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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Autonomous Platform Demonstrator

Army Science Conference
29 NOV – 03 DEC 2010

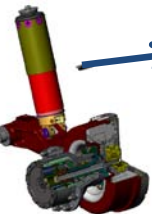
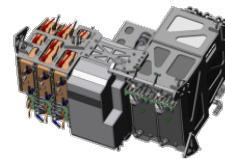
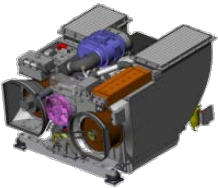
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Thermal and Power Management Systems

ARV SFR Requirements

Series Hybrid Electric Drive



Suspension and Hub Motor Technology

Key Performance Parameter is 80 KPH!

UGV Safety System

APD Specifications	Goal	Unit
Acceleration (0-30 MPH)	10.5	sec
Max Speed (Hardball)	50	mph
Max Speed (Cross Country)	28	mph
Generator Output	197	hp
Fuel	JP8, Diesel	
Battery Energy	21.8	kW-hr
Battery Max Power	282	hp
Traction Motor Power	1,046	hp
Power/Weight Ratio	112	hp/ton
Peak Torque (Sum 6 Wheel Drive)	41,368	ft-lb
Steering Radius	0	in
Vertical Obstacle	39	in
Trench	39	in
V-Ditch	108	in
Ground Clearance	4-25	in
Side Slope	30	%
Longitudinal Slope	60	%
Fording	20	in
Gross Vehicle Weight	9.3	ton
Normal Operating Height	87	in
Minimum Crouched Height	76	in
Overall Length	182	in
Overall Width	98	in
Operating Temperatures	-4 to 113	°F
Available Direct Current Voltages	750, 350, 28 VDC	
Standby Power Available (Genset and Batteries)		
Mechanical Redundancy (6WD, Battery and/or Engine Power)		

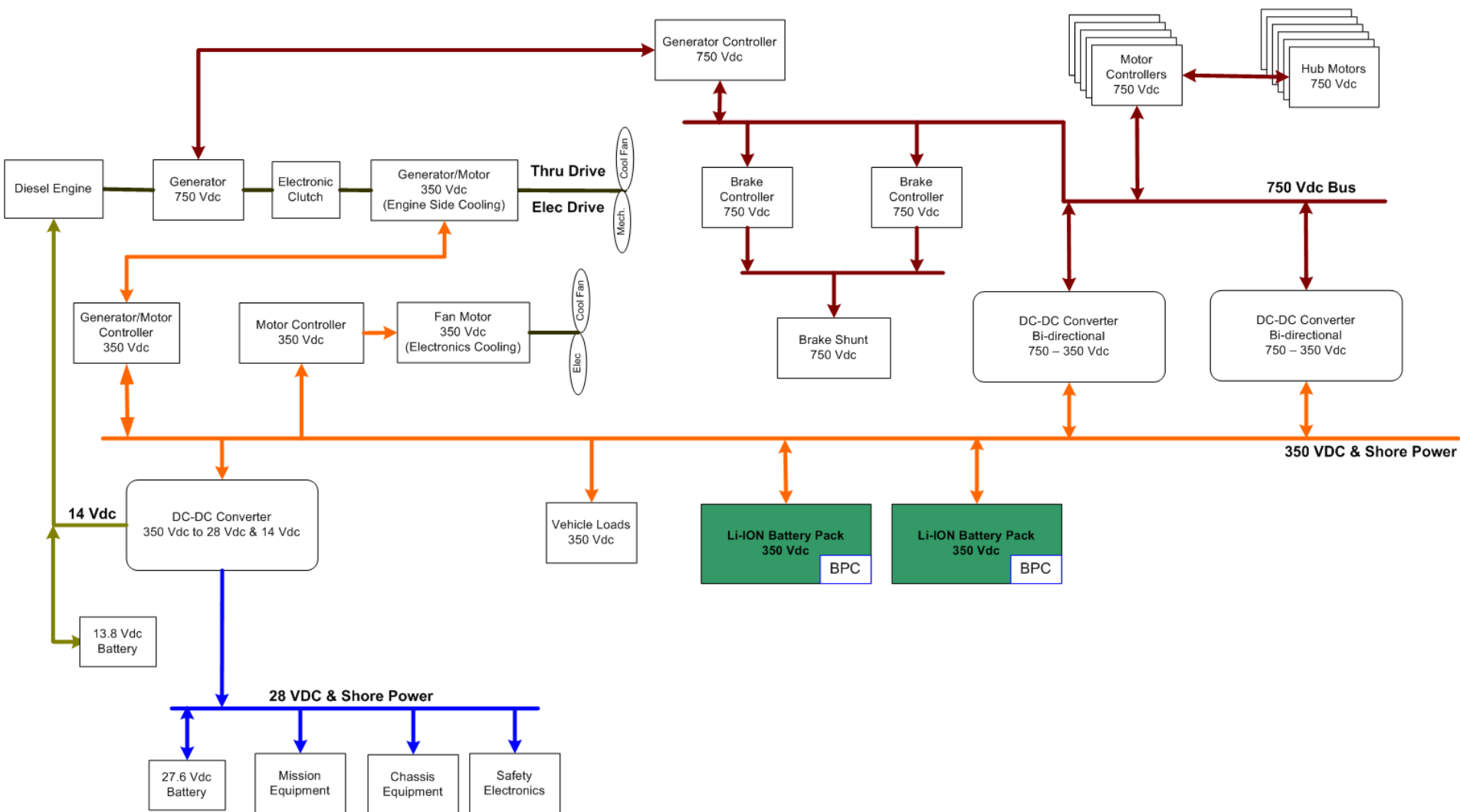
Autonomous Platform Demonstrator (APD)

