

SHRP 2 S05

Status update and current design plans

SHRP 2 Safety Research Symposium

July 17-18, 2008

Washington, DC



S05 Executive Summary

- S05 is on-schedule and on-budget
- 2500 (+/-) instrumentation systems still appear achievable within resource constraints
 - Continuous data collected; will include 5 channels of video
 - Video compression higher quality than “100 Car Study”
 - Can be installed on many vehicle types and models
 - 2-3 machine vision applications, vehicle network, accelerometers, forward radar, passive alcohol sensor, other sensors
 - Initial mock installs: 2-3 hours by nominally trained technicians

Executive Summary (continued)

- Majority of initial research questions can be addressed
 - Includes many that will address countermeasure development or evaluation
- Multiple data collection sites (6 to 8)
 - Process for site selection developed
- Driver testing materials developed and completed
- Data storage, archiving, and access are feasible
- Human use (IRB) materials completed and under review for pilot study, certificate of confidentiality is in-process

Task Review/Summary

- Task 1: Study Design--Research Questions
- Task 2: Analysis Planning and Analysis Methods Workshop
- Task 3: Sample Design
- Task 4: Sample Design Interim Report
- Task 5: Driver Testing
- Task 6: Driver Face and Other Video Recording and Processing
- Task 7: Data Items and Instrumentation Package Specifications
- Task 8: Data Collection, Reduction, Integration, Archiving, Processing and Access
- Task 9: Data System Interim Report
- Task 10: Identify All Requirements for Approval of Human Subjects Research
- Task 11: Crash Investigations
- Task 12: Quality Control and Assurance
- Task 13: Field Trial Design and Interim Report
- Task 14: Conduct of the Field Trial and Interim Report
- Task 15: Management Plan for Full Study, Interim Report, and Analysis Methods Demonstration Workshop
- Task 16: Final Report (Begins 11/30)

