

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

SAE Level	SAE Name	SAE Narrative Definition	Execution of Steering/ Acceleration/ Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System capability (driving modes)	BAST Level 	NHTSA Level 
Human Driver monitors the driving environment								
0	No Automation	the full-time performance by the human driver of all aspects of the <i>dynamic driving task</i>	Human Driver	Human Driver	Human Driver	N/A	Driver only	0
1	Driver Assistance	the <i>driving mode-specific</i> execution by a driver assistance system of either steering or acceleration/deceleration	Human Driver and Systems	Human Driver	Human Driver	Some Driving Modes	Assisted	1
2	Partial Automation	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 <i>dynamic driving task</i>	System	Human Driver	Human Driver	Some Driving Modes	Partially Automated	2
Automated driving system ("system") monitors the driving environment								
3	Conditional Automation	<i>driving mode-specific</i> performance by an automated driving system of all aspects of the <i>dynamic driving task</i> - human driver does respond appropriately to a request to intervene	System	System	Human Driver	Some Driving Modes	Highly Automated	3
4	High Automation	<i>driving mode-specific</i> performance by an automated driving system of all aspects of the <i>dynamic driving task</i> - human driver does not respond appropriately to a request to intervene	System	System	System	Some Driving Modes	Fully Automated	3/4
5	Full Automation	full-time performance by an automated driving system of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a human driver	System	System	System	Some Driving Modes		

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

Current US Dispatch Operations



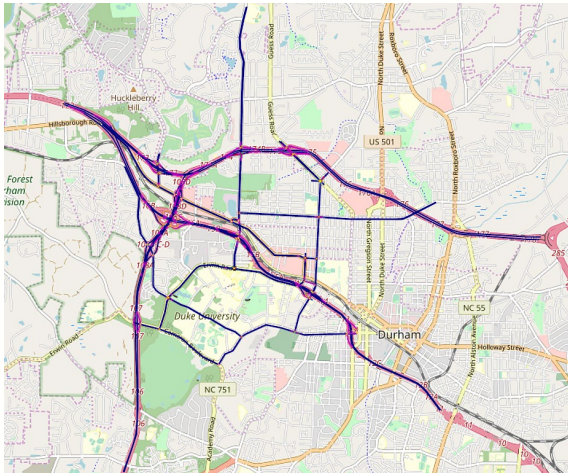
Dispatcher General Functions:

- Communications
- Resource allocation
- High-level navigation
- Contingency management
- Monitoring (audio radio traffic, cameras)
- Event logging
- Training

Examples of Different Classifications of Transportation Dispatchers

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

FUNCTION\CONOPS	OEM AVs (1)	Robo- Taxis (2)	Autonomous Trucks (3)	Public AVs (4)	State/ Regional (5)
Communication	✓	✓	+	+	+
Resource Allocation	✓	✓	+	+	+
Navigation	✓	✓	+	+	+
Contingency Management	✓	✓	+	+	+
Monitoring	✓	✓	+	+	+
Paperwork	✓	✓	+	+	+
Training	✓	✓	+	+	+
Remote Control	✓	✓	✓	✓	(✓)
Passenger Communication	✓	✓		✓	(✓)
Fleet Management	✓	✓	+	✓	(✓)

The checkmarks indicate a new functionality.

The plus signs indicate which existing functions are likely to experience increased.