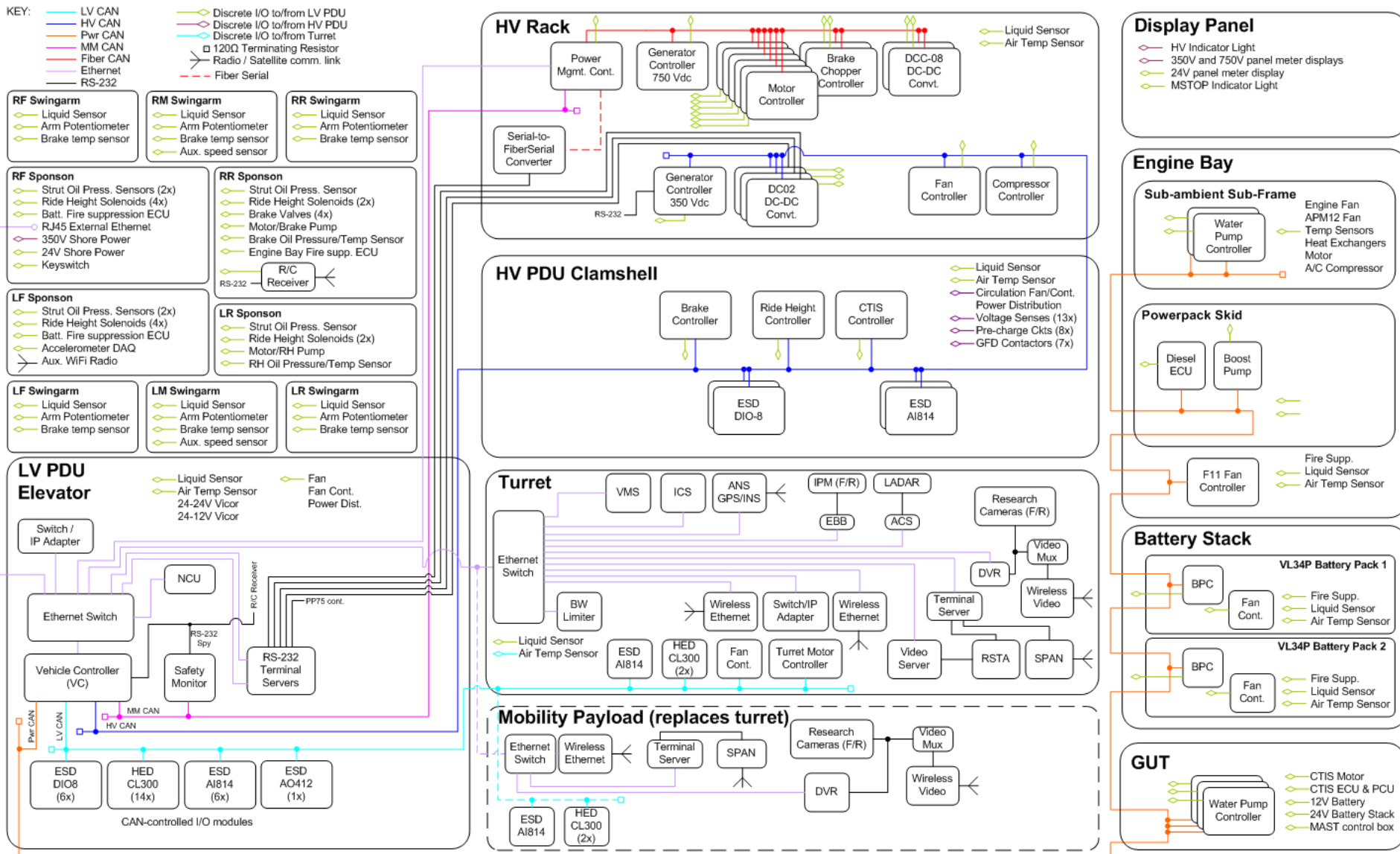
Purpose:

- This platform demonstrator has developed, integrated and tested next generation Unmanned Ground Vehicle (UGV) mobility technologies such as hybrid electric drive systems, advanced suspension systems, thermal management systems, and UGV safety systems. It is capable of reaching speeds up to 50 miles per hour and performing maneuvers at those speeds.
- The APD is the integration platform for the Robotic Vehicle Control Architecture (RVCA) and Safe Operations of Unmanned Systems for Reconnaissance in Complex Environments (SOURCE) Army Technology Objectives (ATO).

Status/Technology Readiness Level :

- The vehicle achieved first drive in early August 2009 and has logged over 4300 kilometers since. The APD underwent an intensive schedule of developmental and mobility testing tightly coupled with experimentation for the RVCA ATO. Testing has culminated with a Soldier Operational Exercise 2.0 conducted in the 4th quarter of Fiscal Year 10 at Fort Hood.
- Current Technology Readiness Level is 6.





Objective:

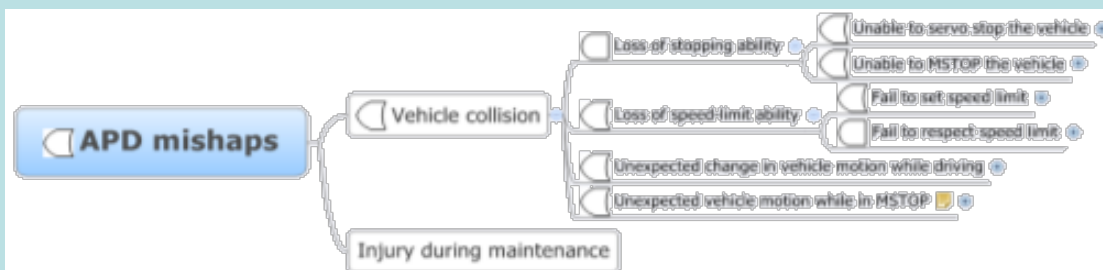
- Enforce and control safe standoff distance between APD and nearby personnel

Approach:

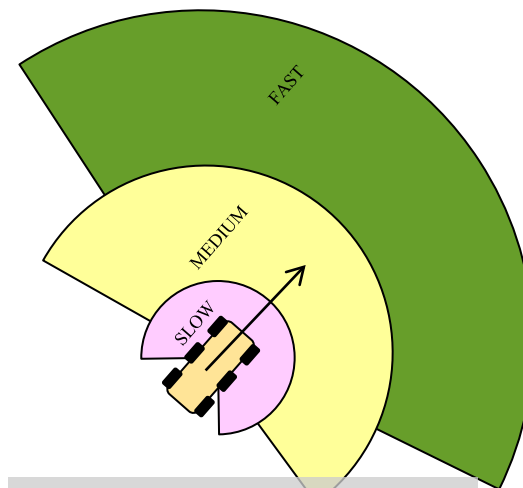
- Provide fail-safe braking mechanisms with well-modeled stopping distance.
- Incorporate *Safety Monitor* for redundant, high-reliability means of restraining vehicle speed.
- Identify and mitigate risks that could lead to failures of braking and speed-limiting.

