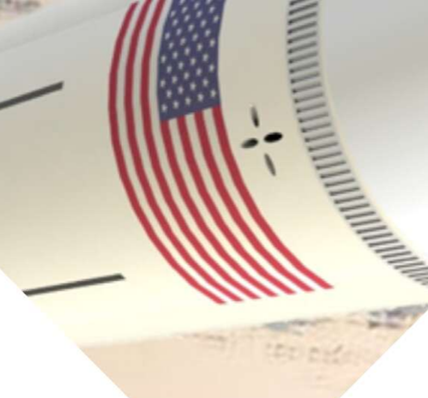


Firehawk

MAKING SPACE TRANSPORTATION SAFE, RELIABLE, AND AFFORDABLE

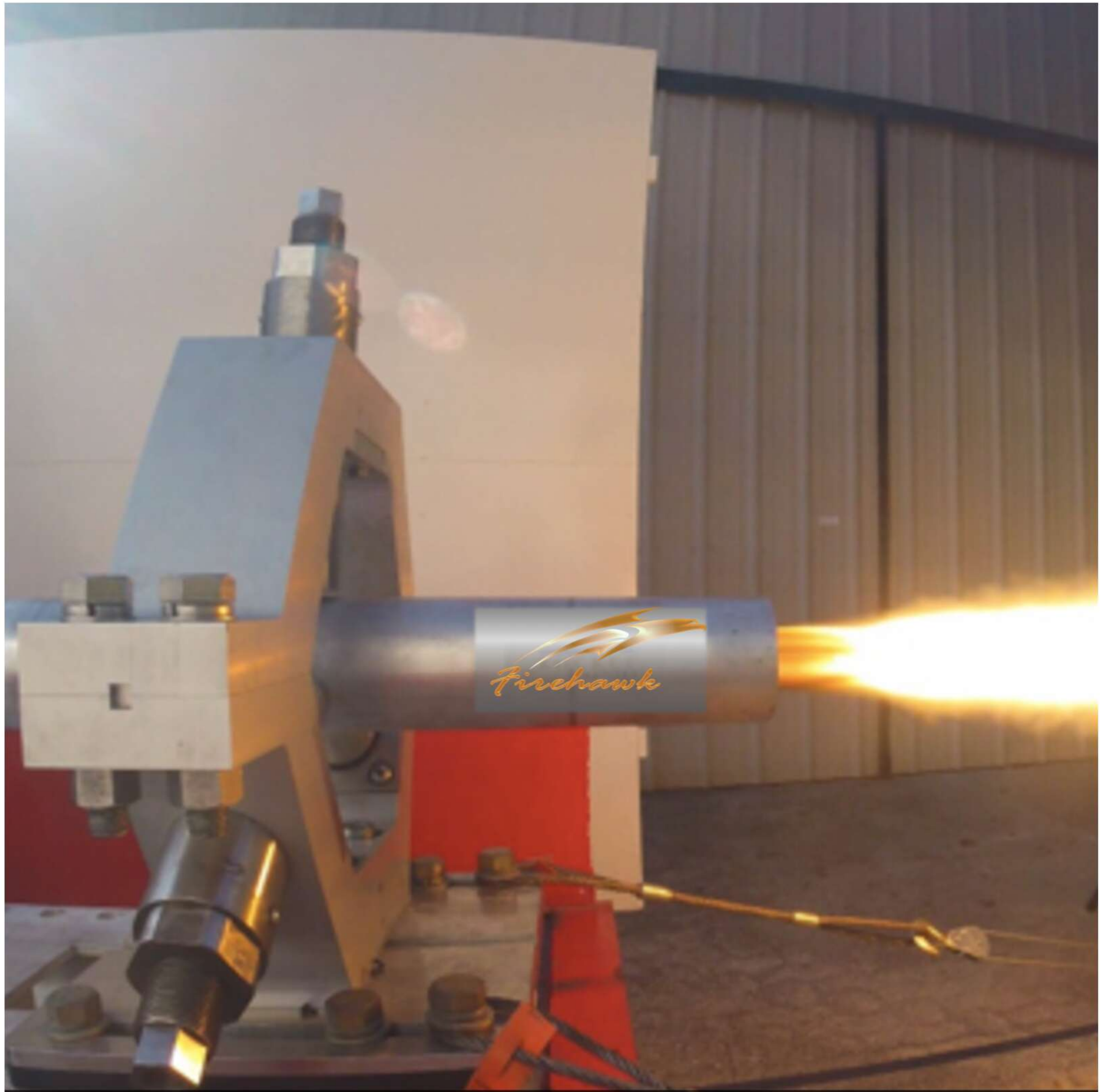
PROBLEMS WITH CURRENT ROCKET ENGINES

