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# TriJet Propulsion for Reusable Hypersonic Vehicles


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# Robust Operation Requirements For Turbine Based Combined Cycle Vehicle

- Subsonic (Mach 0 to 1)
  - Self Ferry
  - Runway Take-Off
  - In-flight Tanking
  - Powered Landing/Go Around Capability
- Super & Hypersonic Operation (Mach 1 to 6)
  - Substantial Positive Thrust Margin Especially During Transonic Flight & Combined Cycle Engine Mode Transition(s)

# Current Major Combined Cycle Propulsion Issues

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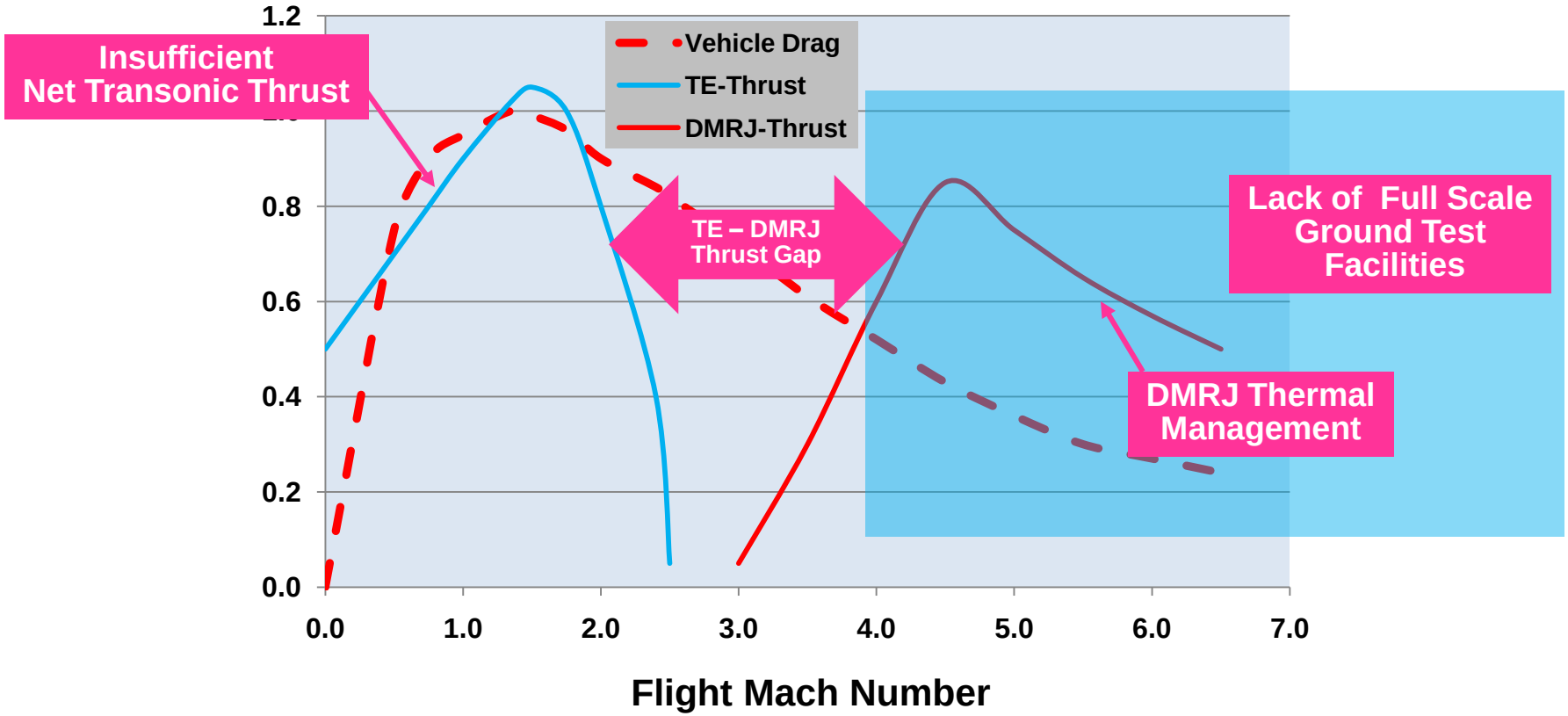
## Normalized Vehicle Drag (Drag/Drag$_{max}$) & Thrust (Thrust/Drag$_{max}$)



