IDEAS: Influence of Degraded Environments on Airspace Safety

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Airspace Health Monitoring

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Primary Goal

- Develop an objective tool for evaluating air traffic health that complements human observations/evaluations.
  - Define quantitative measures of robustness of the system
  - A set of metrics/outputs to define system health

Methodology

- Divide airspace into subregions that contain a single intersection between two flows of aircraft
- Analyze health of intersection area
  - Control commands required to resolve air traffic conflict
  - Ability of aircraft flows to stay within required intersection area (e.g. limit spillover)
- Understand the influence of conflict resolution algorithm on the behavior of the system and its overall health.
  - How do different algorithms improve or degrade system health and robustness?

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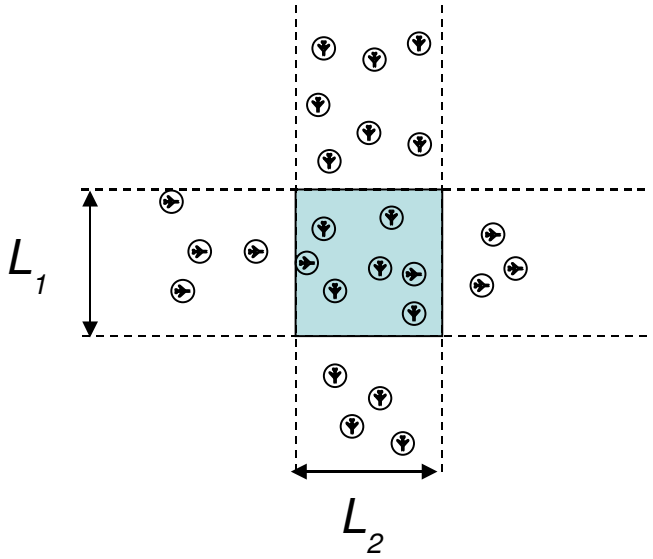
Two-Flow Problem

- Two flows defined by
  - Rates (stochastic, deterministic)
  - Position of entrance and intersection
  - Crossing angle



- We consider multiple conflict resolution algorithms
  - Shift method (All aircraft have the same velocity)
  - Heading change only (All aircraft have the same velocity)
  - Speed and Heading Change (to be completed)
- Output
  - Stochastic Case: Distribution of control maneuvers
  - Deterministic Case: Geometry (e.g. size) of the intersection area

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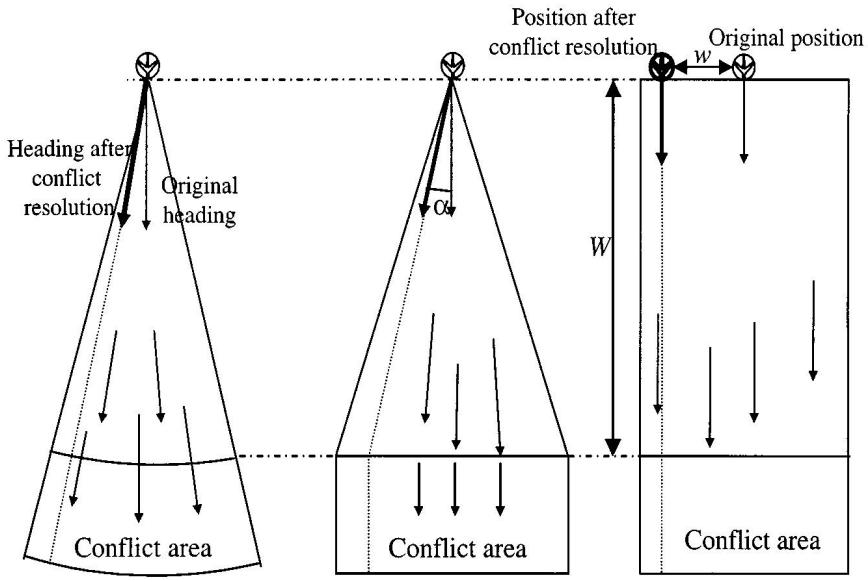
Shift Method

