Ascendant
Engineering Solutions

M4 Weapon Shock Simulator (WSS)

National Defense Industrial Association
Joint Armaments Conference & Exhibition

Small Arms – Training Modeling and Simulation
17 May 2012

WSS Needs / Benefits

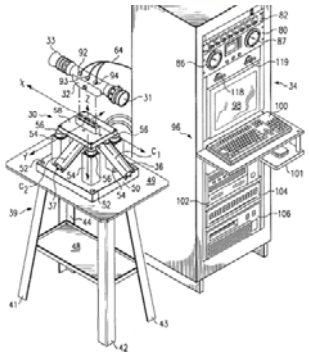
- Small Arms transitioning from Weapons to Weapon Systems
  - Not merely optics - more and more electronics
  - Electronics prone to failure from weapon shocks with peak levels of several thousand G's

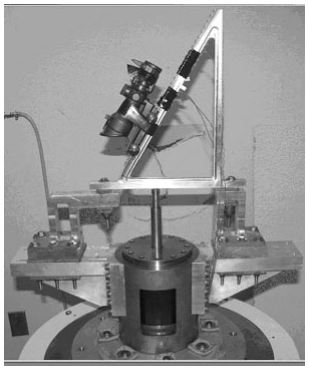
- Engineering evaluation
  - Enables quick in-house testing
  - Significantly reduces test cycle time / cost

- Production lot testing
  - Implemented for Thermal Weapon Sight (TWS) Program – U S Government production contracts - BAE Systems, DRS Technologies, Raytheon
  - Contractual requirement to conduct periodic lot testing by live-fire
  - AES WSS is the only system allowed by US Government to replace live-fire testing

Existing Shock Simulation Technologies and Limitations

- Different techniques have been employed in previous attempts to reproduce weapon shock:
  - Pneumatic drop shock machines
  - HALT/HASS impact-type machines – similar to Raytheon approach – “Weapon Fire Simulation System and Method,” US Patent 6,634,209 B1
  - Shock amplifiers used on electrodynamic shaker

