Notif. of upcoming highway merge	Automated Highway Merging	This function
Lane Routing	Lane-to-Lane Routing within Highway	This function
Execute selected lane change	This function	Lane Change Coordination

2.1.11 Lane Change Coordination

Many lane changes will require coordination with nearby vehicles. The initiating vehicle will send out an inquiry to selected nearby vehicles (identifying them by their position) asking them to increase spacing from the vehicle ahead of or behind them. They will reply with a "can do" or "can't do", and the initiating vehicle will send out an "execute message" to one of the vehicles which replied positively. The Lane Change Coordination function of any vehicle agreeing to assist will send out the appropriate commands to change position.

Description	From System	To System
Execute Lane Change	Lane Change Decision	This function
Own vehicle position	Absolute position sensor	This function
Own vehicle speed	Speedometer	This function
Position, speed of nearby vehicles	Vehicle position sensor	This function
Feasible lane changes query	This function	Lane Changing
Feasible lane changes reply	Lane Changing	This function
Spacing change inquiry*	This function (own vehicle	This function (nearby vehicle)
Spacing change reply*	This function (nearby vehicle)	This function (own vehicle)
Spacing change execute message*	This function (own vehicle)	This function (nearby vehicle)
Ordered speed change	This function	Speed Tracking
Execute Lane Change	This function	Lane Changing

* Senders and receivers are given from the point of view of the vehicle requesting the lane change. This function aboard the receiving vehicle will also handle that end of the communication, with sender and receiver reversed.

2.1.12 Platoon Formation and Dispersal

In Urban Phase 3, platoons are formed with infrastructure assistance, and they travel and disperse cooperatively. Vehicles passing a beacon are queried on their destination; the infrastructure then uses this information to choose groups of vehicles to be gathered into a platoon. Candidate vehicles are held briefly in dedicated lanes similar to railroad sidings until they can be brought together with other platooning candidates or an existing platoon. The infrastructure orders existing platoons to accept additional vehicles; however, the lead vehicle manages any changes needed to accomodate the newcomer. Depatures are coordinated entirely within the platoon with the lead vehicle giving the orders.

Description	From System	To System
Destination and platooning status query	Infrastructure via beacon	This function
Destination/platoon status reply	This function	Infrastructure via beacon
Wait for platoon order (platoon ID, location, time of arrival)	Infrastructure via beacon	This function
Waiting for platoon reply (location)	This function	Infrastructure via beacon
Proceed and join platoon order (platoon ID, speed, time)	Infrastructure via beacon	This function
Seeking platoon query (platoon ID)	Single vehicle	This function
Sought platoon reply (platoon ID, platoon position, speed)	Platoon leader	This function
Location and speed reply (vehicle position, speed)	This function	Platoon leader
Instructions for joining platoon (speed, lane, time)	Platoon leader	This function
Proceeding with intent to join platoon (platoon ID)	This function	Platoon leader

2.1.13 Vehicle Operational Status Monitoring

The AHS vehicle will perform an operational status check before entering automated mode, and at regular intervals (once every TBD minutes) during automated operation. Each subsystem (whether an AHS controller, or a critical vehicle component such as brakes) will be capable of reporting status as OK, non-critical failure, or critical failure. The AHS vehicle will not enter automated mode if any subsystems report failures, and the AHS check-in function, if present, will not allow a vehicle with failures to enter the Automated Highway System. A vehicle which is traveling in automated mode when it detects a failure will follow pre-programmed logic which will depend on the severity of the failure. The action dictated by the logic may be to get off at the next exit, move to the shoulder and stop, hand over control to the driver (depending on the results of this cross-cutting study), or stop in the lane.

Description	From System	To System
Request for subsystem status	This function	Critical AHS and vehicle subsystems
Subsystem status report	Critical AHS and vehicle subsystems	This function
Request feasibility of candidate responses to failure	This function	Lane Change Decision, Driver Status Monitoring, ...
Feasibility of candidate responses to failure	Lane Change Decision, Driver Status Monitoring, ...	This function
Ordered response to failure	This function	Lane Change Decision, Speed Decision, driver interface, ...

