Some Trends in Next Generation Air Traffic Management

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Presented by Pam Binns

National Workshop on Research Directions for High Confidence Transportation CPS: Aerospace

19 November 2008

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Future Air Traffic Management

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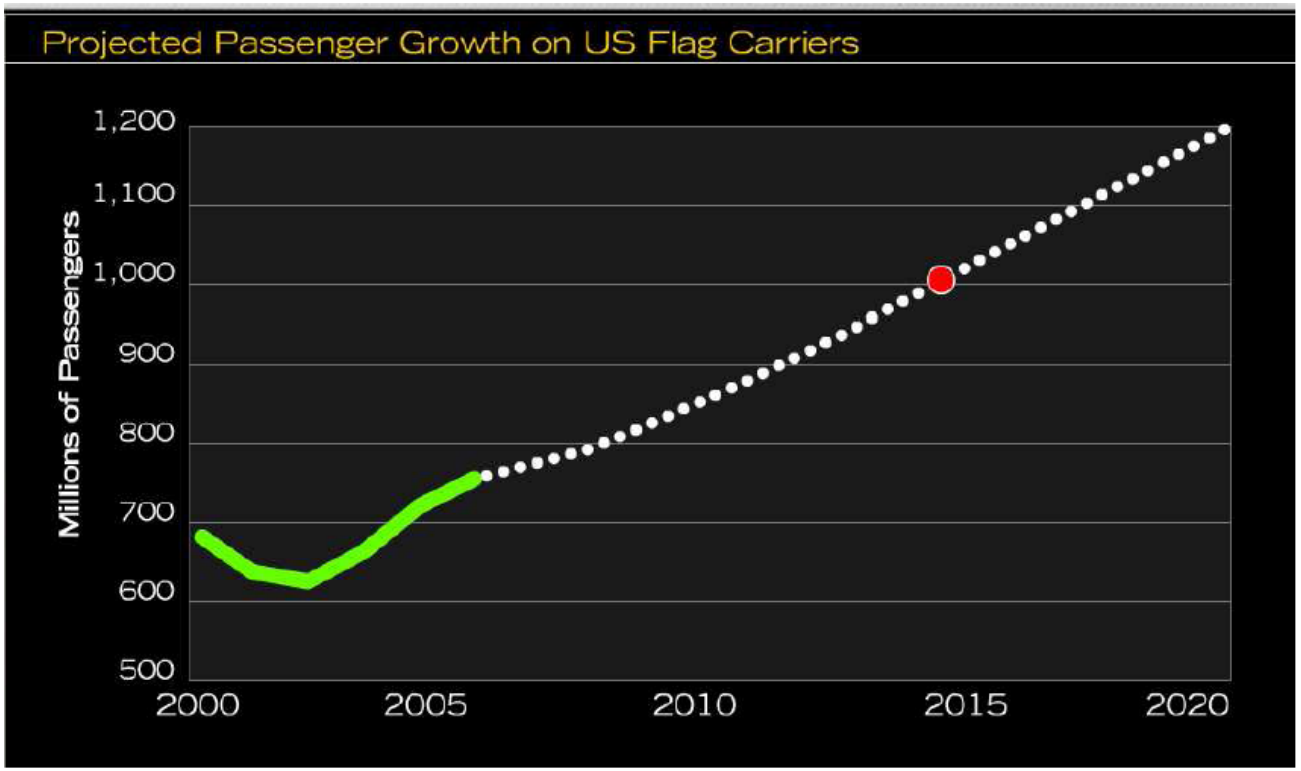
- **Air-traffic around the world projected to double every 10 to 14 years;**
  - **Higher rates of growth expected in the U.S., Asia and trans-oceanic airspace.**
- **ICAO forecasts world air travel growth of 5% per annum until 2020.**
- **Increased ATCo workload contributed to 33% increase in U.S. controller errors from 1996-2000.**



