Requirements-Driven Autonomous System Test Design: Building Trusting Relationships

ITEA Live-Virtual-Constructive Conference

Unmanned and Autonomous System Testing

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Introduction

- Military and civilian users could benefit now from more “autonomous” system collaboration
  - Remove dedicated human operators from each system
  - Surveillance, transport, threat recognition
- Formal methods of general test and evaluation of autonomous systems
  - Standards lacking that apply across system types (air/ground/sea)
  - Need a common language in system development and evaluation

Purpose

- Propose a framework for specifying autonomous system requirements and test planning
  - Common characteristics between air/land/sea based systems
  - Examples based on experiences during DARPA Urban Challenge
- Ultimately, build trusting relationship between human operator and autonomous system

MIT DARPA Urban Challenge Vehicle, Talos

- Land Rover LR3
  - Multi-Modal perception
  - High accuracy GPS/INS
  - Super-computer powered
- Completed Urban Challenge Race 2007
  - 4th Place Overall
  - 60 Miles of autonomous driving

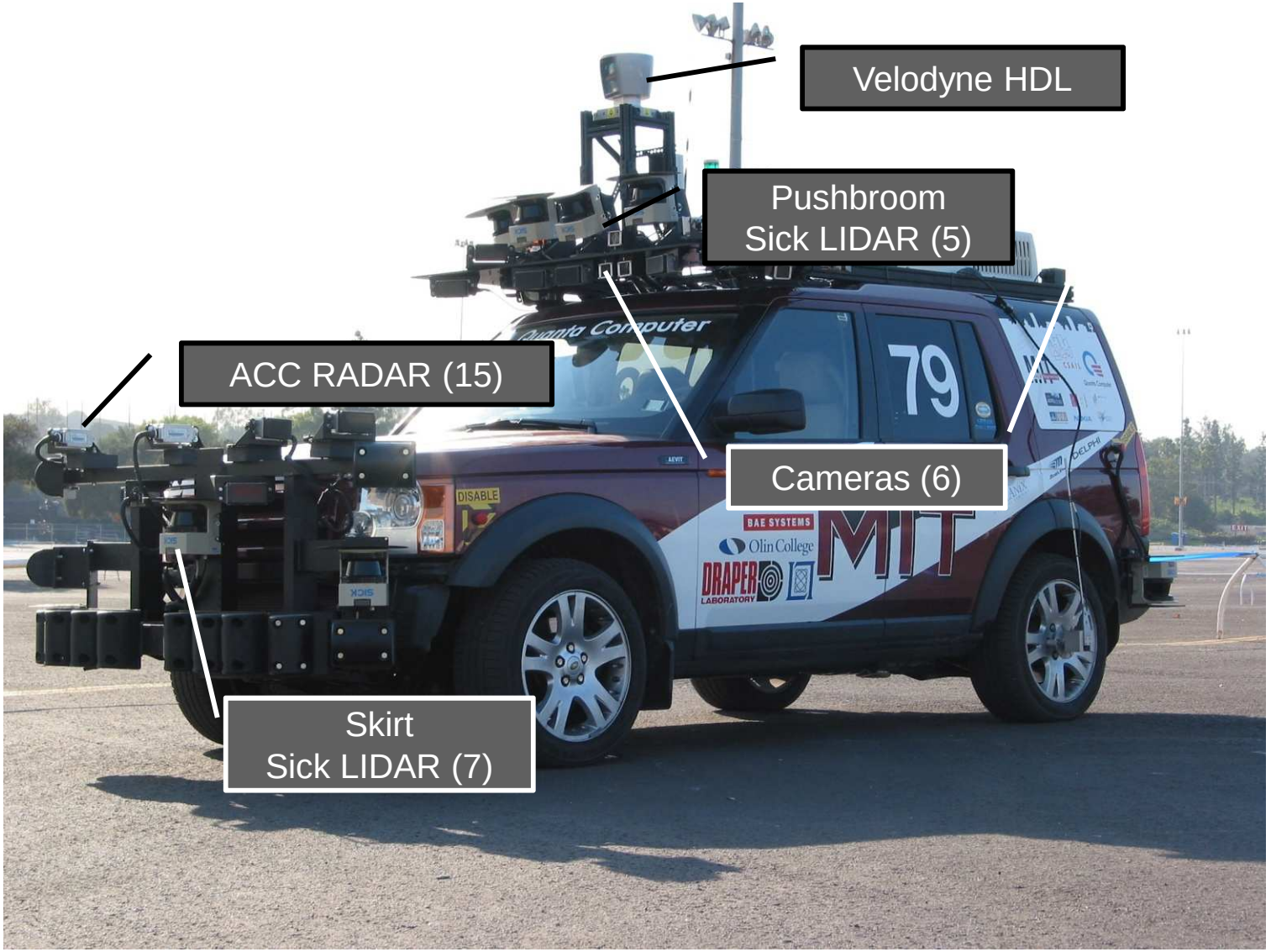


Photo Taken by: T. Jones, October 2007

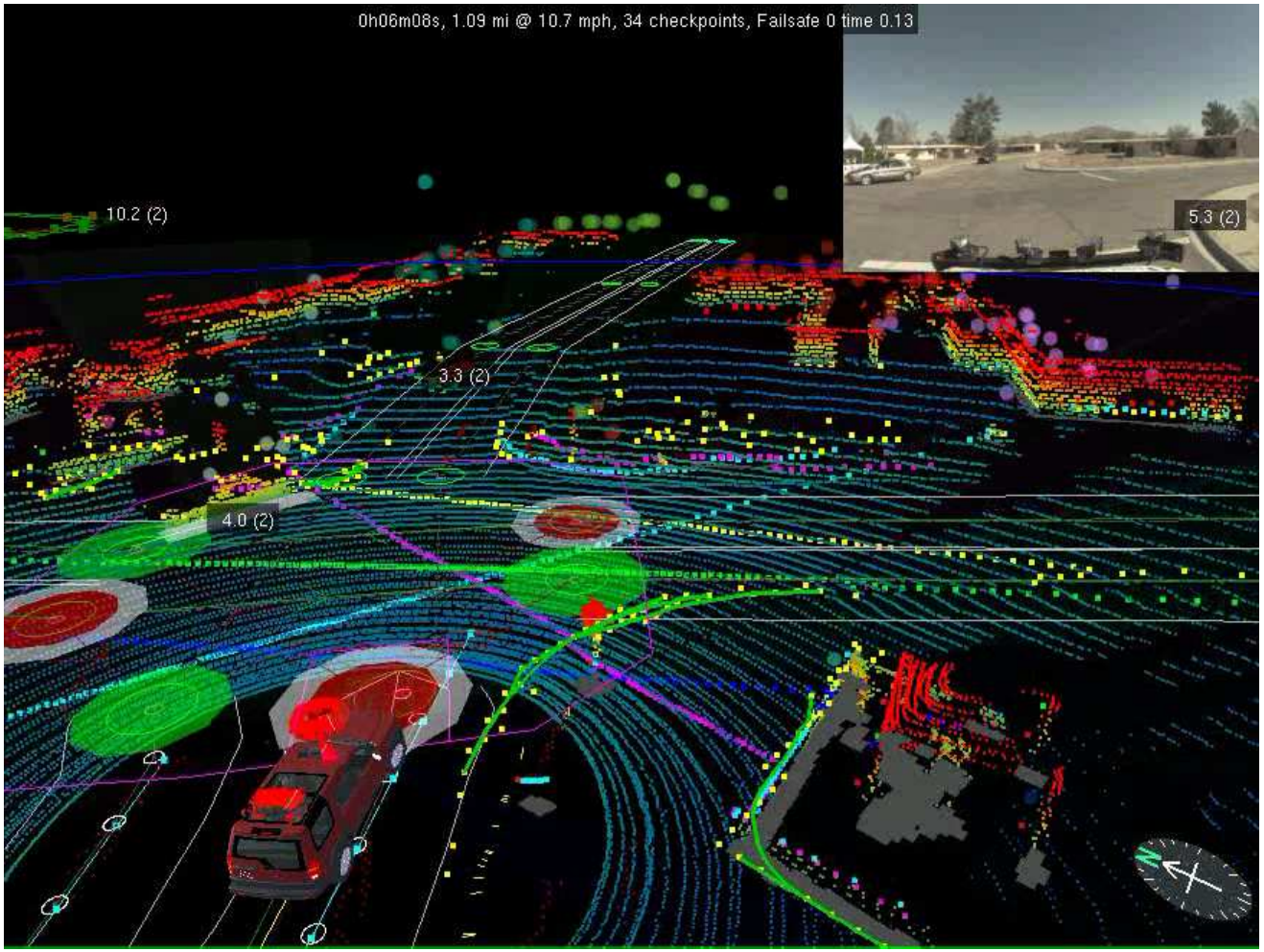
Autonomous System Characteristics

- Environment Uncertainty
- Frequency of Operator Interaction
- Level of Assertiveness