2.1.14 Driver Status Monitoring

The AHS vehicle will be able to perform a driver responsiveness check when appropriate. This status check is expected to be something as simple as pushing two buttons in sequence within a specified time interval. As a minimum, this check will be performed before the vehicle enters automated mode, before the vehicle exits automated mode and the driver resumes control, and before the driver of the lead vehicle is given control of a truck platoon (Intercity Phase 1). Driver status will also be checked in case of system failure if the logic dictates that having the driver resume control is the preferred option. Some sort of driver status check which can be performed while driving may be used as an alertness check for engaged drivers of truck platoons - this is TBD.

Description	From System	To System
Request for driver status	Dedicated Vehicle Exit, Trans. Lane Vehicle Exit, Vehicle Op. Status Monitoring	This function
Driver interface test ordered	This function	Driver Interface
Test result	Driver Interface	This function
Driver status report	This function	Dedicated Vehicle Exit, Trans. Lane Vehicle Exit, Vehicle Op. Status Monitoring

2.1.15 Vehicle Entry

In order to minimize rogue manual vehicles and malfunctioning AHS vehicles, entry into dedicated AHS lanes will be restricted, and vehicles will be checked in by the infrastructure.

2.1.15a Dedicated Vehicle Entry

The vehicle will broadcast its AHS ID, vehicle subsystem status, and driver status. The infrastructure entry controller will validate the ID, and will check account status. The vehicle will then be granted or denied entry to the AHS lane. A dashboard display will show that AHS entry has been approved, and the driver will be prompted to push a button putting the vehicle in automated mode. A physical barrier will block entry until permission is granted and the vehicle signals that it is in automated mode. A radar reflector on the barrier will allow the vehicle to sense that the barrier has been raised.

Description	From System	To System
Vehicle ID, vehicle and driver status	This function	Roadside entry controller
Permission to enter granted/denied (speed, lane)	Roadside entry controller	This function
Barrier status	This function	Vehicle position sensor
Barrier removed	Vehicle position sensor	This function
Enter AHS	This function	Speed Decision, Lane-to-Lane Routing within Highway

2.1.15b Transition Lane Vehicle Entry

The vehicle will broadcast its AHS ID, vehicle subsystem status, and driver status. The infrastructure will validate the ID, and will check account status. The vehicle will then be granted or denied entry to the AHS lane. A dashboard display will show that AHS entry has been approved, and the driver will be prompted to push a button putting the vehicle in automated mode.The vehicle will enter the dedicated lane in automated mode, and broadcast a message confirming AHS entry. Any vehicle which enters the dedicated lane without receiving permission and confirming entry will cause an alert.

Description	From System	To System
Vehicle ID, vehicle and driver status	This function	Entry controller
Permission to enter granted/denied (speed, lane)	Entry controller	This function
Enter AHS	This function	Speed Decision, Lane-to-Lane Routing within Highway
AHS entered (veh. position, speed)	This function	Entry controller
Record of recent entries into AHS at this location	Entry sensors	Entry controller

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2.1.16a Dedicated Vehicle Exit

The vehicle will enter the ramp in automated mode; driver status will be checked before entering the ramp. A roadside beacon will signal the vehicle to enter manual mode, and the driver will be prompted. If he signals by pushing a button that he is ready to assume control of the vehicle, the vehicle will confirm by signaling him and then enter manual mode. A signal will be sent to the infrastructure notifying it that the vehicle has left AHS. The vehicle will not drive onto the manual roadway in automated mode; if the handoff is not completed in time it will pull to the side and stop.

Description	From System	To System
Check driver status in prep. for entering manual mode	Roadside beacon	This function
Request driver status check	This function	Driver Status Monitoring
Driver status	Driver Status Monitoring	This function
Ready to assume control?	This function	Driver interface
Ready to assume control	Driver interface	This function
Transferring control	This function	Driver interface
Enter manual mode	This function	Main AHS processor
Confirm entry of manual mode	Main AHS processor	This function
Exiting AHS	This function	Roadside beacon

2.1.16b Transition Lane Vehicle Exit

The vehicle will enter the transition lane in automated mode; driver status will be checked before entering the lane. A beacon will signal the vehicle to enter manual mode, and the driver will be prompted. If he signals by pushing a button that he is ready to assume control of the vehicle, the vehicle will confirm by signaling him and then enter manual mode. A signal will be sent to the infrastructure notifying it that the vehicle has left AHS. The vehicle will not drive onto the manual roadway in automated mode; if the handoff is not completed it will stop at the next opportunity to do so without obstructing traffic.