ROCKET ENGINES ARE EXPENSIVE

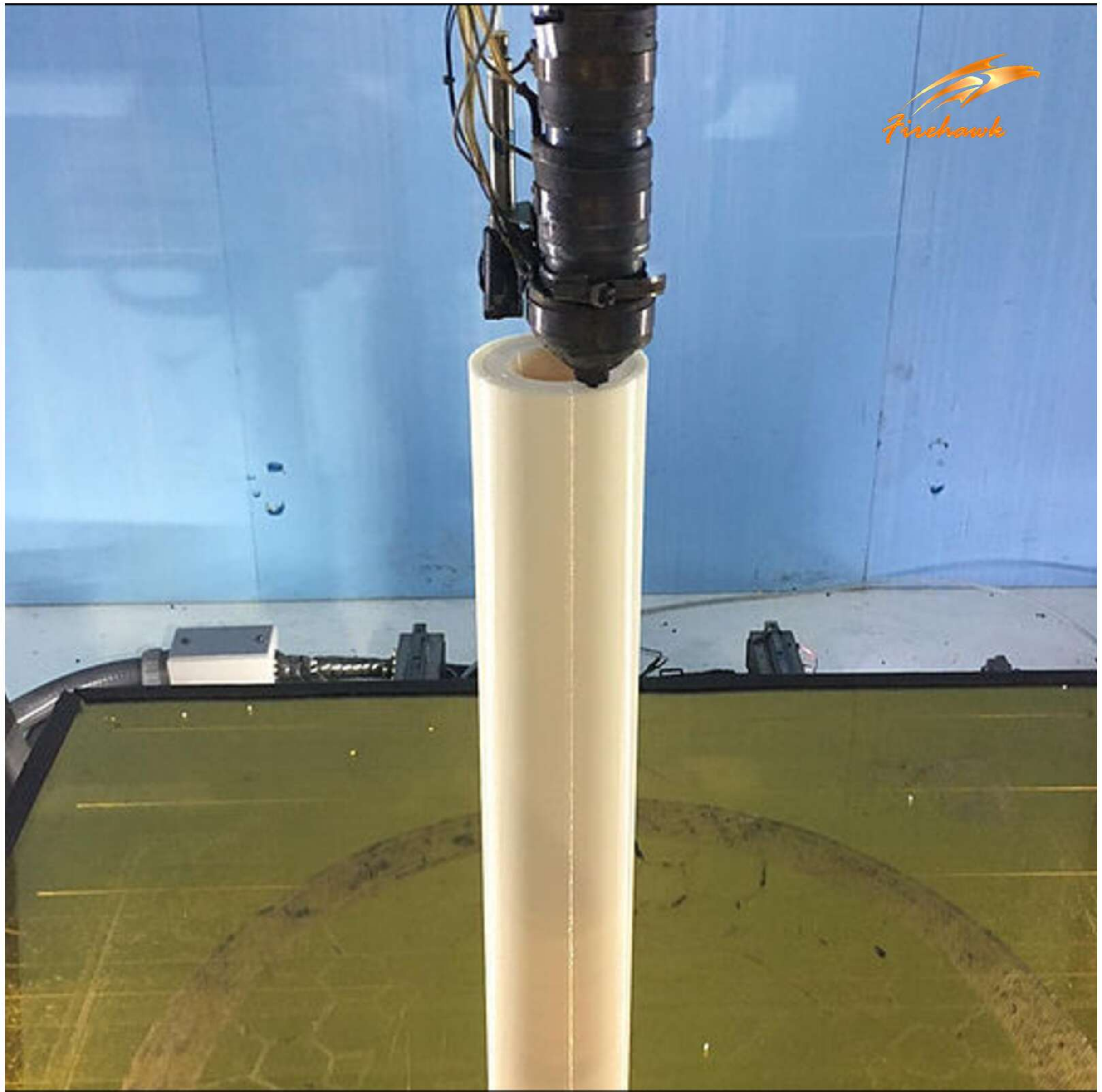
- Developing a new engine can cost hundreds of millions of dollars and take 5-7 years

