



UNITED STATES
DEPARTMENT OF TRANSPORTATION

Human Factors for Connected Vehicles

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(on behalf of the National Highway Traffic Safety Administration)

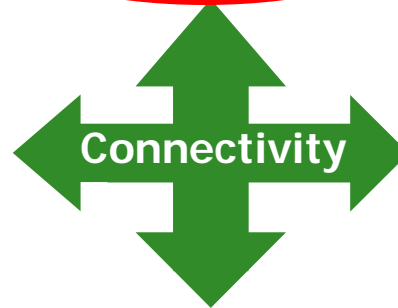
August 4, 2011

The Connected Vehicle

Vehicles and Fleets

Infrastructure

Drivers/Operators



Wireless Devices



Human Factors for Connected Vehicles

■ Outcome Goal

- Connected Vehicle technologies and applications will have Driver Vehicle Interfaces (DVI) that effectively communicate safety information while managing workload and minimizing distraction

■ Product Goal

- Human Factors Guidelines to ensure interfaces are effective without increasing distraction or creating high workload



Key Human Factors

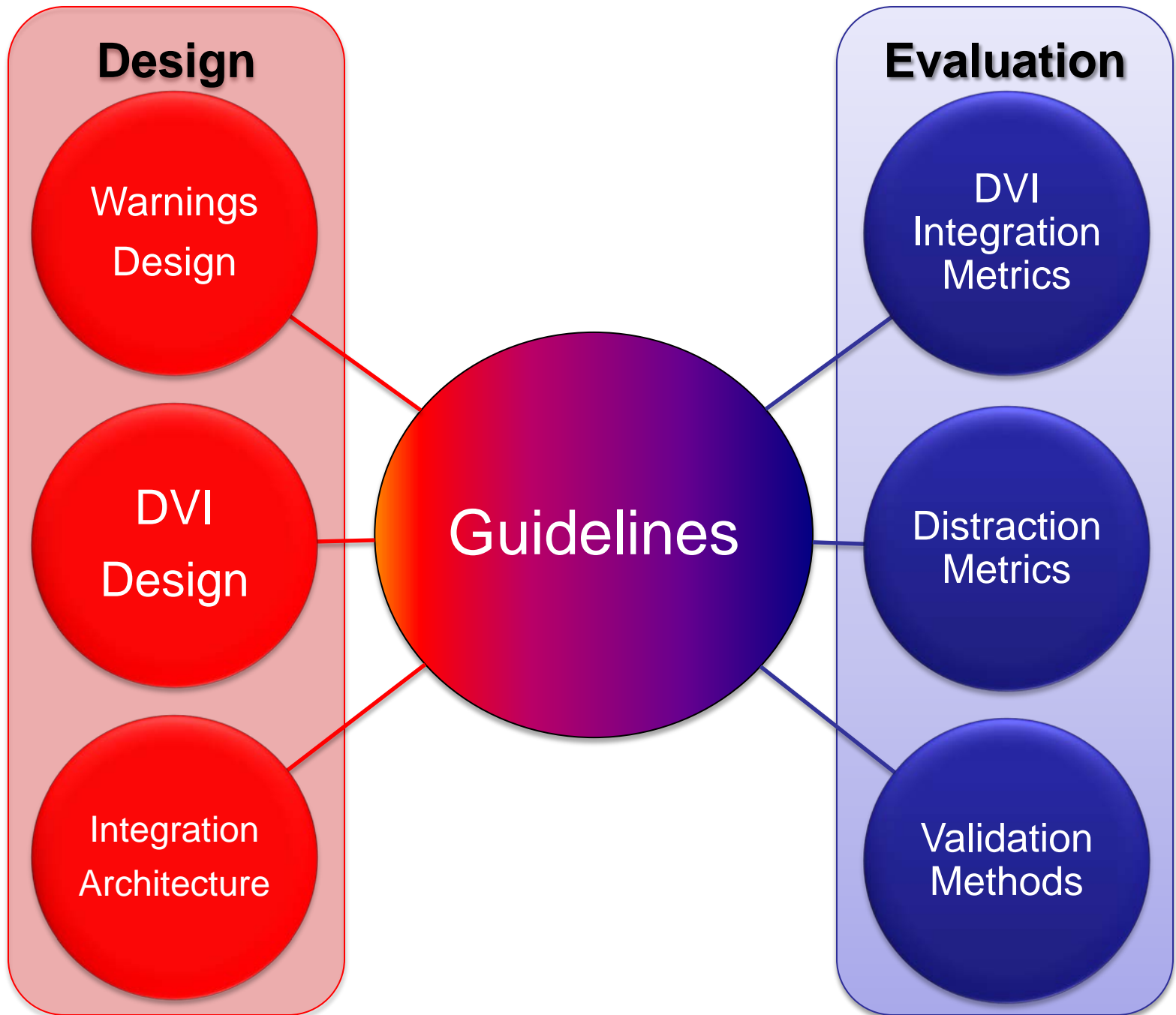
- What makes an effective safety application **interface**?
 - Attracts the driver's attention
 - Directs it to the threat in time
 - Invokes correct and quick driver response
- **Driver distraction** is the diversion of attention from activities critical for safe driving to a competing activity.



