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# Use of Aircraft Intent Information in ATM DSS Functions

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**MITRE**

**Robert D. Geoghan**

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# Overview - Sources of Information

- **Performed search on ADS-B aircraft intent use**
  - **Literature search on aircraft intent**
    - A general search of the internet
    - Documents : ADS-B MASPS, other ADS-B documents, FAA, Eurocontrol, NASA, and CAASD documents
  - **Discussions with knowledgeable persons**
    - FAA, CAASD, & other companies - Raytheon & ARCON
    - Eurocontrol email communications
- **A more comprehensive view of aircraft intent use should be taken** (more than just ADS-B)
- **Added some original ideas on use of intent, including a detailed example, and generated this briefing**

# Briefing Outline

- **Definition of aircraft intent**
- **Future needs of ATM**
- **Sources of intent information**
- **Use of intent information by ATM DSS functions**
  - High level discussion of ATM DSS functional areas
- **Conclusions**
  
- **Detailed example**

# Definition of Aircraft Intent

- **Aircraft intent**
  - The intended future path of an aircraft
  - Applies to the intent of the pilot and the dispatcher
- **Definition applies to aircraft:**
  - In the air during airborne phases of flight
  - On the ground during taxi-out or taxi-in phases
- **Definition applies to different timeframes**
  - Long term intent
  - Medium term intent
  - Short term intent
- **Aircraft intent can change at any time during the life of a flight**

# Improving Air Traffic Management (ATM) Service

- **Three basic needs**
  - **Maintain or increase safety**
    - Implies enough spacing or enough system capabilities for a timely reaction to hazards
  - **Increase system capacity**
    - Implies reduced spacing so more a/c fit in a finite airspace
  - **Increase user flexibility in choosing routes**
    - Implies less traffic organization on fixed standard routes  
(more complex routing)
- **Problem: Improvement in any one need may be inconsistent with satisfying the other two**

# Solution

- **All three needs satisfied by improving information on**
  - Where aircraft are now
  - What they are doing now (maneuvering/not maneuvering)
  - Where they intend to go (intent)
- **Improved information needed for**
  - Improved traffic situation displays for ground personnel and pilots
  - Improved input to automation functions responsible for supporting controllers and pilots

# **Solution is Advanced by Use of Aircraft Intent & Maneuver Information**

- **More accurate surveillance/tracking**
  - Improved current position
  - Improved velocity information for better position predictions
- **Enhanced automation functions (both air & ground)**
  - Improved performance with better input information
- **Presentation of intent and maneuver information directly to controllers and pilots** (presented on situation displays)
- **New airborne automation for possible pilot separation responsibility**
  - Increased pilot situational awareness in time-critical situations
  - More timely responses to critical situations by elimination of controller-pilot communication loop

# Sources of Intent Information & Sources of Intent Change Information

- **NAS filed flight plan or ICAO flight plan**
  - Provides whole flight intent
- **Controller input**
  - Enters or makes adjustments to flight plan (amendments)
- **Pilot and/or airborne equipment**
  - **CPDLC** (in current plans)
    - Air to ground automated sharing of negotiated route/route change information (e.g., RNAV route clearance)
    - RTCA SC-194 currently defining advanced services for using CPDLC (services include detailed data link route exchange/negotiations)
  - **ADS-B** (in current plans)
    - TCP and TCP+1 provide maneuver intent information  
(TCP = Trajectory Change Point)
    - Also, provides maneuver occurrence information

# Maneuver Occurrence Information in ADS-B

- **ADS-B message contains** (in current MASPS)
  - **Turn indicator**
    - Designated as turning right or left, or
    - Not turning
  - **Horizontal velocity vector**
    - Horizontal maneuver start/end can be determined by detecting a change in the velocity vector information
  - **Altitude change rate**
    - Designated as climbing or descending
    - Reported in fpm (feet per minute)
  - **Intended maneuver end can be derived from TCP**
    - Intended end of turn, or destination heading
    - Intended level-off altitude at end of climb/descent
- **Also, may be useful to have in ADS-B message:**
  - **Turn rate** (for track accuracy improvement)

