

Proposal for a Sample Pilot Response Model

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Background

- In order to run closed-loop DAA simulations, we need to emulate a pilot response (maneuver) to DAA guidance.
- Across the variation M&S platforms, can we build consensus on an architecture of a pilot response model?
- It would be advantageous if we documented an “accepted” functional architecture (i.e. inputs/outputs) and model parameter (e.g. pilot response latencies).
- Use pilot-in-the-loop response data and deterministic heuristics for selecting maneuvers for repeatable.
 - Design so alternative still model the “straw-man” pattern, e.g. stochastic sampling of selected maneuvers
- Simple enough that it can be described in the MOPS for the end-to-end V&V activity

Previous Work

- In NASA ACES simulations, we've used a pilot response model based on the Autoresolver algorithm
- It had some strengths and weakness
 - Strengths
 - Alert declaration
 - Response time delay following alert
 - Maneuver selection heuristics
 - Weaknesses
 - Sometimes inconsistent with band guidance
 - Not up-to-date for considering new alerting parameters, TCAS interoperability, and other new guidance requirements

Take-away:

Keep the strengths, and in order to address weaknesses - base the underlying algorithm on MOPS guidance requirements (e.g. OmniBands) rather than Autoresolver

- Because all the guidance requirements are already “cooked” into the band guidance

Previous Work

- Initial pilot model in ACES presented at Feb 2015 SC-228 meeting
- Filename: Requirements Workspace