- First-come, first serve
- Aircraft minimize deviation from center-line



Video 1
Shift Method

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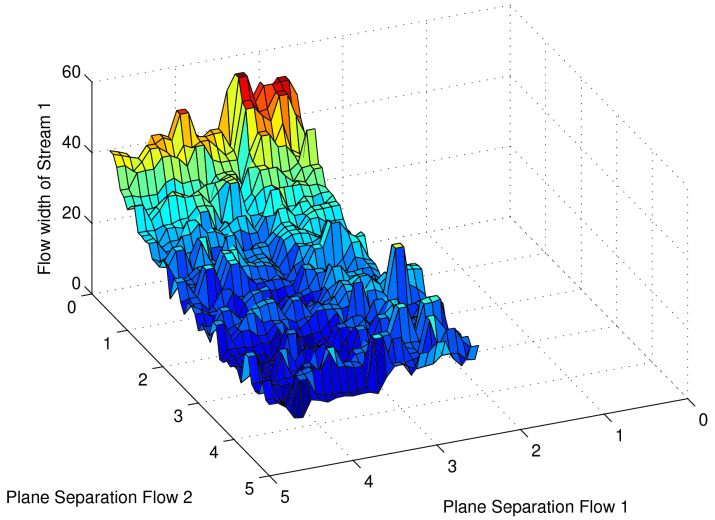
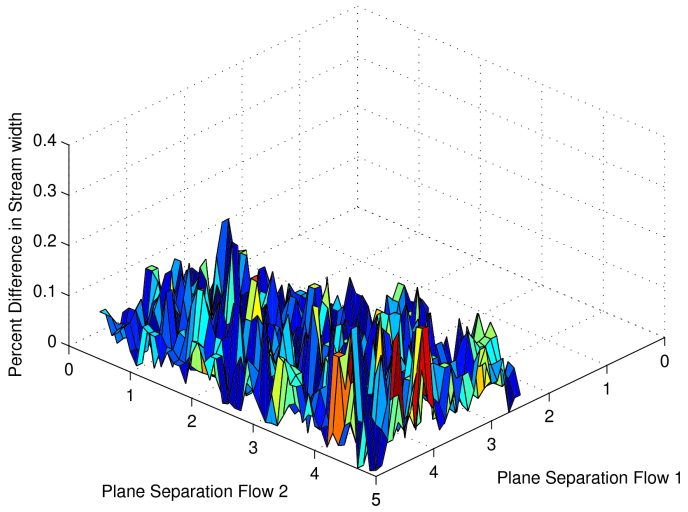
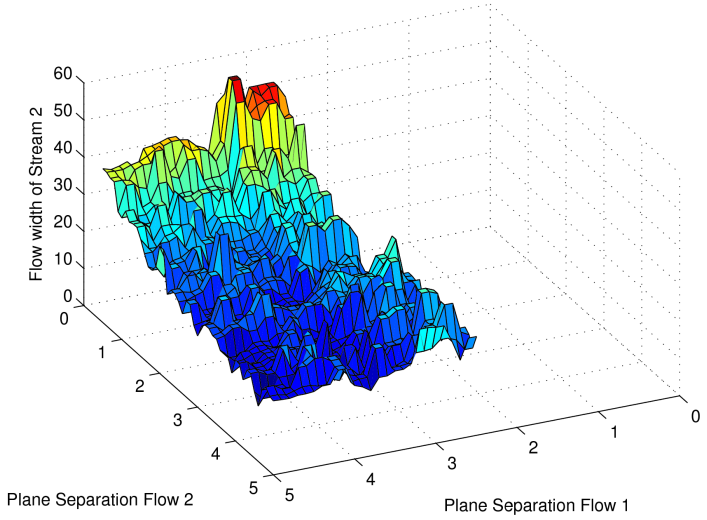
Shift Method

- Maximum deviation is a function of the arrival rates.
- Flow widths are comparable even with different rates.







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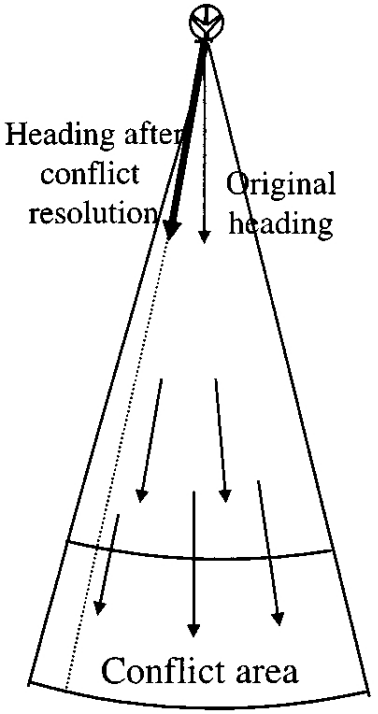
Heading Change

- Case study
  - Standard case
  - Short decision horizon
  - Different flow rates

- Results
  - Distribution of deviation angles



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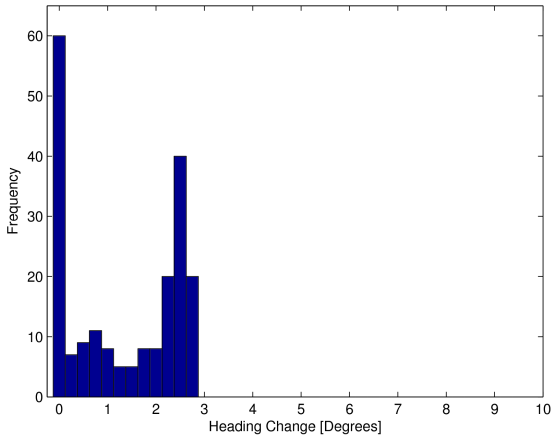
Heading Change Results: Standard Case

