Session 35-GNC-21: “Innovations and Support of the NAS at the FAA”

Paper AIAA-2007-6518:

“Performance Metrics for Tactical Aircraft to Aircraft Conflicts”

Federal Aviation Administration

Presented to: AIAA GNC, Hilton Head, S.C.

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Presentation

- Define Problem
- Outline Method
- Simulation and Data Processing
- Tactical Alerts
- Matching Alerts to Conflicts
- Example

Problem

- **Acceptance Testing of New Air Traffic Control System**
  - Replacement for Host Computer System
  - ERAM – En Route Automation Modernization
- **Key Function – Tactical Conflict Alert**
- **Develop and Apply Accuracy Performance Metrics**

Method

- **Use Current Host Computer System**
- **Representative Sample of Aircraft Traffic Data**
- **Simulate the Computer Processing of the Air Traffic Data**
- **Develop Necessary Computer Software Tools for Analysis**

Simulation and Data Processing

- **Inputs**
  - Derived from Field Recorded Data from Washington Center
  - Flight Plans & Radar Tracks
  - Time Shifted to Create Conflicts
  - Aircraft Above Flight Level 180 Only
  - Airspace Adaptation
- **Host Computer System Running Real Time with No Controllers**
- **Output**
  - Tactical Alerts – Posted, Updated, Deleted
- **Offline Determination of Actual Conflicts**
- **Compare Alerts to Conflicts**

Basic Tactical Alert Types

	Alert Posted	Alert Not Posted
Conflict Occurs	**Case 1:** There is a conflict and there is an alert posted against it ***Valid Alert***	**Case 2:** There is a conflict and no alert is posted for it ***Missed Alert***
Conflict Does Not Occur	**Case 3:** There is no conflict but there is an alert posted ***False Alert***	**Case 4:** There is no conflict and there is no alert ***No Call***

Complicating Factors

- **Start of simulation**
- **End of simulation**
- **Gaps in radar track data**
- **Unreported aircraft maneuvers**
- **Sampled Data**

Supplemental Tactical Alert Types

- **Missed Alerts – Excused**
- **False Alerts – Discarded**

Metrics = Counts

- **Missed Alert Rate**
  - $R_{MA} = MA / C$
  - where R_{MA} = the missed alert rate
  - where MA = number of missed alerts
  - where C = number of conflicts
- **False Alert Rate**
  - $R_{FA} = FA / A$
  - where R_{FA} = the false alert rate
  - where FA = number of false alerts
  - where A = number of alerts

Tactical Alert Data

- **Call Signs for Pair of Aircraft**
- **Start of Conflict**
  - Time
  - Place
- **Each Alert is a Set of Messages**
  - First Posting
  - Updates
  - Deletion
- **Notification Set (NS)**
  - First Posting
  - Deletion
- **Time Parameters**

Matching NS's to Conflicts

- **By Call Signs & Times**
- **Matched = Valid Alert**
  - Posting Time at Least 75s Before Start Time
  - Posting Time Less than 135s Before Start Time
  - Deletion Time After Start Time
- **Unmatched Conflict = Missed or Excused**
- **Unmatched NS = False or Discarded**

Popups

- **Conflict starts soon after**
  - Start of either aircraft radar track
  - After a gap in radar track data for either aircraft
- **Reduces Minimum Warning Time Requirement to Less Than 75s**
  - Matched but Late - Missed (Late) - Upgraded to Valid (Late)
- **NS Soon After Start of Conflict**
  - Unmatched alert (False) and unmatched conflict (Missed) discarded