Completed

Active

To begin at a future date



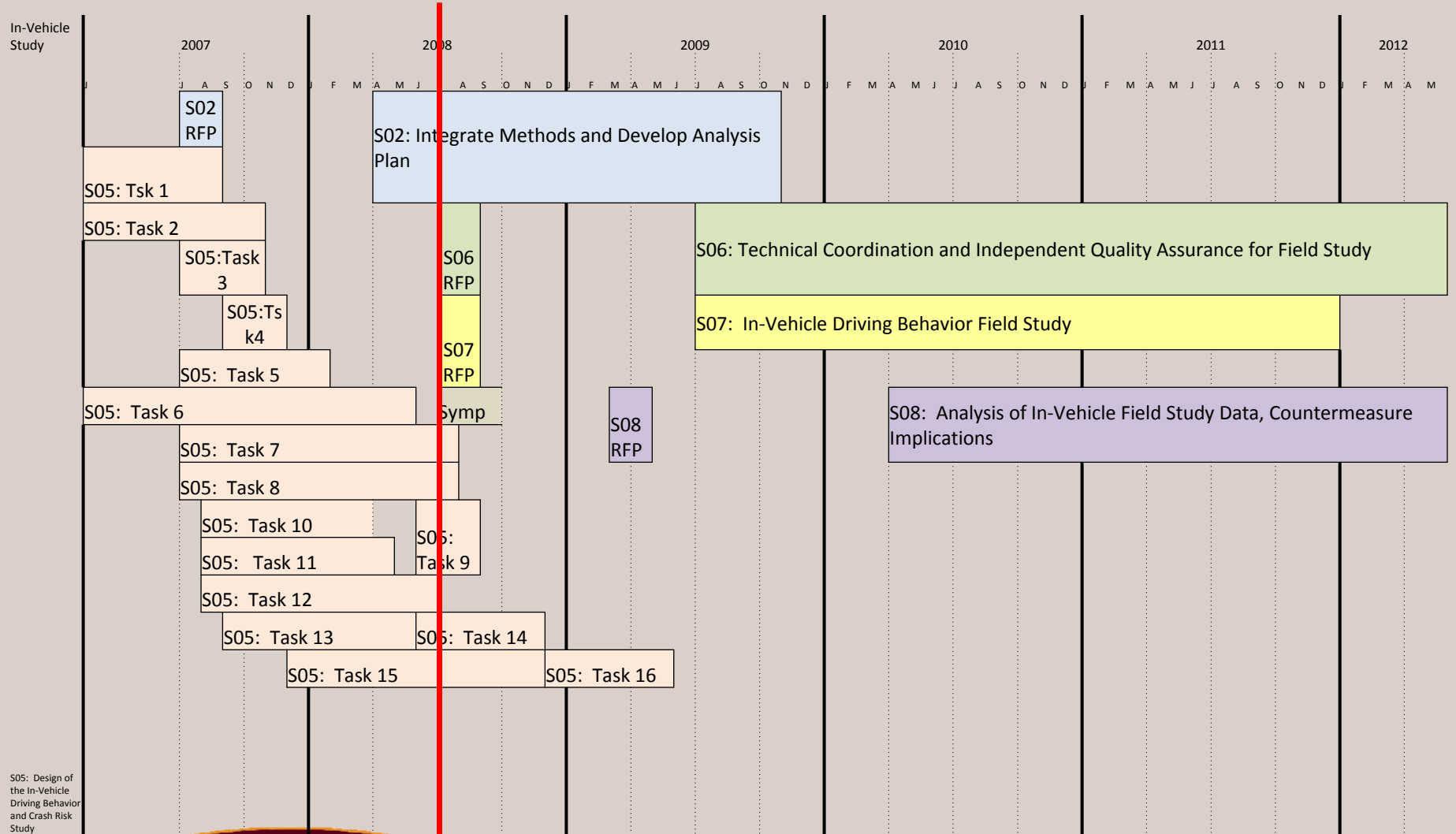
Project Status Summary – Phase II

Task	Due	Status	Technical Risk	Time/ Cost Risk
6 Driver Face/Video	5/31	<ul style="list-style-type: none"> • Goals defined • Compression rates defined • Refining head tracker machine vision • Conducting lane tracker verification testing • Developing traffic signal state detector • Developing Driver ID system 	Moderate (some development and refinements needed)	Low
7 Instrumentation	7/31	<ul style="list-style-type: none"> • Basic prototype developed • Need final camera selections • Integrating additional sensors • Investigating feasibility of cellular communication for crash detection/health checks • Investigating select vehicle makes/models for in-vehicle network use 	Low (VTTI base system complete; other development well underway)	Low

Project Status and Impending Milestones – Phase II

Task	Due	Status	Technical Risk	Time/ Cost Risk
8 Data Collection, Storage, Archive	7/31	<ul style="list-style-type: none">• Analyses in process• Tradeoffs discussion with vendors under consideration	Moderate (Need to develop effective data access systems)	Low