Aircraft Centric Technology Trends

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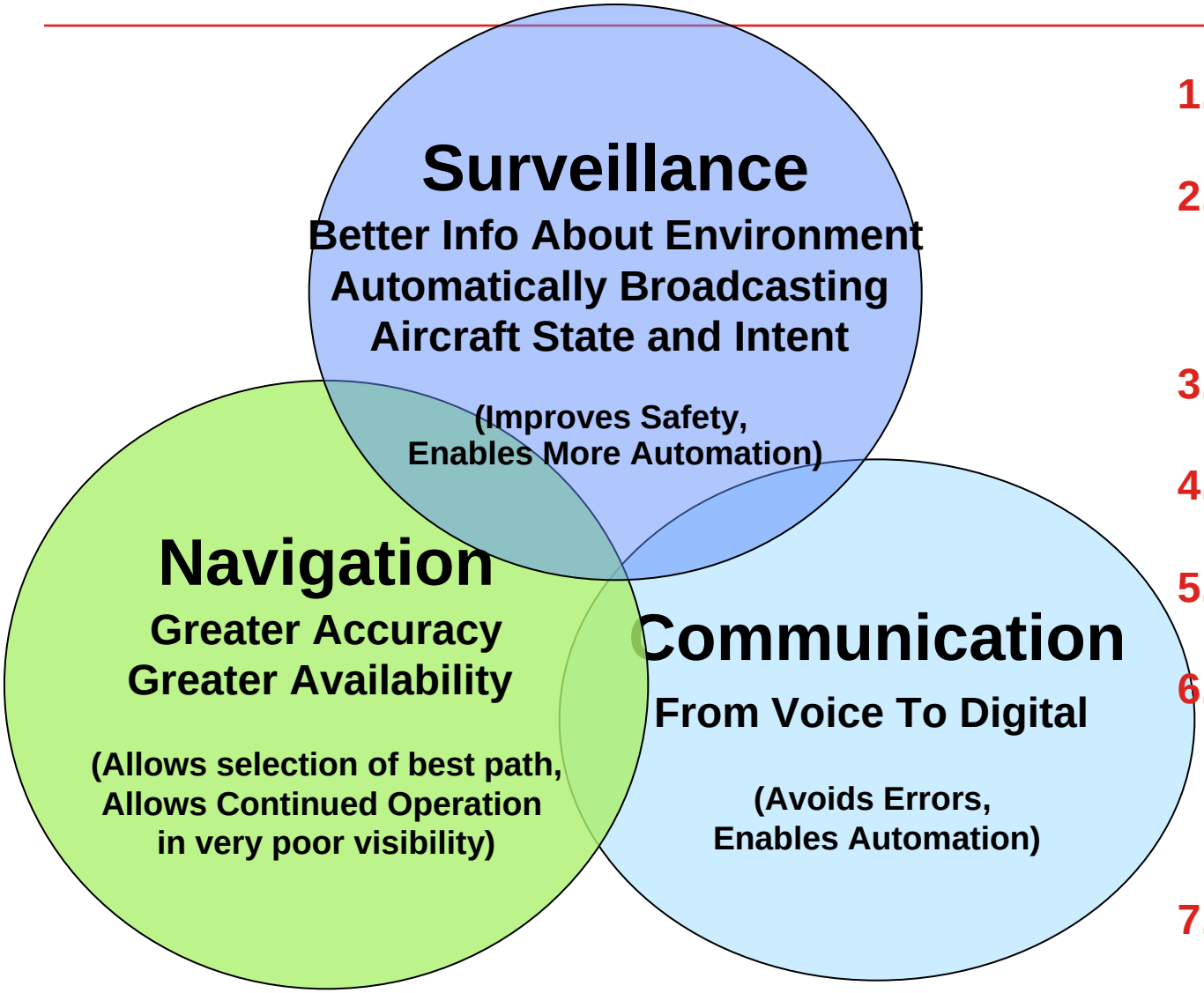

1. Initiate Trajectory based Operations
2. Increase Arrival and departures at high density airports
3. Increase flexibility in terminal areas
4. Reduce impact of weather
5. Improve collaborative ATM
6. Increase safety, security and minimize environmental impact
7. Transform facilities

