Planning the integration and test of a space telescope with a 1 m aluminum primary mirror: the Ariel Mission case

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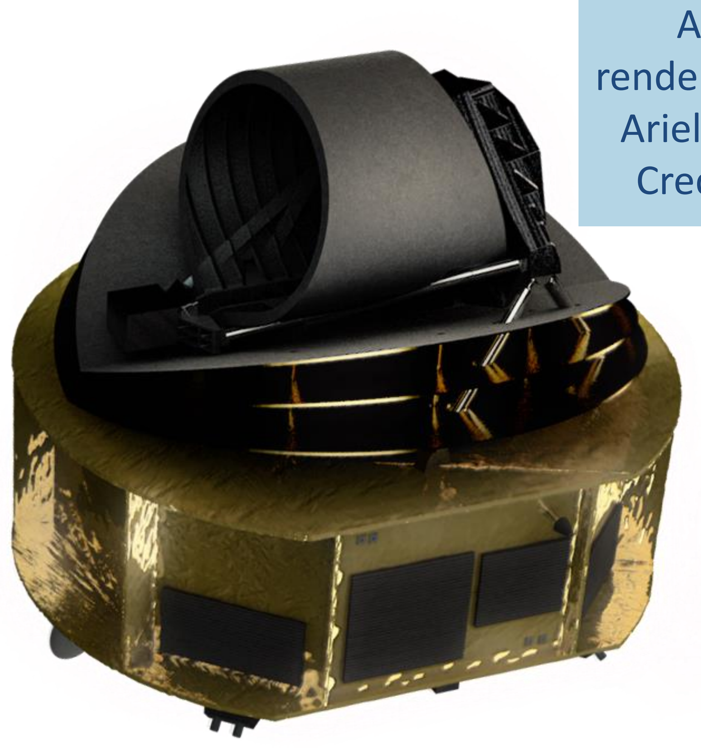
INTRODUCTION

Ariel (Atmospheric Remote-Sensing Infrared Exoplanet Large Survey) is ESA adopted M4 mission to launch in 2029. Its purpose is to study the **atmospheres of exoplanets** using transit and eclipse **spectroscopy,** between 0.5 and 7.8 µm of wavelength.

ARIEL is based on a **1-meter class, all-aluminum,** off-axis Cassegrain **telescope, operating at 50 K**. The secondary mirror is mounted on a roto-translating stage for fine adjustments during the mission.

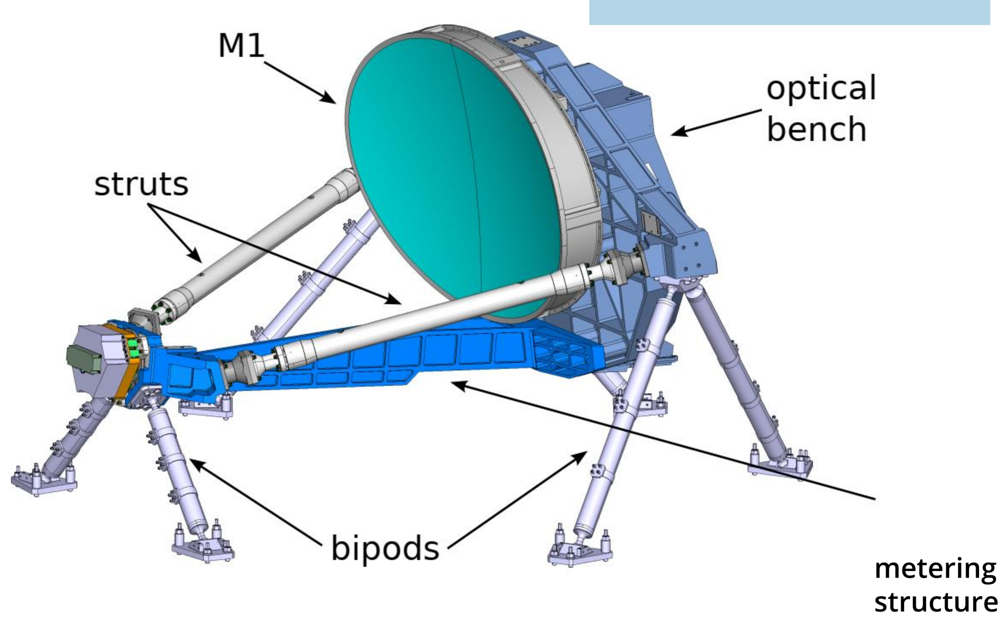


Artistic rendering of the Ariel mission. Credit: ESA.