# Timeframe of Intent Information

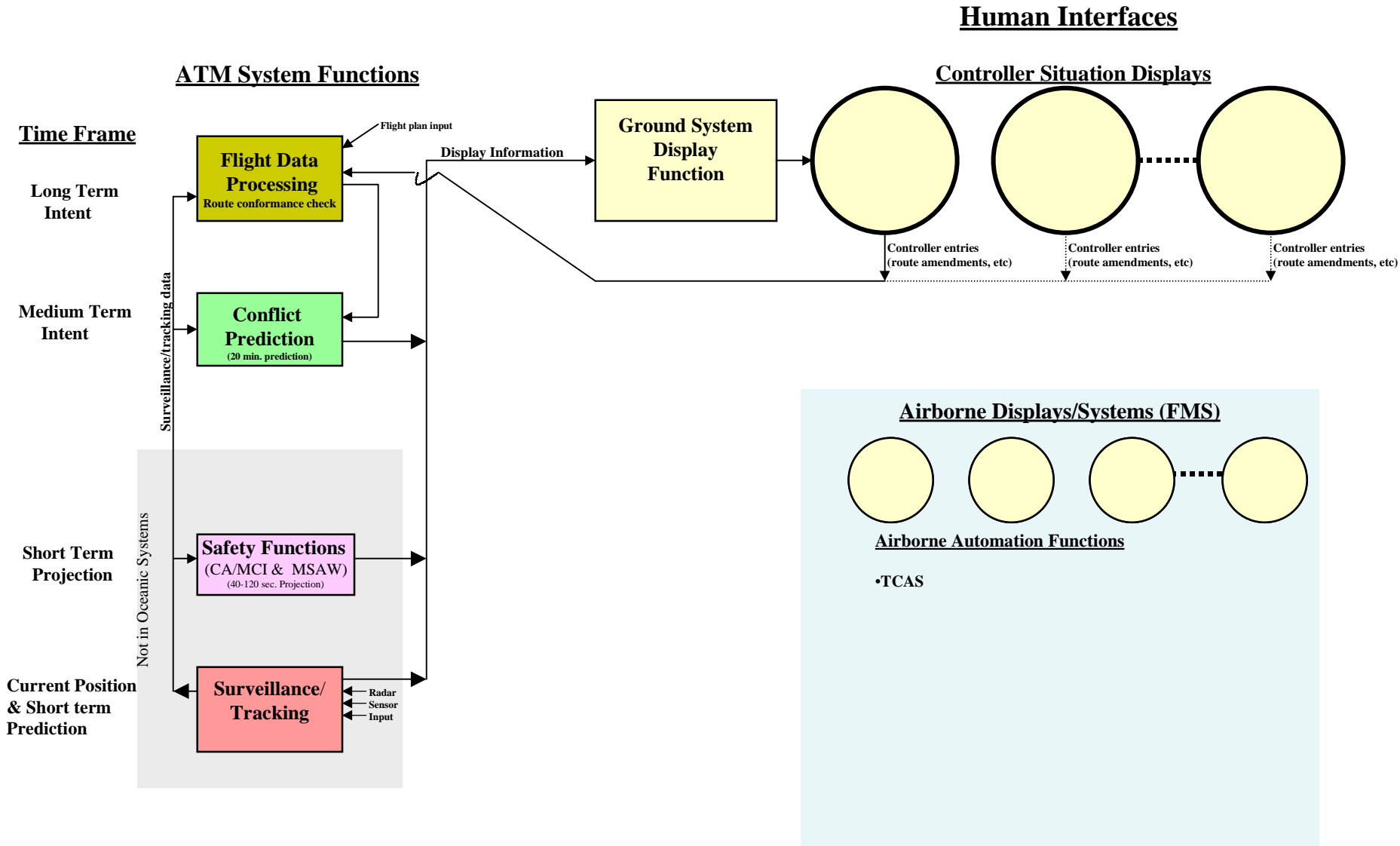
## (Relative to Timeframes of DSS Functions)

