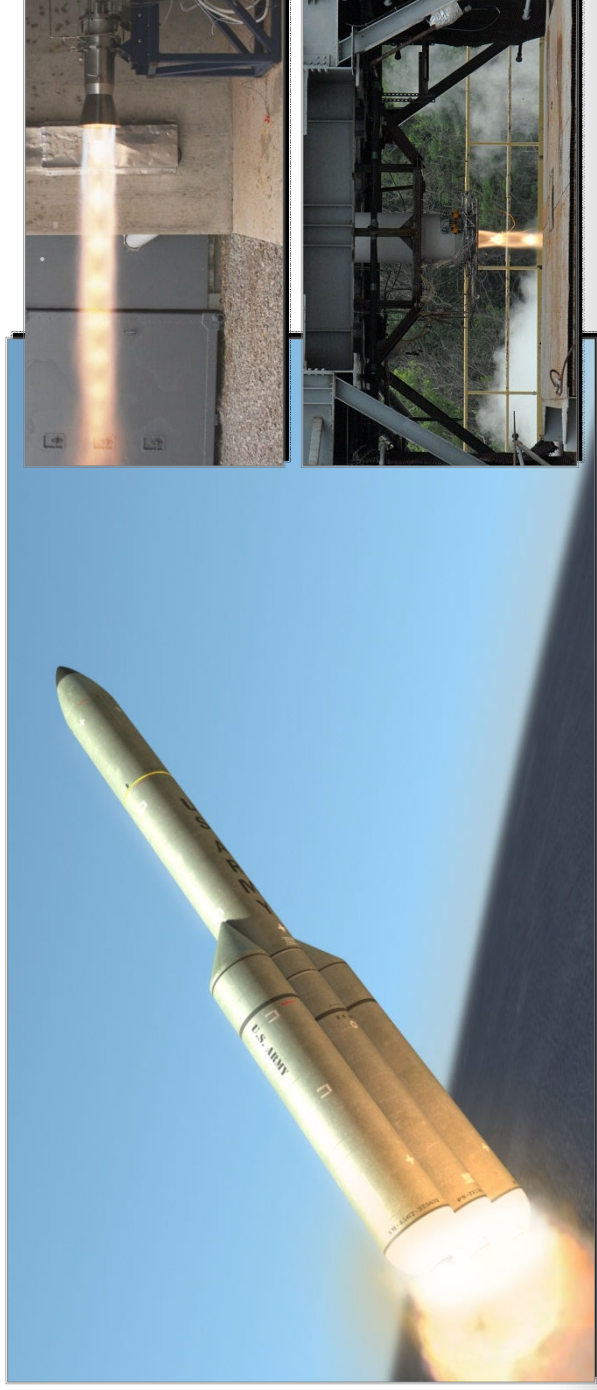


Multi-Purpose NanoMissile System (MNMS) Overview and Future

by
Tim Pickens

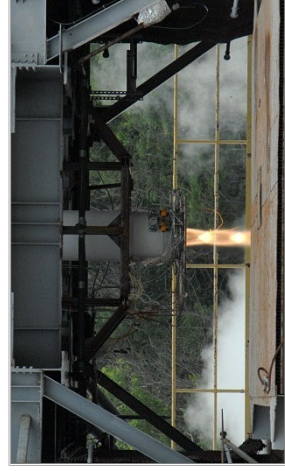
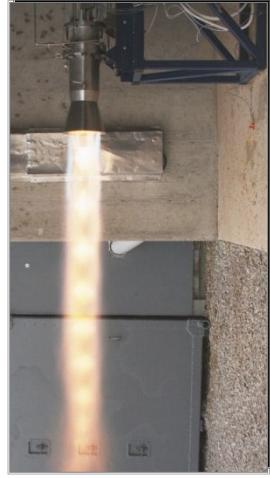
October 26, 2011