The mirrors and supporting structures are all realized in an aerospace-grade aluminum alloy T6061 for ease of manufacturing and thermalization.

Ariel's primary mirror is a **technological challenge**: with an elliptical aperture of 1.1 m x 0.73 m, it will be the **largest aluminum mirror ever to fly** on a space mission.

This required the development of innovative manufacturing processes and demanding integration, alignment and testing procedures.



Ariel Telescope. Credit: TA Team.

INTEGRATION AND ALIGNMENT

Aluminum is easy to machine, but its softness poses one of the biggest challenges to integration, since gravity, thermal gradients and even small stresses induce **deformations** that have large consequences in the optical performance.

For this reason, the integration and alignment sequence has been carefully simulated and planned to consider these effects. The primary is assembled and aligned metrologically (laser tracker) in horizontal position to minimize the **effects of gravity** (**Fig. 1**).

The telescope is then aligned with the line of sight horizontal (**Fig. 2**) with the help of a flat mirror and interferometer, in a double pass configuration.

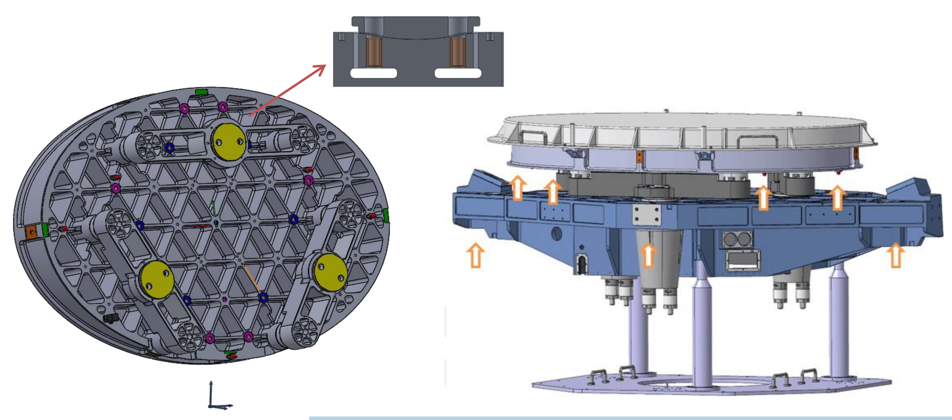


Fig. 1. Primary mirror integration.

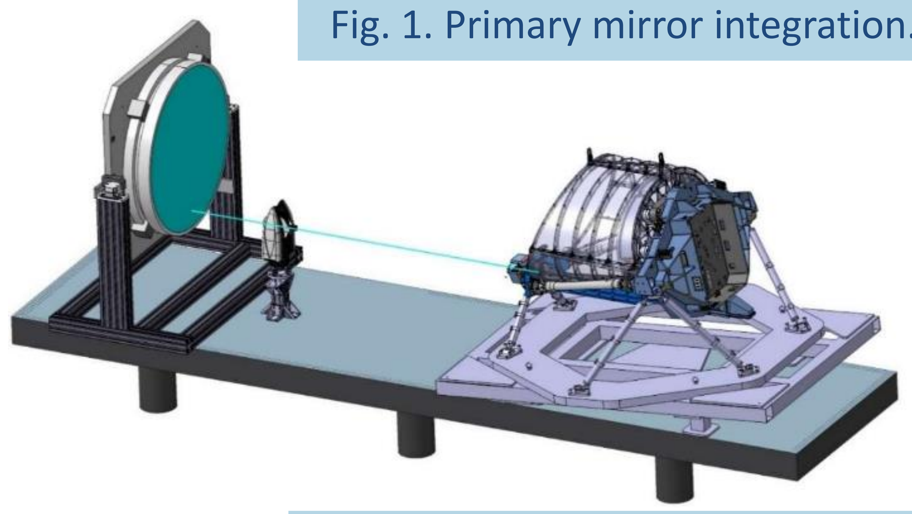


Fig. 2. Telescope alignment.

Fig. 3. Alignment check, inverted gravity vector.