Environment Uncertainty

- Primary driver for required system perception
  - High uncertainty environments require perception in many directions
  - Quantify as potential time to collision with objects in environment
- Perception Coverage Metric
  - Based on percentage of volume around system interrogated by sensing
  - Calculated for human vision and Talos LIDAR system

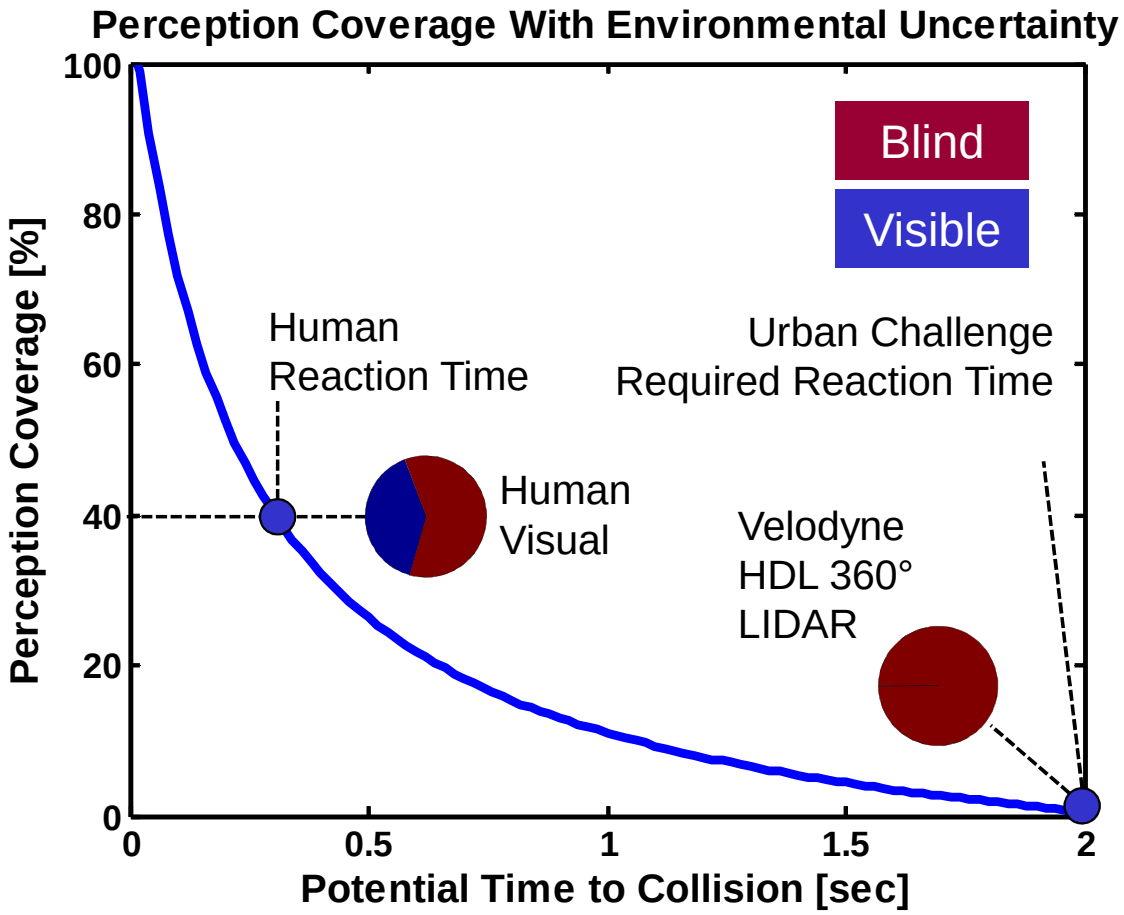
MIT Talos Environmental Perception



- LIDAR Perception
  - Primary object tracking method
  - Driving Surface Detection
- Camera Perception
  - Road markings
  - Lane estimation
- RADAR Perception
  - Distant vehicle warning
  - Not accurate