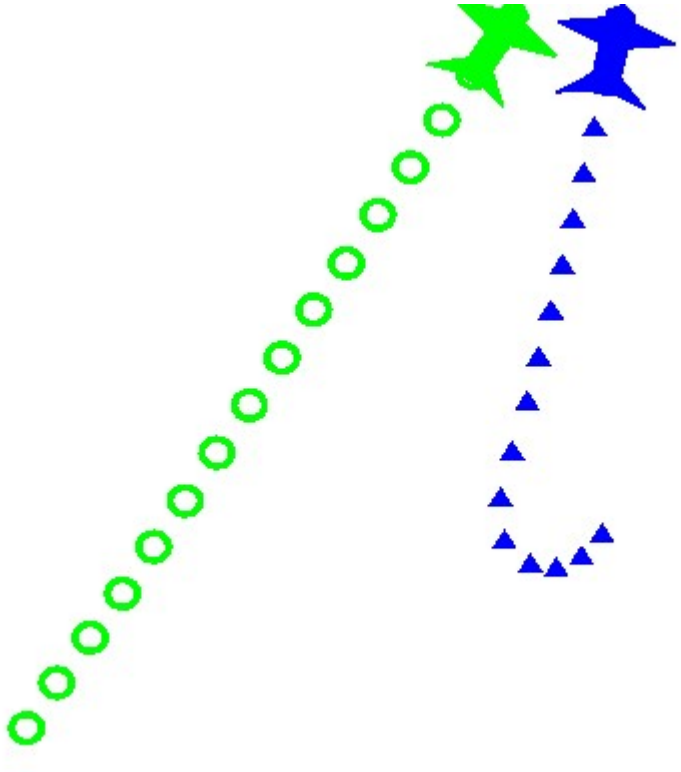
Aircraft Maneuvers

- Controller may maneuver aircraft out of conflict after alert is issued
- False Alert should Not Be Counted
- Linear Extrapolation Used
- Linear Extrapolation Predicts Conflict -> False Alert Discarded
- Both NS Start (Posting) and NS End (Deletion) must match Linear Extrapolation
- Missing Track Data Prevents Linear Extrapolation -> False Alert Discarded

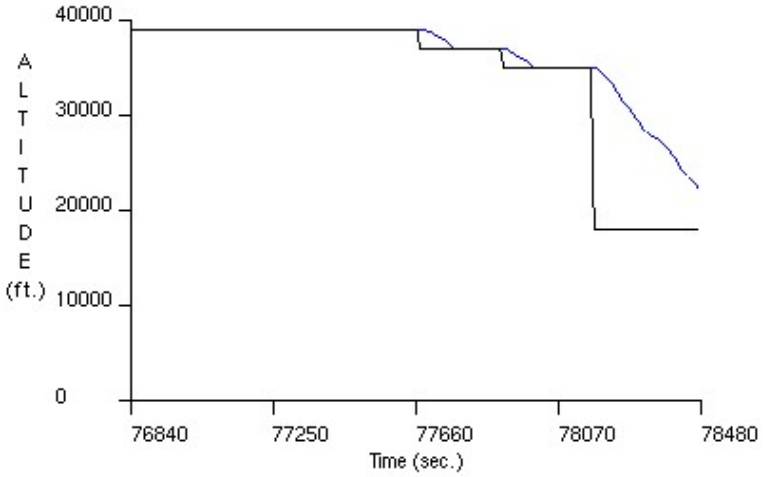
Aircraft Maneuvers – Warning Times

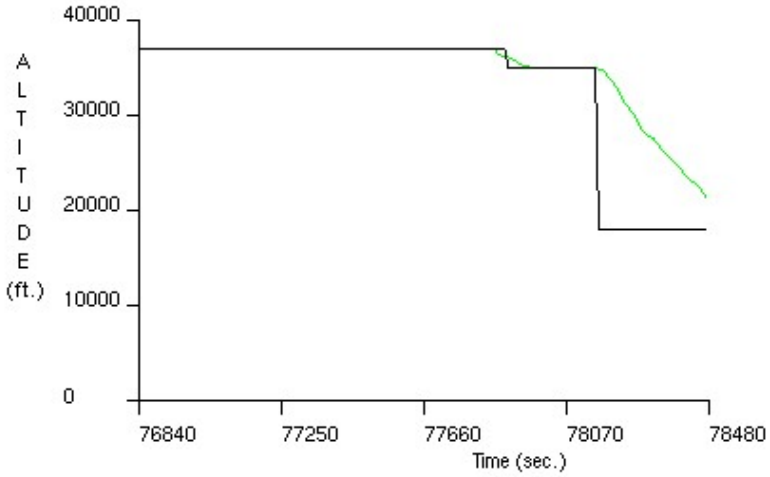
- **Aircraft maneuver may reduce possible warning time**
- **Situation Determined by Linear Extrapolation**
- **How Far Ahead in Time Does the Linear Extrapolation See a Conflict ?**
- **Required Warning Time Reduced to This Value**
- **May Upgrade Missed (Late) to Valid (Late)**

