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MIST-A, the MWIR Imaging Spectrometer onboard the Emirates Mission to the Asteroid belt.

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Seven primordial and water-rich asteroids will be investigated by the Emirates Mission to the Asteroid Belt (EMA), which is scheduled to launch in 2028 [1]. Using solar electric propulsion, the spacecraft will cruise for seven years, traveling over five billion kilometers while navigating around Venus, Earth, and Mars with the help of gravity. Six asteroids will be observed by the spacecraft during as many flybys: 10253 Westerwald and 623 Chimaera in 2030, 13294 Rockox in 2031, 88055 and 23871 in 2032, 59980 in 2033. In 2035 EMA will reach 269 Justitia, a 54.4 km diameter object, and one of the few Main Belt (MB) asteroids that exhibits an intense red spectral color in telescopic observations from Earth [2]. After completing a thorough mapping of its surface, a lander will be dropped onto the surface of 269 Justitia at the end of the mission to demonstrate how resources can be reached in the future. With a mass of about 2,300 kg before launch, the EMA spacecraft, called MBR Explorer, will be designed, built, and tested by the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) as a "knowledge partner" of the UAE Space Agency.

The MWIR Imaging Spectrometer for Target-Asteroids (MIST-A) is designed to gather hyperspectral data on the seven asteroids in order to ascertain their composition and thermal properties. This instrument is Italy's contribution to the EMA science payload [3]. The MIST-A spectral channel optical design is inherited from the JIRAM instrument [4] on board the NASA Juno spacecraft. It is based on a Littrow imaging spectrometer joined to a modified Schmidt off-axis telescope (D=44 mm, f/3.7). The dispersive element of the spectrometer is a flat grating with a blaze angle of 2.56 deg and a groove density of 30.3/mm. A 2D HgCdTe detector with a 36 µm pixel pitch and 2 Me- full well, windowed to a format of 256 spatial samples by 336 spectral bands, is used as focal plane. Two spectral bandpass filters are included in the detector subunit to reject the thermal background of the instrument and sort out grating orders. An exterior radiator passively cools down the optical head to an operating temperature of ≤135 K, while a cryocooler actively cools down the IR infrared detector to ≤85 K.

MIST-A operates with a spectral sampling of less than 10 nm per band within the 2–5 µm spectral range. A one-axis steerable mirror (whose axis is parallel to the slit axis) mounted at the telescope's entrance allows for controlled pointing and scanning capabilities, with offsets up to ±6 degrees from the boresight. Because the position and angular velocity of the scan mirror are pre-set, MIST-A's onboard software and functions enable customizable strategies throughout the mission's several orbital phases, such as close orbits at Justitia and fast target-asteroid flybys.

From a distance of 100 km, the instrument can achieve a swath length of 6.1 km and spatial sampling of 24 m/pixel thanks to its Instantaneous Field of View (IFOV = 238 μrad) and Field of View (FOV = 3.5 degrees). Over time, lateral scans commanded orthogonally to the ground track direction will be used to construct hyperspectral images up to ±6 degrees wide (from the boresight).

The Internal Calibration Unit (ICU) of the instrument is mounted on the side of the telescope's entrance baffle. It offers a reference infrared signal throughout the spectrometer's whole spectral and spatial range thanks to its diffusive screen, which is lit by two MEMS infrared emitters on which are mounted polystyrene filters. By a specific telecommand sequence, the internal scan mirror is rotated to the ICU reference angle in order to gather the ICU signal. To ensure repeatable fluxes, the IR emitters are driven by carefully regulated current levels. Similar ICU designs used in other spaceborne spectrometers have already been successfully utilized [5]. Finally, at the start of each acquisition sequence, an internal background frame is acquired using the ICU target with sources turned off as a reference.

By operating in the MWIR spectral range, MIST-A can identify and map various classes of compounds relevant for primitive targets, such as organic matter [6,7], carbonates, silicates, phyllosilicates, ammonium salts [8,9,10], and water ice [11]. The instrument can measure surface thermal emission longward of 3 μm [12], from which diurnal temperature and thermal properties can be inferred [13]. Moreover, taking advantage of varying illumination and viewing geometries during flybys and orbits at Justitia, spectrophotometric models can derive regolith composition and physical properties [14].

MIST-A will go through a full calibration campaign at INAF-IAPS facilities in Rome following integration and testing at Leonardo Company (Florence). This stage will come before the instrument is finally delivered to LASP in August 2026 where it will be integrated and tested aboard the EMA spacecraft. Phase D2 of the MIST-A project is currently underway after it successfully passed the examination by an independent Critical Design Review board.

INAF/IAPS, Rome, is the MIST-A PI institute and it is responsible for instrument’s calibration, science activities and operations. The primary funding source for the program is the Italian Space Agency (ASI) through science contract 2023-21-HH.0, and industrial contract 2025-33-I.0, with a secondary support from INAF. Leonardo S.p.A. from Campi Bisenzio (Florence) is the MIST-A industrial contractor in charge of the instrument’s design, assembly, qualification and testing.

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