Timeline



S05: Design of the In-Vehicle Driving Behavior and Crash Risk Study

Study Overview

- 4,100 Participants
- 2,600 Data Acquisition Systems (DAS)
 - Continuous 5-channel video, machine vision, kinematics, vehicle network, alcohol sensor, radar
- 2-year data collection
- Up to 8 sites around U.S.
 - Standard (300 Participants)
 - Super (500); Focused (100)
- Broad range of driver Assessments
- Men, Women - All Ages (16-75+)
- Vehicle Types (2002 or later)
 - Passenger Vehicle, Van, Light Truck, SUV

5,200 Data-Years
1,500+ Crashes

S05 Task 7: Develop Data Acquisition System Instrumentation (DAS)

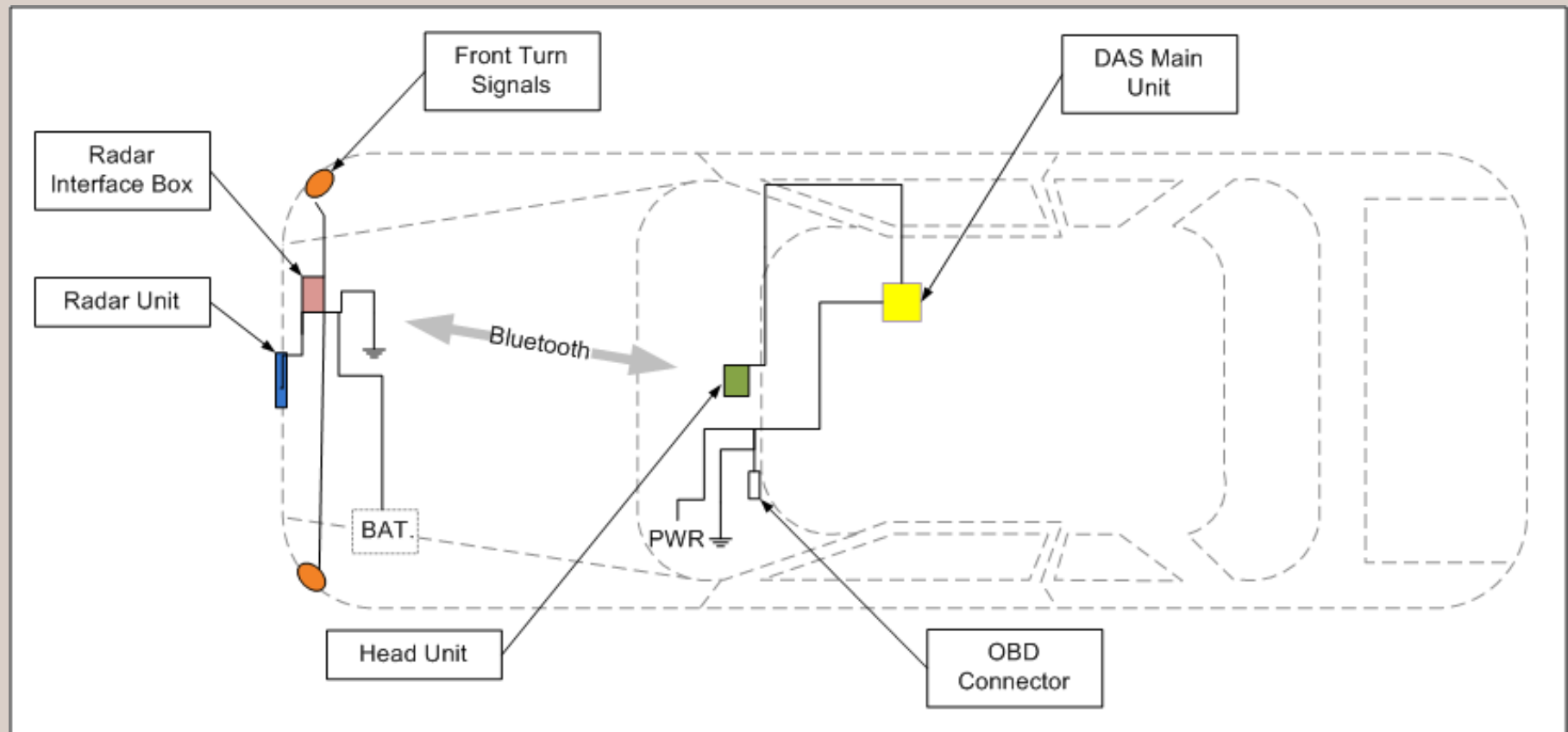
- Enhanced DAS has three components:
 - “main unit” mounted on fire wall or under seat;
 - “head unit” with 5 cameras and other sensors mounted in front of rear-view mirror; and
 - radar unit mounted on front license plate holder with wireless communication link to main unit.
- This allows installations in 2 to 3 hours on almost any vehicle.
- 260 spare DAS units; Main units for downloads and Remove & Replace (R&R) cycle; radars to replace units broken in crashes; head units for camera sensor failures and R&R.