Human Factors Guidelines

- Provide designers with guidance supported by the best available empirical evidence
- Some guidelines are stated as general principles and practices at a functional level
- Other guidelines are highly specific and quantitative, like design criteria
- Greater incorporation of performance-based criteria





Program Scope

■ Multiple User Groups:

- Light vehicles
- Commercial Vehicles
- Transit operators
- Age groups: Older and Younger drivers



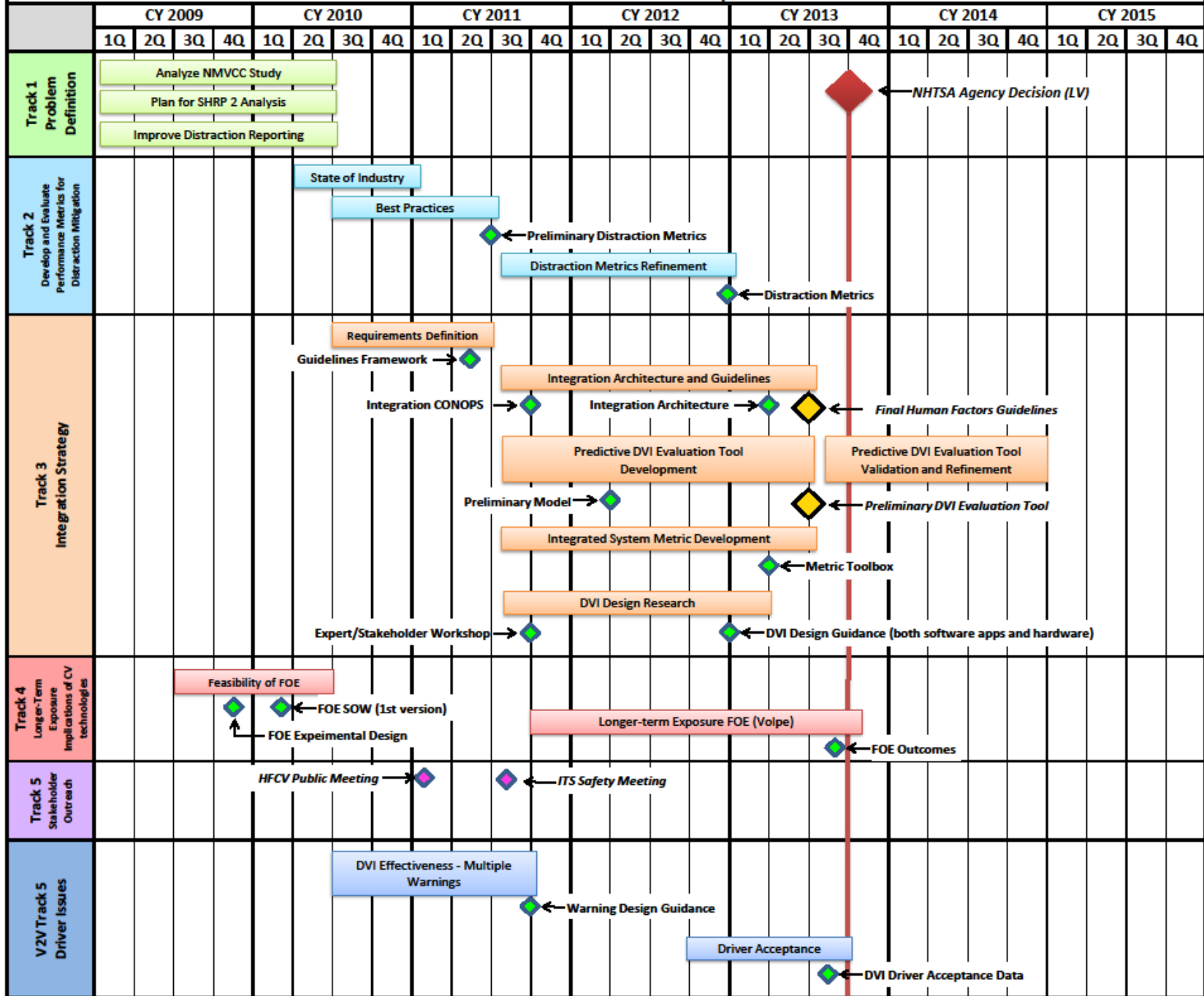
■ Multiple Applications:

- V2V and V2I
- Safety, Mobility, Sustainability
 - Special concern about **non-safety** applications
- Original equipment, Nomadic (carry-in) devices, software “Apps”

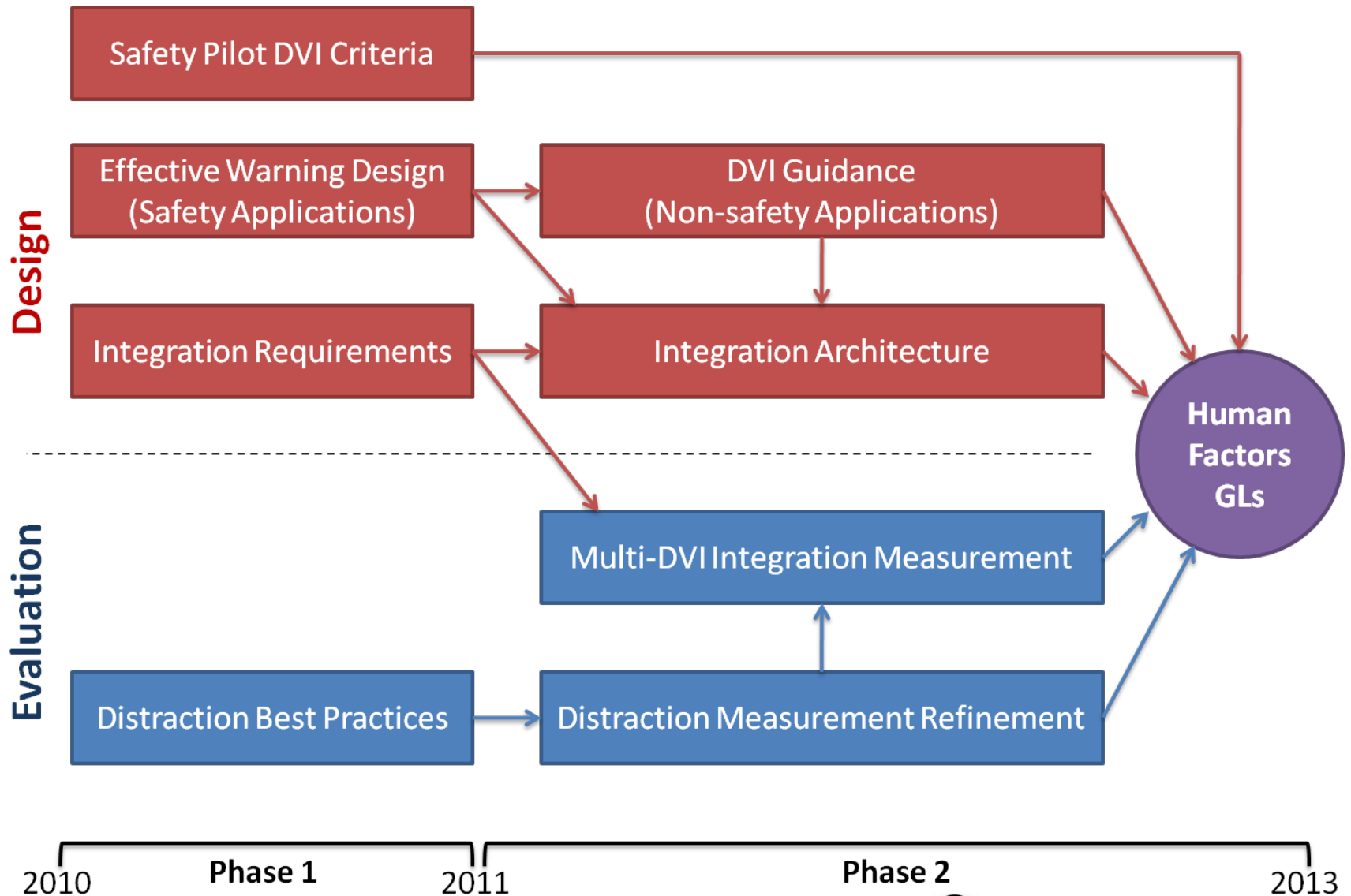


Focus is on “Connected” Applications

Human Factors for Connected Vehicles Roadmap - 17 June 2011



Path to the Guidelines



Phase 1 Activities

- Safety Pilot DVI Design Criteria
- Effective Warnings
 - Data for improving warning design
- Integration Requirements Definition
 - Integration requirements based on preliminary test-track study
 - Framework for the Guidelines Document
- Best Practices for Distraction Mitigation
 - Preliminary Distraction Measurement Protocol for Connected Vehicle systems



Safety Pilot DVI Design Criteria

- Develop DVI Design Criteria for Safety Pilot developers
 - Completed in March 2011
 - Contractor will assess adherence at Driver Clinics and for Model Deployment



Effective Warning Design

- Six studies investigating a range of critical issues for warning design
 1. User-based structure for message coding
 2. Urgency coding within and across modalities
 3. Comparison of alternative warning modalities
 4. Multiple warning events
 5. Message prioritization, display and information management (preliminary)
 6. Nomadic device requirements
- All studies in data collection except Nomadic devices
- Project will be completed in Fall 2011



Integration Requirements Definition

■ Objective:

- Explore the range of potential integration strategies that impact the human's interaction within the CV system

■ Major Activities:

- Identification of multi-DVI integration knowledge gaps
- Conduct experiment on key issues
- Human Factors Design Guidelines Framework development

■ Product:

- Initial integration study results to inform Requirements
- Human Factors Design Guidelines Framework



Experimental Approach

- Test track study conducted on VTTI's Smart Road
- Instrumented Vehicle
 - Data Acquisition System
 - Application Emulator



Device Locations and Applications

□ Device locations



□ Applications (all Android-based)

- Imminent Safety
- Emerging Hazards
- Public Safety/Emergency Management
- Mobility: Traffic Routing
- Public Transit Options
- Environmental Stewardship
- Weather Advisory
- Advertising/Marketing
- Social Networking



