MBR EXPLORER إكسبلورر
مهمة الإمارات لاستكشاف حزام الكويكبات
EMIRATES MISSION TO THE ASTEROID BELT

وكالة الإمارات للفضاء
UAE SPACE AGENCY

الإمـــارات
THE EMIRATES
لا شيء مستحيل
IMPOSSIBLE IS POSSIBLE

Emirates Mission to the Asteroid Belt (EMA)
Program Overview

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Space Resources Roundtable
Colorado School of Mines
7th of June 2024

What is the Emirates Mission to the Asteroid Belt (EMA) ?

- Emirates Mission to Explore the Asteroid Belt is an Emirati interplanetary mission that is part of the Projects of the 50 series of developmental projects being advanced by the government of the United Arab Emirates.
- The mission is being developed in partnership with the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado, Boulder.

وكالة الإمارات للفضاء
UAE SPACE AGENCY

United Arab Emirates

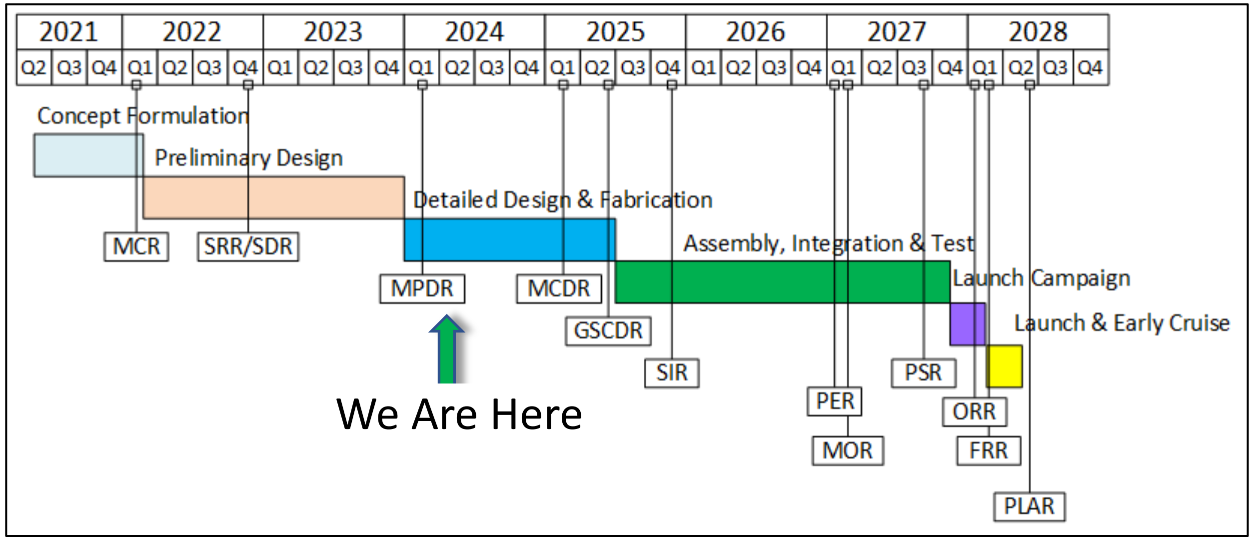
Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

- The mission is an exploration mission that will fly though the inner solar system and then investigate asteroids in the main belt between Mars and Jupiter.
- Payload includes remote sensing package with high-resolution visible imager
- Spacecraft design is based on EMM heritage with augmentation necessary to enable mission operations, specifically in the areas of propulsion and navigation