Description	From System	To System
Check driver status in prep. for entering manual mode	Roadside beacon	This function
Request driver status check	This function	Driver Status Monitoring
Driver status	Driver Status Monitoring	This function
Ready to assume control?	This function	Driver interface

Ready to assume control	Driver interface	This function
Transferring control	This function	Driver interface
Enter manual mode	This function	Main AHS processor
Confirm entry of manual mode	Main AHS processor	This function
Exiting AHS	This function	Roadside beacon

2.1.17 Automated Highway Merging

Merging of the traffic streams from two AHS roadways will be performed jointly by the infrastructure and the vehicles. The infrastructure will prompt vehicles to send their position and speed as they approach the intersection, and use this information to form a detailed picture of traffic flow near the junction. Infrastructure commands will be sent to vehicles ordering them to change speed or increase spacing. This will in effect match vehicles in one traffic stream to gaps in the other traffic stream. Final adjustments of speed and spacing required to interleave the two traffic streams will be negotiated cooperatively by the vehicles.

Description	From System	To System
Send position	Infrastructure via beacon	This function
Current position, speed	This function	Infrastructure via beacon
Ordered speed, spacing, or lane	Infrastructure via beacon	This function
Notification of upcoming highway merge	This function	Road Geometry Recognition, Lane Change Decision

2.1.18 Lane-to-Lane Routing Within a Single Highway

Lane selection on an AHS highway is done primarily by the vehicle, based on a map database for that section of highway downloaded from a roadside beacon at the start of the section. The infrastructure may override the vehicle's choice and order the vehicle to move into a lane for the purpose of flow optimization or traffic control around an incident or work site.

Description	From System	To System
Data on highway lanes	Map database for current highway section	Vehicle database
Data on highway lanes	Vehicle database	This function
Enter AHS	Dedicated Lane Vehicle Entry, Trans. Lane Vehicle Entry	
Travel lane ordered	Infrastructure	This function
Current position	Vehicle position sensor	This function
Lane routing	This function	Lane Change Decision

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2.1.19 Highway-to-Highway Routing

The choice of highways to get the vehicle from its AHS entry point to its AHS exit is made by the vehicle using information from a regional (or perhaps national) database, and information on speeds, closures, and anticipated conditions for each highway segment supplied by the infrastructure. The driver may express a preference for the fastest route, the most scenic route, or request specific waypoints.

Description	From System	To System
Current position of vehicle	Vehicle position sensor	This function
Highway vehicle is currently on	Vehicle database	This function
Requested destination, routing preferences	Driver interface	This function
Highway data	Vehicle regional or national highway database	This function
Average speed based on current conditions for highway segments along possible routes	Infrastructure via beacon	This function
Vehicle routing	This function	Vehicle database

2.1.20 AHS Flow Control

Flow control is performed by the infrastructure based on current average speed and throughput for the highway segments under control of the TOC, knowledge of usual daily, weekly and annual traffic patterns, and on reports from adjacent TOC's. The commands to implement the desired flow patterns are communicated to the vehicles either through roadside beacons, or mobile beacons in the case of incidents.

Description	From System	To System
Link connectivities and capacities	Map database for area being managed	This function
Current average speeds and throughputs for highway segments under control	Infrastructure sensors and roadside beacons	This function
Usual daily, weekly, and annual traffic patterns	TOC Database	This function
Throughput and speed statistics, and incident reports from adjacent areas	Other TOC's	This function
Location and ID of mobile beacons	First responding emergency vehicles with beacon capability	This function
Traffic flow rules	This function	Roadside and mobile beacons

2.1.21 AHS Admission Control

Admission control is performed by the infrastructure based on current average speed and throughput for the highway segments under control of the TOC, knowledge of usual daily, weekly and annual traffic patterns, and on reports from adjacent TOC's. The commands to implement the desired flow patterns are communicated to the vehicles through a roadside beacon at the entry ramp.

