



**MAKING SPACE TRANSPORTATION
SAFE, RELIABLE, AND AFFORDABLE**



PROBLEMS WITH CURRENT ROCKET ENGINES

ROCKET ENGINES ARE EXPENSIVE

- Developing a new engine can cost hundreds of millions of dollars and take 5-7 years



ROCKET ENGINES ARE DANGEROUS

- Solid Rocket motors and liquid bi-propellant engines can and do accidentally detonate
- Traditional rocket engines require upwards of a thousand parts, which increases the probability of something going wrong

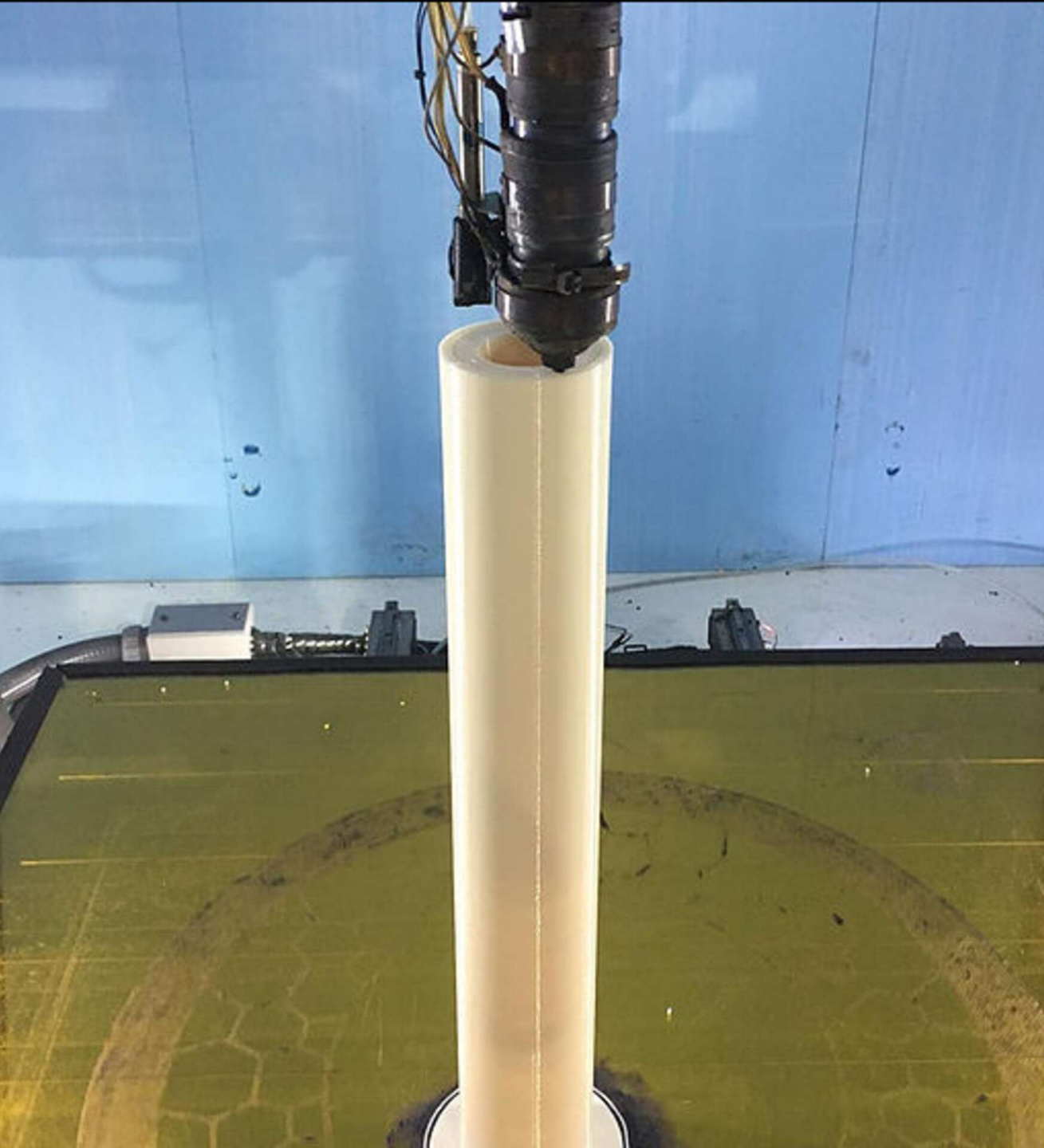




12 Part Engine



3D Printed Fuel



- 95%** - Acrylonitrile Butadiene Styrene Thermoplastic
- 5%** - Nano Aluminum Powder