Emirates Mission to the Asteroid Belt (EMA) – Goals and Objectives

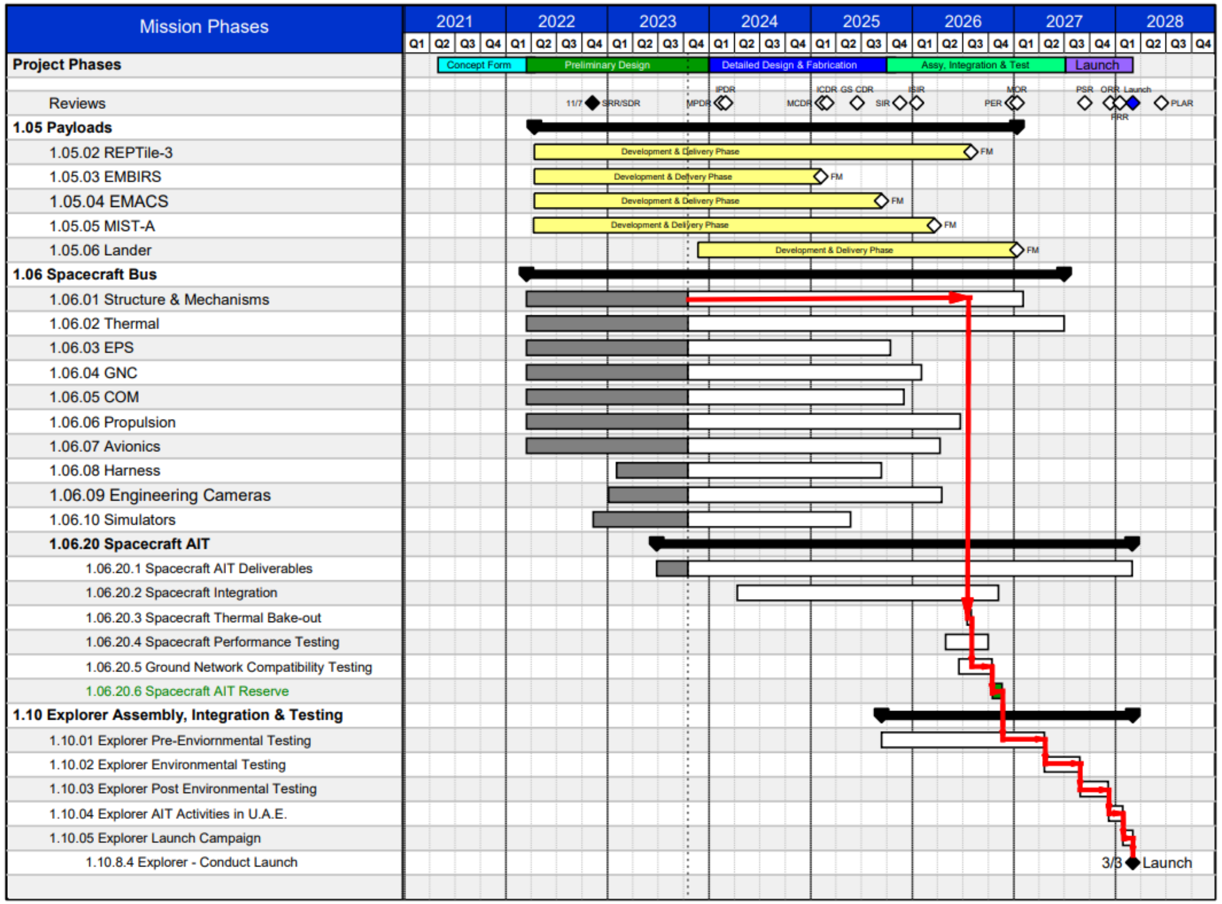
- Program goals
  - Develop and execute a mission that will explore the asteroid belt and will significantly contribute to the scientific and space resources community, while creating routine opportunities for public engagement, especially within the Gulf Region
  - Develop the science and technology commercial sector in the UAE and foster the necessary knowledge within the UAE to create sustainable science and technology initiatives
- Mission implementation goals
  - Unique program aiming for advances in fundamental science and demonstrations of technology
  - Provide opportunities to engage and educate the public in science, research, and space exploration
  - Build a sustainable outer space exploration program in UAE
  - Enable valuable contributions from UAE engineers and scientists
- Mission objectives
  - Launch no later than Q1 2028
  - Employ a Venus gravity assist and reach the main asteroid belt
  - Perform 6 asteroid flybys and rendezvous with a 7th asteroid
  - Leverage UAE private sector
  - Train and prepare UAE engineers to develop outer space exploration systems and instruments in UAE
  - Establish partnerships with international entities in the field of outer space exploration
  - Develop engineering programs in the academic sector
  - Transfer knowledge and know-how to the mission partners

