

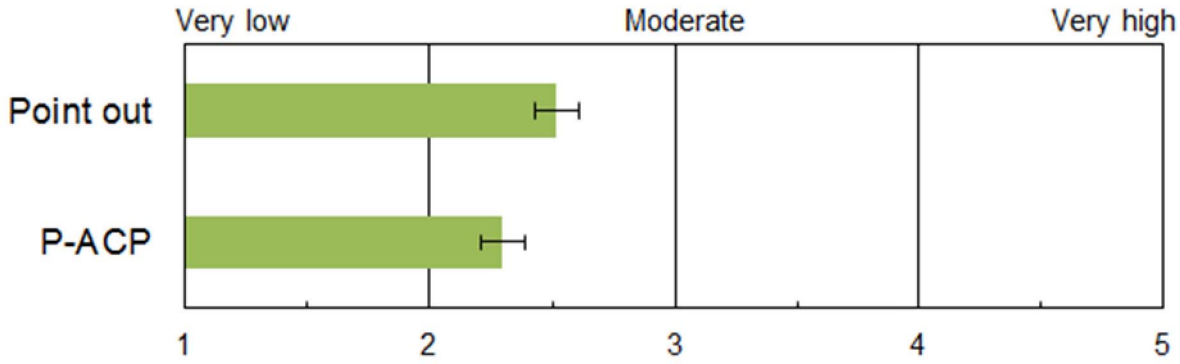
- Mulford responsible for separation of Reddt3 departures from all traffic in Niles' airspace
- Reddt3 departures had to stay on route
- Reddt3 data blocks displayed to Niles
- Data blocks of Modesto arrivals displayed to Mulford between 4,000' and 11,000' in Niles' airspace

Results

- Experiment metrics
  - No differences coordination conditions in
    - Separation violations
    - Arrival times at destinations
- Subjective measures
  - WAK (Workload Assessment Keypads)
    - No difference in conditions/workload low
  - Post-run surveys
    - Analyzed with repeated measures ANOVAs
  - Post-sim survey

Post-run Survey: Slightly Less Mental Activity in P-ACP Condition

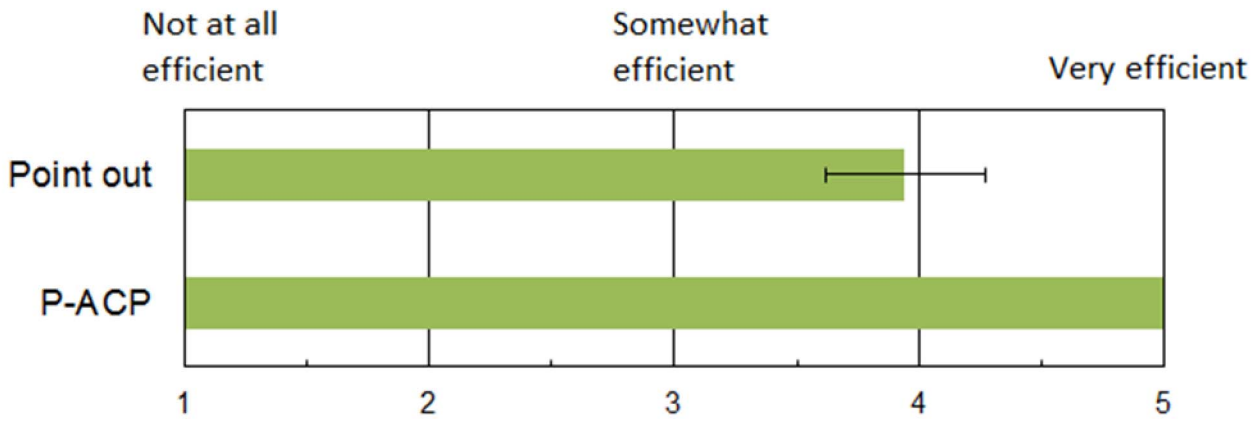
Post-run survey question "In the last run, how much mental activity was required during the busiest time?"



Means 2.5 & 2.3, MS = .02, F(1,2) = 12, p = .074. Error bars = 95% CIs. SEs adjusted per Loftus & Masson (1994) & Morey (2008).

