Hubble Space Telescope
25 years on April 24, 2015
Hubble: from idea to launch

1946
Spitzer’s famous paper

1950

1958
NASA is established

1960

1962
National Academy of Sciences recommends a large space telescope be a US national priority

1970

1976
Combined proposal

1977
US Congress funds the “Large Space Telescope Project”

1980

1985
Hubble is completed

1990

1990

1990

1990
Launch date: 24 April 1990
Launch vehicle: Space Shuttle Discovery (STS-31)
Mass: 24,500 lbs (11,113 kg)
Maximum diameter: 14 ft (4.2 m)
Length: 43 ft (13 m)
Orbit Height: 339 miles (545 km)
Orbit period: 96-97 minutes
Orbit velocity: 16,800 mph (27,037 kph)
In orbit after launch

After in-orbit repair

Galaxy M100
Jupiter: the shrinking red spot
Europa: water?
Jupiter aurora

Saturn rings and aurora

Saturn rings and aurora

Jupiter aurora

Time/Space Location
Time it takes light to reach Earth

Planets
Minutes to hours

Stars
Galaxies
Universe
HST observations of Quaoar

Pluto & New Horizons Mission

"Quaoar" Compared by Diameter with Other Solar System Bodies

Earth: 8000 miles
Earth's moon: 2100 miles
Pluto: 1400 miles
"Quaoar": 800 miles

HST observation of Quaoar

HST observation of Eris

Search area: 83 Hubble WFC3 fields
Locations of potentially targetable discoveries shown

Full moon, at same scale

Single WFC3 field, containing PT1

Discovery images of PT1
Carina Nebula
M16 Pillars of Creation (1995)
Horsehead Nebula: Optical
Horsehead Nebula: Infrared
Fomalhaut b – image of a planet in a debris disk around a nearby star

HD 18733b – observation of methane in an exoplanet atmosphere
death of a star like the sun

Cat’s Eye Nebula
dead of a star like the sun
Bug/Butterfly Nebula
Supernova Remnant
Andromeda: M31
Rose Galaxy
Frontier Field
Abell 2744
## Hubble Discoveries

### Original Science Goals
- The Cosmic Distance Scale and Hubble Constant
- Gas Inside and Outside Galaxies
- Brightness of Supernovae
- Origin and Evolution of the Solar System
- Supermassive Black Holes

### Additional Science Examples
- Source of Gamma Ray Bursts
- Dark Energy and the Universe’s Expansion
- Ages of Stars Beyond the Milky Way
- Gravitational Lensing and Dark Matter
- Star Formation History of the Early Universe
- Imaging and Atmospheric Analysis of Exoplanets
- Star and Planetary System Formation

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![Hubble Telescope](image)
Hubble is Part of Our Children’s Education

A national sample of *Amazing Space* users provides data on selection criteria and use of materials in a variety of settings.

**Reach:**

- 500,000 pre- and in-service teachers
- 6.3 million students per year

Hubble education materials are used in all 50 states.
Hubble 2020 Vision

• HST continues operation through 2020
  – Most productive observatory
  – Strong science synergy with James Webb Space Telescope in 2019-2020 timeframe

• HST Status
  – Healthy instruments, more powerful than ever
  – Healthy spacecraft (gyros, reaction wheels)

• Examples of trending science topics
  – Properties of planetary systems
  – Stellar evolution throughout time
  – Nature of dark matter and dark energy
  – Black hole properties on all scales (stellar to supermassive)
  – Origin and evolution of galaxies
  – Cycles of matter and energy in galaxies
Shuttle Missions for Hubble Launch, Repair, and Refurbishment

**Launch**
- STS-31 Discovery

**Servicing Mission 1**
- STS-61 Endeavour
  - Wide Field Planetary Camera 2
  - Corrective Optics
  - Space Telescope Imaging Spectrograph
  - Axial Replacement Gyros
  - Solar Arrays

**Servicing Mission 2**
- STS-82 Discovery
  - Space Telescope Imaging Spectrograph
  - Near Infrared Camera and Multi-Object Spectrometer
  - Fine Guidance Sensor

**Servicing Mission 3A**
- STS-103 Discovery
  - Advanced Computer
  - Gyros
  - Fine Guidance Sensor

**Servicing Mission 3B**
- STS-109 Columbia
  - Advanced Camera for Surveys
  - Near Infrared Camera and Multi-Object Spectrometer
  - Cooling System
  - Power Control Unit
  - Solar Arrays

**Servicing Mission 4**
- STS-125 Atlantis
  - Wide Field Camera 3
  - Cosmic Origins Spectrograph
  - Space Telescope Imaging Spectrograph Repair
  - Advanced Camera for Surveys Repair
  - Science Instrument and Data Handling Unit
  - Gyros
  - New Outer Blanket Layer
  - Soft Capture Mechanism
  - Batteries
  - Fine Guidance Sensor

**Dates**
- April 1990
- December 1993
- February 1997
- December 1999
- March 2002
- May 2009