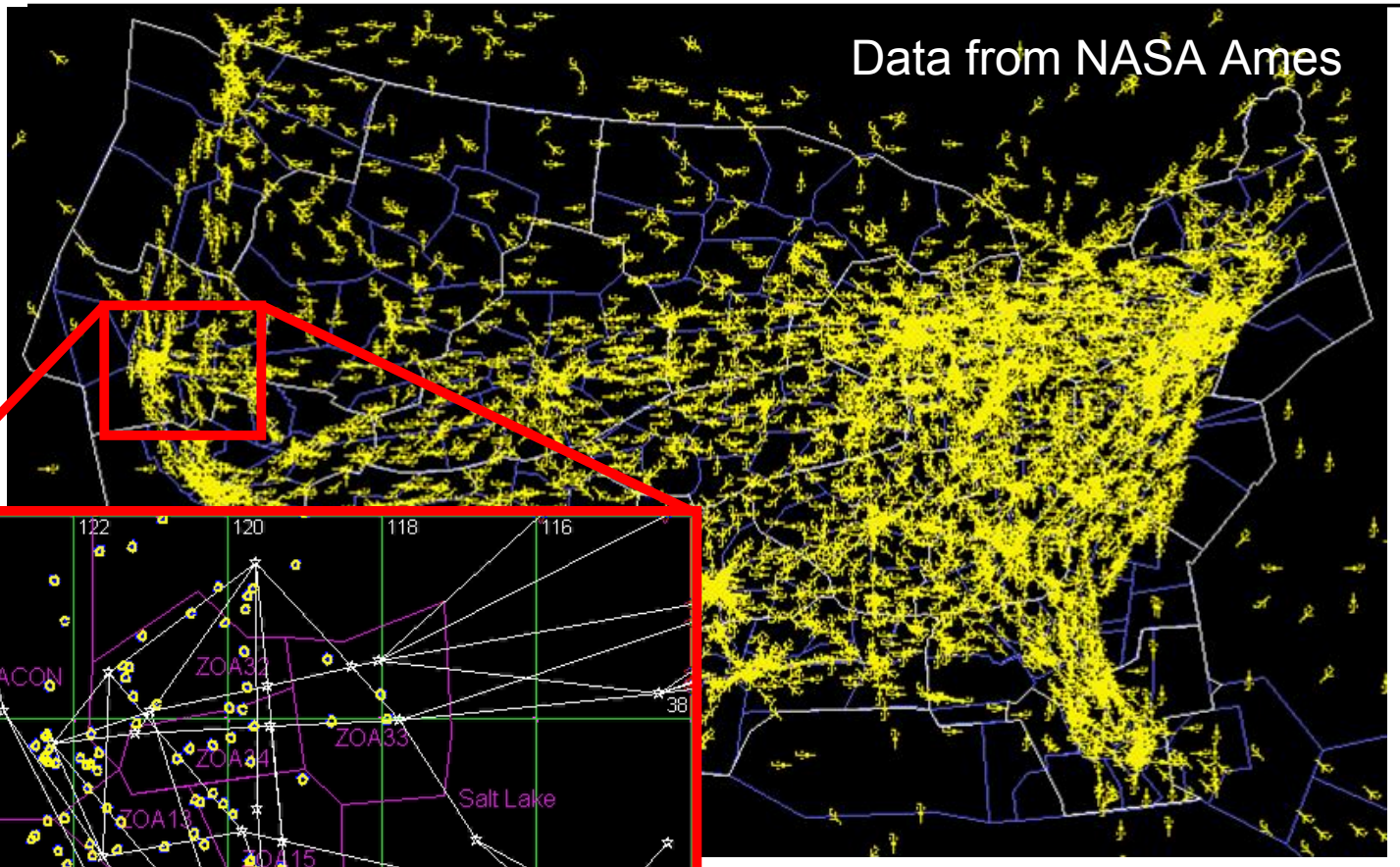
Hybrid and Embedded Control Systems: Applications in Future Avionic Systems