ROCKET ENGINES ARE DANGEROUS

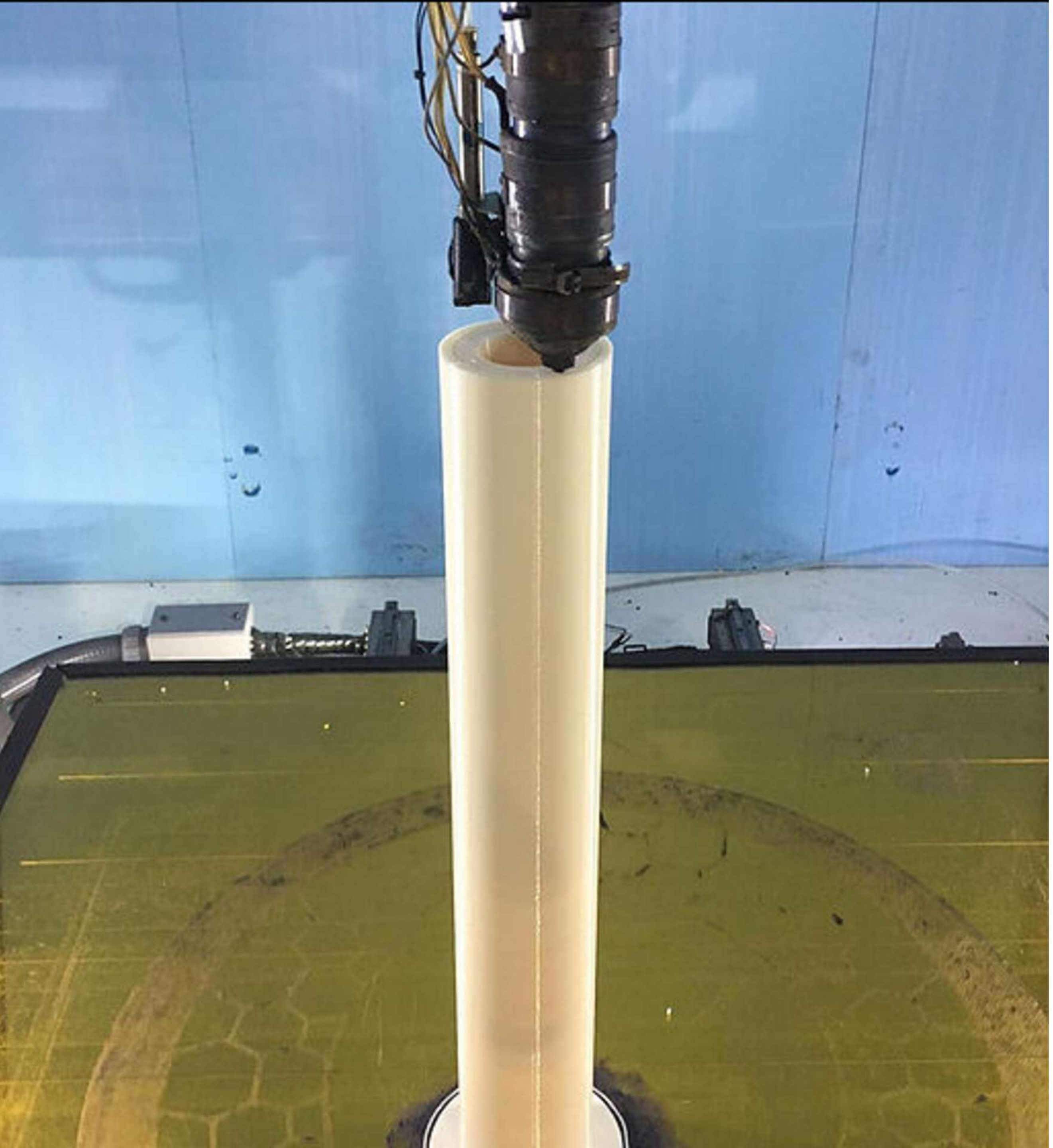
- Solid Rocket motors and liquid bi-propellant engines can and do accidentally detonate
- Traditional rocket engines require upwards of a thousand parts, which increases the probability of something going wrong



12 Part Engine



3D Printed Fuel



95% - Acrylonitrile Butadiene Styrene Thermoplastic

5% - Nano Aluminum Powder

Firehawk

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™
Regression Rate	Low - averages1.0 mm/sec.	High - averages 3.0 mm/sec.
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**