# Aerojet TriJet Concept Operation

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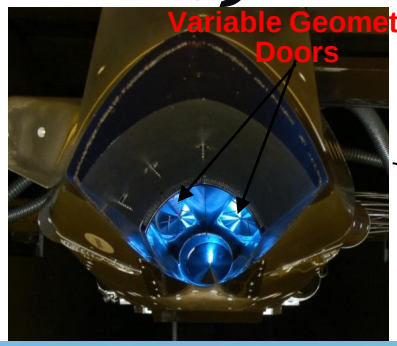
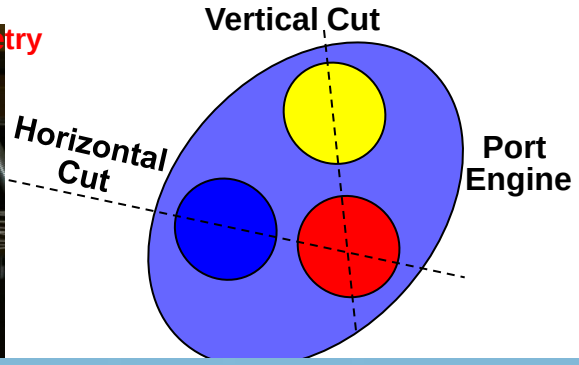
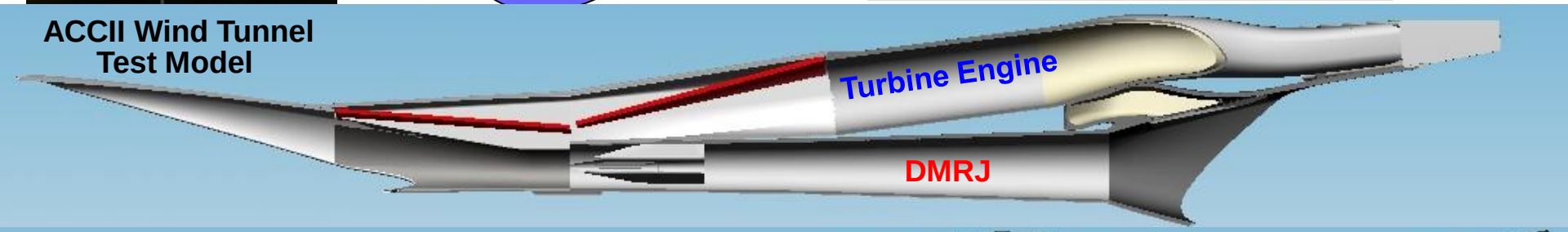


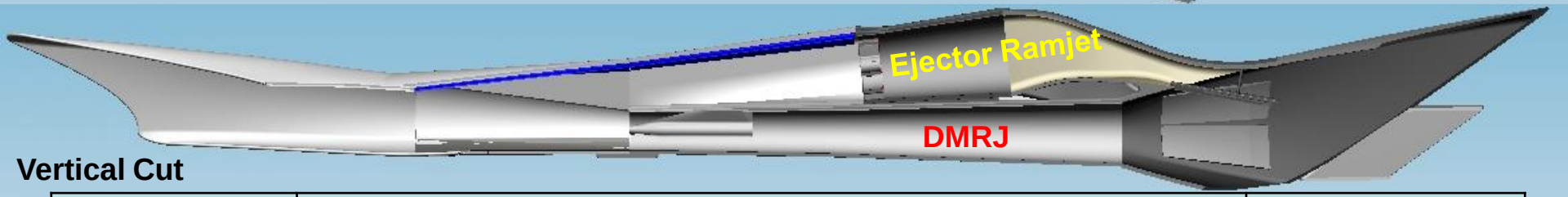




**Front Views**

- Inlet Capture Area
- Mach 2.5 TE (Available Now)
- Mach ~4+ Ejector Ramjet
- Mach 3.5 -7 Dual Mode Ramjet

