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

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

Helium Flow

- Relief valve
- Burst Disk
- Vacuum seal and pressure relief
- Cryogenic Storage Vessel
- Explosive Valve
- Pressure Regulators
- Solenoid Valves
- Fuel/Helium Heat Exchanger
- HEAT EXCHANGER

Diagram showing the flow of helium through various components of the DPS propellant system.
Helium Flow

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

- 2 Oxidizer and 2 Fuel Tanks
- Propellant Retention devices within tanks
- Fuel routed through heat exchanger prior to entering engine

Quantity Gauging

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

- Oxidizer A
- Crossfeed Valve
- Ascent Propulsion Interconnect Valves
- Fuel A-B Crossfeed Valve

System A
- Fuel A
- Ox A
- Helium A

System B
- Ox B
- Fuel B
- Helium B
16 thrust chamber assemblies (TCA’s)
Each produced about 445 N (100 lbf) of thrust
Pulse mode or steady state operation
• 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)
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• Describe the basic components and operation of the
  - DPS
  - APS
  - LM RCS