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
• 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
- Ambient Helium bottle
  - Pre-pressurization of propellants
- Cryogenic helium storage vessel
  - Pressurization after first engine on command
DPS Propellant Pressurization and 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
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
• Nominal Thrust was 15.5 kN (3500 lbf)
• No Throttles
• No Gimbals
• Main components
  - Propellant control valves
  - Injector assembly
  - Combustion chamber
• 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

System 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)
Lunar Module Propulsion Summary

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

Lunar Module Reaction Control System
(LM RCS)

Ascent Propulsion System
(APS)

Descent Propulsion System
(DPS)