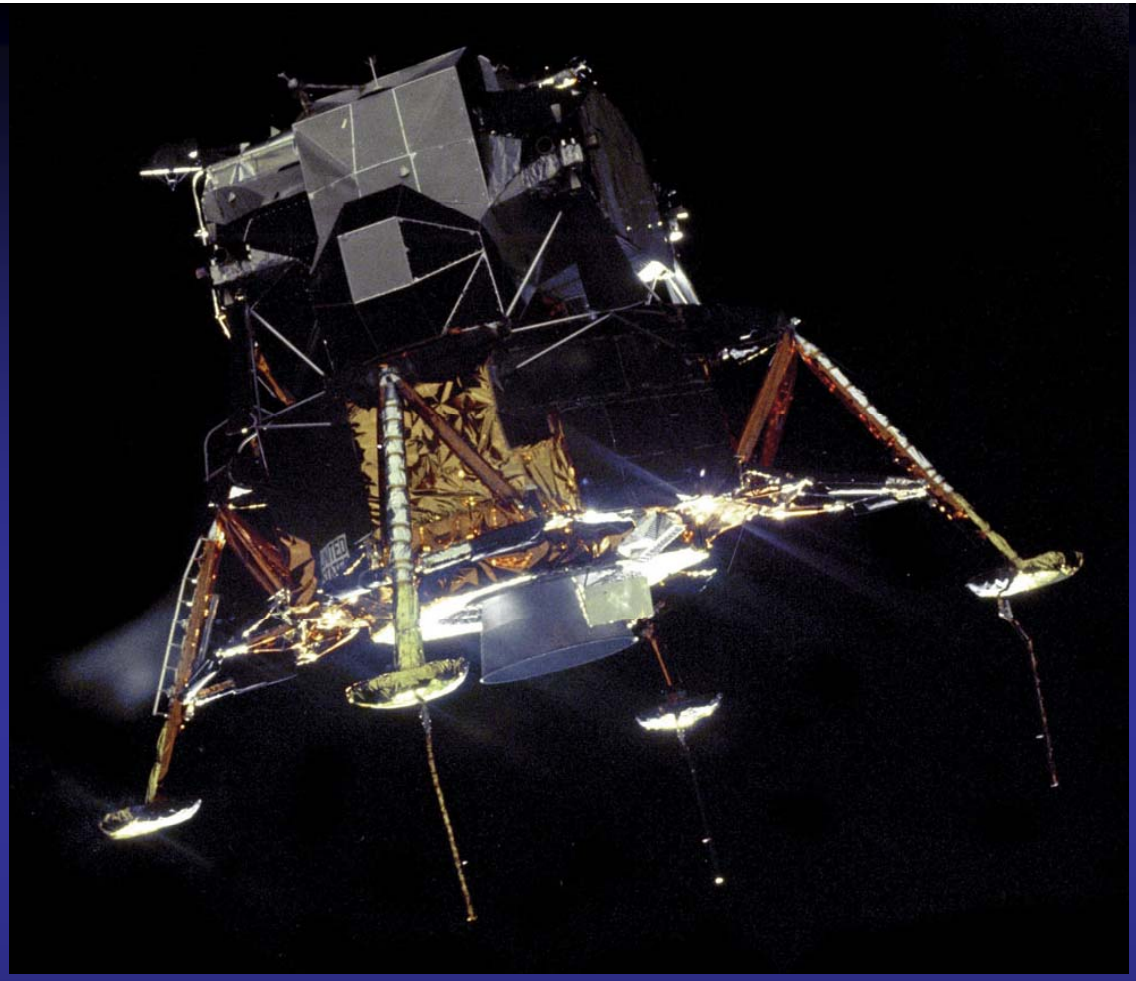
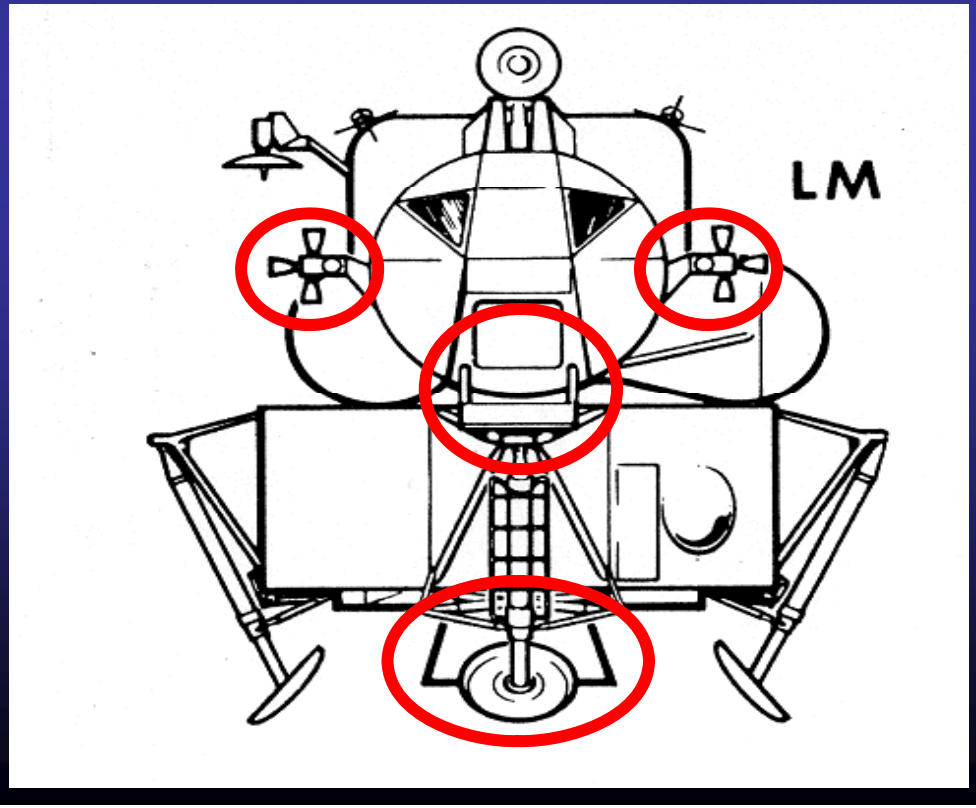


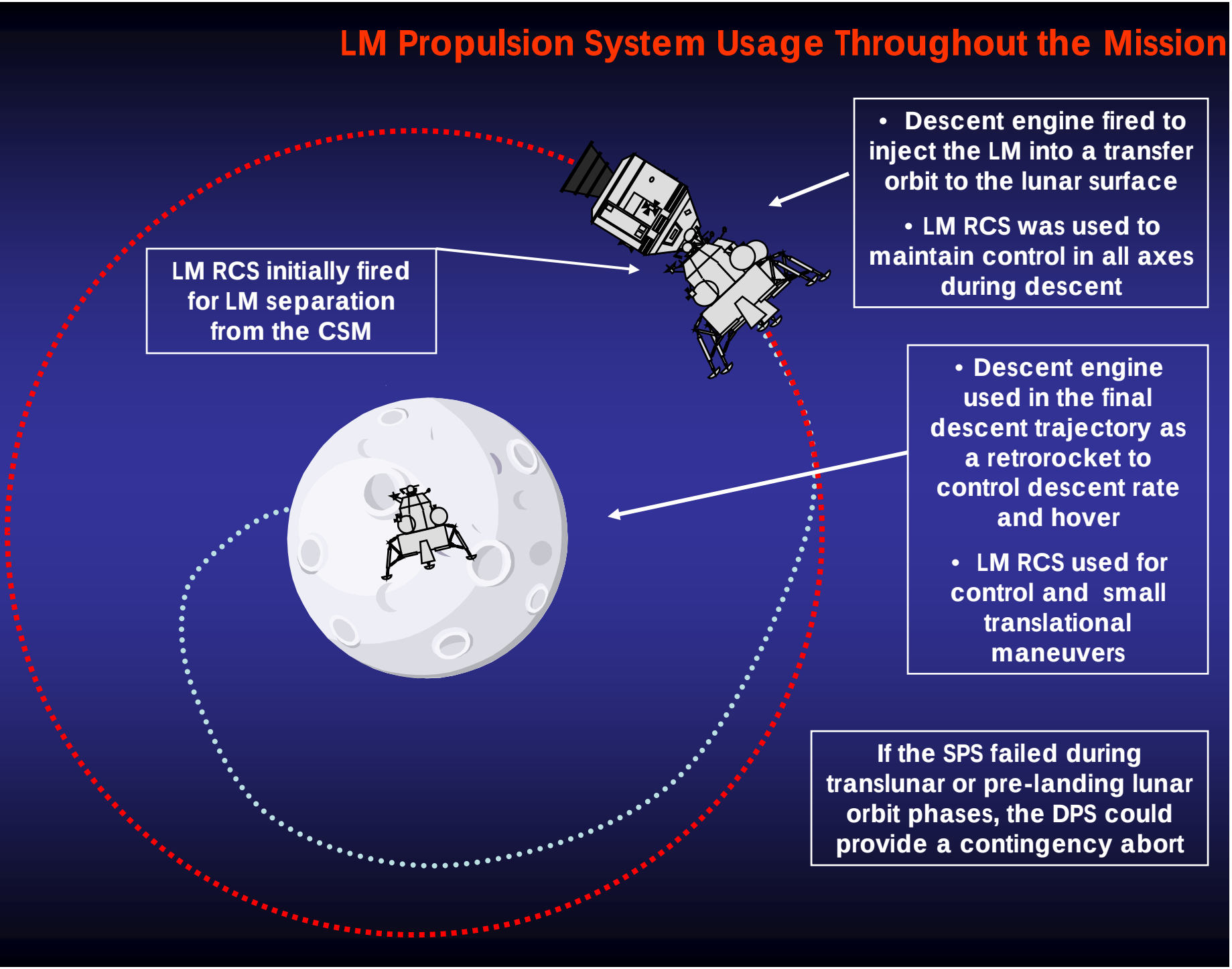
Apollo Lunar Module Propulsion Systems Overview

Lesson Objectives

- Define the systems for LM propulsion and control
- List the times during the mission at which each system was used
- Describe the basic components and operation of the
  - Descent Propulsion system (DPS)
  - Ascent Propulsion System (APS)
  - Lunar Module Reaction Control System (LM RCS)