Description	From System	To System
Link connectivities and capacities	Map database for area being managed	This function
Current average speeds and throughputs for highway segments under control	Infrastructure sensors and roadside beacons	This function
Usual daily, weekly, and annual traffic patterns	TOC Database	This function
Throughput and speed statistics, and incident reports from adjacent areas	Other TOC's	This function
Traffic flow rules	This function	Roadside beacons at entry ramp

2.1.22 Emergency Detection/Monitoring

Emergency detection is perfomed by the infrastructure using inputs from vehicles, beacons, and outside sources. Specifically, vehicles may send reports of critical subsystem failures, obstacles detected, or driver emergency messages. Roadside beacons may send reports that vehicle densities are very high or vehicle speeds are very low. When the infrastructure is alerted to a potential

problem it can gather additional data by polling the vehicles in the vicinity of the problem (using cellular technology) on their speed and following distance.

Description	From System	To System
Report of critical subsystem failures	Vehicle self monitoring	This function
Probable obstacle detection	Obstacle Recognition (vehicle)	This function
Driver emergency message	Driver interface (vehicle)	This function
Vehicle density or speed report	Roadside beacon	This function
Incident reports via cellular phone or from news media	Entered by operator via keyboard at TOC	This function
Individual vehicle speed and following distance request	This function (via cellular)	Vehicles near suspected problem
Individual vehicle speed and following distance report	Vehicles near suspected problem (via cellular)	This function
Incident report	This function	TOC Active Incident Database
Additional information on incident including resources needed	Responders on scene	This function
Resources needed	This function	Emergency Response

2.1.23 Emergency Response and Incident Clearing

This function is triggered by the Emergency Detection function. It is performed in parallel by the vehicle and the infrastructure. It uses pre-programmed logic to decide on the nature of the initial response, and displays the result for review by a human operator, who may override it, but whose input is not required for the response to proceed.

Description	From System	To System
Incident report including nature of incident	Emergency Detection/Monitoring	This function
Ordered actions by vehicles	This function	Vehicles in vicinity of incident
Request for response	This function	Appropriate agency - fire, police, tow truck contractor
Confirmation of arrival on scene	Responder on scene	This function
Additional resources needed	Emergency Response	This function

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Physical Architecture

Location	System Type	System Description	
Vehicle	Sensor	Name	Lateral position sensors
		Function	Identify lane/lane position
		Candidate Techno-logies	Vision system Magnetometer system Radar reflective stripe system
Vehicle	Sensor	Name	Vehicle detection sensors
		Function	Measure range, azimuth and range rate of large objects on roadway within 300 to 400 feet of vehicle
		Candidate Technologies	Doppler (EM) radar Laser radar Vision system
Vehicle	Sensor	Name	Obstacle detection sensor
		Function	Sense (small) objects and animals in the roadway ahead of the vehicle
		Candidate Technologies	Radar Doppler radar Laser radar??
Vehicle	Sensor	Name	Vehicle state sensors
		Function	Sense vehicle speed, accel., heading, and traction
		Candidate Techno-logies	Speedometer, tachometer, accelerometers, gyroscope, compass
Vehicle	Sensor	Name	Absolute position sensors
		Function	Determine true vehicle position
		Candidate Technologies	GPS/Mapping system Count of encoded stripes?? Position from beacons/dead reckoning using veh. state sensors
Vehicle	Sensor	Name	Road condition sensor
		Function	Detect water, snow, ice
		Candidate Technologies	Thermometer, barometer, hygrometer, vision system, traction sensor?

Location	System Type	System Description	
Vehicle	Control System	Name	Speed Controller
		Function	Regulate vehicle speed
		Subsystems	Throttle controller, braking controller
Vehicle	Control System	Name	Steering Controller
		Function	Generate servo commands for steering actuator
Vehicle	Control System	Name	Throttle Controller
		Function	Generate servo commands for throttle actuator
Vehicle	Control System	Name	Braking Controller
		Function	Generate servo commands for braking actuator
Vehicle	Communi-cation System	Name	Vehicle-to-vehicle communication system
		Function	Transfer of vehicle maneuver information among nearby vehicles to support cooperative lane changing, merging, and platooning
		Candidate Technologies	Wireless mobile radio Infrared
Vehicle	Communi-cation System	Name	Vehicle-to-roadside two-way broadcast communication system
		Function	Transfer maneuver and obstacle information concerning local merge/entry/exit area. Roadside transmits general speed or lane change assignments to group; vehicle transmits position and speed
		Candidate Technologies	Wireless mobile radio RFID tag system

