Overview of High Efficiency, Compact Rotating Detonation Rocket Engines

2024 Interplanetary Small Satellite Conference; Tucson, AZ

Presenter:

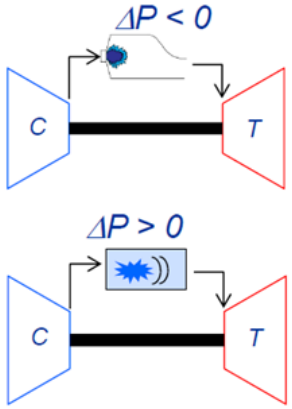
James K. Villarreal, PhD

President, Nobel Works Corp.
UA Adjunct; AME426/526 Rocket Propulsion
Former Assoc. Director, Raytheon

Introducing Supersonic Combustion

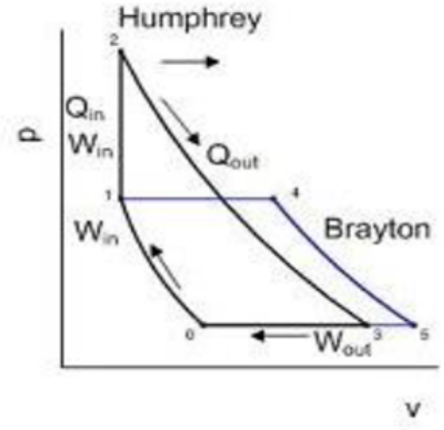
Rotating Detonation Engines versus conventional:

Convention gas turbines combustion results in a pressure loss across the combustor (Brayton cycle)



Pressure gain with *constant volume combustion* ***(Humphrey cycle)***

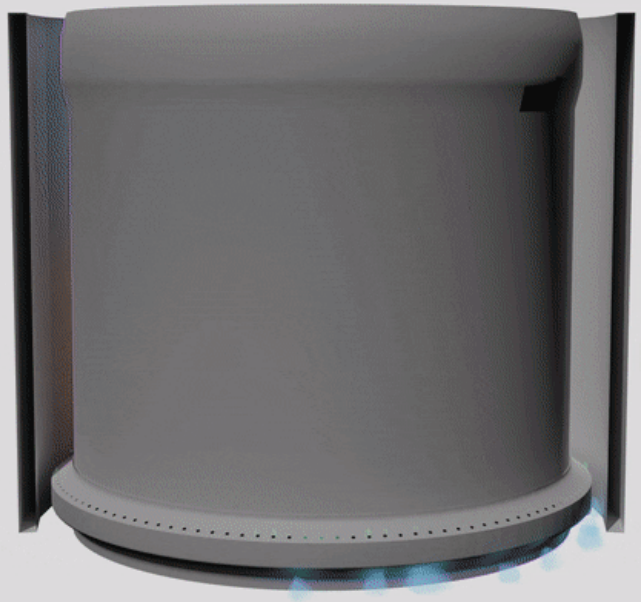
– *Deflagration or detonation pressure wave* increases pressure and peak temperatures at turbine inlet - reduced entropy production during combustion.



Superior Thermodynamics

Improves fuel efficiency by up to **25%**

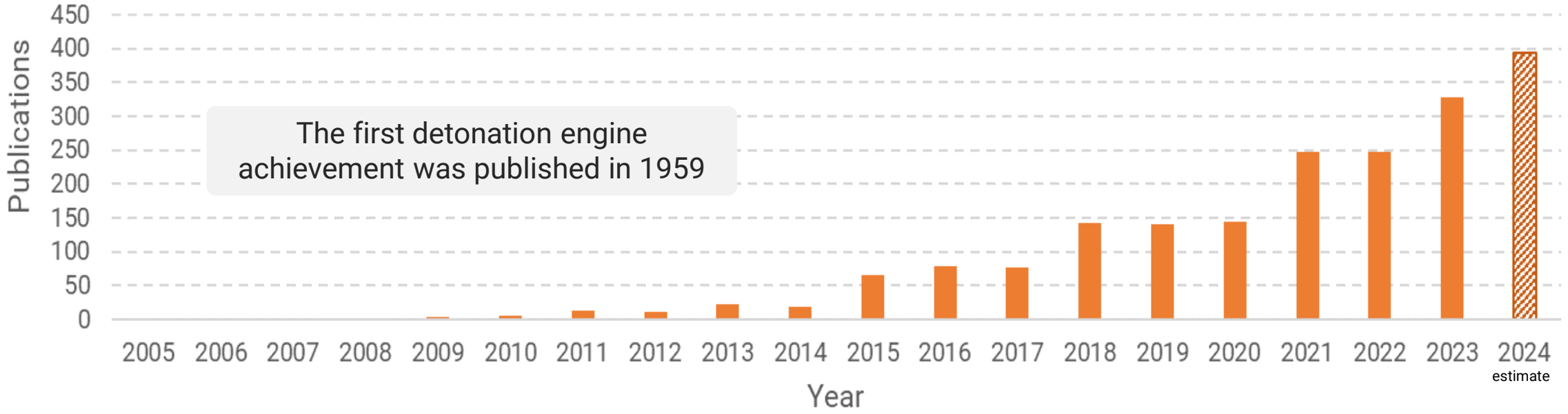
Source: Richards, Geo. National Energy Technology Laboratory. New Development in Combustion Technology. 2014 Princeton CEFRC Summer School on Combustion