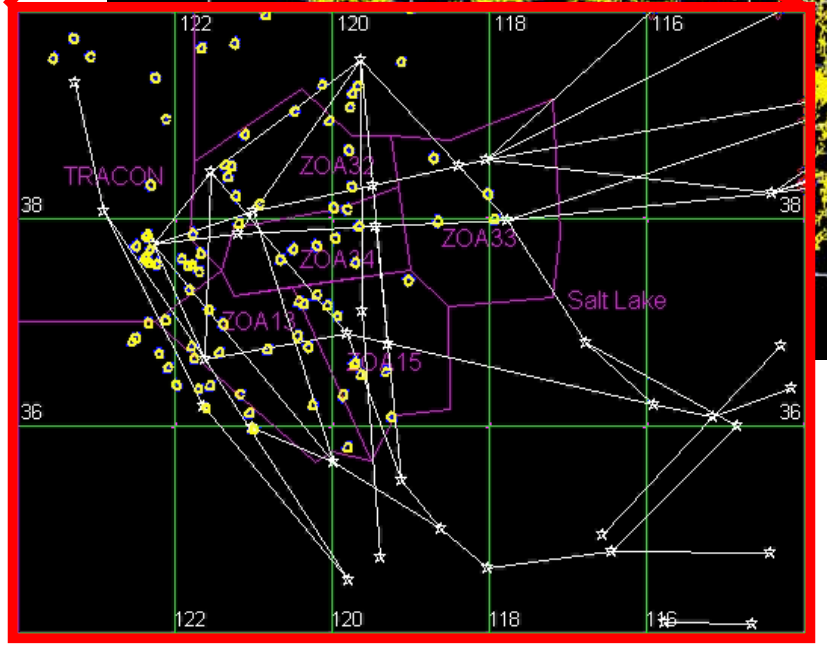
Claire J. Tomlin

Department of Aeronautics and Astronautics
Stanford University

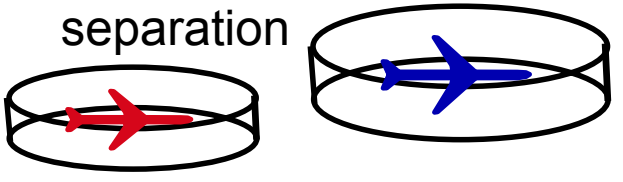
July 7-8, 2005

Air Traffic Control: Separation Assurance

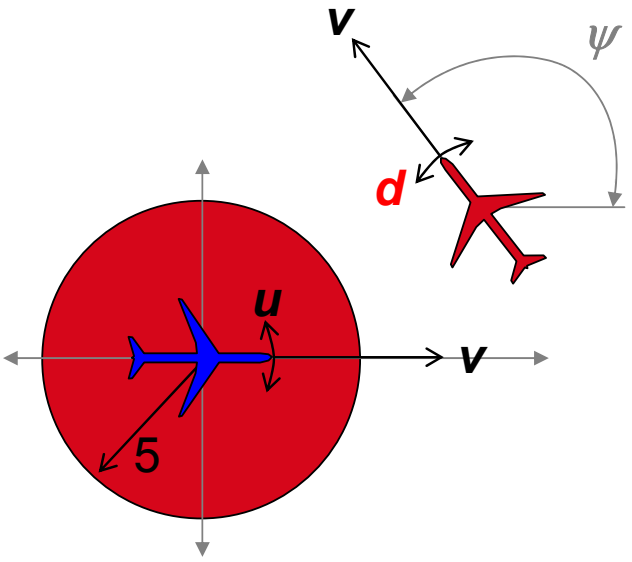




Safety: 5 mile lateral, 1000 ft vertical separation

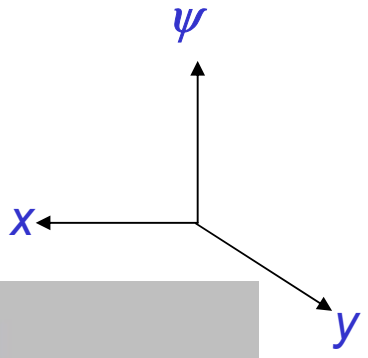


