MODELING, SIMULATION, PROTOTYPING & VALIDATION

The Use and Benefits of Modeling and Simulation With Autonomous Vehicles

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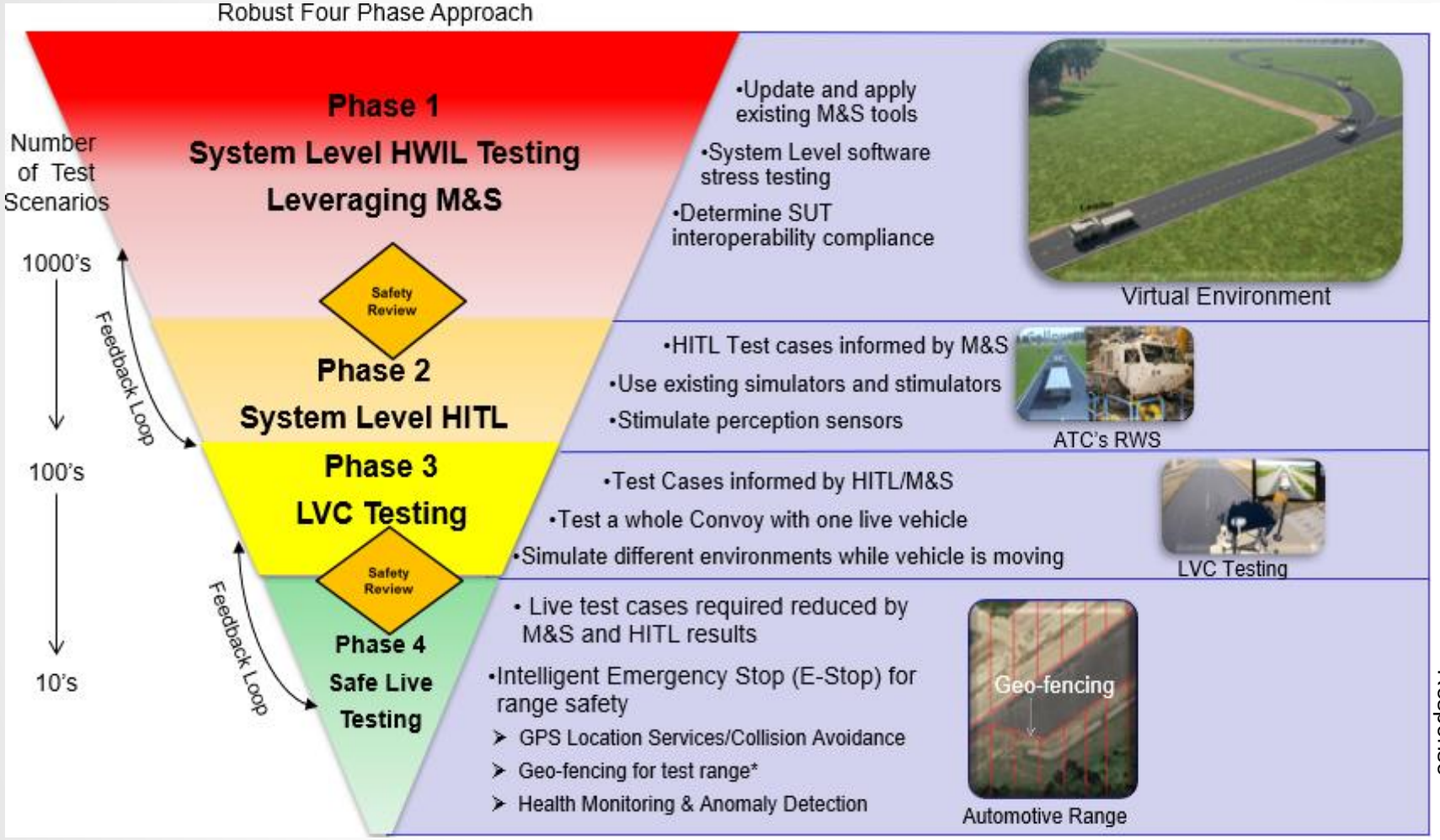
Modeling and Simulation OV-1



ASTCDRIVE
Digital Robotic and Autonomous Systems (RAS) Integrated Virtual Environment

ASTCSEER
Safety Environment, Engagement and Response

DRIVE and SEER allow for more test scenarios to be conducted while reducing the number of live scenarios and ensuring the safe conduct of those live scenarios

SUT – System Under Test
HITL – Hardware in the Loop
RWS – Roadway Simulator
LVC – Live Virtual Constructive
ASTC – Autonomous Systems Test Capability

What Is The Digital Robotic and Autonomous Systems Integrated Virtual Environment?