Near and Mid Term ADS-B Applications

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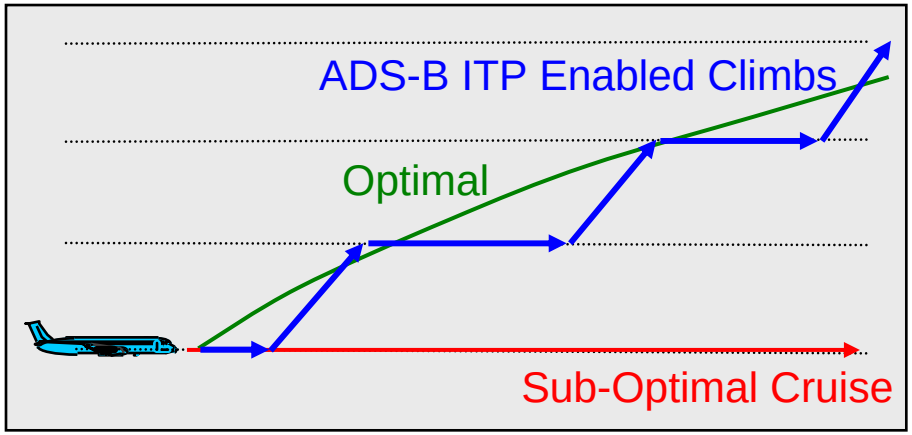
- **Airborne Traffic Situational Awareness**
- **Surface Traffic Situational Awareness**
- **Surface Traffic Indications & Alerts**

- **In Trail Procedure**
  - **Flight Level Change in Oceanic Non-Radar Airspace**
- **Sequencing and Merging**



Operational Efficiency Improvement

ADS-B Strategy High Level Plan

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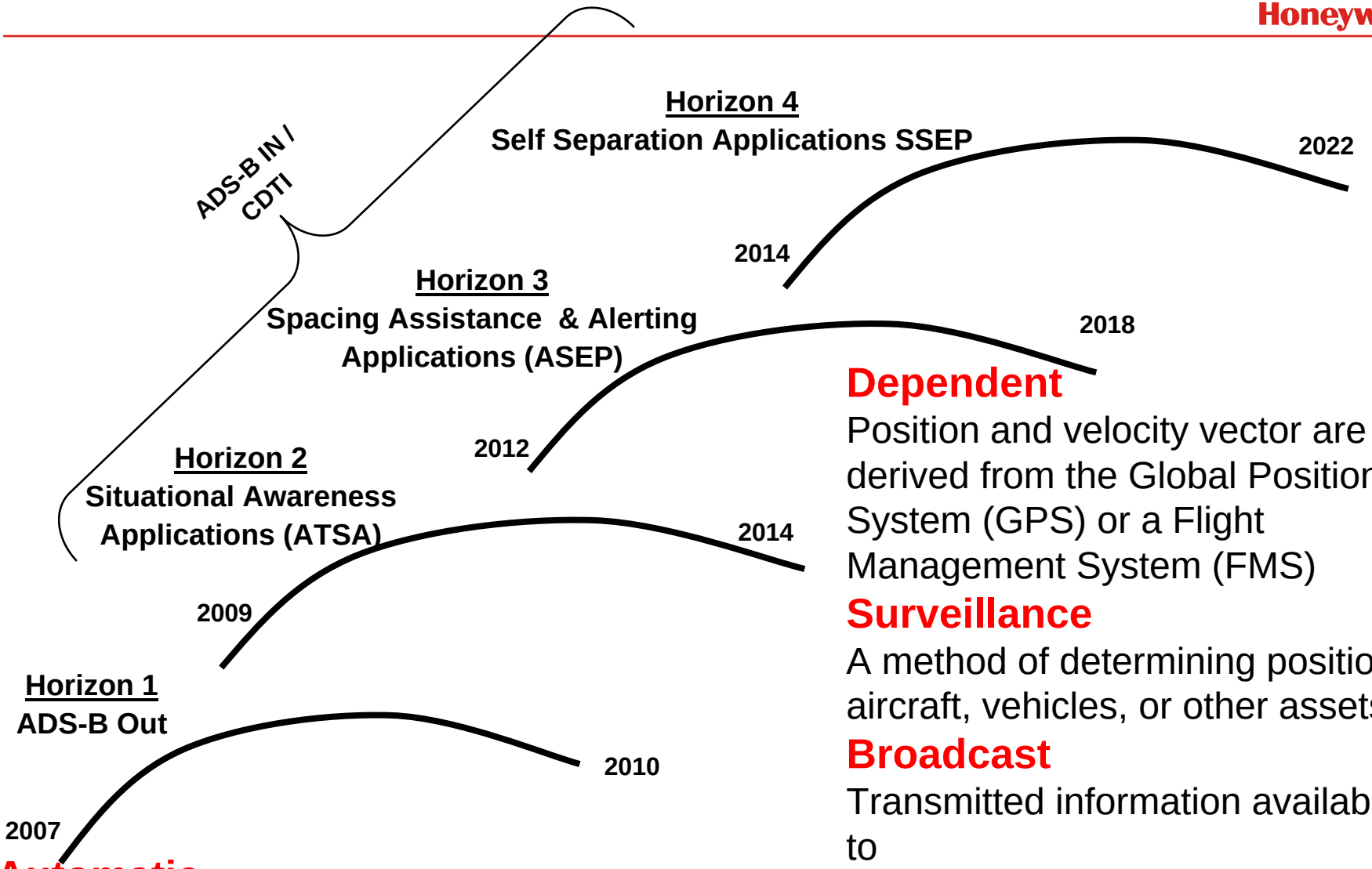