Techniques:

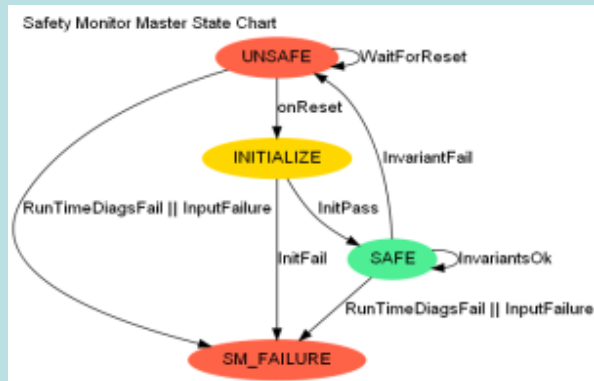
- Identifying hazards that lead to safety mishaps.
- Modeling of correlation between latent hazards with rich instrumentation.
- Firewalling safety-criticality to a subset of vehicle components.
- Developing & testing fault-resistant software for speed limiting.
- V&V testing traced to safety requirements.
- Well structured Safety Program IPT



Careful analysis of mishaps drives safety system design



Reliable speed limiting allows safe standoff distances to be decreased



Safety Monitor ensures that safety invariants are maintained

Objective:

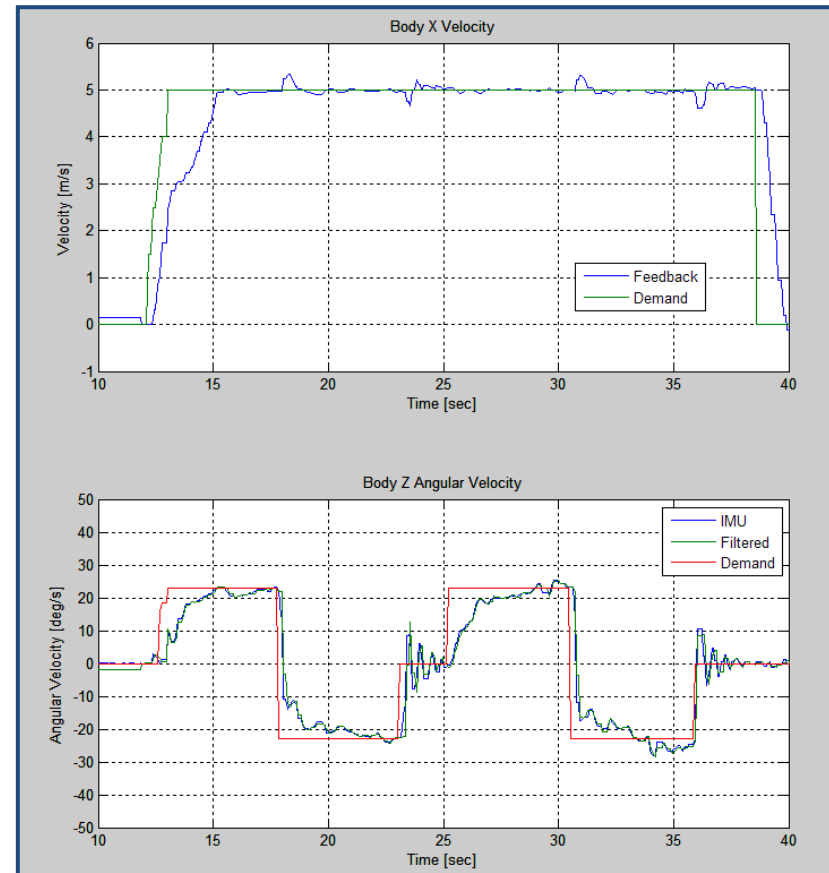
- Create a real-time vehicle controller that exploits the vehicle's independent drives and adjustable suspension for good high speed, on-road performance as well as low-speed, off road performance.

