Concepts of Operations for Autonomous Vehicle Dispatch Operations

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Concepts of Operations (CONOPs)

**Background:**
- Autonomous Vehicles (AVs) will be part of the driving landscape.
- There is an increasing need for remote supervision of AVs.
- There is a need to develop various CONOPs to understand how AVs will affect the future of surface transportation dispatch.

The **purpose** of a CONOPs is to describe the operational needs and systems characteristics for a proposed system (e.g., expected uses, user requirements, and relationships to existing systems).

CONOPs typically include a description of relevant characteristics of current systems and environments, descriptions of a proposed new system, and scenarios illustrating use of the new system in real-world environments, which address both internal and external factors.
## Defining Autonomous Vehicles

Levels of automation in self-driving and driverless cars, as set forth by SAEJ3016

<table>
<thead>
<tr>
<th>SAE Level</th>
<th>SAE Name</th>
<th>SAE Narrative Definition</th>
<th>Execution of Steering/ Acceleration/ Deceleration</th>
<th>Monitoring of Driving Environment</th>
<th>Fallback Performance of Dynamic Driving Task</th>
<th>System capability (driving modes)</th>
<th>BASé Level</th>
<th>NHTSA Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>the full-time performance by the human driver of all aspects of the dynamic driving task</td>
<td>Human Driver</td>
<td>Human Driver</td>
<td>Human Driver</td>
<td>N/A</td>
<td>Driver only</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration</td>
<td>Human Driver and Systems</td>
<td>Human Driver</td>
<td>Human Driver</td>
<td>Some Driving Modes</td>
<td>Partially Automated</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>Part-time or driving mode-dependent execution by one or more driver assistance systems of both steering and acceleration/deceleration. Human driver performs all other aspects of the dynamic driving task</td>
<td>System</td>
<td>Human Driver</td>
<td>Human Driver</td>
<td>Some Driving Modes</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task - human driver does respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>Human Driver</td>
<td>Some Driving Modes</td>
<td>3</td>
<td>Highly Automated</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task - human driver does not respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some Driving Modes</td>
<td>3/4</td>
<td>Fully Automated</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some Driving Modes</td>
<td>3/4</td>
<td></td>
</tr>
</tbody>
</table>
Current US Dispatch Operations

Examples of Different Classifications of Transportation Dispatchers

Dispatcher General Functions:
- Communications
- Resource allocation
- High-level navigation
- Contingency management
- Monitoring (audio radio traffic, cameras)
- Event logging
- Training
Possible New AV-Related Functions

- Remote control/teleoperation
  - Teleoperation
  - Goal-based supervisory control
- Communications with passengers
- Fleet management
  - Platoon monitoring for trucks

Example of Remote AV Teleoperation, Photo Credit: Phantom Auto (Dickey 2018)

Example of the kinds of maps dispatchers will need to monitor
Representative CONOPs

Concept 1: Original equipment manufacturing (OEM) AV dispatch support
  • Manufacturers oversee their AVs
Concept 2: Robo-Taxi Dispatch
  • Rideshare companies oversee their AVs
Concept 3: Autonomous trucking dispatch
  • Dispatchers from freight companies oversee AV trucks
Concept 4: Public transportation AV dispatch
  • Local transit authorities oversee their AV shuttles and busses
Concept 5: State/Regional AV management and dispatch
  • Local and state authorities can direct AVs on their roads, including public AVs like roadside assistance

Not mutually exclusive, could be combined
### Functions per CONOPS

<table>
<thead>
<tr>
<th>FUNCTION\CONOPS</th>
<th>OEM AVs (1)</th>
<th>Robo-Taxis (2)</th>
<th>Autonomous Trucks (3)</th>
<th>Public AVs (4)</th>
<th>State/Regional (5)</th>
</tr>
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<tbody>
<tr>
<td>Communication</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Resource Allocation</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Navigation</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Contingency Management</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Monitoring</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Paperwork</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Training</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Remote Control</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Passenger Communication</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fleet Management</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

The checkmarks indicate a new functionality.

The plus signs indicate which existing functions are likely to experience increased.
There are several CONOPs where the addition of AVs could add to existing dispatcher workload.

It is not clear how various commercial and government industries should plan to alter their current staffing and task assignments to adjust to this new capability.

To illustrate how these agencies can begin to model dispatcher workload impact, a regional dispatch center was modeled to show how the addition of various new AV functions could affect workload and staffing.

- North Carolina Turnpike Authority

Such a model would be useful in the early planning stages of new dispatch centers or for existing capabilities.
Regional Dispatcher Task Analysis

Tasks & Priorities

**Essential**
- Incident Management
- *Remote Control*
- *Passenger Communications*

**High**
- Passover Report
- Center Activity Log
- Monitor Mapping Services
- Post Dynamic Message Sign Messages
- Respond to Reverse Vehicle Notifications (RVNs)
- *Platoon monitoring*

**Moderate**
- Response Plans
- Incident Report
- Camera Tours
- Security Cameras

**Somewhat**
- Submit Maintenance Tickets

**Low**
- Microwave Vehicle Detection (MVD) Report
- Controlled Access Space Conditions

* Indicates a possible new function
Modeling Single Regional Dispatcher Operations

- Discrete Event Simulation
  - DES tool focused on workload for dispatchers developed by the Federal Railroad Administration
  - [http://apps.hal.pratt.duke.edu/shado-webdev/](http://apps.hal.pratt.duke.edu/shado-webdev/)
- Tasks from analysis were included
  - First, a typical dispatcher was modeled for model validation and then the three new tasks (platoon monitoring, AV control, and passenger communications) were added
    - Current operations validated by NCTA personnel
- Other parameters
  - 8 hour shift
  - Typical operations were modeled (non-activated) as well as emergency scenarios (activated)
  - 2000 runs per scenario
Typical Single Regional Dispatcher Workload

Average non-activated dispatch service time per task, with one standard deviation depicted.
Utilization is the percent busy time, the ratio of time doing tasks over shift time. Operations above 70% represent increased risk of human error.
How Two-Dispatcher Operations Could Affect Workload

Utilization is the percent busy time, the ratio of time doing tasks over shift time.
Conclusions

- AVs will bring three new functions to dispatch organizations.
- There are 5 distinct concepts of operations for dispatchers of AVs that embed these functions, which could be combined.
- Current dispatch organizations will need to determine how the addition of one or more of the new functions could affect their current operations and how such operations could affect staffing.
- An example scenario shows that if new AV functions are added to current single dispatch regional operations, even at low frequency, they would increase workload to unacceptable levels.
  - Adding an additional dispatcher provides robustness to increasing operational tempo but dispatchers should share tasks instead of having dedicated tasks.
Acknowledgement

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