Ariane 5 Adaptation and Status for Webb Telescope

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Outline

- ESA involvement in JWST Observatory
- Ariane 5 ECA launcher and its legacy’s
- Mission orbit and Key events
- Ariane 5 ECA adaptation for JWST
- Launch campaign
- JWST shipment
- Conclusions
Overview of Webb and ESA’s contributions to the mission.

ESA contributed **two** of Webb’s four **science instruments**: NIRSpec and 50% of MIRI

**Webb’s partners**
- Webb observes **near-infrared** to **mid-infrared** light
- Webb studies our own **Solar System** and **exoplanets** around other stars
- Webb studies the birth of the **first stars** and **galaxies**

**ESA** provides a team of **astronomers** and **engineers** to support **science operations**

**Webb** will reach space on an **Ariane 5** from **Europe’s Spaceport** in French Guiana, a launch contributed by ESA

**Webb is the largest** and most **powerful** space telescope ever launched
ESA involvement in JWST Observatory (2/2)

- NASA/ESA Partnership for Launch Segment: in place since 2003
  - NASA/ESA MOU defines HQ-level contributions: signed 2006
  - **Joint Project Implementation Plan (JPIP)** for Launch Vehicle, contamination aspects and S/C launch campaign in place: management details of working relationship
  - Launch Service Agreement Contract in place between ESA SCI and Arianespace (AE) in 2015
  - A5ECA JWST Launcher Adaptation Contract in place between ESA STS and ArianeGroup (AG) in 2017
  - Mature working-level relationship between ESA and NASA: leads have been constant since 2008
- NGAS provides support to NASA via launch systems and launch site engineering
- KSC LSP advisory role to NASA JWST Project
- KSC LSP regular interface to ESA STS
- CNES support to ESA STS in the frame of AMOA activities
The European Ariane 5 with JWST will be launched from the Guiana Space Center in French Guiana.

JWST will use the latest version of the Ariane 5 launcher: **Ariane 5 ECA**

Ariane 5 is capable of carrying payloads weighing more than 10 metric tons to geostationary transfer orbit (GTO) and over 20 metric tons into low-Earth orbit (LEO) – with a high degree of accuracy.

With more than 100 launches, Ariane 5 has become one of the world’s leading heavy lift launch vehicles.

**Physical characteristics of Ariane 5 ECA**

- **Height**: 50.5 to 53 meters
- **Number of stages**: 2
- **Fuel**: liquid hydrogen and liquid oxygen and solid propellant for the boosters
Ariane 5’s Legacy

In operation since 1996, Ariane 5 has launched many ESA space science missions.

- **Ariane 5**
  - Height: 53 m
  - Diameter: 5.4 m
  - Mass at liftoff: 780 tonnes
  - 25 years in operation
  - 100+ launches from Europe’s Spaceport in French Guiana

1. **1999** - XMM Newton
2. **2004** - Rosetta
3. **2009** - Herschel
4. **2018** - BepiColombo
5. **2021** - Webb

Image credits:
- European Space Agency
Webb’s journey to L2 and key events

- **L+1 month**: JWST unfolding & start cooldown
- **L+2-3 months**: Instruments are turned on
- **L+4-6 months**: Test instrument capabilities
- **L+6 months**: Begin routine science observations

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Compared to the recurrent Ariane 5 ECA missions (dual payload - GTO – night launch), the main particularities of this mission are:

- JWST launch is a single payload
- Low payload mass (JWST = 6.2 tons) → higher longitudinal acceleration
- Trajectory towards L2 Lagrangian Point with high precision injection → IMU (Inertial Measurement Unit) has enhanced performance
- Day launch over full year launch slot
- Large volume of the payload under the fairing
- Specific cylindrical adaptor (PAS 2624VS - diameter 2624 mm) under the payload

**Trajectory constraints**

- Launch azimuth = 90°
- Classical atmospheric ascent phase
- EPC (Étage Principal Cryogénique/ Main Stage) will fall-down in the Atlantic ocean
A5 ECA Adaptation for JWST (2/4)