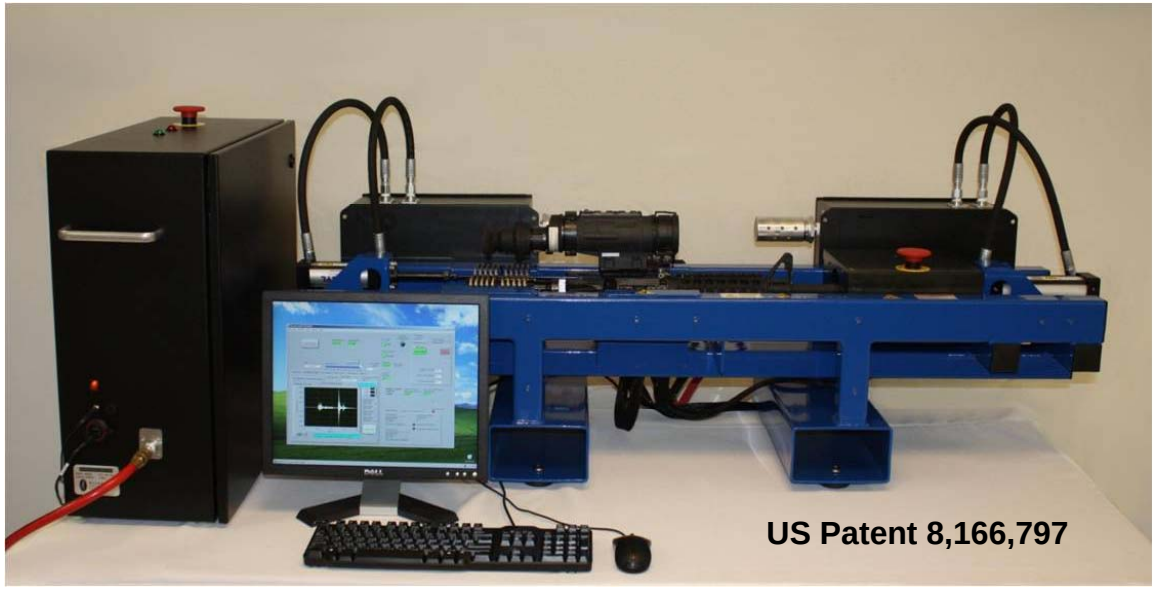




- All of the previous approaches have some or all of these short comings:
  - Poor reproduction of the unique weapon shock time history and/or shock response spectrum (SRS) in all three axes – over or under testing
  - Poor reproduction of weapon mount stiffness and reflected mass / inertia
  - These systems impart an acceleration / shock in G’s, not the impulse force on the weapon from the pyrotechnic event, and the bolt closure impact which can also be significant
  - Low productivity (firing rate)
  - Unable to test over Mil-Spec temperature ranges

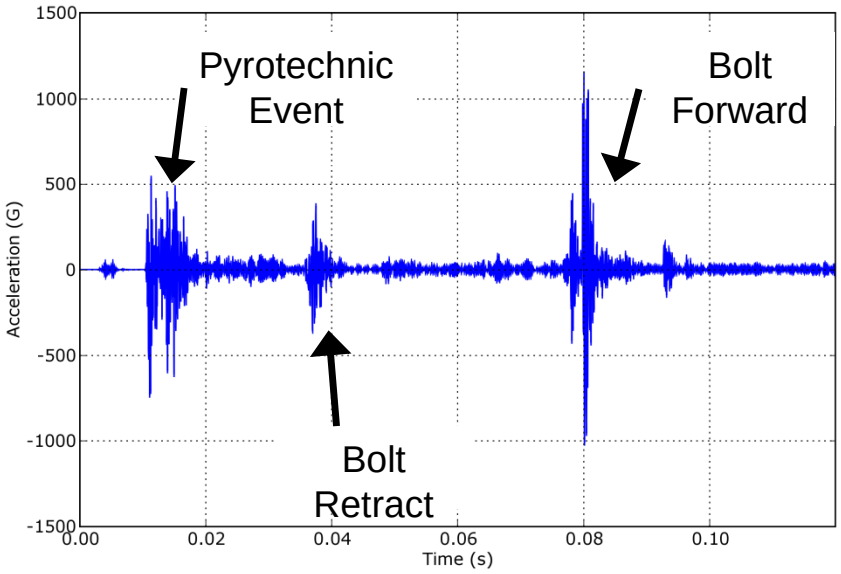
AES Approach

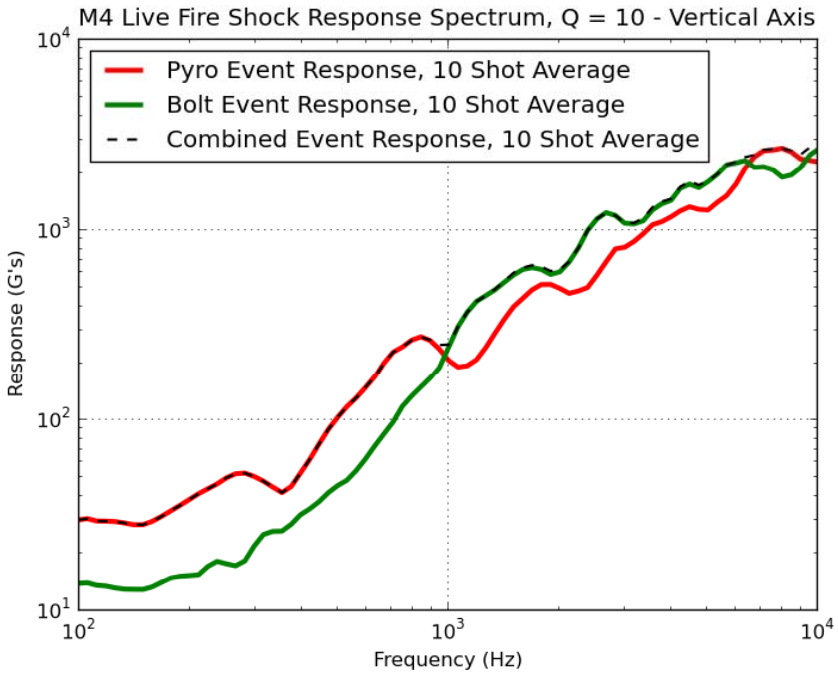
- Investigate the cause for each section of the actual weapon shock
- Reproduce both the shock time history and shock response spectrum (SRS) simultaneously in all three axes
- Reproduce the shock using components of an actual M4 / M16 / AR15 class of weapon to best simulate the reflected stiffness and mass
- Support the weapon components with mounts that simulate the actual stiffness and damping of a soldier firing the weapon
- Automate the process as a piece of high productivity, stand-alone test equipment