Location	System Type	System Description	
Vehicle	Communi-cation System	Name	Infrastructure-to-vehicle two-way addressed communication system
		Function	Provides continuous coverage of lanes to transfer maneuver and obstacle information to specific vehicles. Vehicles transmit ID, position and speed to the infrastructure.
		Candidate Technologies	Wireless mobile radio
Infrastructure	Sensors	Name	Roadway surface monitoring
		Function	Monitor hazardous areas for snow, ice, water on roadway surface
		Candidate Technologies	Hughes Research, Malibu - more information to be obtained
Infrastructure	Sensors	Name	Roadway obstacle monitoring
		Function	Monitor hazardous areas for avalanche, rockfall, mudslide, etc.
		Candidate Technologies	Video detection Laser radar
Infrastructure	Control System	Name	Entry processor
		Function	Check vehicle status, driver status, and AHS traffic conditions before allowing vehicle to enter. Control entry barrier
	Control System	Name	Roadside processor
		Function	Regulate flow of vehicles into merge point. Match vehicles in one traffic stream with "holes" in other traffic stream.
Infrastructure	Control System	Name	Region processor
		Function	Optimize traffic flow for region. Manage incident response.

Location	System Type	System Description	
Infrastructure	Communication System	Name	Vehicle-to-roadside two-way broadcast communication system
		Function	Transfer maneuver and obstacle information concerning local merge/entry/exit area. Roadside transmits general speedor lane change assignments to group; vehicle transmits position and speed
		Candidate Technologies	Wireless mobile radio RFID tag system
Infrastructure	Communication System	Name	Infrastructure-to-vehicle two-way addressed communication system
		Function	Provides continuous coverage of lanes to transfer maneuver and obstacle information to specific vehicles. Vehicles transmit ID, position and speed to the infrastructure.
		Candidate Technologies	Wireless mobile radio
Infrastructure	Communication System	Name	Roadside controller-to-TOC communication system
		Function	Transfer traffic flow information such as vehicle density and speed, local road conditions, and reports of incidents to the TOC. Receive traffic density and roadway status for adjacent regions, ID validation algorithm, and financial status for vehicles.
		Candidate Technologies	Land line Microwave link

Expected Stakeholder Role/Benefits vs Deployment Phase

Urban & Intercity	Phase 1	Phase 2	Phase 3
Rural	**Phase 1**	**Phase 2**	
Vehicle Electronics	Provide vehicle sensors and processors as orig. equip. and for retrofit	Provide vehicle-to-vehicle and infrastr.-to-veh. comm. equip., infrastr. processors and veh. processor upgrades	Upgrade vehicle and roadside comm. equipment for 2-way comm. with specific vehicles.
Highway Design and Construction	Convert conven. lane to AHS by modifying for lane-keeping	Add pavement/ obstacle sensors and roadside beacons. Convert/build dedicated lane where practical	Convert/build separate truck lane on intercity rts., separate transit lane on urban rts. where practical
Trucking	Truck platoons on intercity routes increase driver productivity (non-lead drivers nap)	Platoons w/ disengaged drivers on urban & intercity routes	Separate AHS truck lane where practical on intercity routes
Transit	Lane keeping, long. pos. keeping, collision avoid. features increase safety. More reliable travel times due to navigation	Driver can provide service to passengers en-route without delaying trip	Separate transit lanes reduce trip times, make travel times more reliable
Environmental Interests	Reduction in emissions per vehicle mile due to smoother driving.	Reduction in emissions due to platooning and flow control; narrower lanes possible on urban & intercity rts.	Better flow of truck and bus traffic further reduces emissions where separate lane is provided

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Urban & Intercity	Phase 1	Phase 2	Phase 3
Rural	Phase 1	Phase 2	
Transportation Users	Driver need not concentrate on driving; less stress	Driver fully disengaged: can perform other tasks	Shorter, more reliable trip times, less chance of secondary accident due to better flow cntrl., incident mgmt.
Government Agencies	Set roadway and vehicle standards; gain public confidence in and acceptance of automated vehicles	Set comm. standards; gain public confidence in and acceptance of infrastr. cntrl. of vehicles	Better control of traffic. Help resolve privacy issues assoc. with comm. with identified single vehicles
Insurance Industry	Help resolve liability issues concerning automated vehicles	Help resolve liability issues concerning infrastr. control of vehicles	Infrastr. coord. provides better info. on accidents which occur.