Supersonic wave travels around the annular chamber at 4,500 mph

Source: Oak Ridge National Laboratory. https://www.olcf.ornl.gov/2020/08/26/realizing-the-dream-of-rotating-detonation-engines-through-an-olcf-netl-ge-and-university-of-michigan-collaboration/

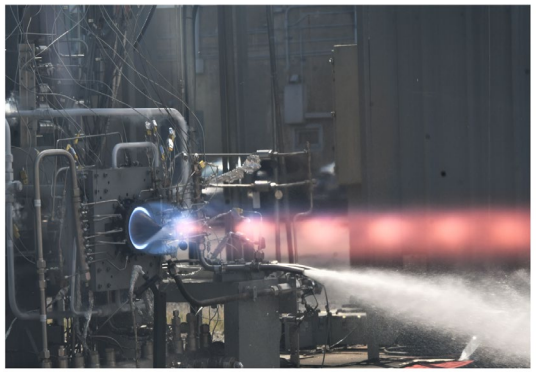
Detonation Engine Momentum!



NASA Validates Revolutionary Propulsion Design for Deep Space Missions

By Ray Osorio

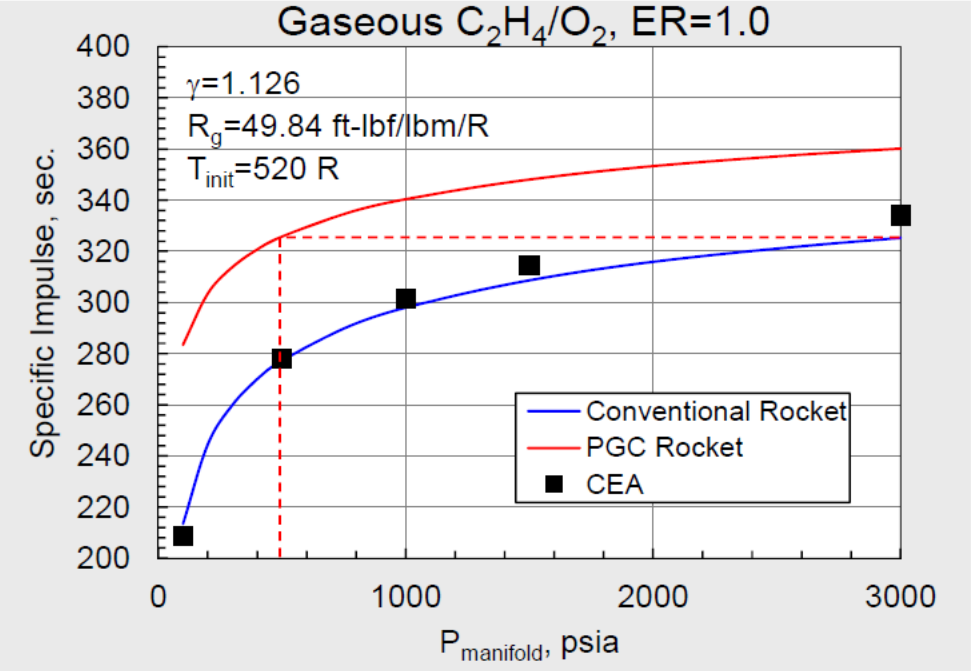
As NASA takes its first steps toward establishing a long-term presence on the Moon's surface, a team of propulsion development engineers at NASA have developed and tested NASA's first full-scale rotating detonation rocket engine, or RDRE, an advanced rocket engine design that could significantly change how future propulsion systems are built.