Pre-Arranged Coordination Procedure Seen as More Efficient than Point Outs

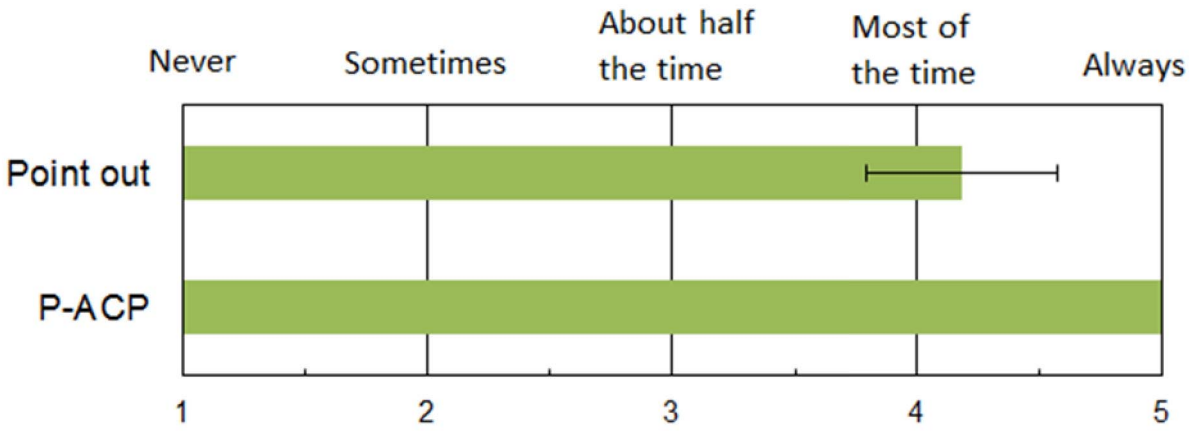
Post-run survey question "In this run, how efficient was the coordination procedure for the Reddt3 departures?"



Means 3.9 & 5.0, MS = 9.4, F(1,15) = 19.0, p <.001, error bar = 95% CIs.

P-ACP Rated as "Always" Timely; Point-outs as Timely "Most of the Time"

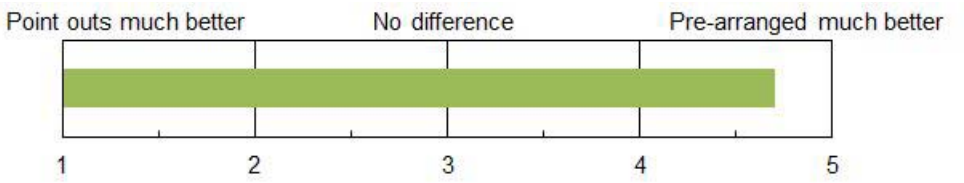
Post-run survey question "All in all, in this run was the coordination accomplished in a timely fashion?"



Means 4.2 & 5.0, MS = 2.6, F(1,14) = 8.2, p =.01, error bar = 95% CIs.

Controllers Thought P-ACP Worked Better Operationally than Point-outs

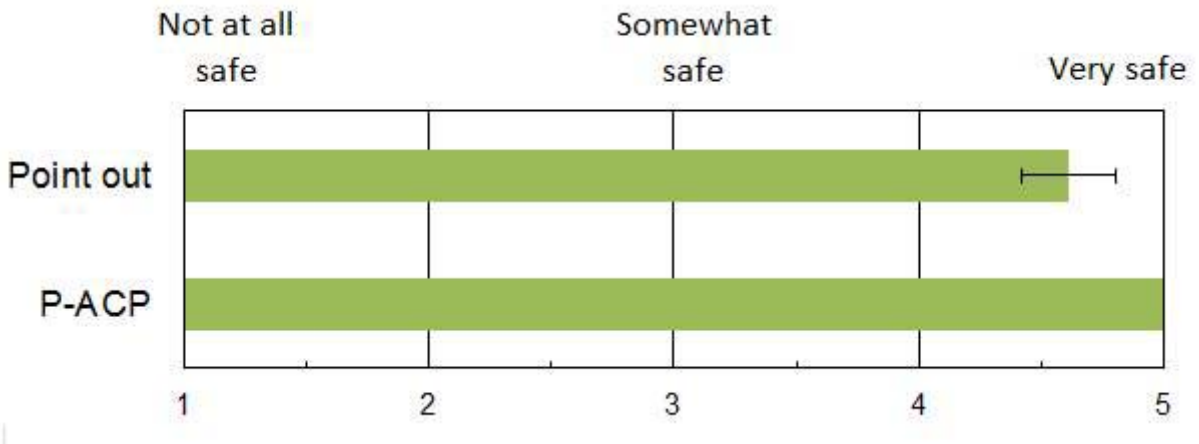
Post sim survey question "Which type of coordination do you think worked better operationally, point-outs or prearranged coordination procedure?"



