Main Propulsion for the Ares Projects

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The NASA Ares Projects Office is developing the launch vehicles to support exploration beyond low earth orbit for decades to come.

Ares I is a crewed vehicle, and Ares V is a heavy lift vehicle being designed to launch cargo into LEO and transfer cargo and crews to the Moon.

The performance, reliability, operability, and cost of the Ares propulsion systems are critical to everything we aspire to do.

Ares propulsion systems are based on heritage hardware and experience from Apollo to the Space Shuttle to current ELVs.

My goal today is to update you on the status of Ares propulsion systems.
Our Exploration Fleet
What Will the Vehicles Look Like?

Earth Departure Stage

Ares V
Cargo Launch Vehicle

Orion
Crew Exploration Vehicle

Altair
Lunar Lander

Ares I
Crew Launch Vehicle
### Launch Vehicle Comparisons

#### Saturn V
- **Height:** 110.9 m (364.0 ft)
- **Gross Liftoff Mass:** 2,948.4 mT (6,500K lbm)
- **Payload Capability:** 44.9 mT (99.0K lbm) to TLI
- **Gross Liftoff Mass to LEO:** 118.8 mT (262.0K lbm)

#### Space Shuttle
- **Height:** 56.1 m (184.2 ft)
- **Gross Liftoff Mass:** 2,041.1 mT (4,500.0K lbm)
- **Payload Capability:** 25.0 mT (55.1K lbm) to TLI
- **Gross Liftoff Mass to LEO:** 62.8 mT (138.5K lbm)

#### Ares I
- **Height:** 99.1 m (325.0 ft)
- **Gross Liftoff Mass:** 927.1 mT (2,044.0K lbm)
- **Payload Capability:** 25.5 mT (56.2K lbm) to LEO

#### Ares V
- **Height:** 116.2 m (381.1 ft)
- **Gross Liftoff Mass:** 3,704.5 mT (8,167.1K lbm)
- **Payload Capability:** 71.1 mT (156.7K lbm) to TLI (with Ares I)
- **Gross Liftoff Mass to LEO:** 187.7 mT (413.8K lbm)

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**Legend**
- **mT** - metric tons
- **TLI** - Trans-Lunar Injection
- **LEO** - Low Earth Orbit
- **LOX/LH2**
- **S-IVB (One J-2 engine)**
  - 108.9 mT (240.0K lbm)
  - LOX/LH2
- **S-II (Five J-2 engines)**
  - 453.6 mT (1,000.0K lbm)
  - LOX/LH2
- **S-IC (Five F-1)**
  - 1,769.0 mT (3,900.0K lbm)
  - LOX/RP-1
- **Upper Stage (One J-2X)**
  - 137.1 mT (302.2K lbm)
  - LOX/LH2
- **Earth Departure Stage (EDS) (1 J-2X)**
  - 253.0 mT (557.7K lbm)
  - LOX/LH2
- **Core Stage (Six RS-68 Engines)**
  - 1,587.3 mT (3,499.5K lbm)
  - LOX/LH2
- **Two 5.5-Segment Reusable Solid Rocket Booster (RSRB’s)**
- **One 5-Segment Reusable Solid Rocket Booster (RSRB)**

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**Building on a Foundation of Proven Technologies**

- **Saturn V:** 1967–1972
- **Space Shuttle:** 1981–Present
- **Ares I:** First Flight 2015
- **Ares V:** First Flight 2018
Ares Vehicles: Commonality & Heritage Hardware

Upper Stage Derived Vehicle Systems

J-2X Upper Stage Engine

First Stage (5-Segment RSRB)

Elements from RSRB

Ares I
25.5 mT (56.2K lbm) to Low Earth Orbit (LEO)

Ares V
71.1 mT (156.7K lbm) to TLI (with Ares I)
63.0 mT (138.5K lbm) to Direct TLI
187.7 mT (413.8K lbm) to LEO

USAF RS-68B From Delta IV RS-68

Delta IV

Note: Vehicles not to scale
Ares I Elements

Encapsulated Service Module (ESM) Panels

Instrument Unit
- Primary Ares I control avionics system
- *NASA Design / Boeing Production ($0.8B)*

Upper Stage
- 137.1 mT (302.2K lbm) LOX/LH₂ prop
- 5.5-m (18-ft) diameter
- Aluminum-Lithium (Al-Li) structures
- Instrument unit and interstage
- Reaction Control System (RCS) / roll control for first stage flight
- Primary Ares I control avionics system
- *NASA Design / Boeing Production ($1.14B)*

Interstage

First Stage
- Derived from current Shuttle RSRM/B
- Five segments/Polybutadiene Acrylonitrile (PBAN) propellant
- Recoverable
- New forward adapter
- Avionics upgrades
- *ATK Launch Systems ($1.96B)*

Upper Stage Engine
- Saturn J-2 derived engine (J-2X)
- Expendable
- *Pratt and Whitney Rocketdyne ($1.28B)*