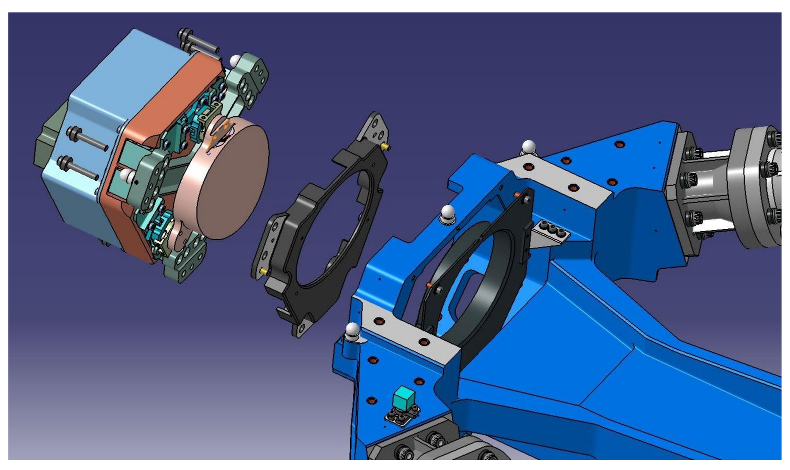


Fig. 4. Secondary mirror shim.

Alignment is then checked again, this time with the gravity vector and mechanical constraints inverted (**Fig. 3**): a subtraction of the interferometric measurements in the two configurations will allow to subtract the effects of gravity from the measurement. After achieving the alignment, the position of the secondary mirror is fixed with insertion of a shim (**Fig. 4**). The shim is only useful to minimize wavefront error on ground, and is therefore replaced before the final end-to-end optical test with the instruments with another shim designed for flight.

TESTING

The Telescope Assembly Engineering Model (EM) will undergo a sequence of tests: vibration, bakeout, TVAC and a final cryo-optical test at T < 50 K (**Fig. 5**), to be performed at the Centre Spatial de Liège (CSL), to verify that the optical performance is not significantly affected by unexpected deformations when reaching the telescope operating temperature.

The telescope is then shipped to RAL Space for integration of the instruments and thermal shielding, and for the final end-to-end cryo-optical testing of the entire mission Payload.

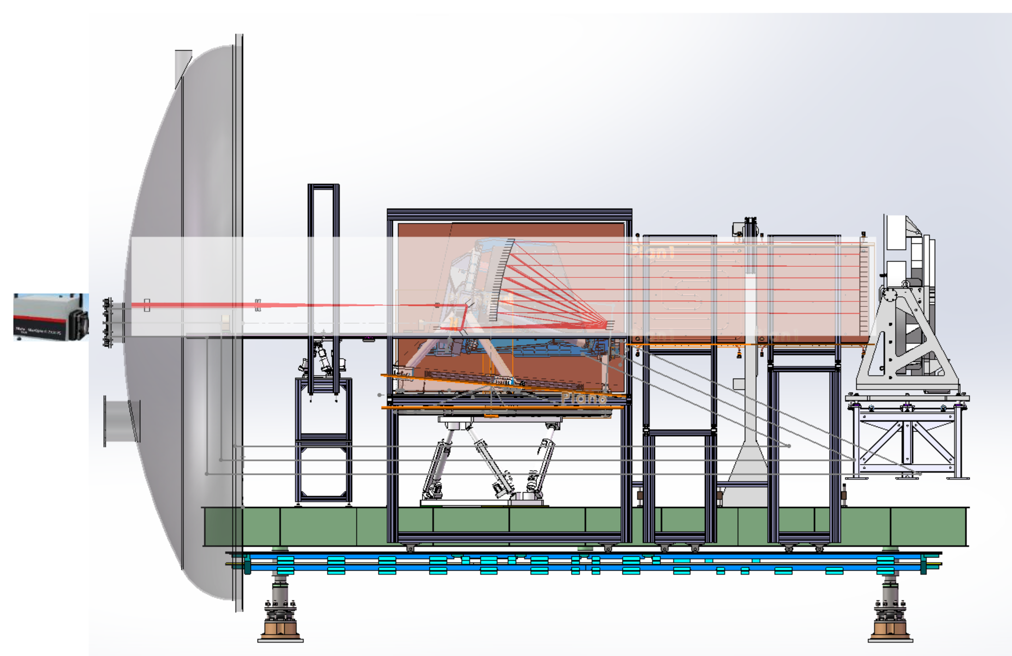


Fig. 5. Cryo-optical measurement setup. Credit: CSL.

ACKNOWLEDGEMENTS

Activities developed under the Implementation Agreement n. 2021-5-HH.0 "Italian Participation to Ariel mission phase B2/C" between the Italian Space Agency (ASI) and the National Institute for Astrophysics (INAF) and under ASI contracts n. 2021-21-I.0 "ARIEL TA Phase B Industrial Activities" and n. 2023-42-I.0 "ARIEL TA Phase C/D1 Industrial Activities ".

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