Image Captured from: http://people.csail.mit.edu/lukesf/files/perception.avi

Perception Coverage

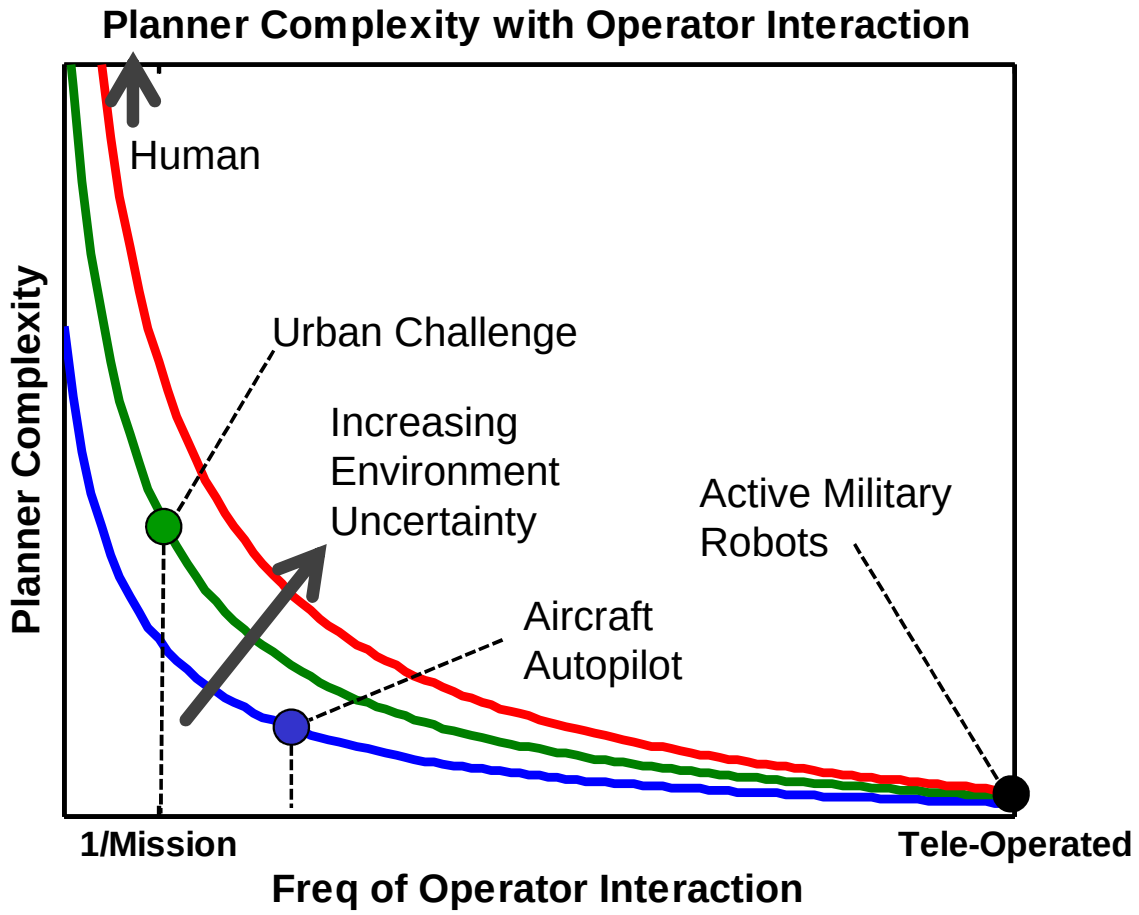


Urban Challenge vehicles largely performed safely – in controlled conditions – with extremely low coverage