US Patent 8,166,797

Typical M4 Live-fire Shock Time History and SRS

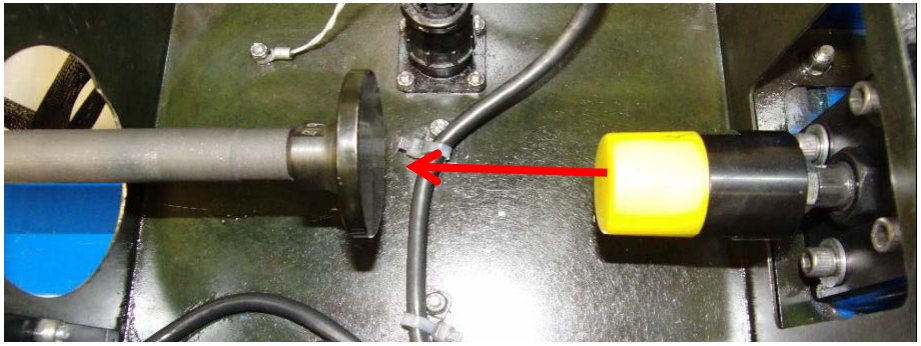




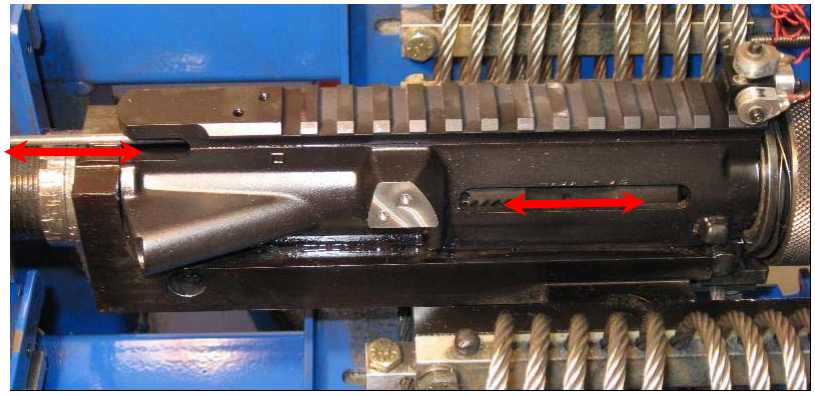
- In some cases, bolt closure SRS exceeds pyro SRS at higher frequencies
- In all cases, bolt closure shock levels are significant and cannot be ignored

Shock Duplication Approach

- Pyro event shock duplicated with manual muzzle impact
  - Optimized mass, velocity and resilience/stiffness of impact head



- Bolt closure shock duplicated with manual bolt actuation
  - AES enhanced the mechanism to better simulate the slight difference between chambering a round and a “dry” bolt closure impact



