Heavy Truck Platform Update

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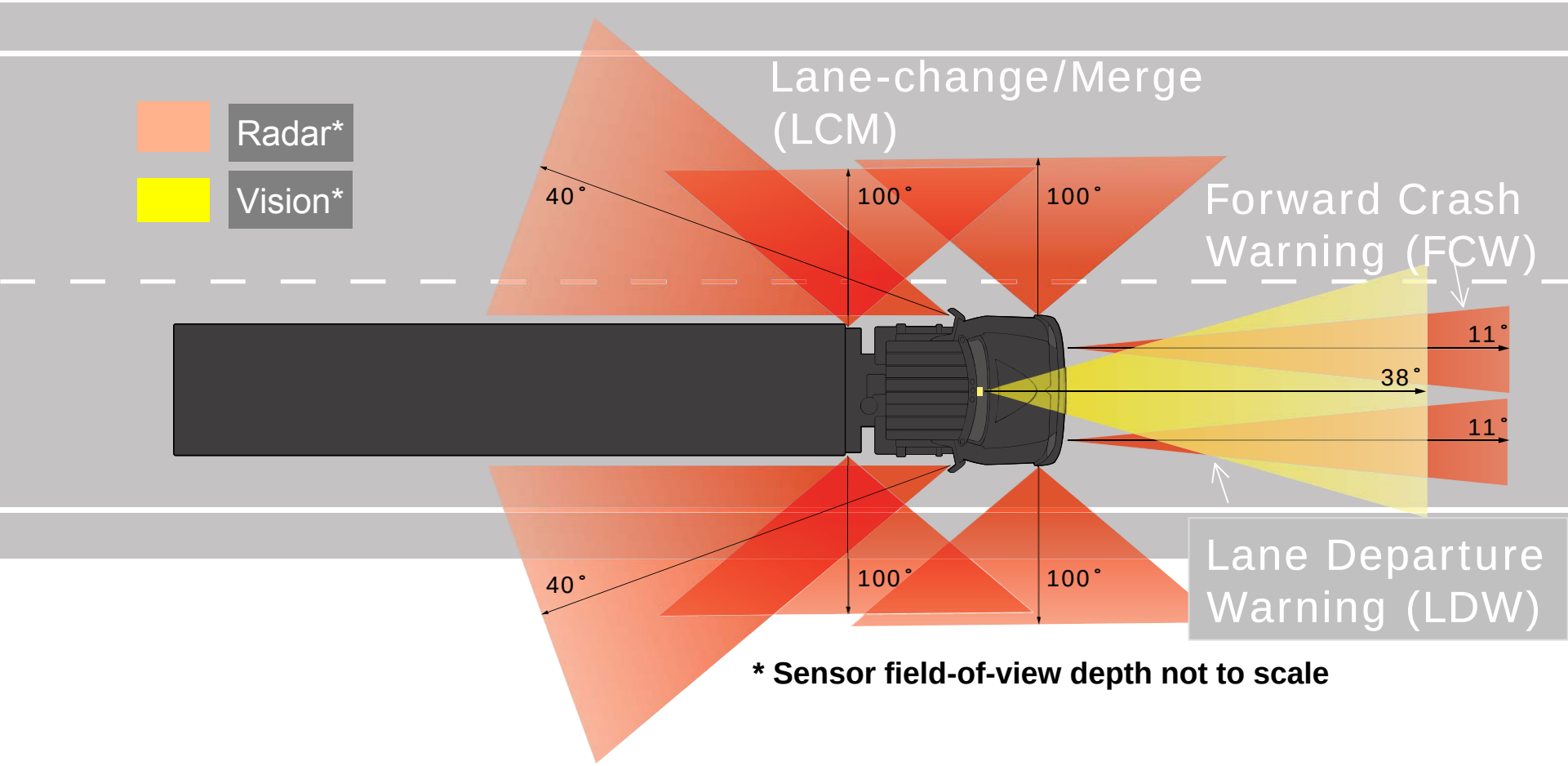
Outline

- System overview
- Year 2 progress summary
- Key developments
  - Functional-requirement-driven development process
  - Subsystem integration
  - Subsystem developments
  - Arbitration/Driver-Vehicle-Interface
- Configuration Change Control
- Phase II development plans
- Field Operational Test (FOT) readiness