- "Pre-arranged helps more when traffic is very busy."
- "Regular point outs are more time-consuming and cumbersome. The pre-arranged is much cleaner."

P-ACP Was Rated as "Very Safe" on Post-Run Survey—Slightly Safer Than Point-outs

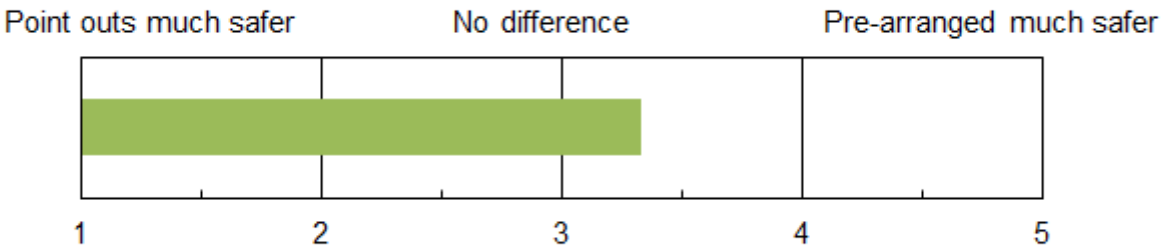
Post-run survey question: "In this run, how safe was the coordination procedure for the Reddt3 departures?"



Means 4.6 & 5.0 *MS* = .68, *F*(1,16) = 7.8, *p* <.01, Error bars = 95% *CI*s.

Little Difference in Safety When Controllers Compared Methods Post-sim

Post-sim question "Which type of coordination do you think was safer—point–outs or prearranged coordination?"



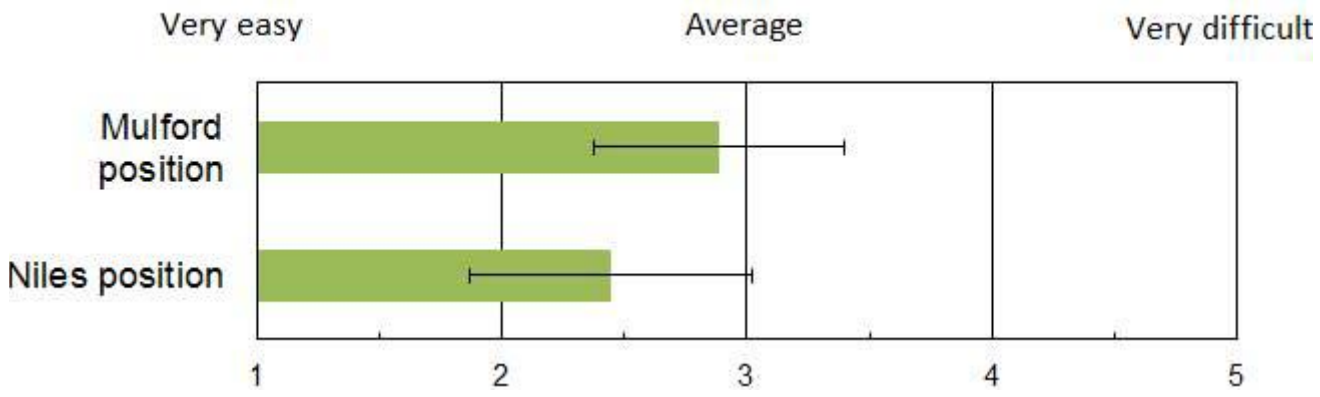
- Comments:
  - "Making point outs and phone calls is distracting--could lead to errors."
  - "[Point outs] force both controllers to answer the other's message."
  - "They are both safe, just different."