Automatic

Periodically transmits information with no pilot or operator input required

Dependent

Position and velocity vector are derived from the Global Positioning System (GPS) or a Flight Management System (FMS)

Surveillance

A method of determining position of aircraft, vehicles, or other assets

Broadcast

Transmitted information available to anyone with the appropriate receiving equipment

Trajectory Based Operations

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- **Strategic de-confliction of trajectories**
  - **Based on trajectory prediction**
  - **Assists controllers in predicting conflicts and resolving them long in advance.**
  - **Goal is to reduce controller workload and increase airspace capacity / throughput.**
- **Trajectory prediction accuracy is key to success of TBO.**
- **Inaccurate predictions will necessitate either re-planning or tactical action, both requiring controller workload.**
- **Two approaches to reducing trajectory prediction error**
  - **Eliminating sources of error**
    - Better modeling of physics and measurement of disturbance environment
  - **Applying feedback control**
    - Detect errors and take corrective action

Trajectory Negotiation Process

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Details are being worked jointly by

- **RTCA SC-214**
- **EUROCAE WG 78**

Key features include:

(1) Trajectory Monitoring

- Trajectory downlink, e.g. ADS-C EPP
- Proposed downlink of earliest / latest ETAs at specified waypoints

(2) Trajectory Clearance Uplink

- 2D lateral route with altitude and time constraints

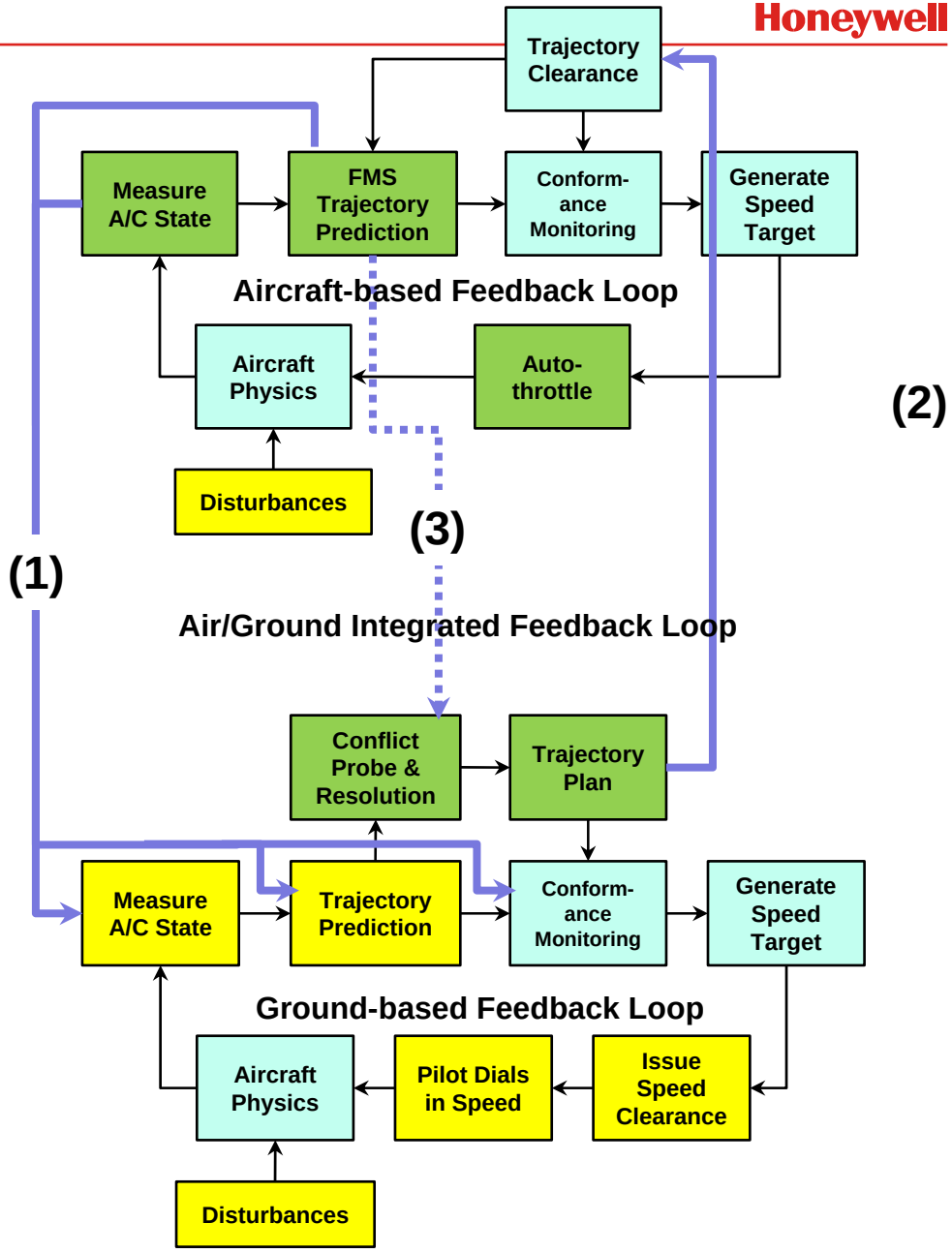
(3) Clearance Request Downlink

- Flight crew proposed modified route

= Replicated Functionality

= Improved Accuracy / Strengths

= Sources of Error



Linear Analysis Results

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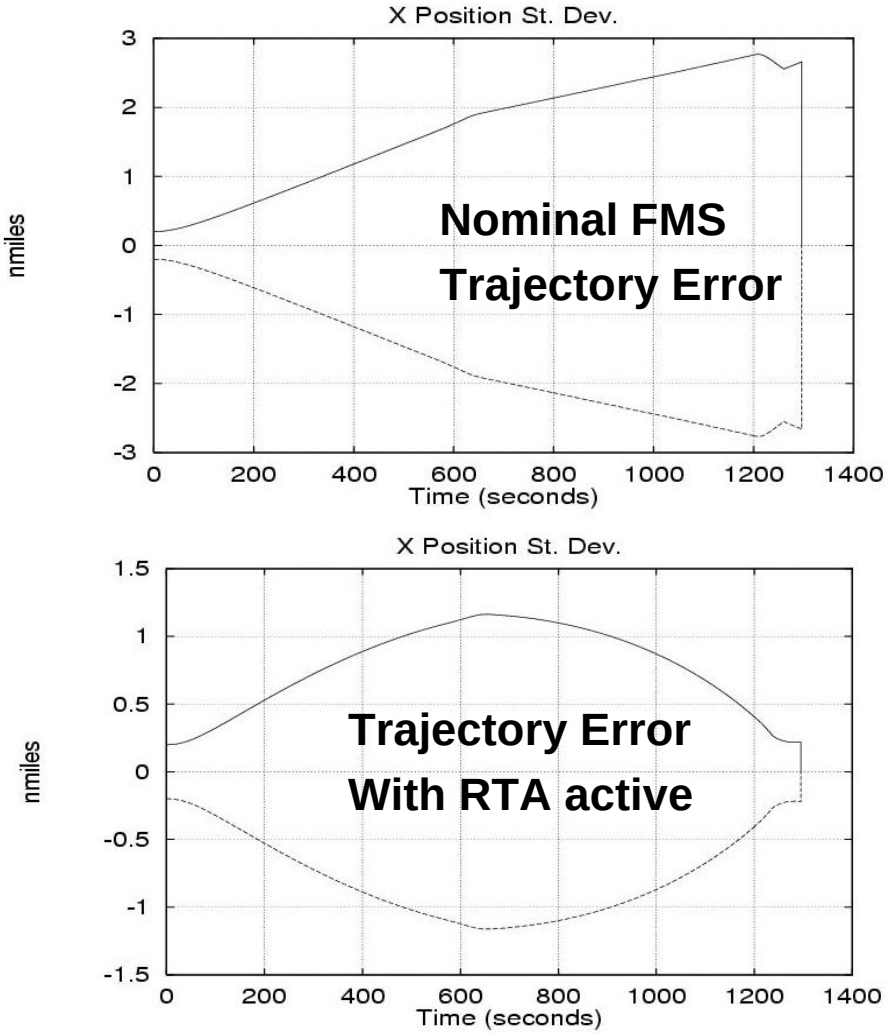
Ref: "Sensitivity of Trajectory Prediction in Air Traffic Management and Flight Management Systems", Michael R. C. Jackson, Ph.D. Thesis, University of Minnesota, Dec 1997.