Programmatic Status



- Spacecraft Integration starts in JUN 2025
- Explorer Integration starts in APR 2026
- Environmental Testing starts in SEP 2026
- Explorer travels to UAE in AUG 2027
    - Environmental Test to be completed in the UAE (Final Mass Properties)
- Launch Campaign starts DEC 2027
- Launch in March of 2028

Integrated Master Schedule (IMS)



Science Goals and Objectives

Understand the origins and evolution of water-rich asteroids

→ "Water" includes H_2O, -OH, and hydrated organic compounds, other volatile species

Determine and map the surficial **volatile content** and **silicate mineralogy** of compositionally diverse water-rich asteroids

Determine the **geologic history**, **interior structure**, and **ice content** of multiple main-belt asteroids

Determine asteroid **temperatures and thermophysical properties** to assess volatile history and surface evolution

Space Resources Goals and Objectives

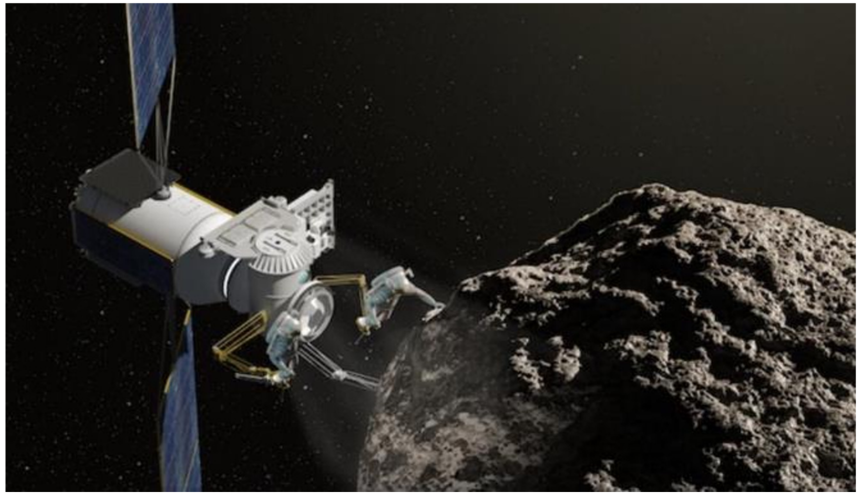
Assess the resource potential of asteroids

Identify and characterize resources including volatiles, silicates, and metals on multiple types of asteroids

Determine resource mass estimates and distributions based on the interior structure of an asteroid

Prepare the way for future asteroid use

Demonstrate proximity operation maneuvers to simulate landing and orbital rendezvous