Frequency of Operator Interaction

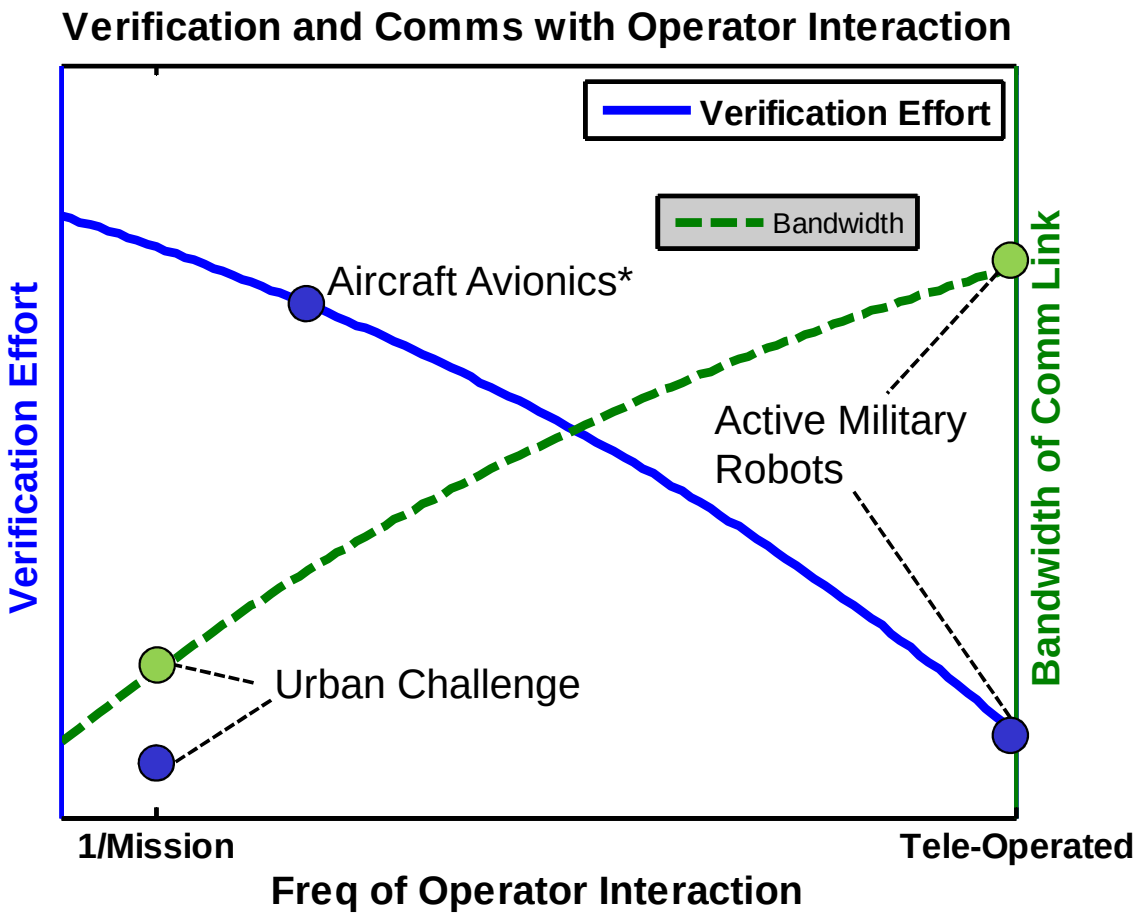
- Autonomous systems will need help from operators
  - Moving away from tele-operation, operators must resolve hard conflicts
  - Drives complexity of on-board “decision making” (Planning)
  - Drives effort required to verify performance and safety
- Planner Complexity & Verification Effort Metrics
  - Comparing Autopilot to Urban Challenge
  - Also dependant on Environment Uncertainty