LM Propulsion System Usage Throughout the Mission



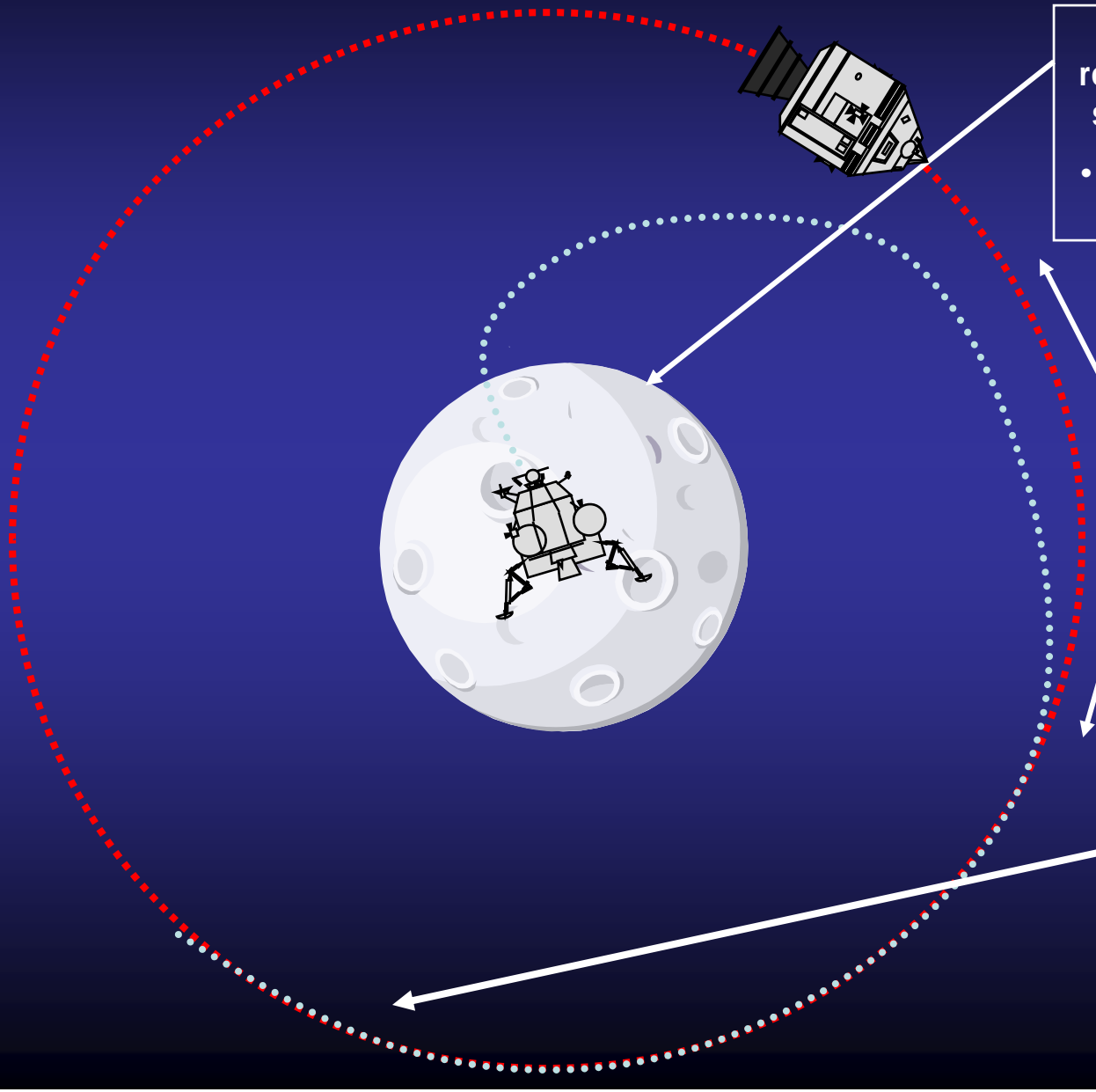
- Descent engine fired to inject the LM into a transfer orbit to the lunar surface
- LM RCS was used to maintain control in all axes during descent

LM RCS initially fired for LM separation from the CSM

- Descent engine used in the final descent trajectory as a retrorocket to control descent rate and hover
- LM RCS used for control and small translational maneuvers

If the SPS failed during translunar or pre-landing lunar orbit phases, the DPS could provide a contingency abort

LM Propulsion System Usage Throughout the Mission



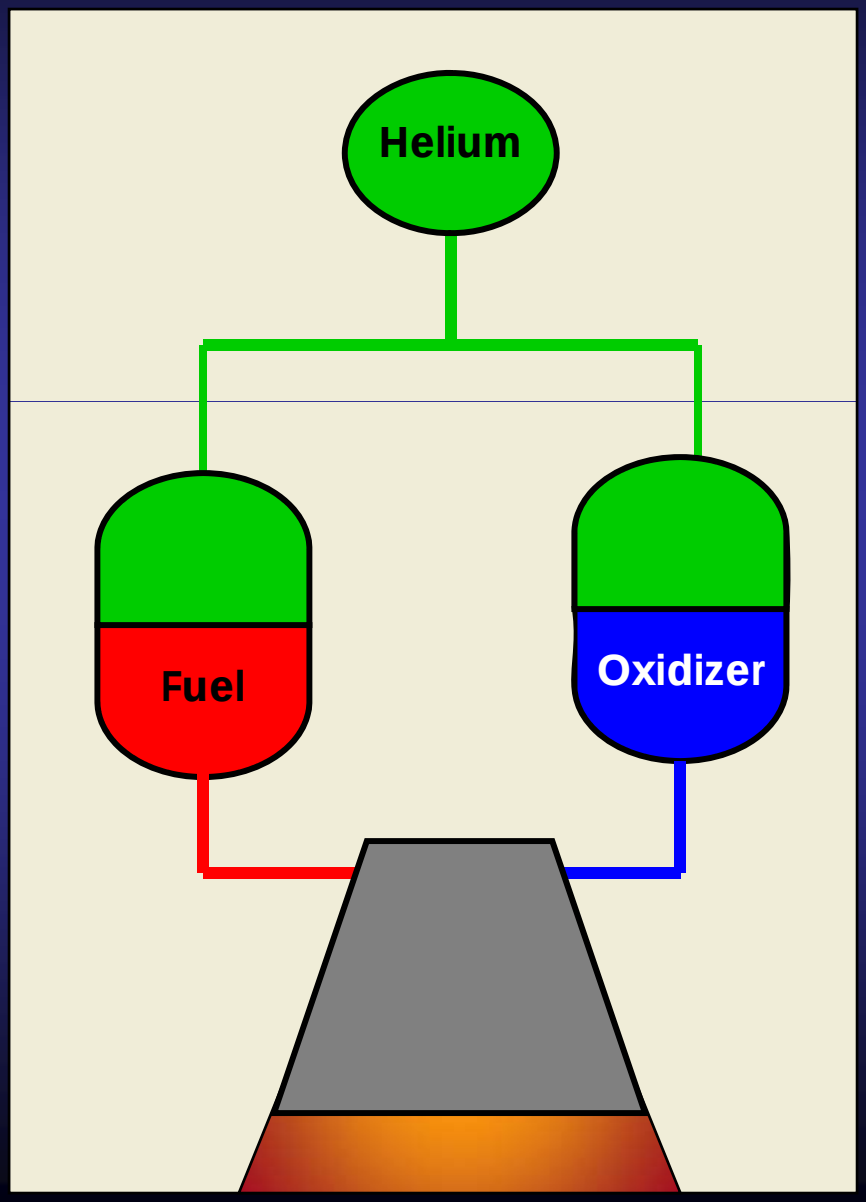
- APS provided thrust required to launch the ascent stage from the lunar surface
- LM RCS used to stabilize the LM during ascent

If an abort had been required during the descent trajectory, either the APS or the DPS could provide an abort to rendezvous with the CSM

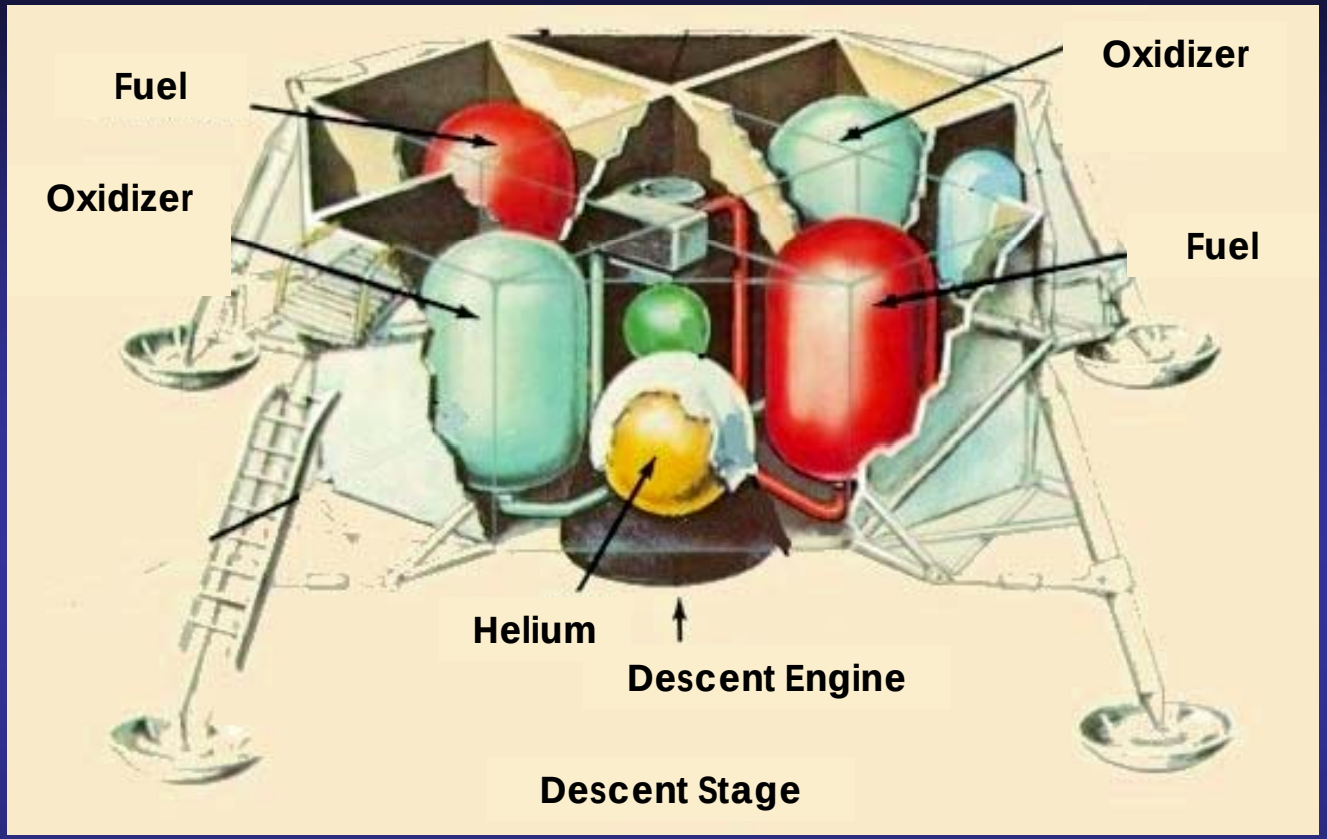
- APS provided the orbital adjustments necessary to rendezvous with the CSM
- LM RCS controlled attitude and provided small adjustments

Propulsion Systems Components

- All pressure fed systems
  - Helium for pressurization
- Hypergolic propellants
  - Fuel: Aerozine -50
  - Oxidizer: Nitrogen Tetroxide