Deliver a representative site assessment for a viable extraction site

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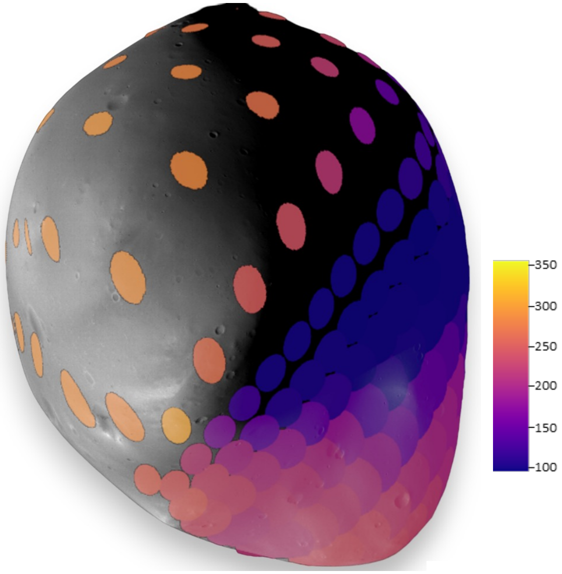
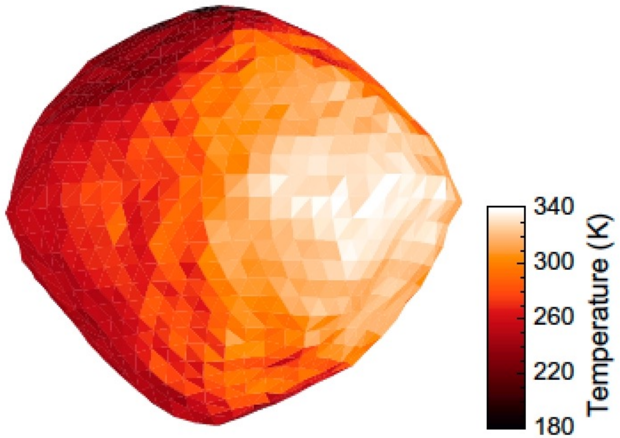
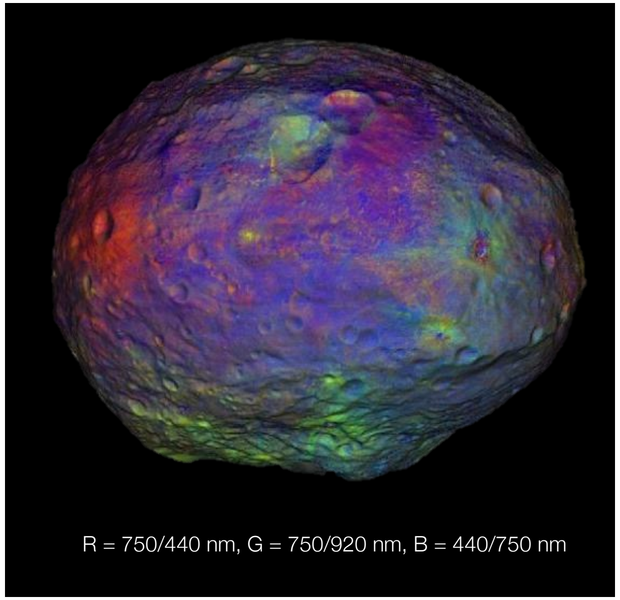
Instrument Payload Remote Sensing Suite Overview