Planner Complexity



Urban Challenge vehicle performance still far below human ability

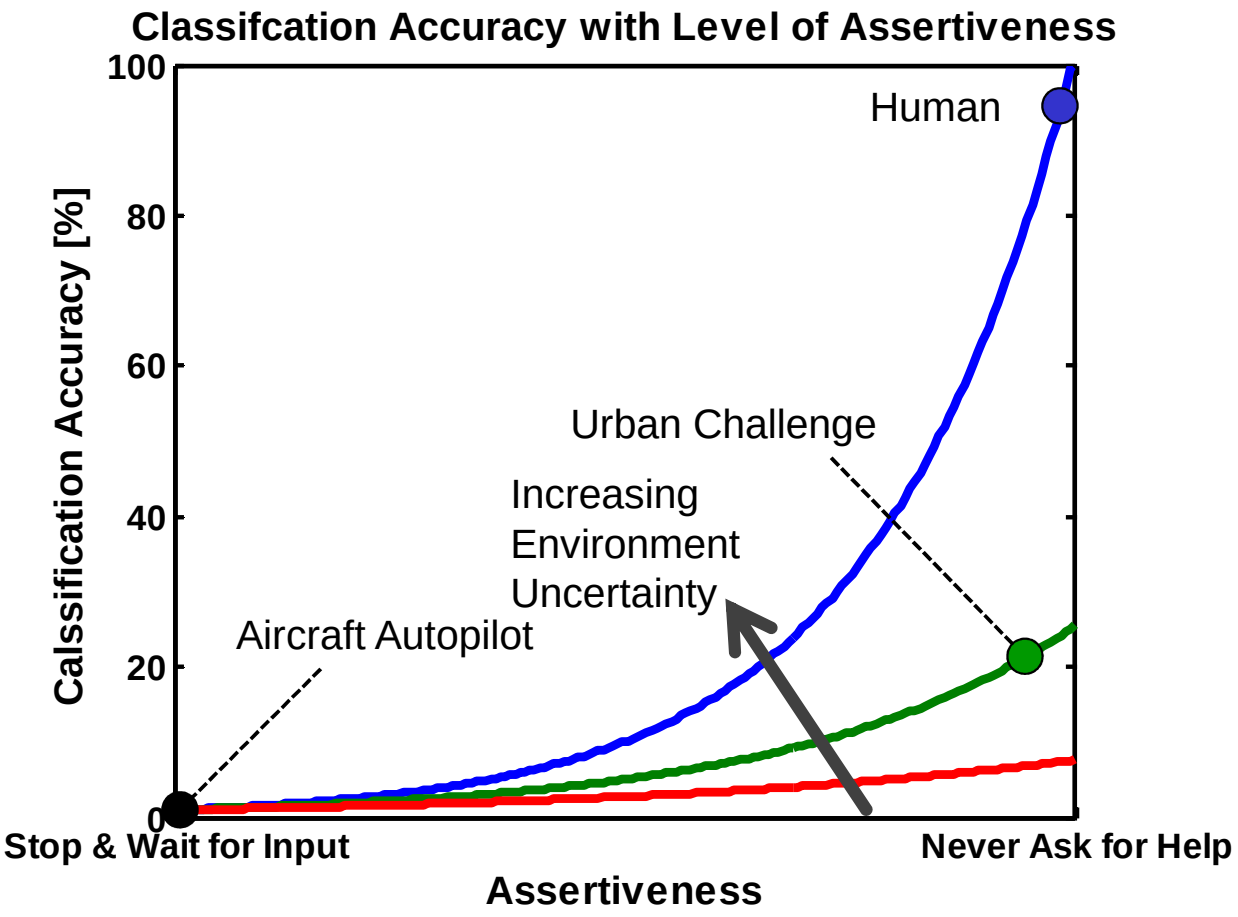
Verification Effort



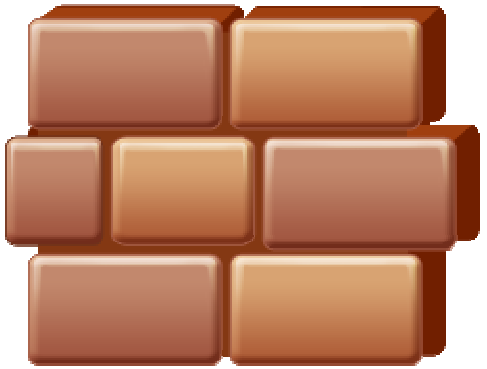
Level of Assertiveness

- How much assertiveness is appropriate for an autonomous system?
  - Assertiveness improves mission effectiveness
  - Drives need for accurate classification of objects
- Classification Accuracy Metric
  - Accurate recognition of objects in real-time difficult
  - Urban Challenge example limited in scope by rules

Classification Accuracy



Or



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Conclusions

- Understanding impact of high level autonomous system characteristic decisions improves requirements development
  - Select missions in low uncertainty environments first
  - Work with operators to establish desired guidelines for interaction frequency and complexity
  - Select the required assertiveness, and educate the collaborators on behaviors
- Test development process simplified and focused by same concepts