- **Long term intent**
  - Flight plan route information
  - Applies to whole or large portion of flight
  - Subject to strategic amendment
- **Medium term intent**
  - Route segments approximately 20 minutes into future
  - Also, can have more fine-grained route definition ( e.g., RNAV routes )
  - Subject to strategic/tactical amendment
- **Short term intent**

Route information for:

  - Only the next 1-2 minutes into the future (en route), or
  - Only seconds into future (terminal)
  - Subject to tactical amendment

# Current ATM/DSS Functions

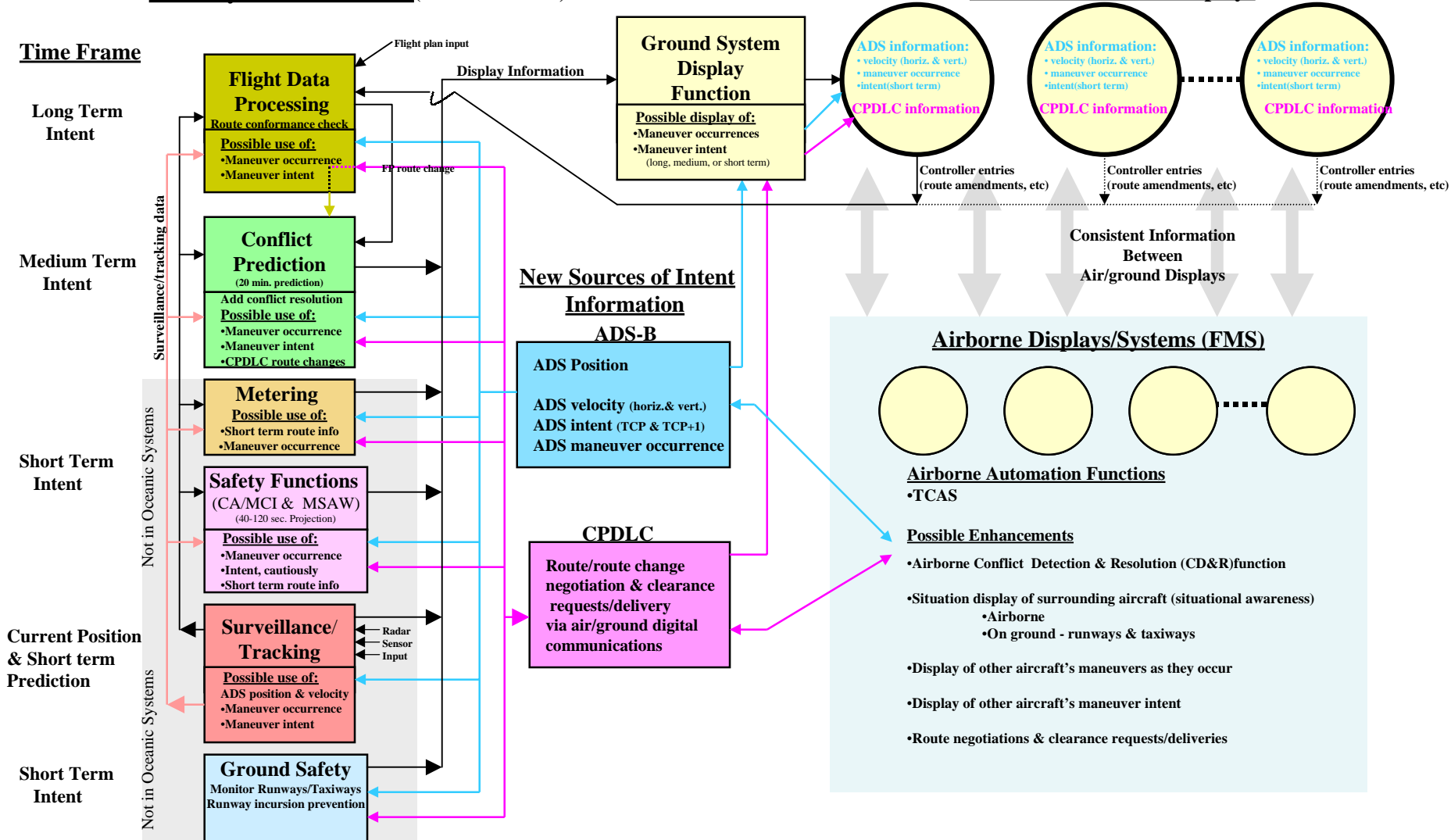


# Use of Intent & Maneuver Occurrence Information in ATM/DSS Functions

## Human Interfaces

### ATM System Functions (+enhancements)

### Controller Situation Displays



# Judicious Use of Intent & Maneuver Information in ATM DSS

- **Aircraft intent contains intended future maneuvers**
  - **Can cautiously believe maneuver intent**  
(Need to characterize availability, reliability, integrity of intent information)
  - **In automation functions must allow for case when intended route is not followed**
- **Maneuver occurrence information**
  - **A maneuver occurrence is happening now, is not future intent**
  - **Can trust more than intent**

# Use of Intent Information for Flight Data Processing

- **Use of ADS-B TCP or CPDLC down linked route information to**
  - Check for conformance with route information in ground system
  - Amend route information in ground system
  - Refine (with more detail) route information in ground system
- **Use of ADS-B maneuver occurrence information to check for conformance with route stored in ground system**
  - Turn indicator or change in horizontal velocity
  - Altitude change rate

# Use of Intent Information for Conflict Prediction (Medium Term)

- **More accurate conflict prediction using better, more up-to-date ground system route information**
  - **Less reliance on controller entry when route change is made or clearance is executed**
  - **More timely triggering of new prediction when a maneuver occurs that is not in conformance with the ground system's route information.**
- **Issue: Are significant changes to the prediction software necessary?**

# Use of Intent Information for Metering Functions

- **Use more definitive route information in metering for more accurate calculations**
  - **Use of CPDLC route information**
