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Digital Highway Measurement System

In Revised Role, Vision, & Approach

Kunik Lee, Ph.D.
Chief Safety Scientist
Office of Safety R&D, FHWA
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Digital Highway Measurement System

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  Transportation Issues to the Strategic IATS Approach,
  and to the DHMS Road Information

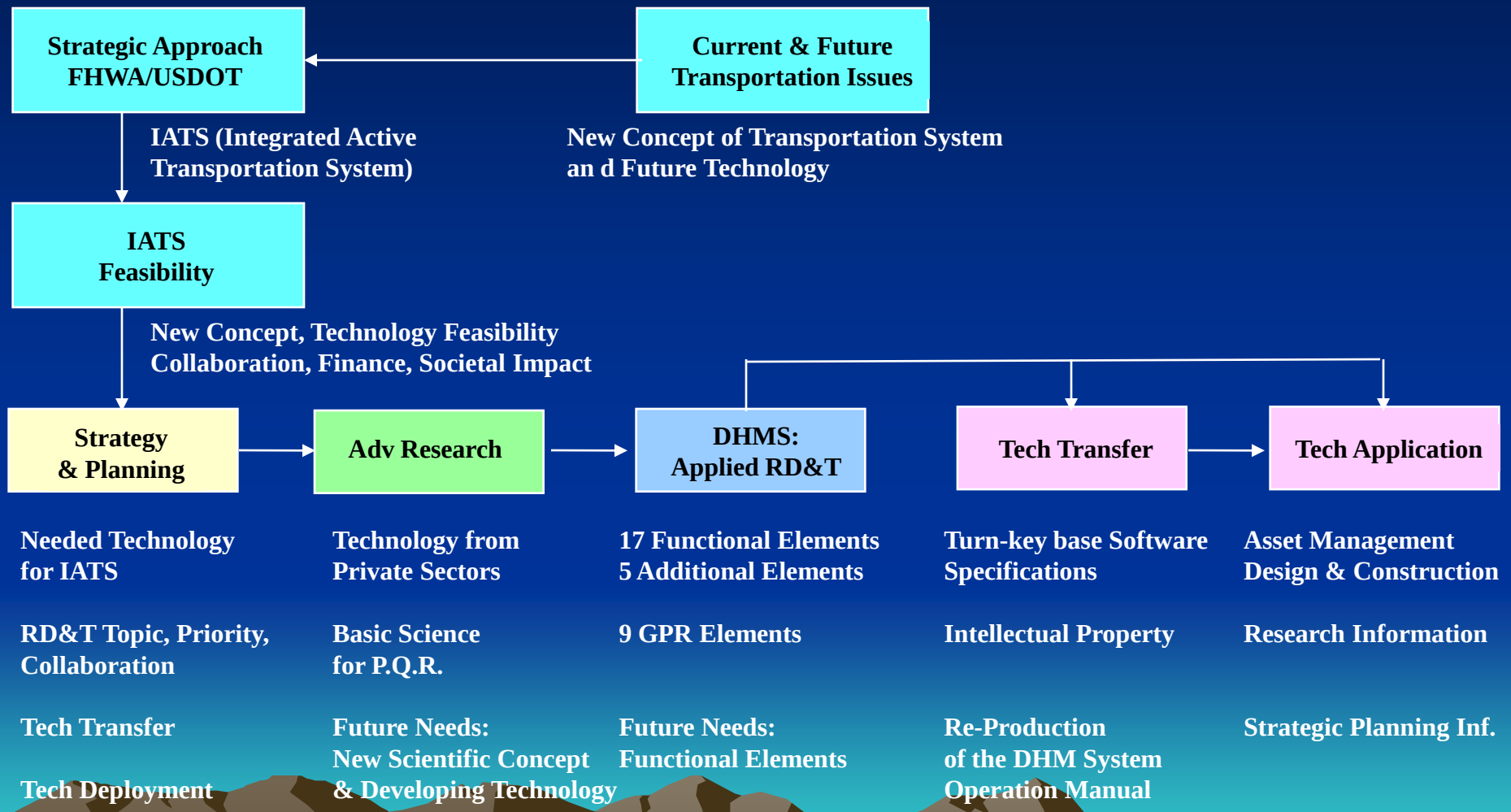
- **What The DHM System is**
  - RD&T for Functional Capability
  - Technology Applications and Technical Advantages
  - Technology Transfer

