EPSC Abstracts
Vol. 16, EPSC2022-861, 2022, updated on 06 Jun 2023
https://doi.org/10.5194/epsc2022-861
Europlanet Science Congress 2022

The mechanical, structural and thermal design of the Telescope Assembly of ARIEL

Gustavo Alonso, Andres Garcia-Perez, Javier Perez-Alvarez, and Alejandro Fernandez-Soler
Universidad Politecnica de Madrid, Ignacio da Riva (IDR/UPM), Spain (gustavo.alonso@upm.es)

The mechanical, structural and thermal design of the Telescope Assembly of ARIEL

- Garcia-Perez, J. Perez-Alvarez, A. Fernandez-Soler, G. Alonso (*)

Instituto de Microgravedad Ignacio Da Riva (IDR/UPM), Universidad Politécnica de Madrid (UPM), 28040 Madrid, Spain

(*) corresponding author

Abstract

The Atmospheric Remote-Sensing Infrared Exoplanet Large-survey (ARIEL) is a space project of the European Space Agency (ESA) Cosmic Vision program [1]. The main goal of this mission is the observation of exoplanets by the transit spectroscopy technique, where the hot and warm gas giants and super-Earth exoplanets represent its main targets [2]. The main scientific purpose is to obtain a better understanding of the chemical composition of the atmospheres of the observed exoplanets, which will allow the development of a greater knowledge in the early formation of planets. The spacecraft is planned to be launched in 2029, with an expected mission life of approximately 4 years in an L2 orbit [1].

The selection of an optimized sample of exoplanets observable by the ARIEL mission with equilibrium temperatures in the 350-500 K rang has been the basis for designing the telescope and optical system, which represent the larger unit of the spacecraft's payload, as well as the detection chain. The preliminary design of the ARIEL mission at the end of Phase A is described in [3], which reports the main design drivers and the requirements needed to achieve the objectives of the project.

The ARIEL spacecraft is composed by a Payload Module (PLM) and a Service Module (SVM). The main payload subsystem is the telescope assembly (TA), which is a Cassegrain layout with 4 main mirrors attached to the structure defined by an optical bench (OB) and a telescope beam (TB), as it is shown in Figure 1. The telescope, through a common optical system, feeds two module channels accommodated on the Optical Bench. The PLM components must be passively cooled to 40–70 K during the operational phase to secure the best conditions for an adequate performance. The TA main parts are made of the same material (aluminium alloy 6061-T6), to achieve a high degree of uniformity and minimize the thermoelastic deformation.

Figure 1. Perspective view of the ARIEL telescope structure.

The purpose of this paper is to ilustrate with the example of ARIEL, the complexity and relevance of the mechanical, structural and thermal design of state-of-the-art instruments for scientific missions, and the importance of the close cooperation between scientists and engineers to achieve the mission goals.

The thermomechanical design of the Telescope Assembly is closely related to the optical design, and given the operating conditions of the Ariel payload, is a key driver to guarantee the successful performance of the mission. This is particularly critical for ARIEL, taking into account the harsh environment of this mission. The satellite is going to be subjected to highly variable thermal loads, which lead to changing thermal environments that affect the design of the scientific instrumentation. The harsh thermal environment of the mission makes the thermal design complex, taking into account the strict requirements of ARIEL. However, this harsh environment provides also an opportunity to gather information to validate first and then improve the thermomechanical design and the simulation tools in a very different range of situations [4].

The mechanical design of the telescope has to consider also manufacturing and integration criteria. The OB component (Figure 2) is, without a doubt, one of the most complex components, from a design point of view, since it fulfills different functions as a support structure, such as:

- It is the support system for 90% of the telescope's optical system, especially the primary mirror (M1 mirror).
- Defines the support points of the complete telescope to the service module (SM) by means of its connection to the rear bipod system.
- Contains the cavity to provide restraint for on-board experiments on the telescope.
- Serves as a support system for the cryogenic wiring of the telescope.
- Provides the interface with part of the system for transportation and handling in integration operations.

The design of this component must satisfy the interface needs of the components that are integrated into it, which requires interaction with most of the scientists' teams.

The structural design involves the creation of numerical models for structural analysis of the Telescope Assembly to evaluate the mechanical behavior in the most severe environments during the space mission. The structural analyses allow the best selection of the design parameters that reach the minimum structural mass while at the same time assure the fulfillment of the structural requirements. An important outcome of the structural design is the definition of the static and dynamic loads that are specified to some ARIEL subsystems such as the M2 Mechanism and the Baffles.

Figure 2. Front and side view of the ARIEL Telescope Assembly structure.

References

- Pascale, E., Bezawada, N., Barstow, J., et al The ARIEL Space Mission. In: MacEwen HA, Lystrup M, Fazio GG, Et al. (Eds) Space Telescopes and Instrumentation 2018: Optical, Infrared, and Millimeter Wave. SPIE, p 16 (2018)
- Tinetti, G., Drossart, P., Eccleston, P., et al.: A chemical survey of exoplanets with ARIEL. Exp. Astron. **46**, 135–209 (2018). https://doi.org/10.1007/s10686-018-9598-x
- Puig, L., Pilbratt, G., Heske, A., et al.: The phase a study of the ESA M4 mission candidate ARIEL.

Exp. Astron. **46**, 211–239 (2018). https://doi.org/10.1007/s10686-018-9604-3
- García-Pérez, A., Alonso, G., Gómez-San-Juan, A. *et al.* Thermoelastic evaluation of the payload module of the ARIEL mission. *Exp Astron* (2021). https://doi.org/10.1007/s10686-021-09704-0