- **Use of maneuver occurrence & intent information to do arrival route conformance checking**
  - **Horizontal direction**
    - **Use of turn indicator, velocity & TCP information**
    - **For more timely conformance checking**
  - **Vertical direction**
    - **Use of altitude rate & TCP information**
    - **For more timely conformance checking (vertical)**

# Use of Intent Information for Safety Functions

- **Use of maneuver occurrence information**
  - Provides a dependable indicator of a maneuver start or end
  - Could be displayed to controllers as a definitive indicator
- **Use of maneuver intent information**
  - Could be used by safety functions, but with caution
  - Alerts should not be totally suppressed based on an intended maneuver
  - A hazardous situation could result if an intended maneuver is not executed
  - A two level alert design may be needed if intent is used
- **Possibility of assigning RNAV routes as A/C intended route**
  - Safety function could then monitor progress along route
  - Treat turns or climb/descents in the route as intended maneuvers

# Use of Intent Information for Surveillance/Tracking

- **Track initiation**
  - **Faster and more accurate track initiations using velocity and/or TCP information**
  - **Quicker use of track information by automated functions such as safety functions (confidence in tracker sooner)**
- **Tracking in maneuvers**
  - **Horizontal direction**
    - **Use of turn indicator, velocity & TCP information**
    - **For better accuracy in turning situations (especially heading accuracy)**
  - **Vertical direction**
    - **Use of altitude rate & TCP information**
    - **For better accuracy in altitude transitions**

# Use of Intent Information for Ground Safety

- **Monitor taxiways and runways**
  - Intended taxi routes delivered to cockpit avionics via CPDLC service
  - Ground function use of ADS-B information to monitor aircraft movement and check for conformance with delivered route

# Use of Intent Information for Display Functions (Ground & Air)

- **Ground situation display**
  - Positive confirmation of pilot's clearance execution on controller display (maneuver occurrence indicators)
  - Indication of pilot future intent on controller display
- **Airborne situation display**
  - A positive indication of maneuver occurrence by surrounding aircraft
  - Indication of future intent of pilots of surrounding aircraft