- **What The DHM System will be**
  - Advancing with Current Technology
  - Developing Next-Generation Technology

- **An Example of DHM Technology Applications**
  The National Workshop in Highway Asset Inventory and Data Collection,
  Durham, NC, September 25, 2008

A. Why USDOT needs The DHM System

- Strategic Approach -



A. Why USDOT needs The DHM System

- The IATS Concept -

Over 360 Fatality Causes will be reduced systematically through Five Strategic Transportation Research Themes with considerations of three major components, Driver, Vehicle, and Infrastructure

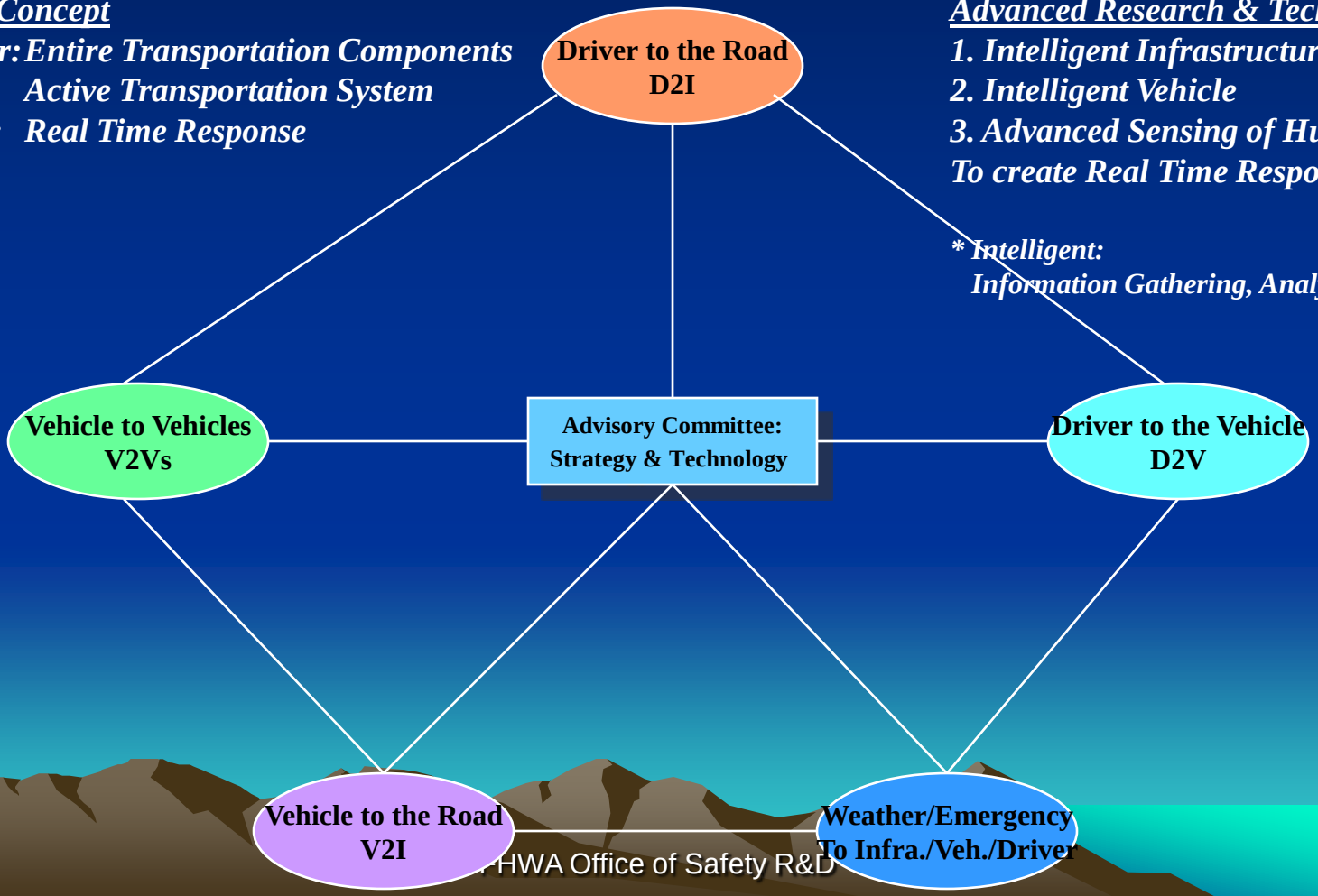
The IATS Concept

1. Consider: Entire Transportation Components
2. Predict: Active Transportation System
3. Prevent: Real Time Response

Advanced Research & Tech

1. Intelligent Infrastructure
2. Intelligent Vehicle
3. Advanced Sensing of Human Factors
To create Real Time Response

**** Intelligent:***
Information Gathering, Analysis, Decision



A. Why USDOT needs The DHM System

- The Road Information for IATS -

The DHM System provides

The required information On, Above, and Under the Ground

For Safety, Mobility, Energy, Environment, and Finance

- **Vehicle to the Infrastructure**
- **Vehicle to Vehicles**
- **Driver to the Infrastructure**
- **Weather and Emergency**
  to the Infrastructure, Vehicle, and Driver

B. What The DHM System is

- Five Major Functions -

- **Establishing the Reference System**
  - DHMS collects Road Data in a ground coordinate system
  - Vehicle Position to calculate Mobility & set up Safety Zone
- **Roadside Geometry**
  - Driver Visibility and Driving Conditions
  - Vehicle Stability
- **Pavement Condition**
  - Tire Friction to the Road for Vehicle Stability
- **Roadside Features and Inventory**
  - Driving Conditions and Driver Protection
  - Vehicle Crash Prevention
- **Sub-Surface Condition**
  - Prediction of Road Conditions