Integrated Safety System

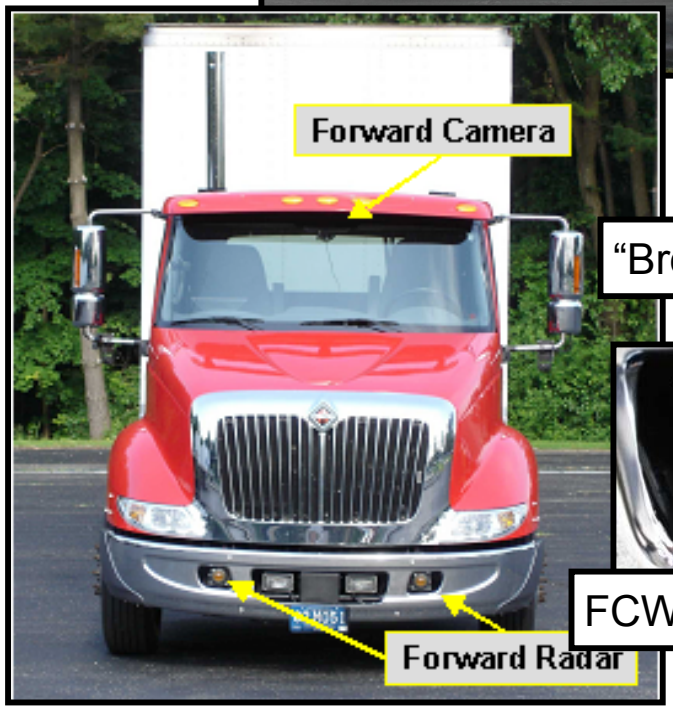


*** Sensor field-of-view depth not to scale**

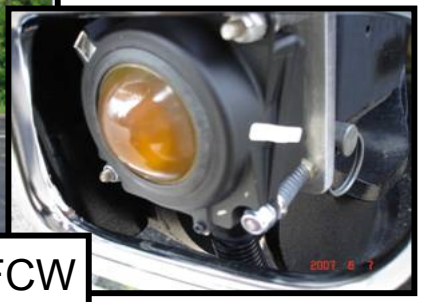
Prototype Vehicles

"Mule" Suburban & "Bronze" ITE 8600

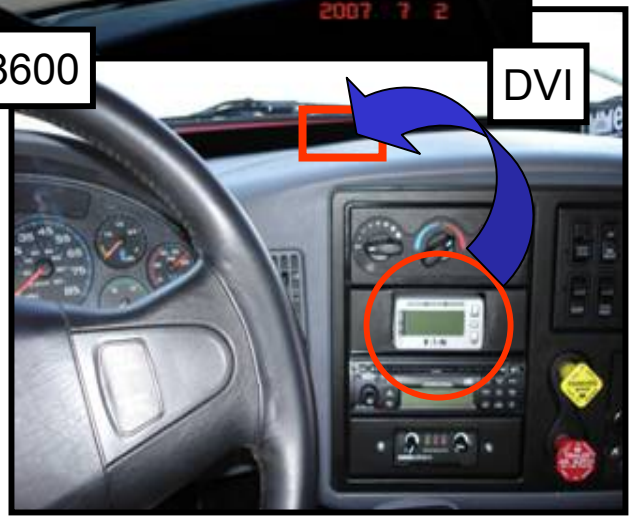
"Mule" Vehicle

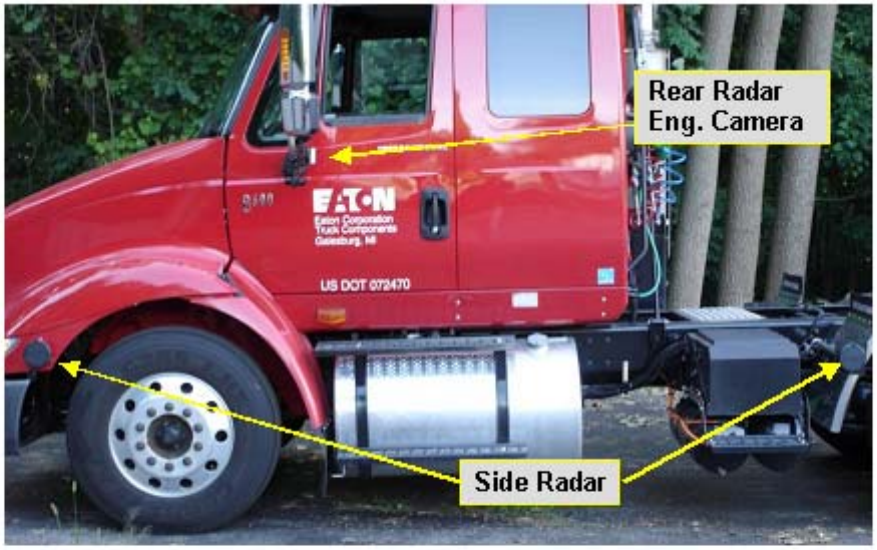