High Maintenance



Flies Coach

ADVANTAGES OF FIREHAWK'S 3D PRINTED FUEL

- Will not accidentally detonate
- Is environmentally benign
- Has unlimited scalability
- Is ready to go within hours of being manufactured
- Can be pre-stored for long periods of time
- Comparable performance to a liquid bi-propellant engine
- Can be composed using local resources on the Moon



ADVANTAGES OF A 12 PART FIREHAWK ROCKET ENGINE

01

Can be designed
and built in less
than a year

02

Is 20% the cost
of competitors'
engines

03

Can be custom
tailored to a
broad-range of
civil and defense
applications

04

They can be mass
produced using
robotics

05

Is capable of
being refueled on
the Moon or Mars
using local
resources



Currently Hybrid Rocket Engines use cast-molded HTPB synthetic rubber fuels, which does not compete with Firehawk's 3D Ultra Hybrid Fuel.

HTPB

Firehawk-3D Ultra

	HTPB	Firehawk-3D Ultra
Regression Rate	Low - averages 1.0 mm/sec.	High - averages 3.0 mm/sec. TM
Vibration	High Vibration	Minimal Vibration
Ability to use aluminum nano-particle additives	No – processing temperature exceeds nano-particle ignition temperature	Yes - our proprietary nanocomposite aluminum additive greatly increases engine performance
Thrust Profile Reliability	Poor – Lacks clustering abilities	High – can cluster engines
Unlimited Thrust Scale	No	Yes – our engines can be upscaled to 100,000 lbf thrust or even higher
Specific Impulse > 300	No - 260 to 280 sec. vac.	Yes – 300 to 340 sec. vac.
Run-to-run thrust profile	Averages 87%	Averages 97.5%
Residual Fuel Fuel Loss	High remainder fuel and excessive fuel loss	Less than 2% remainder & negligible fuel loss

Use of Funds

Armstrong 5K Development	Unit Cost (1,000's)	Phase 1	Phase 2	Phase 2	Phase 4
Engineering Labor	\$255	\$30	\$55	\$85	\$85
Engine Production	\$90	\$0	\$90	\$0	\$0
Oxidizer System Production	\$87	\$0	\$87	\$0	\$0
Fuel Grains	\$115	\$0	\$43.12 (3)	\$71.8(5)	\$0
Technical Labor	\$47	\$0	\$16	\$16	\$15
Engine Tests	\$120	\$0	\$30	\$20	\$70
General Administration	\$235	\$30	\$70	\$80	\$55
Total	\$949	\$60	\$391.1	\$272.8	\$225

\$609 BILLION MARKET



Fulfilling Nasa's need for cost effective, safe rocket engines for future projects such as new lunar landers and spacecraft