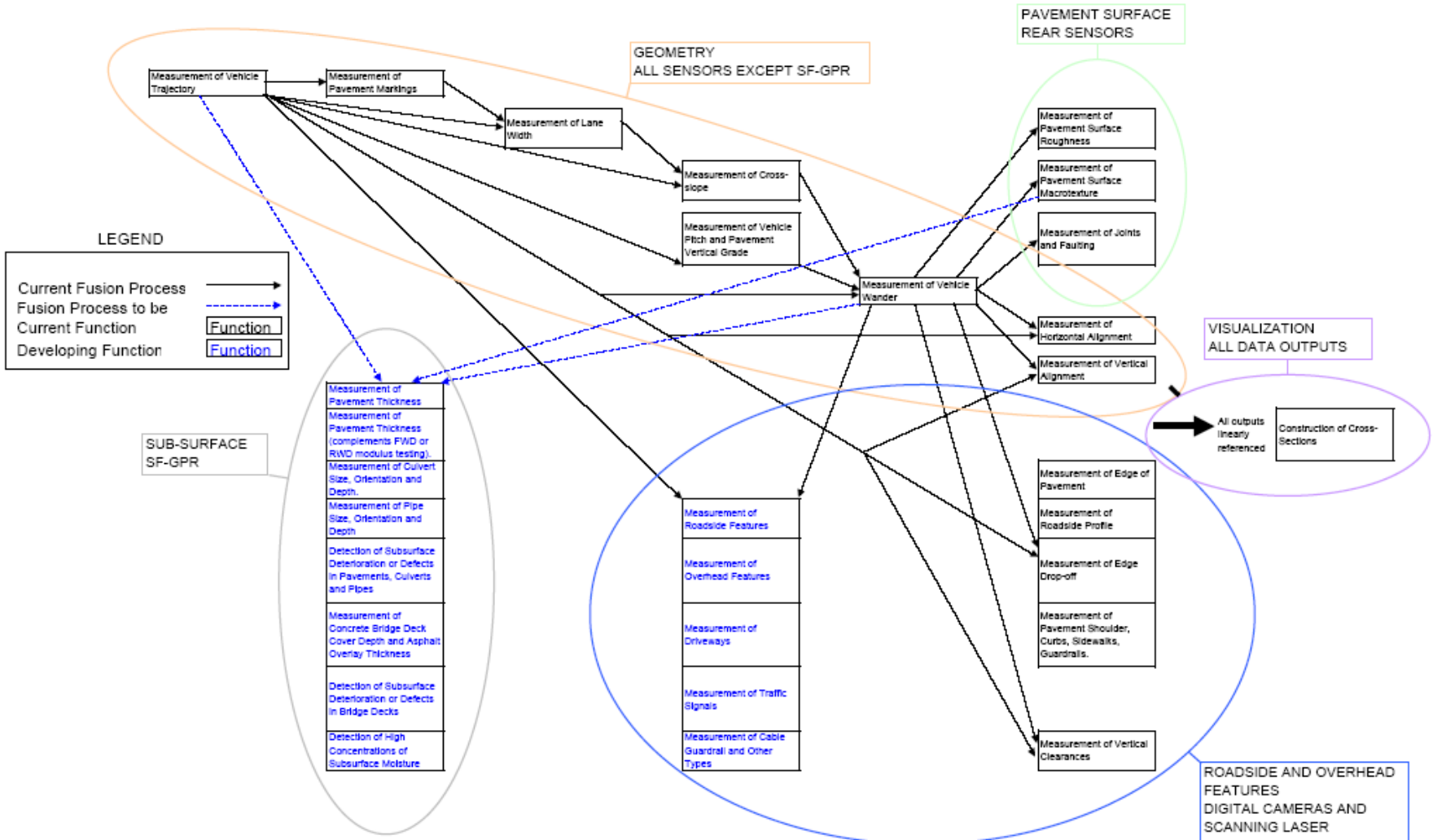
B. What The DHM System is

- Functional Elements -

- **Establishing the Reference System**
  DHMS position with respect to a ground reference frame,
  Sensor measurement relative to DHMS,
  Measurements transformed to the ground reference frame
- **Roadside Geometry**
  Horizontal and vertical alignment, cross-slope and super elevation, pavement width
- **Pavement Condition**
  Roughness, Macro-texture, Joint faults
- **Roadside Features and Inventory**
  Shoulder characters, Roadside profile, Locate and identify signs, barriers, luminaire supports, vertical clearance, etc.
- **Sub-Surface Condition** (Under development)

