TSM&O Consortium Meeting Summary

Meeting Date:	April 2, 2020 (Thursday)	**Time**: 10:00 AM – 12:00 PM
Subject:	TSM&O Consortium Meeting	
Meeting Location:	Teleconference	

I. OVERVIEW

The purpose of this recurring meeting is to provide an opportunity for District Five FDOT staff and local/regional agency partners to collaborate on the state of the TSM&O Program and ongoing efforts in District Five. Jeremy Dilmore gave a short introduction and outlined the meeting agenda.

II. RAISING AWWARENESS OF ARTIFICIAL INTELLIGENCE FOR TSM&O

David Williams presented on a new report published by FHWA on the potential applications of AI in TSM&O.

- Introduces fundamentals of AI technologies and their applications in transportation management systems
    - Split into two main sections:
        - The first section covers the fundamentals of AI
        - The second section gives examples of recent AI efforts within TSM&O and provides insight into what to expect in the future.
- Goal of report to raise the awareness of transportation agencies of the potential benefits, implications, and impacts of using AI for various TMS, TMC, and TSMO operations
- Fundamentals of AI
    - Two common types of AI
        - Strong AI – the ability of a machine to mimic human actions or cognitive functions
            - Problem solving or holding a conversation
            - There are no strong AI systems in existence yet, however digital assistants are making strides in this area
                - Google Assistant
                - Facebook DrQA
                - Amazon Alexa
        - Weak AI or Machine Learning – offer potential to supplant human work in a variety of TSMO areas

- Traffic imagery analysis, incident detection, traffic control and signal timing

- Common Trends in AI Development – Near Term
  - Forbes article on AI trends to watch for in 2019: https://www.forbes.com/sites/janakirammsv/2018/12/09/5-artificial-intelligence-trends-to-watch-out-for-in-2019/#4ff800075618
  - The rise of AI-enabled hardware chips
    - Development of AI-specific hardware chips for embedding machine learning/training in consumer products, industrial processes, and vehicles
  - Convergence of AI and IoT at the edge
    - Movement of machine learning models from centralized Cloud systems to edge IoT devices
  - Interoperability among neural networks via Open Neural Network Exchange (ONNX)
    - Many distributed deep learning tools are available, but none of them communicate well with each other
    - Lack of interoperability is hampering adoption of AI
    - ONNX – developed by AWS, Facebook, and Microsoft
  - Automated machine learning will gain prominence
    - Evolve machine learning models that can address complex scenarios without going through the typical process of training ML models
    - AutoML – speeding the process of building and deploying neural networks
  - Application of AI analysis to IT operations
- General Categories of Machine Learning
  - Chatbots, Computational Linguistics, Q/A Systems
    - Alexa
    - Google Assistant
    - IBM Watson
  - Expert Systems
    - Many incident response modules of freeway management systems
    - "If…then" clauses + logic gates (e.g., AND, OR, NOT, or NAND)
    - Specific problem areas can be tackled when provided with enough "if…then" rules
    - Expert systems still in wide use
      - Medical diagnosis
      - Toxic waste management
      - Nuclear reactor control
      - Identification of potential remedies to system failures during space missions

- Neural Networks and Supervised Learning
  - Learn to do certain tasks through training and by strengthening or weakening the connections between the network of neurons based on presented input data and the expected output result
  - Commonly applied to narrowly defined pattern recognition problems
    - Image recognition (Is this a cat?)
    - Data segmentation (Is this a cat, dog, fire truck, or tuba?)
  - Machine learning algorithms are trained to solve specific problems using this general process
    - Important element of the training process is feedback, which improves the model after implementation and evaluation of real-world results
    - "Supervised" implies only the correct data is provided to the machine (Labeled data)
    - Common ML uses
      - Vehicle Classification
      - CCTV/UAS incident detection
      - TMCs and Bike/Ped detection

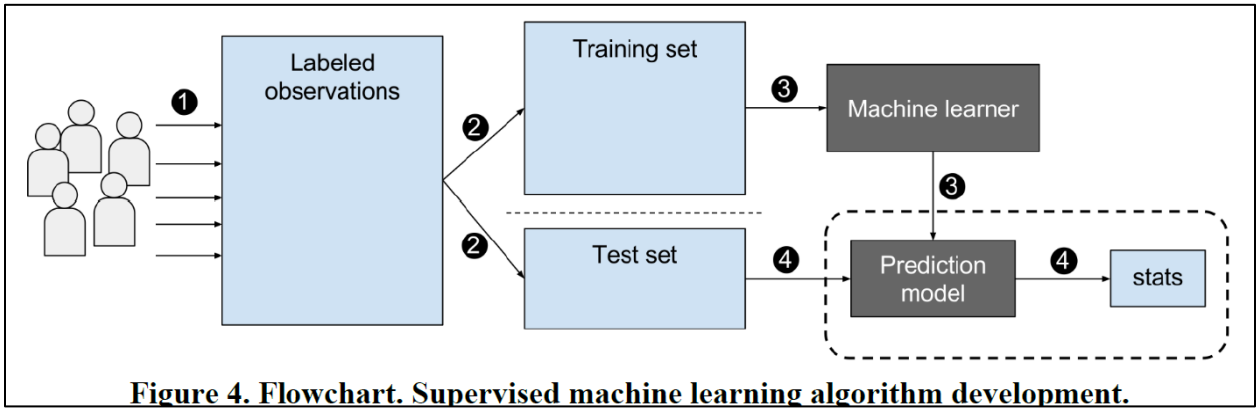


Figure 4. Flowchart. Supervised machine learning algorithm development.

- Fuzzy Logic
  - Fuzzy logic can be integrated with expert systems and neural networks
  - Based on the observation that people make decisions based on imprecise and non-numerical information
    - Truth ranges from *Completely True* to *Completely False*, with large variance in between
  - Fuzzy model/set – mathematical means of representing vagueness and imprecise info
  - "Fuzzy logic allows *if…then* rules to be probabilistic in describing linguistic variables that are modified with adjectives and adverb"
    - E.g. Ramp Metering → "Heavy traffic" – "typical traffic" – "light traffic"

- Machine Learning and Solution Search
  - Many AI purists indicate such programs for game playing should not be called AI nor even machine learning, since they "brute force" search millions of actions according to the rules of the game and do not have "intelligence"
    - They cannot learn from their mistakes or the actions of their opponents
  - In recent years, there are many examples of game-playing programs that do learn from their actions
  - DelDOT is piloting the use of a "game playing" AI system to find novel solutions to ICM
- Unsupervised Learning
  - Learning what actions produce better results
  - No presentation of a correct output for a given set of inputs

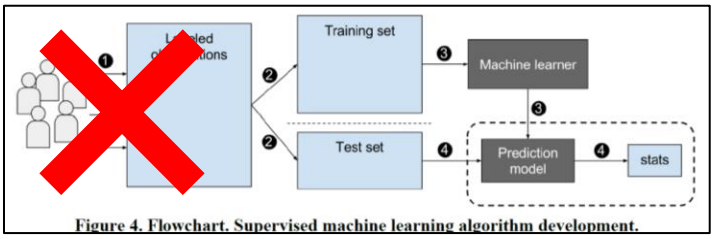


Figure 4. Flowchart. Supervised machine learning algorithm development.

  - Through trial and error, system learns what inputs lead to the best outputs
  - "Deep Learning"
    - DeepMind
    - OpenAI
      - Recently beat World Champion DOTA 2 team; achieved this by playing through 180 years of matches against itself per day
        - Lauded by Bill Gates as a huge milestone in advancing AI
  - Formulation of congestion management as a "game" might find promise in coming years
- Robotics and Driverless Vehicles
  - Robotics – The physical embodiment of AI; can substitute for humans and replicate human actions. Best suited for tasks that are "dull, dirty, and dangerous"
  - Unmanned Aerial Systems (UAS)
  - Driverless vehicles – combination of AI techniques, robotics, computers, and sensors
    - Neural network object classification
      - Fusion of sensor data (LIDAR/Camera agree on object)
    - AI driver models trained by watching good driving behavior
    - AI driver models trained by unsupervised reinforcement learning in simulated 3D environments
    - Anomalies in embedded maps are identified using machine learning

- Artificial Intelligence in TSM&O
    - Commercialization of AI
        - Nearly 1,000 commercial companies involved in providing software and services in some way related to AI
        - Examples of commercially available AI applications:
            - Natural language processing and natural speech synthesis of digital assistants
            - Integrated chatbots in virtual assistants
            - Major cloud service providers now support suites of AI-related tools and software
            - Object recognition and tracking software is widely commercialized
            - Driverless vehicles / UAS are likely to be available in near term
        - For Infrastructure Owners & Operators (IOOs), use of AI may reduce costs, augment staff, improve staff efficiency, provide suggested solutions that humans may not have thought through in advance, and provide convenience in the TMC
        - Each IOO will need to consider if it is more effective to purchase AI functions as a service (aaS) or develop and maintain on-premise
            - For many State DOTs, will likely be a hybrid
        - Pricing models vary based on computing cycles, data storage size, frequency of analytics, and other metrics. There is no prescription for which category should be used – that decision is up to each individual agency.
            - On-Premise
                - Gives IOOs greater control of system, ability to install, manage, and maintain every aspect of system deployment
            - Infrastructure-as-a-Service (IaaS)
                - Deployment provides scalability needs and minimizes responsibility for the DOT. Users are responsible for managing applications, data, runtime, middleware, and operating system.
                - Instead of having to purchase hardware outright, users can purchase IaaS based on consumption (such as database reads/writes, or computing cycles), similar to electricity or other utility billing
            - Platform-as-a-Service (PaaS)
                - Deployment allows users to develop, test, and deploy applications quickly and efficiently.
                - With PaaS, users are only responsible for data and application tiers.
                - Similar to IaaS, users can purchase PaaS on a subscription basis ultimately paying just for what they use
            - Software-as-a-Service (SaaS)
                - Deployment uses the web to deliver applications
                - Most SaaS applications can be easily accessed directly from a web browser on the client's side
                - This model is maintained entirely by the vendor
                - Like the other service models, users typically purchase a subscription to access the application

- Examples of commercialization (p. 26 of the report) include:
  - Google AI – Temporal Action Localization
    - Object recognition in video streams by associating certain moments in video with context
    - Could be used in incident detection
  - Microsoft early-access Lab – Project Knowledge Exploration
    - Turn natural language questions into SQL queries
    - "Which traffic signal had the most emergency vehicle preemptions in November 2018"
      - Verbal/Written question could be automated without a programmer writing queries in SQL format
  - Microsoft early-access Lab – Project Anomaly Finder
    - Offers the potential for transportation management system modules to analyze and report problems with field equipment without extensive software development
    - Currently TMS applications typically have extensive code specifically designed for anomaly detection of various device types
  - Amazon AI on AWS – *Rekognition*
    - Imagery analysis via deep learning neural networks
  - Amazon AI preview - Forecast
    - "Accurate time-series forecasting with no machine learning experience required"

- Maturity of AI Technologies
  - Effort to reduce expertise necessary to stand up an AI system
    - There is a substantial gap between AI talent (software engineers) and need for AI developers. Microsoft, Amazon, Google, and others are focusing on bridging this gap.
  - Migration of some AI software to purpose-built AI hardware
    - Microsoft Brainwave – move Azure Machine Learning tech to hardware to provide real-time performance of anomaly detection in high-speed processes
  - Improved image recognition performance
    - Using Google global image database used to transfer learning into other AI models
  - Enhanced voice recognition
    - Many TMC operations will likely be able to become voice-enabled for those agencies that are so inclined
  - Improved *Supervised Machine Learning* training
    - Amazon launched a learning model marketplace with pre-labeled training sets
    - Reduce labeling by up to 70%
- Examples of AI in TSM&O Applications (details begin on p. 35)
  - Neural network technologies deployed for incident detection using video image analysis and traffic prediction *(FDOT, NDOT, IowaDOT)*

- AI system processes feeds from existing CCTV cameras to identify incidents using AI neural networks
    - Neural networks were trained to recognize scenes that are "incidents" and "not incidents"
    - Cloud-hosted proprietary software
    - Reported benefits
        - Incident detection times up to 12 minutes faster than other input streams
            - Iowa TIMELI system focused on rural area where highway patrol notifications took an extended period to be received
        - Reduction in crashes by 17%
            - Positioned highway patrol assets
            - Advanced warning of downstream congested areas via DMS

- Fuzzy logic ramp metering *(WSDOT, Caltrans)*
    - Used Fuzzy Logic Metering for more than 15 years
        - Other ramp metering algorithms require substantial code and particularly difficult calibration
            - Just 5% of the WSDOT code was for the algorithm; 95% was for interfacing with the data inputs and providing metering outputs to the field controllers
    - The program has evolved and expanded to over 200 ramps; no other ramp metering options have been deployed
    - Reported benefits
        - Mainline efficiency by reducing upstream/downstream occupancy
        - Better performance at maintaining ramp queues than local metering
- Traffic congestion and incident prediction *(DelDOT)*
- Integration of 511 with Alexa *(MTC San Fran)*
- Google Assistant integration *(multiple agencies)*
    - In Surprise, AZ, integrated with ASCT system
    - Allows traffic engineer to query status data using voice commands through a Google Home speaker or any phone or computer
    - ASCT data is uploaded to Azure and available for query up to one year in the past
        - Performance report – 30-minute window for a date and time
            - Cycle time
            - Phase utilization
            - Arrivals on green
        - Problems report for a signal or arterial
            - Preemptions
            - Detector failures
            - Communications quality
- UAS programs that could be enhanced with AI *(20 State DOTs)*
- AVs for crash abatement *(multiple DOTs)*

- Traffic Prediction and Traveler Info *(DelDOT)*
  - ATCMTD funds used to implement AI at various stages of TMC working process
  - Neural Network gaming
  - Objectives achieved:
    - Actively monitoring network
    - Incident alerts
    - Provide info on suspected cause of situation; possible prioritized options. AI tool will then simulate selected option; predicts time to normal operations
    - Evaluate and store results
  - Separate neural network component that detects incidents based on re-identification of vehicle signatures from one set of in-pavement loops to another

- Considering AI Technologies in Transportation Planning, Deployment, and Operations
  - Systems Engineering considerations:
    - Deficiencies in current TSM&O activities to be addressed by AI systems
    - Improvements gained by using AI systems versus traditional systems
    - Maturity of AI technology to support a specific application
    - Prototype status of AI tools/technologies and consensus on practical "day one" applications
    - Appropriate software systems, databases, and computing resources
    - Integration of new systems & software with legacy systems & software
    - Capabilities of agencies to appropriately take advantage of new functions
    - Use of AI technologies beyond TSM&O and collaborations with other departments in the transportation agency
  - Development, Deployment, and O&M of AI systems may place burden on agencies in the areas of:
    - Policy development and legal compliance regarding security/privacy
    - Management/Integration will require highly skilled, in-demand personnel
    - Funding constraints
    - Development of new business processes required for AI applications
    - Management of new types of data and volumes of data
    - Performance Measurement of AI application
  - External Coordination and Collaboration will require capabilities in areas of:
    - Developing guidelines and collaborative agreements
    - Establishing new forms of public-private partnerships
    - Considering partnerships and data packaging with 3rd party providers
    - Developing/Retaining specialized staff and knowledgeable management
    - Developing appropriate authority/responsibility framework
  - List of questions for agencies to consider:
    - Systems and Technology

- Staffing and Organization
- Business Processes
- Collaboration

- Suggested steps for approaching development of AI Applications:
  1. Convene interdepartmental workshop to educate stakeholders and brainstorm potential applications and synergies
  2. Discuss priorities, opportunities, and barriers to AI applications in TSM&O
  3. Determine a high-priority shortlist and a longer secondary-priority list
  4. Review the list of questions in the report and consider your organization's responses to each
  5. Develop a project plan to implement the actions.