"Bronze" International 8600

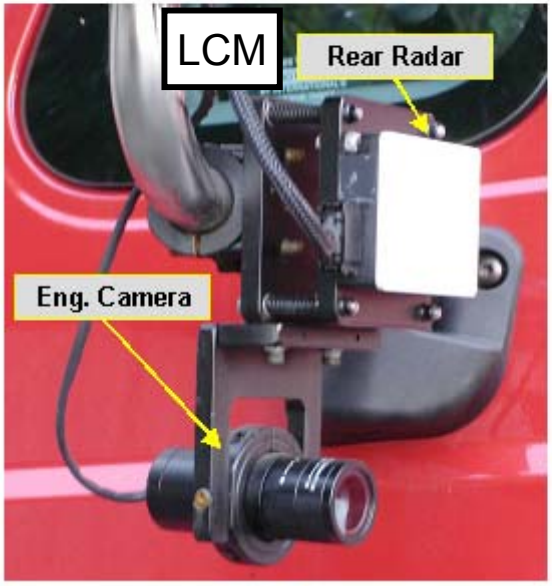


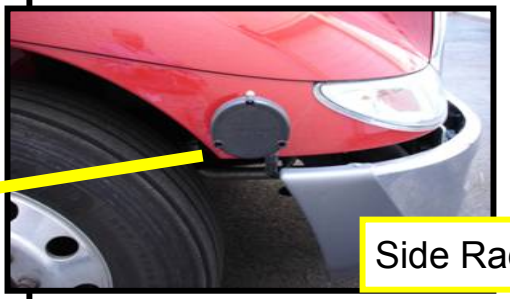
FCW





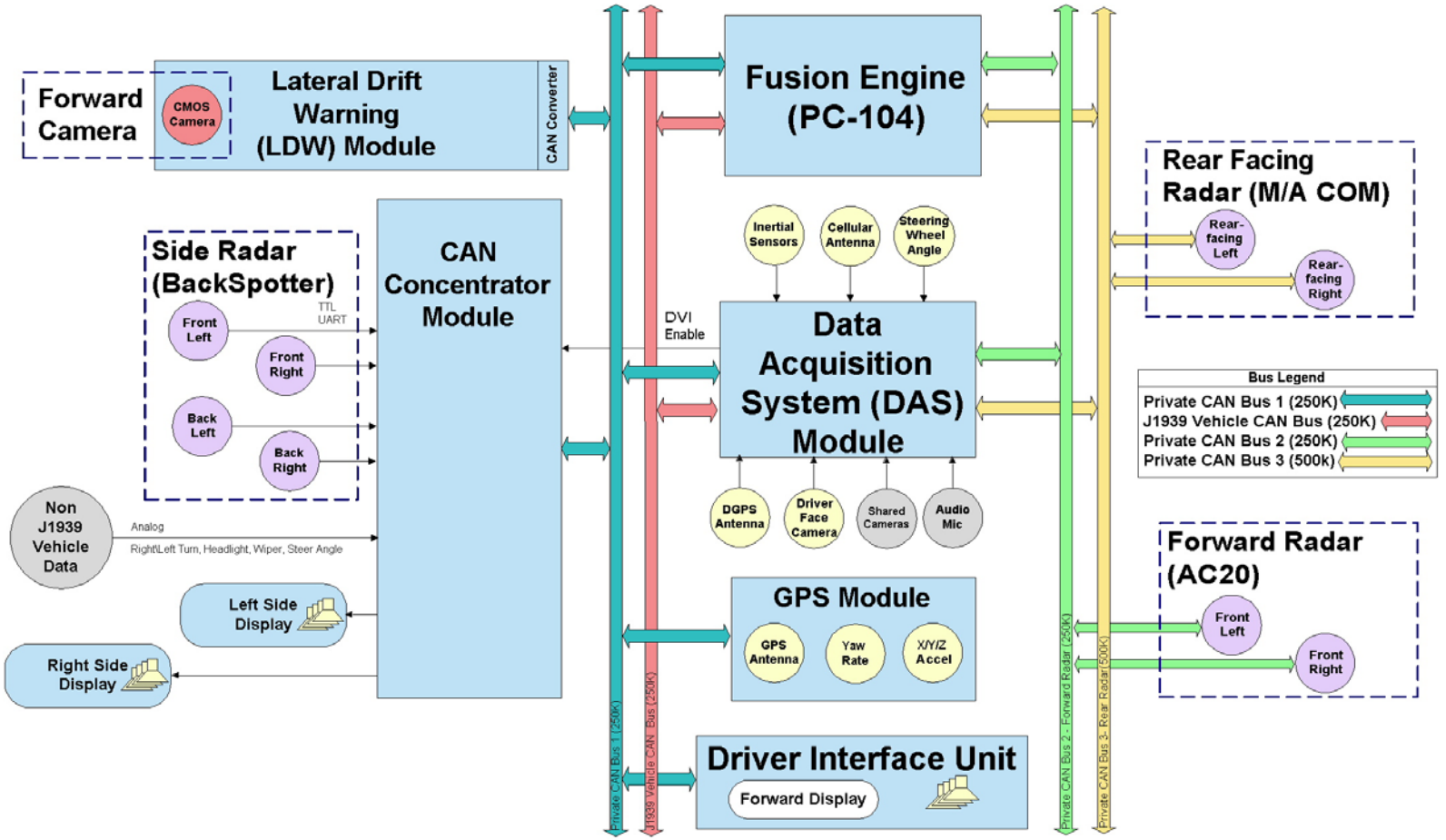
"Bronze" ITE 8600





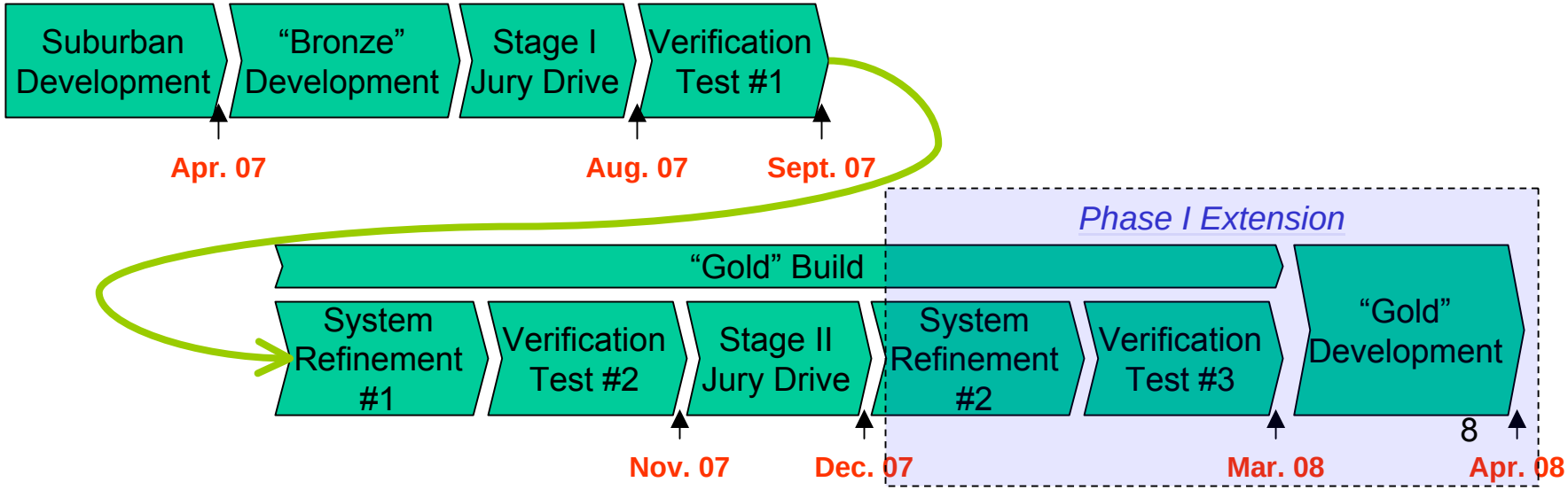
Prototype Vehicles
“Gold” ITE TranStar (8600)

