# **Connected Powertrain**

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**ITS** Texas San Marcos September 30, 2022



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#### **POWERTRAIN ENGINEERING**



swri.org

### Facts About SwRI

- Founded by Thomas Baker Slick Jr. in 1947
- 501(c)(3) nonprofit corporation headquartered in San Antonio, Texas
- Nearly 3,000 employees
- I,500-acre facility; 2.3 million square feet of laboratories & offices
- Applied R&D Service Provider; 10 Technical Divisions – Deep Sea to Deep Space<sup>™</sup>
- More than 1,300 patents
- Revenue 2020 ~ \$700 Million







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### **Connected Powertrain**



Leverage connected and automated information streams (V2V,V2I and V2X) to improve energy efficiency and performance of powertrain



**Powertrain Engineering** 

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### Key Focus Areas



### www.connectedpowertrain.swri.org





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### Air Quality

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## **SwRI NEXTCAR-I Program**

- Demonstrated energy consumption reduction of 20% on **Toyota Prius Prime**
- 3-year program funded by ARPA-E ended fall 2020
- No powertrain hardware changes
- No compromise in emissions, safety or drivability
- 2021 R&D 100 Award











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### **Benefits Distribution**





## **Think Google Maps with Energy**





- Best case energy benefits on dyno (20% +)
- Team doing robustness analysis with more real-world trips

Rengarajan, S., Hotz, S., Sarlashkar, J., Gankov, S. et al., "Energy Efficient Maneuvering of Connected and Automated Vehicles," SAE Technical Paper 2020-01-0583, 2020





Energy [Best v Default]

Decrease

%

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## **Hybrid Vehicle Power-Split Optimization**



9.3% best-case improvement Nominal benefits ~ 3-5%

> Real-time Long Horizon Model Predictive Control of a Plug-in Hybrid Vehicle Power-Split Utilizing Trip Preview, JSAE20199015 / SAE2019-01-2341



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## **Eco-Drive Mobile Application**

- Driver advisory <u>android</u> application for eco-driving
  - Querying TTS servers to parse live traffic signal information over cellular LTE network (DSRC capable)
- Class VIII Trucks Research Study
  - Quantify the benefits of CV technologies
  - SAE J1321 style fuel economy testing (fleet familiar)
  - Air quality (NOx and PM) perspectives
    being quantified









Changes In

6.0

Baseline Test Configuration

is statistically determined based on T/C ratio repeatability

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# **NEXTCAR II**





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## **NEXTCAR II**

- Demonstrate energy consumption reduction of 30%on a Level 4 automated vehicle
  - V2X information for predictive longitudinal and lateral vehicle dynamics
  - cooperative control
  - eco-routing
  - powertrain optimization





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## **SwRI Drive-By-Wire System**

- NEXTCAR II requires actuation of accelerator, brake and steering
- Commercial solution not available off the shelf for project vehicle
- SwRI custom DBW system simulates stock control signals to generate the requested action
- Dedicated CAN interface to AV stack





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# **DOEVTO EEMS**





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## **Energy Efficient Mobility Systems Program**

Active DOE program for extending connected powertrain concepts on different types of powertrains, automation levels and understanding the impact of intelligent infrastructure









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### **Technical Accomplishments and Progress:** 15% Energy Savings on Dyno: Vehicle Testing "Corridor" Results







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## Impact of CAVs on Class 8 Emissions

- Baseline and CAV "eco" cycles produced in simulation were driven by fully-loaded trucks and evaluated on production and low NO<sub>x</sub> (2031+ HD-FTP compliance limit) class 8 engines and aftertreatment configurations
- Eco cycles showed 8%-14% CO<sub>2</sub> reduction
- Tailpipe  $NO_{x}$  remained below the 2031+ HD-FTP compliance limit with low  $NO_x$ system









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# **Vehicle Testing Methods**





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## **CAV Hub Dynamometer**



### The Ego Vehicle (Red) Interacting With Traffic in the Simulator

The Development Vehicle Mounted on The Hub Dynamometer

SAE Automotive Engineering Magazine April 2020, https://www.sae.org/publications/magazines/content/20autp04/



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### Virtual Traffic Enabled Track Testing

- SwRI funded internal research
- Real-time traffic simulator integrated with SwRI L4 vehicle in a digital twin
  - SwRI integrated: VisSim, MATLAB/Simulink, GPS
  - SwRI test track
  - Driver in the loop
  - Richer test scenarios
  - How does algorithm respond?



Dynamic microscopic traffic simulator



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### **Thank You!**

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