Prototype Data Acquisition System (DAS)

- Custom Design
 - Allows for minimal footprint
 - Electrically
 - Physically
 - Custom software
 - Real time system
 - Maximum data automation and checking
 - Specialized tracking information



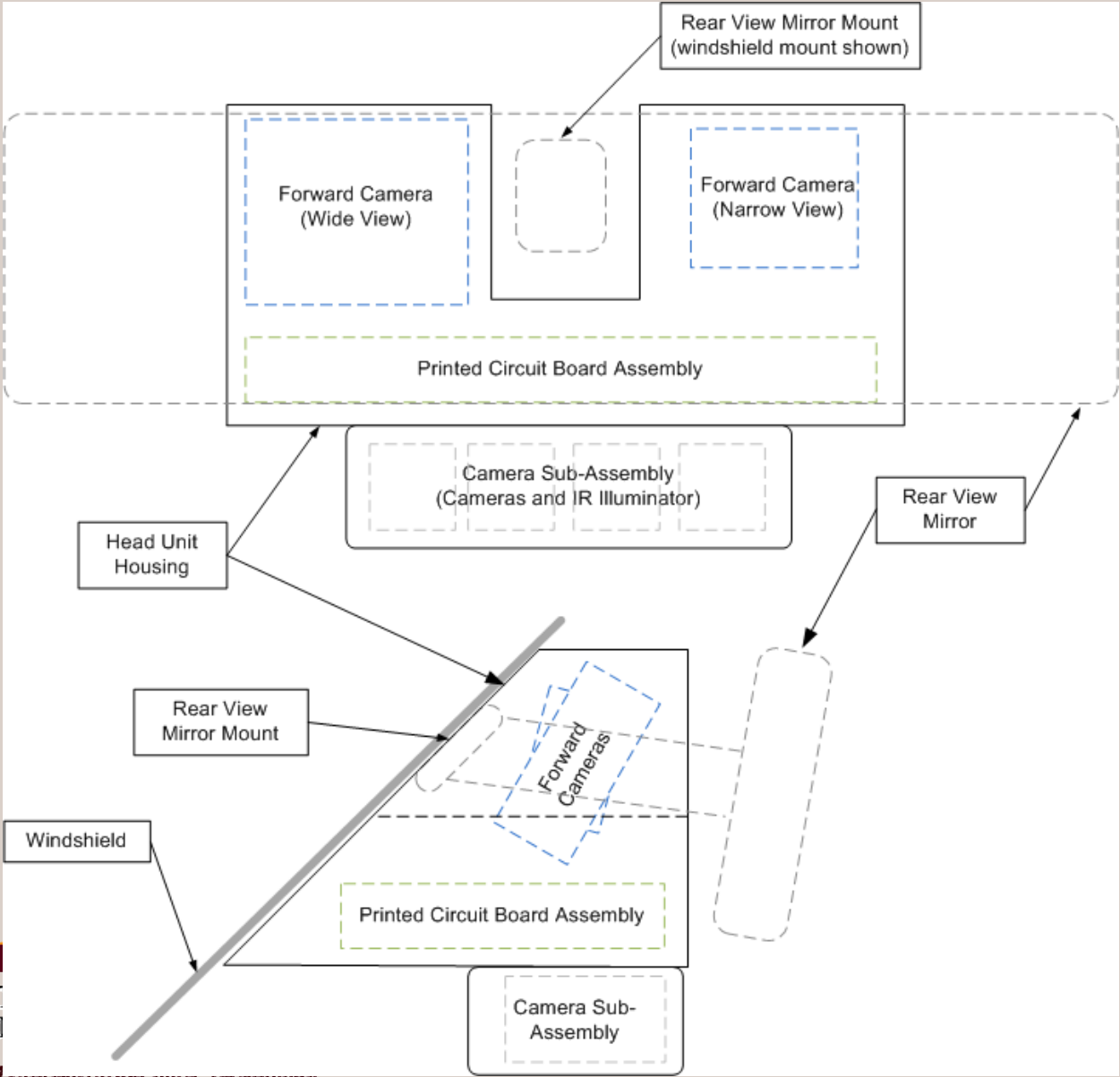
Prototype DAS Components



Prototype DAS

- 5 digital video cameras/views
 - Machine Vision Driver ID
 - Machine Vision Eyes Forward
 - Machine Vision Traffic Signal State Detector (post processed)
 - Machine Vision Lane Tracker
- Accelerometers (3 axis)
 - 10Hz, and 1KHz ACN
- Rate Sensors (3 axis)
- GPS
 - Latitude, Longitude, Elevation, Time, Velocity
- Forward Radar
 - Position and velocity; multiple targets
- Cell Phone + Wi-Fi (80211.g)
 - ACN, health checks, location notification
- Luminance sensor
- RF sensor
- Passive alcohol sensor
- Estimate of sound level
- Incident push button
- Audio (only on incident push button)
- Turn signals
- Vehicle network data
 - Accelerator
 - Brake pedal activation
 - ABS
 - Gear position
 - Steering wheel angle
 - Speed
 - Horn
 - Seat Belt Information
 - Airbag deployment
 - Potentially more variables . . .

Conceptual Head Unit Configuration and Mounting (front and side views above and below, respectively)