Goals:

- Stable and controllable under all conditions.
- Handle smooth and discontinuous demands.
- Optimal performance with turning prioritized higher than velocity control.
- Robust to external disturbances.
- Terrain surface friction estimation.
- Adaptive control system.
- Built-in near roll-over detection and compensation.
- Failsafe operation in case of sensor malfunction.

Approach:

- Develop detailed models in physics based simulation program.
- Calibrate models with existing vehicle data.
- Develop controller and convert to C-code
- Create automated test routines within physics based simulation program.



Velocity and Yaw Command Tracking

Objective:

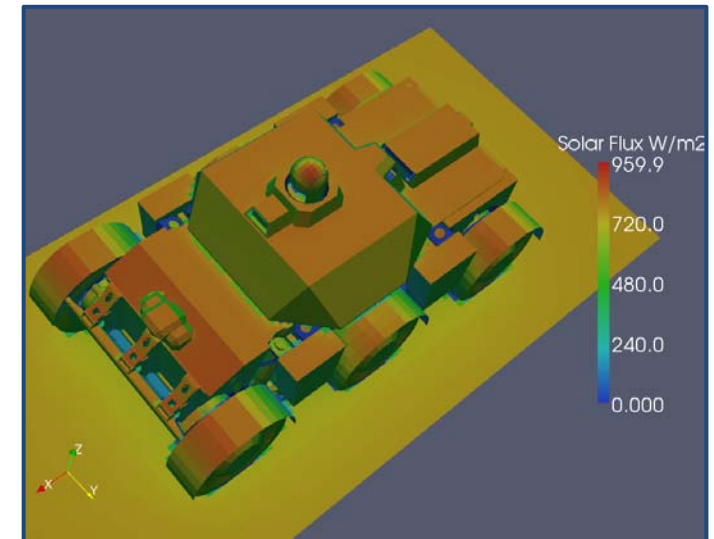
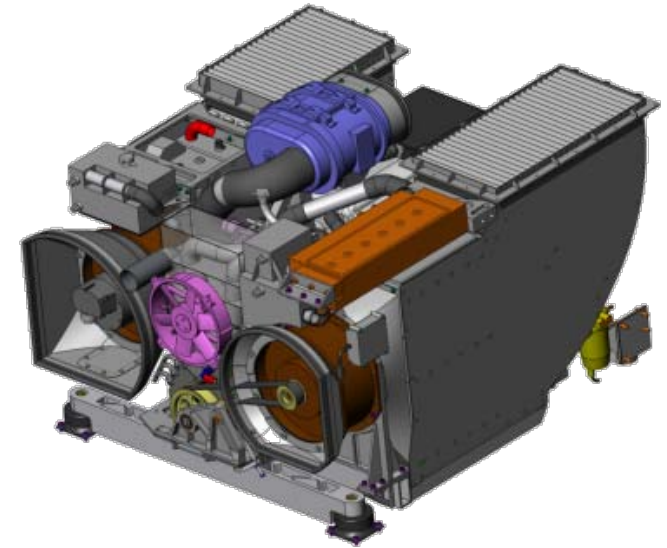
- Reliably operate APD in high thermal environments

Goals:

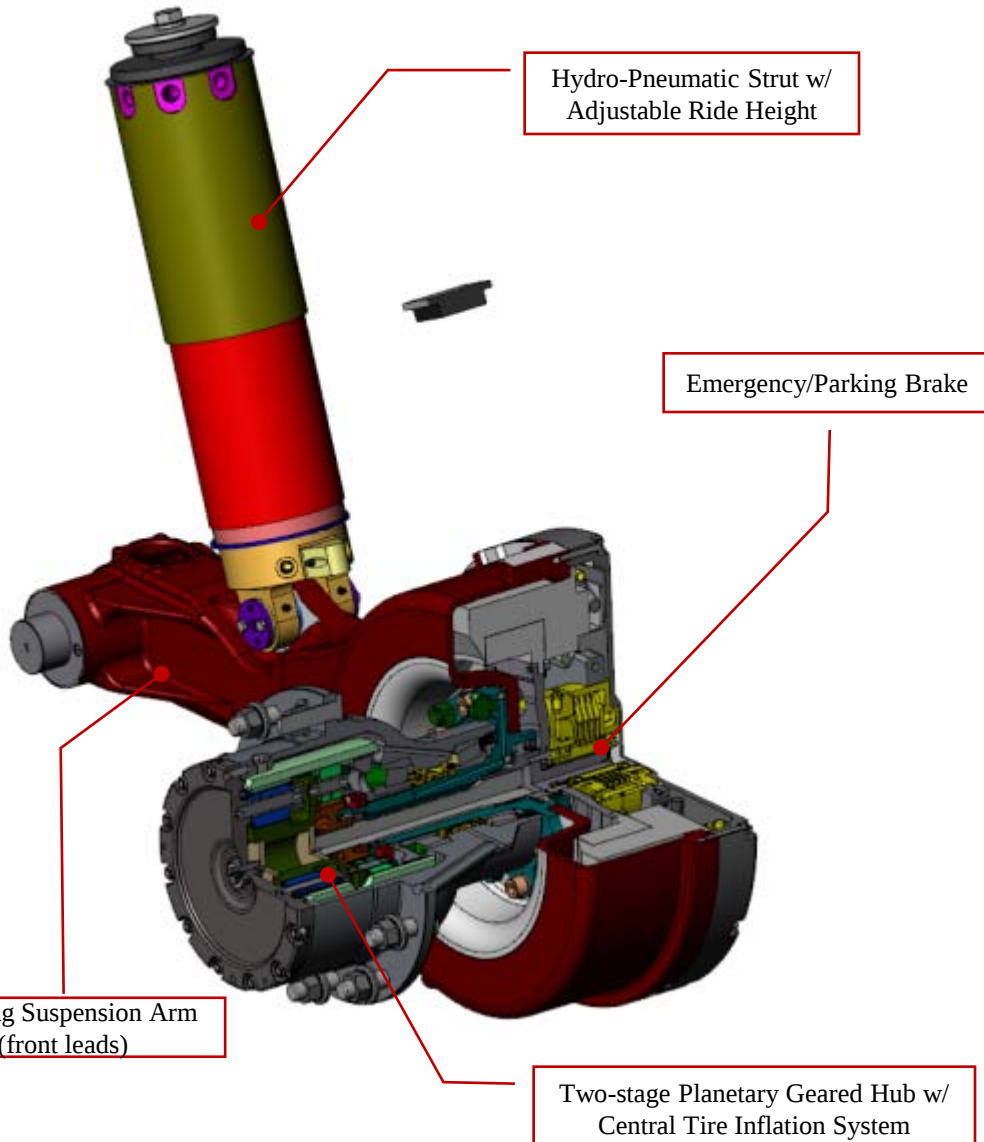
- Provide enough cooling to operate at 80 kph in 45°C
- Provide cooling for ancillary payloads as well
- Minimize volume and weight of cooling system

Approach:

- Minimize cooling loops on the vehicle
- Re-rate components on vehicle to meet lower loop count
- Dual heat exchanger paths to split cooling load
- Model the thermal load using CFD and Solar loading
- Test components early in APD System Integration Lab
- Conduct thermal load test of vehicle in a Chassis Dynamometer Cell



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Fully enclosed, sound-proof engine cell
Provides safe, full power (190kW) testing of engine-generator stack

High Voltage and Low Voltage component rack
All motor, generator, & brake shunt controllers; DCDC converters

Back to Back – Motor & Hub test stands
Provides safe, full power testing of motors/hubs

Power Processing System
Provides source/sink backbone for SIL

Battery Test Cell
Provides safe, heavy load testing of batteries

Insulated, Thermal Chamber
Provides safe room for 45C full load powerpack testing



450kW Dry Cooler
Provides full cooling for engine and all hybrid components

150kW Load Resistor
Provides easy sink for 750V excess power



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