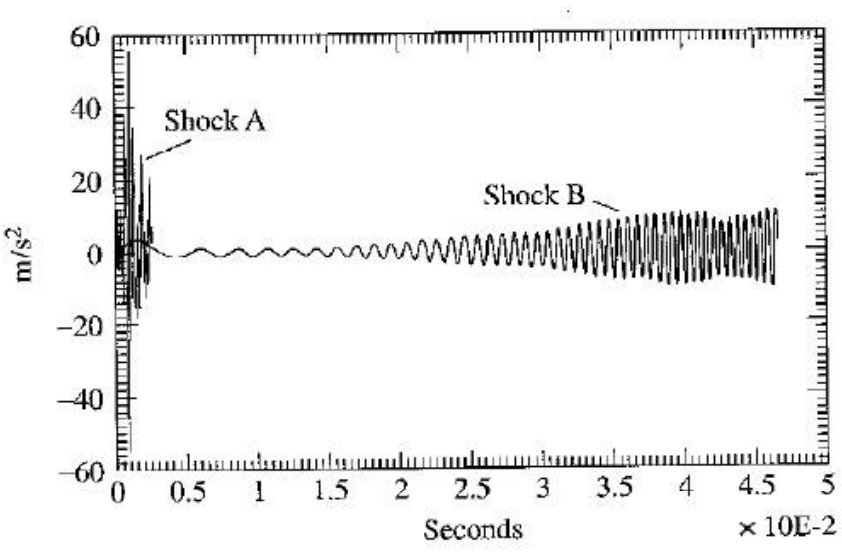
WSS Operation Video (30 FPS)

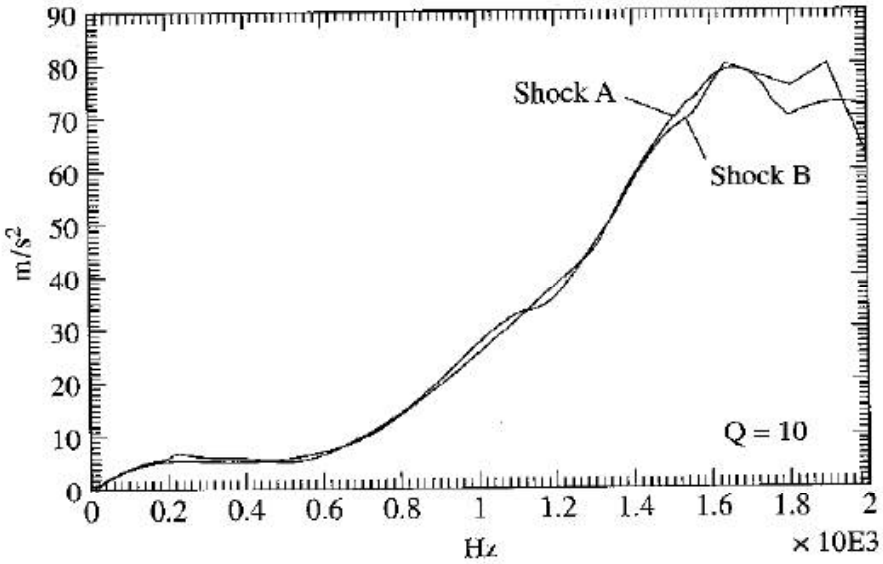
WSS Video

Side-by-side high speed video of AR15 Carbine live fire and WSS prototype

Important / Critical WSS Attributes: Just Matching SRS is Insufficient

- Significantly different shock profiles can produce the same SRS
  - Example from Vibration and Shock Handbook, CRC Press, Clarence de Silva