ASTC's DRIVE is a Virtual Test Center.

DRIVE Overview

MODELING, SIMULATION, PROTOTYPING & VALIDATION

TOOL: UNREAL
Capability: Virtual Environment
EXAMPLE: Digital Twins of ATC's ATEF and Perryman Test Area

TOOL: HITL
Capability: Links Virtual Leader with Live Follower
EXAMPLE: hardware and mechanical check of autonomy

TOOL: RAPT
Capability: Scenario Planning and Evaluation
EXAMPLE: Evaluates multiple scenarios against predetermined criteria which reduces live test scope

High Performance Computing

DRIVE was fielded June 2023

TOOL: DCRA-V
Capability: Data Collection, Reduction, Validation, Analysis
EXAMPLE: Sensor Information, Vehicle Response Data

TOOL: RIOT
Capability: Fault Injection/Fault Analysis
EXAMPLE: Loss of GPS, steering malfunction, loss of LIDAR

TOOL: VANE
Capability: Weather, Obstacles, Time of Day, Sensors
EXAMPLE: Rain, Snow, Fog, Twilight, People, Animals, LIDAR Response

DRIVE uses 6 tools integrated into 1 program that will provide various modeling and simulation capabilities through a Software Integration Lab and the High Performance Computer at Aberdeen Proving Ground.

Software Integration Lab – Phase 1

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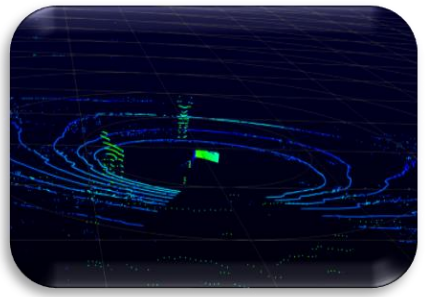
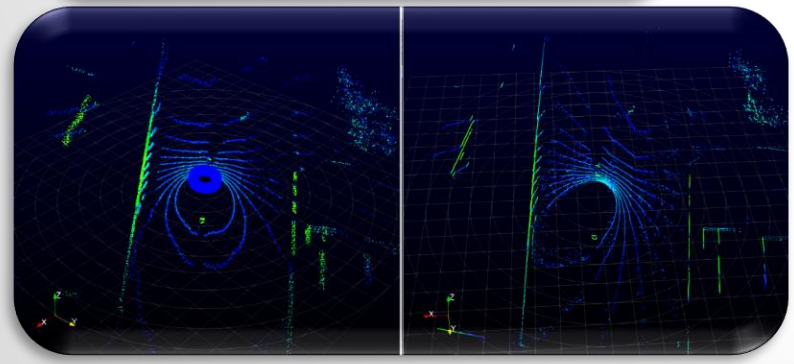
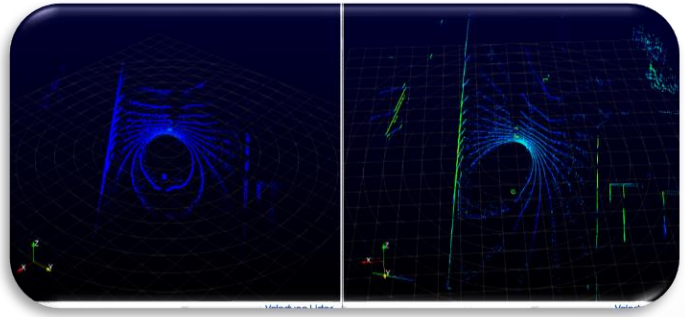