Adaptable Concept Roadway vs Vehicle Compatibility

AHS Functions vs Urban Deployment Phases
Adaptable Concept, Part II

AHS Function	Urban Phase 0	Urban Phase 1	Urban Phase 2-	Urban Phase 2+	Urban Phase 3
Speed tracking	Vehicle	Vehicle	Vehicle	Vehicle	Vehicle
Inter-vehicle separation tracking	Vehicle	Vehicle	Vehicle	Vehicle	Vehicle
Lane keeping	Vehicle	Vehicle	Vehicle	Vehicle	Vehicle
Lane changing	Driver	Vehicle; driver in heavy traffic	Vehicle; infrastr. support by ordering spacing	Coord. among vehicles	Coord. among vehicles
Road geometry recognition	Vehicle	Vehicle	Vehicle; some roadside beacons	Vehicle; some roadside beacons	Vehicle; some roadside beacons
Obstacle recognition	Driver	Vehicle	Vehicle initially; then mobile beacon + vehicle	Vehicle initially; then mobile beacon + vehicle	Vehicle initially; then mobile beacon + vehicle
Obstacle avoidance	Driver	Vehicle if traffic permits; otherwise stop	Vehicle if traffic permits; otherwise stop	Vehicle	Vehicle & infrastructure in parallel
Speed decision	Driver	Vehicle	Infrastr. or vehicle	Infrastr. or vehicle	Infrastr. or vehicle
Inter-vehicle separation decision	Vehicle, driver for exceptions	Vehicle	Infrastr. or vehicle	Infrastr. or vehicle	Infrastr. or vehicle
Lane change decision	Driver	Vehicle; driver in heavy traffic	Infrastr. or vehicle	Infrastr. or vehicle	Infrastr. or vehicle
Lane change coordination	Visual	None for vehicle; visual for driver	Infrastr. can order spacing	Infrastr. can order spacing; coord. among vehicles	Infrastructure + vehicle
Platoon formation & dispersal	None	None	None	Cooperative	Infrastr. assisted formation; cooperative dispersal

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Adaptable Concept Roadway vs Vehicle Compatibility

AHS Function	Urban Phase 0	Urban Phase 1	Urban Phase 2-	Urban Phase 2+	Urban Phase 3
Vehicle oper. status monitor.	Driver, vehicle components	Vehicle	Vehicle	Vehicle	Vehicle
Driver status monitoring	None	Vehicle	Vehicle	Vehicle	Vehicle
Vehicle entry	Driver	Vehicle or driver	Vehicle w/ support of infrastr. ordered spacing	Infrastructure & vehicle	Infrastructure & vehicle
Vehicle exit	Driver	Vehicle	Vehicle + beacon	Vehicle + beacon	Vehicle + beacon
Auto. highway merging	Driver	Vehicle; driver in heavy traffic	Vehicle w/ support of infrastr. ordered spacing	Coord. among vehicles with infrastr. support	Infrastructure + cooperation among vehicles
Lane-to-lane routing	Driver w/ ITS information	Vehicle	Vehicle using info from beacon	Vehicle using info from beacon	Infrastructure or vehicle
End-to-end routing	Driver w/ ITS information	Vehicle	Vehicle	Vehicle	Vehicle
AHS flow control	None	None	Infrastructure, broadcast mode	Infrastructure, broadcast mode	Infrastructure assisted
AHS admission control	None	None	Infrastructure	Infrastructure	Infrastructure

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Adaptable Concept Roadway vs Vehicle Compatibility