# Conclusions

- **Use of ADS-B maneuver occurrence information should be considered as well intent information**
- **Both intent information and maneuver occurrence information will help meet the future needs of ATM**
- **Literature search indicates that usefulness of intent information has been identified and some limited thought has been given to possible uses of intent to improve future ATM functions**
- **More significant research is needed**

# Next Steps

- **Use of intent and maneuver occurrence information in each functional area needs to be defined in more detail**
- **Need to characterize availability, reliability, integrity of intent information**
- **FFP1 functional areas should be included**
  - **Not much was found in literature**
- **As FFP2 functionality is defined, use of intent information should be considered**
- **Need an integrated operational concept of how future capabilities will work together using intent information**
- **Develop a strategy to quantify benefits**

**EXTRA SLIDES FOLLOW**

# **DETAILED EXAMPLE:**

## **Potential use of intent information in the Short Term (Tactical) Terminal Conflict Alert / Mode C Intruder (CA/MCI) Safety Function**

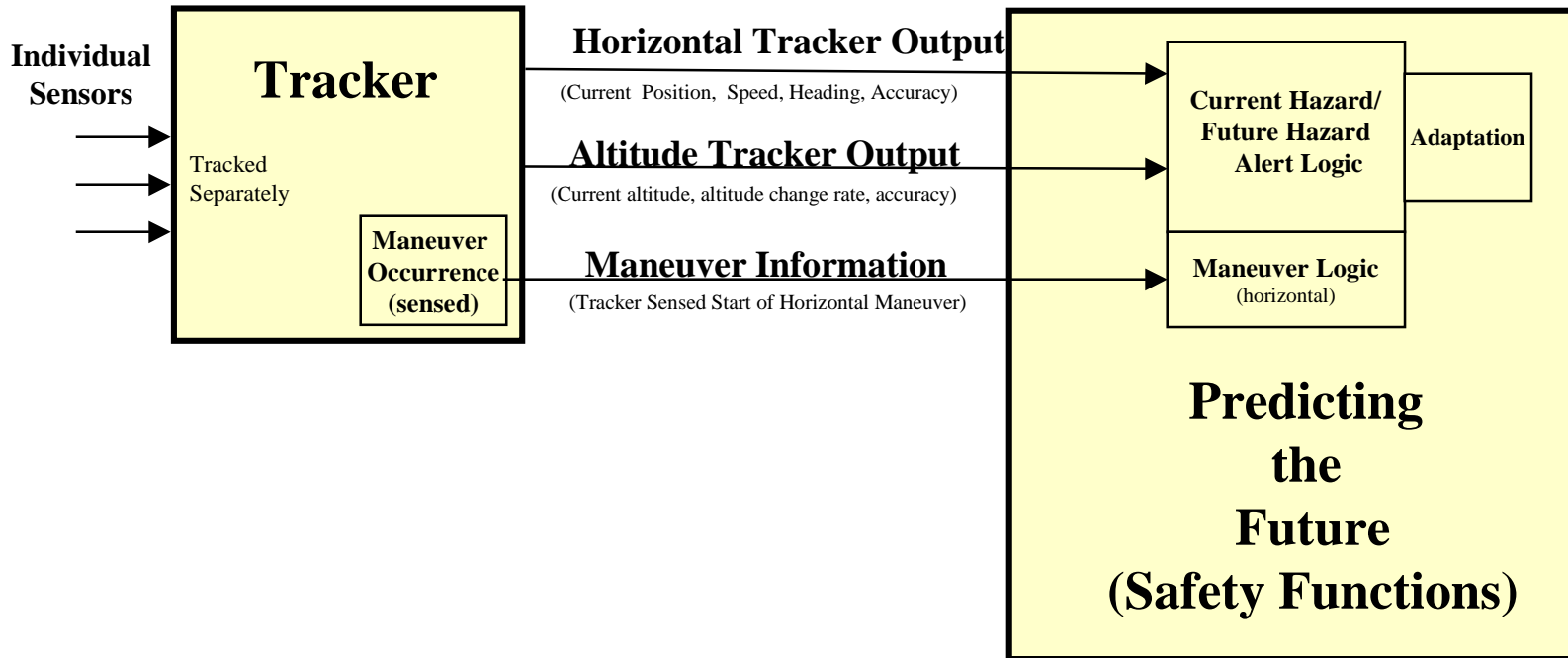
# Terminal Safety Functions

- **Use of maneuver occurrence information**
  - Provides a dependable indicator of a maneuver start or end
  - Could be displayed to controllers as a definitive indicator
- **Use of maneuver intent information**
  - Could be used by safety functions, but with caution
  - Alerts should not be totally suppressed based on an intended maneuver
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  - A two level alert design may be needed if intent is used
- **Possibility of assigning RNAV routes as A/C intended route**
  - Safety function could then monitor progress along route
  - Treat turns or climb/descents in the route as intended maneuvers