Discussion:

Q: How will this affect the jobs and positions held by people currently working in TSM&O?

A: It's unlikely to have a drastic effect for a long while. Initial projects looking into the use of machine learning have shown that it produces unstable results and has great difficulties in coming up with good metrics for practical applications. Additionally, the well structured data sets that we have still have a lot of noise in them that AI is not able to sort through.

Q: Should a similar set of levels be set up for AI automation as the SAE Levels of Automation?

A: That's a good idea. There may be a lot of things on the way which will help to improve AI for TSM&O. Any additional input for what we should focus on next is very welcome.

Q: Is there any performance measurement reporting planned for the Waycare application?

A: JD will follow up on this with Margaret Kublins.

III. NHTSA ALTERS SAFETY RULES TO MAKE ROOM FOR SELF-DRIVING CARS

David Williams spoke briefly on the updates made by the Federal Government to the NHTSA Safety Rules.

- The Federal Government has set out to "do no harm" in the ADS space
- NHTSA is slightly modifying its safety rules to account for ADS technologies
  - Targets unintended and unnecessary barriers to innovative designs
  - "200-series" rules under Federal Motor Vehicle Safety Standards
  - Companies would like precise definitions of "driver" and "driving"
  - No requirement for manual controls in Level 5 ADS
  - AVs will still have to meet strict crash tests – "everyone is a passenger"
- Goal: streamline manufacturers' certification processes, reduce certification costs, and minimize need for NHTSA interpretation or exemption requests
- https://www.futurecar.com/3866/NHTSA-Alters-Safety-Rules-to-Make-Room-for-Self-Driving-Cars

IV. FDOT CAV READINESS STUDY

Jeremy Dilmore presented an update on the FDOT CAV Readiness Study. This document is still in DRAFT form.

- FDOT adopted the CAV Business Plan in January 2019. The study is not yet finalized; it will be sent out when complete. This presentation is a preview showing where we currently stand.
- The Focus Areas:
    - CAV Implementation Prioritization
        1. CAV Project Prioritization
        2. Gap Analysis – FDOT is in this phase now
    - Deployment
        3. Current Funding of Work Program Projects
        4. Current Funding of non-Work Program Projects
    - Communications and Data Storage Readiness
        5. Needs and Criteria for Updating RTMCs
        6. Needs and Criteria for Updating TMCs at Local Agencies
- CAV Implementation Prioritization - Review
    - Identifies the network envisioned to support CAV, finds projects, and prioritizes them
    - Reviewed Five Year WP for eligible candidate projects
    - Once candidate projects have been selected, the second step is to complete a gap analysis to identify deficiencies in readiness to implement CAV deployment, staffing, monitoring, maintenance, and the resources to manage the system
- Gap Analysis
    - Current state of infrastructure and Upgrades needed for CAV
        - Interstates (focus on fiber connectivity)
        - Arterials (fiber and traffic signal controllers capable of CV communication)
            - Priority Corridors
            - Non-Priority Corridors
            - Should be assessed for network connectivity between interconnected and monitored traffic signals (IMTS)
    - Gap Analysis (Interstates) – Questionnaire
        1. Total Available/Non-Allocated Optic Fibers
        2. Available Layer 3 Bandwidth
            - D5 has over 80 Gbps availability for I-4, I-75, and I-95.
        3. Available Spare/Unused Communication Conduits
            - There is still work to be done in getting spare conduit into the ground. Trying to be judicious in making it available.
        4. Network Management Tools
        5. Spare Operator Stations
        6. Currently Budgeted Department Positions
        7. Scheduled Shift Hours for RTMC Operations
        8. Current Contract type for ITS/Network Maintenance
        9. Current Maintenance Contract Requirements for Minimum Personnel

10. Maximum Downtimes allowed by Department Staff and Maintenance Contracts
11. Available Rack Space
    - The rack space shown in the presentation underestimates how much D5 has.
12. Available Disc Space
    - D5 has turned in their data storage information and has discussed with Central Office about how to add this into the survey.
        - Any input on this is welcome
    - Currently have 660 TB in Sanford and more than 660 TB in DeLand so expect to be positioned well.

- Gap Analysis (Priority Corridors)
  - District-identified Priority Corridors with Routes of Significance (RoS)
    - There is currently no criteria for determining priority/non-priority corridors. D5 has determined that any major corridor or route used for detours from a major corridor will receive priority designation.
    - Added a lot of new roads to the priority list.
  - Traffic Signal Controller Upgrades
    - Approximately 80% of traffic signals in D5 are ready for CV applications.
  - Interconnected and Monitored Traffic Signals (IMTS) and Non-IMTS (for potential upgrade prioritization)

District Five – Priority Corridor	Non-ITMS	IMTS	Total Number of Signals
N US 17/92 (Orlando Ave / Mills Ave)	1	26	27
S US 17/92 (Orlando Ave / Mills Ave)	15	7	22
SR 46	0	10	10
SR 414 (Maitland Blvd)	7	4	11
SR 423 / CR 423 (John Young Pkwy / Lee Rd)	1	20	21
SR 435 (Kirkman Rd)	0	18	18
SR 436 (Semoran Blvd)	0	13	13
SR 482 (Sand Lake Rd / McCoy Rd)	0	7	7
US 441 (Orange Blossom Trl)	0	5	5
DISTRICT FIVE TOTAL	**24**	**110**	**134**

- What's Next?
  - Data Storage Survey and Analysis focusing on:
    - Storage Capacity by Data Source
      - SunGuide
      - ATSPM
      - CAV
      - ATMS
      - Network Management Software
      - Maintenance Management Software
      - Other
    - Projected Device Deployments over next 3 to 5 years

        - Physical space available for more servers at the TMC
        - Existing internet connection speed/type/provider for TMC
        - Local agency connections
    - Expecting Central Office to develop recommendations list
    - JD hopes to focus on fog computing/edge IoT devices focus
    - D5 is well positioned for where the implementation of CAV currently stands. Still working on interconnecting and increasing connectivity to traffic signals. Also working on increasing cell-based services.
    - Still looking to what the next thing will be (cloud computing, AI, connected vehicles, etc.) and getting funding for it.

Discussion

Q: Who will be responsible for the cost of installing new cell modems (especially on off-system roads)?

A: The District is planning that any cost above a standard signal installation will fall to the District rather than the local agency.

Q: Can off-system roads piggyback on the contract?

A: We can look into it at a later date.

V. TECHNOLOGY APPLICATION PARTNERSHIPS FOR LOCAL AGENCIES (TAPS-LA) PROGRAM

Jeremy Dilmore presented on the Technology Application Partnerships for Local Agencies (TAPS-LA) program. The program is still in development and subject to change.

- Purpose: assist Florida's local agencies with incorporating and deploying CAV technologies
    - $10M available for local projects
        - Maximum $2M per project.
    - $10M for I-Street project at UF
- TAPS-LA is funded under the CAV program initiative to deploy advanced transportation and congestion management technologies
- Eligible applicants
    - County governments
    - City governments
    - Transit agencies
    - Port authorities
    - Toll authorities
- Advanced Transportation & Congestion Management Tech
    - Advanced traveler information systems
    - Advanced transportation management technologies
    - Infrastructure maintenance, monitoring, and condition assessment
    - Advanced public transportation systems
    - Transportation system performance data collection, analysis, and dissemination
    - Advanced safety systems, including V2V and V2I communications, AV technologies, and other collision avoidance technologies
    - Integration of ITS with smart grid and other energy distribution/charging systems
    - Electronic pricing and payment systems

    - Advanced mobility and access technologies, such as dynamic ridesharing and information systems to support human services for elderly/disabled individuals
- The draft TAPs-LA timeline was presented (and is subject to change); it is subject to change
- Key Process Components:
    - Districts will receive project partnership proposals
    - Districts will identify and screen a maximum of four project proposals and send to Central Office for further consideration
    - Central Office will shortlist a maximum of ten projects for TSM&O leadership
    - Central Office will choose two to four projects to award. Central Office selection committee may include TSM&O leadership team and assistant secretaries.
- Notes:
    - Currently looking for guidance from Central Office for consistency across districts so that no district is disadvantaged and Central Office doesn't get oversaturated with submittals.
    - Looking into matching funds (SU funds can be used) to augment and expand work.

Discussion:

Q: Can these funds be used by regional agencies/for regional projects?

A: The focus of this funding is for local agencies at the city/county level and for grassroots projects. The goal is to involve local agencies in CAV rather than it being pushed on them by the State.

Q: Can this information be shared with MPO/TPO staff?

A: Yes, so long as they are aware of the likely change in the timeline/procurement.

Q: How does this timeline match up with the other application due dates? For example, our R2C TPO application process is January to March.

A: There doesn't appear to be any coordination between timelines, especially as this timeline is set to be pushed back.

VI. CURRENT INITIATIVES

Jeremy Dilmore gave an update on current initiatives in D5.

- Dedicated Short Range Communication (DSRC)
    - Development in space between DSRC and CV2X; temporary license has been given for WIFI users to come into DSRC's portion of the spectrum and use it
    - Currently in comment-response period regarding permanent move of bandwidth from DSRC to WIFI; receiving large volume of comments
    - FDOT remaining flexible regarding DSRC/CV2X; all investments are into devices that are capable of both.
    - FDOT still has applications in place for CV2X but they're in the line to be reviewed
        - CV projects are on-hold until they're approved

- Security Credential Management System (SCMS) – Statewide Procurement
    - Allows for device that talks to infrastructure to determine if communication is between a real RSU and a real car; allows for communication between vehicles and signals.
        - SCMS vendor to keep track of communications and to provide private key encryption
    - RFP from Department - ISS Green Hills was selected
        - they currently handle the USDOT SCMS, so FDOT will be interoperable with them and the Tampa CV Pilot
            - Any CV registered in the US (except in Denver, CO) will also operate in Florida.
        - FDOT developing a process to handle SCMS registration
            - Will be passed along to local agencies once its developed
            - Having not put devices into the field, we will be in a better position to deploy finalized SCMS devices
- Bluemac Bluetooth provider has been bought out by Blyncsy
    - Blyncsy has worked with CFX recently
    - FDOT is reviewing how to move forward with change in vendor; devices in the field will no longer function correctly
    - If any local agencies are in the same situation, Jeremy can send out pricing options
    - Looking at cost comparisons as well as rebate from Blyncsy
- ATSPM
    - Continuing to roll out ATC controllers
    - Continuing to develop interoperability of data from signals
    - www.spm.traffops.com for those with appropriate credentials
    - Newest controllers from Cubiq are coming with new OS
        - Jeremy from Cubiq is doing updates for Melbourne; Jeremy Dilmore is hoping to have Jeremy continue supporting these updates
- PedSafe Project (Phase 1)
    - Vendor making good progress (no issues related to COVID-19). All testing has gone well.
    - Only changeout will be shifting to CV2X
    - Not anticipated to be available before December 2020
- SIIA
    - Data gathering that ties into MIMS; as we go out to gather ATSPM data we're also inventorying signal cabinet info
    - Will demo SIIA at the next consortium
- Measuring CV readiness - NOEMI program
    - Actively updated GIS application showing where we are with devices/infrastructure
    - Will be made publicly viewable so all agencies can access it
- Software
    - ICMS – engaged with FHWA folks regarding five month extension on ICMS work
        - New deadline – November
        - Substantially Complete – September/October
    - Scope adds – Showing lane closures being more efficient

    - CAV communication more integrated
        - Detour messaging to be shown in a specific manner that is as intuitive as possible for drivers
        - Day/time information displayed
        - Ability to link data to Synchro added with time extension
- Route Mode Choice Engine continuing on schedule – set to finish in December 2020.
- OBU Emulator on similar timeline to RMCE. Test app for phone is in development
- TMDD
    - Two of vendors are substantially there
    - Third vendor, Econolite, is much more responsive and making substantial headway
- Need to have a discussion, as a region, regarding SPaT as these various programs come online
    - Based on how much data we'll have from TMDD, SPaT, Bluetooth, how do we capitalize on these data for financial purposes?
        - Benton - need to make sure we find people that are willing to pay for data

Discussion:

Q: Is it possible to make MIMS data (signal inventory control) compatible with Maximo (inventory control software used by OC) import and export function?

A: We haven't gotten to that yet but are looking to explore it in the future.

Q: The ATSPM tool being built looks very impressive. Can we bring in Sasa to present it at the next consortium?

A: Yes, Sasa will be presenting at the next consortium.

Q: Orlando pushing to have something work for SPaT data, but is there any idea about who will pay for it?

A: It's going to be a long and complex discussion. We can begin asking for input at this stage, but this is not expected to be resolved quickly.

VII. NEXT MEETING

- May 28, 2020

VIII. ATTACHMENTS

- A – Presentation Slides
- B – Meeting agenda

END OF SUMMARY

This summary was prepared by Amanda Johnson and David Williams and is provided as a summary (not verbatim) for use by the Consortium Members. The comments do not reflect FDOT's concurrence. Please review and send comments via e-mail to dwilliams@vhb.com so they can be finalized for the files.