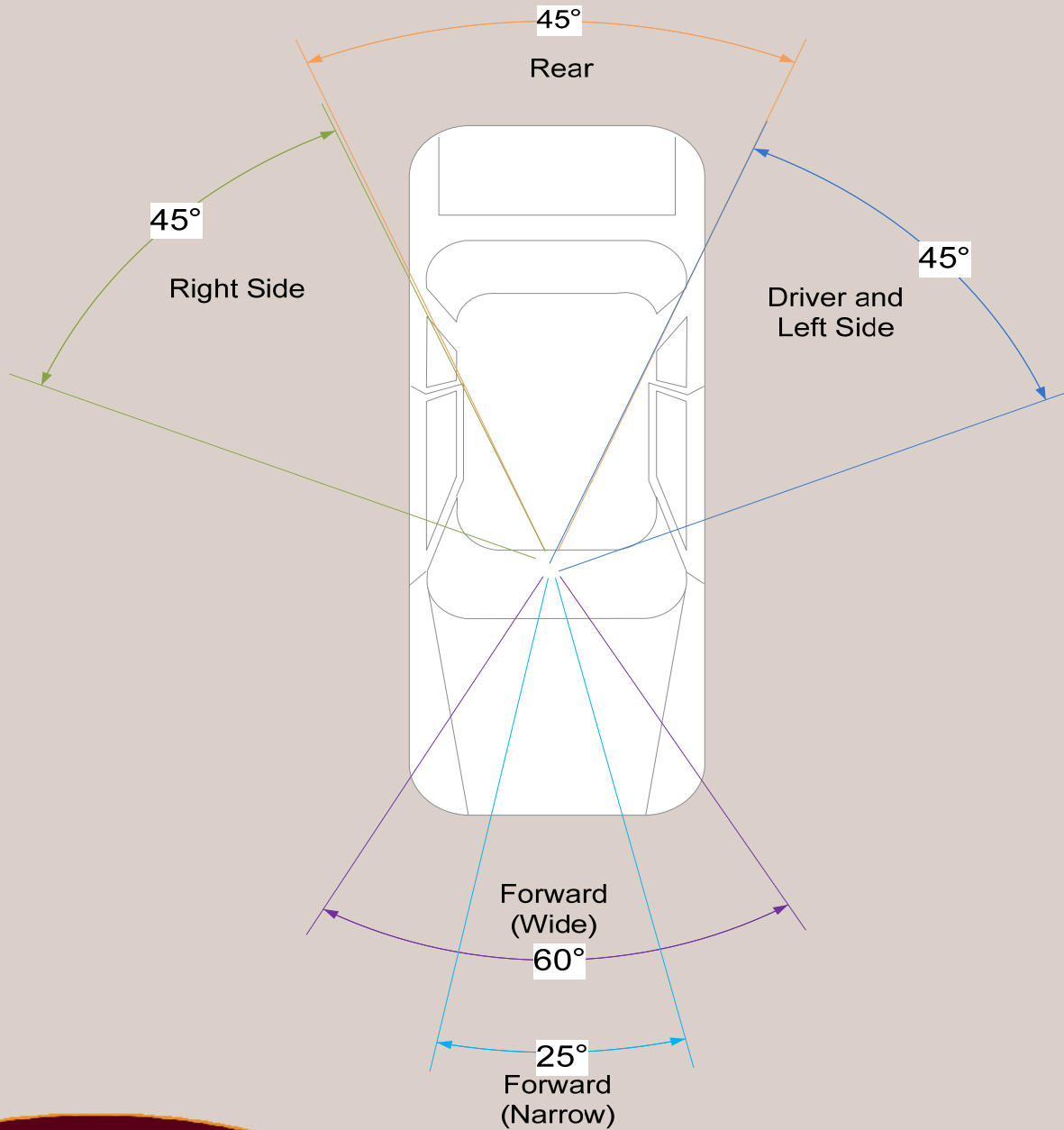


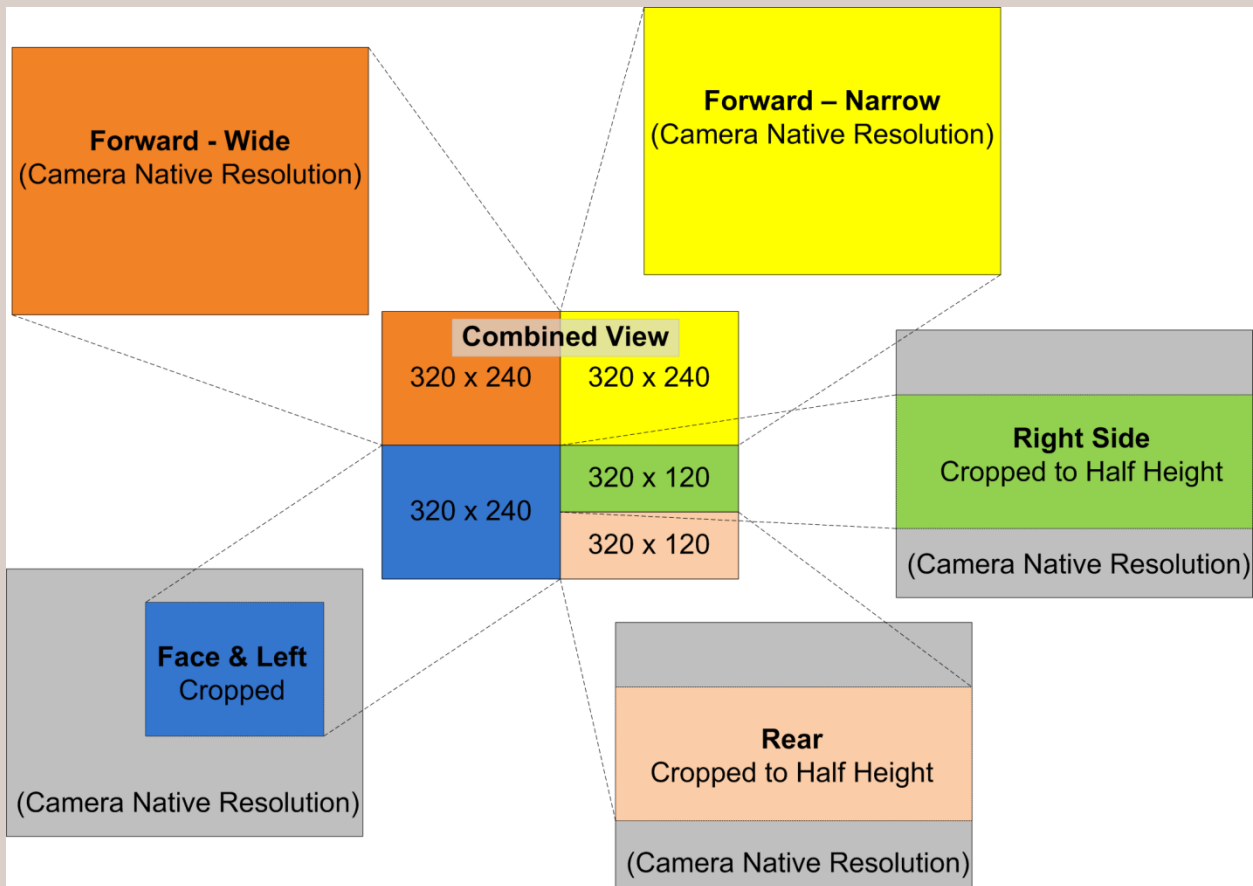
Instrumentation: DAS

- DAS installations performed primarily at site contractor garage; secondarily at a residence or place of work via data service vans. Driver assessments performed at the same time that the DAS is being installed.
- Data downloaded from 325 vehicles per site from site contractor personnel at least every six months by R&R of main DAS unit; health checks performed via cellular link and Wi-Fi data link as available.
- Data transferred from each S07 site to the S06 oversight/integration contractor via encrypted VPN.
- Data remains resident on main DAS unit until quality control check verifies redundant copies at the site contractor and at the oversight/integration contractor.

Instrumentation: Enhanced DAS

- On-board data storage for at least 6 months.
- Continuous data collection at 10 Hz, including compressed video.
- Buffered, uncompressed video collected at 30 Hz, capable of being saved for 10-second intervals when triggered (e.g., for crash events).
- Cameras: Forward-view(2), driver face plus left-side view, rear-window view, right-side view.
- Forward view: Machine-vision supportive color cameras with anti-blooming technology and low-light capability.
- Remaining three cameras: Low-cost, small-form-factor black-and-white cameras that are sensitive to IR illumination.





