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Artificial Bandits and Wingmen

a project on FCAS autonomy

Petter Ögren

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Messages from This Morning

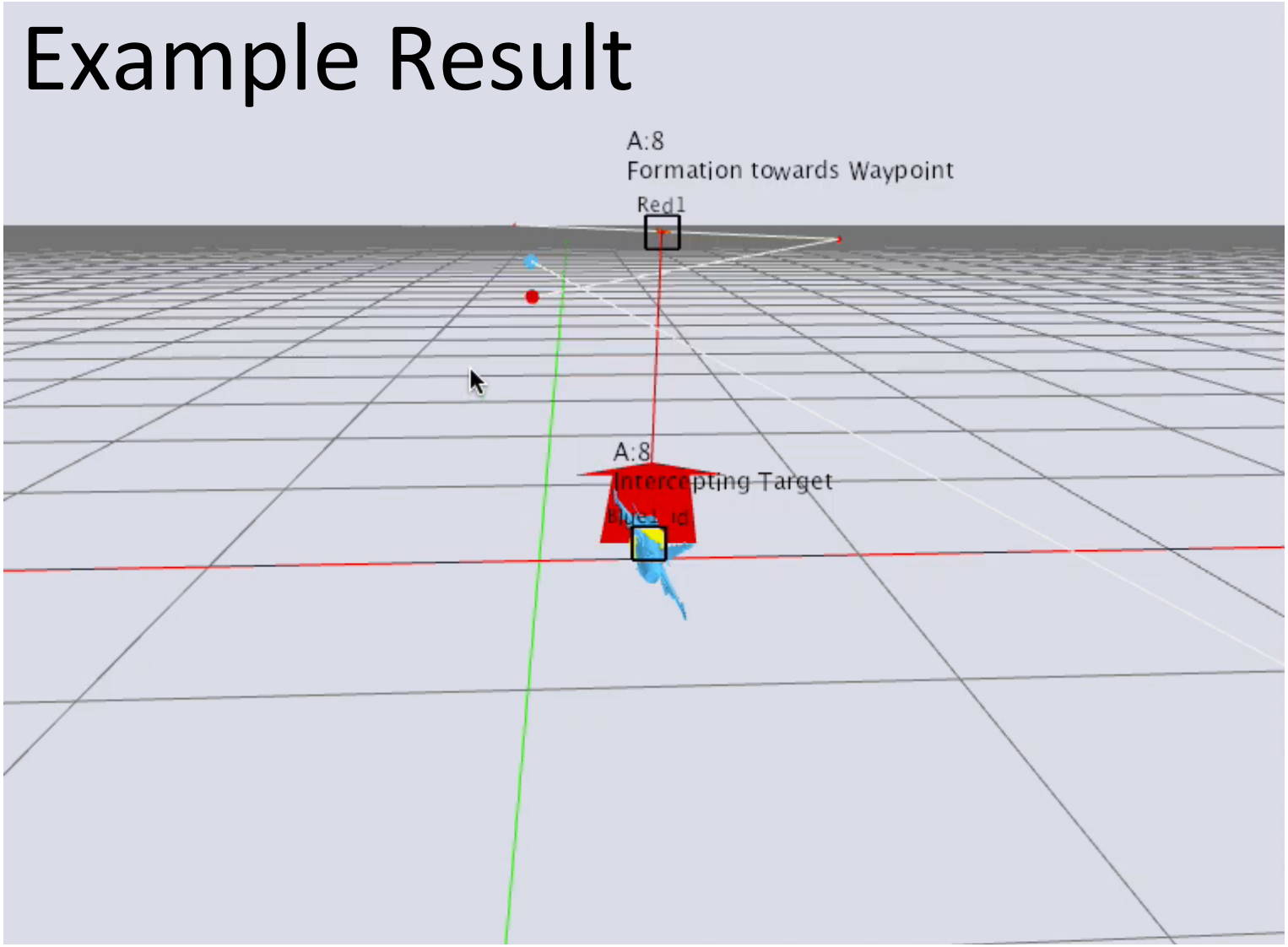
- *"Autonomy is a current priority"*
  - AFRL Commander McMurry

- *"A key trend is Automation and Autonomous systems"*
  - Saab Director of Future Business, Lars Sjöström:

Outline

- Problem Formulation
  - USAF Perspective
  - Robust, Efficient, Transparent Autonomy
  - White Box vs Black Box Autonomy
- Results so far
- Focus Ahead