Integration Requirements Conclusions

- **Display Location:**

- The mobile device was less effective at presenting imminent safety information and was less favorable

- **Unexpected Finding:**

- Lower “Glance times to Device” and shorter “Maximum Glance Duration” to mobile device compared to fixed and integrated
 - Not indicative of safer performance; rather, too hard to look/too unsafe to look
 - Supported by subjective results

- **Application-specific findings:**

- The Internet and environmental applications resulted in the longest maximum glance durations and Internet, environmental and advertising applications received the lowest preference ratings.



Best Practices for Distraction Mitigation

- **Objective:**

- Develop test procedures that can be used with production vehicles and nomadic technologies to assess distraction potential and usability.

- **Major activities:**

- Expert/Stakeholder interviews
- Experiments

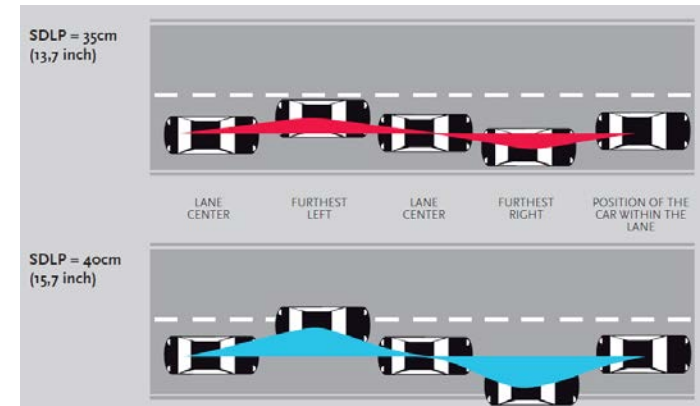
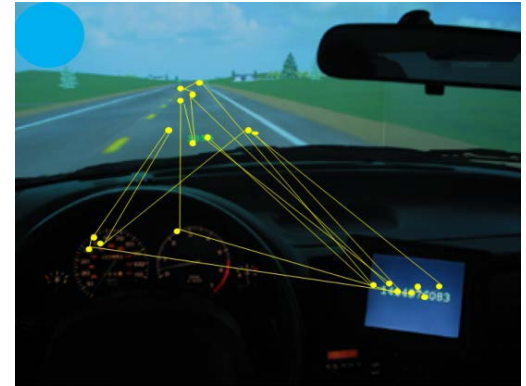
- **Product:**

- Test Procedures for Evaluating Distraction Potential in Connected Vehicle Systems: Performance Metrics



Best Practices Report

- CV-AWARE: Connected Vehicle-Attention Workload Awareness Road-Centered Evaluation
 - CV-AWARE method showed good cross platform repeatability
- 14 performance metrics extracted from experimental data building upon distraction metrics developed in non-Connected Vehicle studies
- Cost and resource requirements discussed for each metric
- Future research needs identified