- **RTA Reduces Trajectory Error**
  - **Nominal FMS trajectory sensitivity shown with a given set of disturbances**
    - Very similar results to Tailored Arrivals
    - My error sources appear to be about 50% worse (2.6 mile vs. 1.5 mile St Dev)
  - **RTA control reduces trajectory sensitivity most dramatically at end, but also through whole trajectory.**



Example from Tailored Arrivals results

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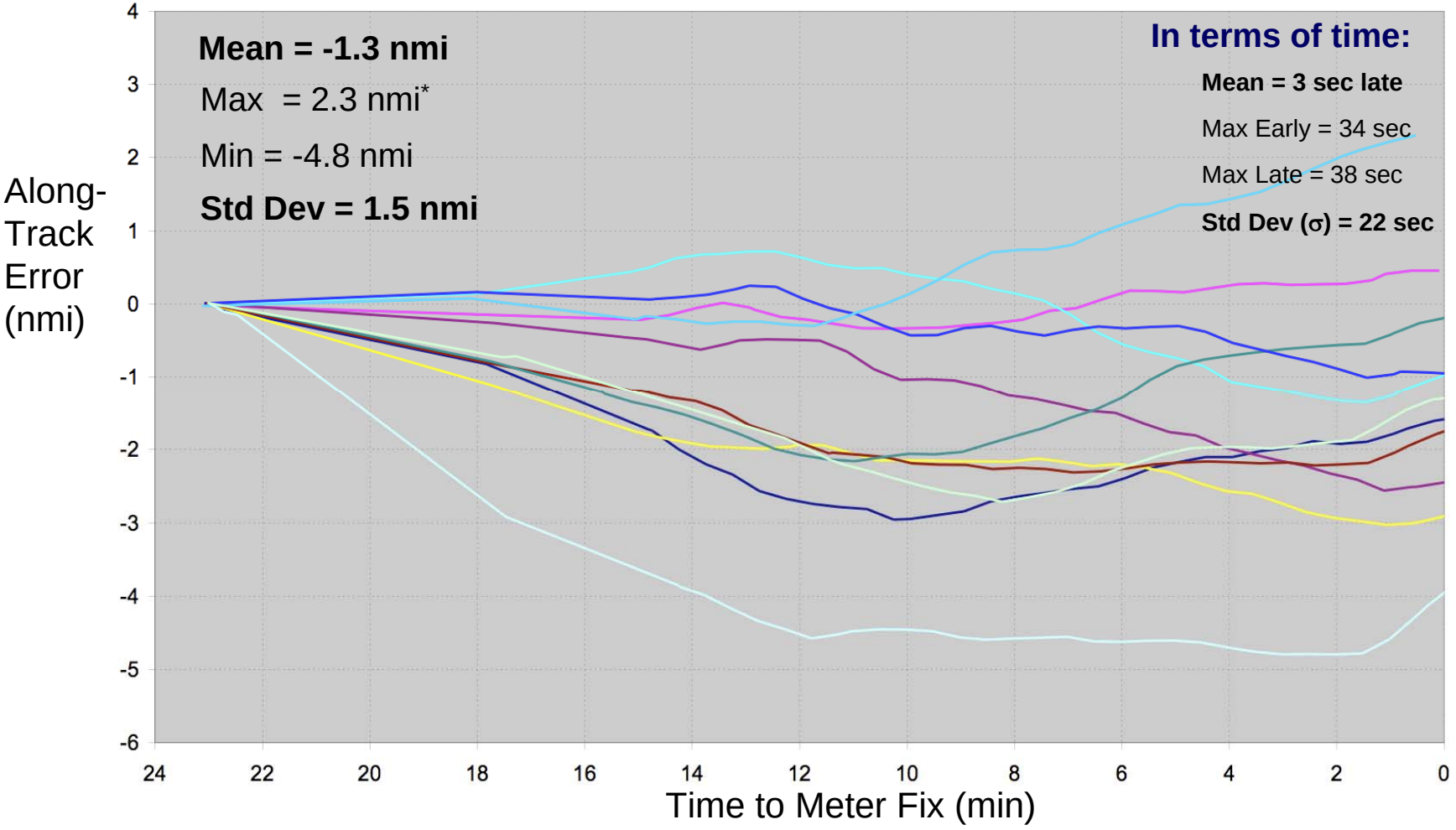
Enroute Descent Advisor – Along Track Prediction Accuracy - 23 min time horizon