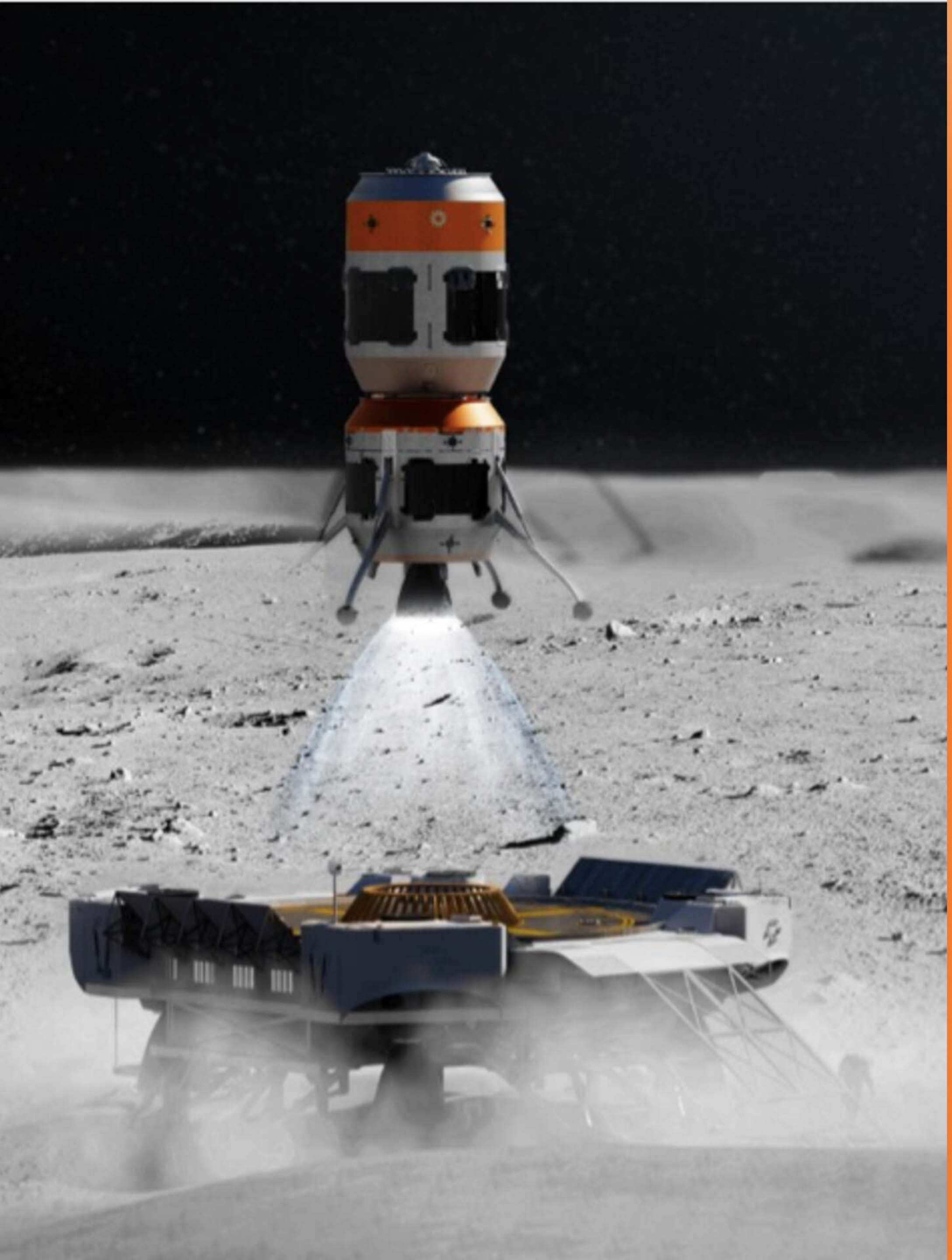
$609 BILLION MARKET

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



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.

National Aeronautics and
Space Administration
John C. Stennis Space Center
Stennis Space Center, MS 39529-6000

From: Ramona Travis
Subject: Stennis Space Center: Mandatory Preliminary Proposal (MPP) Letter of Concurrence
Company: Firehawk Aerospace
Title: Advanced Rocket Propulsion Technology to Support a Lunar Transportation System
Date: 03-04-2020

I have reviewed the Mandatory Preliminary Proposal (MPP) submitted by Firehawk Aerospace in which the Stennis Space Center is a proposed partner and I concur that the MPP accurately characterizes the preliminary discussions between Firehawk Aerospace and Stennis Space Center.