System requirements and constraints

- Two mission trajectories to be qualified (season dependant)
- Extremely low fairing residual pressure at fairing separation
- Sun illumination: specified SAA gauge corresponding to a oscillating barbeQ mode → dedicated Roll command laws and specific roll control activation profiles
- Non collision and non-contamination requirements at JWST separation (distancing manoeuvres)
- Implementation of an “End-of-Life Manoeuvre” to position Ariane 5 Upper Stage on a liberation orbit after payload release and distancing manoeuvre

Launcher H/W adaptations

- Fairing venting system adaptation to reduce residual pressure at fairing jettisoning (demonstrated in flight prior JWST)
- Need for a 3rd battery due to mission duration with the execution of the “End-of-Life Manoeuvre” (Δt ~1000s)
- Specific cylindrical adaptor
A5 ECA Adaptation for JWST (3/4)

Sun Aspect Angle constraint
A5 ECA Adaptation for JWST Launcher (4/4)

**Upper Part**
- “Out of Autoclave” payload fairing with HSS3+ expanding tube separation system & foam acoustic protection (FAP)
  - *Actuated vent valves and sealed honeycomb for JWST*
- PAS 2624VS (Payload Adaptor System) – adapter with low-shock clamp band separation system
  - *Reinforced for JWST load non-uniformity*
- Cone 3936 w/ glass fiber membrane for environmental isolation
- VEB (Vehicle Equipment Bay) - composite structure with upper stage avionics and fairing interface and *VIKI camera*

**Cryogenic stretched Upper stage:**
ESC–D (Étage Supérieure Cryotechnique de type “D”) with LH2/LOx and HM7B engine and *additional battery*
- ISS (Inter Stage Structure) with expanding tube separation system

**Main stage:**
- EPC (Étage Principal Cryotechnique) LH2/LOx with Vulcain 2 main engine

**2 Solid Rocket Boosters:**
- EAP (Étage d’Accélération à Poudre), P240 with welded joints
Launch Timeline

ASSEMBLY AND INTEGRATION

-55 days
Webb arriving at Paria<br>cab<br> harbour

-29 days
Main stage positioned on launch table

-7 days
Webb placed on Ariane 5

-6 days
Webb encapsulated in the fairing

-1 day
Ariane 5 rolls out to launch pad

LAUNCH

Launch From Europe’s Spaceport in French Guiana

+2 min
Booster separation

+3 min
Fairing separation

+9 min
Main stage separation

EN ROUTE TO L2

+27 min
Spacecraft separation

+30 min
ESAs tracks Webb in early orbit phase

Europe’s Spaceport in French Guiana
Launch campaign

- 75 days of launch campaign in preparation area (S5B and S5C)
- JWST arrives at L-55 days (around mid-October 2021).
- JWST launch campaign duration = 2 x telecom
  - Classical: unpacking; functional tests, pressure tests; tank loading; mating on launcher; fairing encapsulation
  - No deployment
  - All activities under laminar air flow created by HEPA filter walls
- Move to Batiment d’Assemblage Final at D-11 days for combined operations with launcher
  - Work under specifically developed clean tent (Halo bag and shower curtain between BAF platform)
- Mating on launcher at D-7
- Fairing encapsulation at D-6
- General dress rehearsal at D-4
- Chronology spanned over 2 days (17 and 18 December 2021)
JWST shipment to French Guyana (1/2)

- **Chartered ocean vessel (Maritime Nantaise Colibri)** – Port of Long Beach to Kourou sea port via Panama channel
  - JWST Observatory in STTARS, oversized MGSE on trailers, GSE packaged in sea containers, 3 purge tube trailers.
- **Chartered air flights (US Air Force C5M Galaxy (2))** – LAX to Cayenne airport
  - EGSE and select MGSE in sea containers.
- **Ocean freight shipped in advance** – Baltimore port to Cayenne sea port.
  - HEPA filters, Halo/VLS, CC equipment, tool boxes, networking equipment in sea containers; 4 Purge Tube trailers.
- **HAZMAT ocean freight shipped in advance** – Fort Lauderdale, FL to Cayenne
  - Propellant in HAZMAT certified sea container.
- **Common carrier shipper (DHL)** – any local facility to Arianespace
  - Miscellaneous shipments (small packages, emergency equipment)
JWST shipment to French Guyana (2/2)
Conclusions