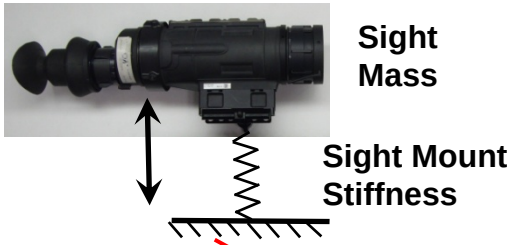




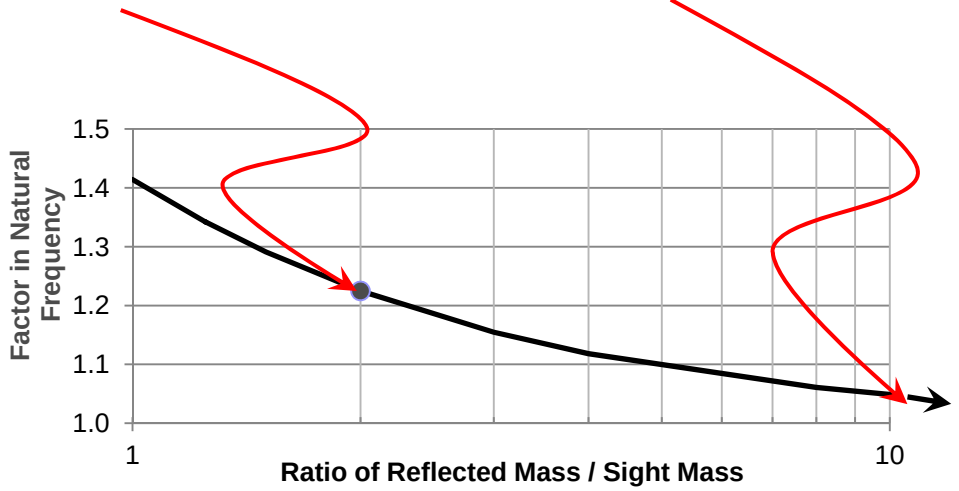
- A nonlinear system will respond very differently to these two shocks
- Examples of typical nonlinearities include such things as gap closures - battery spring contacts, electrical connectors; O-ring seal (nonlinear load-deflection); bolted joint / covers

Important / Critical WSS Attributes: Matching Reflected Mass / Stiffness of Weapon

- Simple analogy of sight on weapon as mass / spring system:

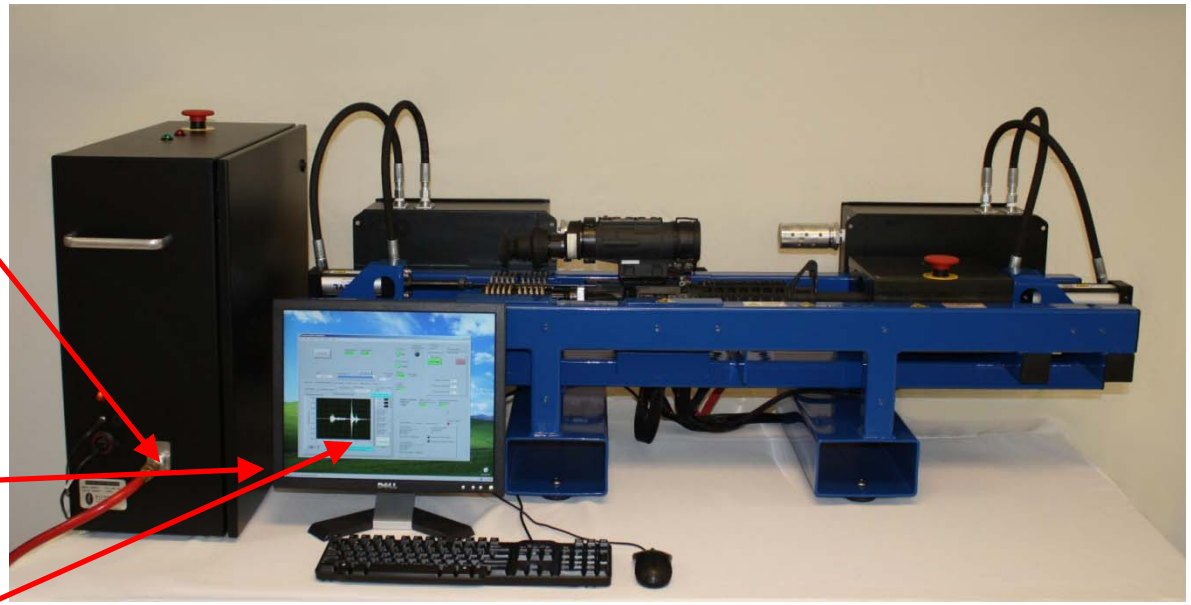


- Natural frequency on weapon would be ~25% higher than if sight were fastened to heavy fixture
- Testing on rigid fixture (ratio >>10) would not result in accurate natural frequencies