Welcome to the TSM&O Consortium Meeting

April 2, 2020

Transportation Systems Management & Operations

Meeting Agenda

1. Welcome
2. Raising Awareness of AI for TSMO – Report
3. NHTSA Adjusts Safety Rules
4. FDOT CAV Readiness Study – Update
5. TAPs-LA Program
6. Current Initiatives

Raising Awareness of Artificial Intelligence for TSMO

David Williams, VHB

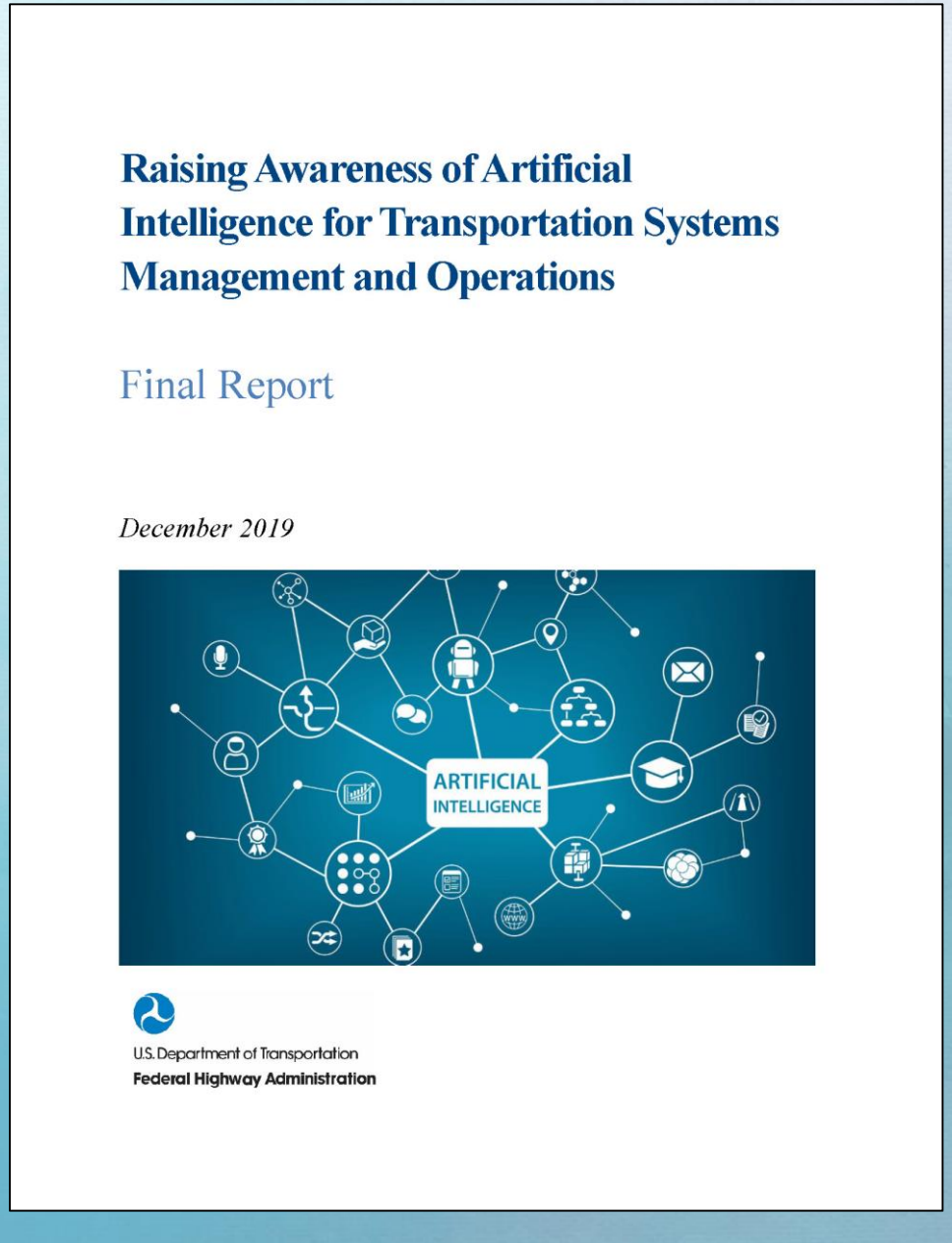
FDOT TSM&O
Transportation Systems Management & Operations

Transportation Systems Management & Operations

CENTRAL FLORIDA TSM&O CONSORTIUM

Raising Awareness of AI for TSMO

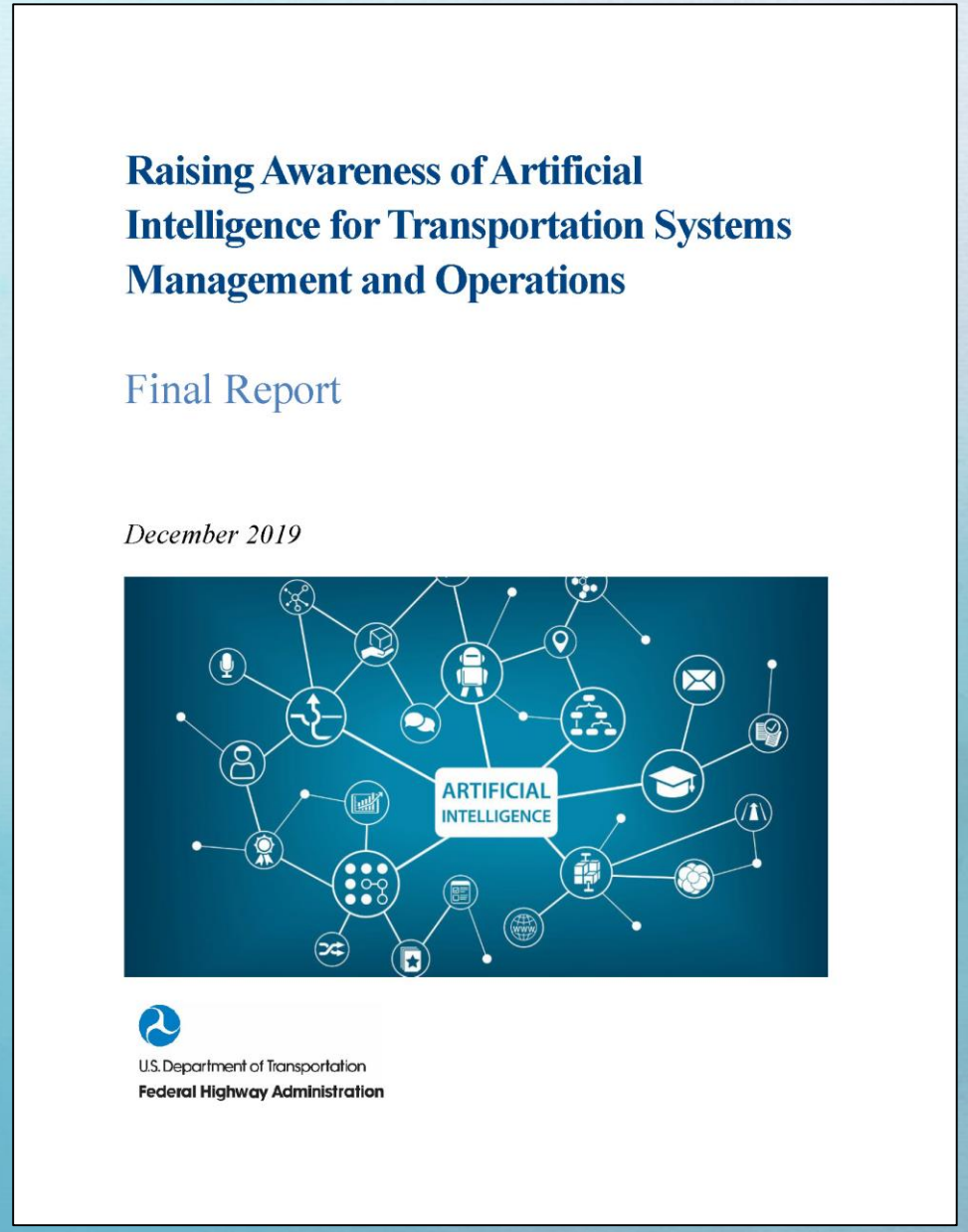
- Introduces fundamentals of AI technologies and their applications in transportation management systems
- Goal of report to **raise the awareness** of transportation agencies of the potential benefits, implications, and impacts of using AI for various TMS, TMC, and TSMO operations



Raising Awareness of AI for TSMO

Two common types of AI

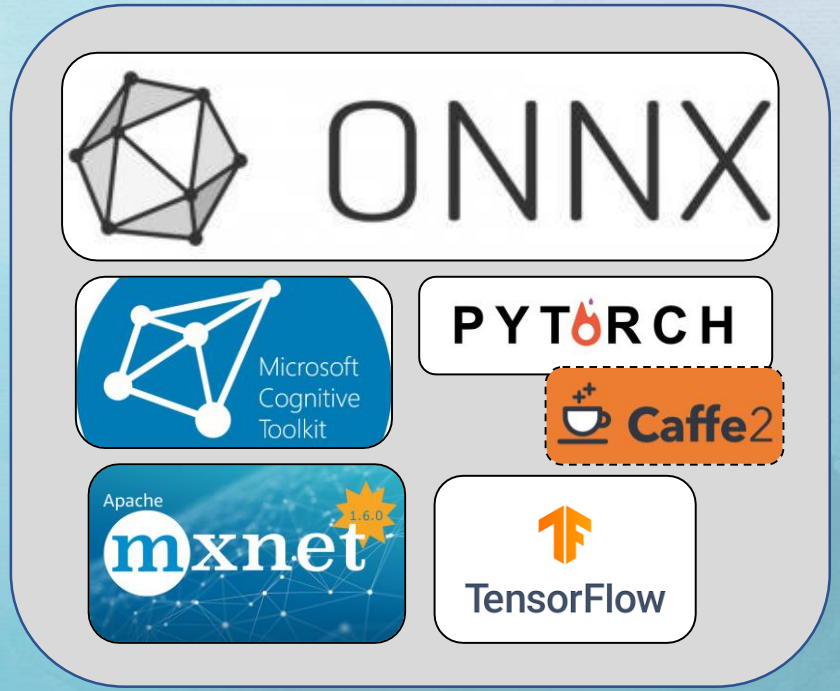
- **Strong AI** – the ability of a machine to mimic complex human actions or cognitive functions
  - Problem solving or holding a conversation
- **Weak AI** or **Machine Learning** – offer potential to supplant human work in a variety of TSMO areas
  - Traffic imagery analysis, incident detection, traffic control and signal timing



Common Trends in AI Development – Near Term

https://www.forbes.com/sites/janakirammsv/2018/12/09/5-artificial-intelligence-trends-to-watch-out-for-in-2019/#4ff800075618

- The rise of AI-enabled hardware chips
- Convergence of AI and IoT at the edge
- Interoperability among neural networks
  - Open Neural Network Exchange (ONNX)
- Automated machine learning will gain prominence
- Application of AI analysis to IT operations



General Categories of Machine Learning

- **Chatbots, Computational Linguistics, Q/A Systems**
  - Alexa, Google Assistant, IBM Watson
- **Expert Systems**
  - Many incident response modules of freeway management systems
  - "If…then" clauses + *logic gates*

Invented in 1960s

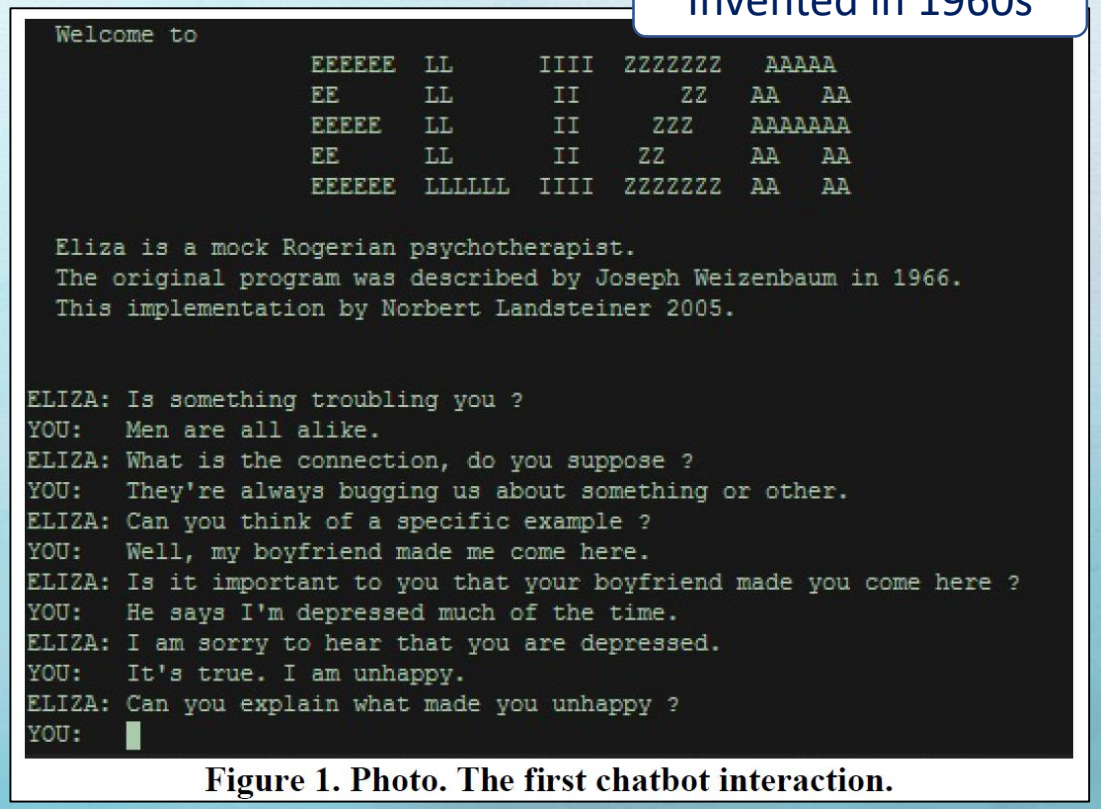


Figure 1. Photo. The first chatbot interaction.