Prototype DAS Camera under consideration

Conventional Camera



Camera with Autobrite®



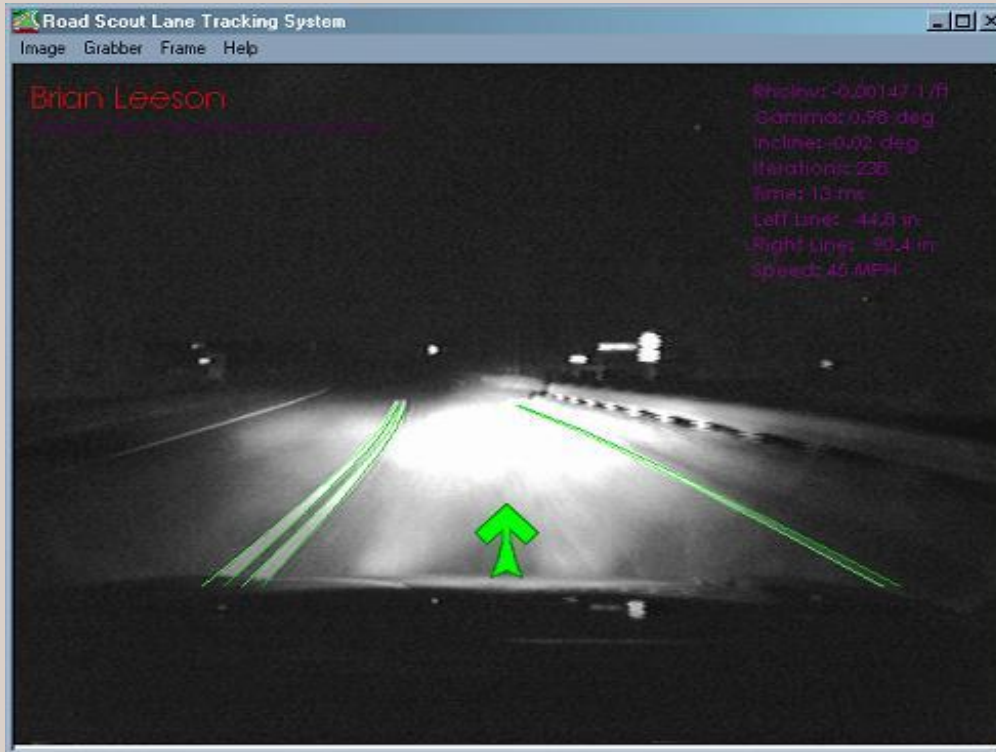
Autobrite® provides high dynamic range so that details in both bright and dim areas are clearly visible.



Prototype Lane Tracker: Current VTTI System

- Data can work in real time (full resolution) and post process (compressed, lower resolution)
- Produces numeric values for use in database
- Markers indicate lane changes
- System distinguishes lane type (solid, dashed, double, etc.)
- System determines if camera is centered to vehicle
- System continuously calibrates and assess its confidence levels

VTTI Machine Vision Lane Tracking: 6 MVMT and counting



Lane Tracker

- Inputs include width of vehicle
- Outputs include lane width, marker styles, tilt, yaw, lane change, and distance from lane, road curvature and incline
- Currently under testing to validate/measure the abilities and frailties of the system.
 - Variety of weather and lighting conditions (day, night, rain, etc.)
 - Variety of road geometries and lane marker qualities
 - Variety of road types (urban, rural, etc.)

Prototype Eyes Forward/Head Tracker: VTTI Prototype

- Face image is located with machine vision
 - electronically centered in the video frame
 - digitally zoomed into the face so excess background image can be discarded to yield approximately 1/3 of original frame size
- Determines general driver gaze location
- Features an embedded IR light source
- Works in all lighting conditions
- Final video is saved at the same compression rate as all other video data collected

Traffic Signal State Detector: UMTRI post-hoc system under development

- First prototype stage
- Post-hoc use of compressed forward scene images and vehicle data to determine the presence and signal state of traffic signals
- Can be used to locate vehicle with respect to the intersection

Traffic Signal State Detector

- Inputs include:
 - Time stamped color images (10 hz sequence)
 - Database with almost synchronous signals (speed, yaw rate, acceleration, GPS heading, latitude, longitude)
 - Database(s) identifying signalized intersections
 - Camera calibration, location & alignment to vehicle
 - Additional secondary data (reverse gear state, wiper state, brake switch, lead vehicle range, time of day)
 - Intersection geometry information is desirable including stop line location

Traffic Signal State Detector

- Outputs include:
 - Log changes in signal status (Presence of traffic signal, Signal state for vehicle's turning movement (R, Y, G), Indicator type (flashing, arrow or circular), Confidences in all of the above)
 - Associate signal faces with intersection(s) and turning movements
 - Location of intersection stop line and/or point at which crossing lanes would be intruded upon
 - Database tables which note epochs with different signal status values, assign indices for face intersection and turning movement, and note locations of stop lines/point of intrusion into crossing path.

One key to SHRP2's success is access to variables from the vehicle network

- Logistically we cannot instrument the vehicles to capture all the desired information within our time/resource constraints.
- The more information that can be obtained from the vehicle network the more potential uses there are for this data
 - Consider this information in the context of what you are interested in as a potential user of the system
 - National resource
- Request for network information was made by SHRP 2 staff to the Auto Alliances

Alliance of Auto Manufacturers

- Use 2002 or newer models
- Add permission to get EDR data to IRB form -- Complete
- Provide radar specification – Complete
- Provide accuracy timing requirements for DAS info.
- It maybe difficult to get network information from any vehicle
 - May need to give preference to vehicles with more critical network information available
 - Potential sampling concerns doing this that will need to be worked through
- Identify subset of desired models from each manufacturer

Association of International Auto Manufacturers

- Work with subset of vehicles
- Beginning to work with individual manufacturers to establish details of data logistics

Automatic System Health Status

- Status Information
 - Hard Drive Status
 - Measured Data Status
 - Camera Status
- Communicate via Wi-Fi or Cellular
- Provides the ability to chart the progress of the study