Example Result



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Problem Formulation

- Future Combat Air System (FCAS):
  - Mix of Manned and Unmanned systems
  - Distributed Sensors and Weapons
  - Flexible and Adaptive
- Needs:
  - **Autonomous Decision Making**
    - Robust, Transparent, Efficient
  - **Human Autonomy Team**
    - Robust, Transparent, Efficient

ArBaWing Project Goals

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USAF Perspective

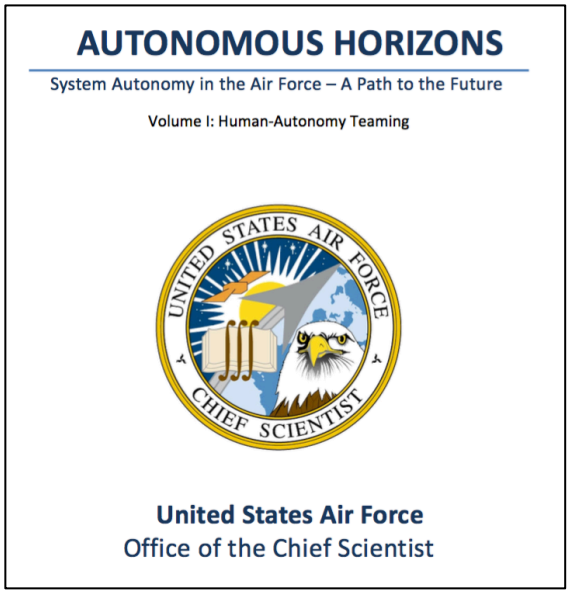
USAF Vision:

- Human-Autonomy Teams

Critical factors:

- **Robustness**
- Autonomy Levels
- Ease of interaction
- Automation **transparency**

(i.e. Robust, Transparent, Efficient)



Mica Endsley

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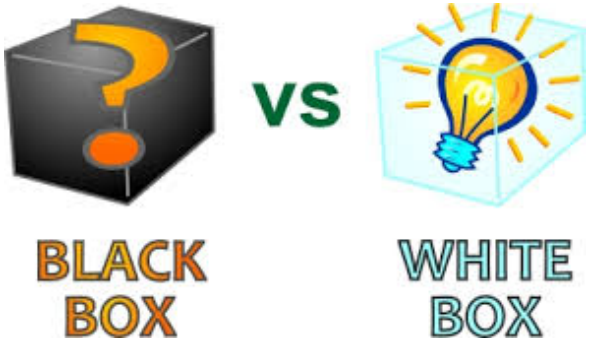
Why Robust and Efficient Autonomy?

- Why Robust?
  - Combat is unpredictable
  - Avoid brittle autonomy (narrow assumptions)
- Why Efficient?
  - Need to win combat

Why **Transparent** Autonomy?

- Operator needs to
  - Know What system does and Why
  - Trust System
  - Stay in the Loop
- Rules of Engagement → Transparency
  - Why did you fire?
  - Changes between missions

Approaches to AI



- Black Box Examples
  - Deep Learning
- State-of-the-Art on
  - Alpha Go
  - Object recognition
  - Old Atari games (several)

- White Box Examples
  - Finite State Machines
  - Subsumption Architechture
  - **Behavior Trees**
- State-of-the-Art on
  - New Computer games
  - Air Combat Simulation