AHS Function	Urban Phase 0	Urban Phase 1	Urban Phase 2-	Urban Phase 2+	Urban Phase 3
Emergency detect./monitoring	Driver	Driver & vehicle; infrastr. notified	Driver & vehicle; infrastr. notified	Driver & vehicle; infrastr. notified; nearby vehicles warned	Driver & vehicle; infrastr. notified; nearby vehicles warned
Emerg. resp./incident handl.	Present capabilities	Present capabilities	Vehicle initially; infrastr. support for flow control and emerg. vehicles; mobile beacons	Vehicle initially; infrastr. & coop. support for flow cntrl. and emerg. vehicles; mobile beacons	Infrastr. & vehicle in parallel; infrastr. & coop. support for flow cntrl. and emerg. veh.; mobile beacons
Driver interrupt handling	Driver override on all functions	Driver override on all functions	Interrupt trip, change dest., choose route	Interrupt trip, change dest., choose route	Interrupt trip, change dest., choose route

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Adaptable Concept Roadway vs Vehicle Compatibility

AHS Functions vs Rural Deployment Phases

AHS Function	Rural Phase 0	Rural Phase 1	Rural Phase 2
Speed tracking	Vehicle	Vehicle	Vehicle
Inter-vehicle separation tracking	Vehicle	Vehicle	Vehicle
Lane keeping	Vehicle	Vehicle	Vehicle
Lane changing	Driver	Vehicle; driver in heavy traffic	Coord. among vehicles
Road geometry recognition	Vehicle	Vehicle	Vehicle; some roadside beacons
Obstacle recognition	Driver	Vehicle	Vehicle initially; then mobile beacon + vehicle
Obstacle avoidance	Driver	Vehicle if traffic permits; otherwise stop	Vehicle cooperatively
Speed decision	Driver	Vehicle	Infrastr. or vehicle
Inter-vehicle separation decision	Vehicle, driver for exceptions	Vehicle	Infrastr. or vehicle
Lane change decision	Driver	Vehicle; driver in heavy traffic	Infrastr. or vehicle
Lane change coordination	Visual	None for vehicle; visual for driver	Infrastr. orders spacing + coop. among vehicles
Platoon formation & dispersal	None	None	Cooperative

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Adaptable Concept Roadway vs Vehicle Compatibility

AHS Function	Rural Phase 0	Rural Phase 1	Rural Phase 2
Vehicle oper. status monitor.	Driver, vehicle components	Vehicle	Vehicle
Driver status monitoring	None	Vehicle	Vehicle
Vehicle entry	Driver	Vehicle	Infrastr. orders spacing + coop. among vehicles
Vehicle exit	Driver	Vehicle	Vehicle + beacon
Auto. highway merging	Driver	Vehicle; driver in heavy traffic	Infrastr. orders spacing + coop. among vehicles
Lane-to-lane routing	Driver w/ ITS information	Vehicle	Vehicle
End-to-end routing	Driver w/ ITS information	Vehicle	Vehicle
AHS flow control	None	None	Infrastructure, broadcast mode
AHS admission control	None	None	Infrastructure

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Adaptable Concept Roadway vs Vehicle Compatibility

AHS Function	Rural Phase 0	Rural Phase 1	Rural Phase 2
Emergency detect./monitoring	Driver	Driver & vehicle; infrastr. notified	Driver & vehicle; warning broadcast by vehicle & infrastr. notified
Emerg. resp./incident handl.	Present capabilities	Present capabilities	Vehicle initially; infrastructure broadcast support for emerg. vehicles; mobile beacons
Driver interrupt handling	Driver override on all functions	Driver override on all functions	Interrupt trip, change dest., choose route

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Adaptable Concept Roadway vs Vehicle Compatibility