Most Alerting Features Worked Well

- In both conditions
  - Niles sufficiently alerted to Reddt3 departures in his airspace from display of Reddt3 data blocks
    - Average rating of 5.0 on a 1-5 scale
- Point-out
  - Niles found it easy to notice Mulford's point-outs of Reddt3 departures
    - Average rating of 4.7 on a 1-5 scale
- P-ACP
  - Mulford sufficiently alerted to traffic in Niles' airspace from display of full data blocks
    - Average rating of 5.0 on a 1-5 scale

Point-out Problem #1: Difficulty Noticing Point-out Acceptance

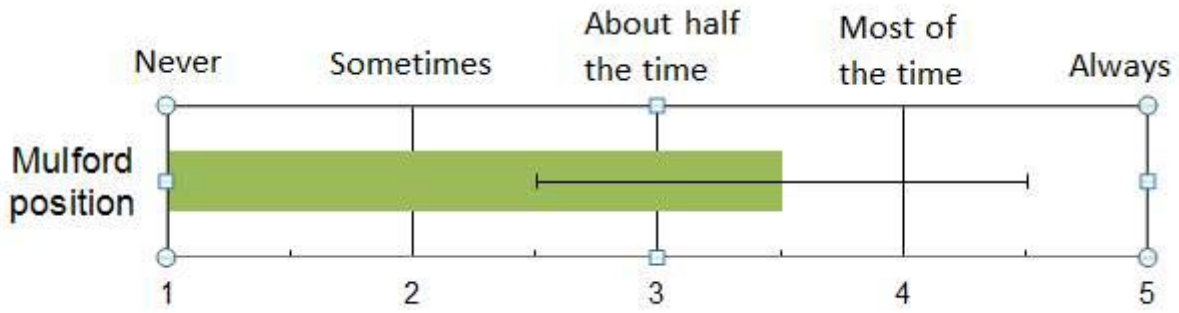
Post-run survey question for Mulford and Niles, "In this run, how difficult was it for you to notice when your point-outs were accepted by the other controller?"



"Difficult to determine if Niles accepted my point-out. I had to redo or call to verify" (Run 7).

Point-out Problem #2: Over Half the Time Niles Did Not Point Out Conflicting Traffic

Post-run survey question for Mulford, "In this run, if there was traffic that conflicted with the Reddt3 departures, did Niles point out this traffic?"



- Reason? Possibly Niles took responsibility for separating this traffic from the Reddt3 departures
- However, two of the Mulford controllers stated that *there were times when Niles should have pointed out traffic to Mulford and did not (e.g., when PO accepted when traffic in close proximity to the departure)*
- Controller commented that better training would solve this problem

Point-out Problem #3: Time Pressure Had an Impact on Some Operations

Post-run survey question for Mulford & Niles: "In the last run, was there time pressure on even a single one of these [point-out] coordinations?"

- Yes on 4/9 point-out runs

Post-run survey question for Mulford: "If there was a delay in point out coordination, did it have an impact on the REDDT3 aircraft?"

- Yes on 4/9 point-out runs

Final Question Integrating Workload, Efficiency, and Safety

Post-sim question: "If you were in charge of implementing shared airspace operations in the field, please indicate which method of coordination you would put in place: point-outs or prearranged coordination procedures?"

- All said P-ACP

Summary

- For both methods, reports from the field indicate need for tightly prescribed rules that are well-designed and trained
  - These rules exist (FAA requirements)
- In a simulation of shared airspace operations, compared to point-outs, well-designed and trained P-ACPs were judged as
    - More efficient
    - More timely
    - Low workload
    - Safer
    - Having fewer problems overall

Contact Information

Bonny.Parke@nasa.gov

References

- [1] Capozzi, Brian J, Stephen C. Atkins, Seongim Choi, 2009, Towards optimal routing and scheduling of metroplex operations, AIAA 2009-7037, *Proceedings of the AIAA Aviation Technology, Integration, and Operations Conference.*
- [2] Xue, Min, Shannon Zelinski, 2012, Optimal integration of departures and arrivals in terminal airspace, AIAA 2012-4977, Minneapolis, *Proceedings of the AIAA Guidance, Navigation, and Control Conference*.
- [3] Grayson, Ralph L., 1981, Information transfer in the surface component of the system: Coordination problems in air traffic control. In C.E. Billings & E. S. Cheaney (Eds.) *Information Transfer Problems in the Aviation System* (pp. 25-45). Retrieved on 8-26-14 from http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19810022620.pdf#page=29
- [4] Chevalley, Eric, et al., 2014, Decision support tools for climbing departure aircraft through arrival airspace, 33rd Digital Avionics System Conference, Colorado Springs, Colorado.