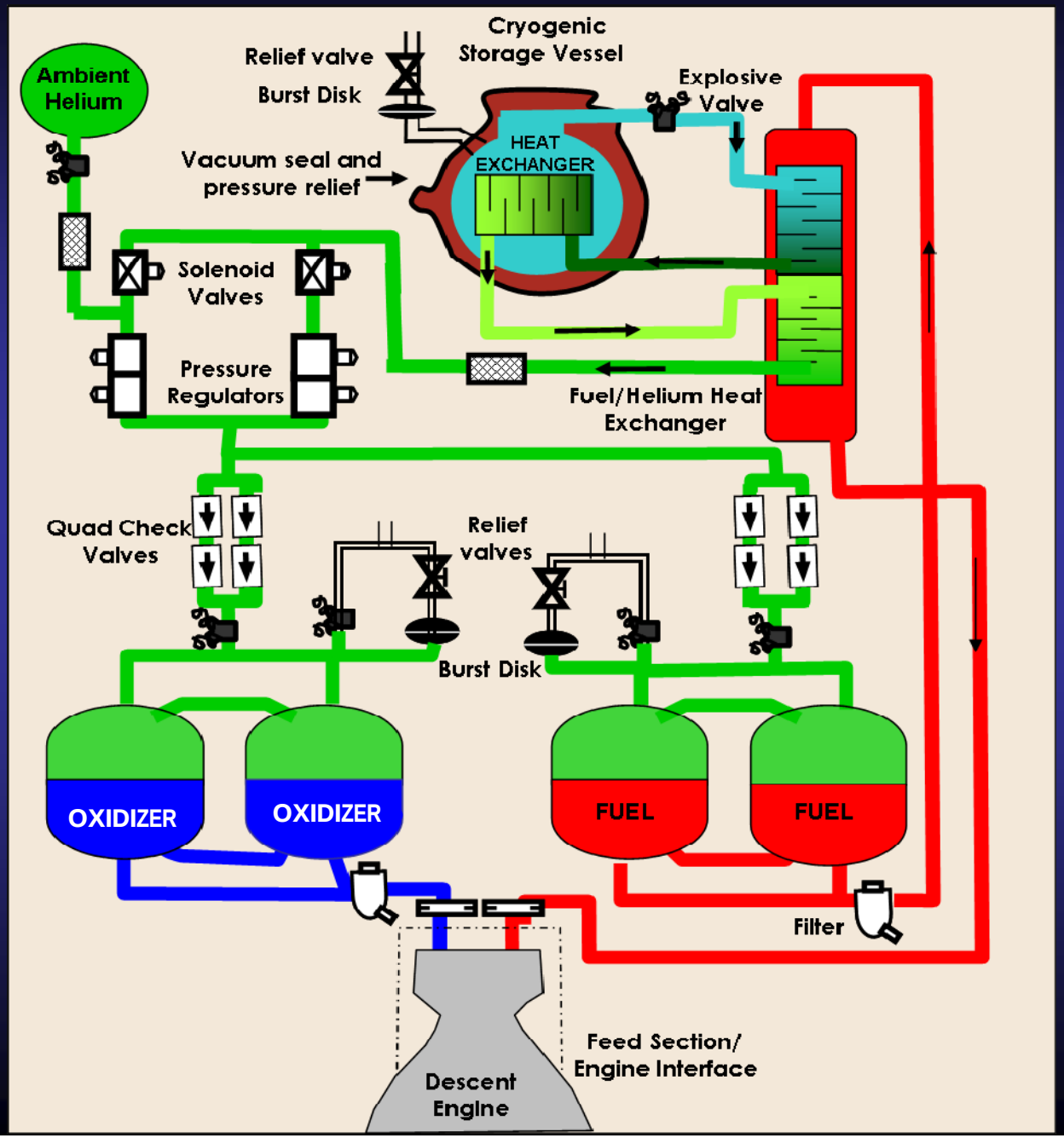


LM Descent Propulsion System Overview

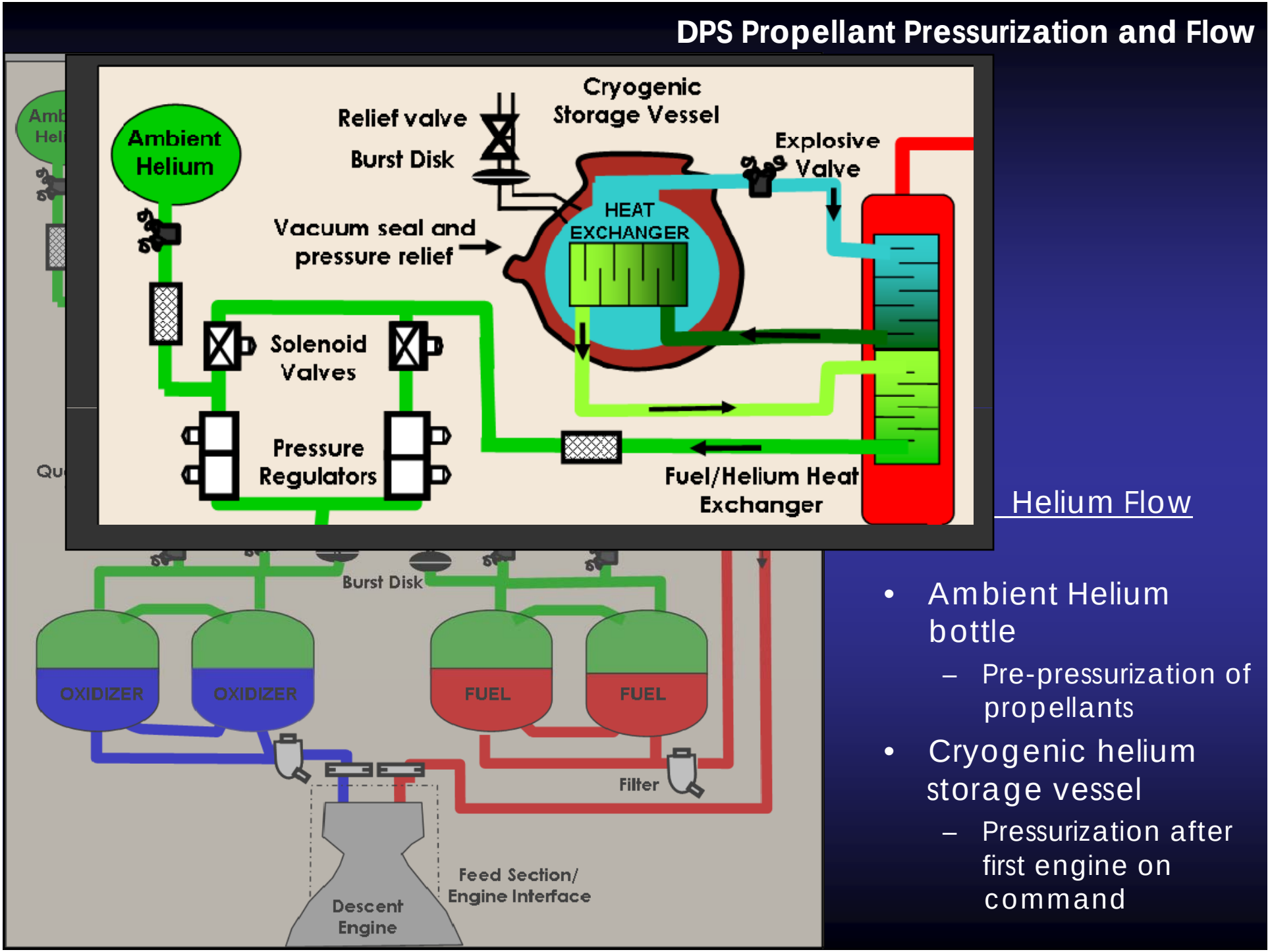


- All components located in descent stage of the LM
- Hypergolic propellants
  - 2 fuel and 2 oxidizer tanks
- Two methods for propellant pressurization

DPS Propellant Pressurization and Flow



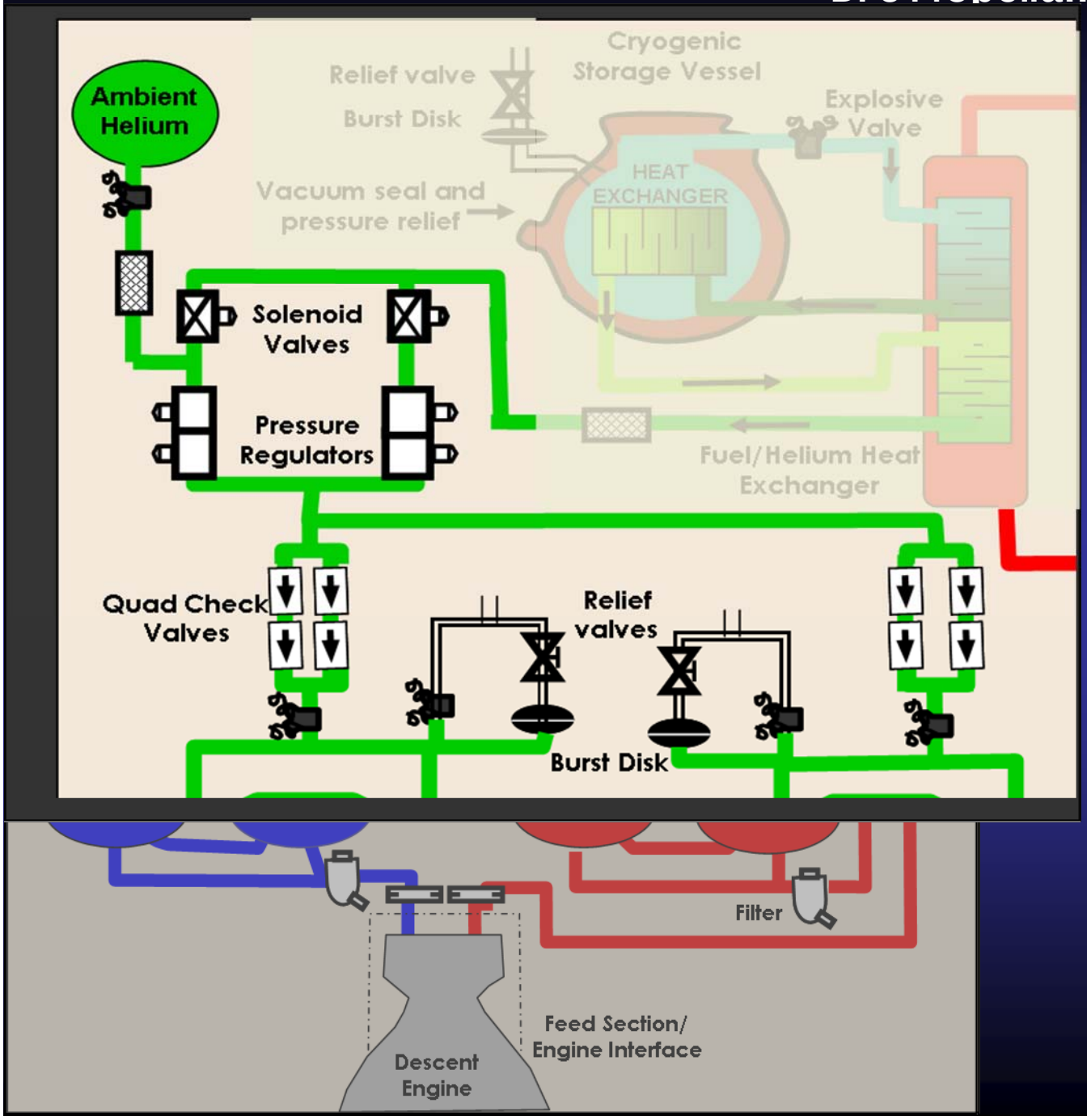
DPS Propellant Pressurization and Flow



Helium Flow

- Ambient Helium bottle
  - Pre-pressurization of propellants
- Cryogenic helium storage vessel
  - Pressurization after first engine on command