Heavy Truck System Architecture



Year 2 Summary of Progress

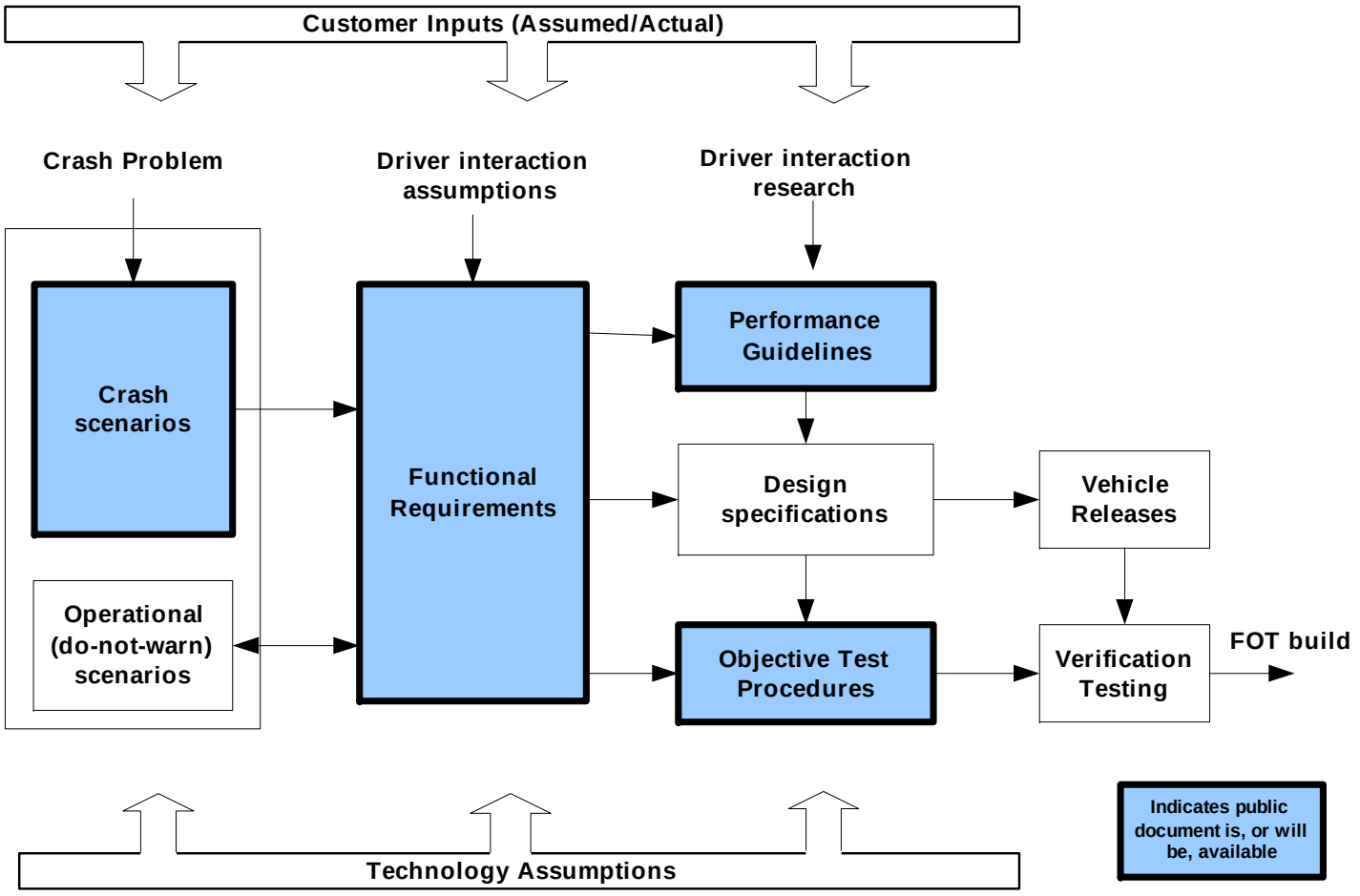
- Development and testing that are complete
  - Subsystem development and integration
  - System implementation on two prototype vehicles: the “Bronze” and the “mule” vehicle
  - Verification testing of IVBSS: on-track and on-road
  - Pilot (Stage 1 & 2 Jury Drive) testing
- The “Gold” truck build is nearly complete



Year 2 Summary of Progress

- Major deliverables:
  - Functional Requirements
  - Performance Specifications
  - Objective Testing Procedures (OTP)
  - Driver-Vehicle-Interface (DVI) Specifications
- Other major activities
  - International Truck and Engine Corporation (ITE) joins IVBSS team and co-leads integration efforts for Phase I ("Gold" vehicle/FOT1 template vehicle)
  - Side vision subsystem not incorporated
    - Difficulties in hardware implementation: EMC Issues, power conditioning and etc.
    - Less-robust outdoor performance: vibration, dirt and etc.
    - Had been a stretch goal.