B. What The DHM System is

- Five Major Function Development -

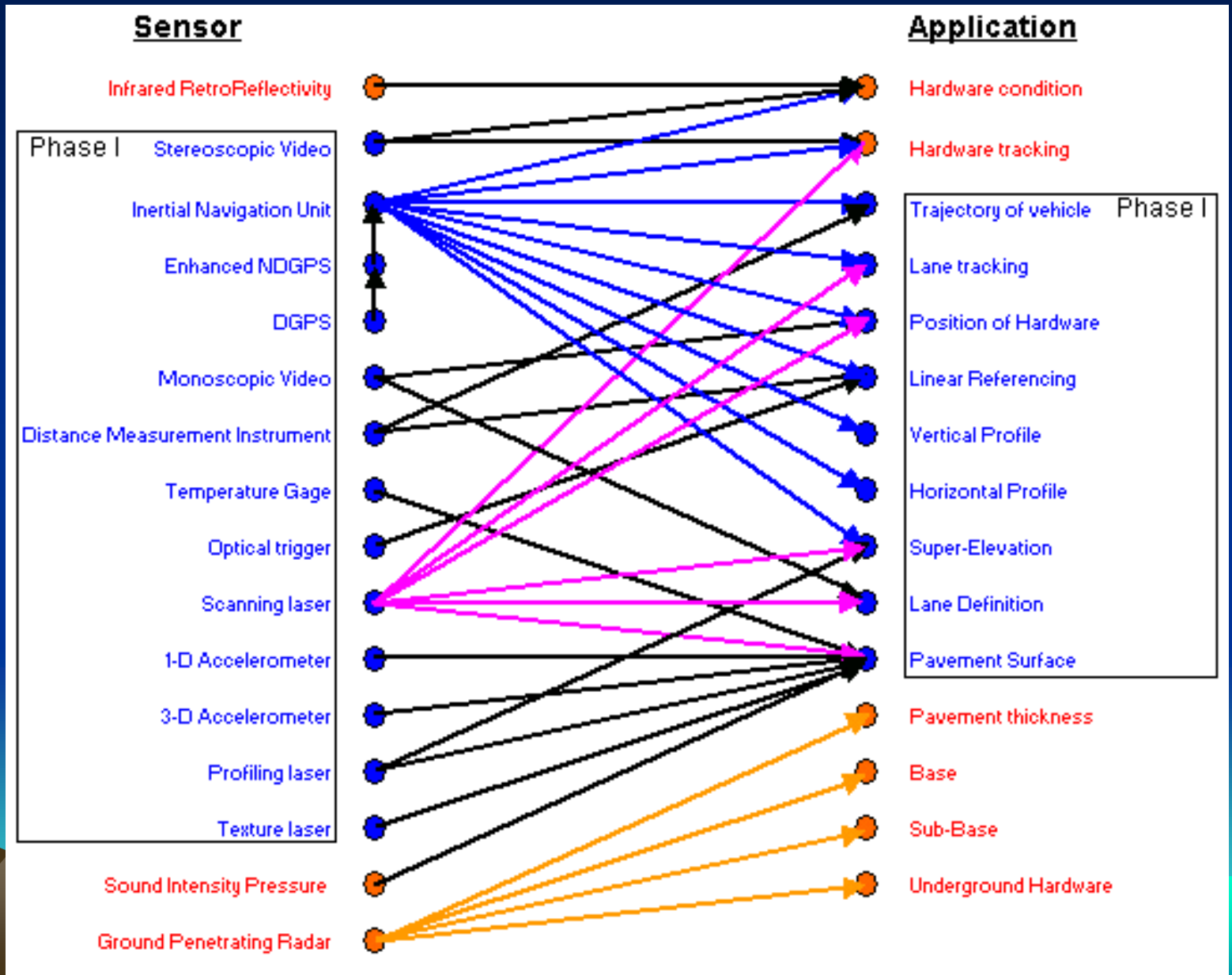


B. What The DHM System is

- Hardware: Sensing System -

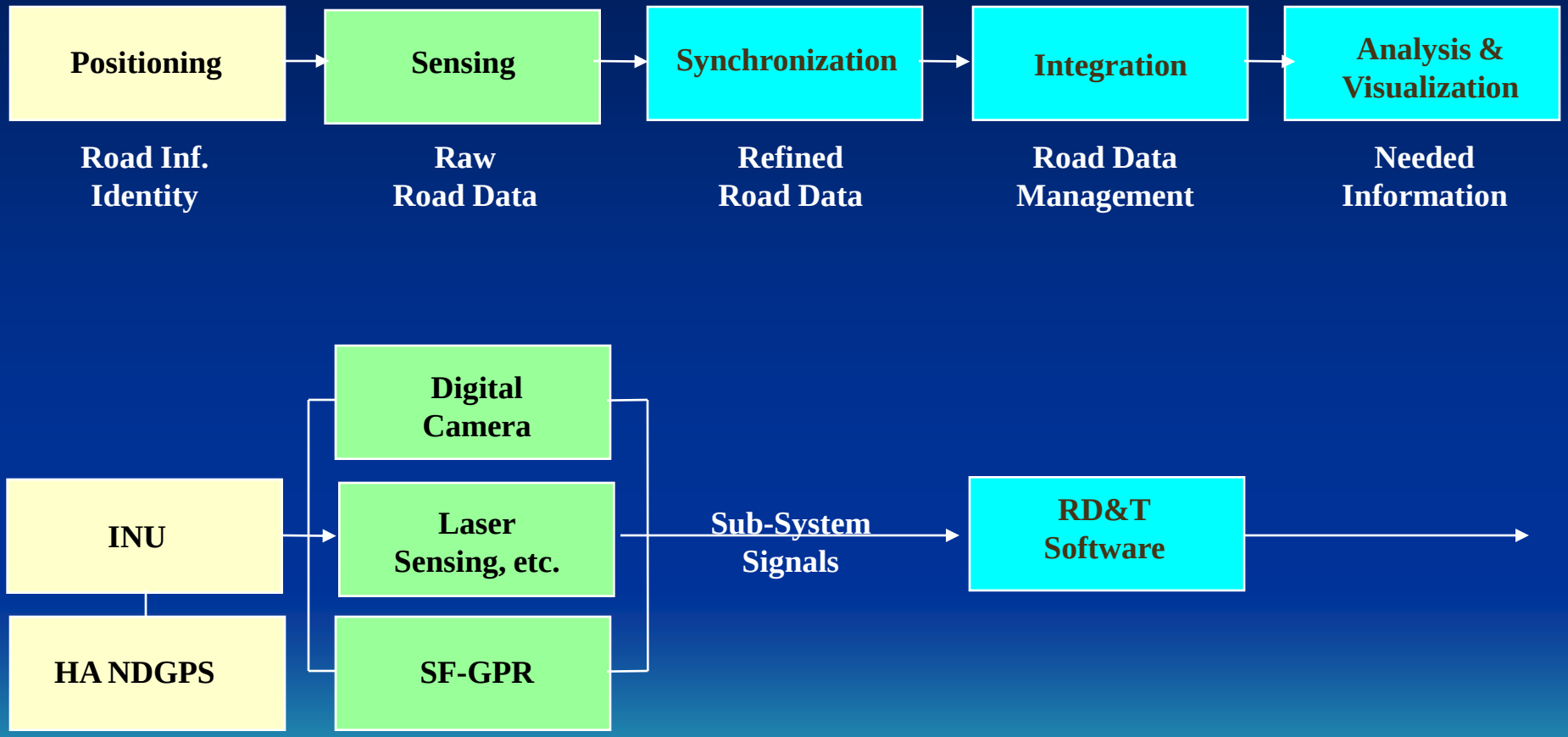
B. What The DHM System is

- Sensors to Functional Elements -



B. What The DHM System is

- RD&T Software for Field Applications -



The activities for technology transfer for mass production, such as a turn-key base software, specification, and operational manual, to follow the prototype development.

B. What The DHM System is

- Technology Applications -

- **Asset Management**
  a. Build Planning:
     Road Geometry, Pavement, Signs, Signals, etc.
  b. Pavement Inspection and Repair:
     Failed Road and Prediction of Road Failure
     Pavement Life with Temperature and Sound Pressure
     Vehicle Stability with Tire Frictions to the Road
  c. Underground Information:
     Pavement Thickness, Underground Hardware, etc.

- **Planning, Engineering Design, and Construction**
  Road Geometry, Pavement Life, Marking, Intersection Safety, Driver Visibility, Roadway Signs, Turn Signals, etc.

B. What The DHM System is

- Technology Applications -

- **Research Information**