DPS Propellant Pressurization and Flow



Helium Flow

- Pressure Regulators
- Check valves
- Burst Disks
- Relief Valves

DPS Propellant Pressurization and Flow

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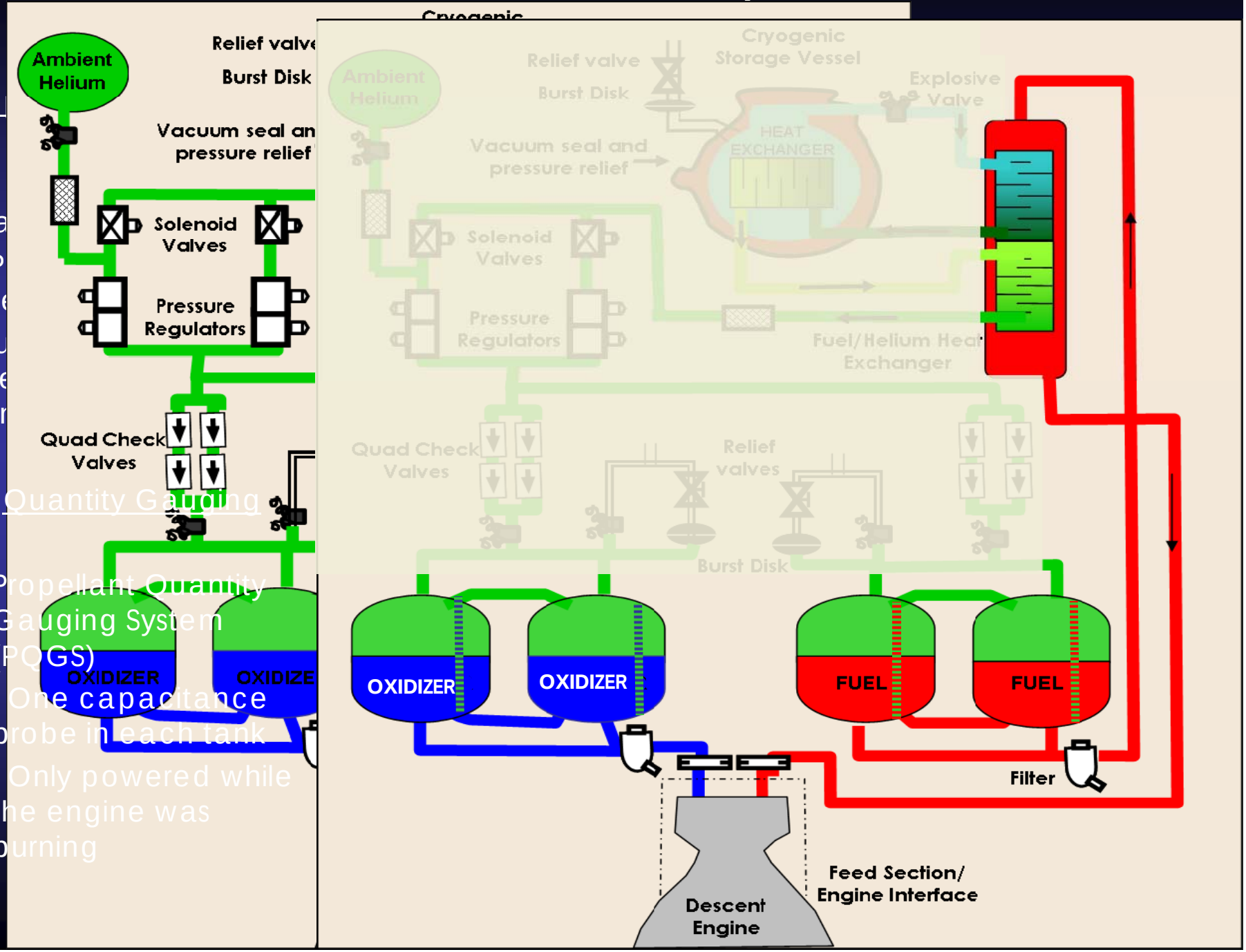
Quantity Gauging

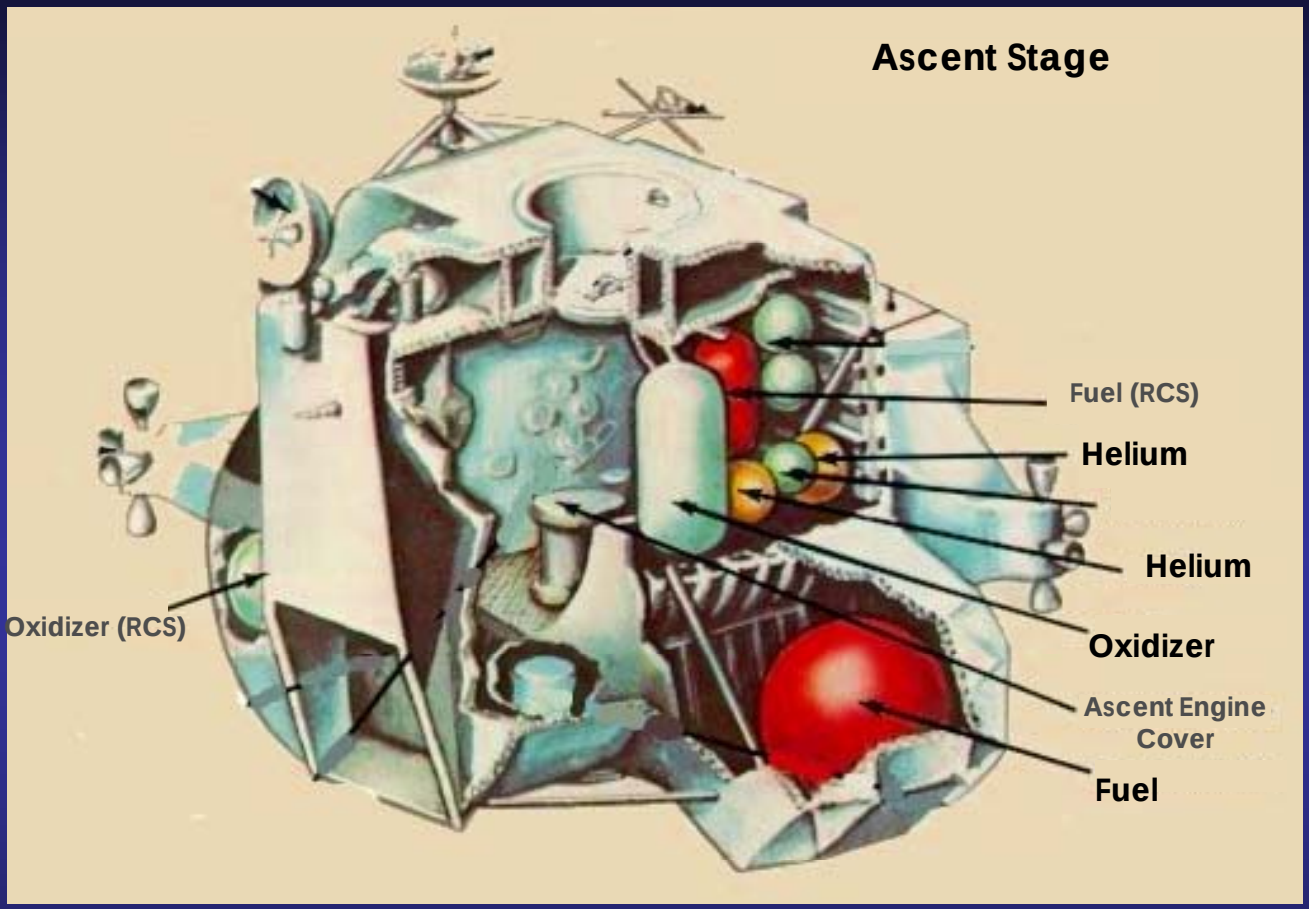
- Propellant Quantity Gauging System (PQGS)
- One capacitance probe in each tank
- Only powered while the engine was burning



DPS Engine

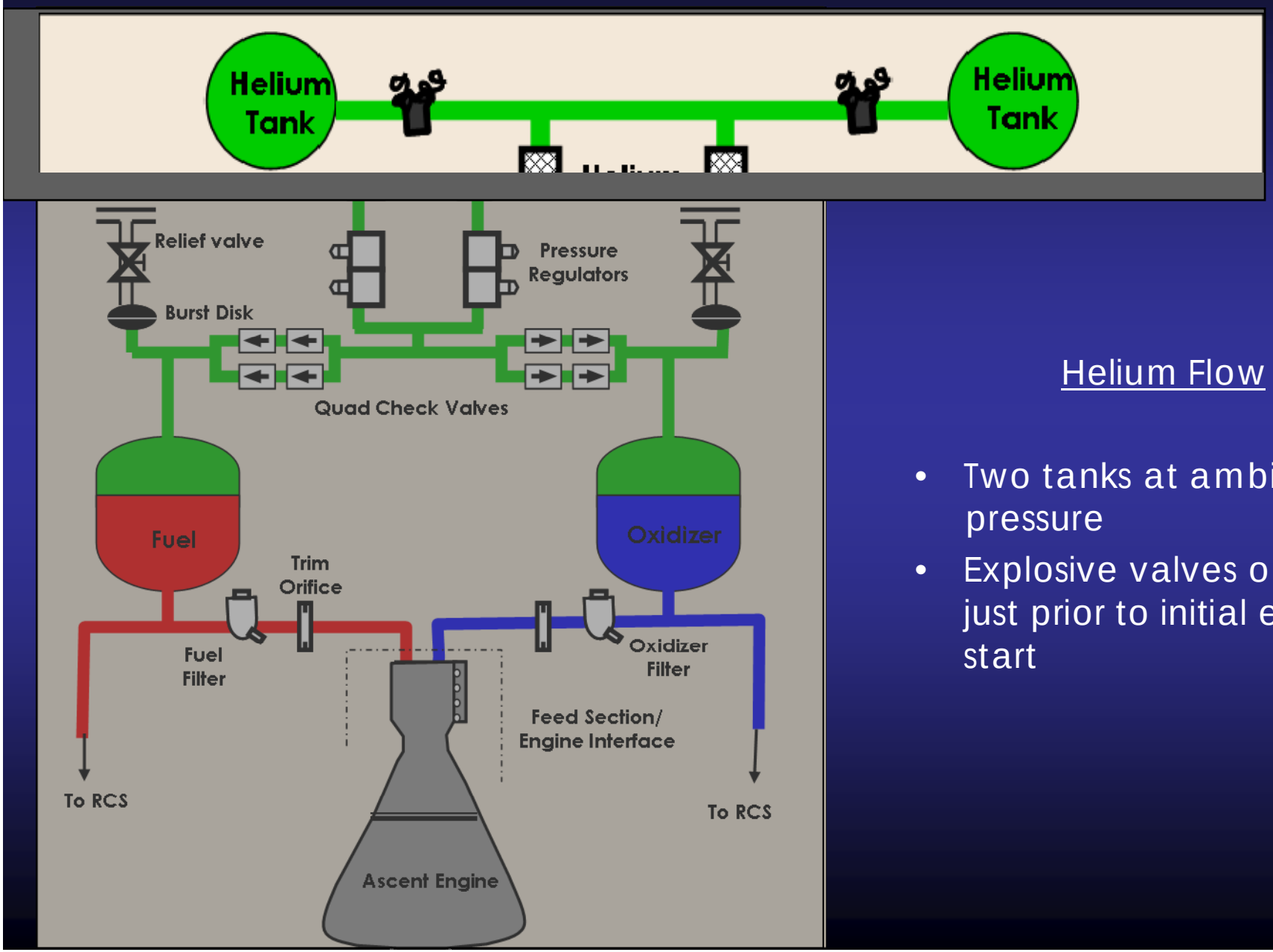
- Max Thrust – 46.7 kN (10,500 lbs)
- Throttles
  - 10:1 range
  - 1050 to 10,500 lbs thrust
- Gimbals
  - ±6 degrees in any direction
- Main components
  - Propellant control valves
  - Injector assembly
  - Combustion chamber