Functional-Requirement-Driven Development



Key Functional Elements

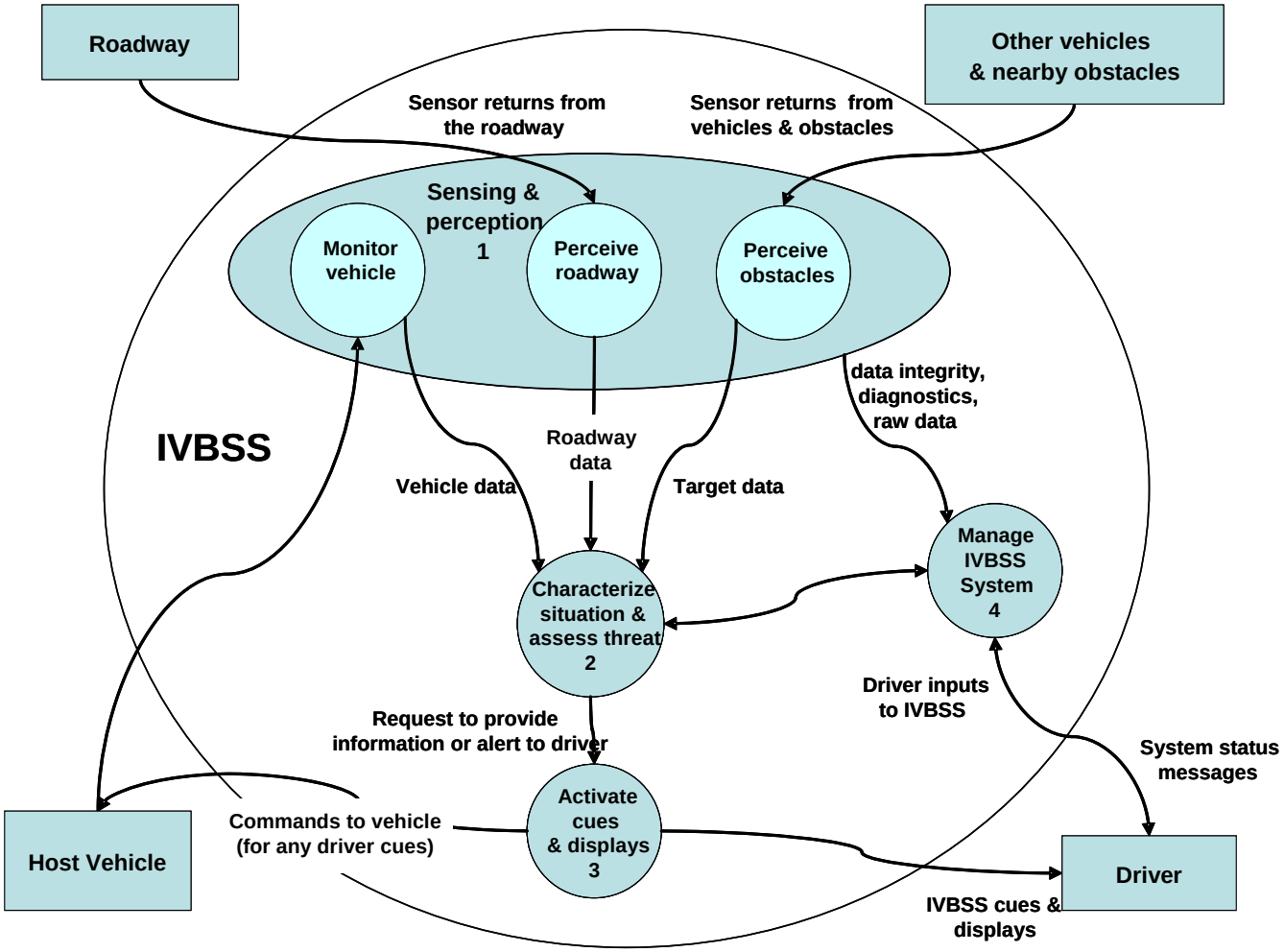
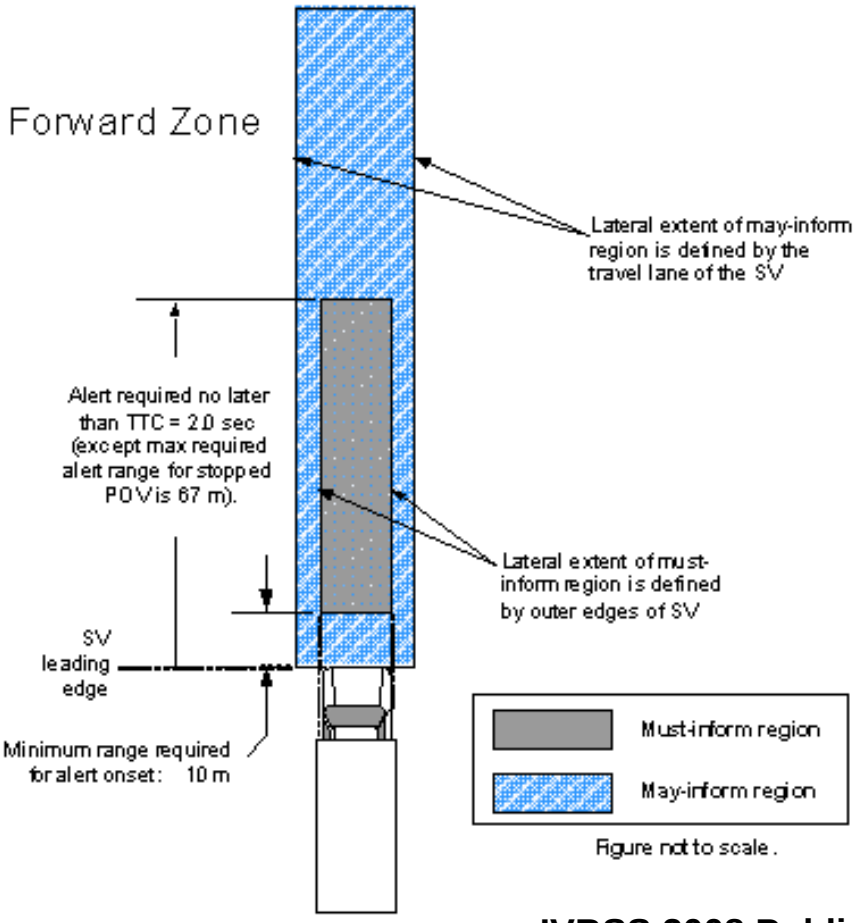