Hardware in the Loop

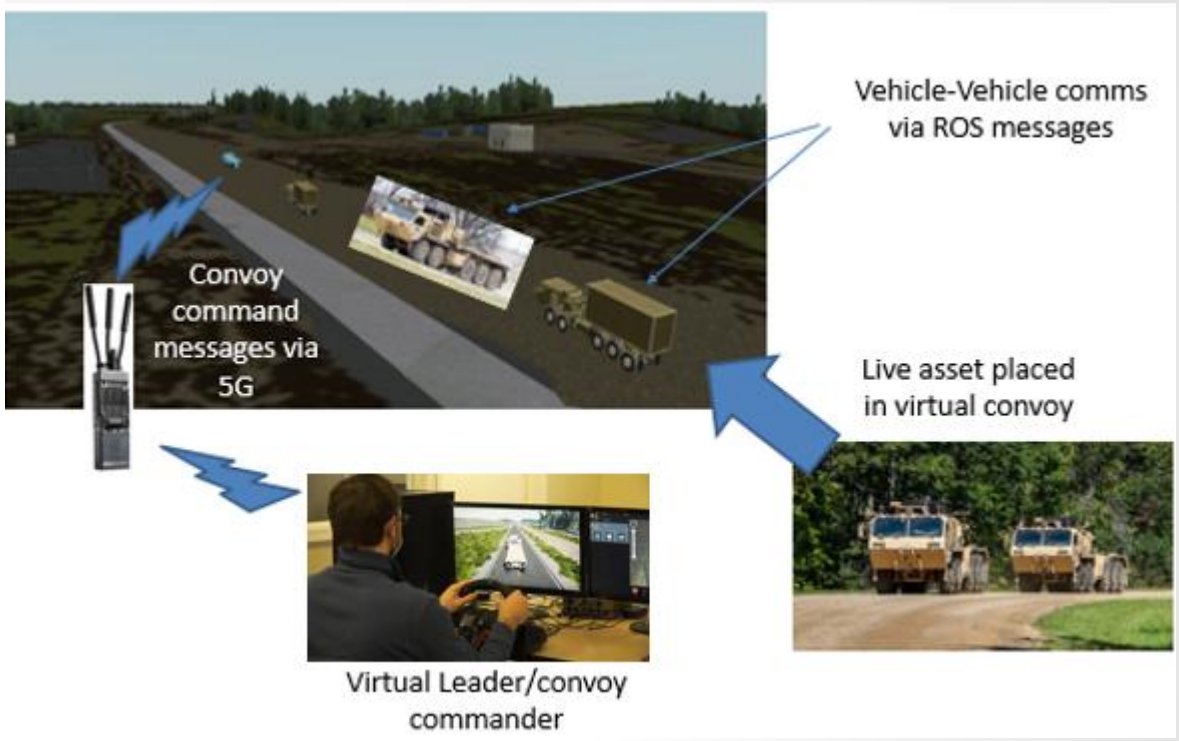
Extensive Hardware in the Loop Testing – Phase 2