**ACCII Wind Tunnel Test Model**




**Vertical Cut**

| Mach Range | Door Settings (No Doors in DMRJ Flowpath) | | | | Comment |
|---|---|---|---|---|---|
| | Turbine Engine | | Ejector Ramjet Engine | | |
| | Inlet | Exit | Inlet | Exit | |
| 0 to 1+ | Open | Open | Open | Open | |
| 1+ to 2.5 | Partial Open | Partial Closed | Open | Open | |
| 2.5 to 4+ | Closed | Closed | Partial Open | Partial Closed | Sustained Aero Choke |
| 4+ to 7 | Closed | Closed | Closed | Closed | |

# Vehicle TriJet Engine Set

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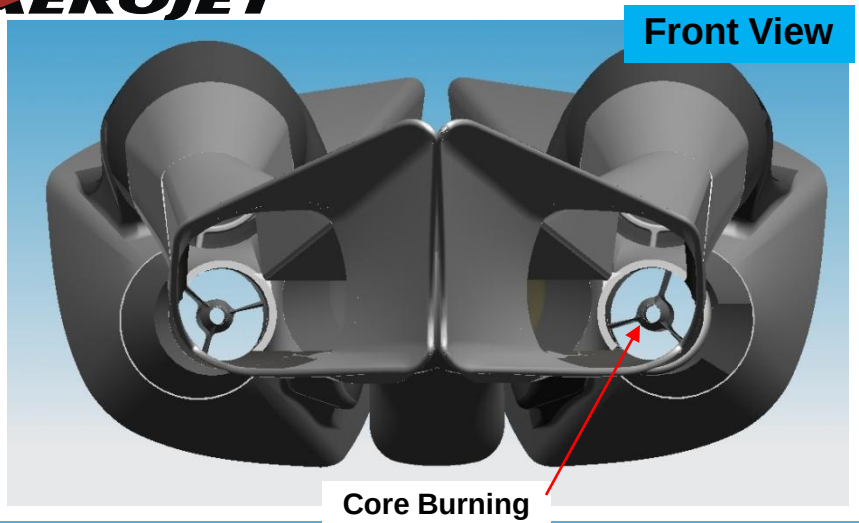


