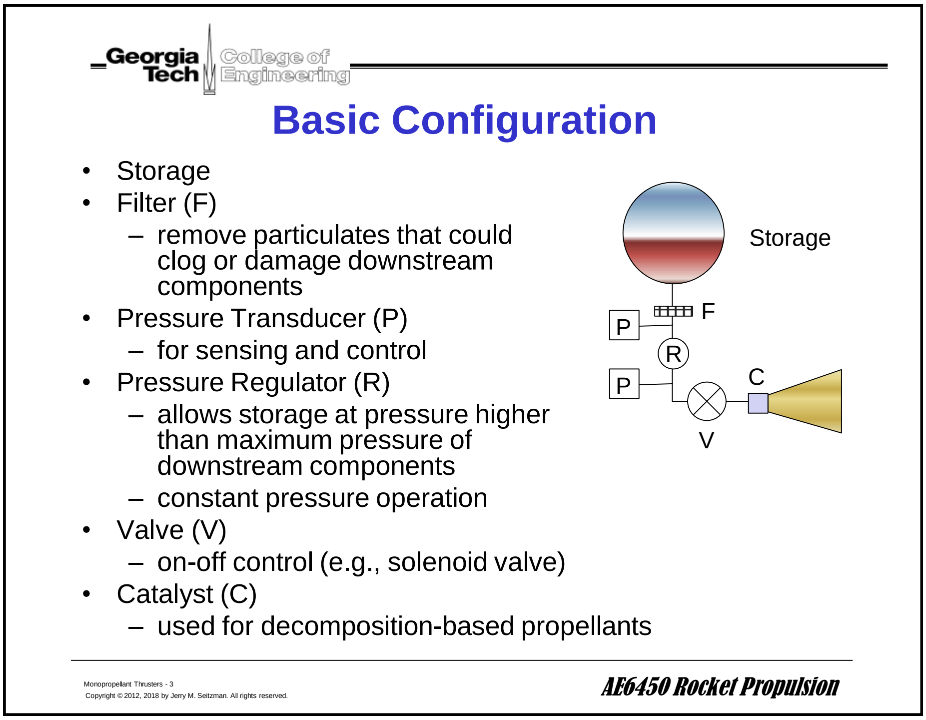
Monopropellant Thrusters

- Good place to apply our basic thermodynamic analysis
- Employed for small, “low” thrust applications
  - small satellite attitude control
- Advantages
  - reliable
  - low complexity
  - safe (storage), good material compatibility
  - low contamination of vehicle due to exhaust

AMPAC-ISP Monarc^{TM} 445
100 lb, 235 sec

Basic Types

- Three primary types
  1. **Cold gas thrusters** — *solely pressure driven*
  2. **Decomposition-based** — *+chemical energy*
     - exothermic heat release
     - requires catalyst
  3. **Resistojets** — *+electrical energy*
     - a type of electrothermal thruster



Basic Configuration

- Storage
- Filter (F)
  - remove particulates that could clog or damage downstream components
- Pressure Transducer (P)
  - for sensing and control
- Pressure Regulator (R)
  - allows storage at pressure higher than maximum pressure of downstream components
  - constant pressure operation
- Valve (V)
  - on-off control (e.g., solenoid valve)
- Catalyst (C)
  - used for decomposition-based propellants