WSS Product Features / Attributes

- System requires no significant facilities infrastructure - operates on 110V AC and shop air
- Portable - small footprint (5’ X 1.5’ X 1.5’) and lightweight (< 200 lb)
- Simple UI – minimal training to operate/repair
- Process monitoring to ensure accurate shock time history and SRS reproduction
- Ability to test / evaluate virtually any M4 accessory mounted on receiver or RAS

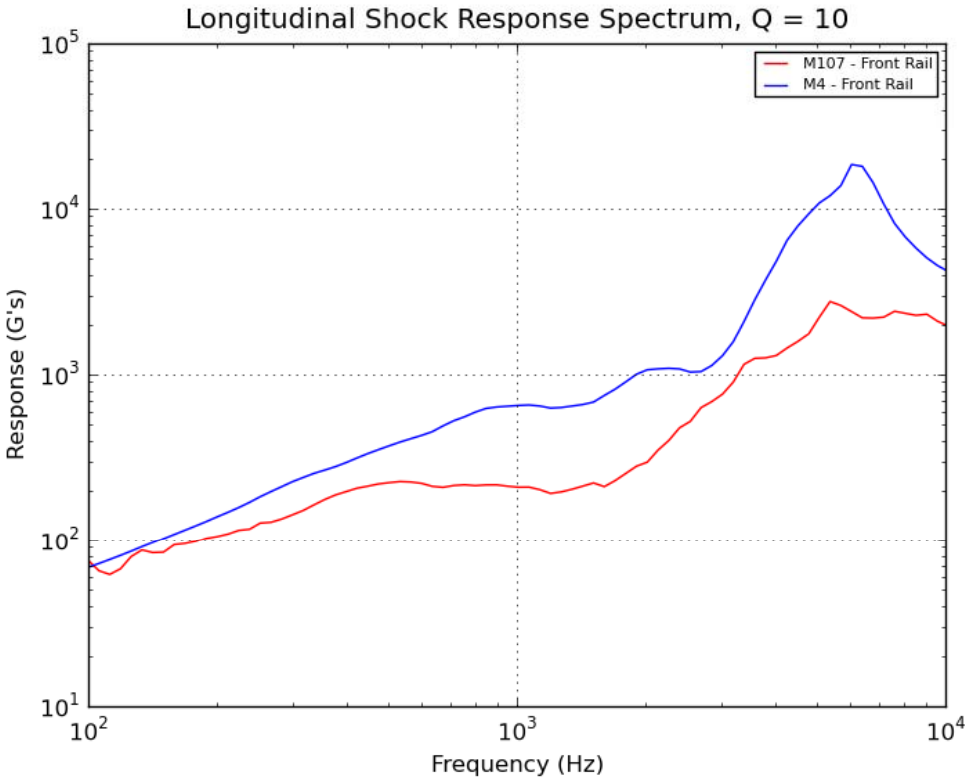


WSS Product Features / Attributes

- Built In Test (BIT) to replaceable module level
- Minimal scheduled maintenance
- Operates in environmental chamber over Mil Spec temperature ranges
- Sustained rate of 300 shots per minute