SC-228_Santiago_DAA_Model_Updates_ACES_FEB25.pptx

Goals of this briefing

- Review a concept for modeling pilot response
- Get feedback

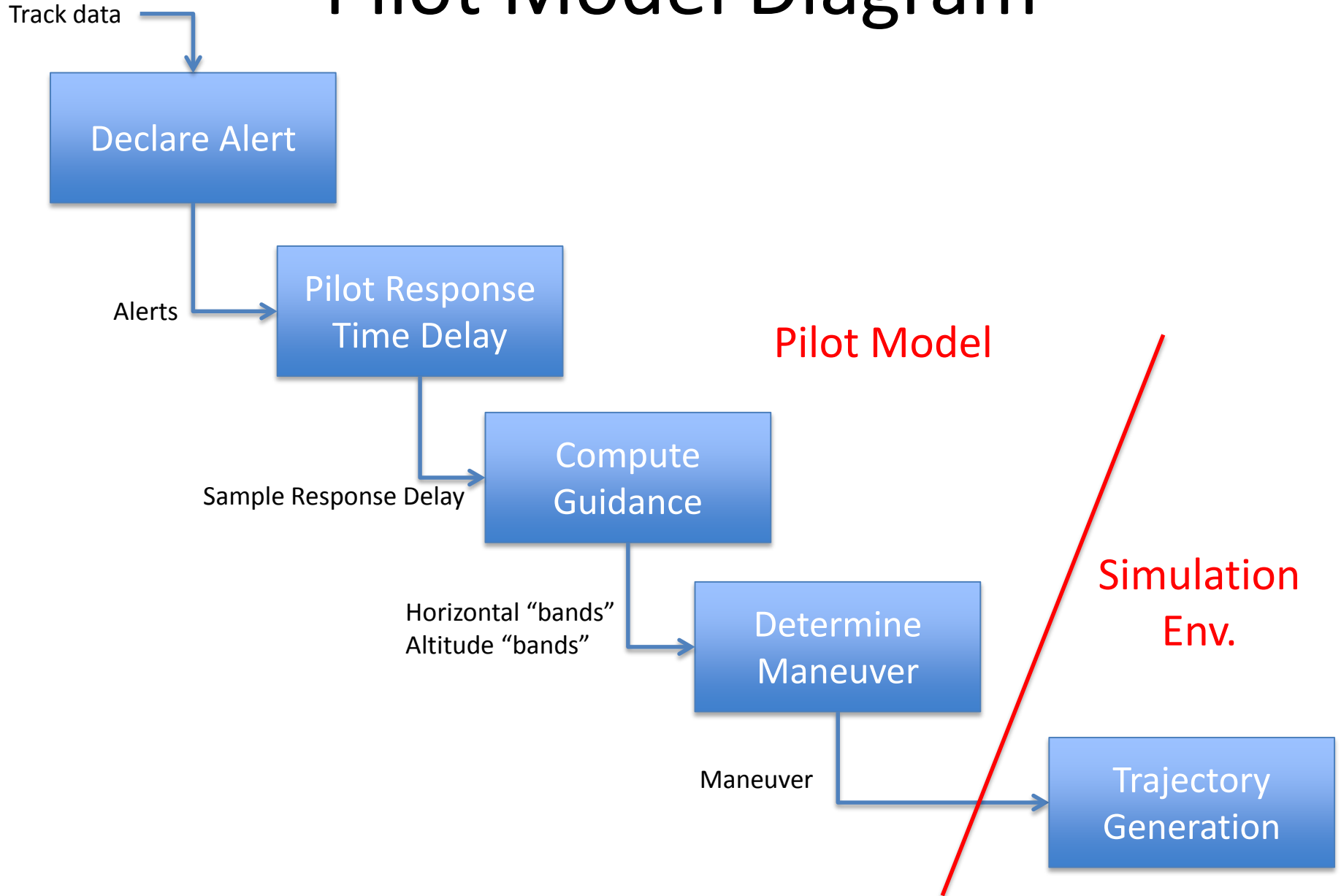
Next Steps

- Get a recommendation and incorporate the group's feedback into concept