Any discussions between Firehawk Aerospace and Stennis are non-binding until and unless Stennis Space Center provides Firehawk Aerospace with a Letter of Intent to support a final ACO proposal and Firehawk Aerospace is selected for award.

Signed:

Ramona Pelletier Travis

Ramona Pelletier Travis, PhD
Stennis Space Center Chief Technologist and
ACO 2020 Stennis POC

Stennis Space Center

April 1st, 2020

Letter of Intent (LOI) To Purchase Rocket Engines
From Firehawk Aerospace, Inc.

Kepler Aerospace, 2908 Enterprise Lane, Midland, Tx, 79706 (hereinafter Kepler) intends to purchase certain hybrid rocket engines/systems from the Firehawk Aerospace, 82 I ST SE Washington, D.C., (hereinafter Firehawk). The purpose of the LOI is to summarize our companies' discussions to date and confirm our respective intentions regarding the proposed transaction.

Kepler intends to purchase rocket engines/systems designed and manufactured by Firehawk Aerospace. Firehawk will work with other contractors to help Kepler integrate the engines from the rocket designs through construction.

Kepler and Firehawk will work to conclude a contract in the next 90 days, which is June 30, 2020. Kepler understands that Firehawk will work to design and construct propulsion engines/systems to match the specifications for the payload provided by Kepler.

Kepler understands that Firehawk is currently raising capital for the research and development of rocket engines. Kepler also understands that Firehawk will be working with Stennis Space Center and others on the design and testing of engines and that the immediate goal of Firehawk is to design and build an engine for a 25,000 lbf thrust test.

In the event a contract is not signed on or before June 30, 2020 and this LOI is not extended by the Parties herein, for any reason, Kepler or Firehawk may terminate the negotiation without any liability.

This agreement will supersede and replace any previous written or oral agreement made to date.

Kepler Aerospace Ltd.
Brent Nelson, Chairman

Firehawk Aerospace Inc.
Will Edwards (CEO)

Andrew Edwards

2908 Enterprise Lane, Midland, Texas 79706
www.kepleraerospace.com

Kepler Aerospace

31 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

RON JONES

Founder, Chairman & Chief Scientist
ron@firehawkaerospace.com

STEVE EDWARDS

Founder, Dir. Of Government Relations
steve@firehawkaerospace.com

WILL EDWARDS

Founder, CEO
will@firehawkaerospace.com

Supporting Team

Dr. Max Kandula
Sr. Rocket Propulsion Engineer, KBR

Neil Hicks PE
Sr. Rocket Test Engineer, KBR

Rick Neff
Additive Manufacturing SME

Dr. Daniel Kirk
Sr. Rocket Propulsion Scientist, Florida Tech

Nathaniel Rutkowski
Propulsion Engineer I

Raghav Bhagwat
Propulsion Engineer I

Howard McKeon
Government and Defense Contracting

David Keysor
Government and Defense Contracting

Buck McKeon
(Fmr.) Chair of the House Armed Services Committee

Cheree Kiernan
Sr. Government Business Development SME

Advisors

Cheree Kierman

CEO Integrated Launch Solutions

Former Boeing ground launch expert

Daniel Kirk, PhD

Assoc. Dean for Research, Florida Institute of Technology

Rocket Propulsion Consultant to ULA and Blue Origin

Rick Neff

Additive Manufacturing Expert, Consultant

Former Cincinnati executive and developer of the BAAM giant-scale printer designed by Oak Ridge National Laboratories

Firehawk

Advisors cont’d

Cliff Beek

CEO Cloud Constellation

Global New Space industry expert

Jess Sponable

Principal ICEFOX

Former DARPA Experimental Spaceplane Program Manager

Anjelo Karavolos, PhD

Aerospace Scientist, Biologist, and Civil Engineer

Former Lockheed Martin and NASA researcher

Greg Place

Principal Wonder Assets

Chemist, Material Scientist, and nano-materials expert

Firehawk

Partners

Florida Institute of Technology

Stennis Space Center & Marshall Space Flight Center

C5BDI Consulting

KBR Engineering

Integrated Launch Solutions

McKeon Group

Thank You

Contact:
Will@FirehawkAerospace.com

Firehawk