MNMS History

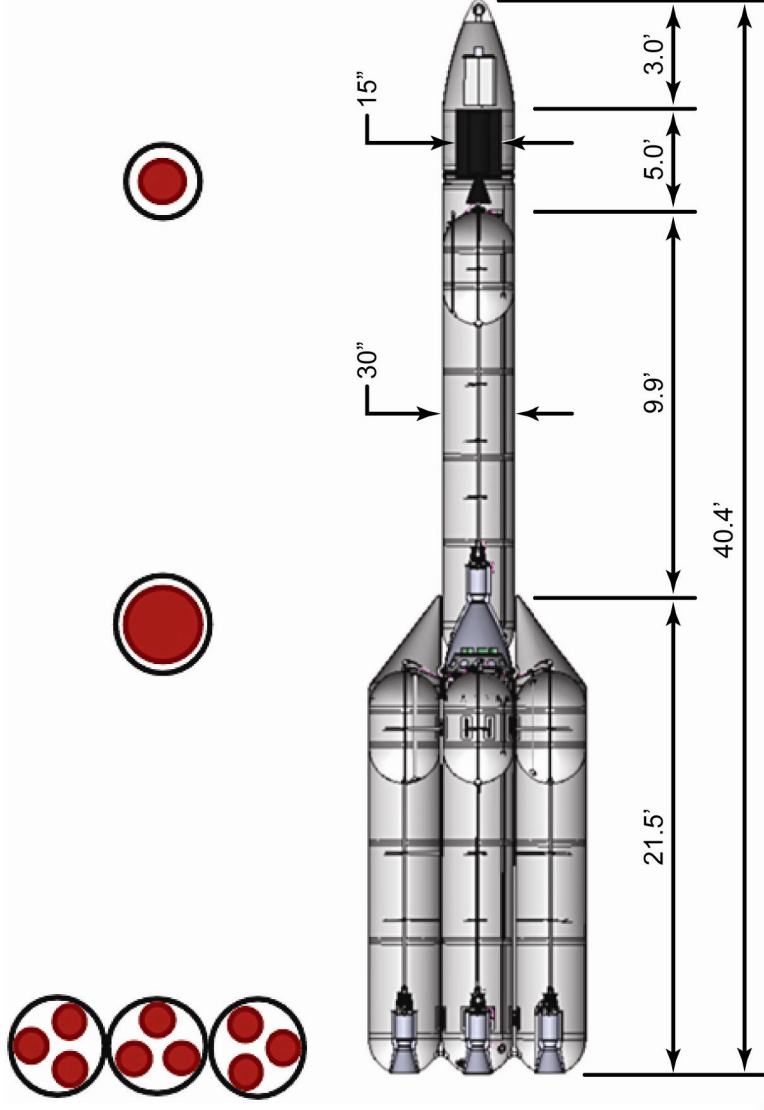
- **Previously demonstrated Multi-Purpose NanoMissile System (MNMS)**
 - ◆ Low cost, responsive with utilization of COTS technology
 - ◆ Designed to deliver 10-kg payload to 450-km orbit
 - ◆ Used environmentally responsible, inexpensive, highly available propellants (nitrous oxide-ethane)
 - ◆ Successfully demonstrated 3,000-lbs thrust booster in a 60-sec static fire

- **Easily adaptable building block approach to increase payload weight and orbital altitudes**



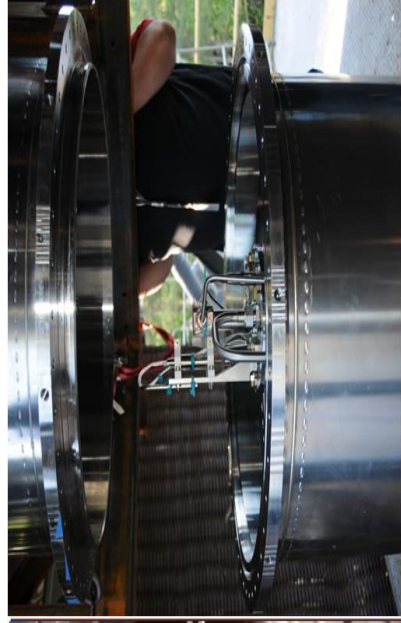
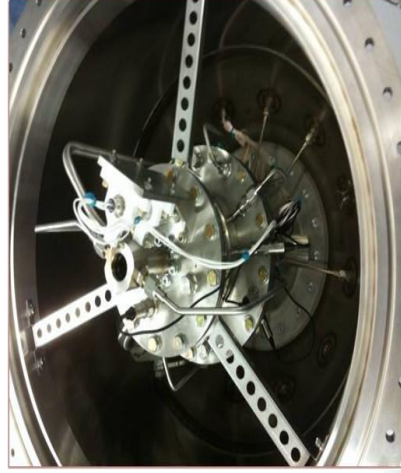
MNMS/SWORDS Vehicle Design 10-25 kg to LEO