LM Ascent Propulsion System Overview



- All components located in ascent stage of the LM
- Hypergolic propellants
  - 1 fuel and 1 oxidizer tank
- Helium for propellant pressurization

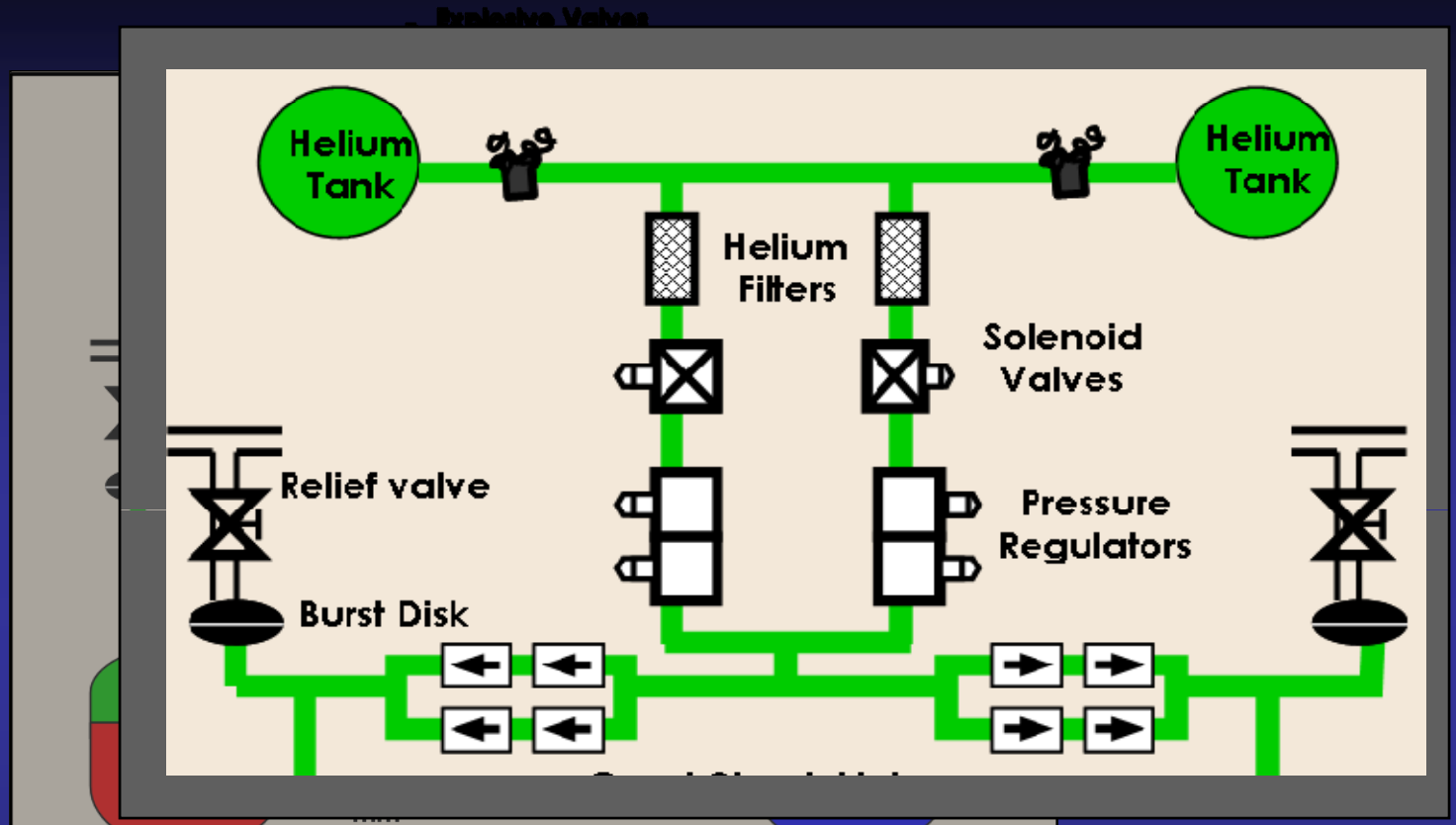
APS Engine Propellant Pressurization and Flow

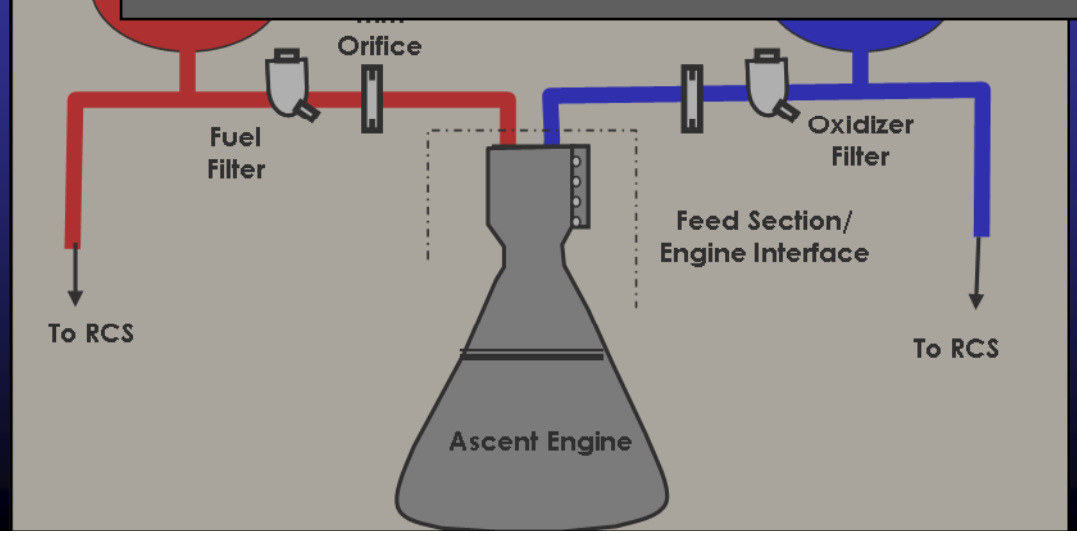


Helium Flow

- Two tanks at ambient pressure
- Explosive valves opened just prior to initial engine start

APS Engine Propellant Pressurization and Flow

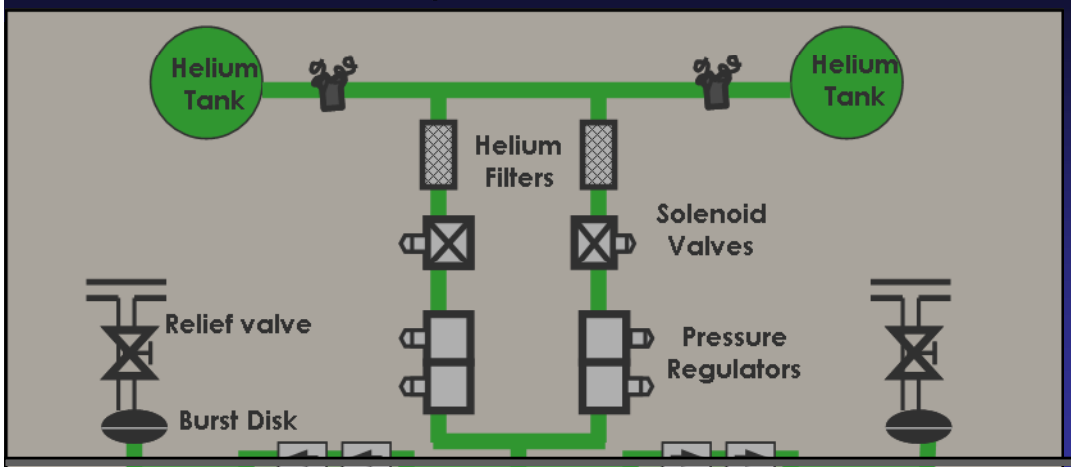


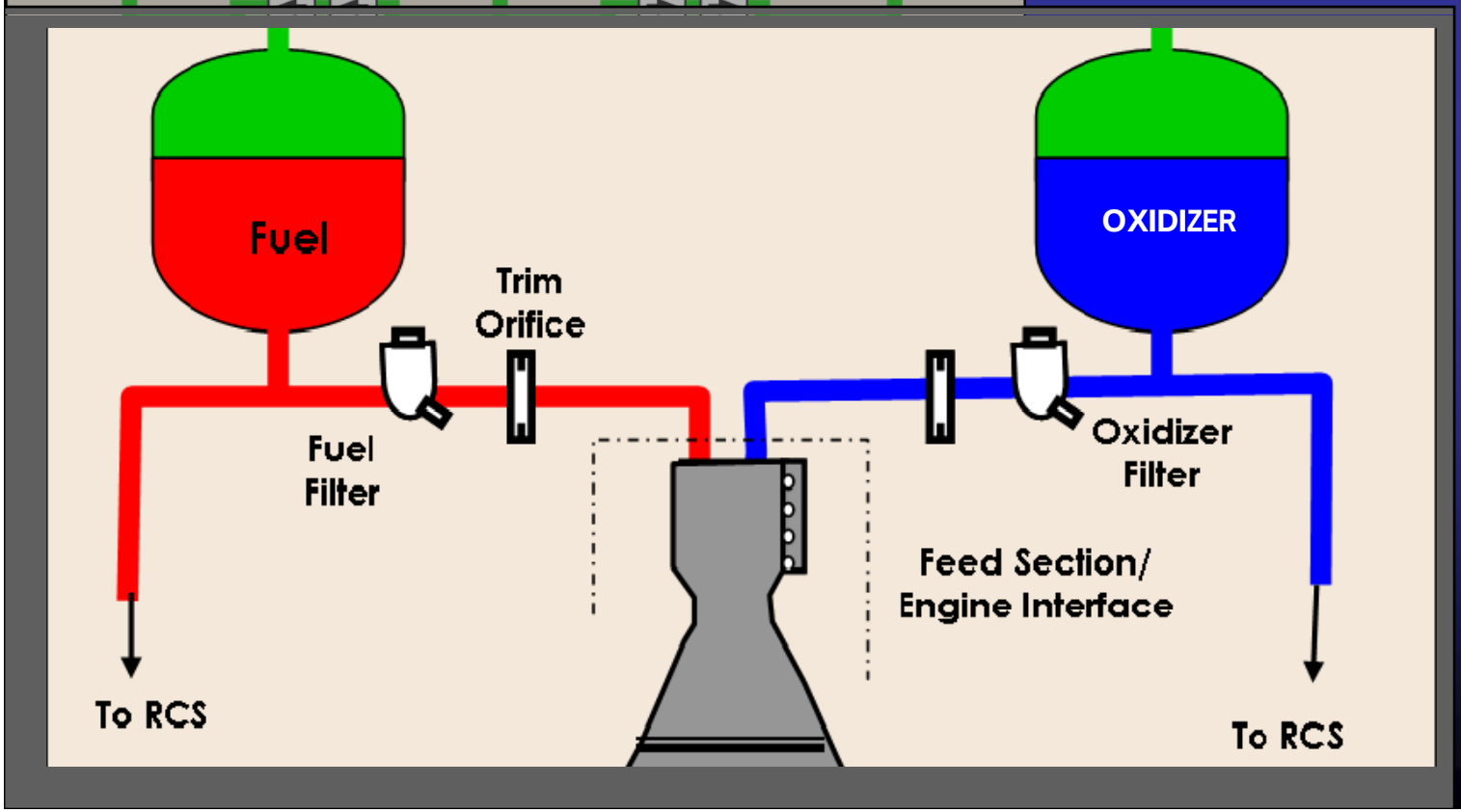


Helium Flow

- Filters
- Solenoid Valves
- Pressure Regulators
- Check Valves
- Relief Valve & Burst Disk