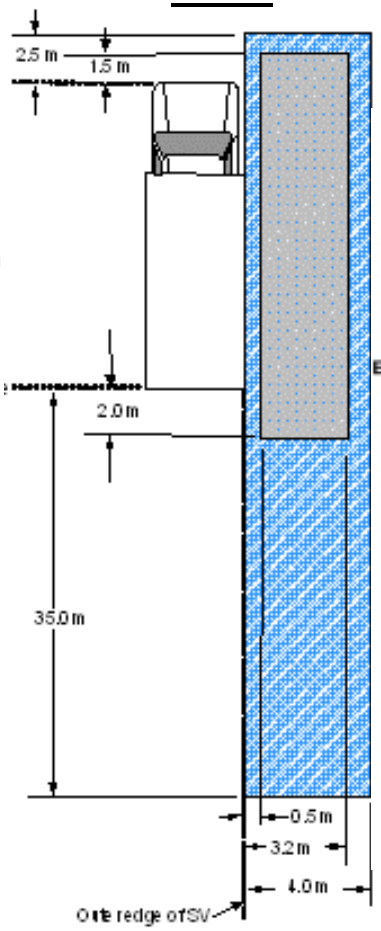
Figure shows only the interactions directly with or within IVBSS

Warning Zones

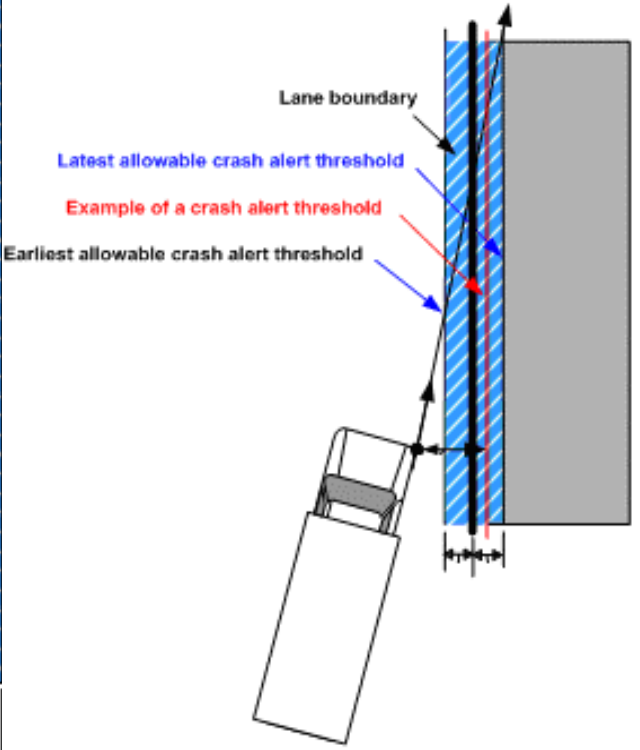
FCW



LCM

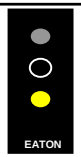
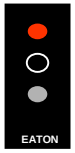
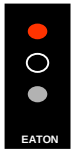


LDW

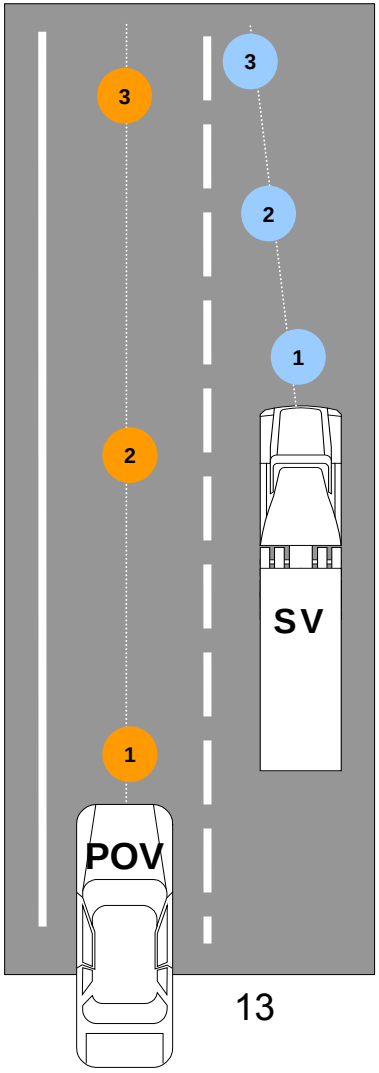


Example

- LCM: Lane-change into approaching POV (Obj. Test LC-6)

