The Emirates Mission to the Asteroid Belt (EMA) Targets: Geological Considerations M. R. El-Maarry[1], M. E. Landis[2], D. J. Sheeres[3], H. AlMazmi[4], P. O. Hayne[2] [1]Department of Earth Sciences, and the Space and Planetary Science Research Group, Khalifa University, Abu Dhabi, UAE (mohamed.elmaarry@ku.ac.ae). [2]LASP, University of Colorado Boulder, USA. [3]University of Colorado Boulder, USA, [4]UAE Space Agency.

Introduction: The UAE's Emirates Mission to Explore the Asteroid Belt (EMA) is going to explore seven asteroids in the Main Belt (MB) in a series of flybys from 2030 to 2033 culminating with a rendezvous phase at (269) Justitia in 2034 [1]. Justitia is possibly water rich as it is spectrally more similar to a Trans-Neptunian object than a main belt asteroid [2], although more recent studies suggest alternative interpretations to its spectral properties [3]. The list of candidate flyby targets [4] includes a wide variety of bodies that will provide context for Justitia. Moreover, many of the targets belong to collisional families. The mission's investigations are going to provide new insights into the dynamical evolution of small bodies in the MB, in addition to providing new insights into how icy small bodies physically evolve across the solar system. One of the principle goals of the mission is to determine the geologic history, interior structure and ice content of the target asteroids. Here, we demonstrate our plan to achieve this goal.

Instrument payload and mapping coverage: The payload will encompass a high resolution visible and IR camera (EMACS), and mid-wave and thermal infrared imaging spectrometers (MIST-A, and EMBIRS, respectively) [5-8]. The mission's coverage of each of the six flyby targets is expected to be at the most 50%, which is still going to allow for regional mapping of these targets. During the flybys, we expect to achieve spatial resolutions ranging from 6 to 12 m/pixel at closest approach, and accounting for target-specific smear, which would be a substantial improvement on most prior asteroidal flybys in the MB (Fig. 1). Global mapping and sub-meter resolutions are expected at Justitia during orbital and proximity operations phases.

Features of interest: The mission's combinations of instruments and expected high spatial resolution allows for the characterization of general structural properties as well as various surface features necessary for a better understanding of the geologic history of the targets:

Global shape and spin: The shape morphology and spin state of the asteroids provides specific constraints on the surface and interior strength of the given bodies. Given spectral information it is possible to constrain the likely bulk density of the body, which then informs the surface slope structure, the interior pressure, and the implied strength of different components of the global body. This is especially true if the asteroid has a bifurcated structure, as frequently seen.

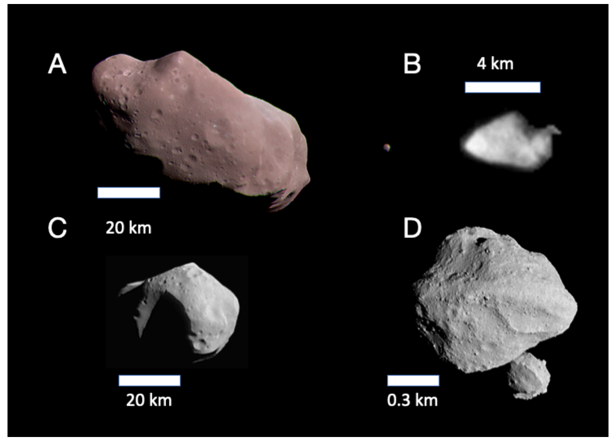

Figure 1. A number of MB asteroids visited during flybys. [A] 243 Ida (and its moon Dactyl) was visited by Galileo. Despite being an S-type asteroid, it is nevertheless similar in size to 269 Justitia as well as one of EMA's flyby targets, and was viewed at a resolution of ~25 m/pixel at closest approach, so provides a representative view of what EMA would be able to resolve on the surfaces of its flyby targets. [B] 5535 Annefrank is a small ~4.5-wide collisional fragment. Its size and its collisional history offer an analog for many of EMA's targets. However, EMA plans to achieve more than an order of magnitude higher spatial resolution. [C] 253 Mathilde arguably offers the best analog for Justitia given that it's a C-type, ~50 km-wide, and low density body (~1.3 g/cm3), as well as displaying a low geometric albedo of less than 5% [9]. However, we note that Mathilde was imaged at ~160 m/pixels at closest approach. [D] Finally, Dinkinesh and its binary companion Selam were recently visited by the Lucy mission. Its binary nature (previously unknown) and rubble pile appearance hint at the wealth of unexpected insights that EMA could provide during its long and multiple encounters in the MB.

At Justitia, the EMA mission will measure that body's shape, spin state and gravity field. The combination of these measurements will enable the interior density distribution of this body to be constrained, and could detect significant mass anomalies in its interior. Also, this information makes it possible to analyze the surface environment and implied strength in detail, providing new insight into this class of primitive bodies, and enabling comparison with other primitive asteroids and comets.

Impact craters: The mission will characterize impact crater morphologies and is designed to observe as many extant craters as possible to derive relative surface ages and to observe any ejecta derived from the near-surface region. Given that a number of the flyby targets are expected to be members of collisional families, deriving even a relative surface age can also be used along with dynamical considerations of family age to shed more light on the dynamical evolution and the post-collisional modifications in asteroidal families.

Boulders: Boulders hold a record of dynamical and erosional events that affect a small body's surface. The spatial resolution will be sufficient to characterize regional boulder distributions and their geologic context. The wide variety of targets spectral types will help correlate target composition to boulder size-frequency distribution variations, if any. These can be then compared to other small bodies that have been similarly characterized in the past, including comets and Near-Earth Asteroids (NEAs). At Justitia, higher spatial resolutions may also aid in characterizing individual boulder morphologies to assess the origins, potential compositional or textural diversities, and weathering patterns that affect boulders on small bodies.

Lineaments: Characterizing various lineaments including fractures, grooves, pit-chains and other features will help in investigating the tectonic history of the targets, their bulk properties, and possible collisional effects in the targets that belong to collisional families.

Potential activity: Finally, while none of the targets are currently known to be active asteroids, The mission could observe activity that may be difficult to detect with Earth-based observations. Many of the targets are spectral types that are thought to be hydrated. Whether that hydration is due to hydrated minerals or water ice is still to be determined for each target. However, several mechanisms (including impacts and collisions) have been put forward to explain short-term activity, not necessarily ice-related, in asteroids [10]. In fact, activity in the form of particles ejected from the surface was observed on the NEA Bennu by the OSIRIS-Rex mission [11] with multiple potential mechanisms being considered, so it possible that EMA may be able to detect variable forms of activity, particularly during the reconnaissance of Justitia.

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