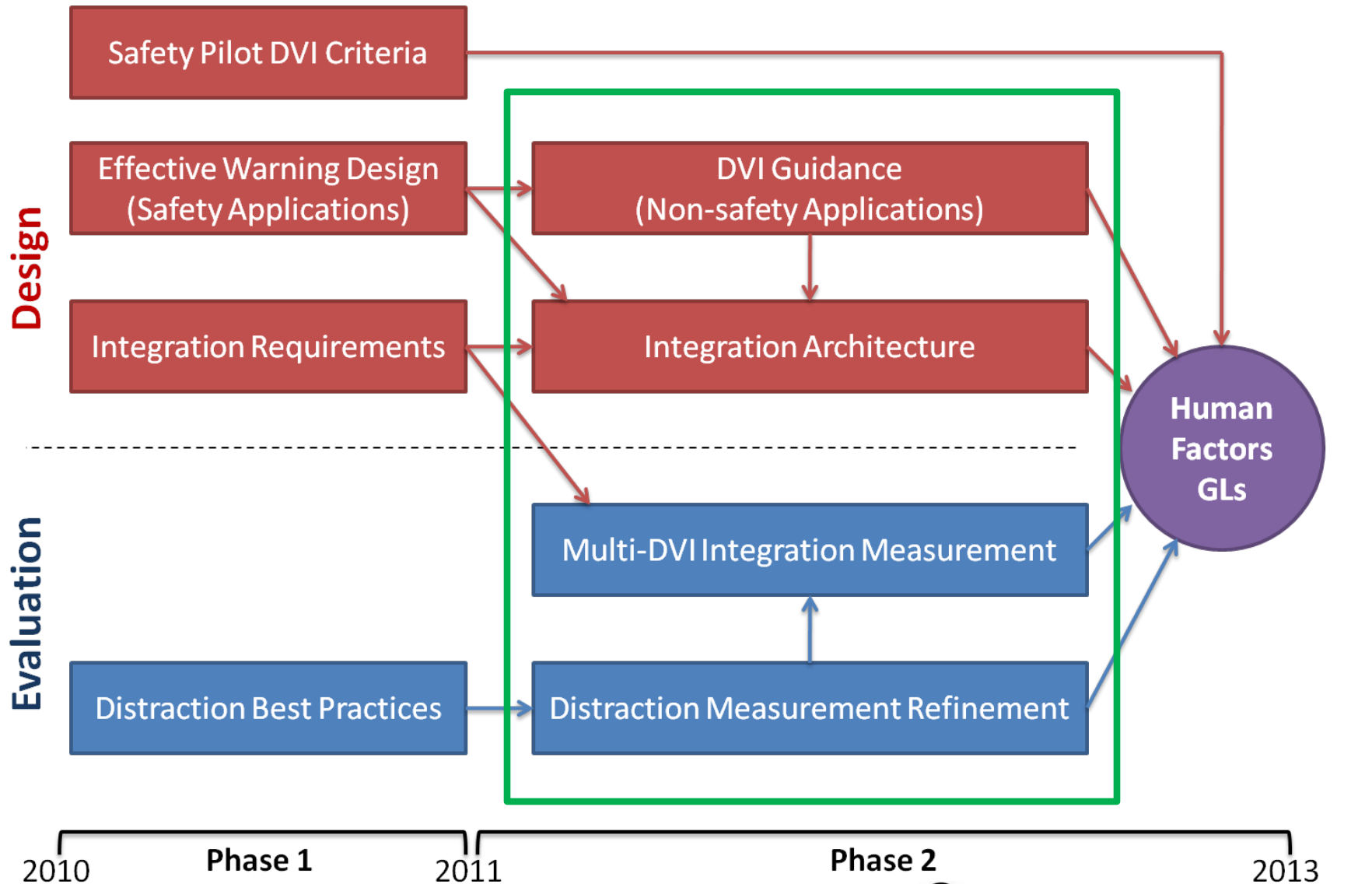


Phase 1 Accomplishments - CY2011

- Safety Pilot DVI Design Criteria
 - Completed in March
- Effective Warnings
 - Five of 6 studies currently collecting data or completed
 - All will be completed Fall 2011
- Integration Requirements
 - Final Report delivered June 2011
 - Design Guidelines Framework completed in June 2011
- Best Practices
 - Final Report delivered May 2011



Path to the Guidelines: Phase 2



DVI Guidance Research

- Stakeholder/Experts Workshop
 - Bring together key researchers to discuss the outcomes of Phase 1 and plans for Phase 2
- Develop DVI guidance with focus on non-safety applications and connectivity issues
 - Main activity for addressing key design guidance gaps
 - Light Vehicles, Heavy Vehicles, Transit Operators
 - Age groups
 - Includes vehicle-to-Infrastructure issues