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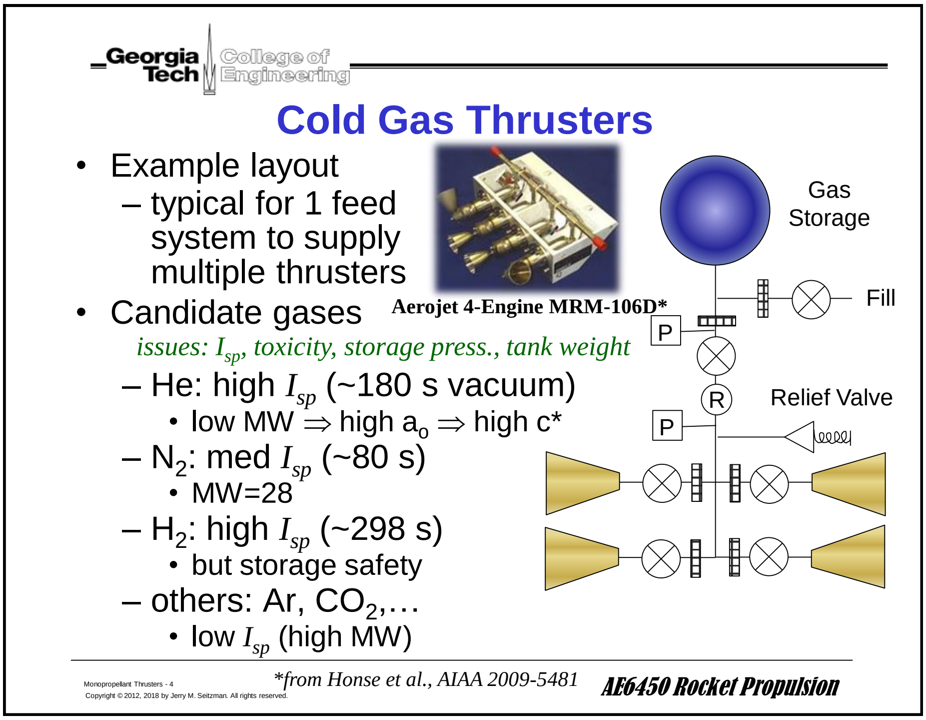
AE6450 Rocket Propulsion



Cold Gas Thrusters

- Example layout
  - typical for 1 feed system to supply multiple thrusters
- Candidate gases

Aerojet 4-Engine MRM-106D*

issues: I_{sp}, toxicity, storage press., tank weight

  - He: high I_{sp} (~180 s vacuum)
    - low MW ⇒ high a_o ⇒ high c*
  - N_2: med I_{sp} (~80 s)
    - MW=28
  - H_2: high I_{sp} (~298 s)
    - but storage safety
  - others: Ar, CO_2,…
    - low I_{sp} (high MW)

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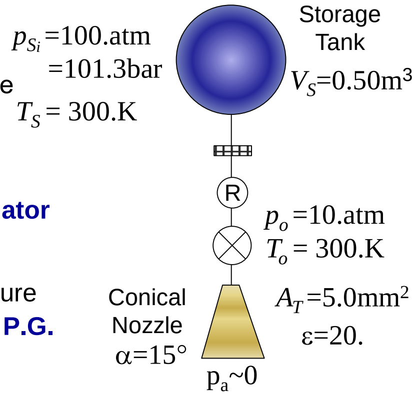
*from Honse et al., AIAA 2009-5481

AE6450 Rocket Propulsion

Example: N_2 In-Space Cold Gas Thruster

- **Goals/Find**
  - Steady-state 1) I_{sp}, 2) τ, 3) “burn time”, 4) total impulse
- **Assumptions**
  1. **Perfect regulator**
     p_o=10 atm until p_S<10 atm
  2. **Isothermal tank and regulator**
     heat xfer from satellite fast enough to compensate expansion drop in temperature
  3. **Thermally and calorically P.G.**
     N_2: R=296 J/kgK and γ=1.4
  4. **Adiabatic and reversible flow** (isentropic) after regulator
  5. **Neglect transients**
     with 3+4 ⇒ ideal rocket



Analysis: N_2 In-Space Cold Gas Thruster

- I_{sp}

$$\boxed{= 73.8s}$$

Analysis: N_2 In-Space Cold Gas Thruster

- τ

$$\boxed{=8.4N} \quad =1.9lb_f$$

- Δt_b steady
  - time until pressure in storage drops to 10bar

Δt_b

$$\boxed{=4400s=1.2hr}$$

Analysis: N_2 In-Space Cold Gas Thruster

- I_{total}

$$\boxed{=37.1kN\ s} =8.3klb_f\ s$$

- Which values would change with throat size?
  -
- Which values would change if include T_o drop?
  -