General Categories of Machine Learning

- **Neural Networks and Supervised Learning**
  - Narrowly defined pattern recognition problems
    - Image recognition (Is this a cat?)
    - Data segmentation (Is this a cat, dog, fire truck, or tuba?)
  - Machine learning algorithms are trained to solve specific problems using this general process

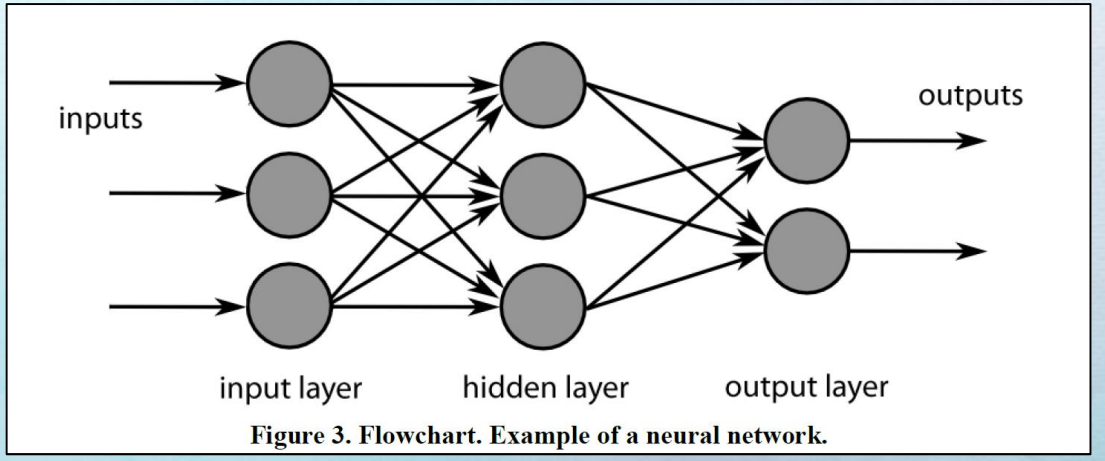


Figure 3. Flowchart. Example of a neural network.

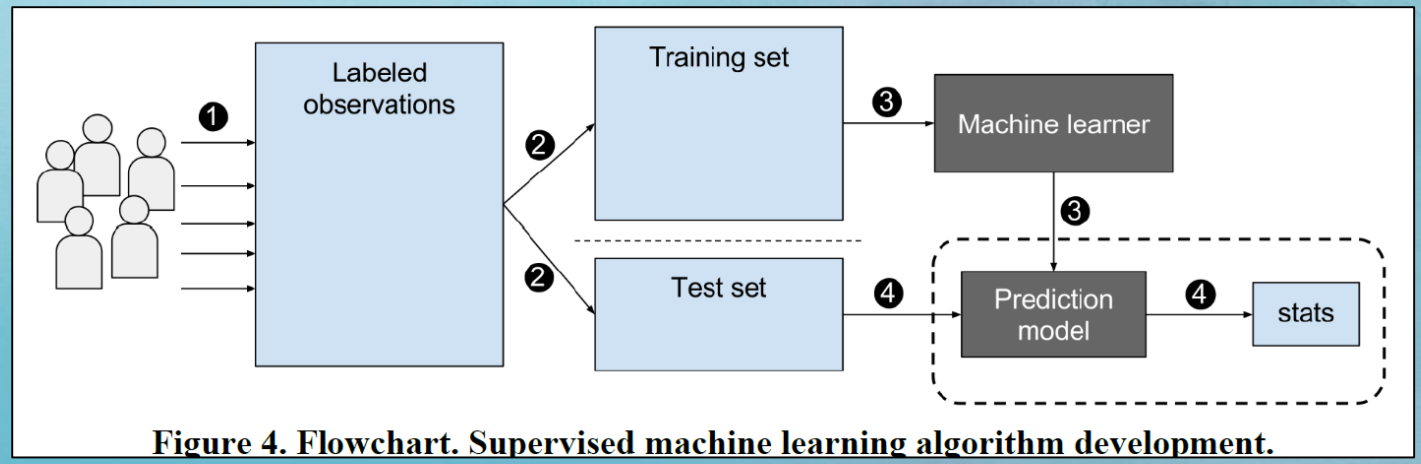


Figure 4. Flowchart. Supervised machine learning algorithm development.

General Categories of Machine Learning

- **Fuzzy Logic**
  - Based on the observation that people make decisions based on imprecise and non-numerical information
    - Truth ranges from *Completely True* to *Completely False*, with large variance in between
  - Fuzzy model/set – mathematical means of representing vagueness and imprecise info
  - "Fuzzy logic allows *if…then* rules to be probabilistic in describing linguistic variables that are modified with adjectives and adverb"
    - Ramp Metering → **"Heavy traffic"** – "typical traffic" – "light traffic"

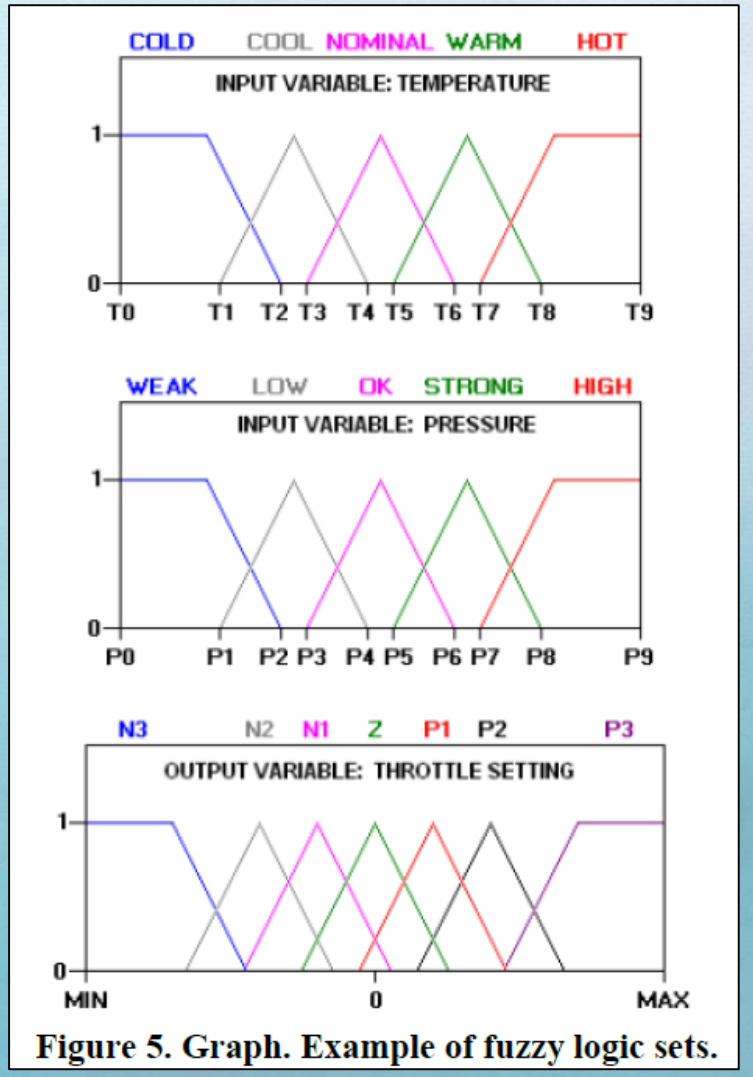


Figure 5. Graph. Example of fuzzy logic sets.

General Categories of Machine Learning

- **Machine Learning and Solution Search**
  - IBM Deep Blue vs Gary Kasparov
    - Searched up to 20 rounds of potential actions in selecting its next move

General Categories of Machine Learning

- **Unsupervised Learning**
  - Learning what actions produce better results
  - No presentation of a correct output for a given set of inputs
  - Through trial and error, system learns what inputs lead to the best outputs
  - "Deep Learning"
    - DeepMind
    - OpenAI
  - Formulation of congestion management as a "game" might find promise in coming years
    - **TMC Operator VERSUS the transportation network (coming soon)**

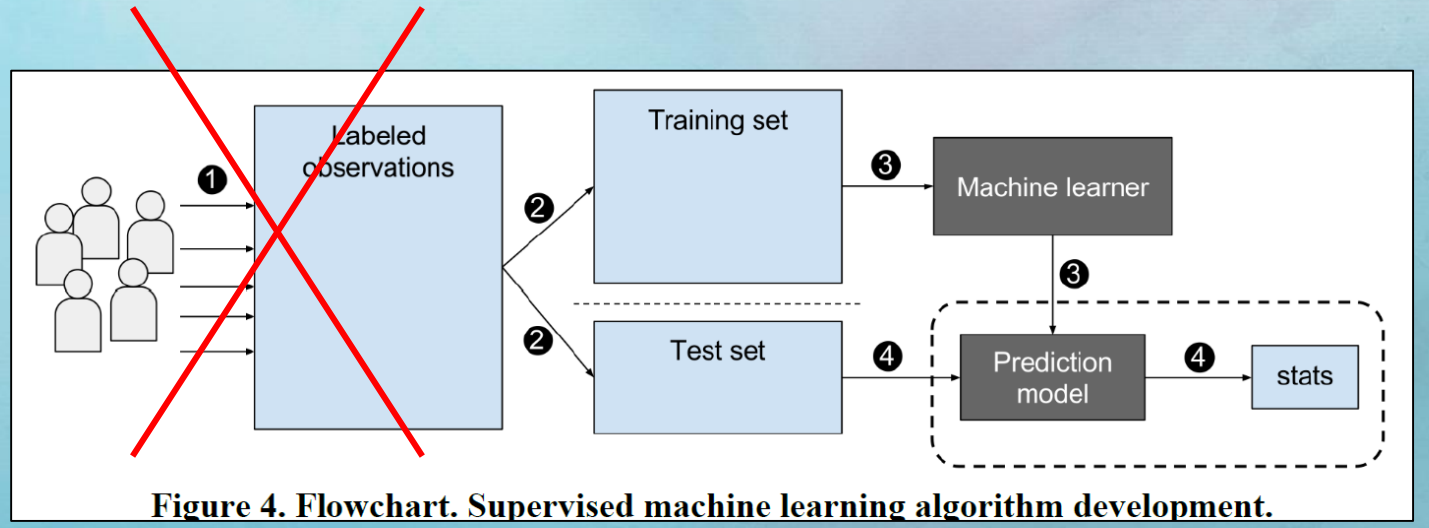
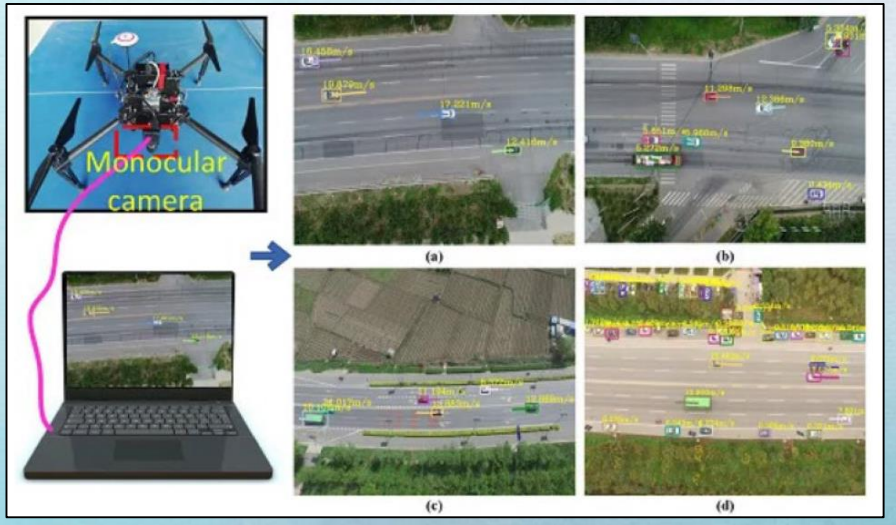


Figure 4. Flowchart. Supervised machine learning algorithm development.

General Categories of Machine Learning

- **Robotics and Driverless Vehicles**
  - Robotics – can substitute for humans and replicate human actions
  - Unmanned Aerial Systems (UAS)
  - Driverless vehicles – combination of AI techniques, robotics, computers, and sensors
    - Neural network object classification
      - Fusion of sensor data (LIDAR/Camera agree on object)
    - AI driver models trained by watching good driving behavior
    - AI driver models trained by unsupervised reinforcement learning in simulated 3D environments
    - Anomalies in embedded maps are identified using machine learning



Commercialization of AI

- Nearly 1,000 commercial companies involved in providing software and services in some way related to AI
- Examples of commercially available AI applications:
  - Natural language processing and natural speech synthesis of digital assistants
  - Integrated chatbots in virtual assistants
  - All major cloud service providers now support suites of AI-related tools and software
  - Object recognition and tracking software is widely commercialized
  - Driverless vehicles and UAS are likely to be available in near term for use by IOO
- For IOO, use of AI may reduce costs, augment staff, improve staff efficiency, provide suggested solutions that humans may not have thought through in advance, and provide convenience in the TMC

Commercialization of AI

- Each IOO will need to consider if it is more effective to purchase AI functions as a service (aaS) or develop and maintain on-premise
  - For many State DOTs, will likely be a hybrid
- Pricing models vary based on computing cycles, data storage size, frequency of analytics, and other metrics

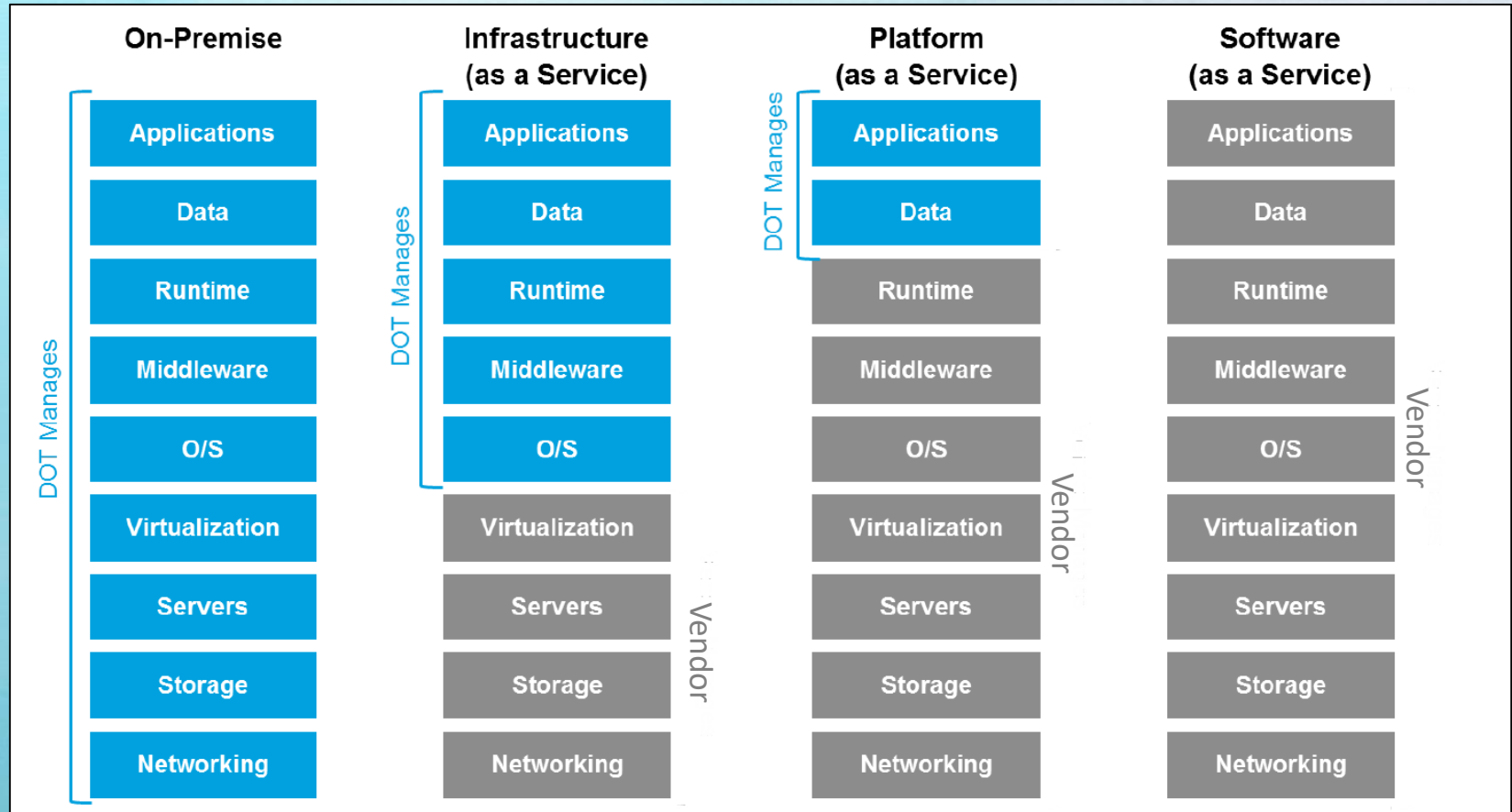


Figure 12. Chart. Information technology considerations for on-premise, infrastructure-as-a-service, platform-as-a-service, and software-as-a-service implementations.
(Source: Deloitte, 2016.)