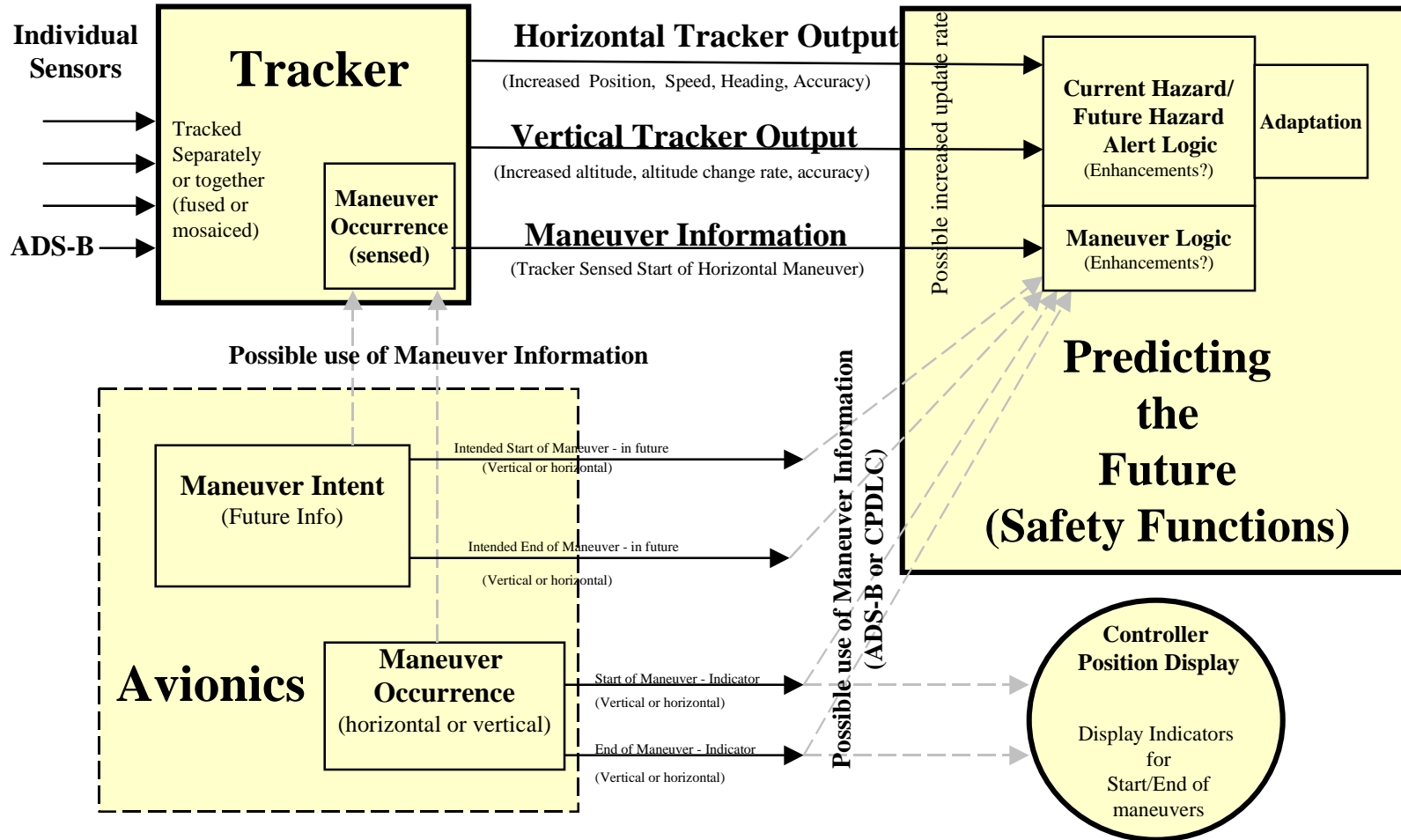
# Current Terminal CA/MCI Design

- **Current terminal safety functions base alerts on surveillance data, tracking of surveillance data and adaptation**
  - Hazardous situations are identified using surveillance position data
  - Prediction into future is made possible by tracking surveillance data
    - Via using velocity for straight-line projections
    - Via sensing the start of horizontal maneuvers
  - Adaptation allows
    - Adjustment of safety function logic (via parameterization)
    - Special geographically sensitive logic
- **Current design of terminal CA/MCI has 40 second lookahead in an attempt to achieve a nominal 30 second warning time**