  Road Geometry, Roadside and Overhead Features,
  Vehicle Stability on the Road,
  Driving Simulator,
  Traffic Density, etc.

- **Strategic Planning Information**
  Needed Infrastructure Information
  to develop the Strategy and Planning of IATS

B. What The DHM System is

- Technical Advantages -

- **Integrated Data Collection at Highway Speed**
  - Static Features On, Over, and Under the Ground
- **Accuracy and Reliability**
  - Positioning (without GPS), Sensing Range, Retro-reflectivity, etc.
- **Qualitative Features**
  - Synchronization and Fusion of sub-system outputs
  - Signal Processing and Pattern Recognition on sensor base, including image processing in stereoscopy
- **Quantitative Aspects**
  - Increased repeatability, reliability, and resolution

B. What The DHM System is

- Technology Transfer-

- **DHM System Demonstration**
  TRB and NCDOT in 2008 and several State DOTs in 2009

- **Pooled Fund Study**
  a. Road Data Collection and Analysis
    1) Infrastructure Maintenance, Condition improvement, Failure prediction,
    2) Optimization of Driving Conditions
    3) Infrastructure Engineering, Design and Construction
  b. Highway Research to improve DHM System Technology

- **Production DHM**
  a. SHRP 2 Program for Mass Production and Data Collection
  b. License Agreement with private vendors
    1) Turn-key base Software
    2) Specifications and Operation Manual

C. What The DHM System will be

- RD&T Plan -

	Phase 1	Phase 1.a.	Phase 1.b.	Phase 2	Phase 3
	Static Features 09/03 ~ 05/ 06	Static Features 05/06 ~ 08/10	Commercialization 09/06 ~ 08/10	Transient Features 01/10 ~ 1213	Dynamic Features 01/14 ~ 12/19
Strategy	1. On/Over the Ground with 17 elements	1. Add'l 5 Elts 2. 3-GPR with 9 Elt's	1. RD&T Assessment 2. Complete Static Feature with additional elements 3. Improved 3D-GPR + IR 4. Quality & Reliability		
RD&T	1. A Brief of Algorithm Process	1. HW Improvement 2. Image Processing 3. Laser to LiDAR 4. Radar to LADAR 5. 3D-GPR Develop. Plan			
Tech Transfer			1. Turn-key base Software 2. Spec. & Op. Manual 3. IP 4. Production DHM		
Tech Deploy	1. Road Data Collection & Analysis	1. DHMS 2. ULIP 3. 3-D GPR	1. Rodeo – TRB 2. Rodeo – NC 3. Demo – State DOT		

C. What The DHM System will

- Advanced Research -

- **Advancing with Current Technology**

  1. Complete Integration of Research Algorithms
  2. to address 17 current DHM-Functions
  3. and 5 additional DHM and 9 new GPR functions.