Stack Integration
- 927.1 mT (2,044.0K lbm) gross liftoff mass (GLOM)
- 99.1 m (325.0 ft) in length
- *NASA-led*
Mass: 733 mT (1,616 lbm)
Thrust: 15.8 MN
Burn Duration: 126 sec
Height: 53 m (174 ft)
Diameter: 3.7 m (12 ft)
**Propellant Load:** 138 mT (304K lbm)  
**Total Mass:** 156 mT (344K lbm)  
**Dry Mass:** 16.3 mT (36K lbm)  
**Dry Mass (Interstage):** 4.1 mT (9K lbm)  
**Length:** 25.6 m (84 ft)  
**Diameter:** 5.5 m (18 ft)  
**LOX Tank Pressure:** 50 psig  
**LH$_2$ Tank Pressure:** 42 psig
Upper Stage Engine Element challenge:
Design an engine...
based on an evolution of the Apollo/Saturn era J-2 (GG cycle, 230,000 lbf, 424 seconds $I_{sp}$)...
increased to 294,000 lbf (1.3M Newtons) thrust...
increased to 448 seconds of specific impulse (highest ever $I_{sp}$ for an engine of this class) ...
nearly two years faster than an engine of this class has been developed...

and make it work for two different vehicles with two different missions, keeping as much commonality as possible.
**J-2X Engine**

*Used on Ares I and Ares V*

**Turbomachinery**
- Based on J-2S MK-29 design

**Gas Generator**
- Based on RS-68 design

**Engine Controller**
- Based directly on RS-68 design and software architecture

**Regeneratively Cooled Nozzle Section**
- Based on long history of RS-27 success

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**Flexible Inlet Ducts**
- Based on J-2 & J-2S ducts

**Open-Loop Pneumatic Control**
- Similar to J-2

**HIP-bonded MCC**
- Based on RS-68 demonstrated technology

**Metallic Nozzle Extension**
- New design

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**Mass:** 2.5 mT (5,511 lbm)
**Height:** 4.7 m (15.4 ft)
**Diameter:** 3.05 m (10 ft)
**Thrust:** 1,308K N (294K lbm) (vac)
**Isp:** 448 sec (vac)
**Height:** 4.7 m (15.4 ft)
**Diameter:** 3.05 m (10 ft)
**Operation Time:** 500 sec.
**Altitude Start / On-orbit Restart**
**Operational Life:** 8 starts/ 2,600 sec

*Pratt & Whitney Rocketdyne, Inc.*
Ares V Elements

**Earth Departure Stage (EDS)**
- One Saturn-derived J-2X LOX/LH₂ engine (expendable)
- 10-m (33-ft) diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures, instrument unit and interstage
- Primary Ares V avionics system

**Stack Integration**
- 3,704.5 mT (8,167.1K lbm) gross liftoff mass
- 116.2 m (381.1 ft) in length

**Solid Rocket Boosters**
- Two recoverable 5.5-segment PBAN-fueled boosters (derived from current Ares I first stage)

**Core Stage**
- Six Delta IV-derived RS-68 LOX/LH₂ engines (expendable)
- 10-m (33-ft) diameter stage
- Composite structures
- Aluminum-Lithium (Al-Li) tanks
RS-68 to RS-68B

* Redesigned turbine nozzles to increase maximum power level by ≈ 2%

Redesigned turbine seals to significantly reduce helium usage for pre-launch

Helium spin-start duct redesign, along with start sequence modifications, to help minimize pre-ignition free hydrogen

* Higher element density main injector improving specific impulse by ≈ 2% and thrust by ≈ 4%

Increased duration capability ablative nozzle

♦ Other RS-68A upgrades or changes that may be included:
  • Bearing material change
  • New Gas Generator igniter design
  • Improved Oxidizer Turbo Pump temp sensor
  • Improved hot gas sensor
  • 2nd stage Fuel Turbo Pump blisk crack mitigation
  • Cavitation suppression
  • ECU parts upgrade

♦ RS-68A Upgrades
What Progress Have We Made?

♦ Ares I
  • Ares I, First Stage, & Upper Stage PDRs complete in ’08
  • Numerous First Stage development and static motor casting & firing tests, wind tunnel, nozzle, materials, parachute drop tests complete
  • All Ares I-X hardware at KSC for ‘09 launch

♦ J-2X
  • Completed PDR in ’07, CDR in ’08
  • SSC A-1 test stand converted, A-3 stand construction under way to support J-2X
  • Numerous heritage, component, subscale, and powerpack tests and CFD completed in support of turbomachinery, combustion devices, etc.
  • Casting/machining trials under way/long-lead parts procured

♦ Ares V
  • Subscale main injector tests, analysis conducted on RS-68B
  • LCCR establishes POD concept ’08
  • RFP for concept definition issued ‘09

For more information go to www.nasa.gov/ares