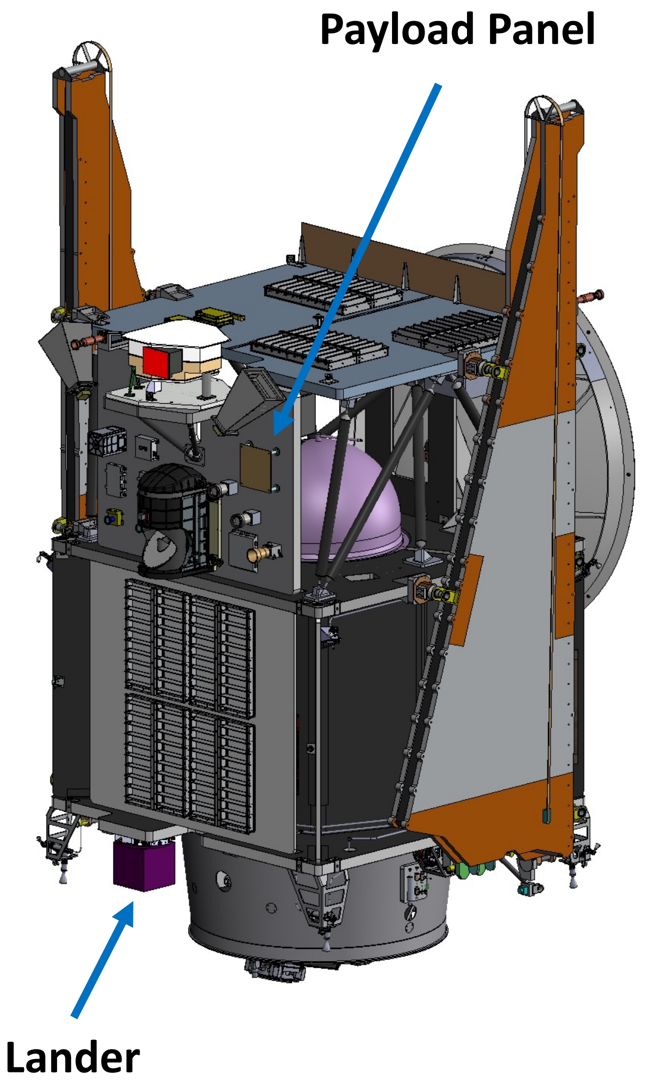




EMBIRS: Infrared Spectrometer	Visible Narrow Angle Camera	Infrared Camera	MIST-A: Midwave-infrared (MWIR) Spectrometer
Wavelengths: 6-100+ μm Measurements: surface composition of silicate minerals using emissivity spectra Example shown: Deimos from Emirates Mars Mission	Wavelengths: RGB Color Measurements: Images for geologic context and shape model/gravity model construction, navigation, surface ages (crater counting) Example shown: Asteroid 433 Eros from NEAR Shoemaker (NASA)	Wavelengths: 8-14 μm Measurements: surface temperatures (with models can give subsurface layering), rock abundance (surface age), porosity of material Example shown: Thermal model of (101955) Bennu, Emery et al. (2014)	Wavelengths: 2-5 μm Measurements: Surface composition, including water ice, organics, and ammoniated compounds (signs of aqueous alteration) Example shown: Asteroid 4 Vesta from Dawn (NASA)

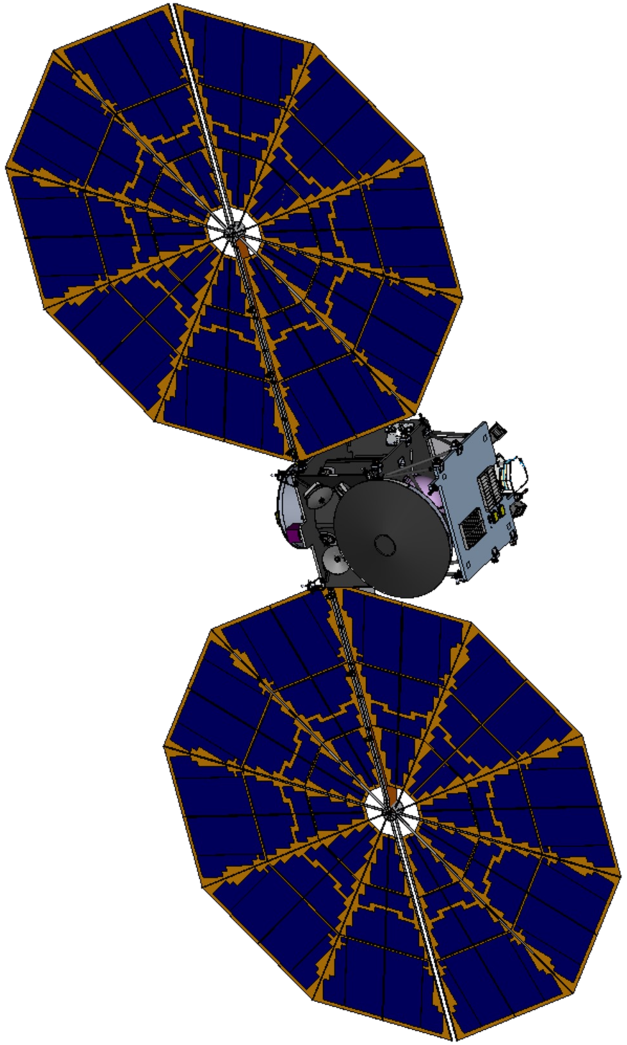
EMA Payloads

- REPTile-3
  - Small, low-mass and low power particle detector
  - Measures solar energetic particles relevant to space weather affecting asteroid surface composition.
- Lander
  - Developed by 971 and Sadeem (Private companies in the UAE)
  - Will be deployed at Justitia
  - Concept will be finalized by the end of Q2 2024