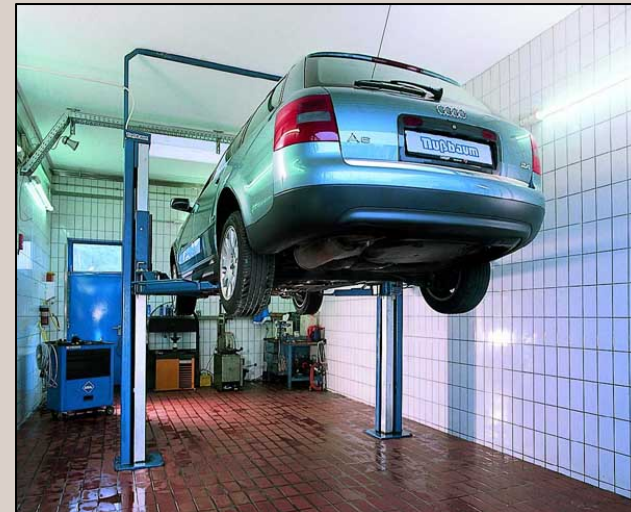
Automatic Collision Notification (ACN)

- Several inputs into the ACN algorithm
 - Acceleration
 - Air Bag Deployment
 - Task 14 will test and refine
- Uploads summary data to a server
 - ID, Time, Location, Severity, Video
 - Summary data is placed into a queue
 - Notification is sent to an operator



Installation – Lessons Learned

- Requirement for SHRP 2: 3 hour install time
- Need Garage Space
 - More conducive to difficult installs
 - Not impeded by the weather
 - Co-located with the researchers for assessment
 - Uniform Calibrations
 - Goal: 90+% in garage
- Stereo Installer Model
 - Poor Quality
 - Installations
 - Debugging
 - Calibration
 - Expensive



Installation – Lessons Learned

- What to expect
 - Car failures: Everything due to system
 - Ex: Car Batteries: 5-7 year lifespan
 - +/-1000 battery failures
 - Condition of the cars
 - Cleanliness
 - State of repair
 - Will car run for a year?
 - Animals



Sample Design Summary

- Task 1 (Research Questions)
- Task 2 (Analysis Planning/Analysis Methods)
- Task 3 (Sample Design)
- Task 4 (Sample Design Interim Report)

S05 Sample Design Recommendation Process

- Research questions were used to generate top level requirements
- Trade-off analyses were conducted to identify projects needs/wants and feasible alternatives
- Cost estimate model was developed and used to evaluate each tradeoff
- Three sampling statisticians were added to project team to consult on each tradeoff

S05 Sample Design Recommendations

- Target number of vehicles = 2,600 light vehicles of all types in service for 2 years all with enhanced DAS; 1,500 installed in 2 sets of vehicles for 1 year; 1,100 installed in a single set of vehicles for 2 years.
 - Largest sample within project resources: 4,100 primary participants; 5,200 data years; 7,600 total drivers with usable data.
 - 3,600 drivers stratified equally by gender and “functionally” (e.g., “teens” or “young adults”) across all ages (16 to 75+ years).
 - An additional 500 drivers specially recruited who utilize new and near-future advanced vehicle systems including safety features and telematics.

S05 Sample Design Recommendations

- Continuous data collection
 - Greatest data flexibility (exposure calc., etc)
 - Storage availability makes this feasible
- Data stored in raw form as practical
 - Greatest flexibility for calculating summary measures/surrogates
 - Video will still require some level of compression, but will be continuous
- Only light vehicles will be used, however, all light vehicle types (passenger, light truck SUV, mini-van) will be represented.
- “Enhanced DAS” units will be used throughout and will answer the vast majority of the identified research questions.

Sample Design (age X gender)

Gender: Age Range	Age Range Description	Year 1	Year 2	Years 1 & 2	Total Participants	Total Data-Years	% of All Drivers (16+)	Ratio of Sample % to Pop % (disregards drivers under age 16 and the 500 advanced veh participants.)
M: 16-19	Teen	125	125	50	300	350	2.4	3.29
M: 20-34	Young Adult	125	125	50	300	350	13.1	0.60
M: 35-49	Middle Adult	125	125	50	300	350	15.1	0.52
M: 50-64	<i>Younger</i> Older Driver	125	125	50	300	350	12.1	0.65
M: 65-74	<i>Middle</i> Older Driver	125	125	50	300	350	4.1	1.93
M: 75+	<i>Older</i> Older Driver	125	125	50	300	350	3	2.63
TOTAL MALE							100.00%	
F: 16-19	Teen	125	125	50	300	350	2.3	3.43
F: 20-34	Young Adult	125	125	50	300	350	12.9	0.61
F: 35-49	Middle Adult	125	125	50	300	350	15	0.53
F: 50-64	<i>Younger</i> Older Driver	125	125	50	300	350	12.2	0.65
F: 65-74	<i>Middle</i> Older Driver	125	125	50	300	350	4.3	1.84
F: 75+	<i>Older</i> Older Driver	125	125	50	300	350	3.4	2.32
TOTAL FEMALE							100.00%	
Any	<i>Adv. Vehicle Technology</i>			500	500	1000		

Totals: 1,500 1,500 1,100 4,100 5,200

2006 Data Source: http://www.fhwa.dot.gov/policy/ohim/hs06/driver_licensing.htm



S05 Sample Design Recommendations

– Total # of regions

- Up to eight regional data collection sites covering relatively homogeneous regions of the 48 contiguous states. Flexibility for one or two “super” sites and a few smaller sites.
 - Northwest
 - Southwest
 - Midlands
 - Midlands West
 - Midlands East
 - South
 - Southeast
 - Northeast

Other Tradeoffs Considered

- Representative vs. risk-prone sample
- Participant pay vs. ability to attract/retain participants
- Total # of Sites vs. # of DAS Managed per site
- Stratification variables to include vs. difficulty of filling cells
- Total years of data collection vs. cost per data-year
- Miles radius per site vs. a contractor's ability to manage the square mileage
- Van teams per DAS vs. team's ability to manage the site area