Acknowledgement: from Rich Coppenbarger, NASA Ames Research Center



Multiple RTA Effect on Uncertainty

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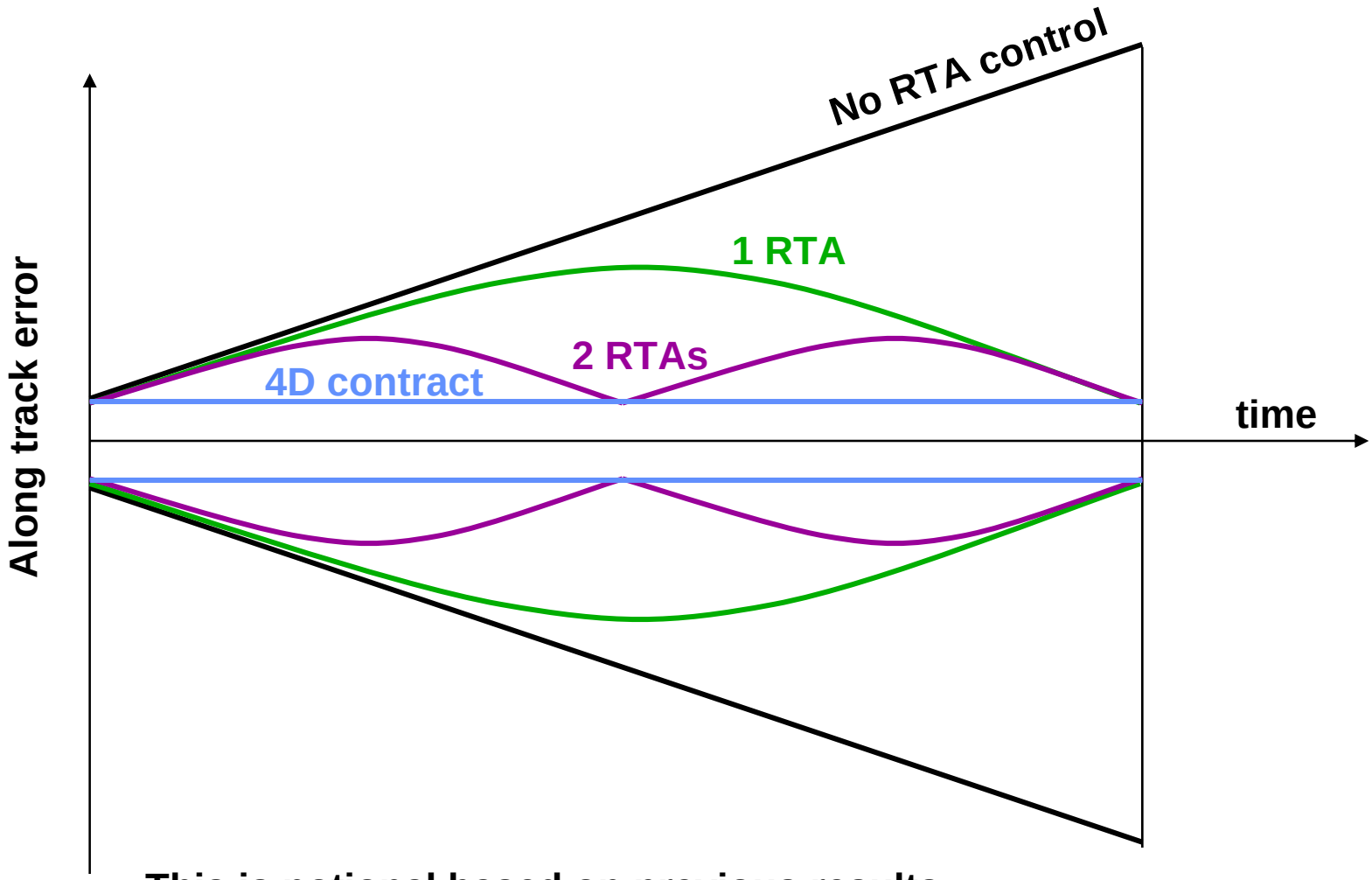