Commercialization of AI

- Examples (starting p26)
  - Google AI – *Temporal Action Localization*
  - Microsoft early-access lab – *Project Knowledge Exploration*
  - Microsoft early-access lab – *Project Anomaly Finder*
  - Amazon AI on AWS – *Rekognition*
  - Amazon preview – *Forecast*

Maturity of AI Technologies

- Effort to reduce expertise necessary to stand up an AI system
- Migration of some AI software to purpose-built AI hardware
- Improved image recognition performance
- Enhanced voice recognition
- Improved *Supervised Machine Learning* training

Examples of AI in TSM&O Applications (details begin on p35)

- Neural network technologies deployed for incident detection using video image analysis and traffic prediction *(FDOT, NDOT, IowaDOT)*
- Fuzzy logic ramp metering *(WSDOT, Caltrans)*
- Traffic congestion and incident prediction *(DelDOT)*
- Integration of 511 with Alexa *(MTC San Fran)*
- Google Assistant integration *(multiple agencies)*
- UAS programs that could be enhanced with AI *(20 State DOTs)*
- AVs for crash abatement *(multiple DOTs)*

FDOT, NDOT, IowaDOT – Incident Detection

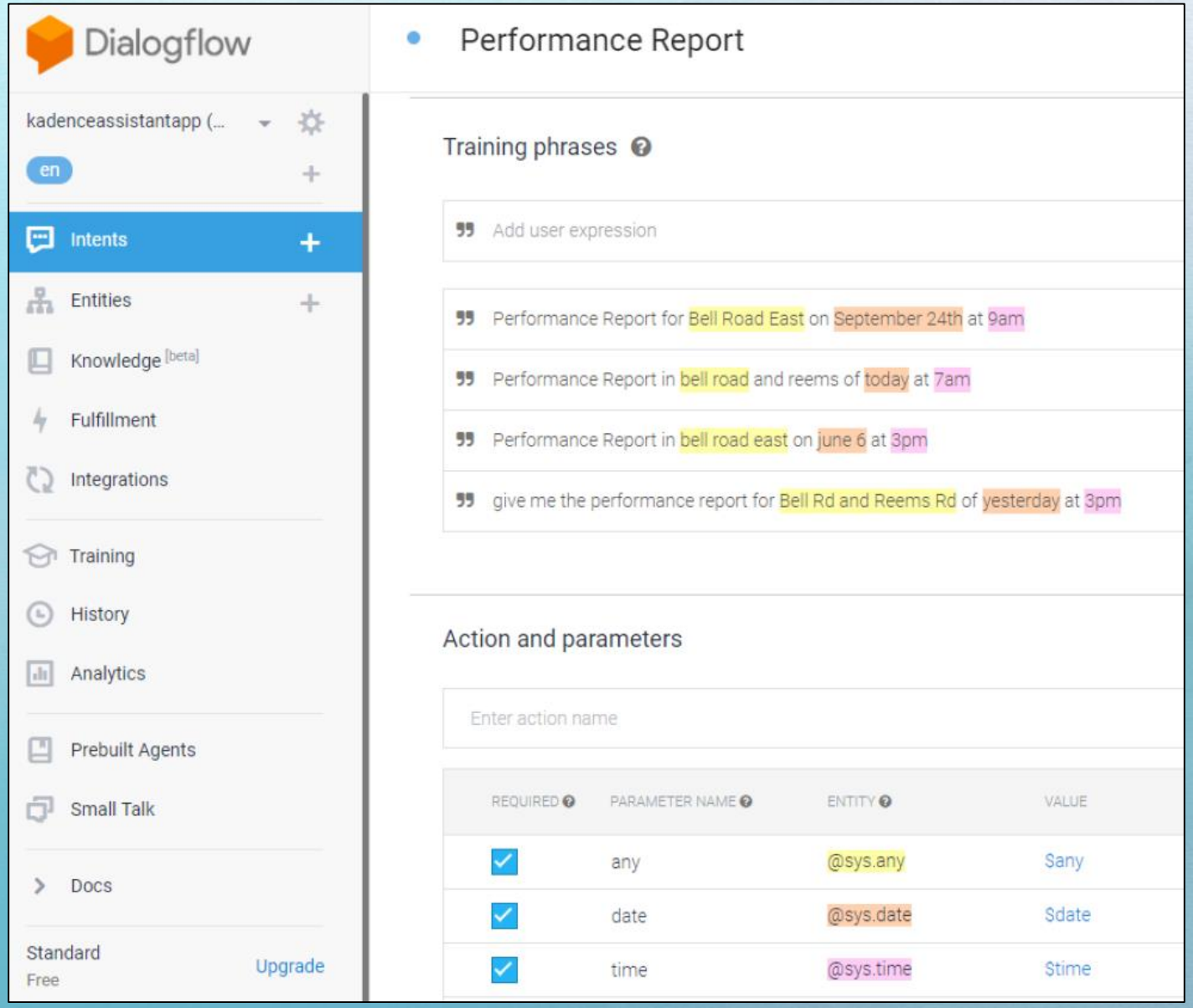
- AI system processes feeds from existing CCTV cameras to identify incidents using AI neural networks
  - Neural networks were trained to recognize scenes that are “incidents” and “not incidents”
  - Cloud-hosted proprietary software
  - Reported benefits
    - Incident detection times up to 12 minutes faster than other input streams
    - Reduction in crashes by 17%
      - Positioned highway patrol assets
      - Advanced warning of downstream congested areas via DMS

Washington State DOT – Ramp Metering

- Used Fuzzy Logic Metering for more than 15 years
  - Other ramp metering algorithms require substantial code and particularly difficult calibration
    - Just 5% of the WSDOT code was for the algorithm; 95% was for interfacing to the data inputs and providing metering outputs to the field controllers
- The program has evolved and expanded to over 200 ramps; no other ramp metering options have been deployed
- Reported benefits
  - Mainline efficiency by reducing upstream/downstream occupancy
  - Better performance at maintaining ramp queues than local metering

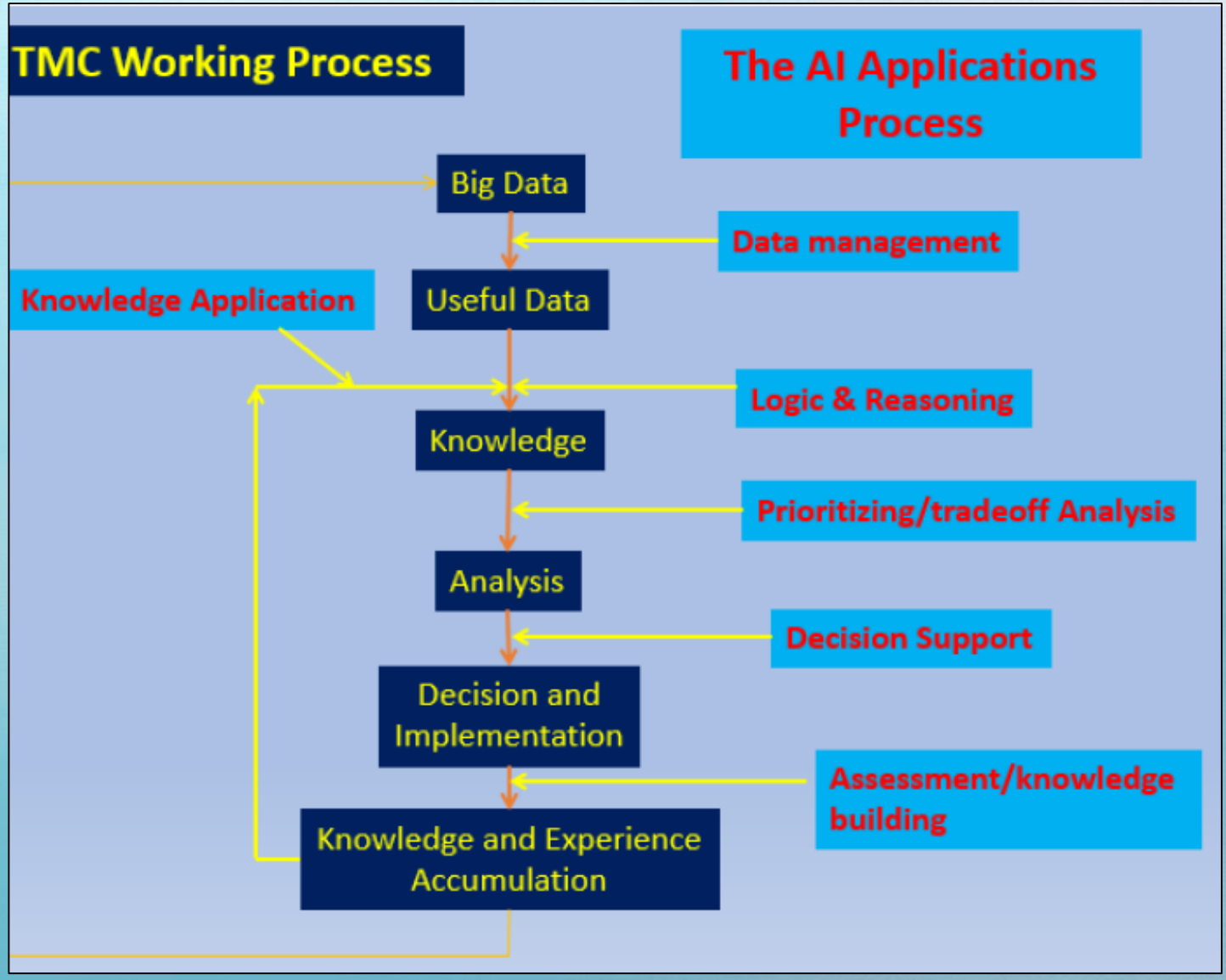
Surprise, AZ – Google Assistant Interface

- Integrated with ASCT system
- Allows traffic engineer to query status data using voice commands through a Google Home speaker or any phone or computer
- ASCT data is uploaded to Azure and available for query
  - Up to 1 year in the past



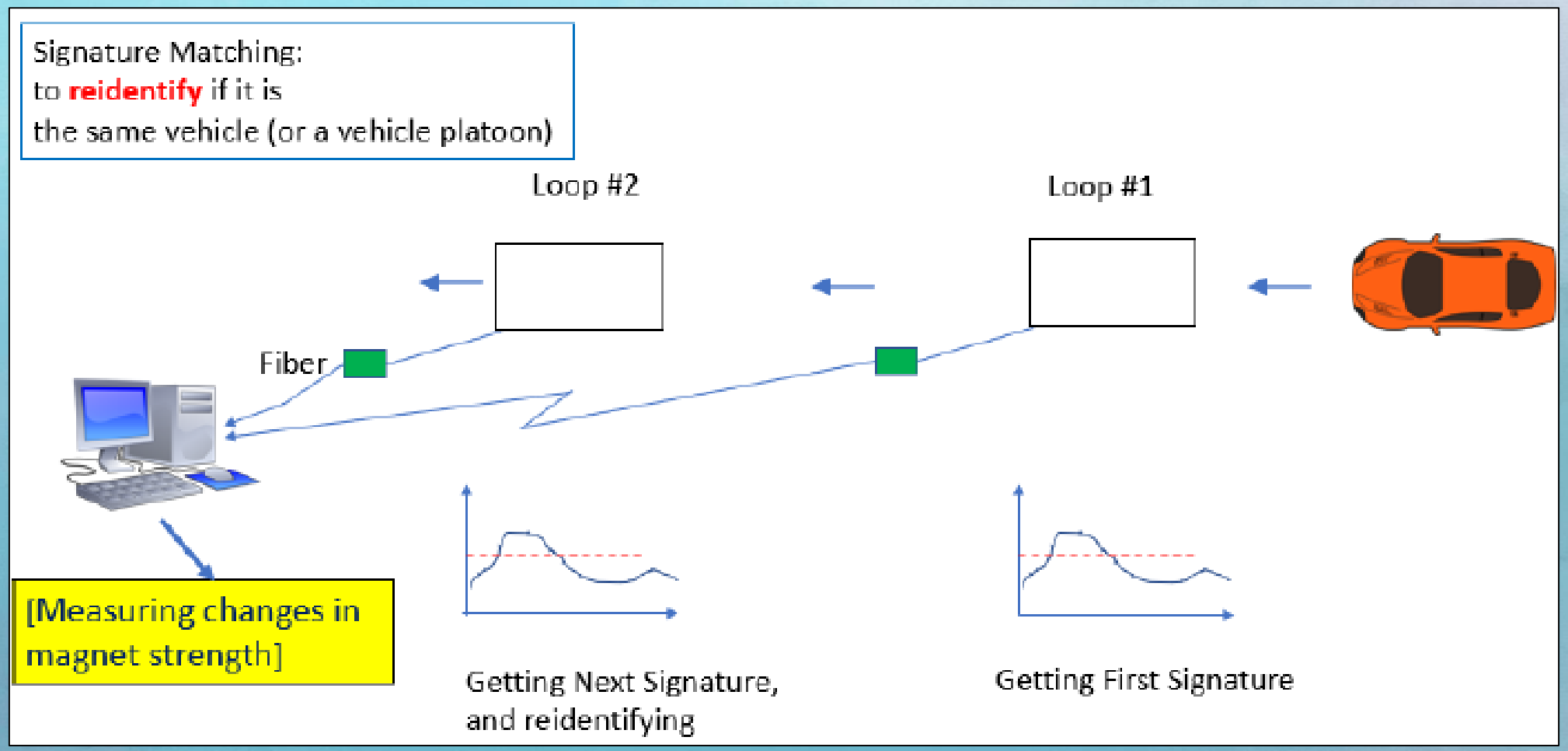
Delaware DOT – Traffic Prediction and Traveler Info