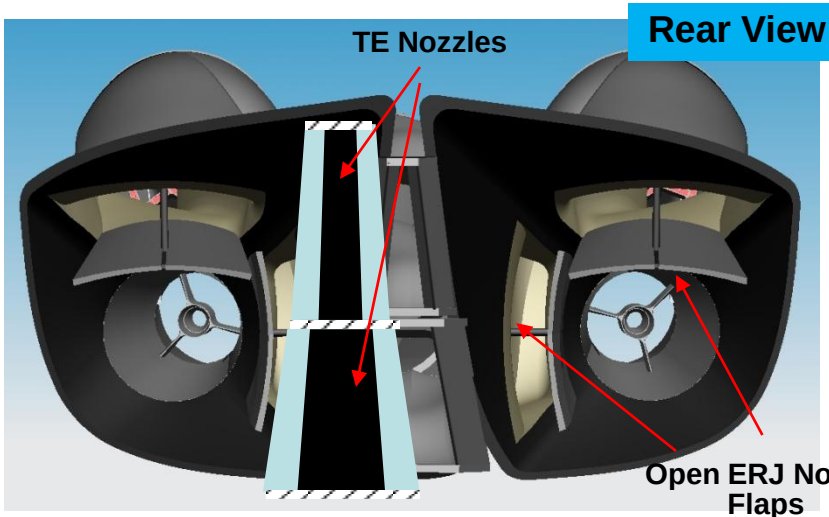


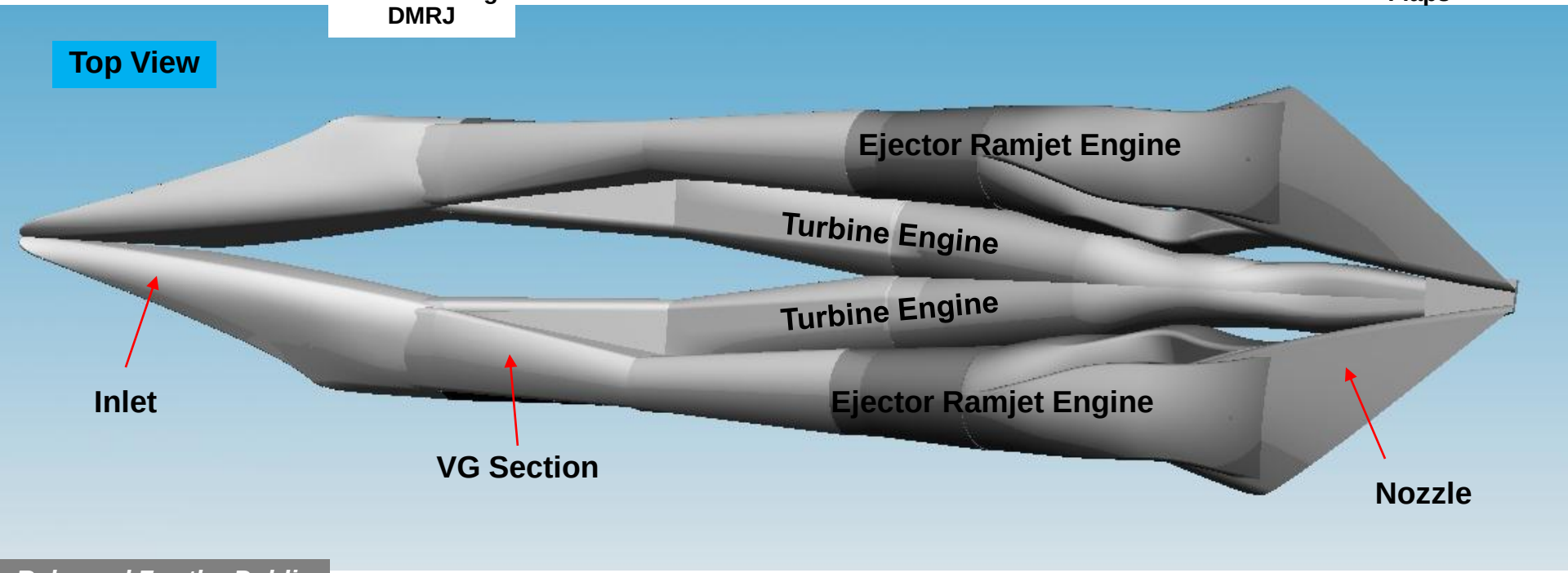

# Aerojet Combined Cycle Inward-turning Inlet (ACCII)

**US Patent 7,216,474**

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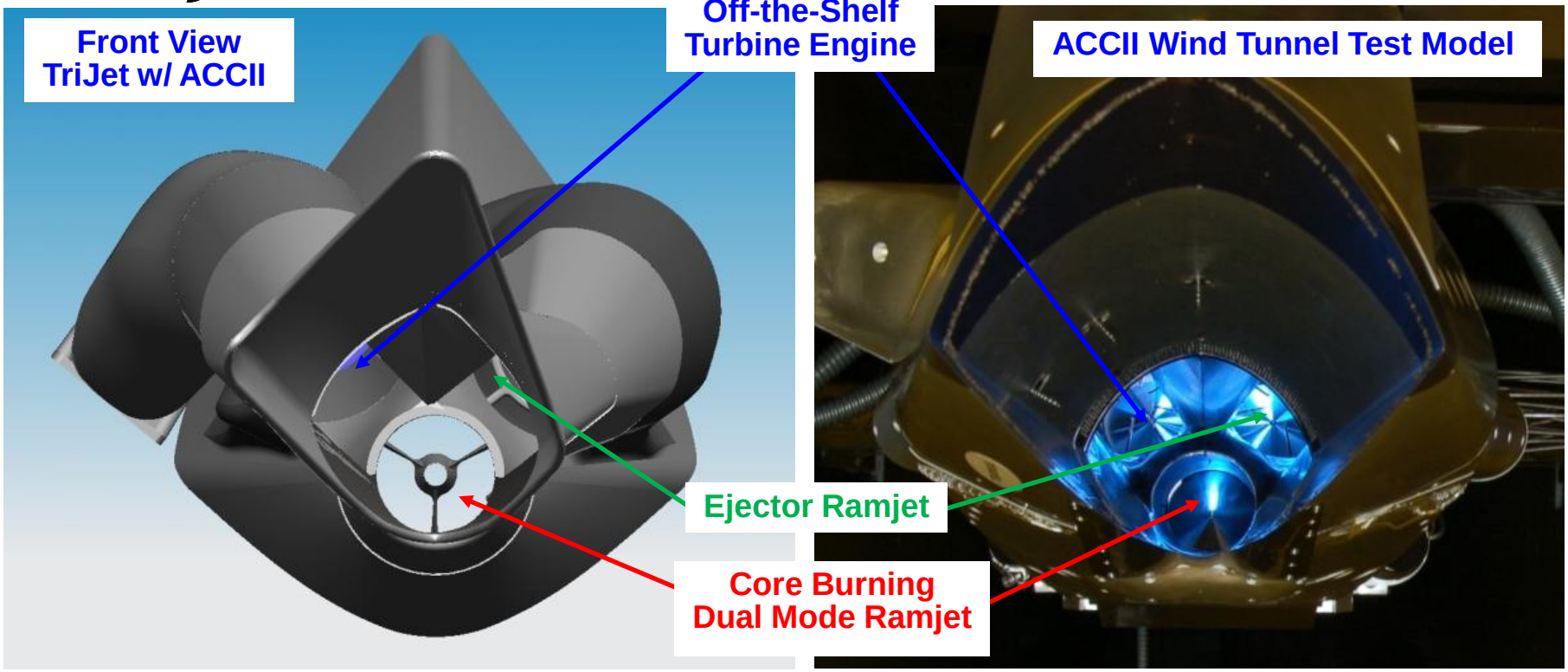


- Over 8,000 Data Points Collected from Mach 0 to 4.6
- Turbine Engine Demands Met Across the Entire Mach Range, While Maintaining a Started Inlet System at Supersonic Speeds
- Integrated Inlet Operation with all Three Inlet Systems Back Pressured and Interacting Simultaneously Demonstrated
- Internal Mass Flow Redistribution Via Door Actuation and Back Pressure Demonstrated

# Sustained Aero-Choke (SAC) Concept
# US Patent 7,886,516

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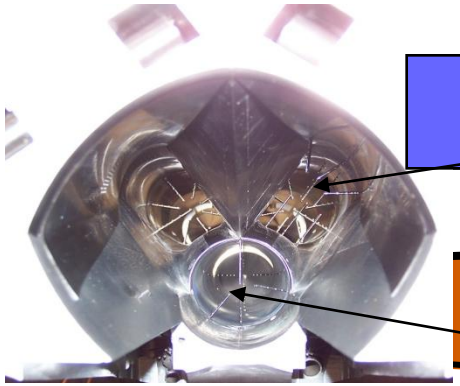