Example of Workload Impact

- 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*

* Indicates a possible new function

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

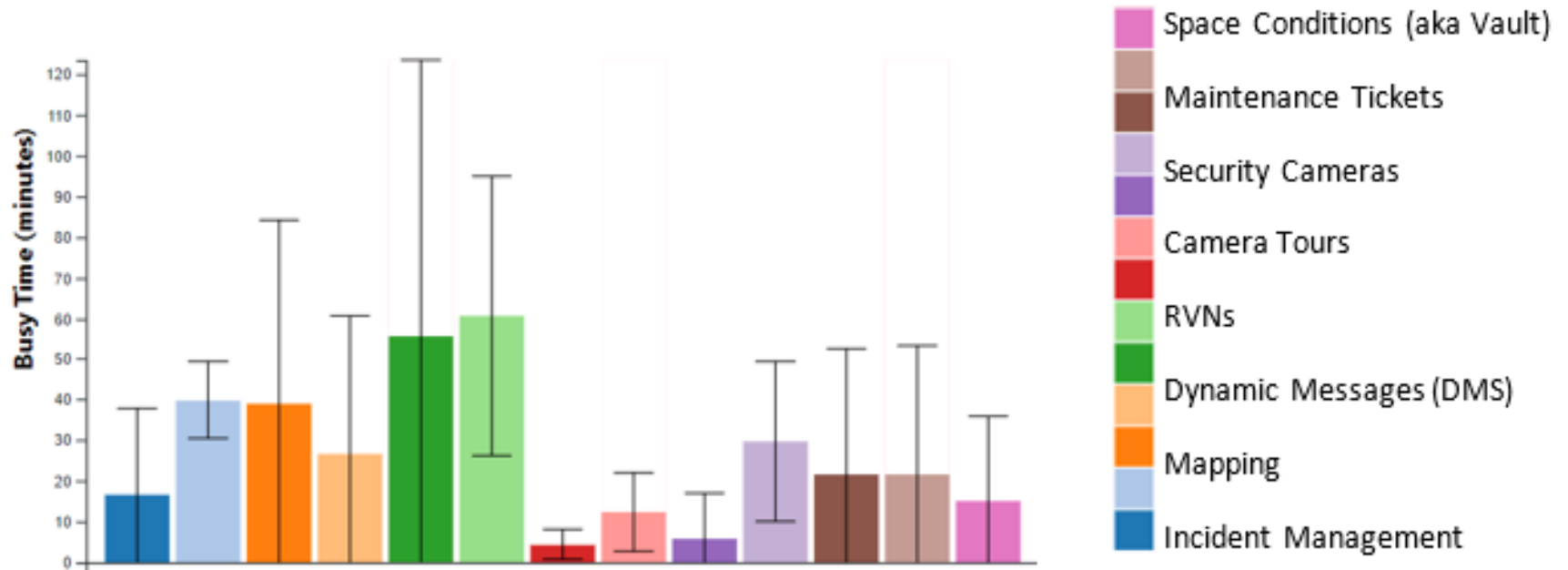
Low

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

Modeling Single Regional Dispatcher Operations

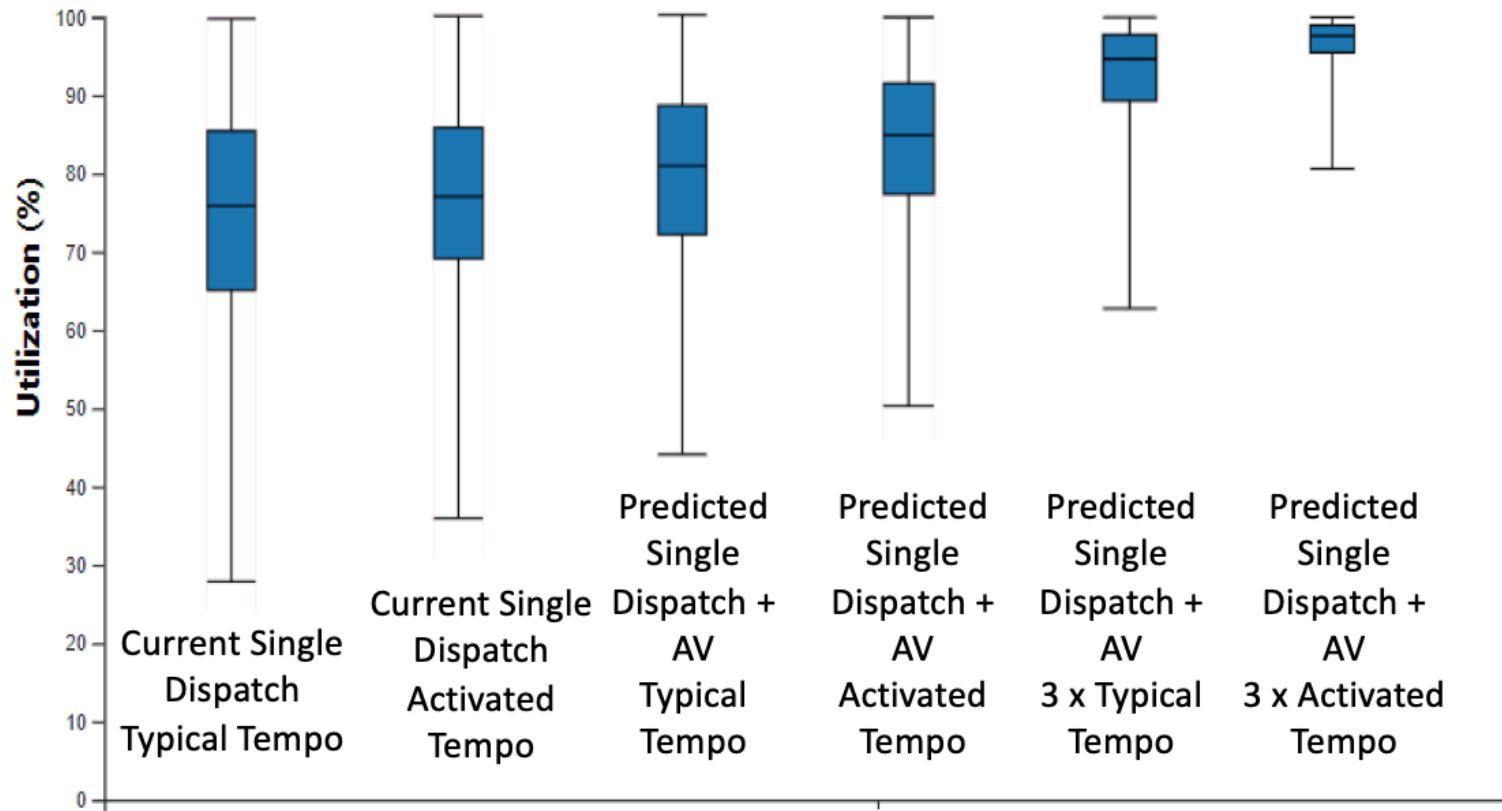
- Discrete Event Simulation
 - DES tool focused on workload for dispatchers developed by the Federal Railroad Administration
 - <http://apps.hal.pratt.duke.edu/shado-webdev/>
- Tasks from analysis were included
 - First, a typical dispatcher was modeled for model validation and then the three new tasks (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