- **Developing Next-Generation Technology**

  1. Basic Science with New Technical Concepts:
     Sensing, Data Processing. Data Storage and Management,
     Image Processing, and Visualization, etc.
  2. Latest Technology from Private Institutions
  3. Needed Future Technology:
     RD&T to implement The IATS Concept

D. An Example of DHM Technology Applications

The National Workshop
in Highway Asset Inventory and Data Collection

Durham, North Carolina

September 25, 2008

Appendix
- Detailed Functional Applications -

- **Establishing the Reference System**

  a. Vehicle position established in a ground reference frame
  - HA ND GPS: Initial position
  - INU: Continuous position

  b. Sensors establish the positions and orientations of the objects of interest with respect to the vehicle

  c. Measurements transformed to ground reference frame

  d. Pavement marking, vehicle wander, lane width, vehicle pitch, vehicle trajectory from INU and DMI data

Appendix
- Detailed Functional Applications -

- **Roadside Geometry**
  - Horizontal and vertical alignment
  - Cross-slope and super elevation
  - pavement width

- **Roadside Features and Inventory**
  - Edge drop-off, roadside profile, pavement shoulder
  - Locate and identify signs, barriers, luminaire supports, etc.,
  - Vertical clearance

Appendix
- Detailed Functional Applications -

- **Pavement Condition**
  1. Roughness:
     Using rear mounted profiling laser and accelerometers, an inertial profile can be computed and processed with the Internal Roughness Index (IRI) ride quality algorithm

     The highway geometry vertical profile can also serve as a profile source for the IRI algorithm

  2. Macro-texture:

Appendix
- Detailed Functional Applications -

- **Pavement Condition**

1. Roughness:

2. Macro-texture:
   LMI Selcom 2008 macro-texture lasers compute mean profile depth (MPD) using the ASTM E1845 algorithm or the proprietary ROSAN algorithm

   Uses for texture data include aggregate segregation analysis, and noise and friction estimate

3. Joint faults:

Appendix
- Detailed Functional Applications -

- **Pavement Condition**
  1. Roughness:

  2. Macro-texture:

  3. Joint faults:
     LMI Selcom 2008 macro-texture lasers identify and measure transverse joints and faulting at the joints. Joint width, depth, and spacing are determined from the 1mm spaced texture data.

     Faulting data can be used as one measure for pavement condition indices.

Appendix
- Detailed Functional Applications -

- **Sub-Surface Condition**

1. Ground Penetrating Radar creates 3-D Map
   a. Sub-surface feature detection, measurement, and imaging
   - Output is a series of longitudinal sections
   - Plan views of GPR results can be generated by combining elevation plots and cross sections

2. Technology

Appendix
- Detailed Functional Applications -

- **Sub-Surface Condition**

1. Ground Penetrating Radar creates 3-D Map

2. Technology
   a. Data collection
   - large antennas operate over the full bandwidth of the system, while small or medium ones over a fraction of the system bandwidth
   - use 3 or more full bandwidth antennas. Each collects depth profiles at full range of depths.

Appendix
- Detailed Functional Applications -

- **Sub-Surface Condition**
  1. Ground Penetrating Radar creates 3-D Map
  2. Technology

     b. Data Processing

     - Detailed images of pavement materials, deterioration, and condition, including moisture gradient under pavement
     - measure pavement thickness and key features in data using 1-D layer stripping method, and refine the data using 2-D or 3-D migration methods
     - Step-Frequency Radar covers substantial bandwidth, and increases post processing efficiency
     - Specific frequencies can be notched out of emitted spectrum to avoid interference with other nearby receivers

Meeting The Challenge, Together!