- Build consensus
- Go or no-go?
 - Did we build “accepted” guidelines for modeling the pilot for closed-loop analyses?
 - Do we think it's a priority?

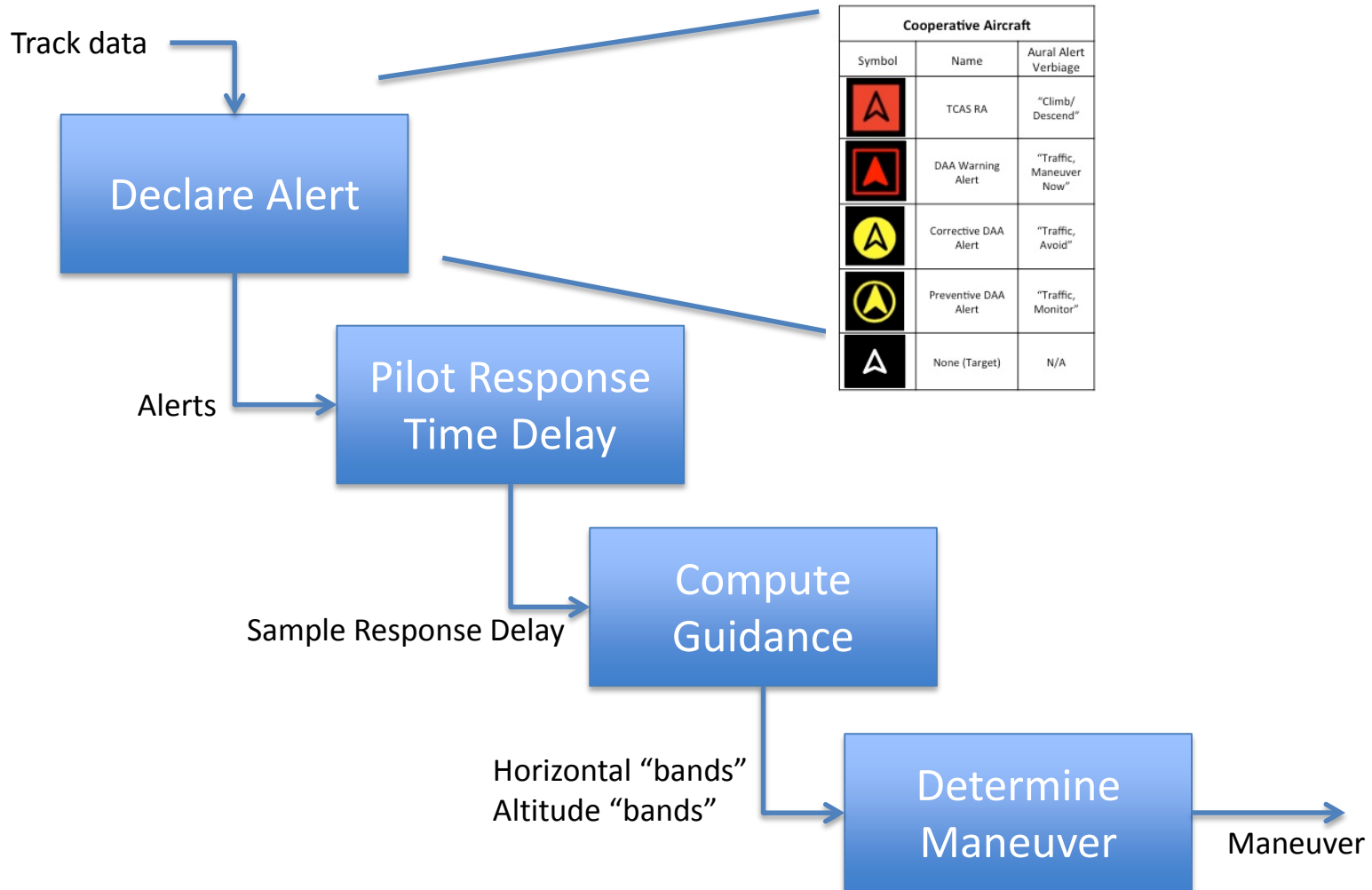
Exit Criteria (if Go)