- ATCMTD funds used to implement AI at various stages of TMC working process
- Neural Network gaming
- Objectives achieved:
  - Actively monitoring network
  - Incident alerts
  - Provide info on suspected cause of situation; possible prioritized options
    - AI tool will then simulate selected option; predicts time to normal operations
  - Evaluate and store results



Delaware DOT – Traffic Prediction and Traveler Info

- Separate neural network component that detects incidents based on re-identification of vehicle signatures from one set of in-pavement loops to another



Considering AI Technologies in Transportation Planning, Deployment, and Operations

Systems Engineering considerations:

- Deficiencies in current TSM&O activities to be addressed by AI systems
- Improvements gained by using AI systems versus traditional systems
- Maturity of AI technology to support a specific application
- Prototype status of AI tools/technologies and consensus on practical “day one” applications
- Appropriate software systems, databases, and computing resources
- Integration of new systems & software with legacy systems & software
- Capabilities of agencies to appropriately take advantage of new functions
- Use of AI technologies beyond TSM&O and collaborations with other departments in the transportation agency

Considering AI Technologies in Transportation Planning, Deployment, and Operations

Development, Deployment, and O&M of AI systems may place burden on agencies in the areas of:

- Policy development and legal compliance regarding security/privacy
- Management/Integration will require highly skilled, in-demand personnel
- Funding constraints
- Development of new business processes required for AI applications
- Management of new types of data and volumes of data
- Performance Measurement of AI application

Considering AI Technologies in Transportation Planning, Deployment, and Operations

External Coordination and Collaboration will require capabilities in areas of:

- Developing guidelines and collaborative agreements
- Establishing new forms of public-private partnerships
- Considering partnerships and data packaging with 3rd party providers
- Developing/Retaining specialized staff and knowledgeable management
- Developing appropriate authority/responsibility framework

Considering AI Technologies in Transportation Planning, Deployment, and Operations

List of questions for agencies to consider

- Systems and Technology
- Staffing and Organization
- Business Processes
- Collaboration

✓ Do we have a champion for the development and deployment of AI systems?	☐
✓ Is this champion in our organization?	☐
✓ Does our organization embrace technology and innovation? Is there a commitment from leadership to advance technology?	☐
✓ Are there tangible steps to take to promote a culture that embraces technology?	☐
✓ What groups or divisions will have primary involvement in deploying, operating, or maintaining AI applications and related infrastructure?	☐
✓ Which division of the organization will be responsible for success? IT? TSMO? Geographic information systems (GIS)? Other?	☐
✓ Can we partner with other divisions or groups within our organization that are also interested in developing and deploying AI technologies?	☐

✓ Do we have experience with other databases used by the AI technology or system?	☐
✓ How do we deploy databases and can existing clusters or virtual machines be used for AI applications?	☐
✓ What other on-premise computing resources will be required? Do we have adequate space for new hardware in existing computing and data centers?	☐
✓ Do we have experience with the many AI applications that require merging data from multiple sources and formats?	☐
✓ What database and operating system technologies do our current TMSs rely on?	☐
✓ How will we integrate our legacy TMS with new AI software?	☐
✓ Can we replace or integrate certain elements of AI software with legacy TMS systems?	☐
✓ What application programming interfaces (API) do our current legacy TMSs have? If APIs do not currently exist, can they be developed?	☐
✓ What API standards do we support? Can the AI software or systems use these API standards, or will new integration be required?	☐
✓ How much of the system will be deployed on-premise versus in the Cloud?	☐
✓ Can we use public Cloud hosting or do we need a private Cloud or hybrid Cloud environment?	☐
✓ What sensitivities to data protection and personally identifiable information does use of the Cloud for AI applications present? Do we know what requirements or organizational policies are already in-place for handling Cloud applications and data storage? *(See note below)*	☐
✓ Are their cybersecurity issues to be addressed when using AI applications? What vulnerabilities or sensitivities may arise by use of AI software?	☐
✓ What policies or procedures are necessary for use of open-source AI software?	☐
✓ What policies or procedures are necessary for use of vendor proprietary or trade secret AI software?	☐
✓ What procurement models and methods of procurements can we use and have experience with? Does our organization preclude use of any procurement method?	☐
✓ Can the AI software and supporting databases and systems be procured as SaaS? PaaS? IaaS? DaaS? Traditional licensing?	☐
✓ Do we understand how software maintenance, updates, upgrades, and modifications will be handled?	☐
✓ Do our current vendors of TMS and related systems have experience with AI applications?	☐

Considering AI Technologies in Transportation Planning, Deployment, and Operations

Suggested steps for approaching development of AI Applications

1) Convene interdepartmental workshop to educate stakeholders and brainstorm potential applications and synergies
2) Discuss priorities, opportunities, and barriers to AI applications in TSM&O
3) Determine a **high-priority shortlist** and a **longer secondary-priority list**
4) Review the list of questions in the report and consider your organization's responses to each
5) Develop a project plan to implement the actions.

Questions?

NHTSA Alters Safety Rules to Make Room for Self-Driving Cars

David Williams, VHB

NHTSA Alters Safety Rules

- **The Federal Government has set out to "do no harm" in the ADS space**
- NHTSA is slightly modifying its safety rules to account for ADS technologies
  - Unintended and unnecessary barriers to innovative designs
  - "200-series" rules under Federal Motor Vehicle Safety Standards
  - Companies would like precise definitions of "driver" and "driving"
  - No requirement for manual controls in Level 5 ADS
  - AVs will still have to meet strict crash tests – "everyone is a passenger"
- Goal: streamline manufacturers' certification processes, reduce certification costs, and minimize need for NHTSA interpretation or exemption requests
- https://www.futurecar.com/3866/NHTSA-Alters-Safety-Rules-to-Make-Room-for-Self-Driving-Cars

FDOT CAV Readiness Study

Jeremy Dilmore, District Five TSM&O

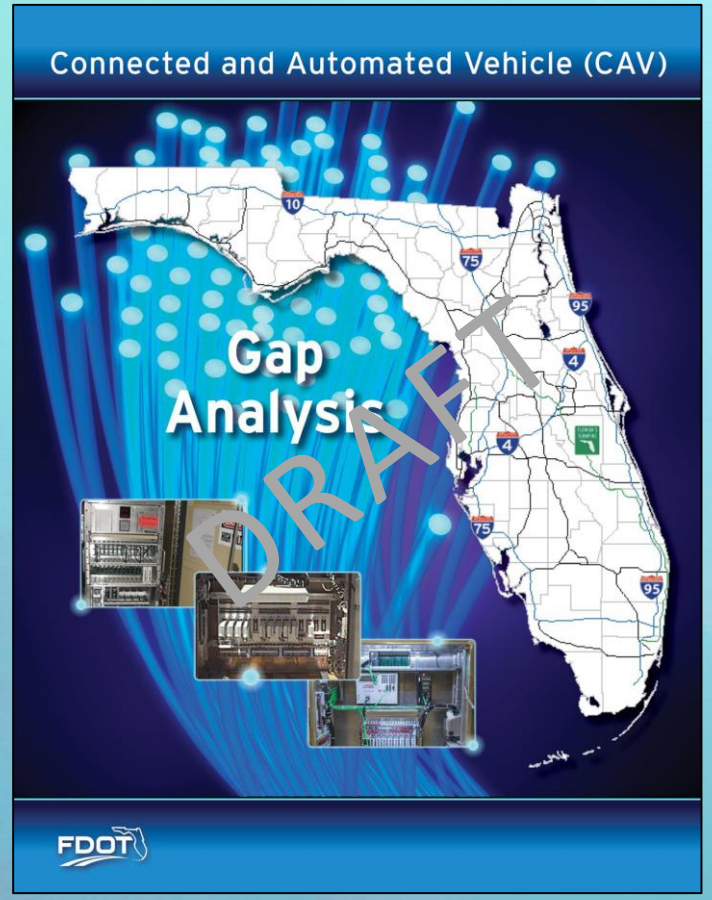
FDOT CAV Readiness Study

- FDOT adopted the CAV Business Plan in January 2019

Three Focus Areas

- CAV Implementation Prioritization
  1) CAV Project Prioritization
  2) Gap Analysis
- Deployment
  3) Current Funding of Work Program Projects
  4) Current Funding of non-Work Program Projects
- Communications and Data Storage Readiness
  5) Needs and Criteria for Updating RTMCs
  6) Needs and Criteria for Updating TMCs at Local Agencies

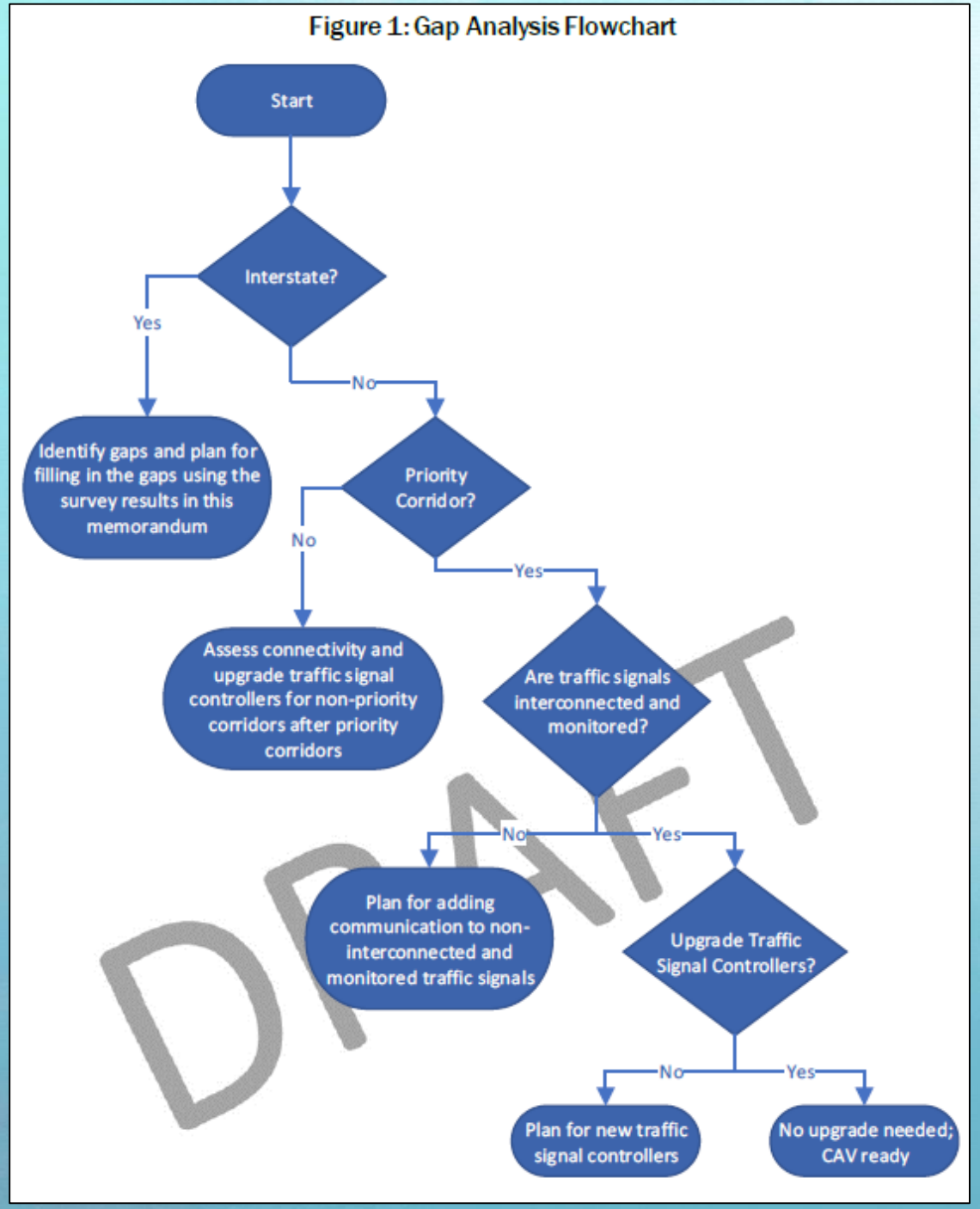
Gap Analysis



- Current state of infrastructure and Upgrades needed for CAV
  - Interstates (focus on fiber connectivity)
  - Arterials (fiber and traffic signal controllers capable of CV communication)
    - Priority Corridors
    - Non-Priority Corridors
    - Should be assessed for network connectivity between interconnected and monitored traffic signals (IMTS)