Proposed solution

&

Combination

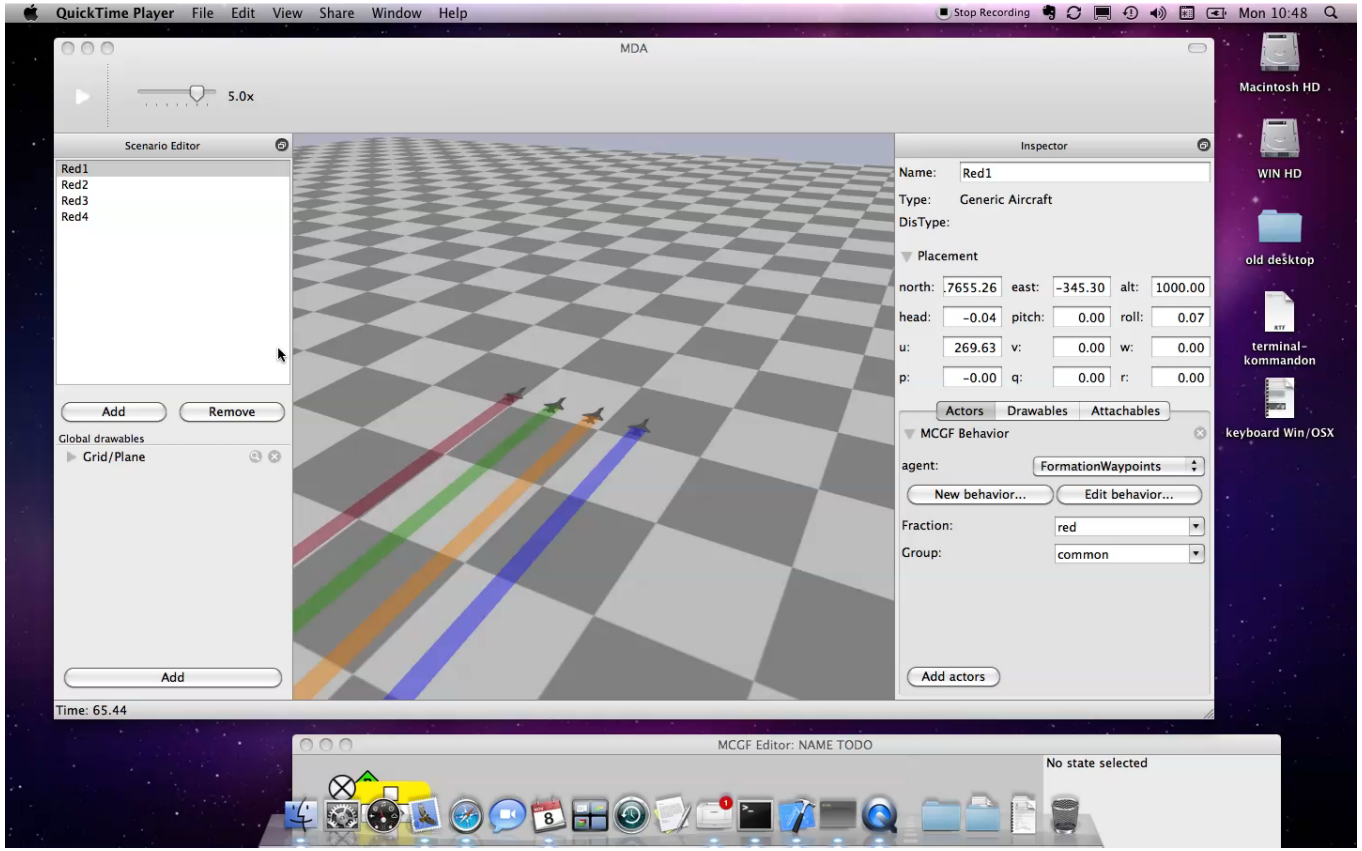
- **Deep Learning**
  - Efficiency (extra)
  - Needs 30 million training data points
    - from White box design

- **Behavior Trees**
  - Transparency
  - Robustness
  - Efficiency (State-of-Art)
- and...
  - Rules of Engagement check
  - Verification/Validation
  - Quick adaptation to change (Amraam->Meteor)

AI tool: Behavior Trees

- From Computer Game AI
- Generalizes earlier approaches
  - Finite State Machines
  - Subsumption Architecture
  - Teleo-Reactive Approach
  - Decision Trees
- BT editors for Major Game Engines:
  - Unreal Engine
  - Unity 3D
  - Pygame
- Advantages
  - Modularity
  - Flexibility
  - Reuseability