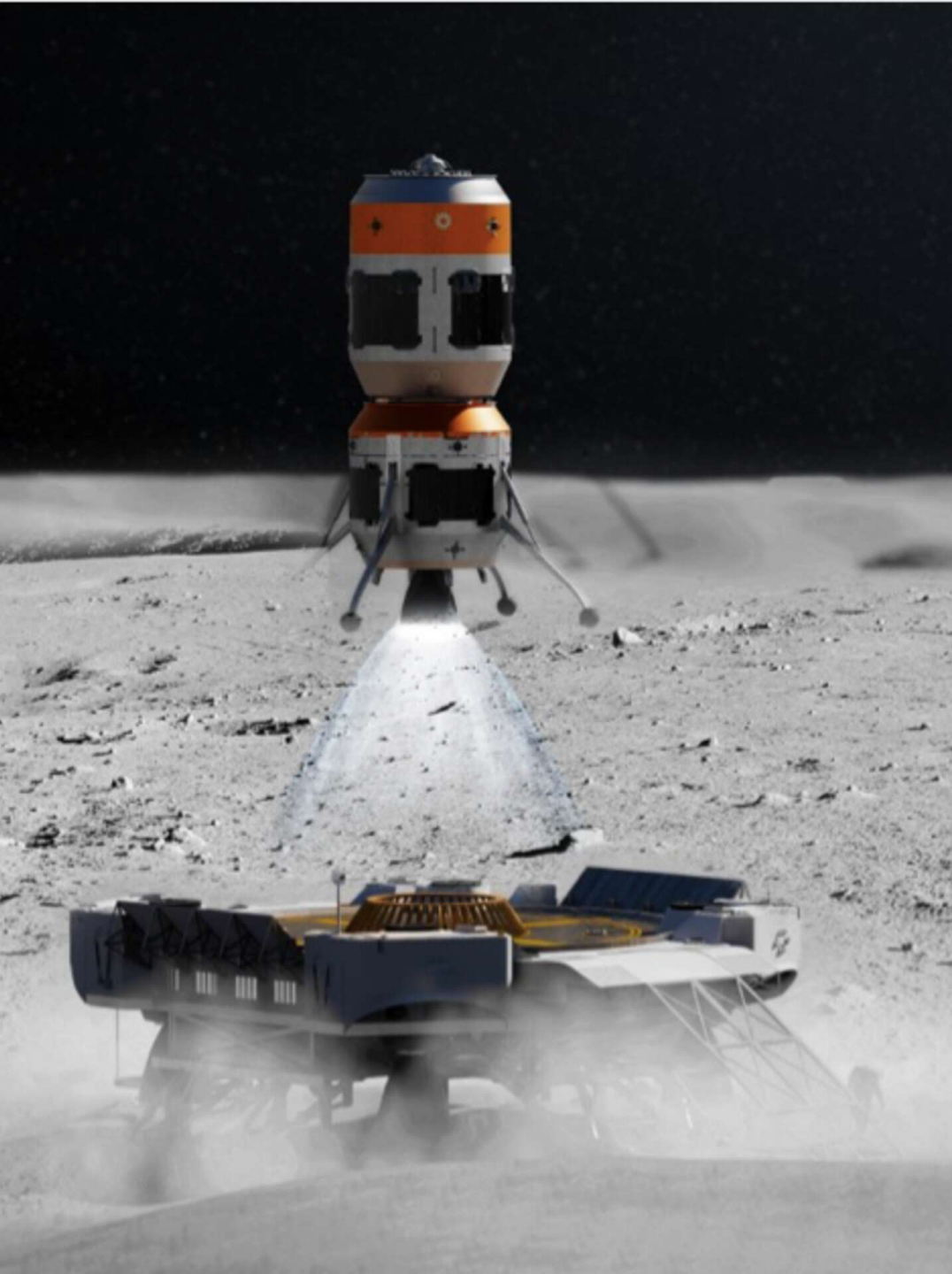


Supplying the commercial market with the safest, most cost-effective rocket engines

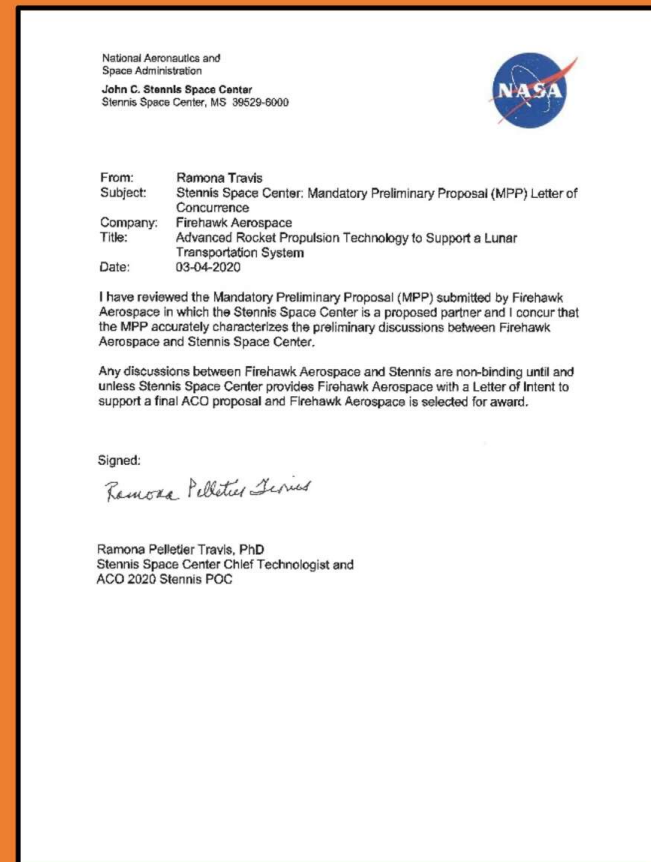


Providing the U.S. Department of Defense with new, safe, reliable engines capable of extending the life of satellites.