Scenario	Func. Req.	Implementation
(1) POV enters Adjacent Zone	Advisory warning shall be given	Level-1 Side-display 
(2) SV turns on the turn signal and TTLC > Threshold	Advisory warning shall be given	Level-2 Side-display 
(3) SV changes lanes and TTLC ≤ Threshold	Audible collision alert shall be given	Audible collision alert  

* TTLC: Time to lane crossing

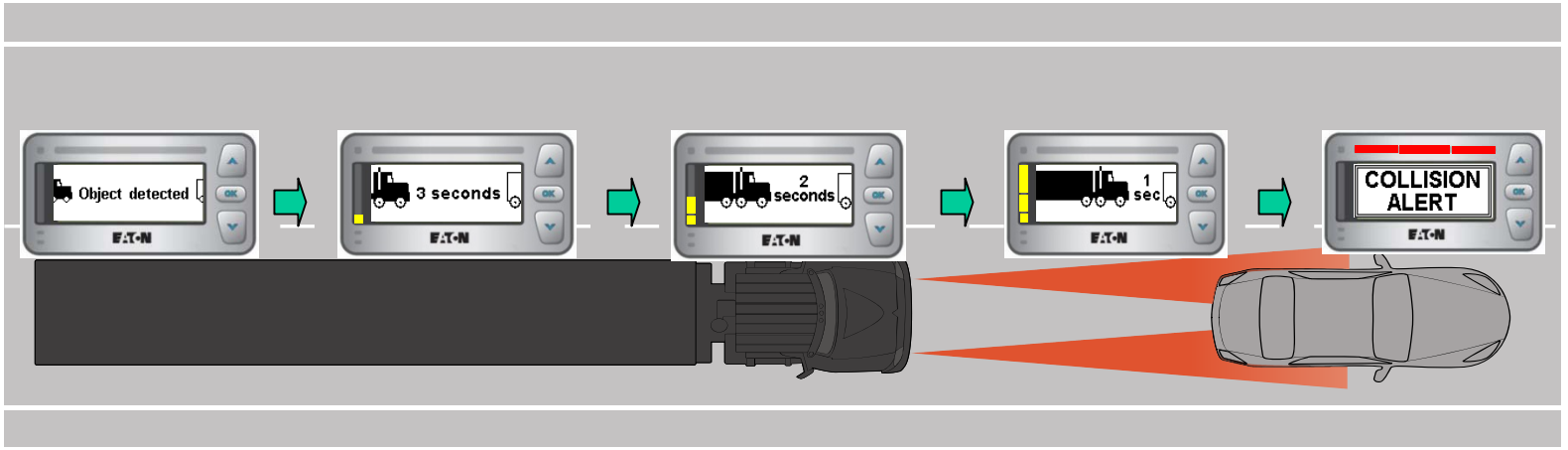


Subsystem Integration

- Lane-change/merge & lane departure:
  - LCM uses lane position information from LDW to determine lateral motion of the subject vehicle;
  - LCM uses lane boundary information from LDW to
    - Manage the timing of warning;
    - Mitigate false alerts against roadside objects and opposing traffic;
  - LDW uses the lateral clearance information from LCM to manage the timing of warning;
- Lane-change/merge & forward warning:
  - LCM uses FCW information to determine opposing traffic in adjacent lane that is used for alert management/suppression.
- Forward warning & lane departure:
  - LDW uses FCW information (e.g. distance to the nearest forward obstacle, and the estimated road curvature) to improve lane-tracking performance

Key Subsystem Developments

- Forward crash warning:
  - Twin, product-intent Doppler radars
  - Fleet-proven VORAD approach: a progressive warning scheme (VORAD = Eaton radar system product):
    - headway based advisories + collision imminent warnings;
    - Visual + audible (for impeding or short-range threat only)



Key Subsystem Developments

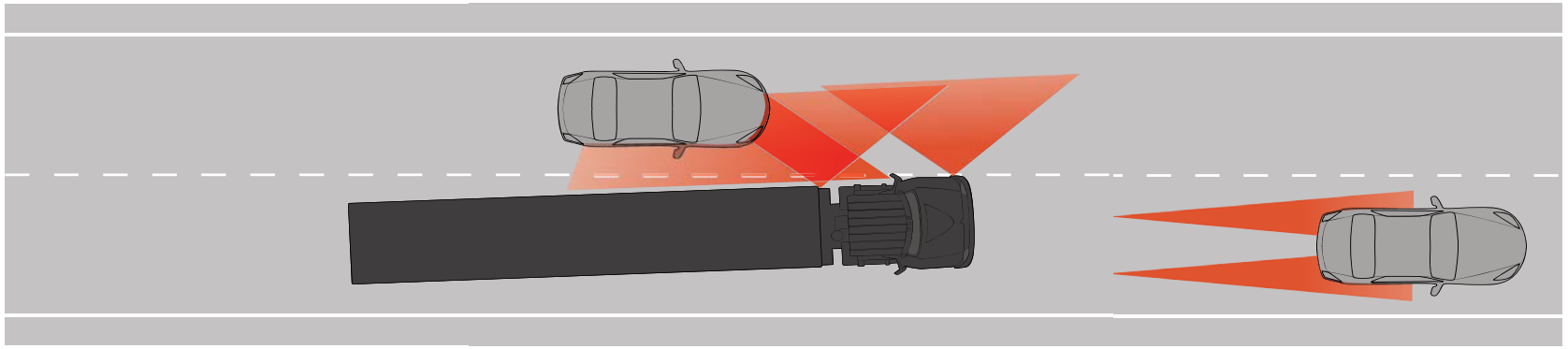
- Lane-change/merge warning:
  - A tractor-only approach (fleet preferred)
  - Challenges:
    - Trailer reflections & articulation (ghost signals);
    - Sensor noise at large distance;
    - Uncertainty of the driver's intention.
  - Multi-level, directional warning
    - 2 visual advisories + 1 auditory collision alert;
  - Major efforts during the Extension
    - Improved presence detection
    - False alert mitigation
      - Roadside obstacles, opposing traffic
      - Vehicles at one lane over and fast overtaking vehicles