Results so far: Formations



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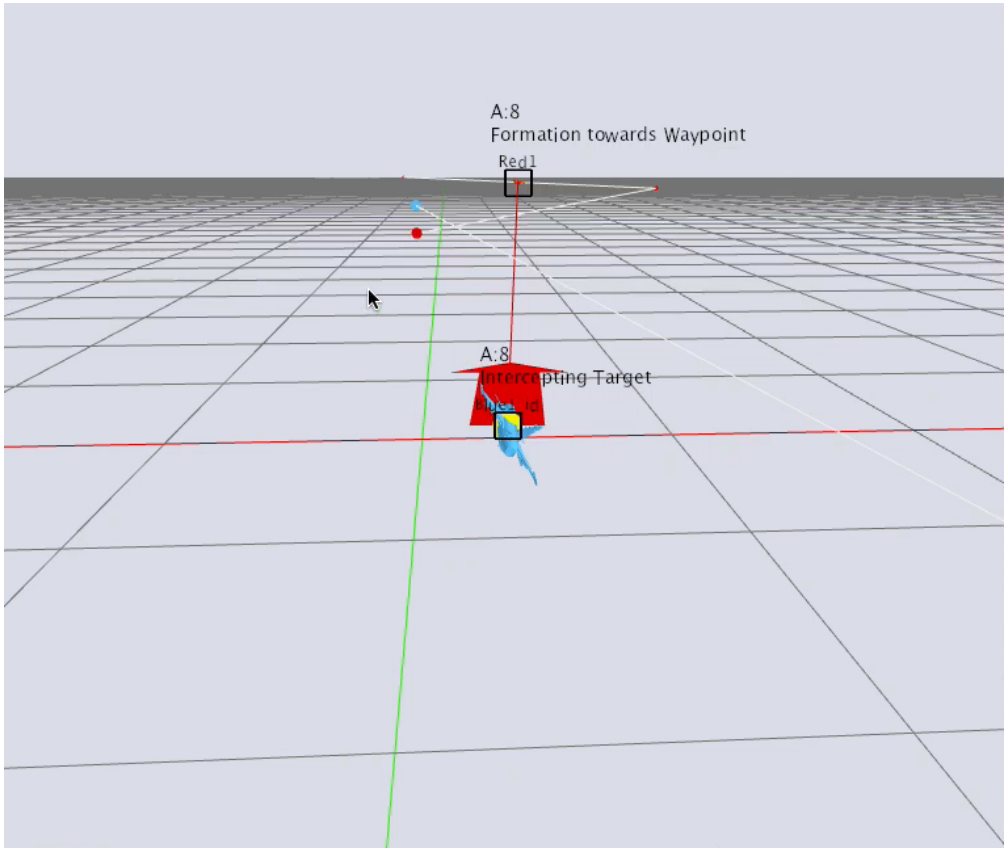
Results so far: Combat 1 vs 1



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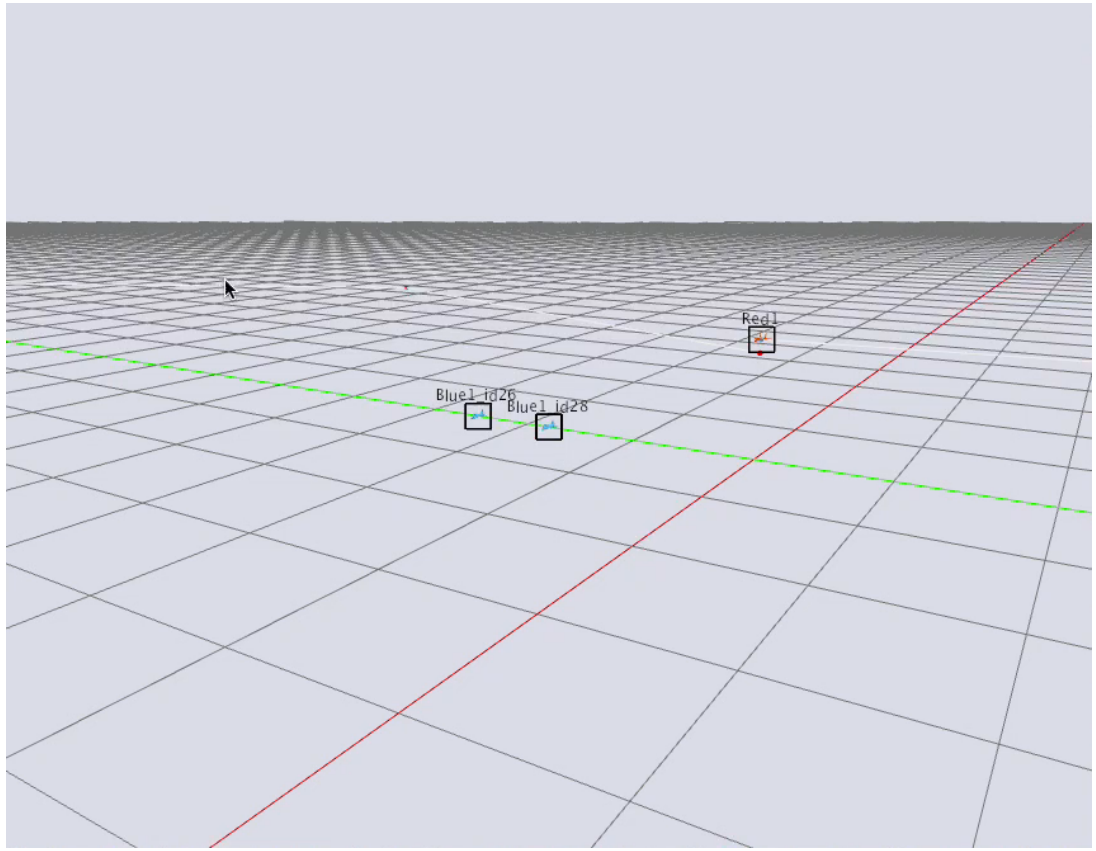
Results so far: Combat 2 vs 1