Integration Architecture & Guidelines

- Concept of Operations
- Integration Architecture
 - Message Priority scheme
 - Modality scheme/guidance/conflict matrix
 - Evaluation procedures
- Guidelines
 - Final HF Guidelines produced in this Task



Integrated System Measurement

- Overall “Metric Toolbox” for evaluating multiple, integrated DVI-based Connected Vehicle systems and applications
 - Non-safety and safety applications
 - Validation efforts
 - Light Vehicles, Heavy Vehicles, Transit Operators
 - Age groups
 - Includes vehicle-to-Infrastructure issues



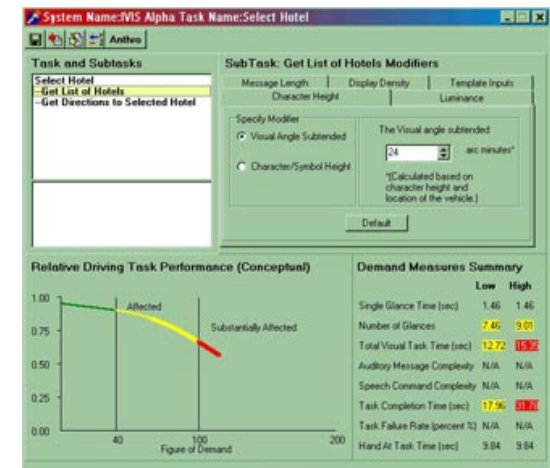
Distraction Metric Refinement

- Follow-on to Phase 1 Best Practices work
- Incorporate expert interview outcomes
- Produce more complete and tested Distraction Metrics with emphasis on connectivity issues
 - Situation Awareness
 - Interruption/resumption issues
 - Light Vehicles, Heavy Vehicles, Transit Operators
 - Age groups
 - Includes vehicle-to-Infrastructure issues



Predictive DVI Evaluation Tool - NEW

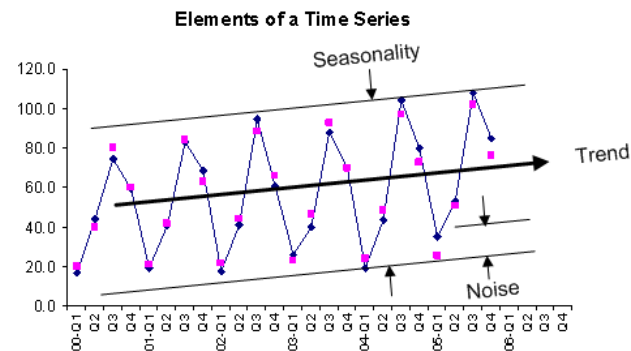
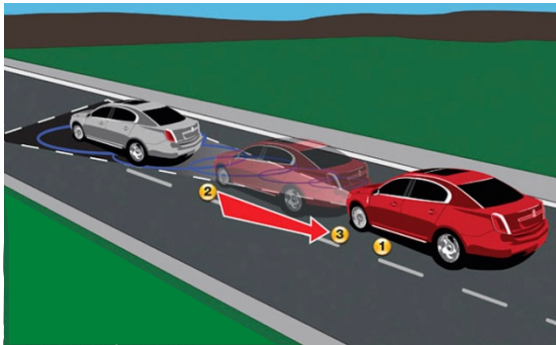
- Software tool for designers to be able to estimate distraction potential or workload issues for their DVI and system configurations
 - A new program product that does not feed guidelines directly
 - Very useful for designers
 - Will likely produce partially validated tool



Other Phase 2 Activities

■ Longer-term Exposure Field Operational Experiment

- Managed by Volpe Center
- To be awarded early this Fall



Phase 2 Accomplishments - CY2011

- Stakeholder/Experts Workshop
- Concept of Operations for Multi-DVI Integration
- Additional Analyses from Phase 1 data
- Literature Reviews and Gap Analyses
- Draft Work Plans for studies
- FOE Kick-off



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