- Draft a white paper describing architecture and assumptions of “accepted” pilot model
- Create example implementation of pilot response model (not currently part of NASA’s plan, however there is potential reordering priorities and create a change request)
- Use example implementation or implement your own version (that meet “accepted” architecture and requirements) within your simulation environment for V&V activities

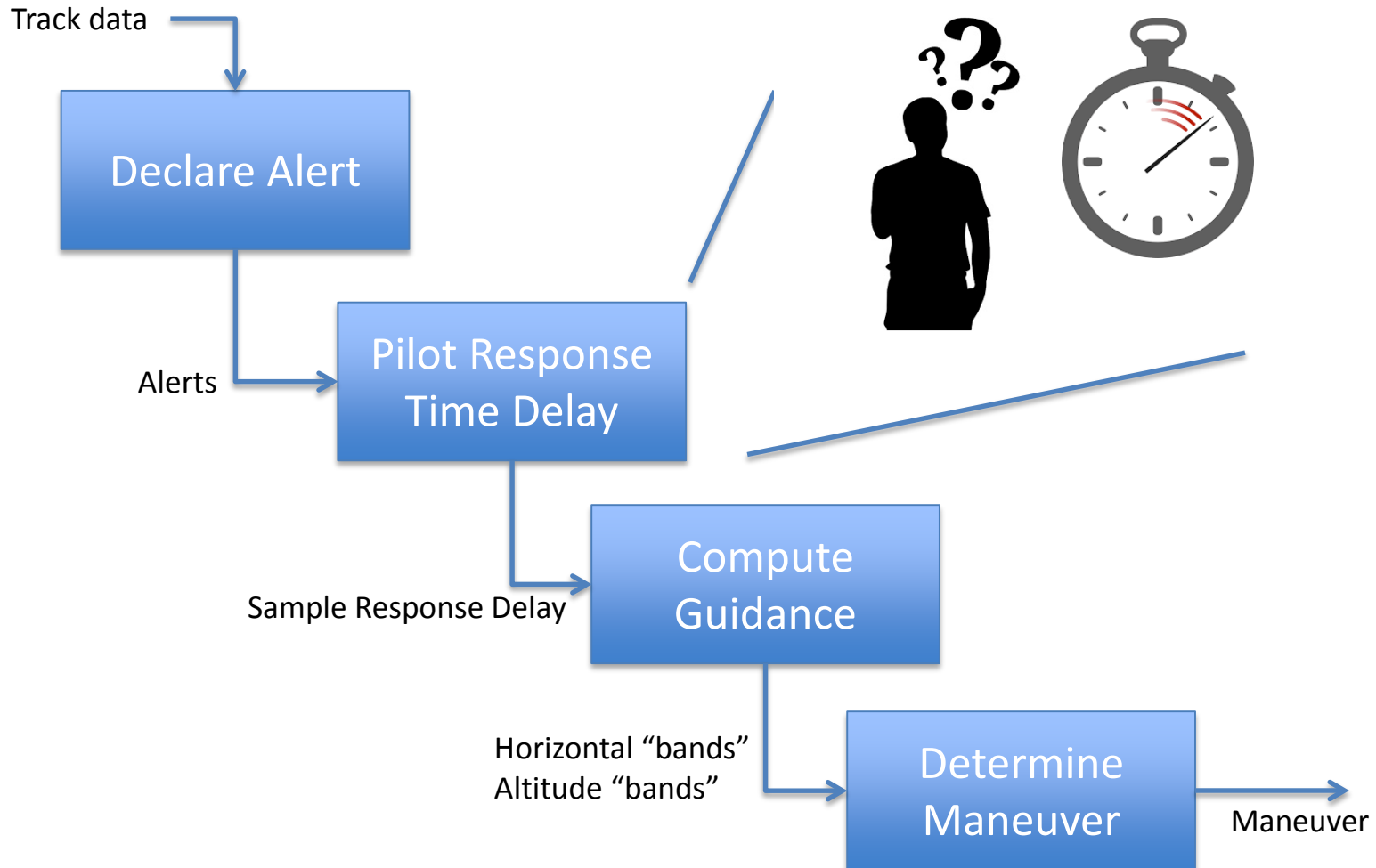
Pilot Model Diagram



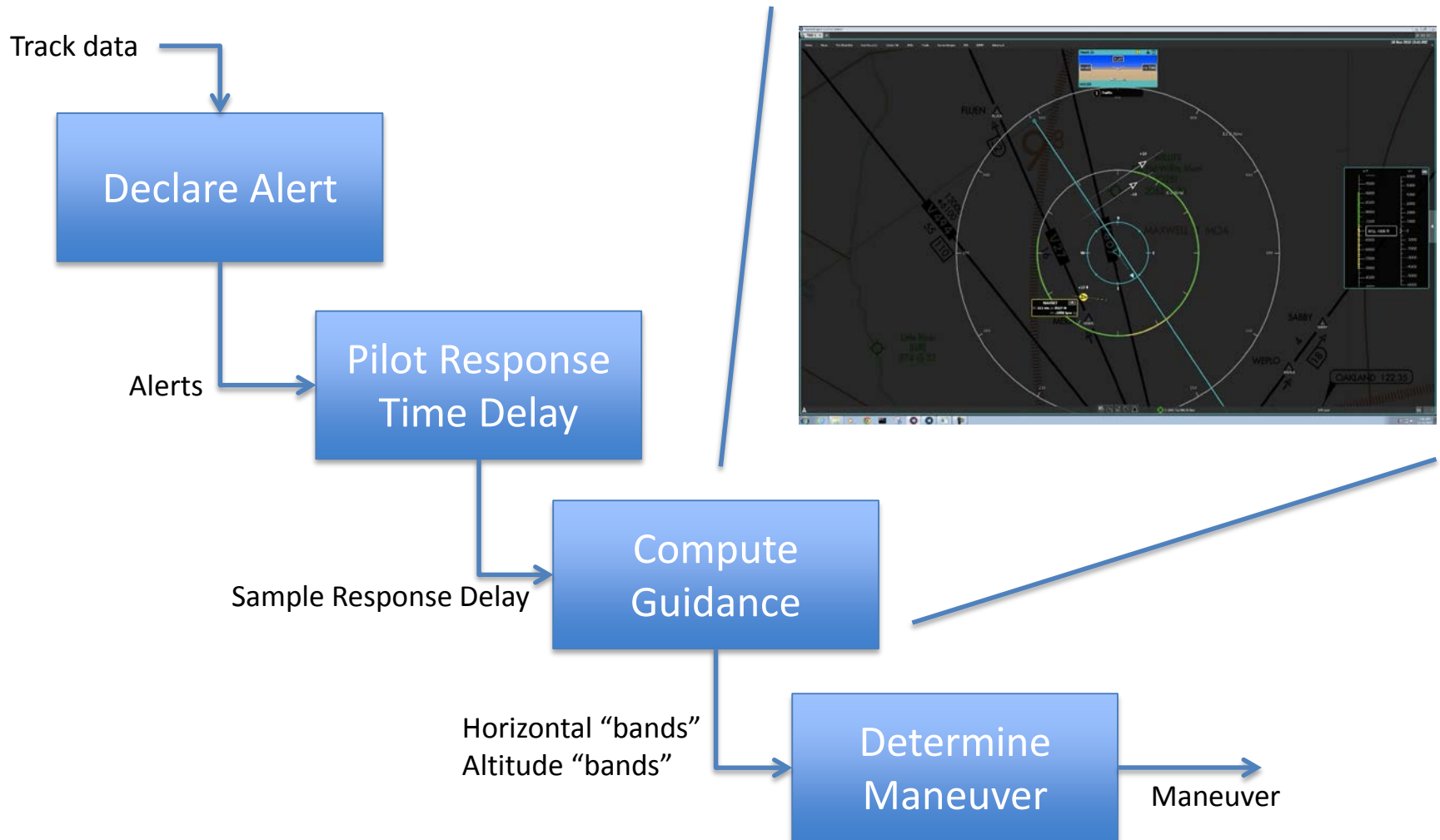
Pilot Model Diagram (cont.)