- The **SWORDS** vehicle design is based on MNMS design
 - ♦ MNMS engines on first and second stage
 - ♦ Restartable peroxide/kerosene 3rd stage
 - ♦ Same stainless steel tank design as MNMS for 1st and second stages
 - ♦ Entire vehicle can be shipped assemble on semi-truck trailer



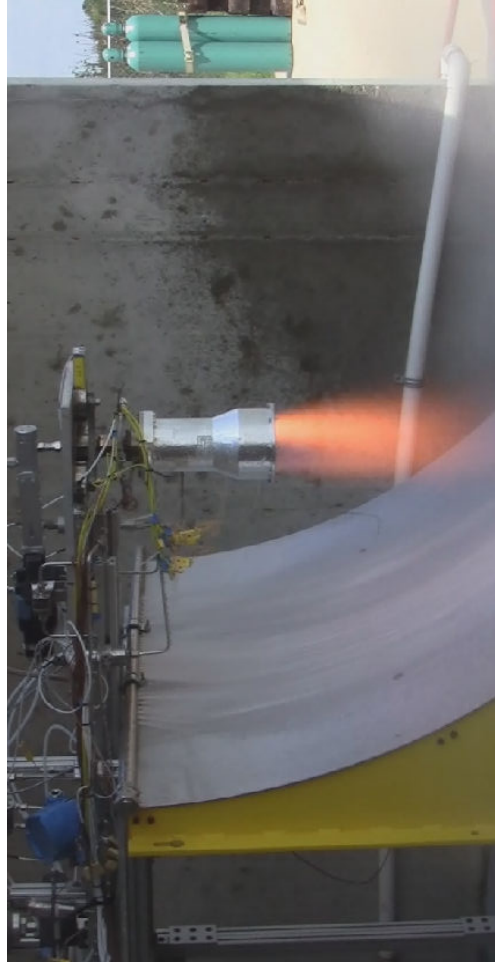
First and Second Stage Design

- **First Stage and second stage design is similar to demonstrated MNMS design:**
 - ◆ **First stage**
 - Uses 3 demonstrated 3000-lbf MNMS engines
 - 30” diameter vs. 24” diameter MNMS
 - Demonstrated laser welded stainless steel construction
 - VaPak self pressurization using nitrous oxide and ethane
 - ◆ **Second stage:**
 - Single engine with stainless steel tanks
 - Same injector and chamber as 1st stage with larger expansion nozzle



Third Stage Design

- **Design based on WGTA and Google X PRIZE engine designs**
 - ◆ **90% peroxide/kerosene (non-toxic storable propellants)**
 - ◆ **Maintains catalyst pack for ignition and performance**
 - ◆ **Scaled up Google X PRIZE engine design**
 - ◆ **Preliminary sizing shows 80% mass fraction achievable.**
 - ◆ **Avionics mass included**
 - ◆ **Constant pressure helium pressurization system**
 - ◆ **Initial Stage vacuum T/W of 1.3**