WSS and Future Opportunities

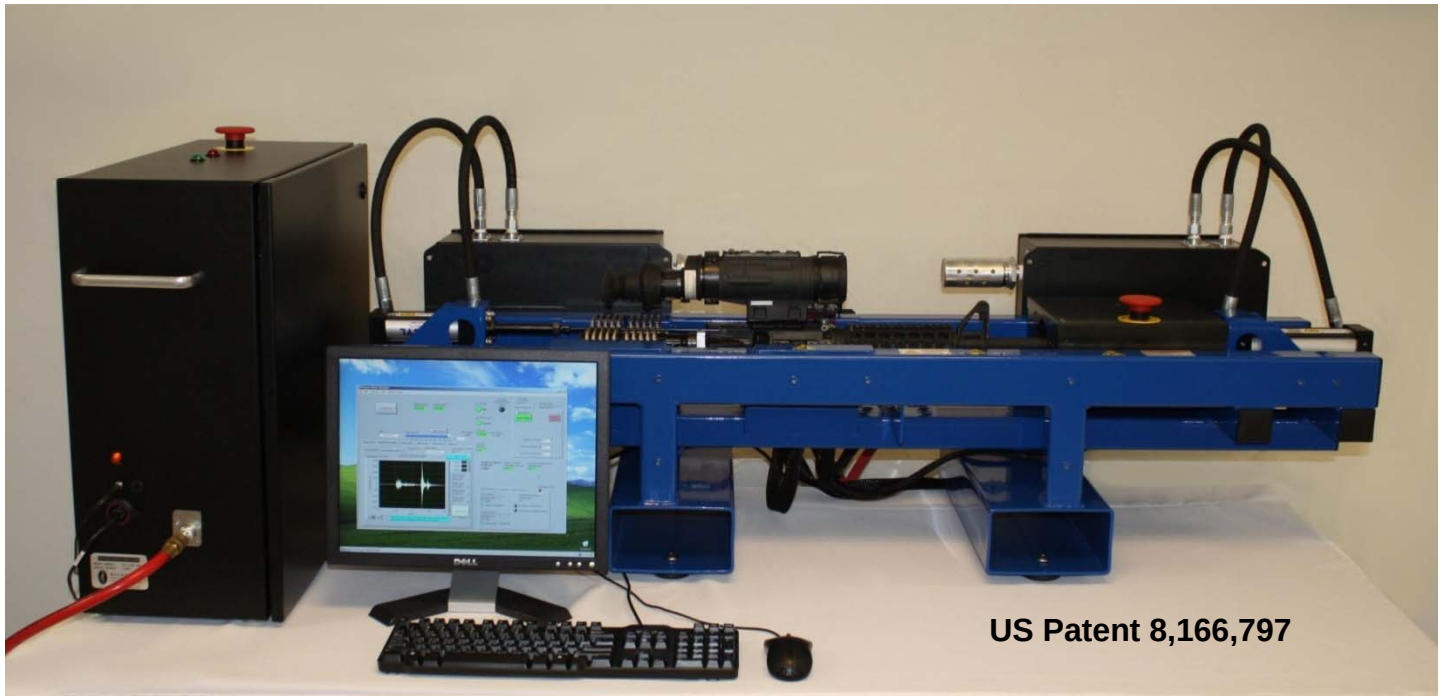
- AES or its defense customers have measured weapon shocks on a number of weapon systems in addition to the M4
  - M107, M110, M203 (on M4), M240B, M249, Mk19
- Except for the M110 and M203 (mounted under M4), the M4 has the most severe weapon shocks - probably due to the low weight of the upper receiver / barrel – larger bore M107 SRS comparison



- With this in mind, weapon accessories verified on WSS will essentially be pre-verified for many other weapon systems

WSS Product Status

- US Government report “ANALYSIS OF LIVEFIRE VERSUS RIFLE SHOCK SIMULATOR DATA,” by Ronald G. Merritt, NAWCWD, China Lake, CA, March 31, 2011
  - Provided substantiation for using WSS in place of live-fire for testing TWS
  - US Army procured WSS for testing at their White Sands Missile Range test facility
- AES currently supporting WSS units procured by multiple defense customers approved for use by US Army to replace live-fire testing
- Commercial sector acquired WSS for evaluating weapon / sighting system



WSS and Future Opportunities

- AES responded to MARCORSYSCOM, RFI " Small Arms Weapon Shock Simulator" - Solicitation M67854-11-I-1086 in September 2011
  - Develop a WSS to simulate weapon shock for 19 small arms from M9 A1, 9mm pistol to MK19, 40mm Machine Gun
  - AES submitted response / proposal approach for modular WSS capable of with simulating weapon shock
- AES open to opportunities to develop customized solutions for simulating unique shock from weapon systems
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