Example: Aircraft in Conflict

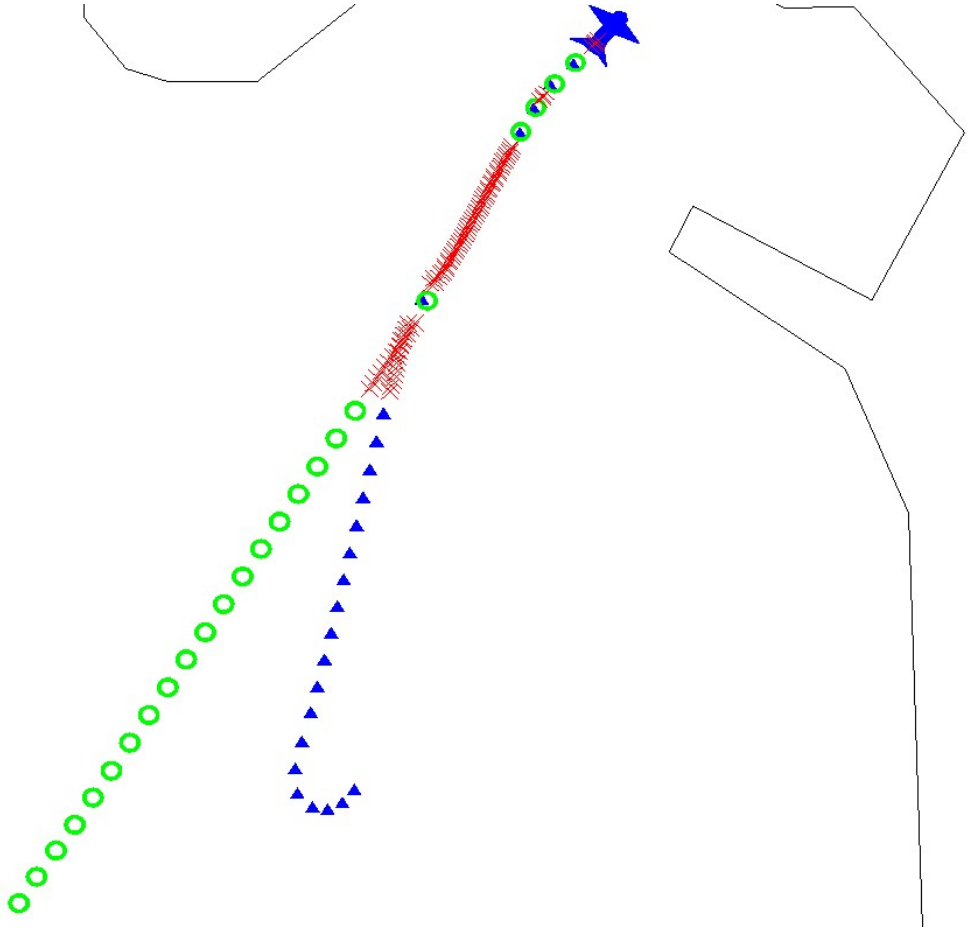


Example: Aircraft in Conflict

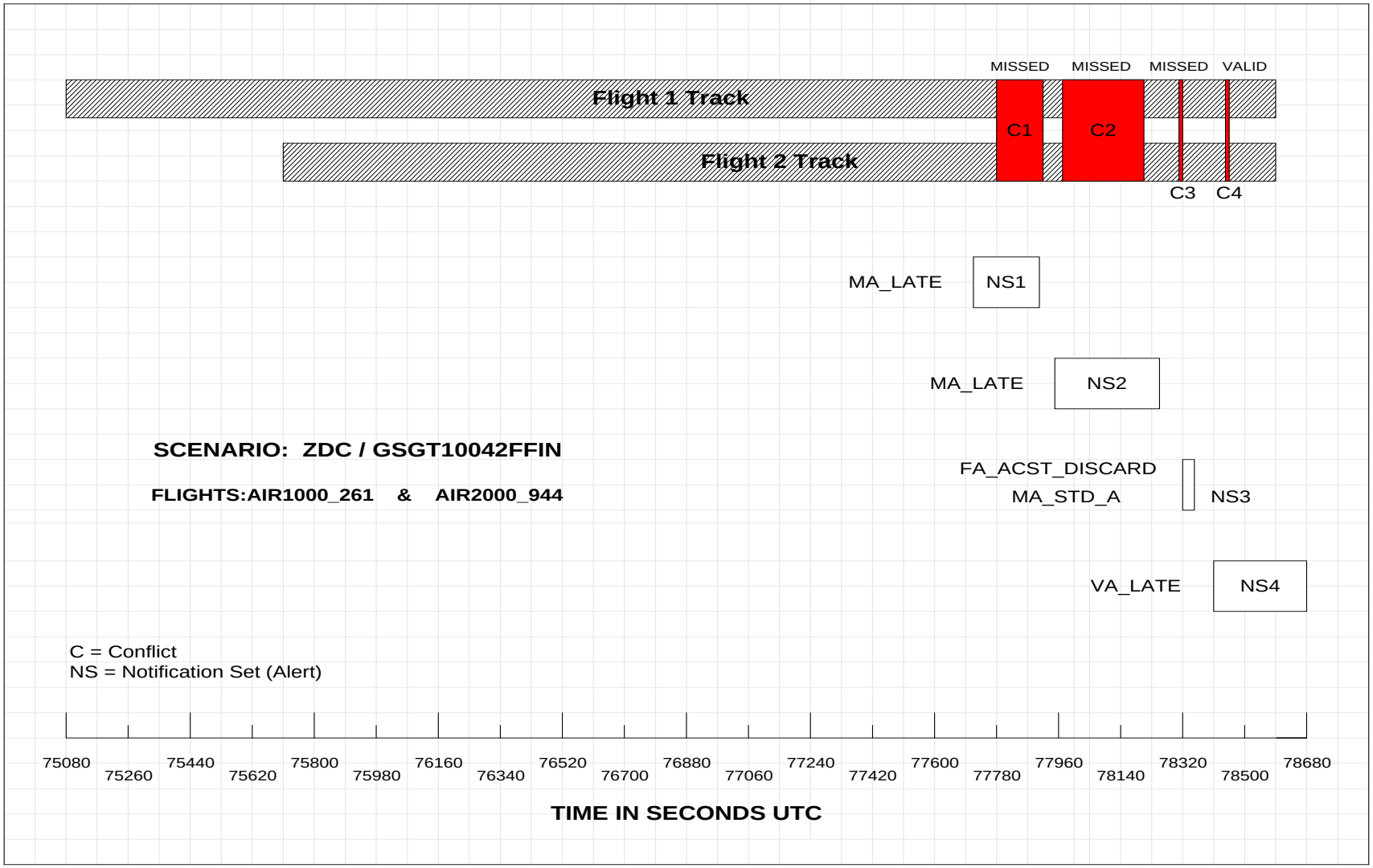




Example: Aircraft in Conflict



Example of Tactical Conflict Alert Data



Conclusions

- **Tactical Alerts Accuracy Metrics**
  - Defined
  - Many Nuances
  - Implemented
  - Tested
- **Somewhat Arbitrary**
- **Suitable for System Comparison**

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Backup Slides

Other Factors

- Alerts Posted and then Withdrawn Before a Conflict are Labeled False
- Alerts Posted During Conflicts Discarded (Otherwise Would Be False)
- False Alerts Binned by Minimum Normalized Separation Distance
- Radar Track Data Sampled at 10s Intervals
- Tactical Alert Data Sampled at 1s Intervals
- 1 Sample Conflicts Ignored
- Conflicts Merged When Less Than 40s Apart