Gap Analysis

Flow diagram used for gap analysis

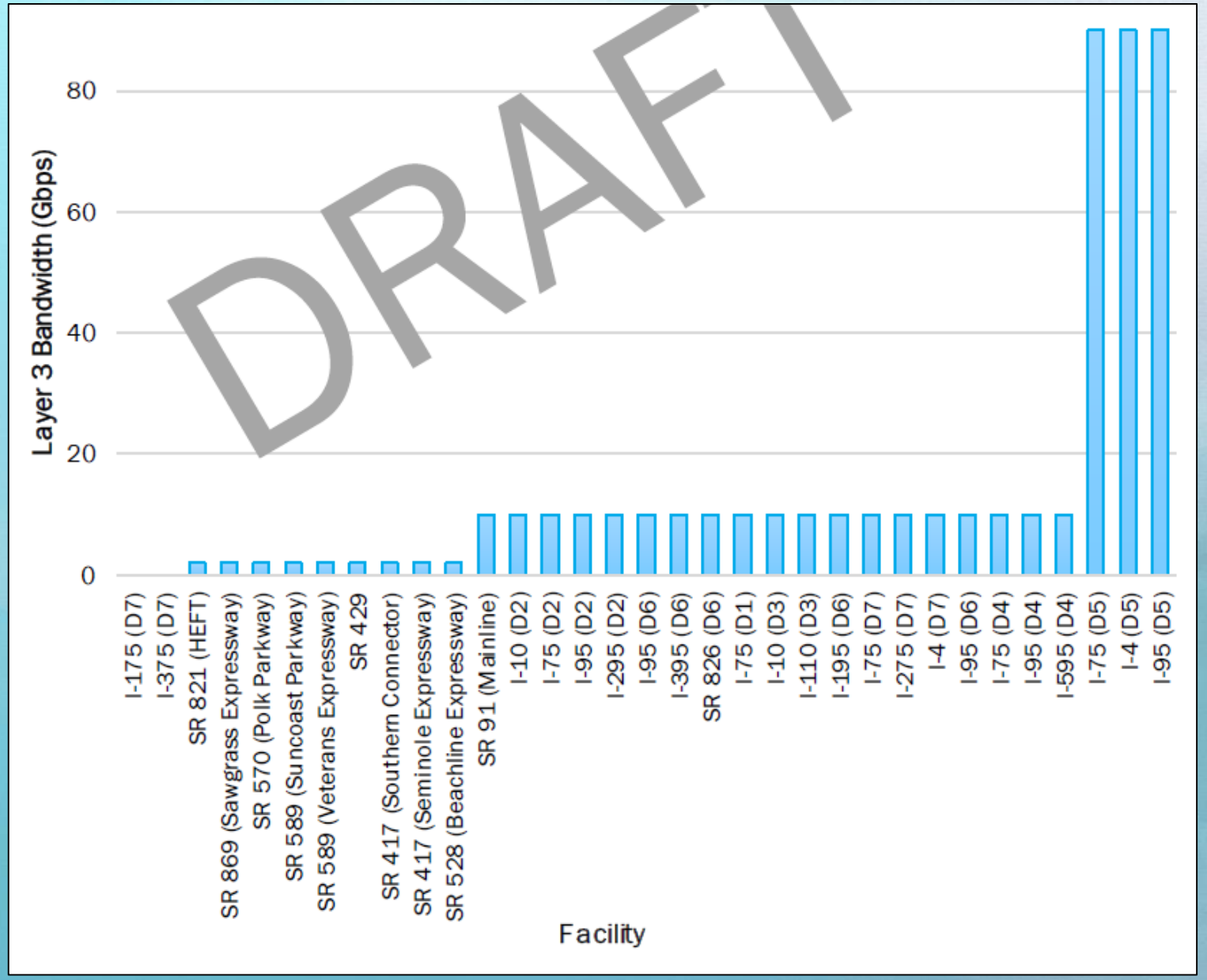


Gap Analysis (Interstates) – Questionnaire

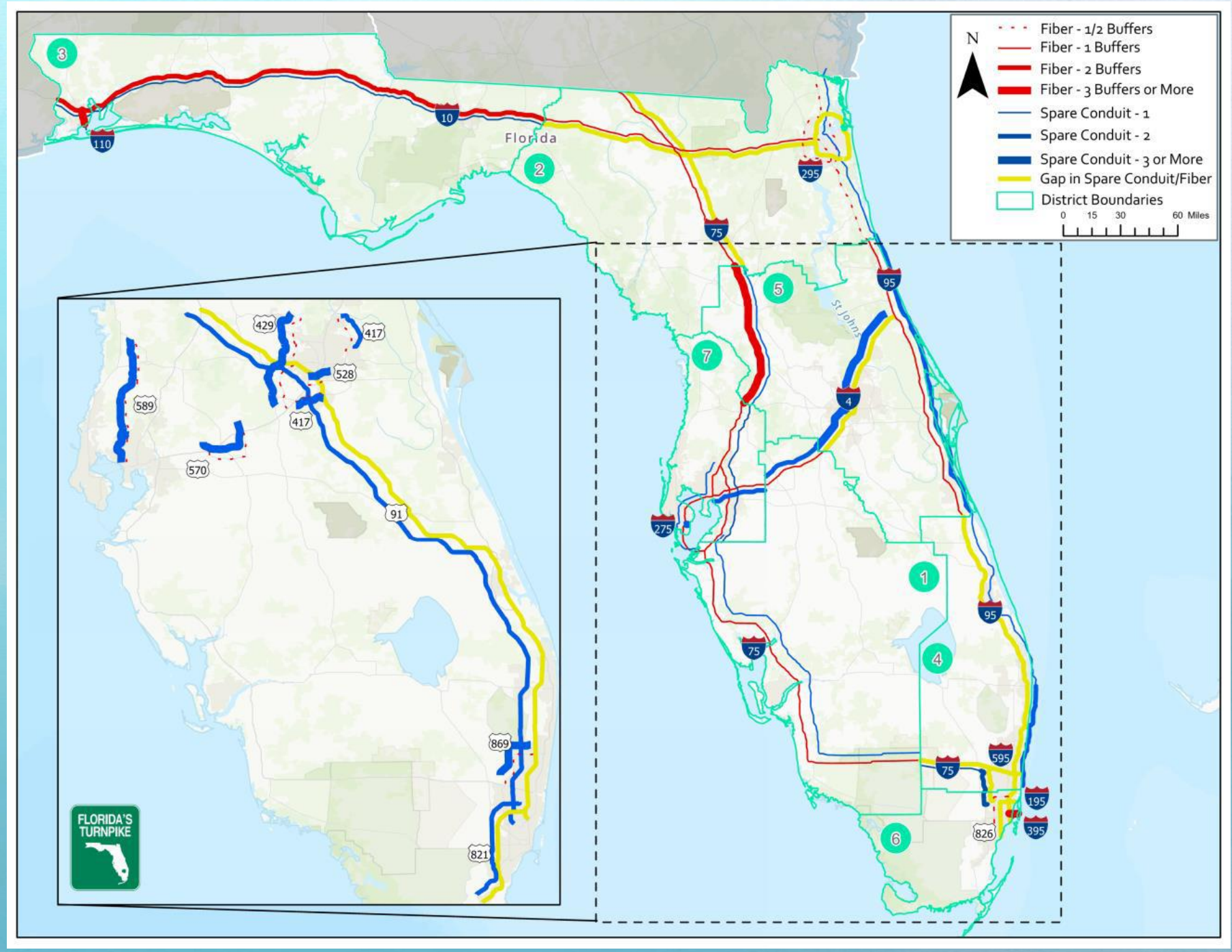
1. Total Available/Non-Allocated Optic Fibers
2. Available Layer 3 Bandwidth
3. Available Spare/Unused Communication Conduits
4. Network Management Tools
5. Spare Operator Stations
6. Currently Budgeted Department Positions
7. Scheduled Shift Hours for RTMC Operations
8. Current Contract type for ITS/Network Maintenance
9. Current Maintenance Contract Requirements for Minimum Personnel
10. Maximum Downtimes allowed by Department Staff and Maint. Contracts
11. Available Rack Space

Gap Analysis (Interstates) – Questionnaire

Layer 3 Bandwidth (Gbps)

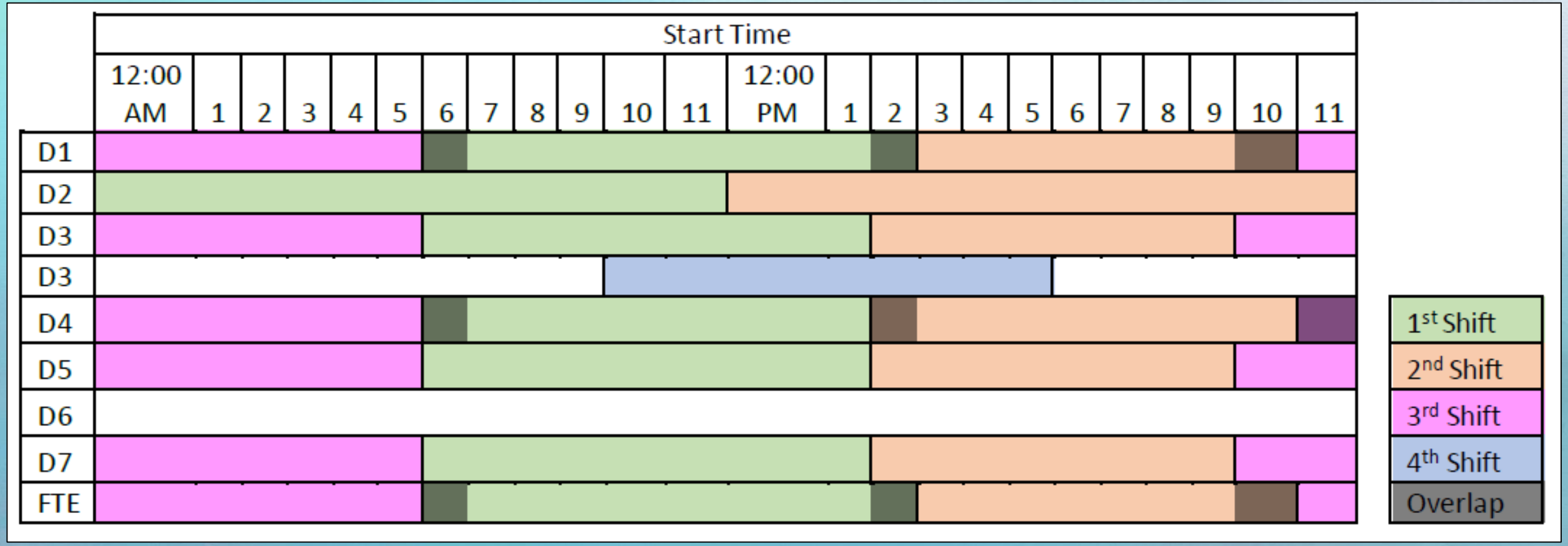


Spare Fiber and Conduit



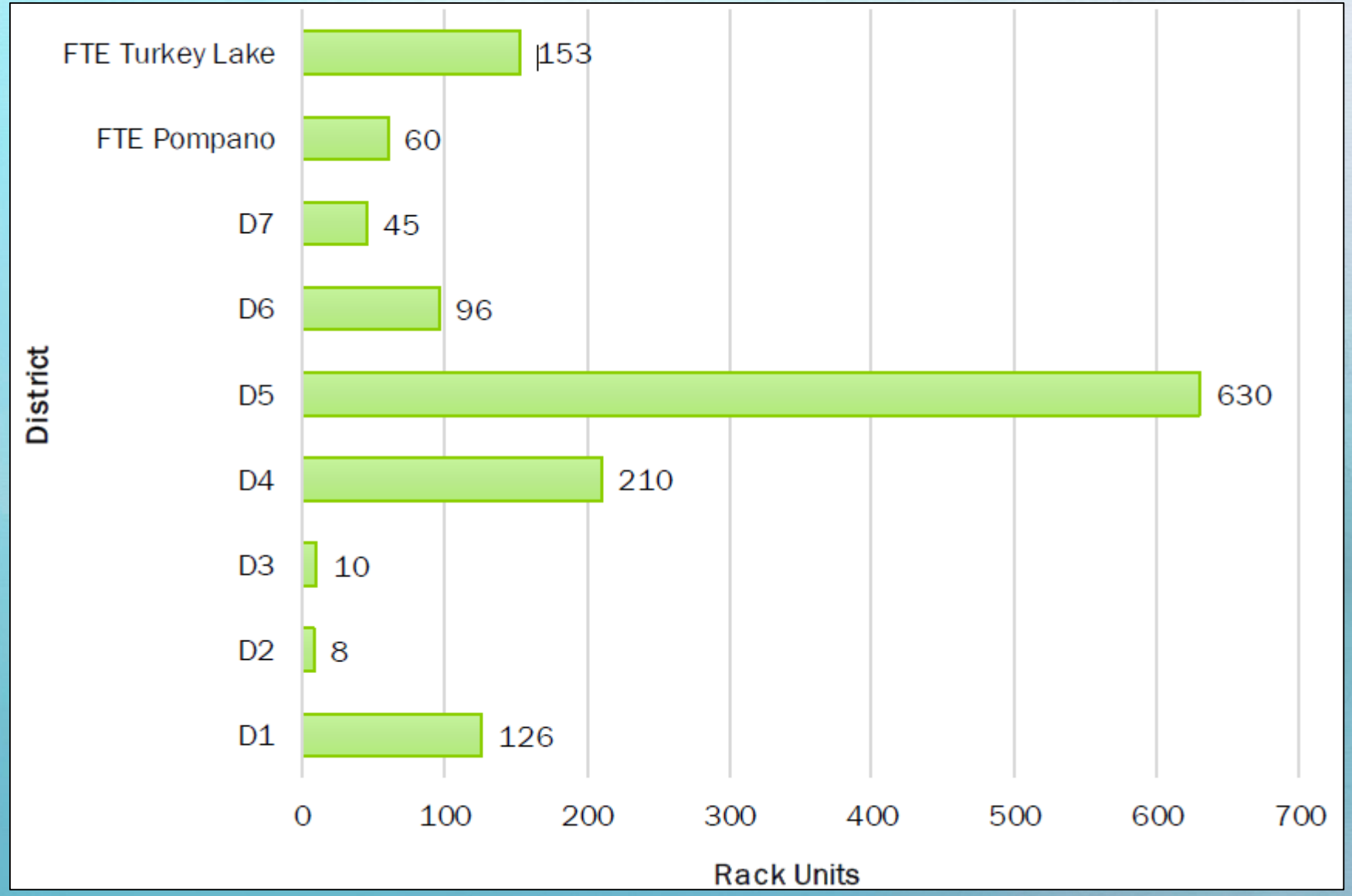
Gap Analysis (Interstates) - Questionnaire