High Level Design Drivers

- The DeltaV required by the mission trajectory and ConOps is the primary driver for the spacecraft design
  - Requires the use of both a Solar Electric Propulsion (SEP) system as well as a traditional hydrazine system
- The large solar distance of the main asteroid belt and the extremely high power required by the SEP system combine to drive a very large and complex power system
  - Requires a 20 kW array (at Earth) or ~80 m^2 of solar arrays
  - Dual-voltage power bus (high-voltage for SEP and low-voltage for the bus avionics)
  - Large Power Production Unit (PPU) for the SEP system
  - Design for the Low Intensity Low Temperature (LILT) effects on the photovoltaic cells
  - Heat rejection from the (~93.5% efficient) PPU
- The flyby, rendezvous, characterization phase, and landing aspects of the ConOps drive development of the GN&C suite
  - Requires on-board autonomous navigation (TALONS), and the associated sensors (navigation cameras)



EMA Flight Phases & ConOps

EMA Program Overview – Interplanetary Tour

Main-belt Asteroid Tour and Rendezvous Mission

to *understand origins and evolution of water-rich asteroids and their potential as a resource*

- 3 Planetary flybys (Venus, Earth, Mars)
- 6 asteroid flybys
- 1 rendezvous (269 Justitia) w/ Lander deployment
- 7 years Launch to Landing
- UAE Capability Development

Selected Asteroids

1. 10253 Westerwald [None]
2. 623 Chimera [Chimaera Family]
3. 13294 Rockox [Baptistina Family]
4. 88055 (2000 VA28) [Like Ryugu and Bennu?]
5. 23871 (1998 RC76) [Erigone Family]
6. 59980 (1999 SG6) [Eos Family]
7. 269 Justitia [Red like Kuiper Belt objects]

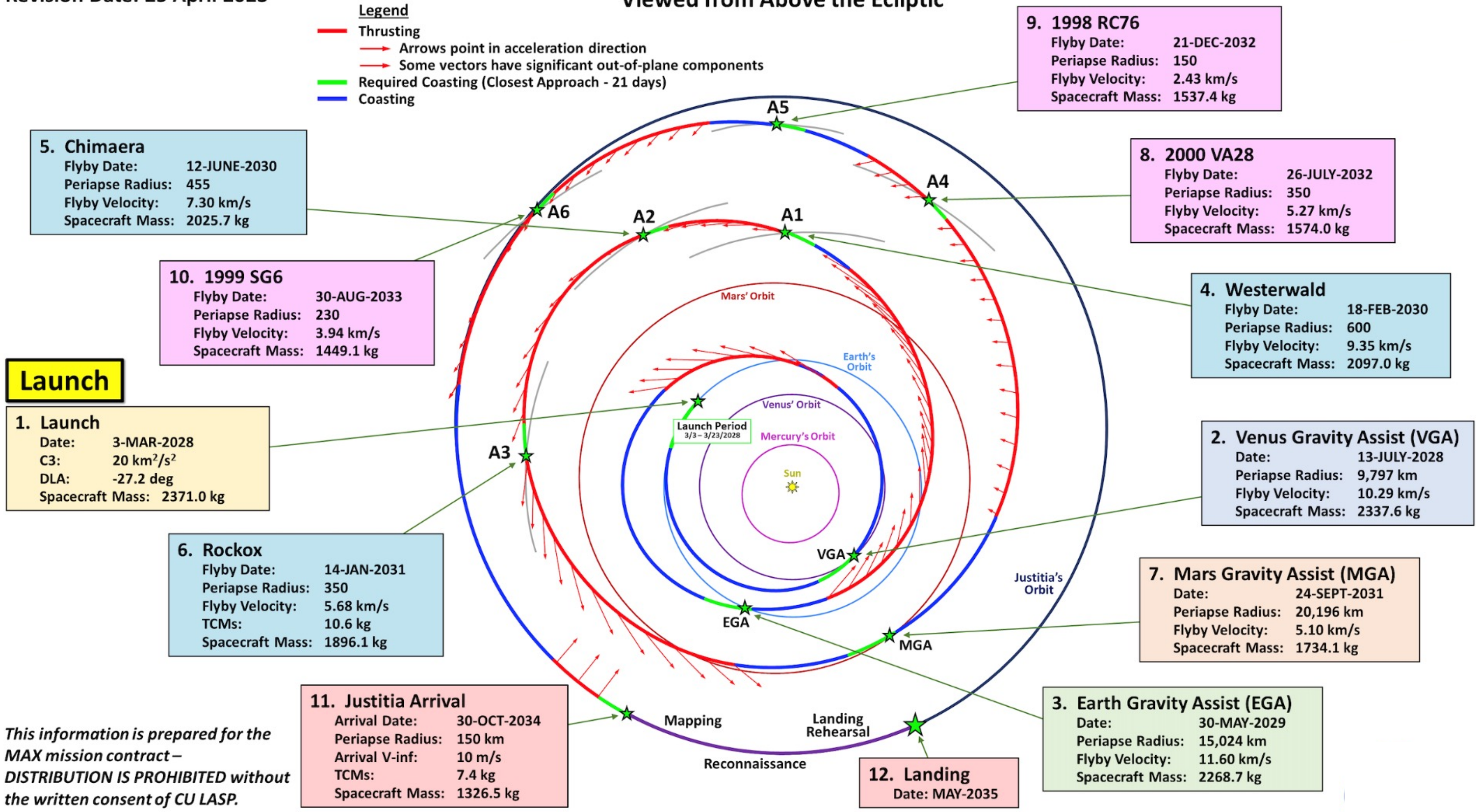
Asteroid	Diameter (km)	Encounter Speed (km/s)	Minimum Closest Approach Distance (km)	Angular Rate at Closest Approach (deg/s)	Trajectory Induced Smear (m/s)
10253 Westerwald (2116 T-2) 18 FEB 2030	2.3	9.4	600	0.90	18
623 Chimaera (A907 BC) 12 JUN 2030	44	7.3	455	0.93	357
13294 Rockox (1998 Q0105) 14 JAN 2031	5	5.7	350	0.93	41
88055 (2000 VA28) 28 JUL 2032	5	5.3	350	0.91	40
23871 (1998 RC76) 21 DEC 2032	6.7	2.4	150	0.91	53
59980 (1999 SG6) 30 AUG 2033	8	3.9	230	0.92	64