AHS Functions vs Intercity Deployment Phases

AHS Function	Intercity Phase 0	Intercity Phase 1	Intercity Phase 2	Intercity Phase 3
Speed tracking	Vehicle	Vehicle	Vehicle	Vehicle
Inter-vehicle separation tracking	Vehicle	Vehicle	Vehicle	Vehicle
Lane keeping	Vehicle	Vehicle	Vehicle	Vehicle
Lane changing	Driver	Vehicle; driver in heavy traffic	Coord. among vehicles	Coord. among vehicles
Road geometry recognition	Vehicle	Vehicle; some roadside beacons	Vehicle; some roadside beacons	Vehicle; some roadside beacons
Obstacle recognition	Driver	Vehicle	Vehicle initially; then mobile beacon + vehicle	Vehicle initially; then mobile beacon + vehicle
Obstacle avoidance	Driver	Vehicle if traffic permits; otherwise stop	Vehicle	Vehicle & infrastr. in parallel
Speed decision	Driver	Vehicle	Infrastr. or vehicle	Infrastr. or vehicle
Inter-vehicle separation decision	Vehicle, driver for exceptions	Vehicle	Infrastr. or vehicle	Infrastr. or vehicle
Lane change decision	Driver	Vehicle; driver in heavy traffic	Infrastr. or vehicle	Infrastr. or vehicle
Lane change coordination	Visual	None for vehicle; visual for driver	Infrastr. can order spacing; coord. among vehicles	Infrastructure + vehicle
Platoon formation & dispersal	None	Cooperative for trucks only	Cooperative	Infrastr. assisted formation; cooperative dispersal

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Adaptable Concept Roadway vs Vehicle Compatibility

AHS Function	Intercity Phase 0	Intercity Phase 1	Intercity Phase 2	Intercity Phase 3
Vehicle oper. status monitor.	Driver, vehicle components	Vehicle	Vehicle	Vehicle
Driver status monitoring	None	Vehicle	Vehicle	Vehicle
Vehicle entry	Driver	Vehicle or driver	Infrastructure & vehicle	Infrastructure & vehicle
Vehicle exit	Driver	Vehicle	Vehicle + beacon	Vehicle + beacon
Auto. highway merging	Driver	Vehicle; driver in heavy traffic	Coord. among vehicles with infrastr. support	Infrastructure + cooperation among vehicles
Lane-to-lane routing	Driver w/ ITS information	Vehicle	Vehicle using info from beacon	Infrastructure or vehicle
End-to-end routing	Driver w/ ITS information	Vehicle	Vehicle	Vehicle
AHS flow control	None	None	Infrastructure, broadcast mode	Infrastructure assisted
AHS admission control	None	None	Infrastructure	Infrastructure

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Adaptable Concept Roadway vs Vehicle Compatibility

AHS Function	Intercity Phase 0	Intercity Phase 1	Intercity Phase 2	Intercity Phase 3
Emergency detect./monitoring	Driver	Driver & vehicle; infrastr. notified	Driver & vehicle; infrastr. notified; nearby vehicles warned	Driver & vehicle; infrastr. notified; nearby vehicles warned
Emerg. resp./incident handl.	Present capabilities	Present capabilities	Vehicle initially; infrastr. & coop. support for flow cntrl. and emerg. vehicles; mobile beacons	Vehicle & infrastr. in parallel; infrastr. & coop. support for flow cntrl. and emerg. veh.; mobile beacons
Driver interrupt handling	Driver override on all functions	Driver override on all functions except trucks following in platoon	Interrupt trip, change dest., choose route	Interrupt trip, change dest., choose route

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Adaptable Concept Roadway vs Vehicle Compatibility

Roadway vs Vehicle Compatibility

	Roadway Character. (down column)	Manual	Pre-Auto.	Autonomous	Receive Infrastr. Broadcast	Infrastr./ Veh. Two-Way Comm.	Veh./Veh. Two-Way Comm.
Vehicle Characteris. (across row)		Vehicle has no AHS capabil.	Lane and long. pos-keeping; manual lane changing	Lane and long. pos-keeping; auto. lane changing when traffic permits	Auto. plus ability to receive and exec. cmnds. from infrastr., broadcast pos. and spd.	Auto. plus ability to exchange messages with infrastr. and execute orders	Auto. plus ability to exchange messages and negotiate with other vehicles
Mixed traffic, no infrastr.	Current freeway lanes	Yes	Yes	Yes	Yes	Yes	Yes
Dedicated lane, no infrastr.	Roadway enhanced for lane keeping	No	No	Yes	Yes	TBD (see note)	Yes
Dedicated lane, one-way veh./infrastr. comm.	Commands broadcast by infrastr.	No	No	No	Yes	TBD (see note)	TBD (see note)
Dedicated lane, two-way veh./infrastr. comm.	Comm. between infrastr. and individ. veh.	No	No	No	Must upgrade	Yes	TBD (see note)

Note: Subject to communications hardware module definition.