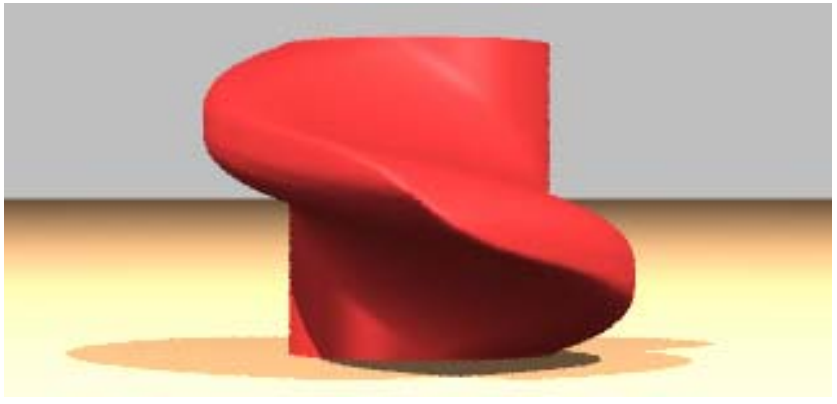
Automatic Separation Assurance

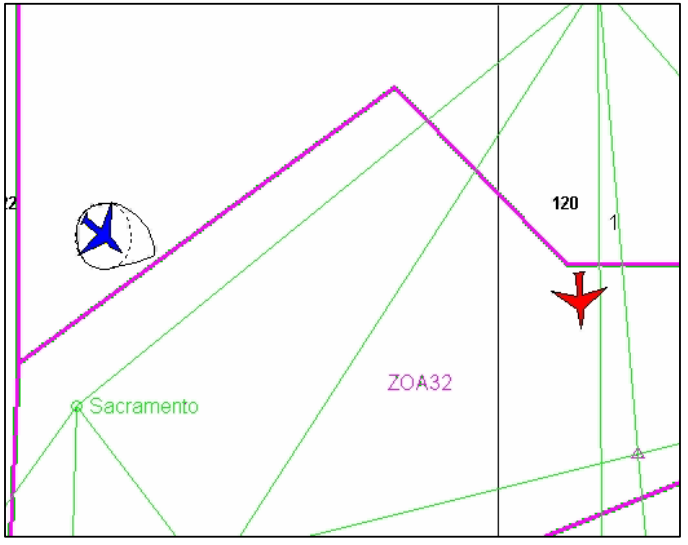


Differential game formulation:

Compute the set of states for which, for all possible maneuvers (d) of the red aircraft, there is a control action (u) of the blue aircraft which keeps the two aircraft separated.