Next-generation missile propulsion systems

NASA Progress and Examples of RDRE Benefits

More efficient!

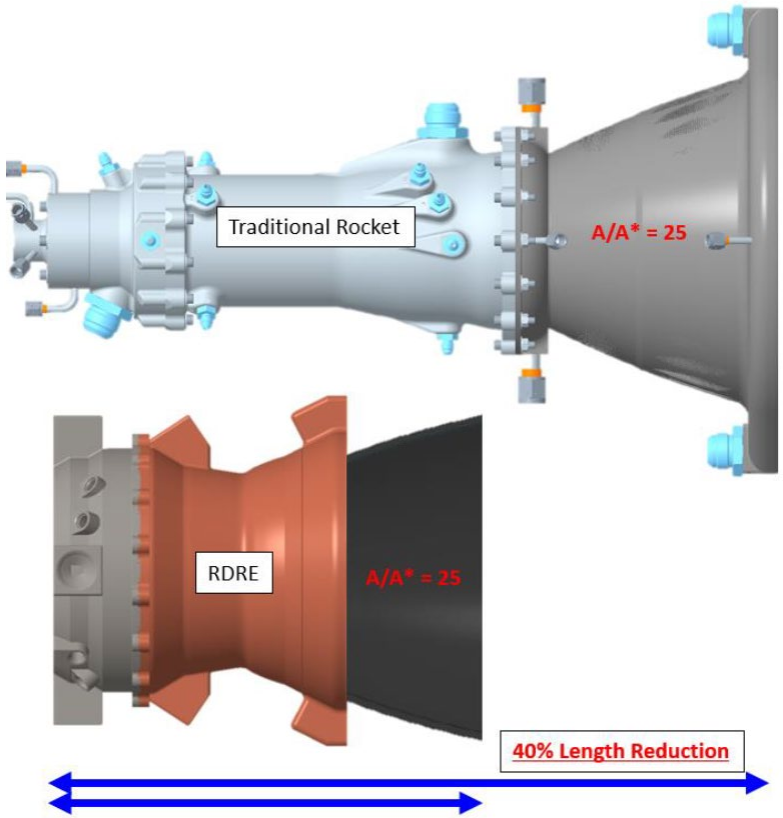


PGC Rocket at $P_{manifold}$ of 488 psia Delivers Same I_{sp} as Conventional Rocket at $P_{manifold}$ of 3000 psia

Smaller or Even No Pumps ➔ Better T/W

Source: Paxon, Daniel. NASA Glenn Research Center. *A Case for Basic Rotating Detonation Engine Research*. DARPA RDE Stakeholders Day. 26 May 2016

More compact!



Source: Teasley, et al. NASA Marshal Space Flight Center. *Current State of NASA Continuously Rotating Detonation Cycle Engine Development*. 2023 AIAA propulsion and Energy Forum.

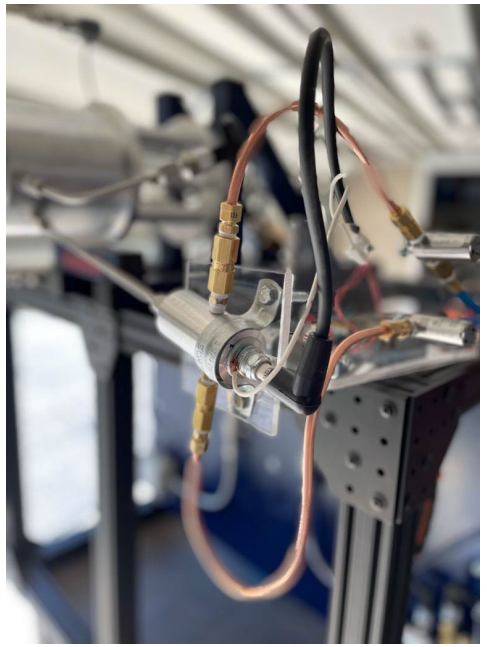
Mission level benefits:

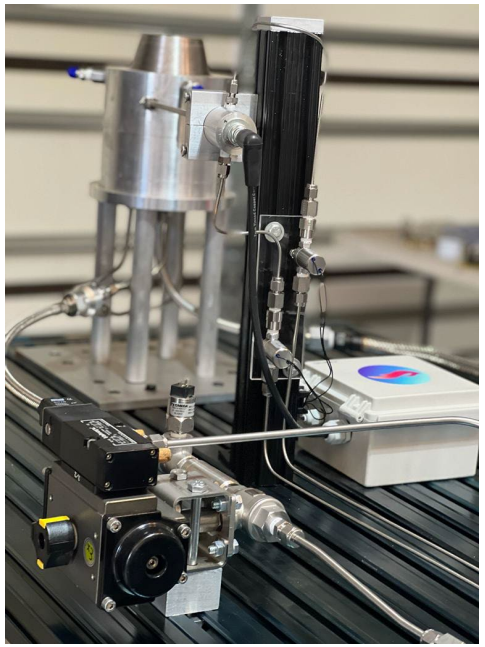
$$\Delta v = v_e \ln \frac{m_0}{m_f}$$

Rocket Equation and Aircraft Range equations have an exponential dependency on fuel efficiency

$$R = \frac{\eta}{SFC}\frac{C_L}{C_D}\ln\left(\frac{W_{initial}}{W_{final}}\right)$$

Supersonic Combustion Technology – it works!





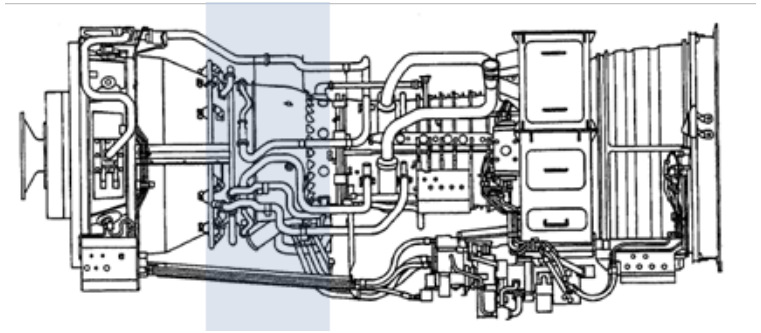
Nobel builds and tests supersonic combustion engines for commercial and aerospace

- Shell contract testing Hydrogen/Air RDEs for use in commercial energy production
- Long duration (> 1-min, until it ran out of fuel) sustained detonation waves

Phase II SBIR: Pulsed Detonator for Scramjet Ignition and Combustion Augmentation using On-board Resources

Other Activities: Drop-in Combustor Replacements in Energy

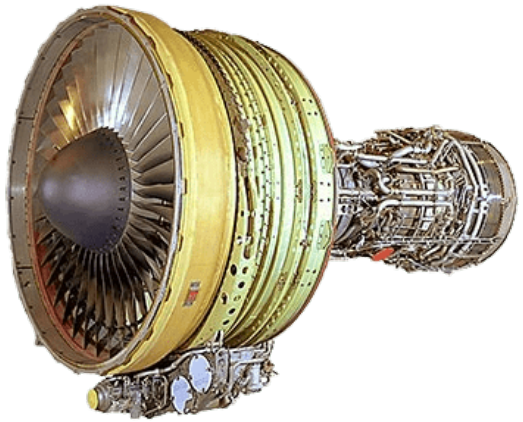
Detonation engine simulations in digital twins of popular gas turbines