Video 2
Heading (Standard)



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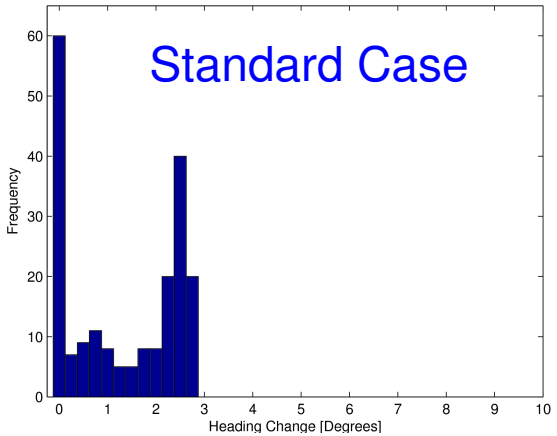
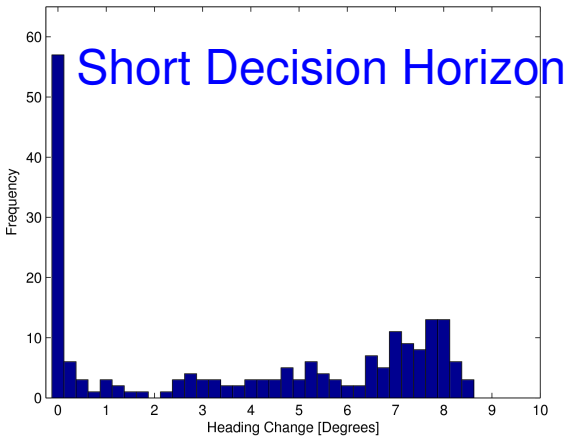
Heading Change Results: Short Decision Horizon

Video 3
Heading (Short)





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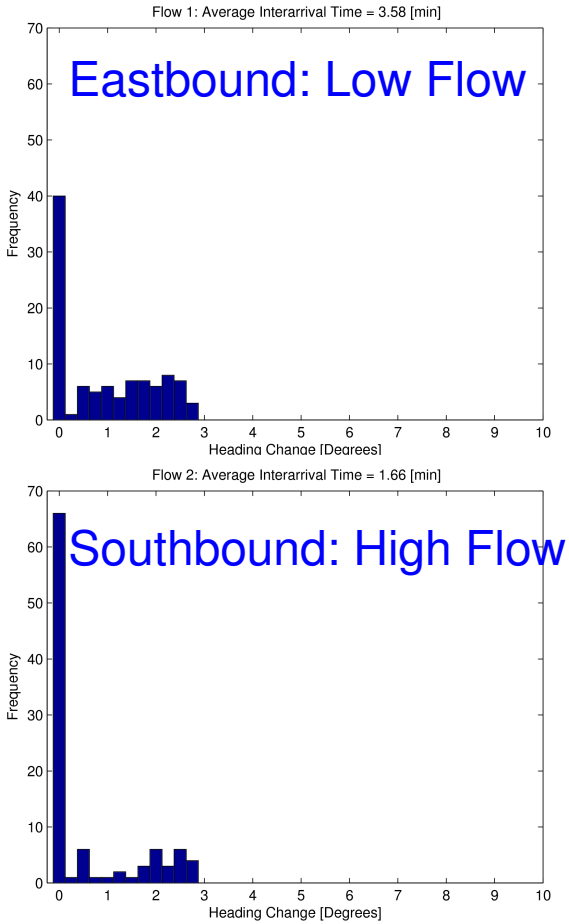
Heading Change Results: Different Flow Rates

Video 4
Heading (Flows)



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Thoughts

- Start to define measures of capacity and system health for a given airspace configuration

  "Capacity" = {(r1,r2) | max(deviation) <= intersection area}

  "Health" = P(max(deviation) <= intersection area | (r1,r2))

- Many factors determine the system capacity and health
  - Initial configuration (Distance to intersection, crossing angle, etc)
  - A determining factor for maximum flow-width is given by max(r1,r2)

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Future Works

- Analytical solution for maximum flow width for the deterministic case.
- More simulations over several configurations
  - To better determine maneuver distributions
  - To better conceptualize health of the system for developing a monitoring tool.
- Compare additional conflict resolution algorithms
  - Develop model for human controller (machine learning)
- Synthesis results from single intersection case to the sector and center levels
  - How does conflict resolution results at one intersection affect future intersection areas?