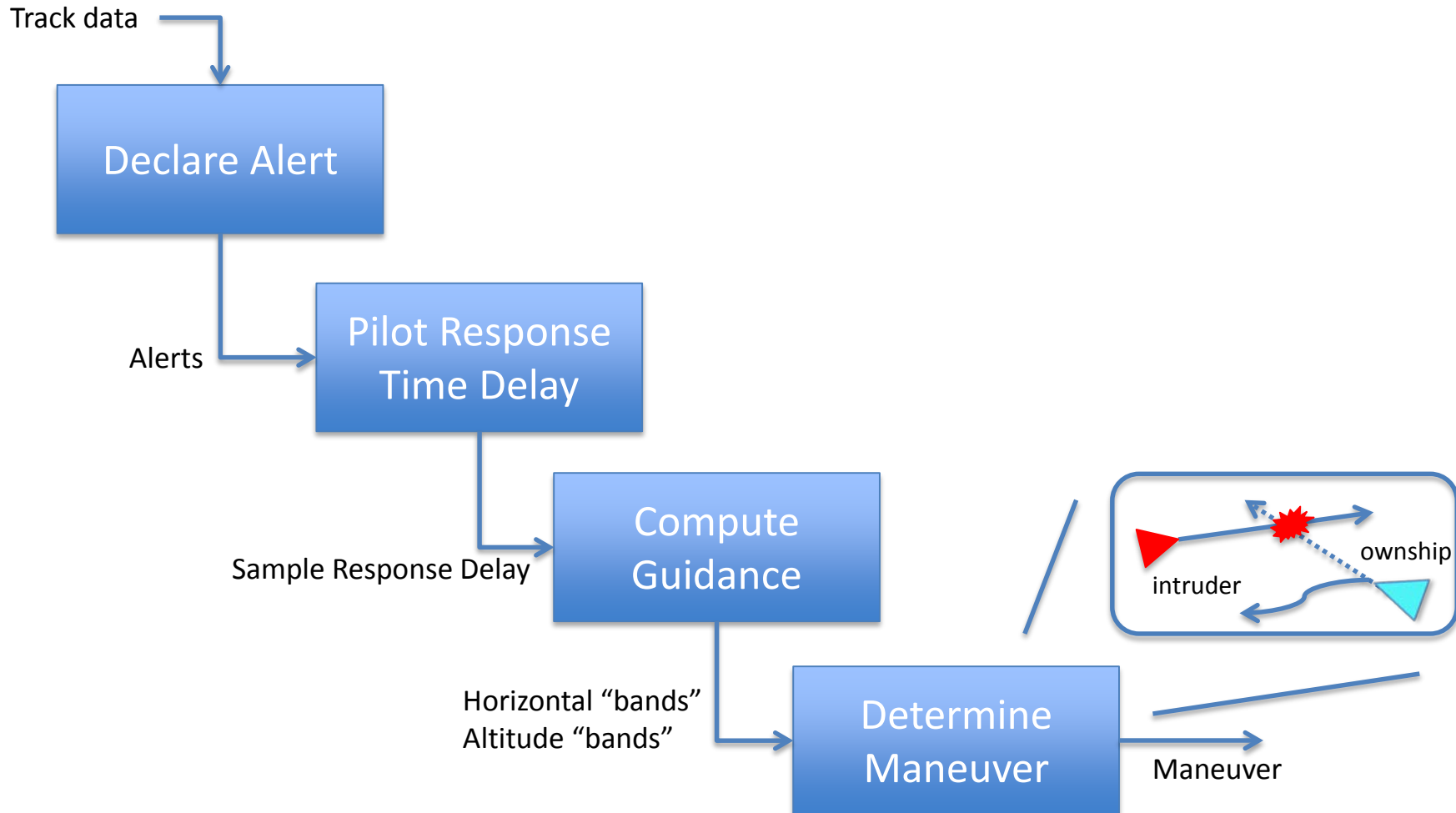
Pilot Model Diagram (cont.)

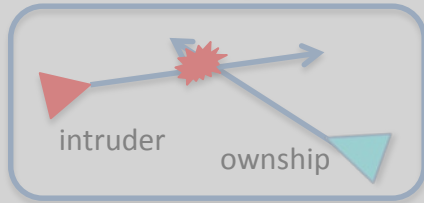


Pilot Model Diagram (cont.)



Pilot Model Diagram (cont.)





Evaluate ownship/intruder and declare alert, if exists

Is alert declared for first time?



No

Yes

Is alert Warning?



Yes

No - corrective

Generate guidance after 10 seconds

Generate guidance after 25 seconds

Is Well Clear Recovery?

Is Well Clear Recovery?

Yes

No - Normal Guidance

Yes

No - Normal Guidance

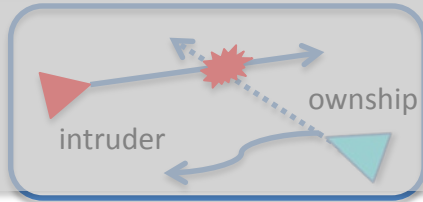
*Maneuver Determination for Recovery Guidance

