Air Traffic Controller Conduct of a No-Closer-Than-Spacing Operation

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Outline

- Introduction
- Background
- Method
- Results and Discussion
- Conclusions and Recommendations
Introduction
Sponsor Organizations

- This Cockpit Display of Traffic Information (CDTI) Assisted Pilot Procedure (CAPP) research was conducted with funding from the Federal Aviation Administration (FAA) Next Generation Air Transportation System (NextGen) Human Factors Division (ANG-C1) in support of the Aircraft Certification (AIR) and the Flight Standards Service Flight Technologies and Procedures Division (AFS)
Background
Automatic Dependent Surveillance-Broadcast (ADS-B)

Sample uses:
Traffic awareness and spacing

Sample uses:
Improved or new surveillance

Call sign
Category
3-D Position
3-D Velocity and options

ADS-B Out

Ground receiver

Cockpit Display of Traffic Information (CDTI)

ADS-B In
CAPP Overview (1 of 3)

- Around final approach, Air Traffic Control (ATC) instructs the CAPP aircraft flight crew to space from a Traffic To Follow (TTF)
  - With a no-closer-than (NCT) distance that is close to, but no less than, the separation minimum
  - “American 456, CAPP 3.2 miles behind United 123.”

- ATC maintains separation responsibility during CAPP, and monitors for separation issues but does not determine where the aircraft is relative to the exact NCT value

- Main objective is to set up the CAPP aircraft for a transition to visual separation operations where there is expected to be a further reduction in the spacing between aircraft
  - Visual separation and visual approaches allow for increased efficiency and higher throughput than instrument approaches
    - Conditions must be (at least) at or above a 1000 foot (ft) ceiling and visibility 3 nautical mile (NM) or greater. ATC facilities have additional requirements (e.g., ceiling requirement for vectoring aircraft)
CAPP Overview (2 of 3)

- Flight crew’s task is to make spacing judgments and manage speed via a CDTI to stay outside of the NCT value
  - Using distance and differential ground speed from traffic, including spacing range alerts
    - As with a concept called CDTI Assisted Visual Separation (CAVS) that is used during visual approaches when keeping the TTF in sight becomes difficult (e.g., haze or city lights). The CDTI is used by the flight crew to keep the TTF in sight so visual arrivals, and the associated higher arrival rates, can continue
  - No speed guidance
    - As with a concept called Interval Management where ATC provides a specific spacing goal to achieve (e.g., 90 seconds) and on-board speeds are provided to the flight crew to achieve the spacing goal
  - If unable to remain outside the NCT value, they contact ATC
CAPP Overview (3 of 3)

No closer than value applied

Cloud Ceiling
VMC

CAPP Aircraft

CAPP Operations

ILS

TTF

FAF

Runway

Profile View

Adaptation of original figure from RTCA and EUROCAE (2013b).

CAPP

To Visual

TTF in sight ⇒ Transition to CAVS*

Cloud Ceiling
VMC

CAPP Aircraft

FAF

TTF

Runway

Profile View

Visual separation applied

* The transition to CAVS may also include use of the out-the-window visual scene to space from the TTF

FAF – Final Approach Fix
GS – Ground Speed
ILS – Instrument Landing System
VMC – Visual Meteorological Conditions
Method
Research Goals

- Conduct the first simulation of CAPP to determine concept feasibility and operational acceptability to both flight crews and controllers
  - Support the validation of the concept and claimed operational value
  - Support the next steps of CAPP development
Independent Variables (1 of 2)

- **Weather Conditions — Cloud ceiling**
  - Related to NCT value and transitional to visual separation
    - For example, a lower ceiling (shorter final) may allow for a lower NCT value
  - Wanted to determine the most reasonable altitudes to transition into visual separation and achieve the intended benefit
    - Too high of an altitude may allow for visual operations without CAPP
    - Too low of an altitude was expected to prevent any benefits from a transition to visual separation
  - Based on reviews with subject matter experts, decided to examine 1800 ft (exit cloud layer ~6 NM final) and 3300 ft (exit cloud layer ~11 NM final)
Independent Variables (2 of 2)

- **NCT value**
  - Wanted to determine what is…
    - Close enough (to ensure a benefit)
    - Far enough (to not concern the controller about separation or spacing issues)
  - Based on reviews with subject matter experts, decided to examine two numbers: one closer to the separation standard (+ 0.2 NM) and one further from the separation standard (+ 0.5 NM)
    - Any smaller value was expected to be difficult to detect by ATC and potentially lead to breakouts
    - Any larger value was expected to have an impact on the throughput and ability to close further during visual separation
  - The NCT value was only applicable during CAPP, a lower value could be selected for the visual separation / CAVS segment of the approach
Environment – Overview

ATC (n = 11 from various facilities)

Standard Terminal Automation Replacement System (STARS)-like functionality

Voice Frequency

Flight Deck

Boeing 777-like cab

Pseudo-pilot
ATC STARS-Like Display Data Block

- Added indication (#) of CAPP capable aircraft to the left of the aircraft identification
  - Believed to be compatible with other ADS-B out indications

- Also, allowed for the use of scratch pad to indicate CAPP is active for an aircraft by entering “CP”

- Implementation is not the final design, only notional for the simulation. Could be a potential implementation though
Environment – Airspace and Traffic