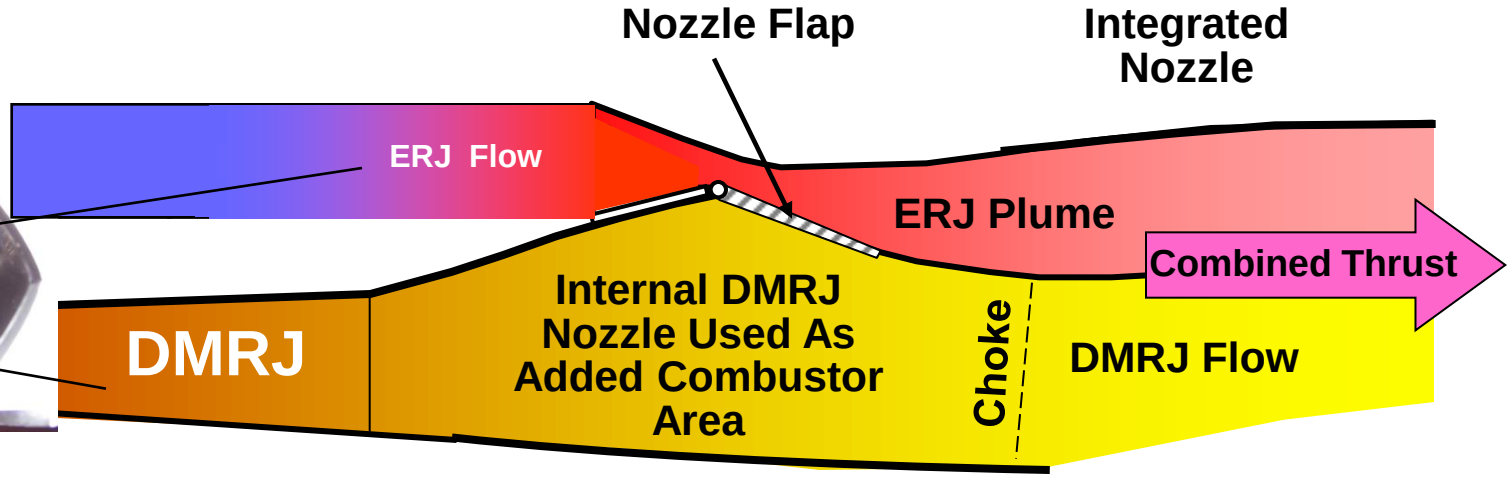


**Objective**

- **Use DMRJ/Nozzle to Provide Substantial Thrust Augmentation Over Mach 2.5 – 4.0 Range**

**Approach**

- **ERJ Plume Provides Sustained Aerodynamic Choke For DMRJ Combustor**
  - **Increases Effective DMRJ Combustor Area Ratio Allowing Additional Heat Release in DMRJ Part of Nozzle**
  - **Enables Robust, Mach 2.5 Ramjet Operation of DMRJ**

# "Core Burning" Reduces Wall Heat Load 40% Relative To "Wall Burning"
# US Patent 7,797,943

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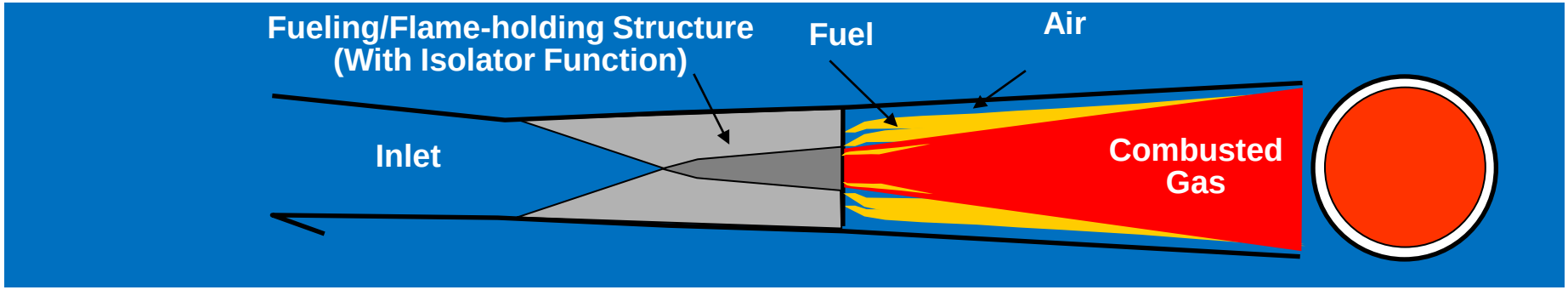