Detailed Reason Codes

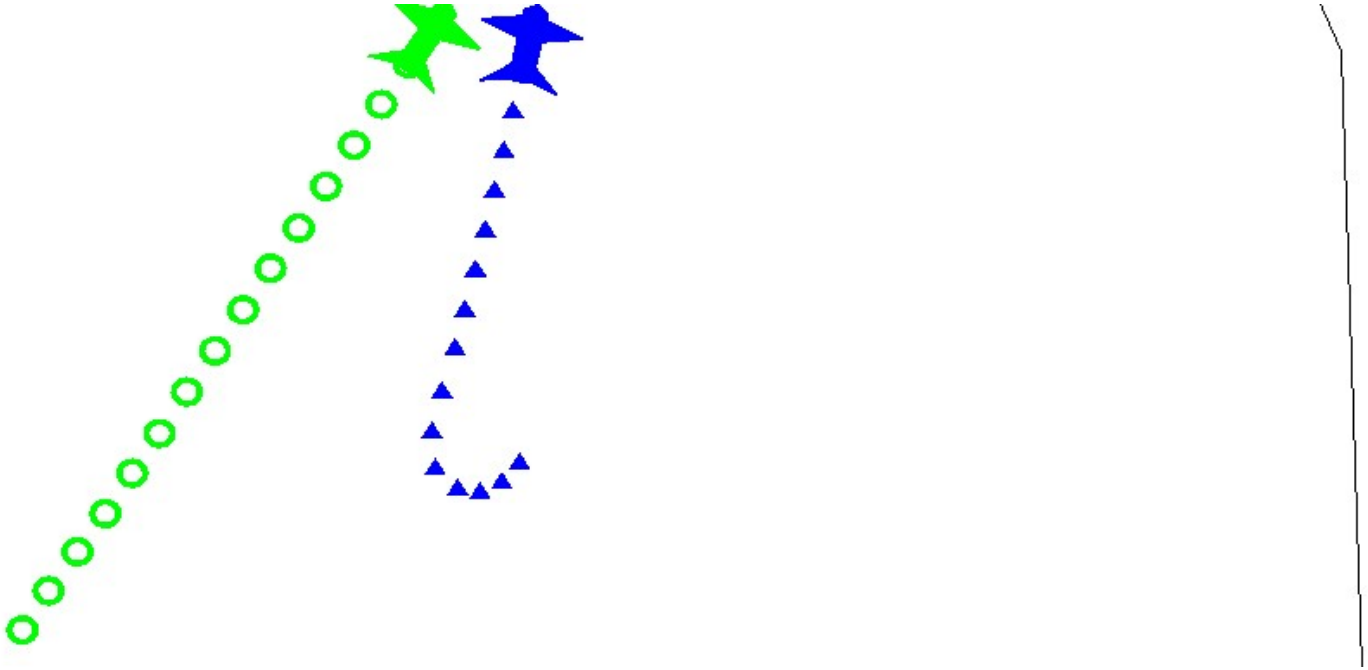
INDEX	ALERT TYPE	REASON CODE (ABBREVIATED)
1	VALID	VA_STD
2	VALID	VA_LATE
3	MISSED	MA_STD_A
4	MISSED	MA_STD_B
5	MISSED	MA_LATE
6	FALSE	FA_STD1
7	FALSE	FA_STD2_A
8	FALSE	FA_STD2_B
9	FALSE	FA_STD3
10	DISCARD	MA_DISCARD
11	DISCARD	FA_NOTRK_DISCARD1
12	DISCARD	FA_NOTRK_DISCARD2
13	DISCARD	FA_NOTRK_DISCARD3
14	DISCARD	FA_ACST_DISCARD
15	DISCARD	FA_EVENT_DISCARD_A
16	DISCARD	FA_EVENT_DISCARD_B