# Predicting the Future in Currently Fielded Terminal Systems



# Possible Enhancements for Predicting the Future

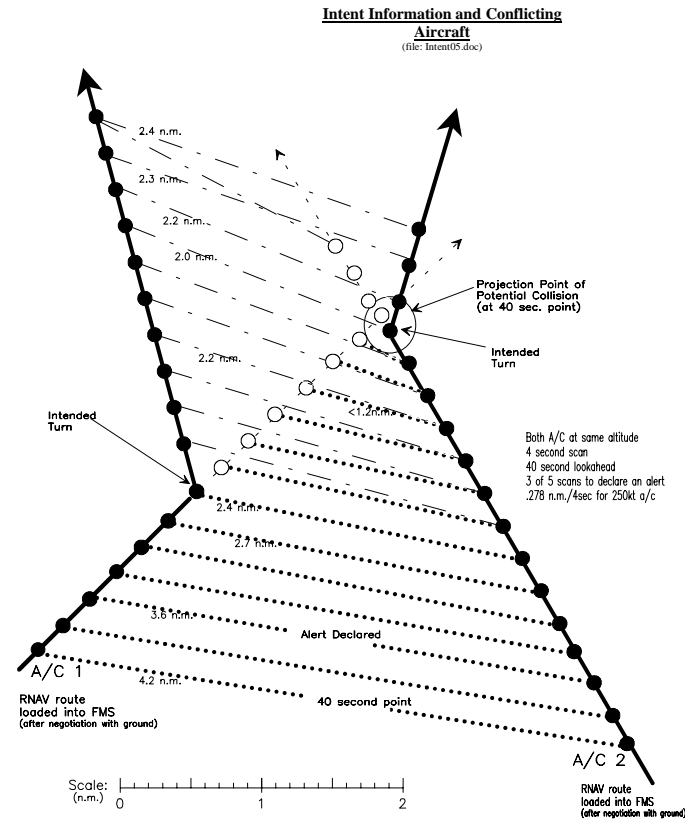


# Proposal: Create a Two-Level Alert Algorithm for Conflict Alert/ MCI

- **1. The current alert**
  - Warns controller of a hazardous condition between two aircraft
- **2. A new alert associated with intended maneuvers**
  - A “maneuver-must-occur” alert
- **Questions need to be addressed:**
  - Suppose an intended maneuver causes a hazardous situation?
  - Suppose hazardous situations exist for both maneuver and non-maneuver conditions?