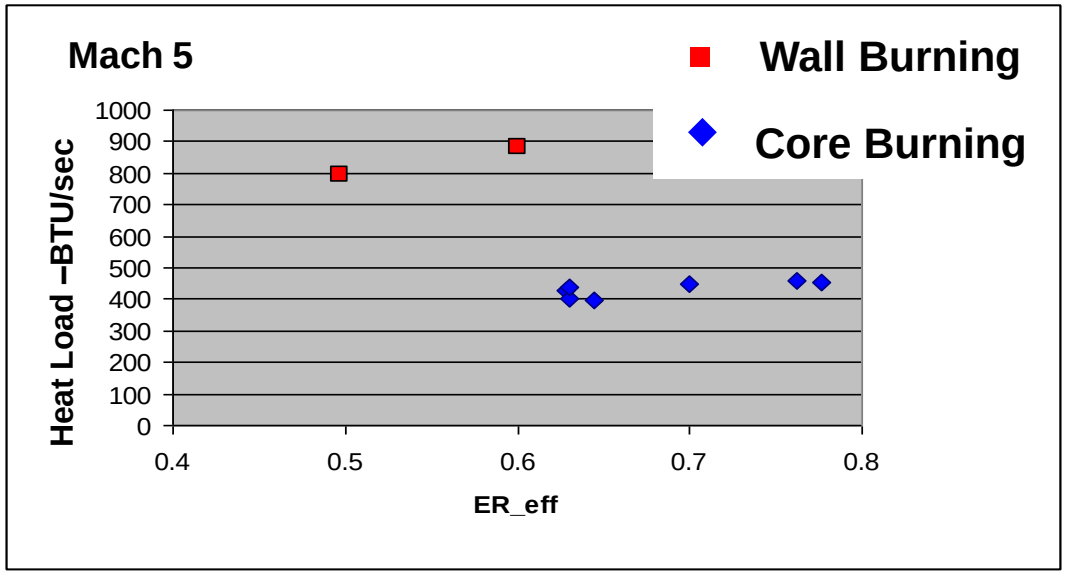


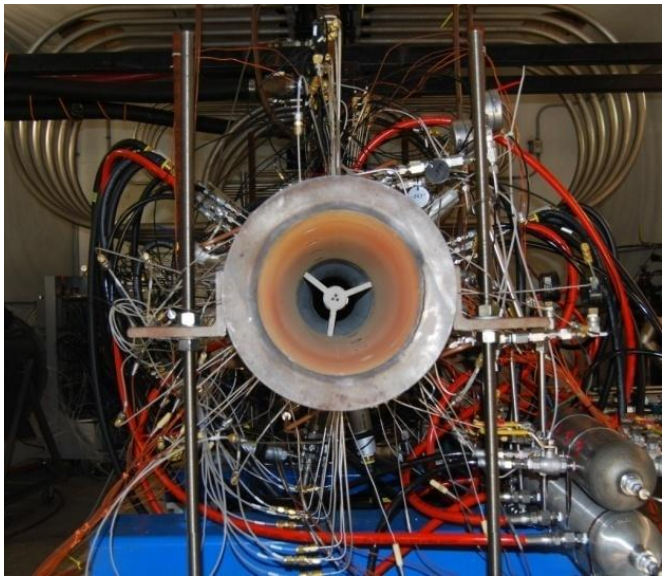

# Successful Flameholding and "Core Burning" Demonstrated

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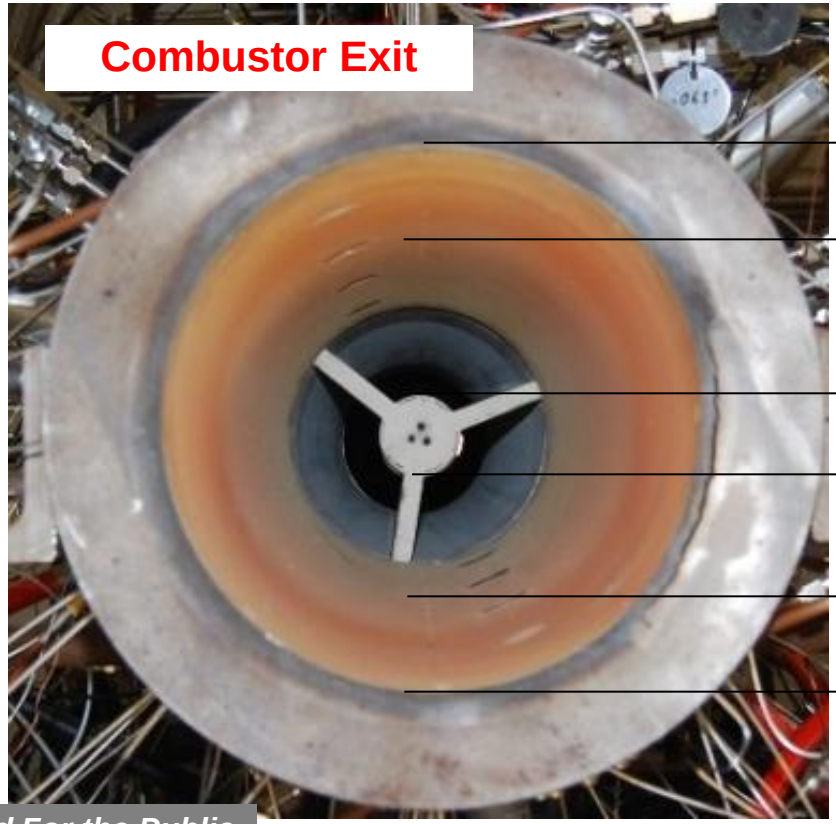
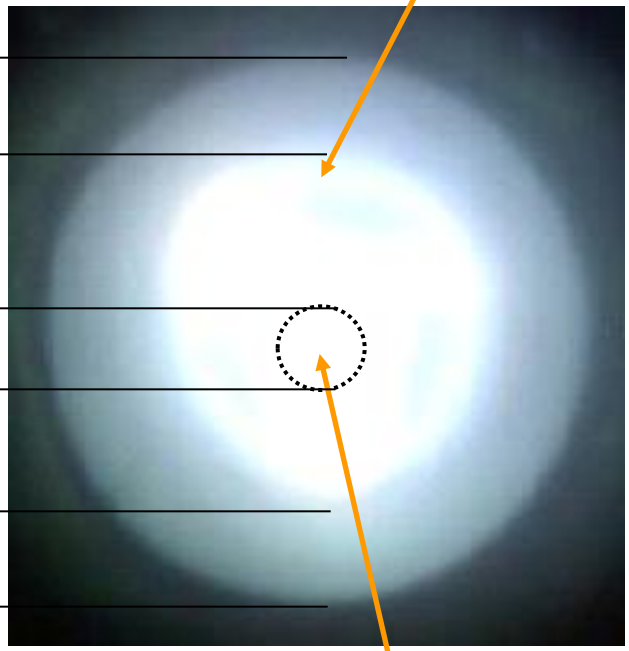



"Core Burning" – Flame Propagates From Center, Staying Off Wall



Central Flameholder

# TriJet Addresses Current TBCC Issues

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**Transonic Thrust Margin** ..... *Assist Turbine Engine (TE) w/ Ejector Ramjet (ERJ)*

**Off-the-Shelf (OTS) TE/ State-of-the-Art (SoA) DMRJ Thrust Gap** .. *Use ERJ & Sustained Aero Choke To Bridge Gap*

**DMRJ Cruise Thermal Management** ..... *Use Core-Burning To Lower Heat Load*

**No Full Scale Ground Test Facilities**..... *Build Mach 6+ Vehicle and Operate w/ Robust OTS TE and SoA ERJ up to Mach 3. Install DMRJ and Use Vehicle for "Envelope Expansion" to Mach 6*