ATC's Roadway Simulator

ATC's Combat Systems Support Laboratory

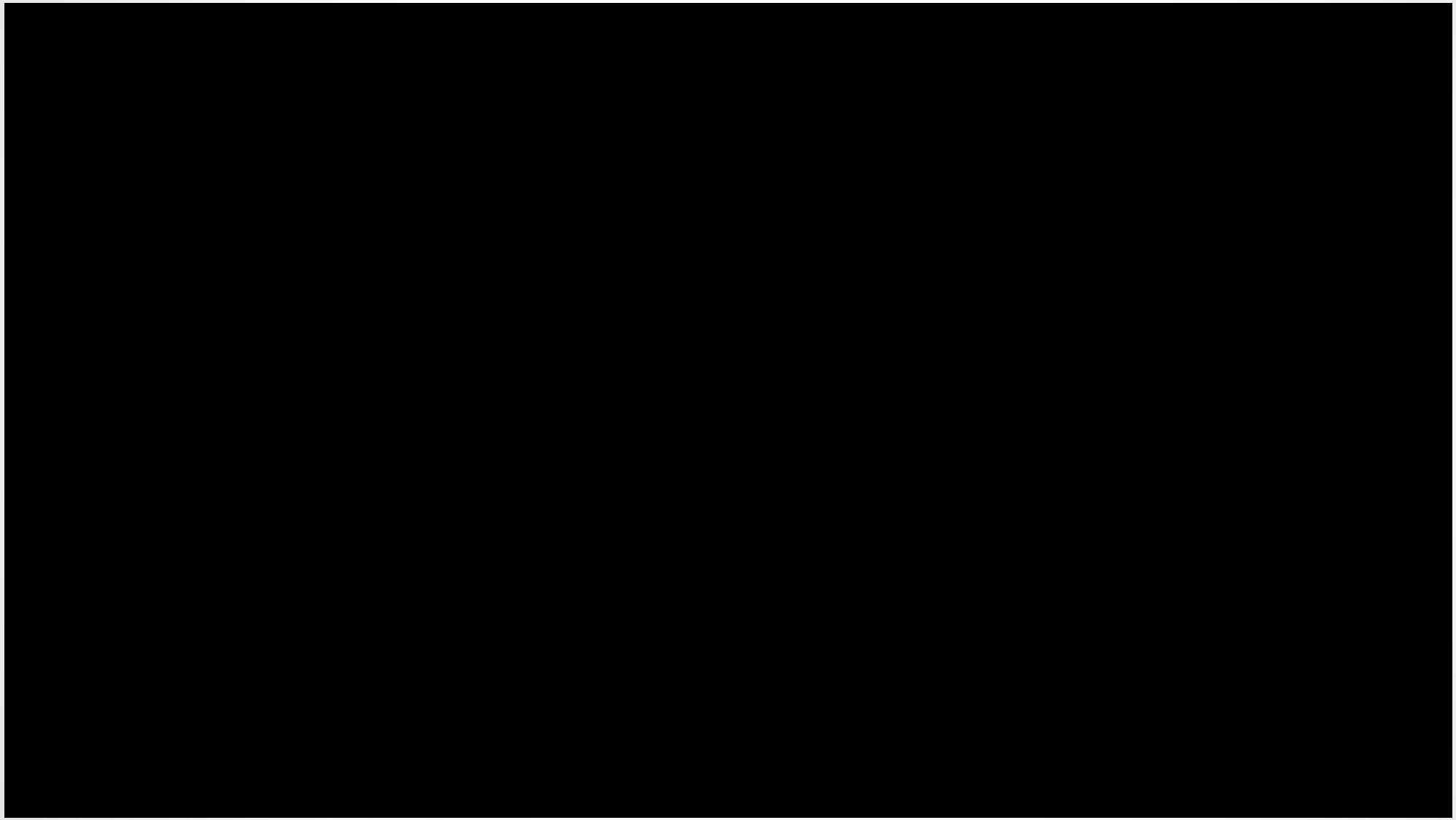
ATC's EMI Chamber

Live Virtual Constructive Testing – Phase 3



Hardware in the Loop Video

Live Virtual Constructive Video



What is Safety Environment, Engagement and Response (SEER)?

SEER (Phase 4) is hardware/software applique kit that will allow unmanned operations to occur with no safety driver but still allow the test team control over the systems under test allowing more repeatable definite data to be collected.

SEER Overview

Capability: Intelligent Emergency Stop
Example: SEER will detect if the system's emergency stop failed to operate and stop the vehicle as well as allow the Test Engineer to stop it through a button press if something undesirable was observed.

Capability: Mobile Safety Zone
Example: Examine Radar, LIDAR, and other information to keep a safe distance from other objects especially other vehicles. SEER would cause the vehicle to come to a safe stop if that cannot be achieved.

Capability: Anomaly Detection
Example: SEER will detect electrical and mechanical anomalies and bring the vehicle to a safe stop if they are present.

Capability: Geo Fencing
Example: Examine Position and cause the vehicle to come to a safe stop if it departs the allowable location.

SEER's expected delivery date is 2Q FY 25

ASTC SEER will facilitate ATC with conducting unmanned operations while still having control of the systems under test.

Stage 1 Benefits

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A typical ATV-S test is about 1,000 miles over the course of 8 weeks

Typical ATV-S testing has required 2 additional weeks of retesting

	Live	ASTC
Time of Scenario	15 minutes*	15 minutes*
# of hours per day	12 (8 actual testing)	24
# of hours per week	60	168
# of scenarios per hour	3	400
# of scenarios per day	24	9,600
# of scenarios per week	120	67,200
# of personnel needed per day	20	6
~Cost Per Day	$16,800	$3,780
~Cost Per Week	$84,000	$16,800
Retest Cost	**$168,000**	**$1,050**
Fuel Cost	**$9,600**	**$0**
Total Cost	**$914,400**	**$18,900**

*Based on one lap with a four vehicle convoy around the Automotive Technical Evaluation Facility
ATV-S = Autonomous Transport Vehicle System

Modeling can run a typical Leader Follower test phase in 2.5 hours collecting 192 Gigabytes of test data, and reducing the cost by a 1/50th