Key Subsystem Developments

- Lane departure warning:
  - CAN communication: reduces latency and improves communication reliability.
  - Interoperability across platforms – added software flexibility to operate and communicate on both Heavy Truck and Light Vehicle platforms.;
  - Field upgradeability – units no longer need to be shipped back for software upgrades;
  - Robust single box design – makes LDW more resistant to interference from outside environment;
  - Fine-tune LDW warning threshold for false alert mitigation

Key Subsystem Developments

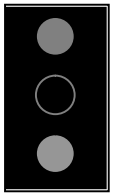
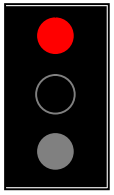
- Arbitration developed for scenarios with multiple potential threats (- another level of the Integration of the IVBSS Program)
  - Globally prioritized warnings;
  - Rule-based approach;
  - False/unnecessary alert management (major effort during the Phase 1 Extension)
    - Suppression on consecutive alerts of the same type within a short amount of time;
    - Suppression on alerts at low speed;



Key Subsystem Developments

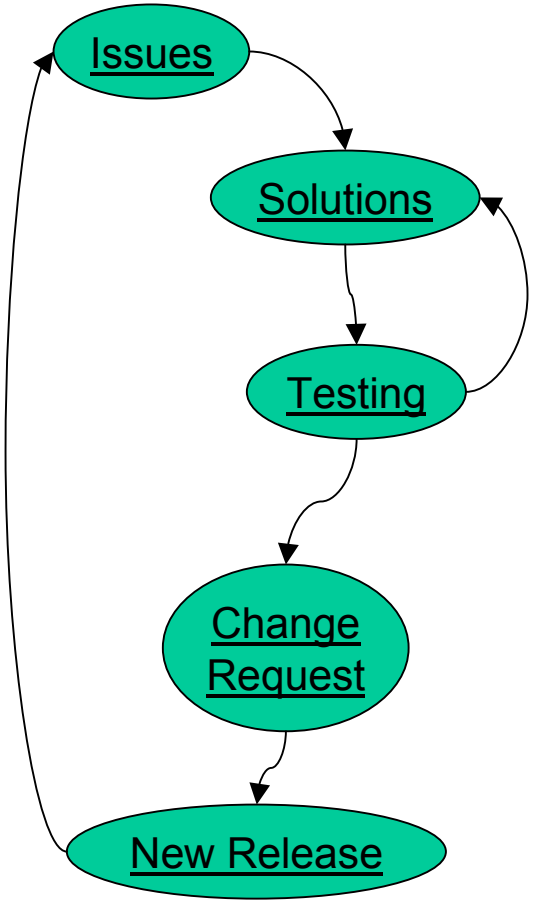
- Driver-Vehicle-Interface (DVI) designed & integrated
  - Commercial hardware with IVBSS features
  - The three functionalities are integrated;
  - At most one auditory alert to the driver at any moment;
  - Multi-level: Visual + audible;
  - Directional: central + side
- Revisit the sound choice
  - Based on driver feedback through pilot testing and verification testing
  - Major effort during the Phase 1 Extension

Examples of DVI Operation

Cond. Code	Initiation Condition	Visual Displays Side	Visual Displays Forward	Auditory Display (Directional)
FCW-3	Forward object within 2s headway (and no higher priority alert) AND opening OR closing	N/A		Opening=None Closing=Short Alert
FCW-6	Slower moving vehicle in the front	N/A		Repeating Alert
LDW-1	Subject vehicle drift just outside the lane boundary toward an unoccupied lane			Directional lane excursion warning
LCM-3	Adjacent vehicle detected AND lane change maneuver IS detected		N/A	Right/Left channel side collision warning

Configuration Change Control

- Version Identification
  - Each sub-system has an associated version number
  - Version numbers are collected by the Data Acquisition System (DAS) throughout all the testing
  - Software version control through StarTeam
- Change control:
  - Since the first verification test, all the changes have been reviewed by US DOT.
  - Software testing:
    - Offline testing through previous data;
    - Real-time testing on the road.
  - Full documentation of major software changes provided via release notes to US DOT.



Phase II Development Plans

- Continue migration to International 8600/TranStar platform ("Gold" Vehicle/FOT Vehicles);
- Upgrade LCM to accommodate different type of ConWay trailers (different trailer axle radar reflections);
- Adjust lateral drift system to allow drivers' technique of going wide in curves with tractor to maintain lane position with trailer(s);
- Complete FOT DAS development;
- Add diagnostic information into Driver-Vehicle-Interface (DVI).

(Field Operational Test)

Phase II FOT Readiness

- Conway has submitted a letter to International (intent to buy)
- Fleet vehicle build (FOT1 thru FOT10):
  - Manufactured: Garland, TX
  - International (Fort Wayne): Checkout & Truck S/W Programming
  - Eaton/UMTRI (Michigan): Upfit of Sensors & Data system
  - International provides support/observation
- Fleet vehicles move into service directly with FOT to follow (with Conway coordination)

Phase II FOT Vehicle