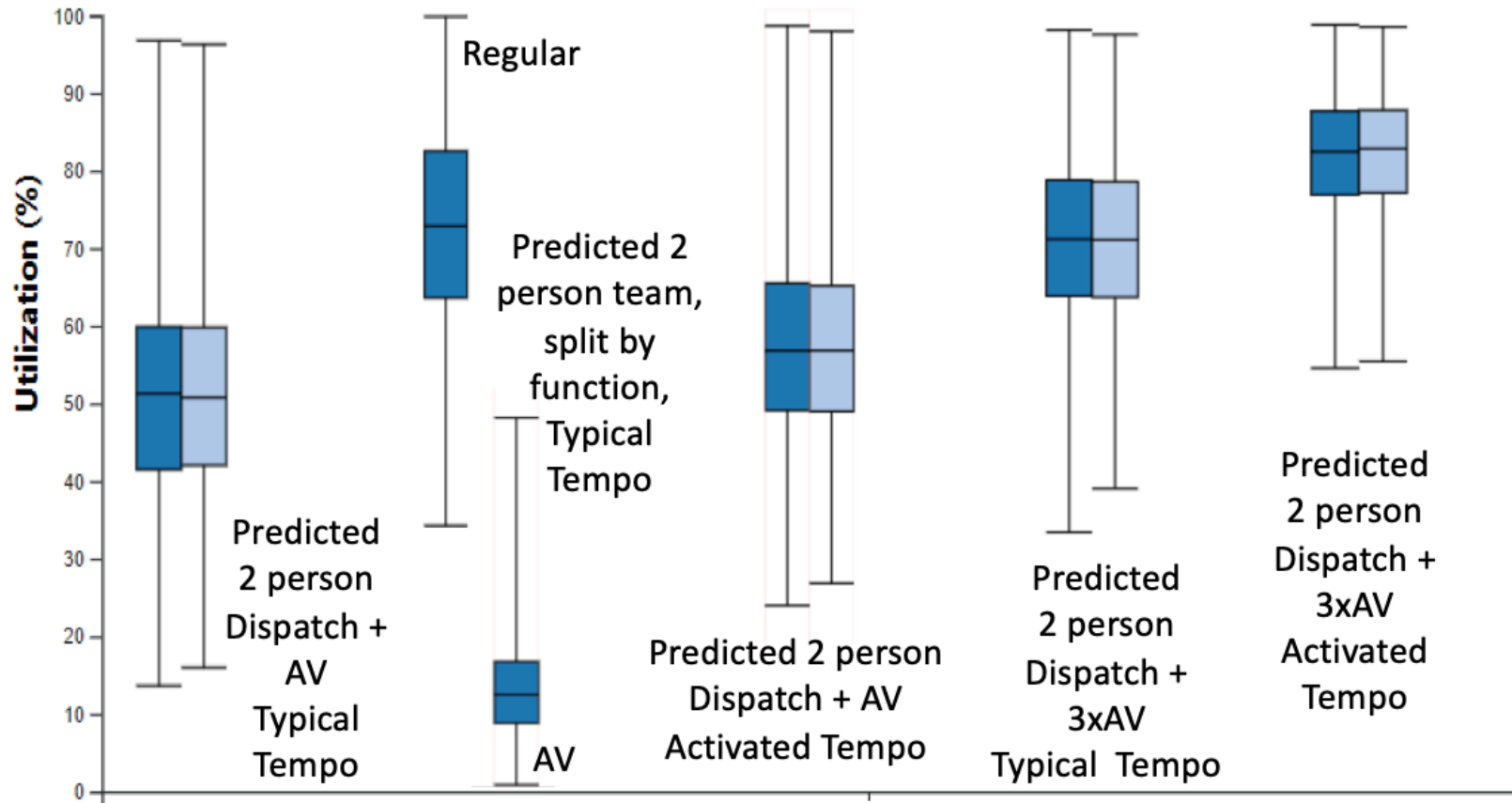
Average non-activated dispatch service time per task, with one standard deviation depicted.

Single Dispatcher Workload w/ New AV Tasking w/ Increasing Operational Tempo



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.

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