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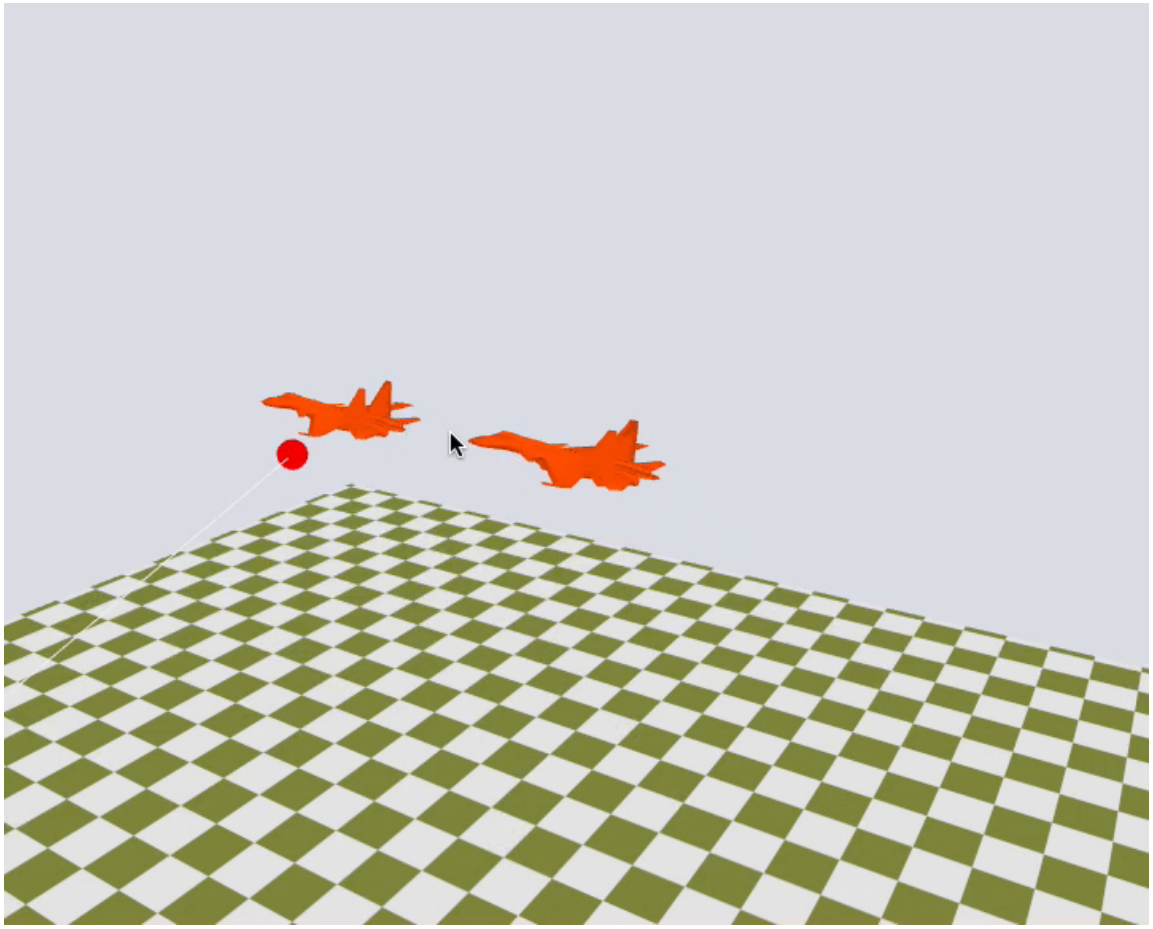
Results so far: Combat 2 vs 2