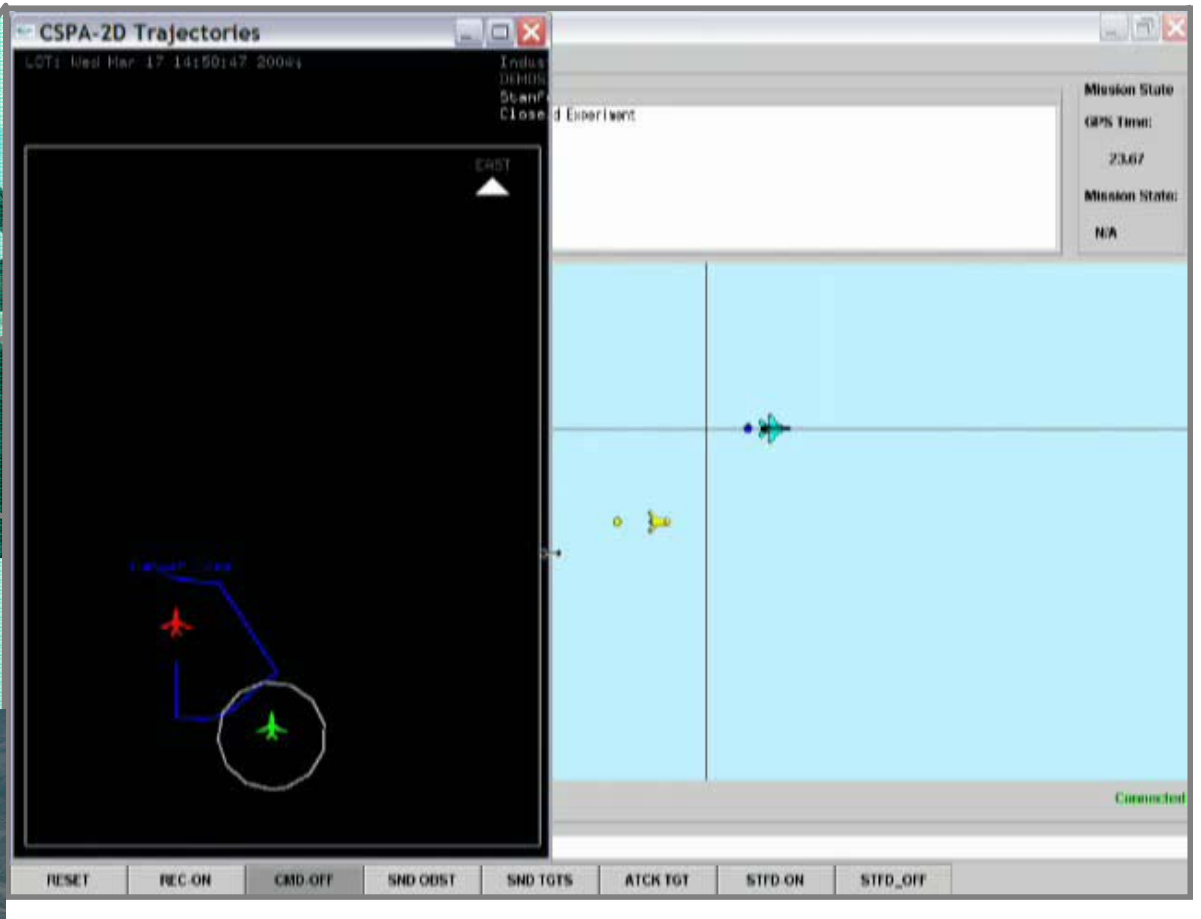






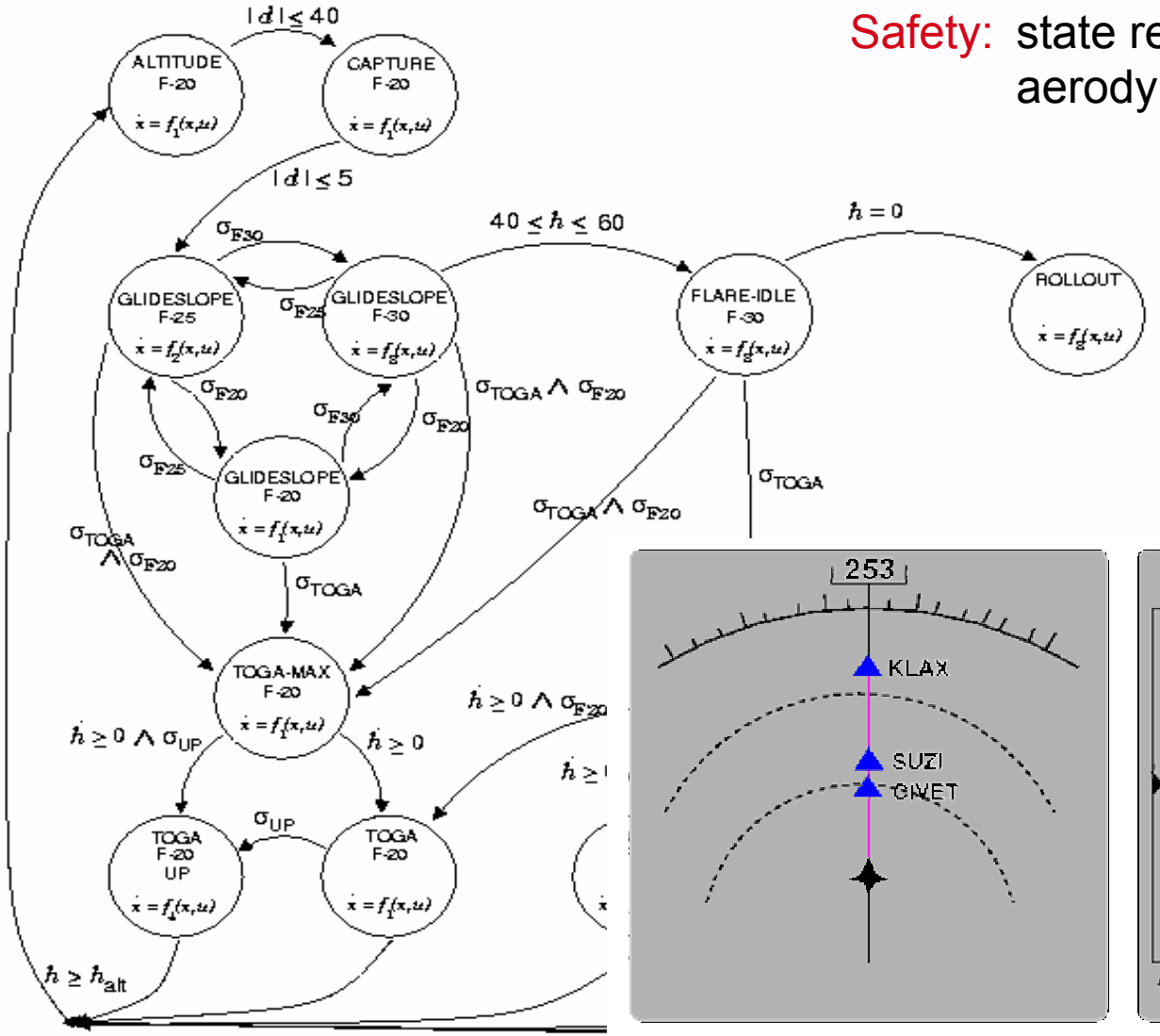
Test at Edwards Air Force Base – June 2004

T-33 Cockpit

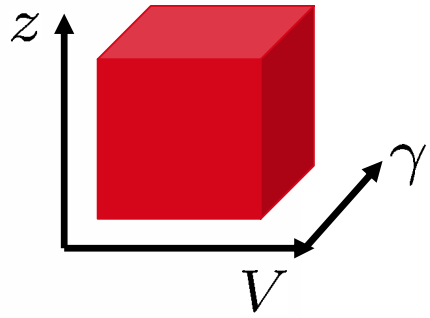


[DARPA/Boeing SEC Final Demonstration:
F-15 (blunderer), T-33 (evader)]