APS Engine Propellant Pressurization and Flow

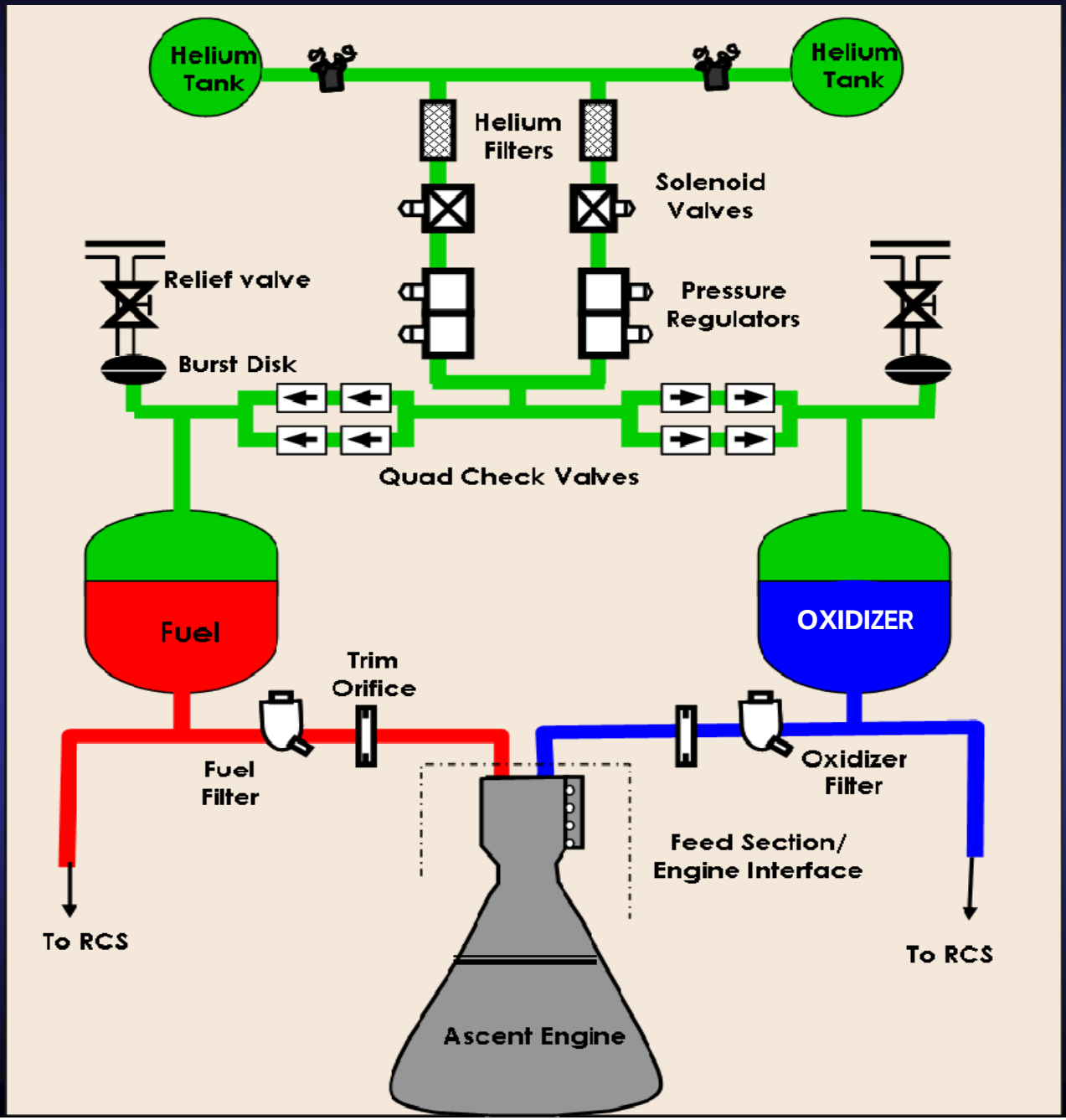




Propellant Pressurization

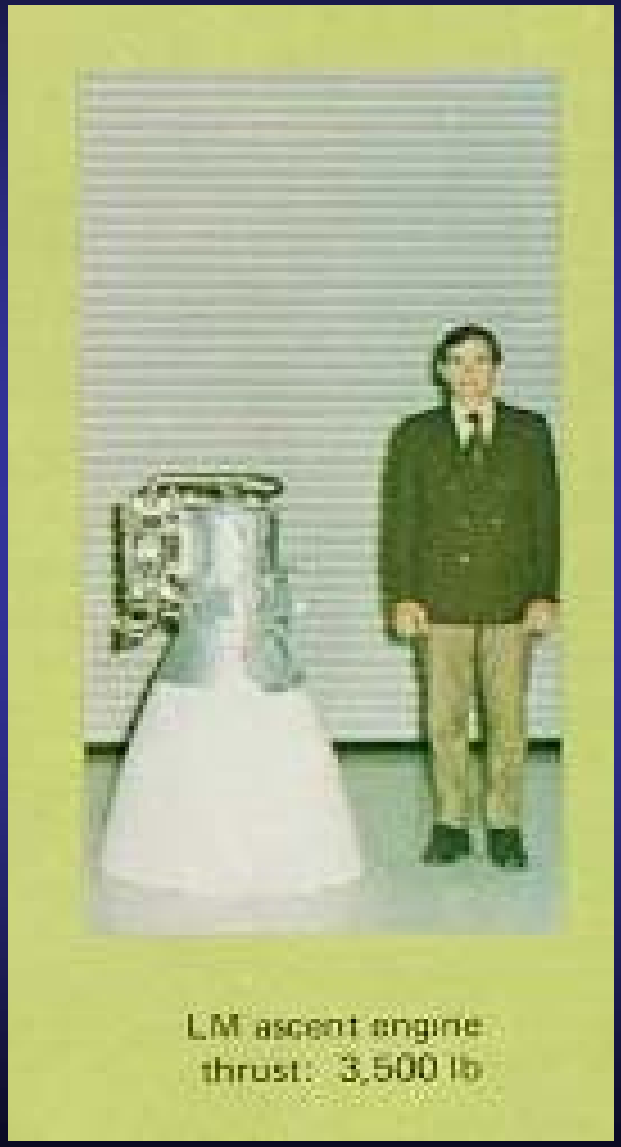
- One oxidizer and one fuel tank
- Helium pressure acted directly on the propellants
  - Two paths from tank
    - » Ascent Engine
    - » LM RCS

APS Engine Propellant Pressurization and Flow



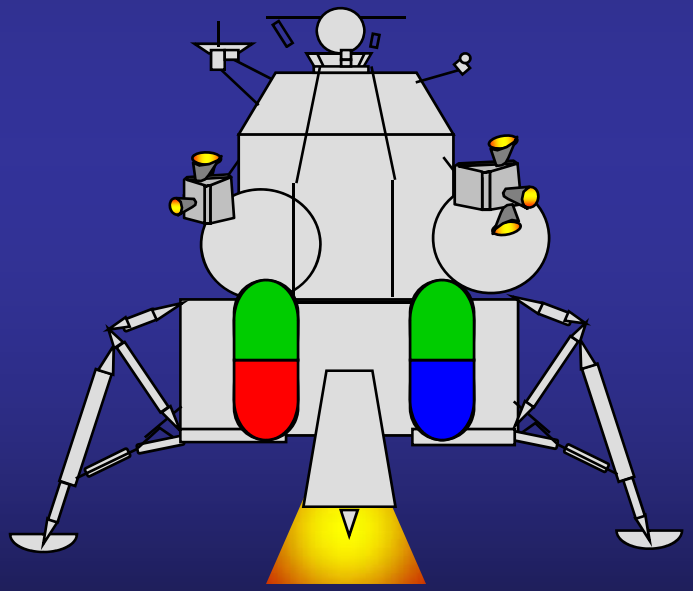
APS Engine

- Nominal Thrust was 15.5 kN (3500 lbf)
- No Throttles
- No Gimbals
- Main components
  - Propellant control valves
  - Injector assembly
  - Combustion chamber

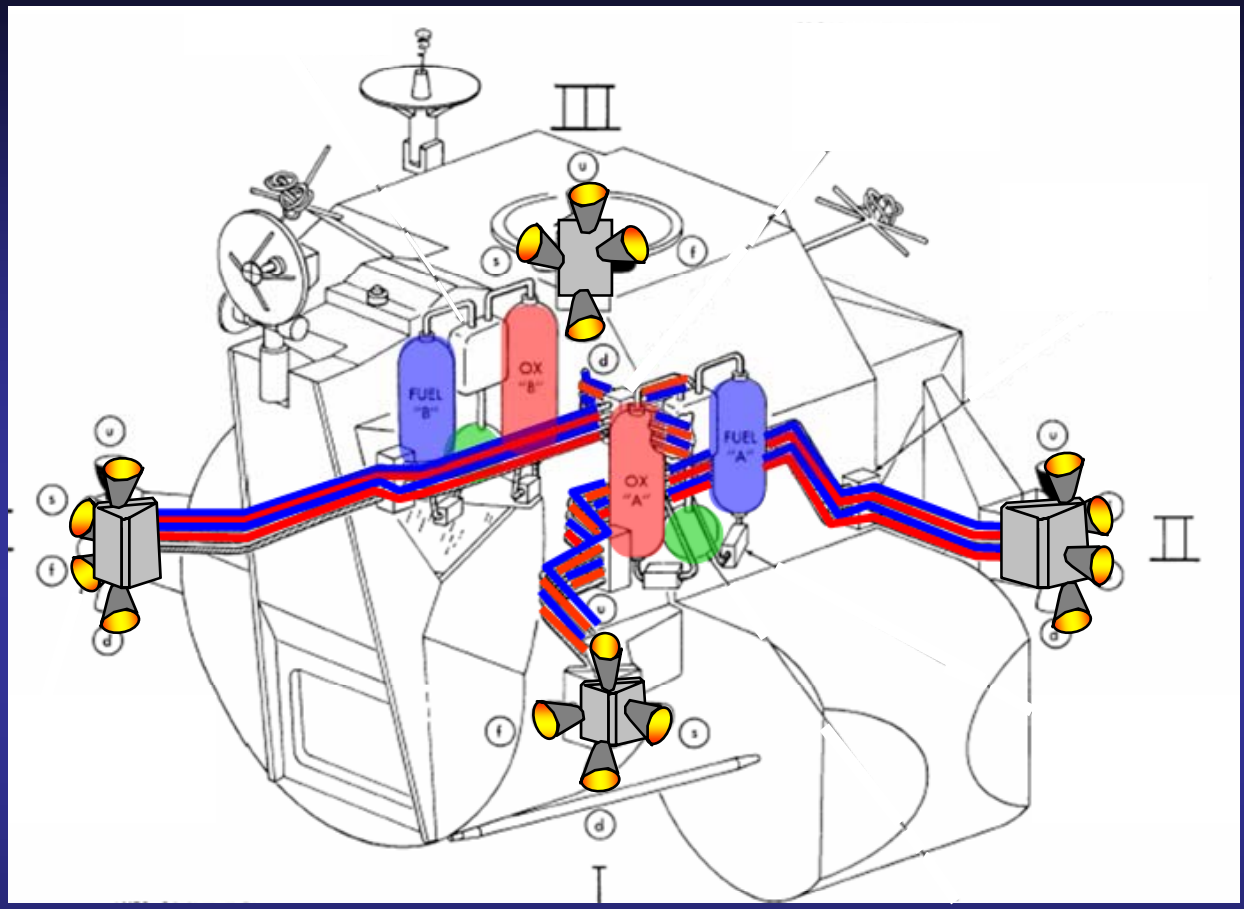


DPS and APS Operation

- Commands generated via the Primary Navigation and Guidance System (PNGS) or the Abort Guidance System (AGS)
  - Engine On/Off commands
  - Throttle commands for the DPS
- Backup manual control option
  - Throttling via the Thrust/Translation Controller Assemblies (TTCA's)
- Propellant settling via RCS prior to use of either APS or DPS