*Maneuver Determination for DAA Guidance

*Maneuver Determination for Recovery Guidance

*Maneuver Determination for DAA Guidance

* See slide 8 for more detail

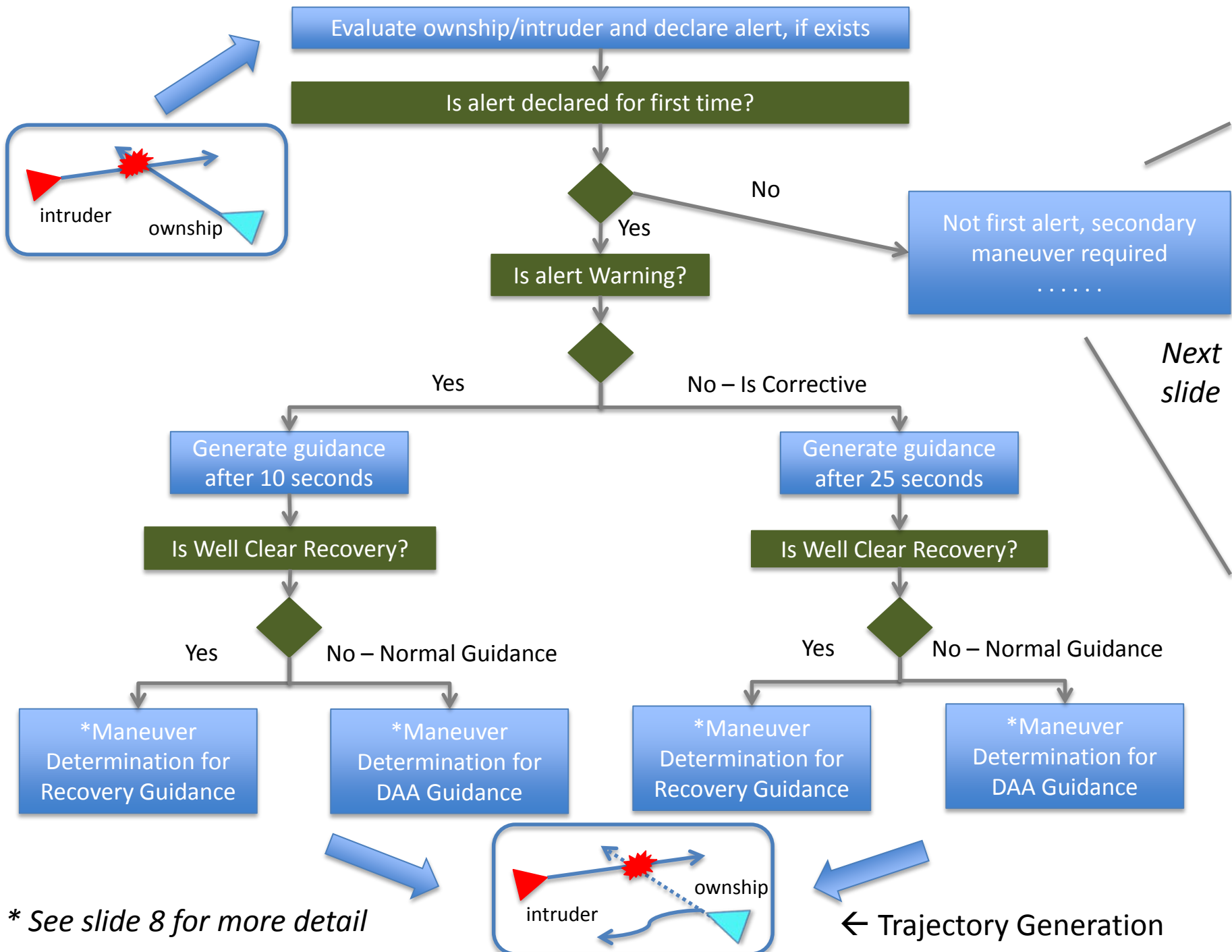


← Trajectory Generation

Walkthrough FLOW Diagram

Not sufficient clearance
 ...
 ... required

Next slide



** See slide 8 for more detail*

Next slide

← Trajectory Generation

Evaluate ownship/intruder and declare alert, if exists

Is alert declared for first time?

Not first alert, secondary maneuver required
.....

Prev. slide

Yes
No

Secondary maneuver required

Generate updated guidance after 5 seconds

Is Well Clear Recovery?