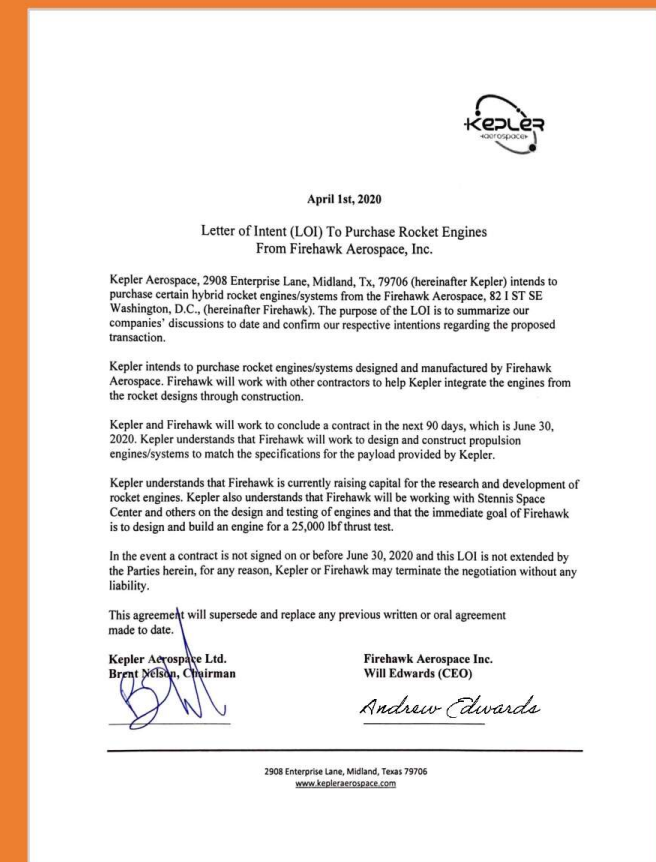




Firehawk has two letters of concurrence to design and test a rocket engine for lunar landers from NASA as well as a letter of intent from a satellite launcher firm to custom design an engine for their launcher.



Stennis
Space Center



Kepler
Aerospace

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Hot-fire engine tests have proved our patented technology works.

5 AWARDED PATENTS

- **U.S. Patent No. 9,453,479:** Solid Fuel Grain for a Hybrid Propulsion System of a Rocket and Method of Manufacturing
- **U.S. Patent Number 9,822,045:** Additive Manufactured Thermoplastic-Aluminum Nanocomposite Hybrid Rocket Fuel Grain and Method of Manufacturing
- **U.S. Patent Number 9,890,091:** Persistent Vortex Generating High Regression Rate Solid Fuel Grain of a Hybrid Rocket Engine and Method of Manufacturing
- **U.S. Patent Number 10,286,599 (Continuation-in-part Patent No. 9,822,045):** Additive Manufactured Thermoplastic-Aluminum Nanocomposite Hybrid Rocket Fuel Grain and Method of Manufacturing
- **U.S. Patent Number 10,309,346 (Continuation-in-part Patent No. 9,890,091):** Persistent Vortex Generating High Regression Rate Solid Fuel Grain for a Hybrid Rocket Engine and Method of Manufacturing



INTELLECTUAL PROPERTY ADVANTAGE

Our fuel grains are backed by five U.S. utility patents providing us a monopoly on:

- The production of hybrid rocket fuel grains using advanced additive manufacturing systems.
- High-regression rate, single port designs that are fuel volume efficient.
- The use of all forms of nano-scale particle size aluminium powder as a fuel additive.

We are the only firm that has a patent on methods to increase combustion residence time and reduce L/D ratio to enable improved fit for missile propulsion.

Founders and Management



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Integrated Launch Solutions



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Thank You

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