This is notional based on previous results

Multiple Waypoint RTA Example

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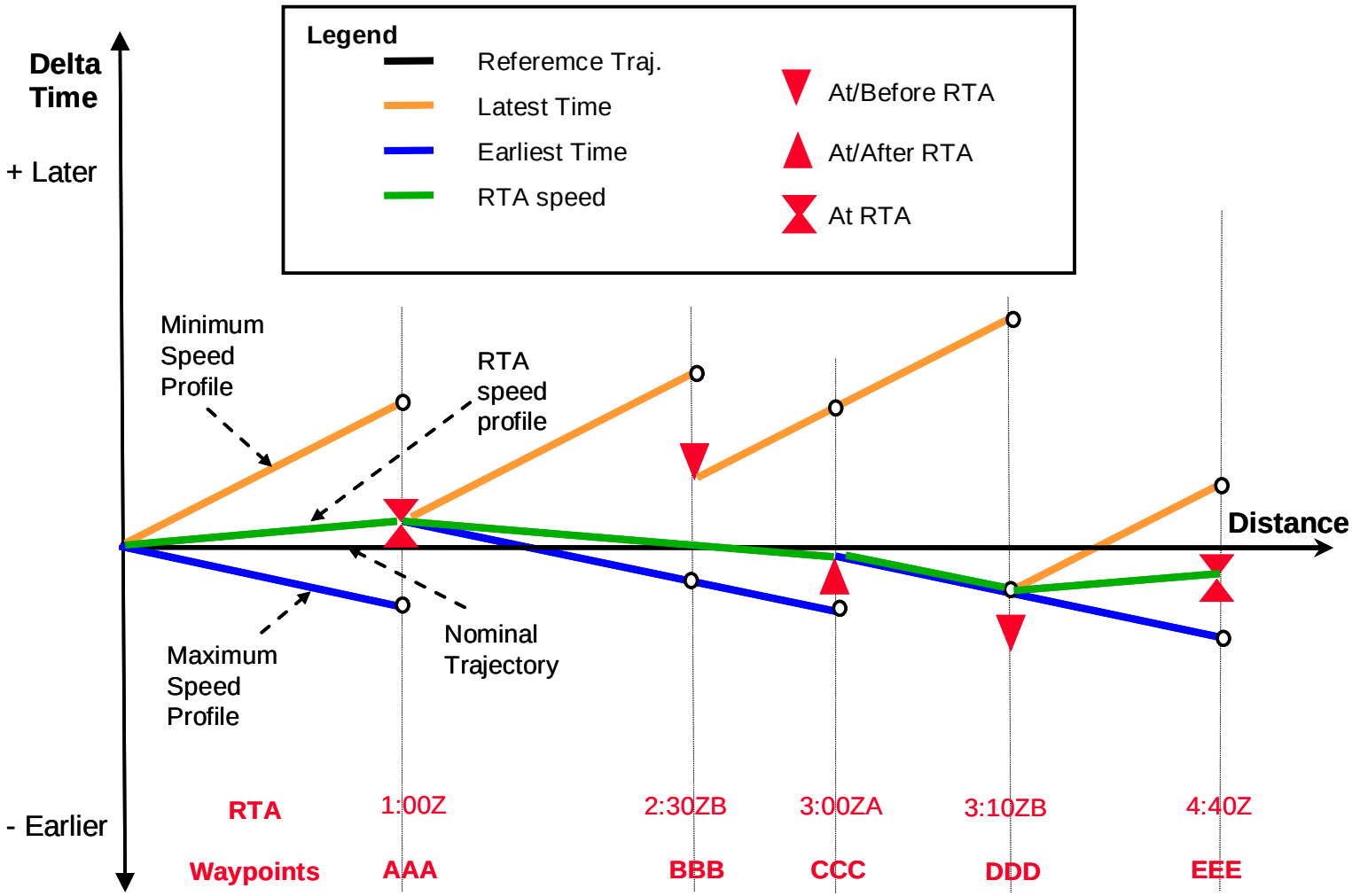

Challenges to Trajectory Based Ops

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- Consensus on long-term operation concept
  - NexGen, SESAR, Boeing, Airbus, etc.
- Standards for the datalink communications
  - RTCA, EUROCAE committee underway
- Coordinated development of ground and airborne capability
  - Neither air nor ground systems will be built without confidence in the other
- Mixed equipage
  - The system must be able to provide benefit with only a portion of aircraft equipped
- Business case
  - The cost to build must be recouped by benefits within a reasonable time period.

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