SoftInWay incorporated

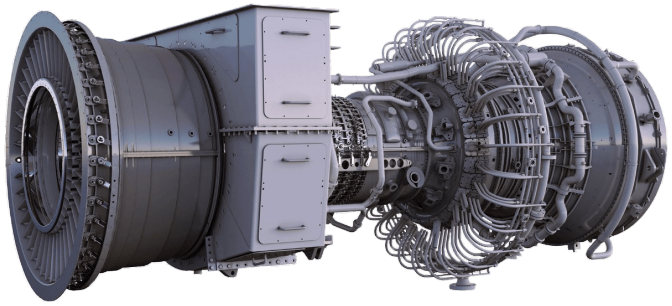
PROENERGY

NPS PRAESTANTIA PER SCIENTIAM 1909 NAVAL POSTGRADUATE SCHOOL



CF-6 Turbofan Jet Engine

Introduced 1971 and used on Boeing 767/777 and Airbus A300/A330



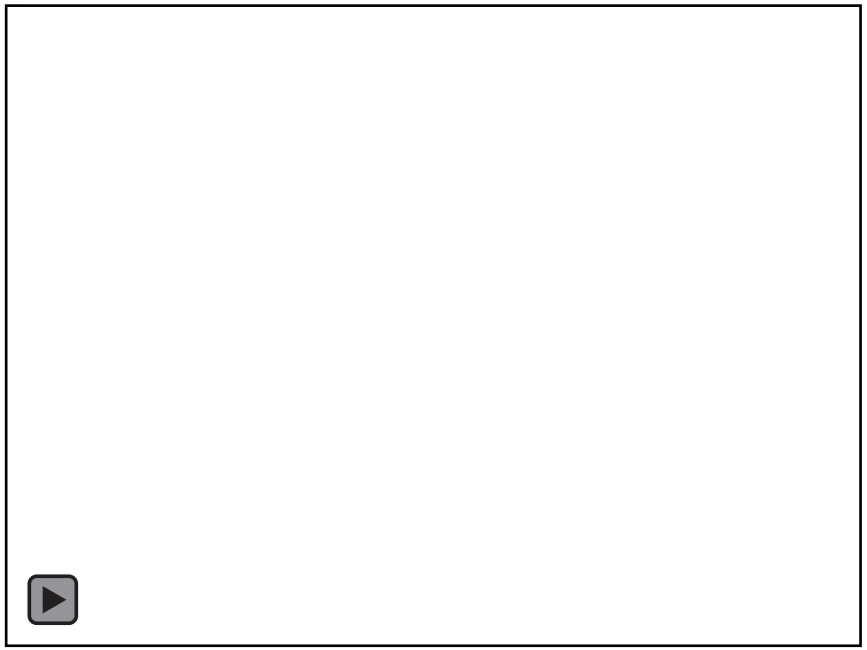
LM2500 / LM6000

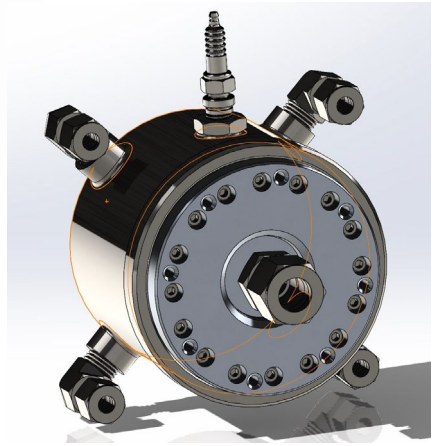
Repurposed as “aero-derivative” gas-fired powerplants

LM2500 Marine Gas Turbine

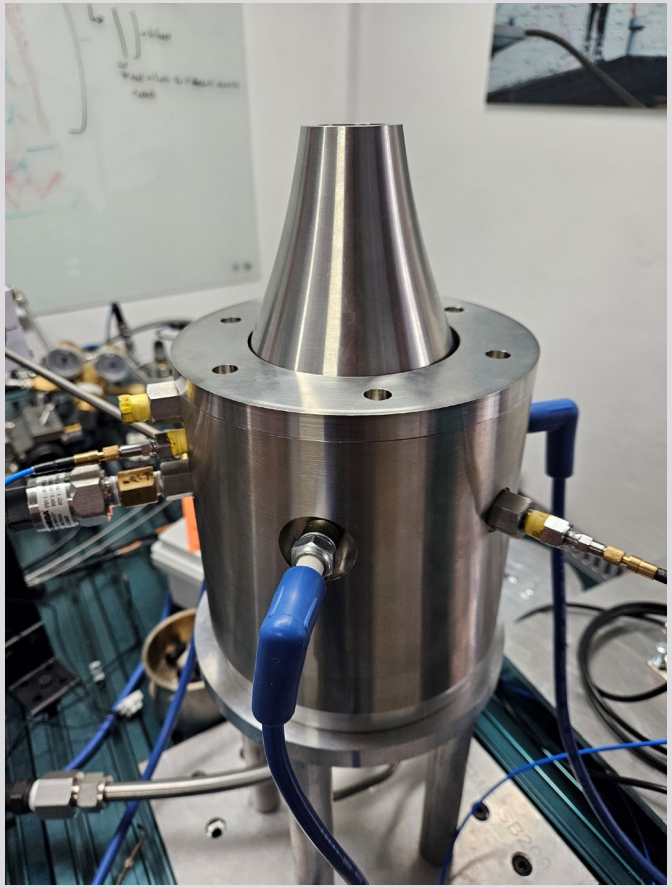
Predominant turbine used in the U.S. Navy and 29 other navies

Nobel-UA Projects: Rockets and Other Things that Make Fire





Optimizing unique aerospike nozzles for rotating detonation engines



nobel

Additional Information

GET IN TOUCH
+1 602 448 1683

LOCATION
Tucson, Arizona

WEB OFFICE
enterprise@nobel-works.com
www.nobel-works.com