LM RCS Overview



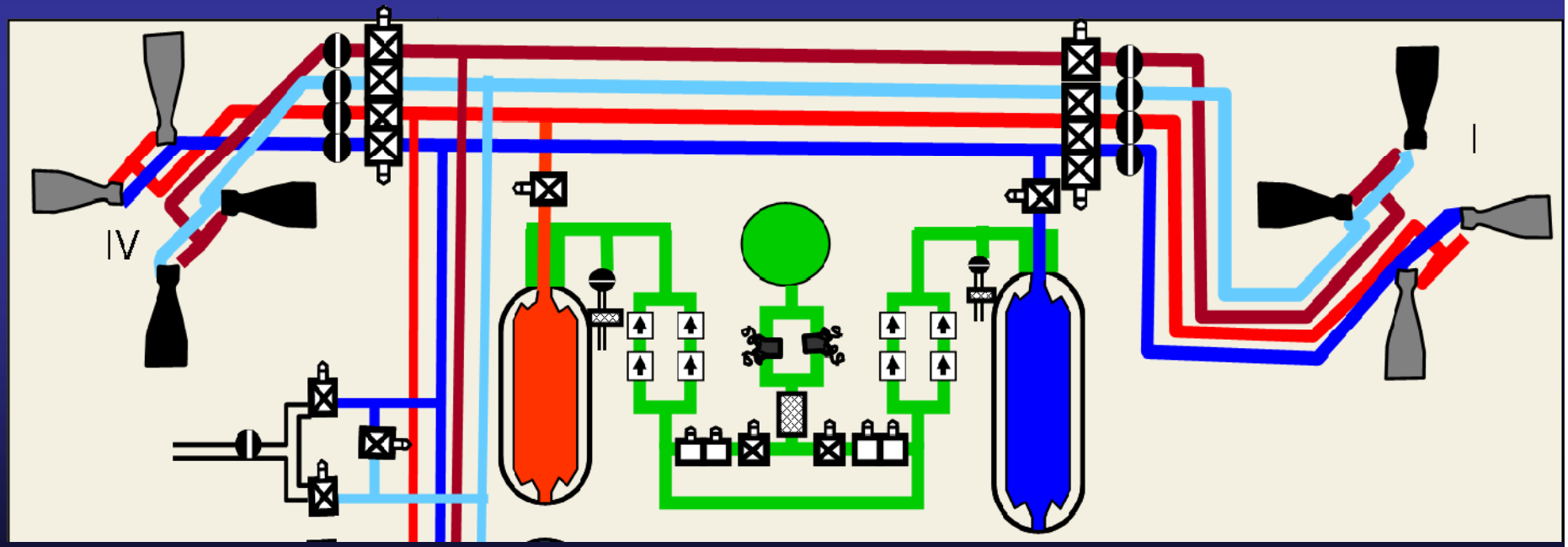
- Two Redundant Systems, A and B
- Operated simultaneously, but either system could provide control
- All components contained within the ascent portion of the LM
- Each system supplied propellant for eight jets

LM RCS Overview

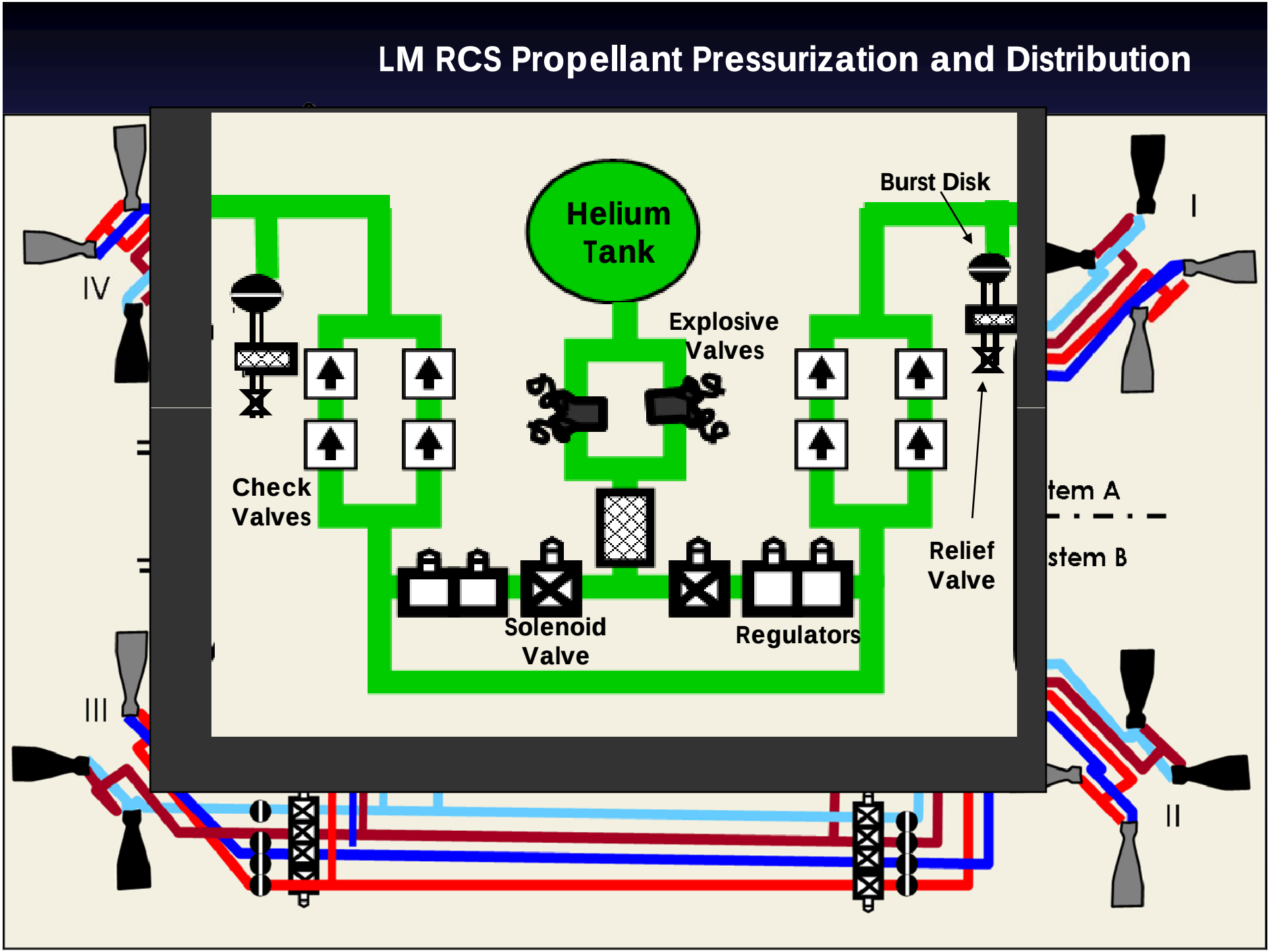
Each System Contained

- One Helium tank and associated helium components
- One oxidizer and one fuel tank
- Propellant distribution lines and components

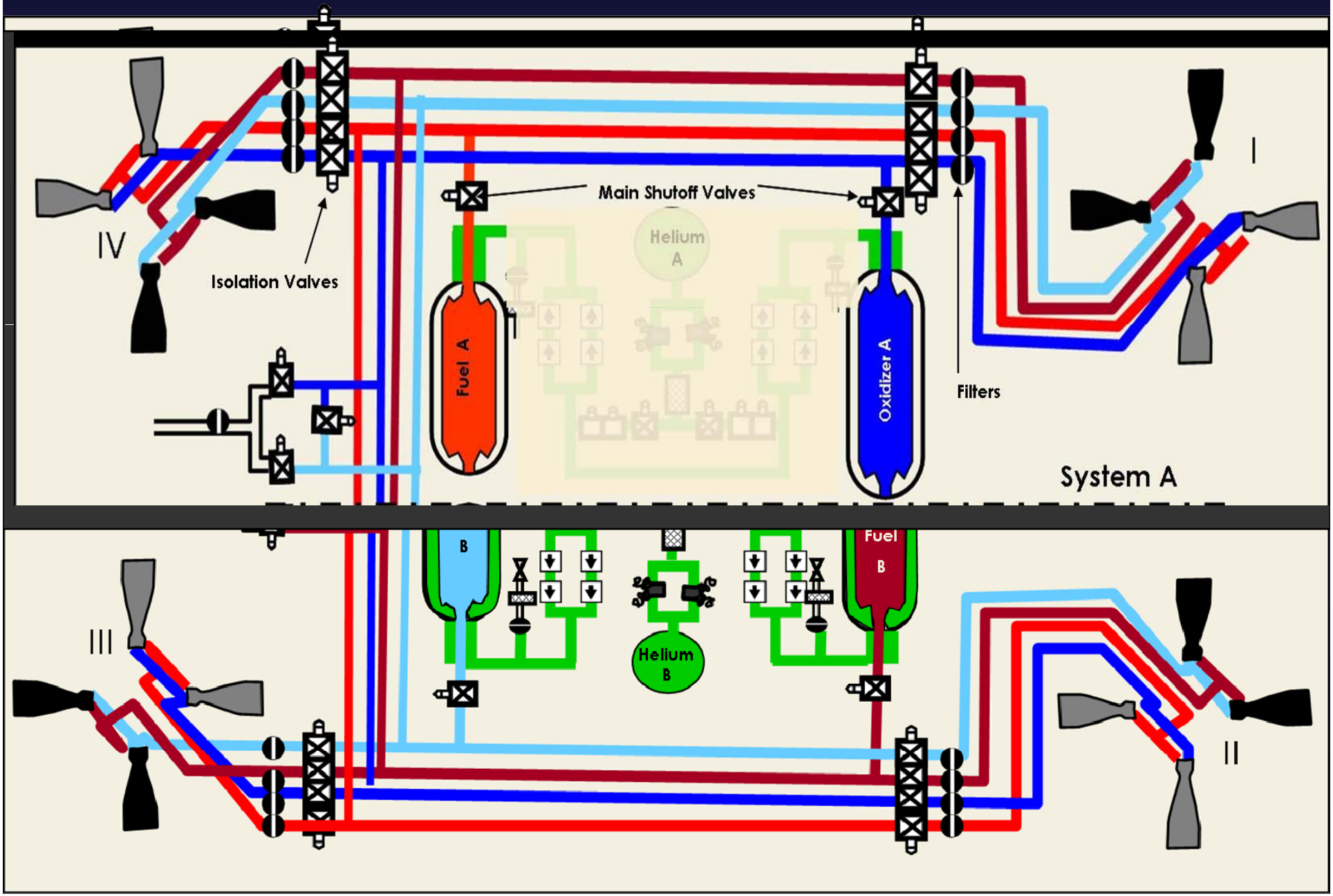
- Each system supplied propellant for eight jets
- Interconnect and crossfeed capability



