# NASA Rotating Detonation Rocket Engine Concept Development Status & Scope

Doug Perkins

NASA Glenn Research Center

June 10, 2021

# NASA Has Been Creeping Into RDRE Research The Last ~4 years

- Started with 2 NASA Space Technology Research Fellowships at Purdue starting between 2017-2018 (Nozzles, Liquid Hydrocarbon Fuel/Heat Transfer)
- Added 2 small 1-year NASA GRC IR&D efforts in FY19 (Nozzle Design, Cycle Code)
- Added 1 STTR Phase I Award – Spectral Energies/Purdue in August 2019. Selected to go to Phase II, starting February 2021. (Laser diagnostics for liquid fuel at high pressure, publically available code validation data)
- Added 3 Early Stage Innovation (ESI) grants starting in March 2020 – 3 years, $550K total each
    - Purdue (Heister/Pourpoint) – Hypergolics – RP/MON25
    - Alabama (Agrawal) – Disk RDRE – CH4/O2
    - UCLA (Spearrin) – Hypergolics – MMH/NTO
- Added internal support at GRC from NASA STMD in March, 2020 – Computational Tools Development & Modeling/Design Support
- Added two more NSTRF students at Purdue starting in 2020 (manifold dynamics, laser diagnostics)

# And More Recently…

- Added NASA "Collaborative Opportunities" award in January 2021 for NASA MSFC/In-Space collaboration on RDRE design with testing to be performed at NASA MSFC starting winter of 2021.  NASA GRC is supporting nozzle and injector design.
- Added another NSTRF student at University of Alabama, Huntsville – May 2021 – Injector design and manufacturing
- Other small university awards expected…

**Total budget for NASA RDRE research in FY21 is ~$2.0M.  Decision point on focused development effort at the end of FY23.**

Program driver within NASA is in-space applications – orbital transfer, landers. etc.

**While increased $I_{sp}$ will always be of interest, decreased feed pressure and decreased engine length are also of significant interest for certain applications, particularly landers.**

# Key Technology Interests

- Pressure Gain!
  - Decreased feed pressure – down to similar value as equivalent traditional rocket
  - Implies high “diodicity” injector designs
  - High frequency response injectors
  - Minimize parasitic deflagration – Fuel lead?
- Application relevant average chamber pressure operation
  - Need combustor area change/throat to backpressure combustor
- Repeatable, “classical” RDE wave structures
- Liquid Fuels
  - Space storable are preferred for NASA right now, but considering the overall system TRL, more tractable fuels can and should be considered for research purposes.
  - Minimize number of waves to give reasonable injector recovery/injection/mixing time.
- Modeling and validation data
  - You can’t design high performance RDRE’s empirically
  - It is just about all about the injection system and injected propellant behavior at this point. The next level of importance is the deflagration behavior. Detonation wave structure is considerably less important.
- While nozzles are obviously a key technology, this is a lower priority until we get the combustor right.