- Ariane 5 ECA adaptation development and qualification activities for JWST mission are well on track (Launch System Technical Qualification Review (LTQR) completed – some remaining actions and open work) for launch on 18 December 2021 at 9:20 KRU time (exact time TBC)

- JWST launch (VA256) will be the third Ariane launch of 2021 (VA255 to be launched before JWST on 22 October 2021 with SES-17/Syracuse 4A)

- Successful VA254 launch on 30 July 2021 with no delay after 11 months of interruption confirming readiness of Ariane 5

Thanks for your attention!
### Ariane 5 ECA launcher technical data

#### Payload fairing

| Diameter | 5.4 m |
| Height   | 1.7 m |
| Mass     | 2675 kg |

- Two halves - Sandwich CFRP sheets and aluminium honeycomb core
- Acoustic protection: Foam sheets
- Separation: Horizontal and vertical separations by leak-proof pyrotechnical expanding tubes

#### SYLDAAS

| Diameter | 4.56 m |
| Height   | Total height of standard version: 4.903 m |
| Mass     | From ~2.45 to 5.35 kg, depending on height |

- Sandwich CFRP sheets and aluminium honeycomb core
- Separation: Leak-proof pyrotechnical expanding tube at the base of the cylinder

#### Adapters

| Clampband | Ø937 Ø1194 Ø1888 Ø2624 |
| Pylonuts  | Ø1663 |

#### Cones 3930 or LVA 3930

| Height   | 283 or 1187 mm |
| Mass     | 200 or 170 kg |

- Monolithic CFRP cone and glass fiber membrane

#### VEB

| Structure | Sandwich CFRP sheets and aluminium honeycomb core |
| Avionics  | Flight control, flight termination, power distribution and telemetry subsystems |

#### Cryogenic Upper Stage (ESC-A)

| Size      | Ø9.4 m x 4.711 m between 1/F rings |
| Dry mass  | 4350 kg |
| Structure | Aluminum alloy tanks |
| Propulsion| HM7B engine + 1 chamber |
| Propellants loaded | 14.9 t of LOX + LH2 |
| Thrust    | 67.5 kN |
| ISP       | ~446 s |

- Feed system: 1 turbo-pump driven by a gas generator
- Pressurization: GHe for LOX tank and LH2 for LH2 tank
- Combustion time: ~945 s
- Attitude control: Pitch and yaw: gimbaled nozzle
- Avionics: Guidance from VEB

#### Cryogenic Main Core Stage (EPC)

| Size      | Ø9.4 m x 23.8 m (without engine) |
| Dry mass  | 12460 kg |
| Structure | Aluminum alloy tanks |
| Propulsion| Vulcain 2 - 1 chamber |
| Propellants loaded | 1.70 t of LOX + LH2 |
| Thrust    | 960 kN (SL) 1390 kN (Vacuum) |
| ISP       | ~310 s (SL) 432 s (Vacuum) |

- Feed system: 2 turbo-pumps driven by a gas generator
- Pressurization: GHe for LOX tank and LH2 for LH2 tank
- Combustion time: ~540 s
- Attitude control: Pitch and yaw: gimbaled nozzle
- Avionics: Flight control, flight termination, power distribution and telemetry subsystems, connected to VEB via data bus

#### Solid Rocket Booster (EAP)

| Size      | Ø3.05 m x 31.6 m |
| Structure | Stainless steel case |
| Propulsion| Solid propellant motor (MPS) |
| Propellant| 240 t of solid propellant per EAP |
| Mean thrust | 7000 kN (Vacuum) |
| ISP       | 1274.5 s |

- Combustion time: 130 s
- Attitude control: Steerable nozzle
- Avionics: Flight control, flight termination and telemetry subsystems, connected to VEB via data bus + autonomous telemetry

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