- ILS approach operations transitioning to visual separation operations
  - Controller told to vector aircraft on to 10 NM final for the 1800 ft ceiling and 15 NM final for the 3300 ft ceiling
    - Both intercepts allowed for approximately 5 NM for conducting CAPP before a transition to visual separation / CAVS
    - Approximately eight miles of visibility

- Medium to high density traffic
- All aircraft were large category and capable of acting as a TTF
- Mixture of CAPP capable (70%) and non-CAPP capable aircraft
Scenarios

- Four scenarios examined each ceiling (1800 v 3300 ft) by each NCT value (3.2 v 3.5 NM)

- Extra events / off-nominals
  - Aircraft went inside the NCT value requiring the controller to intervene
    - Question: Does the controller detect and intervene in a timely, appropriate manner?
  - No transition out of CAPP into visual separation
    - Question: Does the operation still work out well without the transition into visual separation?
  - Controller allowed the flight crew to use the CDTI to maintain visual separation from the TTF during CAPP
    - Question: Is the concept acceptable if the flight crew is responsible for separation?
Data Collection

- **Subjective**
  - Questionnaires after each run and at end of simulation
    - Acceptability of displays and concept, responsibilities, etc.

- **Objective**
  - Collected by observer and/or lab systems
    - Spacing within aircraft pair at CAPP initiation, at CAPP end, and at visual separation/CAVS end
    - Frequency of pilot and ATC initiated go-arounds/breakouts and termination
    - Frequency of missed CAPP opportunities and lack of transition to visual separation/CAVS
    - Communications issues
Results and Discussion
Spacing within CAPP Pairs at Initiation

- CAPP was initiated with a noticeable range of spacing dispersion
  - 55% were initiated with tight spacing. Aircraft paired with tight spacings averaged 4.1 NM (SD=0.5) and with wide spacings 5.6 NM (SD=0.7)
  - Tight spacing is what is expected at busy facilities where CAPP would be used
**Spacing within Tight Spacing CAPP Pairs**

- **Across full operation**
  - Minimal closure for the 1800 ft and 3.5 NM condition
  - Similar closures for the 3300 ft conditions
  - Significant effects for ceiling and NCT values at CAVS end
    - Pair ended up closer for the:
      - 3.2 NM v 3.5 NM NCT value
      - 3300 ft ceiling v 1800 ft ceiling
Subjective Feedback (1 of 2)

- CAPP was operationally desirable and acceptable under all variables (both with and without a transition to visual separation / CAVS)
  - Controllers reported the ability to detect separation issues
  - The 3300 ft ceiling appeared to be more acceptable than the 1800 ft ceiling
  - The 3.5 NM NCT value, at times, appeared to be more acceptable than the 3.2 NM value
    - However, the 3.2 NM NCT value appears to better approximate the spacing desired by ATC and may be sufficient for ceilings that allow for additional closure after a transition into visual separation / CAVS
- Acceptable and reduced workload
- Roles and responsibilities were clear
  - However, responses showed some variability with respect to separation responsibilities. Responses suggest controllers may be willing to retain separation responsibility, but it appears they prefer the flight crew be issued separation responsibility during CAPP
Subjective Feedback (2 of 2)

- The CAPP instruction was acceptable, including the use of TTF call sign
  - Errors were minor and most were corrected / resolved

- The necessary display information was available

- The transition to visual separation / CAVS was acceptable
  - However, controllers appeared to have some issues when aircraft were unable to transition to CAVS
    - Based on observations, this is believed to be more of an issue for the 1800 ft ceiling where the controller was waiting for this to transfer the CAPP aircraft to the tower
    - Additionally, this appeared to be an issue when trying to determine whether or not to let the aircraft continue spacing when close to the NCT value. It may have been more acceptable to have the aircraft closer to the NCT value (and the separation standard) if the transition to visual separation / CAV was imminent
Off – Nominal Events

- All controllers detected the condition where an aircraft went inside the NCT value
  - An event that would lead to a separation issue requiring intervention
- Controllers did not appear to report any specific issues with the lack of transition from CAPP to visual separation / CAVS and it did not cause controllers to breakout an aircraft
Conclusions and Recommendations
Conclusions

- **CAPP appears to have benefits and is worth pursuing when there is a transition to visual separation / CAVS**
  - Without this transition, not enough data was available to draw final conclusions on the benefits of CAPP, but controllers reported there was some benefit
  - Pilots used the NCT value as a goal (versus a distance to remain far away from) and set in an even lower spacing for CAVS. Having a target spacing goal will be particularly important to realize the benefits of reduced spacing

- **The lowest ceiling examined in the simulation gave little time to gain the benefit of additional closure during CAVS**
  - The CAPP aircraft appeared to be able to get closer to the TTF with a lower NCT value and / or more time for CAVS (i.e., higher ceiling)
Select Recommendations

- Continue to examine the ceilings under which CAPP is beneficial and determine the extensibility
  - The 1800 ft ceiling gave little time to gain the benefit of additional closure during CAVS. Higher ceilings will allow for additional closure to a more desirable final spacing. However, a ceiling much higher than 3300 ft may allow for visual operations without the need for CAPP

- Consider starting CAPP deployment with no transfer of separation responsibility. After experience, consider a transfer of separation responsibility (in the context of clearly defined roles and responsibilities) to gain greater benefits, and to achieve a more acceptable and desirable implementation

- Consider whether Interval Management can achieve the intended goal of CAPP (to support the transition to visual separation / CAVS). Interval Management may allow the flight crew to more accurately, and with reduced variance, achieve a precise goal prior to transitioning to CAVS
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