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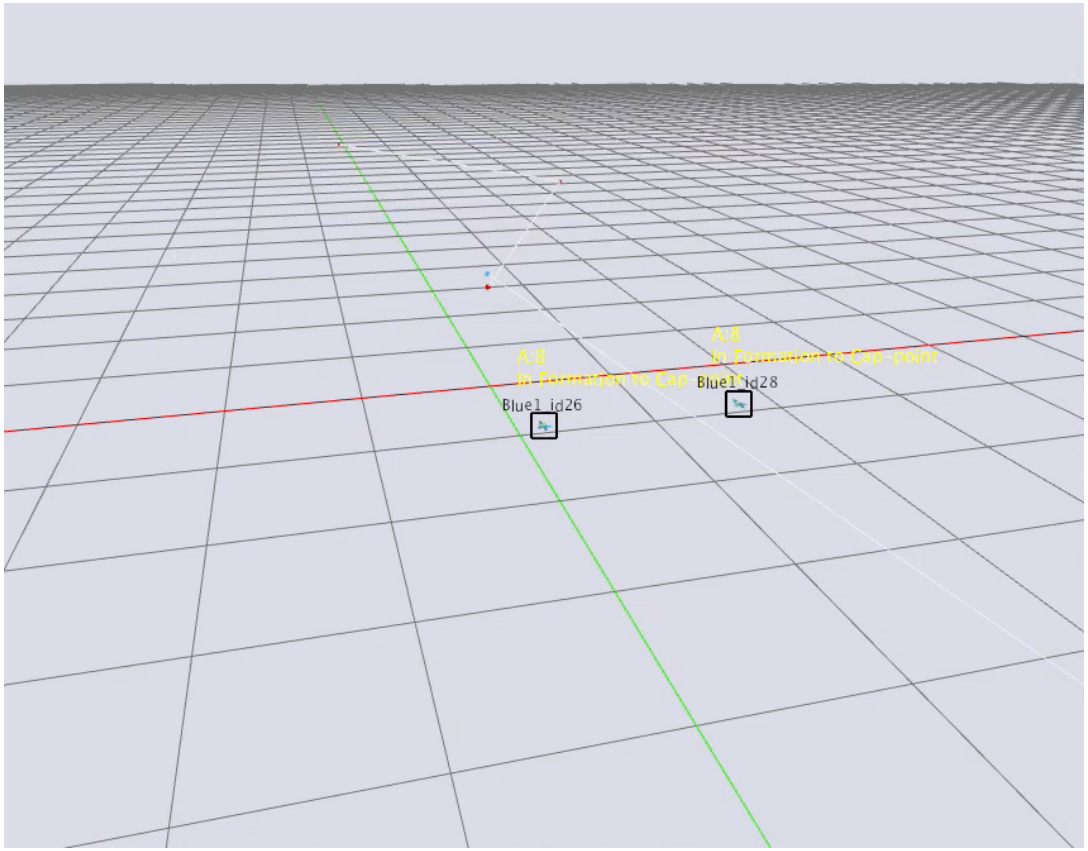
Results so far: Patrolling



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Results so far

- Code **running daily** at FLSC (air combat sim. center)
- 4 pilots vs 4 virtual
  - kills on both sides
  - hard to tell who is who

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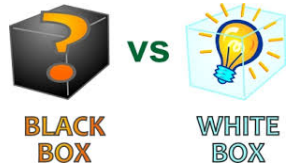
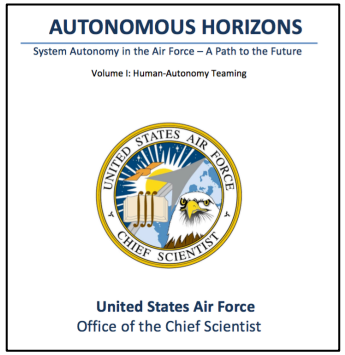
Focus Ahead for KTH/Saab

- Investigate Human-Autonomy Teams
  - Combine White/Black Box Solutions
  - Different Autonomy Levels
  - **Robustness, Efficiency, Transparency**





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Organization: Key Partners

- Petter Ögren
  - Associate Prof. in Robotics and Autonomous Syst, KTH
  - 9 years at FOI, designing **Air Combat behaviors at FLSC**
- Henrique Costa Marques, PhD
  - Former Brazilian **Air Force Pilot**
  - ITA researcher in Autonomous Air Combat
- Joao Alexandro B. M. Vilela
  - Former Brazilian **Air Force Pilot and flight instructor**
  - AEL Business Development manager
- Lars Pääjärvi
  - Head of Sensor Fusion and **Tactical Control**, Saab Aeronautics

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Funding

- ITA/AEL
  - 2 MSc students during 2016
  - 2 PhD students starting 2017
    - AEL Funding for 1 PhD student at ITA
- KTH/Saab
  - 1 MSc student 2016
  - **Will apply for NFFP7 project**

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Thank You…

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