# Example:

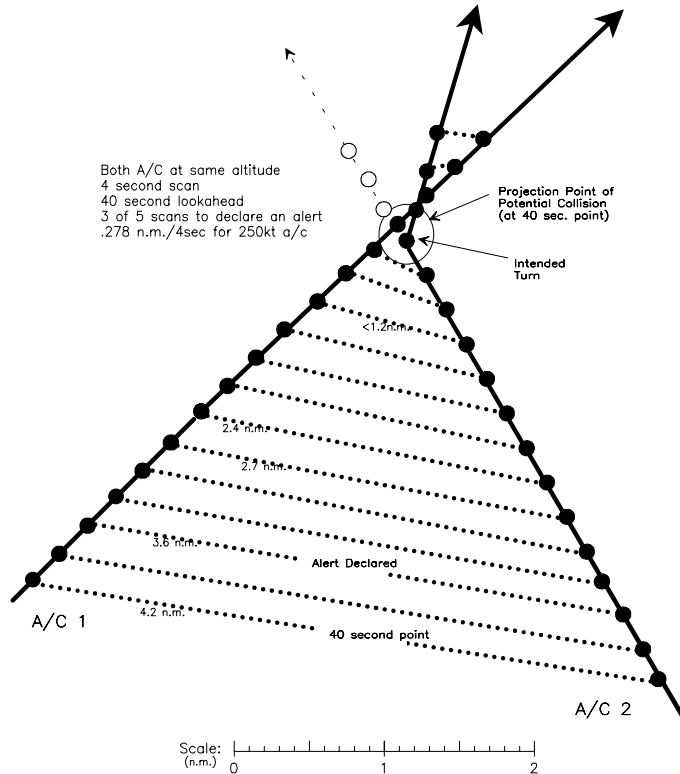
## Intent Information and Conflicting Aircraft (Two Intended Turns; Both A/C at Same Altitude)



ACTION: Issue a "maneuver—must—occur" alert for A/C 1 to controllers involved

# Example: Intent Information and Conflicting Aircraft (One Intended Turn; Both A/C at Same Altitude)

Intent Information and Conflicting Aircraft  
(file "Intent06.doc")

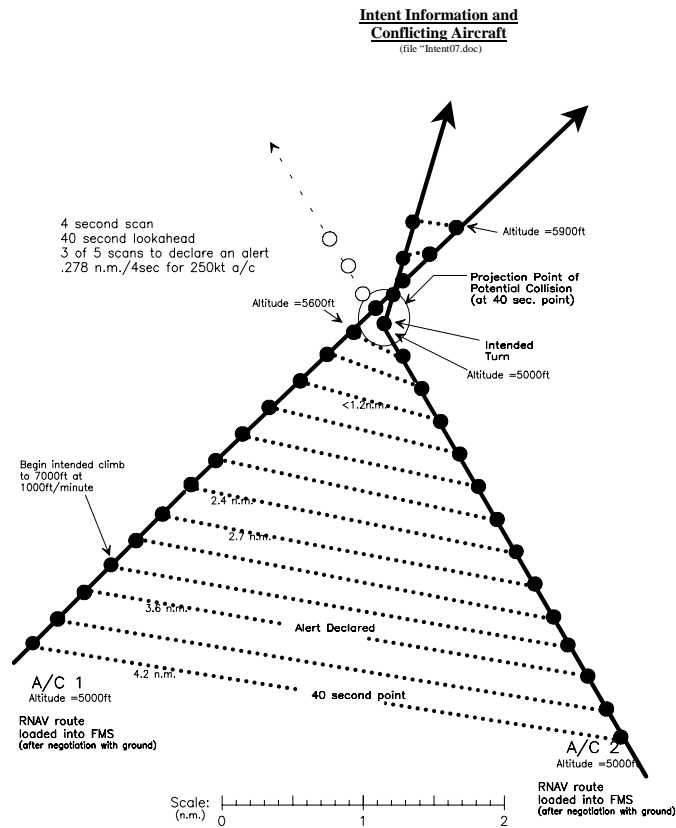


ACTION: Issue a normal Conflict Alert to controllers involved

# Example:

## Intent Information and Conflicting Aircraft

(One Intended Turn; Plus One Intended Altitude Maneuver)



ACTION: Issue a "maneuver—must—occur" alert for A/C 1 to controllers involved

# Maneuver Alert Logic Added to Conflict Alert/MCI