Timeliness Metrics

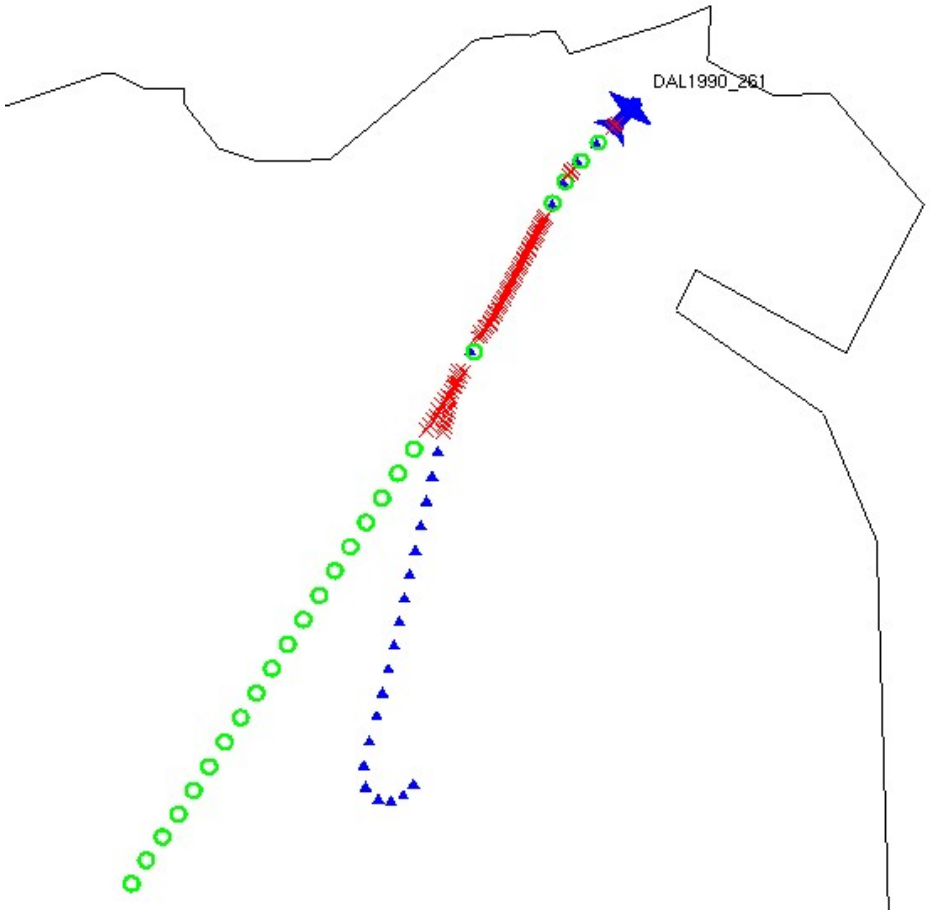
- **Warning Time**
  - $AWT = ACST - NS_{to}$

– where AWT = Actual Warning Time
– where ACST = Actual Conflict Start Time
– where NS = the start time of the valid alert Notification Set

Example: Aircraft in Conflict

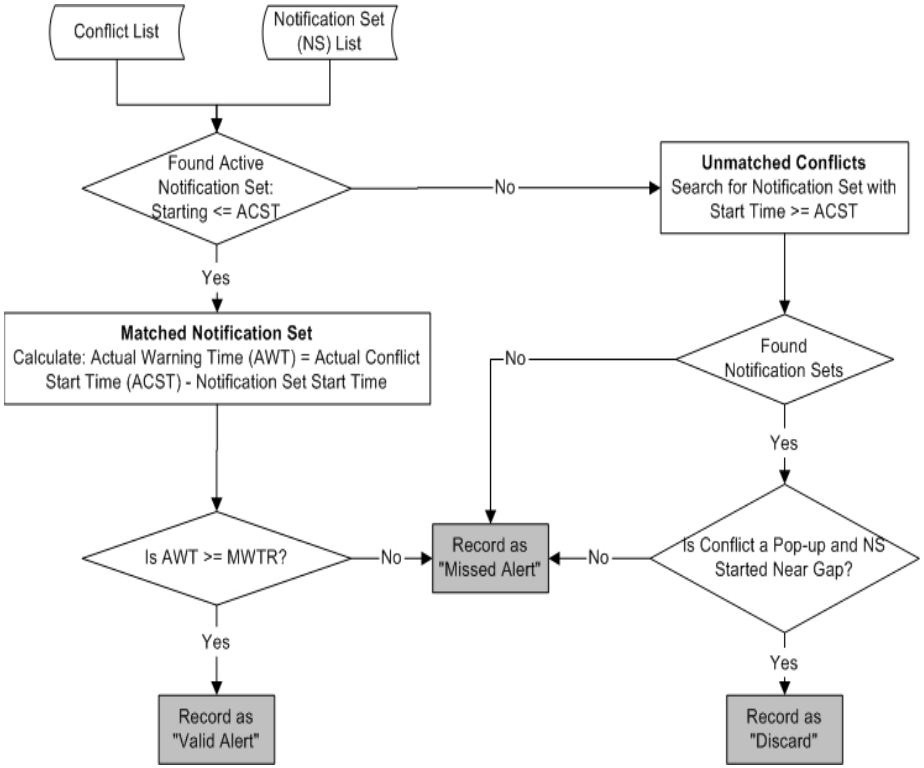


Example: Aircraft in Conflict



Flowchart: Valid & Missed Alert Events

Table 1



Flowchart: False Alerts & Discards

Table 1