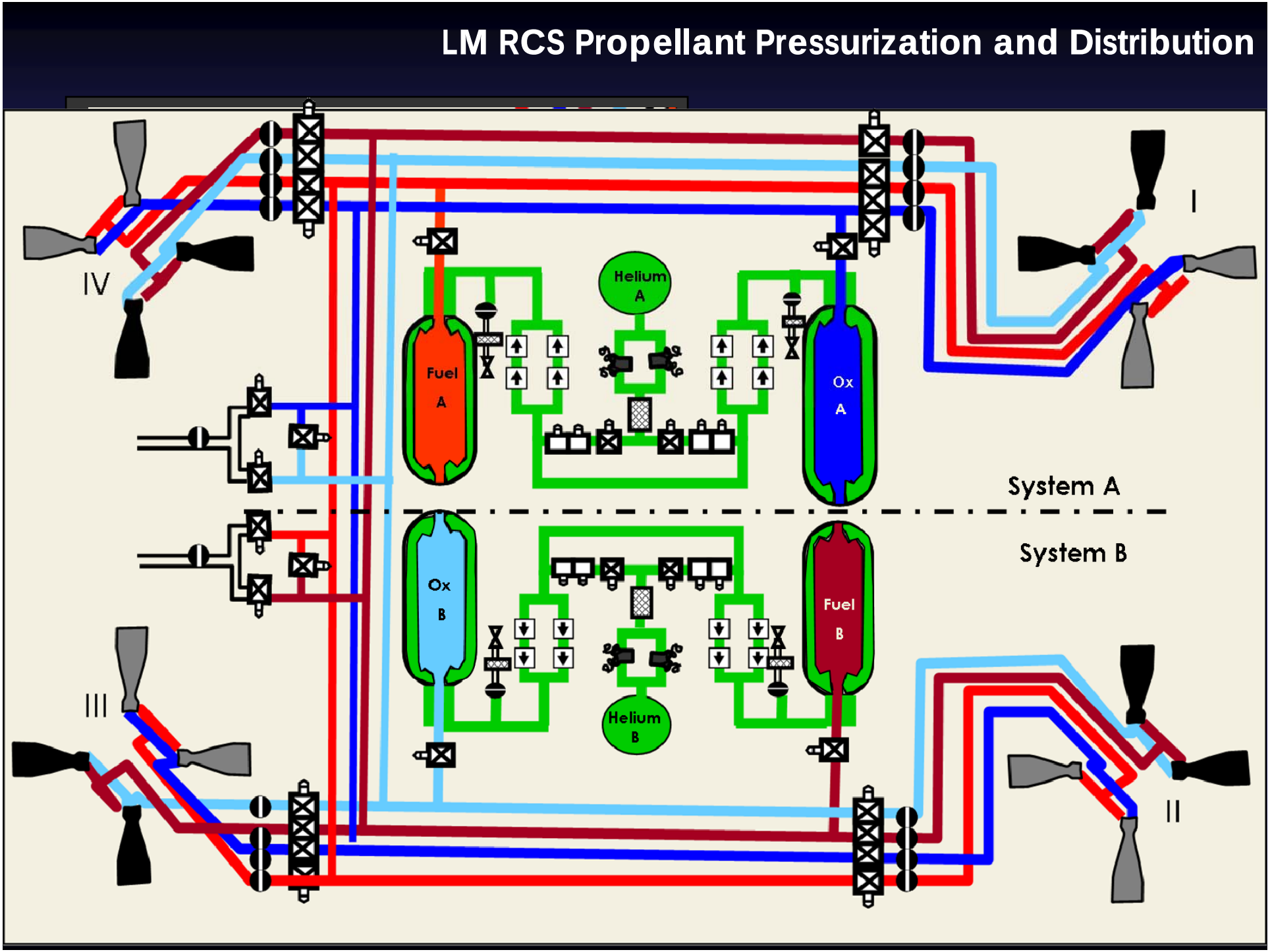
LM RCS Propellant Pressurization and Distribution



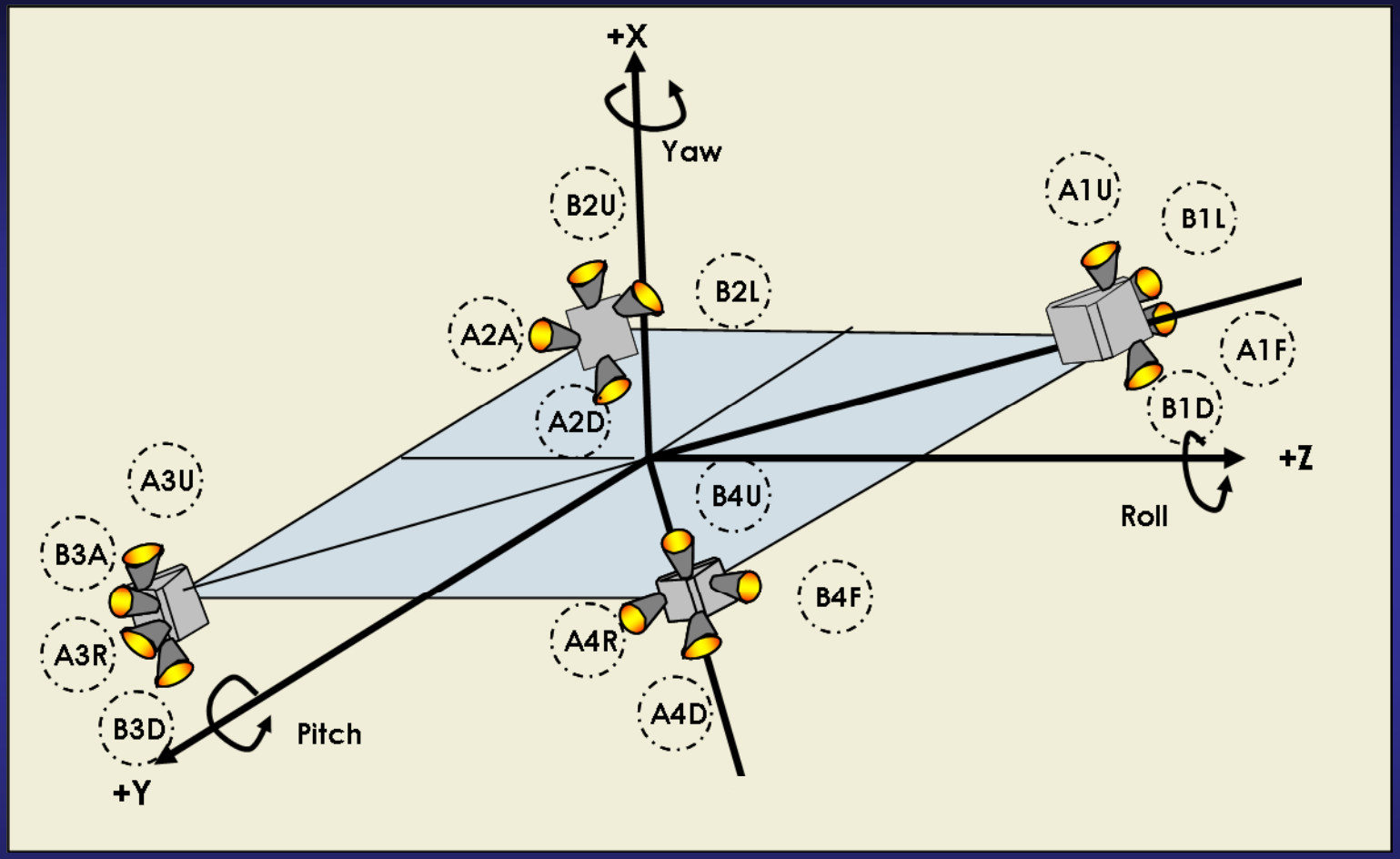
LM RCS Propellant Pressurization and Distribution



LM RCS Propellant Pressurization and Distribution



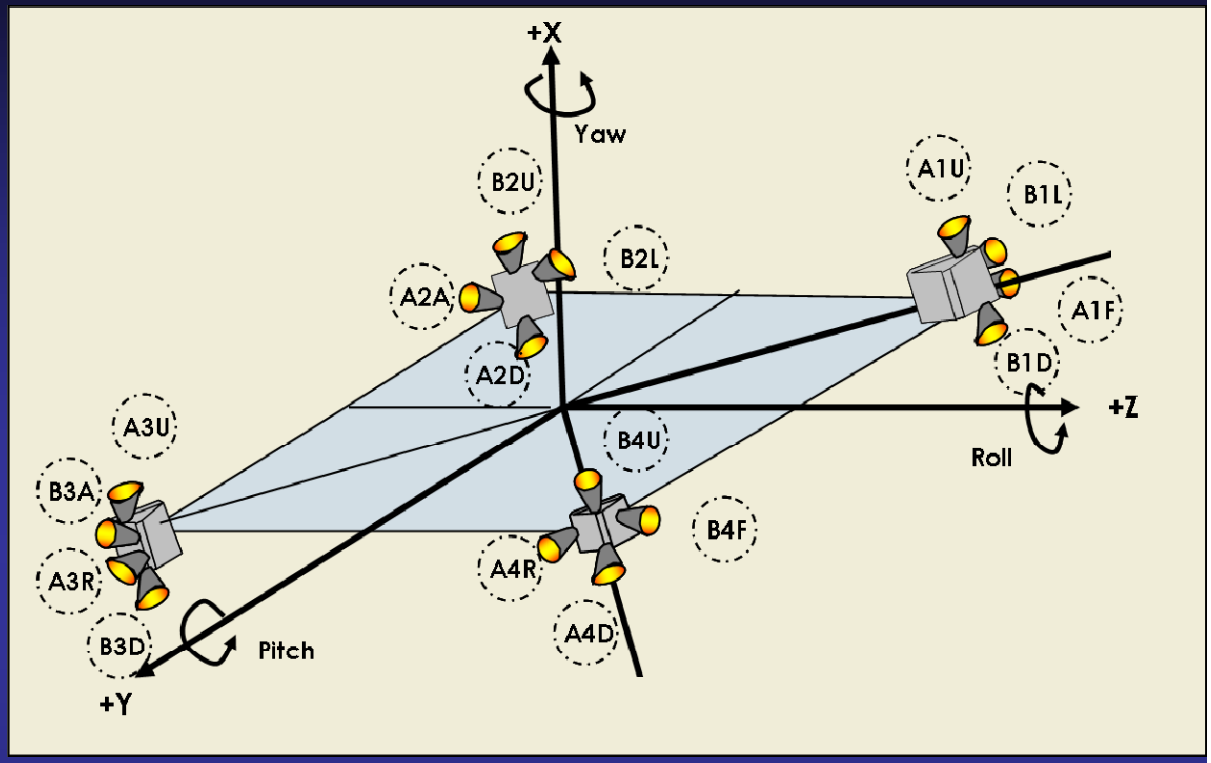
LM RCS Thrusters



- 16 thrust chamber assemblies (TCA's)
- Each produced about 445 N (100 lbf) of thrust
- Pulse mode or steady state operation

LM RCS Operational Use

- Provided rotational and translational maneuvers
- Modes of control
  - Automatic
  - Semi-automatic
  - Manual
- Commands generated from
  - Primary Guidance and Navigation Subsystem (PGNS)
  - Abort guidance section (AGS) of the Stabilization and Control Subsystem (SCS)



Lunar Module Propulsion Summary

- Define the systems for LM Propulsion and control
- List the times during the mission at which each system was used
- Describe the basic components and operation of the
  - DPS
  - APS
  - LM RCS