



AR Propulsion System PWST Needs/Challenges

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AR Propulsion Systems

- AR provides a wide variety of propulsion systems which could benefit from passive wireless sensor technology (PWST)
- This presentation is scoped to PWST needs/challenges specifically for the following types of rockets/motors/engines:
 - ***Solids***
 - ***Liquids***
 - ***Air-breathing Hypersonics***

Solids

- Description: Solid rocket motors (SRMs) generate thrust from burning solid propellants (fuel and oxidizer)
- Applications:
 - **Launch Vehicle**: Solid motors are used to boost a space vehicle from a pad
 - **Missile**: SRMs provide the thrust for strategic and tactical missiles



<http://rocket.com/files/aerojet/images/media/LaunchVehAtlasV.jpg>



<http://www.af.mil/News/Photos.aspx?igphoto=2000760888>



<http://rocket.com/files/aerojet/images/media/TacticalArmyTACMS.jpg>

Solids (cont.)

- PWST Needs/Challenges:
 - Parameter measurement: stress, strain, temperature, humidity, acceleration, deformation (multiple measurement types from a given sensor is a plus)
 - Unique identification capability
 - Auto-ignition avoidance (energetic material compatibility / EMI requirements)
 - Long-term reliability (on the order of 40 to 50 years)
 - Tight repeatability (minimal drift is a must)
 - Robust (especially in terms of temperature and G-shock)
 - Calibrate-able (if embedded)
 - Wireless reader (usable on a strategic missile confined within silo)
 - Light-weight (grams) and small (minimal impact to assembly/performance)

BOTTOM LINE: Need to define **system readiness** via **propellant/liner/insulation system health status** (pre-flight focused)

Liquids

- Description: Liquid rockets generate thrust from burning liquefied propellants (fuel and oxidizer)
- Applications:
 - **Launch Vehicle**: Liquid rockets are used to boost a space vehicle from a pad, as well as for maneuvering it in space



http://rocket.com/files/aerojet/images/media/spaceshuttlemain1_0.jpg



cp0046 15 NSS 2015 RL10 engine

Liquids (cont.)

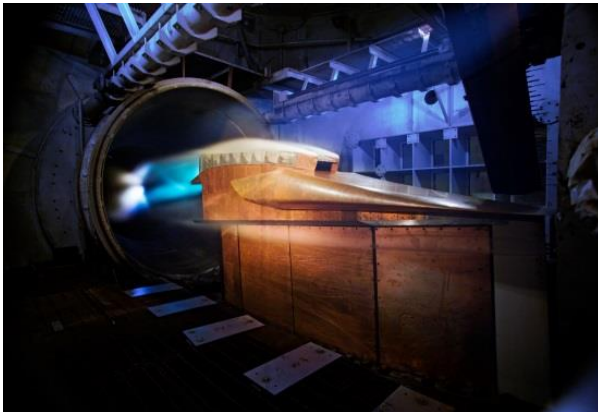
- PWST Needs/Challenges:

- Parameter measurement: speed (pump), temperature, pressure, flow, acceleration, position (multiple measurement types from a given sensor is a plus)
- Unique identification capability
- Tight repeatability
- Robust (especially in terms of cryogenic-to-high-temperature thermal shock)
- Smart / local processing with data validation and calibration capabilities
- High-speed processing capability (on the order of milliseconds for operational control)
- Reusability

BOTTOM LINE: Need to define **propulsion system capability** via **overall system health status** (pre-flight, flight, and post-flight)

Air-breathing Hypersonics

- Description: Hypersonic engines generate thrust from burning fuel using external ram-air (oxidizer)
- Applications:
 - **Cruise Vehicle**: Hypersonic engines provide the thrust for cruise vehicles
 - **Missile**: Hypersonic engines provide the thrust for missiles



<http://rocket.com/files/aerojet/images/media/hypersonics1.jpg>



<http://rocket.com/files/aerojet/images/media/hypersonics2.jpg>

Air-breathing Hypersonics (cont.)

- PWST Needs/Challenges:

- Parameter measurement: position (shock-train; actuator), speed (pump), temperature, pressure, flow, acceleration (multiple measurement types from a given sensor is a plus)
- Unique identification capability
- Tight repeatability
- Robust (especially in terms of high-temperature)
- Smart / local processing with data validation and calibration capabilities
- High-speed processing capability (on the order of milliseconds for operational control)
- Reusability

BOTTOM LINE: Need to define **propulsion system capability** via **overall system health status** (pre-flight, flight, and post-flight)

Summary

AR Propulsion System PWST Needs/Challenges							
	Parameter Measurements				<ul style="list-style-type: none"> - Robust - Tight repeatability - Unique ID 	<ul style="list-style-type: none"> - High-speed - Reusable - Smart 	<ul style="list-style-type: none"> - Auto-ignition avoidance - Calibrate-able - Light-weight & small - Long term reliability - Wireless reader
	<ul style="list-style-type: none"> - Acceleration - Temperature 	<ul style="list-style-type: none"> - Flow - Position (actuator) - Pressure - Speed (pump) 	<ul style="list-style-type: none"> - Deformation - Humidity - Strain - Stress 	<ul style="list-style-type: none"> - Position (shock wave) 			
Solids	X		X		X		X
Liquids	X	X			X	X	
Hypersonics	X	X		X	X	X	

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