Task 5: Driver Assessment Summary

- Developed with Expert Task Group Involvement
- Relevant Dimensions
 - Functional Abilities
 - Perception (especially visual ability)
 - Cognition/Visual
 - Psychomotor Skill
 - Physical Capability
 - Psychological Testing
 - Medical/Health Conditions
 - Driving Knowledge and History

Driver Testing Criteria Applied

- **Comprehensiveness** – each relevant dimension to be sufficiently covered by an assessment.
- **Evidence of Predictive Value** – sound evidence exists to indicate that the test is predictive of relevant driving behaviors or safety outcomes.
- **Feasibility of Administration** – feasibility of administration within an approximate two-hour window of opportunity.
- **Uniqueness** – each assessment was selected to measure a unique construct or characteristic.
- **Persistence** – measurement of a relatively stable characteristic (e.g., selective attention), not a transient one (e.g., fatigue).
- **Feasibility of Replication** – assessments were only included where it was determined that they could be feasibly and reliably replicated at each site.

Driver Testing Selected Assessments

- SHRP2 Field Study: Initial In-Person Health Questionnaire
- SHRP2 Field Study: Off-Site Detailed Medical History
- Optec 5000/5500 Vision Tester
- Motor Free Visual Perception Test (MVPT)
- Useful Field of View (UFOV®)
- Trail Making Test (A & B)
- Jamar Hand Dynamometer
- CARDS and DeJoy Risk Perception Questionnaires Combined
- Barkley's ADHD Quick Screen
- Modified Manchester Driver Behavior Questionnaire
- Sensation Seeking Scale
- Sleep Hygiene Questionnaire/Epworth Sleepiness Scale
- Morningness-Eveningness Scale
- Driving Knowledge Test

S05 Task 6 Status: Video Automation

Candidate systems operating or under development

- Lane Tracker
- Eyes Forward/ Head Tracker
- Traffic Signal State Detector
- Driver ID

S05 Task 8

Data Collection, Reduction,
Integration, Archiving, Processing
and Access



Data Collection

- 2500 vehicles instrumented for 2 years
- 12,000 mi/yr @ 35mph (~ 343 hrs/yr)
- Video compression 4MB/min
- 1.5 objects tracked/radar (avg. continuous)
- Sensor frequency (1 Hz – 30 Hz; 1000Hz*)

Yields:

- 400TB video data (storage only)
- 100TB sensor (raw) data; 185,000,000,000 rows
- That's a **BIG** database; but within the current state-of-the-art

Data Reduction

- Raw (sensor) data will be transformed, as needed, to agreed units of measure and loaded into a database (approximately 500GB/day).
- SQL data access provided by ODBC/JDBC
- SQL queries and custom applications will allow researchers to identify potential events of interest.
- Video reduction may be required to confirm the event and to answer research questions.

Data Integration

- Database must support spatial data (Lat/Long) from GPS to allow integration with other data sources.
- Service-oriented architecture could allow data abstraction and integration with external sources.
- A middleware solution could intercept resource intensive queries from novice users (i.e. - `SELECT * FROM 185B rows`).

Data Archiving

- Data's research life-span is 30+ years
- Data preservation is paramount for all data.
- Rotating disks will fail as they age
 - RAID (disk) arrays mitigate the risk of losing data, but are subject to catastrophic failure during the time a new disk is installed and the array is restored.
- Restoring a 100TB database from tape could take more than a month.
- Recommend: 2 data centers with data synchronization over a high-speed link.

Data Processing

- A vehicle's collected data will be processed at one of the regional centers where a strict protocol will ensure it is:
 - extracted, stored and backed up on a secure server located at the regional center.
 - run through a Quality Control process
 - transferred to the primary Data Center
 - verified for complete and accurate transfer
 - loaded into the database (sensor data) or stored on a file server (video data) in the primary data center.

Data Access

- 3 user access levels:
 1. Public – access to reduced, de-identified data sets via a web front-end (similar to FARS)
 2. Limited – secure, role-based access to reduced, de-identified data sets and the corresponding de-identified video.
 3. Full – secure, role-based access to all data and video from an on-site location or via VPN (additional security may require a USB security token or biometric identity).
- Data access via SQL (ODBC/JDBC), web services or a middleware component.

User Characteristics

- Goal is easy access for a broad range of users:

From single researcher with minimal resources,

To

Large-scale operations with many available tools and techniques

Data Center Recommendation

Build 2 identical data centers (a primary and secondary) where data at the primary site can be synchronized over a 40Gb link to the secondary site.

This will provide:

- the best opportunity to preserve data for an extended period. Estimated time to restore a 100TB database from tape backup is greater than 30 days.
- failover protection and business continuity in case of a hardware failure or a disaster
- high availability during scheduled maintenance windows, when failed disks are being restored and when data is being migrated to new storage

Questions?

Task 3: Sample Design

Task 4: Sample Design Interim Report

Task 5: Driver Testing

Task 6: Driver Face and Other Video Recording and Processing

Task 7: Data Items and Instrumentation Package Specifications

Task 8: Data Collection, Reduction, Integration, Archiving, Processing and Access

Task 10: Identify All Requirements for Approval of Human Subjects Research

Completed

Active