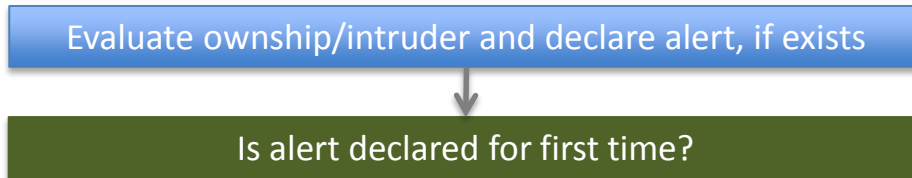
Yes
No – Normal Guidance

Maneuver Determination for Recovery Guidance

Maneuver Determination for DAA Guidance



Declare Alert



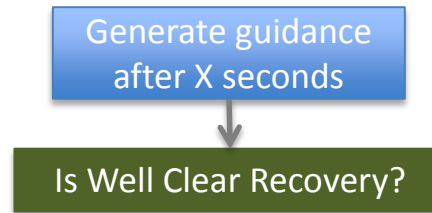
- **Baseline assumption:**
 - MOPS Must Alert thresholds and constant velocity track extrapolation
- **Refinement:**
 - Design common “Declare Alert” interface, so external alerting algorithms could be utilized

Pilot Response Time Delay

Is alert Warning?

- Baseline assumption:
 - Corrective Alert: use constant 25 seconds, i.e. informed by PT5 pilot response time analysis
 - Warning Alert: use constant 10 seconds, i.e. informed by PT5
- Alternative Solution:
 - Gamma distribution built off Corrective and Warning response time data from PT5

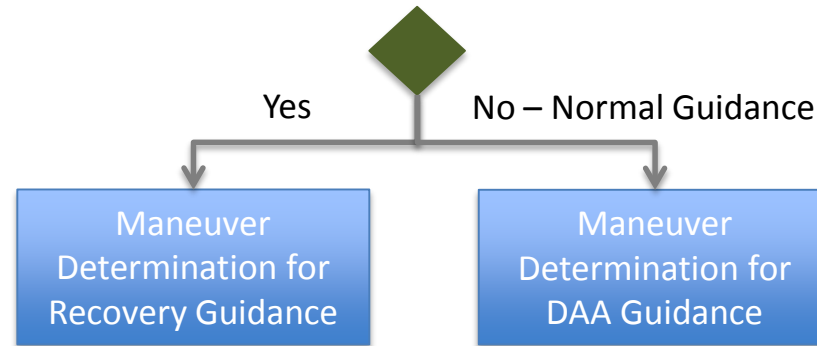
Compute Guidance



- **Baseline Assumption**

- Utilize the guidance (e.g. OmniBands) would provide pilot depending on whether it's in well clear recovery mode or normal DAA guidance
- Inputs to guidance required to generate bands: DAA guidance separation thresholds (i.e. used to determine green, yellow, and red bands), ownship climb/descend rates, ownship bank angle or turn rate

Determine Maneuver



Most Challenging Aspect of Pilot Model

- Heuristic that favors altitude or heading maneuver given encounter type (ownship level or transitioning, intruder level or transitioning)
- Heuristic that favors altitude or heading maneuver given intruder type (ADS-B, or Mode S or Radar)
- Once maneuver type is selected, maneuver to edge of bands (i.e. green bands), plus some buffer (e.g. 5 degrees) such that deviation is minimized (40-deg right turn preferred over 60-deg left turn)
- For encounters requiring secondary action, adding a heuristics that considers minimizing reversals is recommended (e.g. switch from turn left to turn right)
- Incorporate basic right-of-way rules

Trajectory Generation

- UA performance...
- Trajectory generation required for maneuvers; this would be inherit to the individual simulation platform (e.g. ACES, 2-PAIRS, USAF/MITLL CASSATT)
- Trajectory generation needed to close the loop, perform the maneuver, so risk ratios and other metrics can be calculated
- Kinematic trajectory generation is probably good enough
 - Roll rate, bank angle, load factor, and climb/descend rates

Concluding Remarks

- We should agree on the scope and assumptions of pilot model for end-to-end V&V activities
- Common interface could be created for each module
- Straw-man pilot model needs to be hooked up to simulation platform (target generation with time updates)