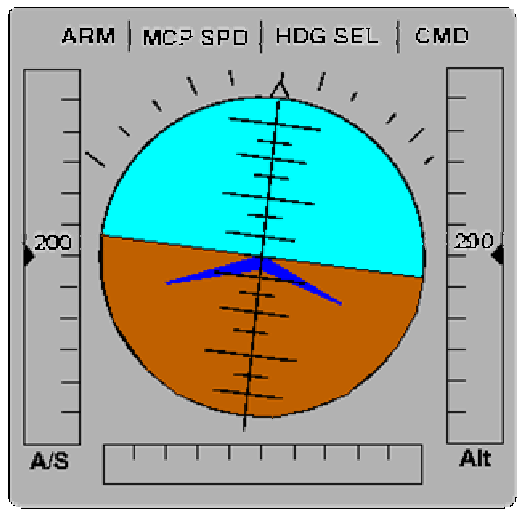
Mixed Initiative Control: Autoland



Safety: state remains inside aerodynamic envelope

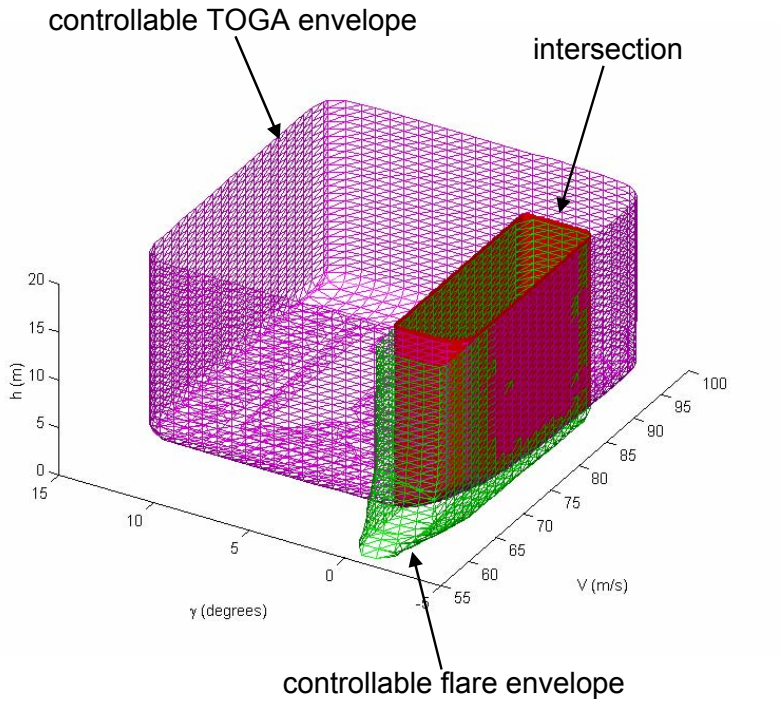


what the pilot sees

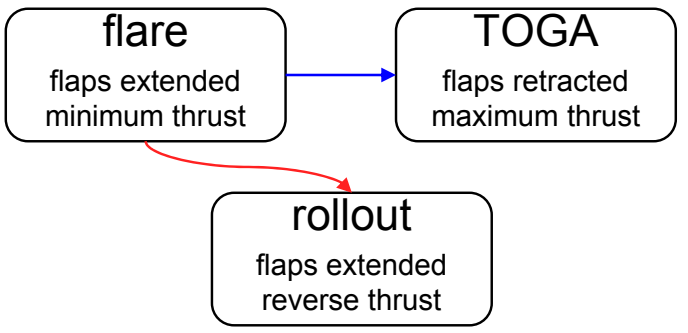


Application to Autoland Interface

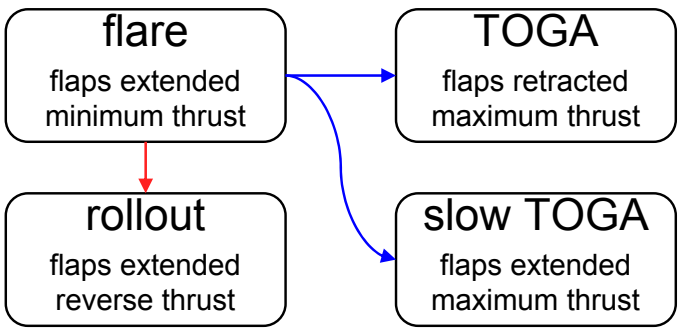
- Controllable flight envelopes for landing and Take Off / Go Around (TOGA) maneuvers may not be the same
- Pilot's cockpit display may not contain sufficient information to distinguish whether TOGA can be initiated



existing interface



revised interface



The future…

- **New airborne sensors: an information-rich environment**
  - GPS/WAAS
  - data-link communications
- **New control strategies: quick to adapt, isolate problems, blend with human control**
  - automatic collision avoidance
  - automatic routing and scheduling
  - learning models and situations from data tracks
  - Free flight?
  - Personal aviation?
- **A safe, efficient, and fair system in which human controllers and automation seamlessly share authority over air traffic control**