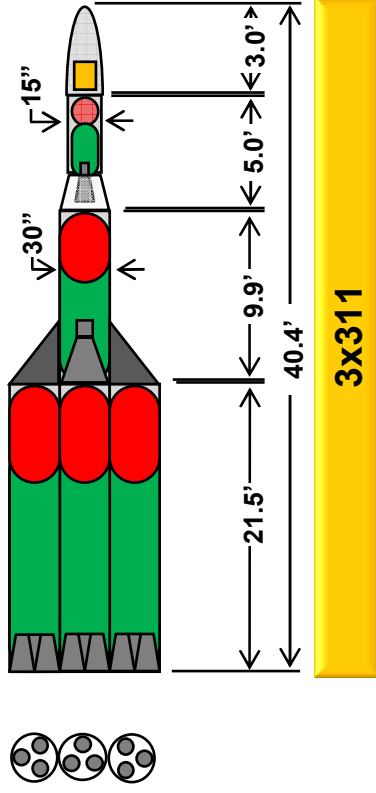
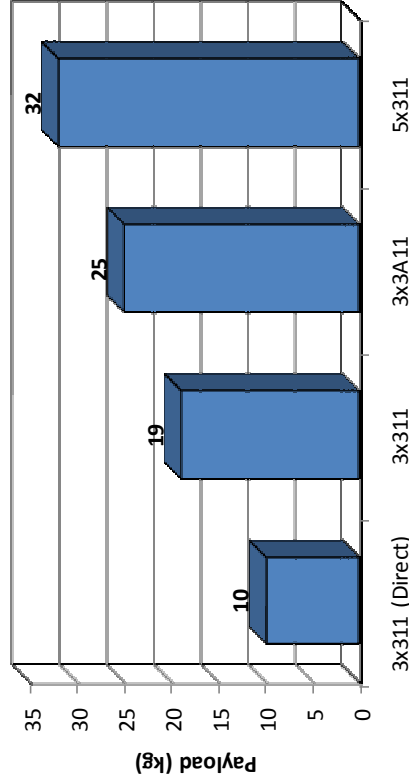


Vehicle Configuration Growth Path

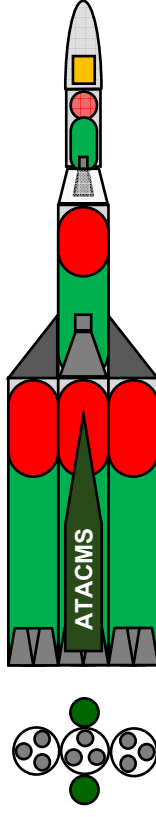
- Configuration has performance growth potential by using ATACMS or additional 1st stage boosters

Table and Chart of Payload to 750 km Circular Orbit

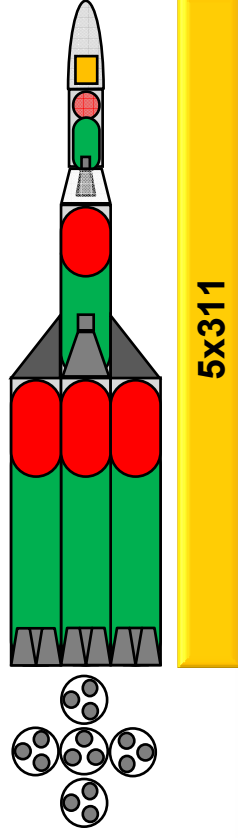
Vehicle	Payload (kg)	GLOW (lbm)	Mission Profile
3x311 (Direct)	10	20,100	Direct
3x311	19	20,100	Restart
3x3A11	25	24,200	Restart
5x311	32	32,000	Restart



3x311



3x3A11



5x311

Propulsion System

▪ Propulsion system engine performance:

	1st Stage	2nd Stage	3rd Stage
Fuel	Ethane	Ethane	Kerosene
Oxidizer	Nitrous Oxide	Nitrous Oxide	Peroxide (90%)
Total Ignition Thrust (lbf)	26,344 (sl)	4,322 (vac)	244 (vac)
Vacuum Isp (sec)	249.2	286.5	280
Number of Engines	9	1	1

- ◆ 1st and 2nd stage performance based on propulsion system testing for MNMS
- VaPak blow-down effect (regressive) for 1st and 2nd stage engines
- ◆ For peroxide/kerosene, assumed:
 - Initial Stage vacuum T/W of 1.3 (not including payload mass)
 - Vacuum thrust is constant
 - Assumes constant pressure feed system