Shift Hours for RTMC Operations



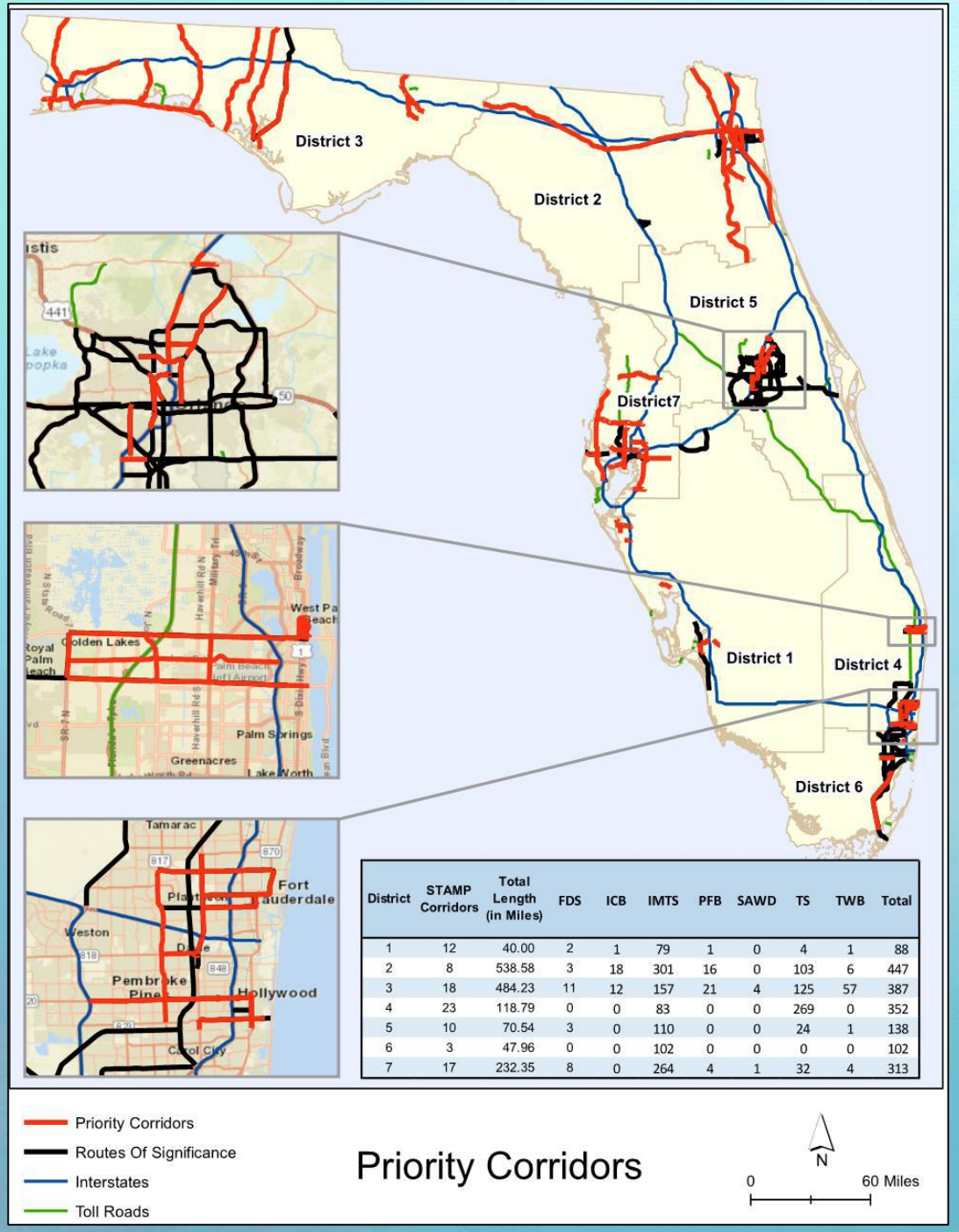
Gap Analysis (Interstates) - Questionnaire

Available Rack Space



Gap Analysis (Priority Corridors)

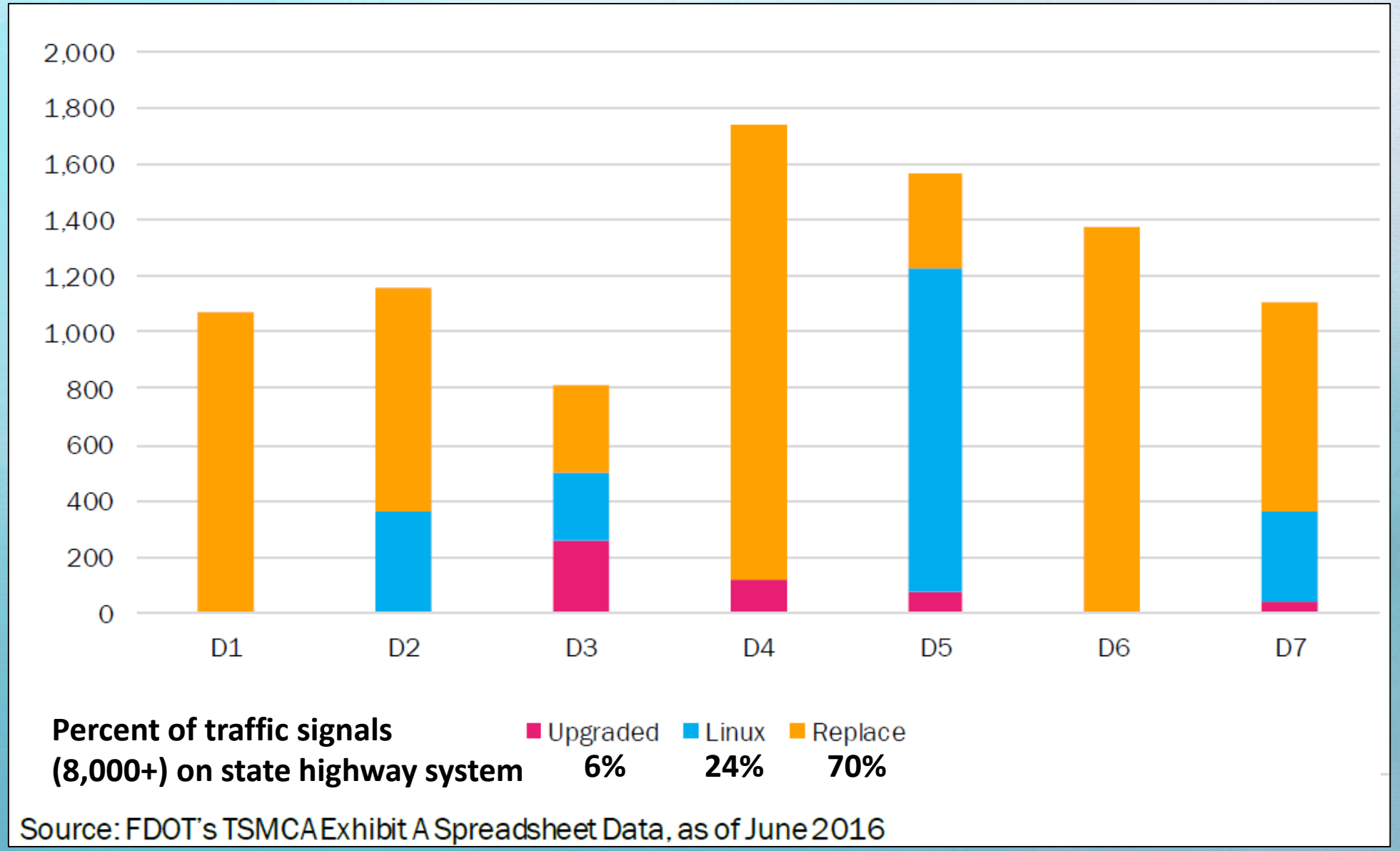
- **District-identified Priority Corridors** with **RoS**



District	STAMP Corridors	Total Length (in Miles)	Traffic Controller Types							
			FDS	ICB	IMTS	PFB	SAWD	TS	TWB	Total
1	12	40.00	2	1	79	1	0	4	1	88
2	8	538.58	3	18	301	16	0	103	6	447
3	18	484.23	11	12	157	21	4	125	57	387
4	23	118.79	0	0	83	0	0	269	0	352
5	10	70.54	3	0	110	0	0	24	1	138
6	3	47.96	0	0	102	0	0	0	0	102
7	17	232.35	8	0	264	4	1	32	4	313

Gap Analysis (Interstates) - Questionnaire

Traffic Signal Controller Upgrades



Percent of traffic signals (8,000+) on state highway system

Upgraded	Linux	Replace
6%	24%	70%

Source: FDOT's TSMCA Exhibit A Spreadsheet Data, as of June 2016

Gap Analysis (Priority Corridors)

Interconnected and Monitored Traffic Signals (IMTS) and Non-IMTS

(for potential upgrade prioritization)

District Five – Priority Corridor	Non-ITMS	IMTS	Total Number of Signals
N US 17/92 (Orlando Ave / Mills Ave)	1	26	27
S US 17/92 (Orlando Ave / Mills Ave)	15	7	22
SR 46	0	10	10
SR 414 (Maitland Blvd)	7	4	11
SR 423 / CR 423 (John Young Pkwy / Lee Rd)	1	20	21
SR 435 (Kirkman Rd)	0	18	18
SR 436 (Semoran Blvd)	0	13	13
SR 482 (Sand Lake Rd / McCoy Rd)	0	7	7
US 441 (Orange Blossom Trl)	0	5	5
DISTRICT FIVE TOTAL	**24**	**110**	**134**

What's Next?

- Data Storage Survey and Analysis
  - Storage Capacity by Data Source
  - Projected Device Deployments over next 3 to 5 years
  - Physical space available for more servers at the TMC
  - Existing internet connection speed/type/provider for TMC
  - Local agency connections

Technology **A**pplication **P**artnership**s** for Local Agencies (TAPS-LA)

Jeremy Dilmore, District Five TSM&O

FDOT TSM&O
Transportation Systems Management & Operations

Transportation Systems Management & Operations

CENTRAL FLORIDA TSM&O CONSORTIUM

TAPS-LA Program

- **Still in development**
- Purpose: assist Florida's local agencies with incorporating and deploying CAV technologies
- TAPS-LA is funded under the CAV program initiative to deploy advanced transportation and congestion management technologies
- Eligible applicants
  - County governments
  - City governments
  - Transit agencies
  - Port authorities
  - Toll authorities

Technology Application Partnerships for Local Agencies

TAPs-LA

$10M
TAPs-LA
@ Districts

$10M
I-STREET
@ UF

Vital Few:
ART
Safety
Mobility
Innovation

Performance –centric CAV Program

I-STREET

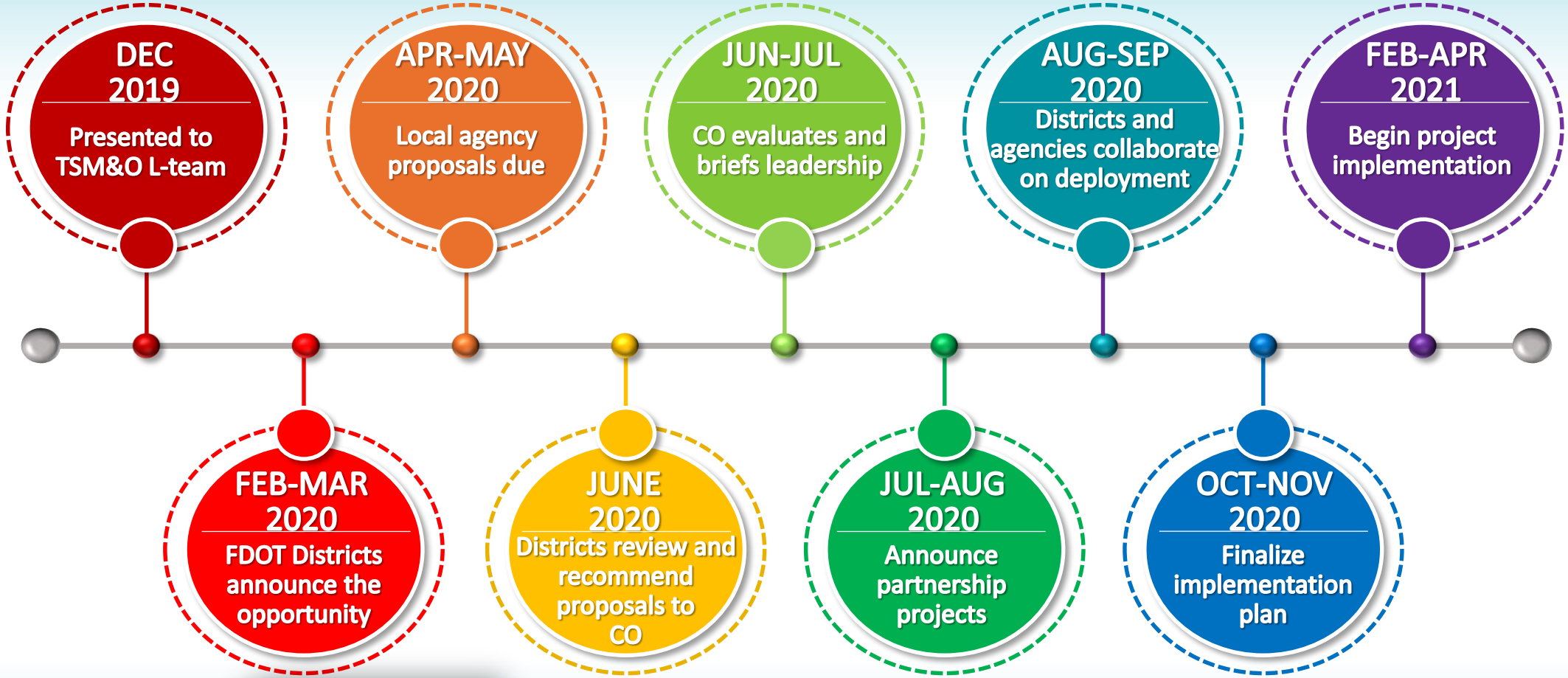
TRANSPORTATION INSTITUTE
UNIVERSITY OF FLORIDA

ART – Attract, Retain, Train

FDOT TSM&O
Transportation Systems Management & Operations

FLORIDA CONNECTS
Moving To Safe and Congestion-Free Transportation

TAPs-LA Timeline and Process



Technology Application Partnerships for Local Agencies

TAPs-LA

- Districts solicit proposals from local agencies
- Districts recommend projects to Central Office
- Central Office briefs TSM&O Leadership team
- FDOT leadership selects 2-4 projects per year

Current Initiatives

Jeremy Dilmore, District Five TSM&O

THANK YOU!

Next Consortium – May 28, 2020

TSM&O Consortium Meeting

MEETING AGENDA
Teleconference

April 2, 2020
10:00 AM-12:00 PM

1) WELCOME

2) RAISING AWARENESS OF ARTIFICIAL INTELLIGENCE FOR TSM&O

   - David Williams, VHB

3) FDOT CAV READINESS STUDY

   - Jeremy Dilmore, District Five TSM&O

4) TECHNOLOGY APPLICATION PARTNERSHIPS FOR LOCAL AGENCIES (TAPS-LA) PROGRAM

   - Jeremy Dilmore, District Five TSM&O

5) CURRENT INITIATIVES

   - Jeremy Dilmore, District Five TSM&O