Interplanetary Tour

Preliminary Design Review (PDR)
Revision Date: 25 April 2023

PDR Trajectory

Sun-centered EMO2000
Viewed from Above the Ecliptic



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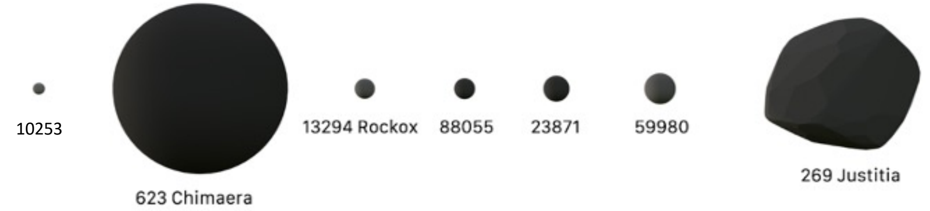

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Flight Phases

- There are 9 distinct flight phases
  1. Launch – Separation, Deployments, Initial Acquisition & Tracking
  2. Early Operations – First 30 days
  3. Cruise – Consists of multiple segments
  4. Planetary Flyby Gravity Assists – Venus, Earth, Mars
  5. Asteroid High-Speed Flyby Encounters – 6 distinct high-speed asteroid flybys
  6. Rendezvous & Proximity Operations – Asteroid characterization & landing site selection
  7. Landing – Spacecraft descent and lander deployment
  8. Extended Mission – Opportunity for EMA to continue Science & Space Resources investigations
  9. Decommissioning – Spacecraft passivation and operations close-out
- Navigation will consist of a combination of radiometric tracking, ground-based optical navigation and on-board autonomous navigation
- Planetary Protection (PP) will be described in the EMA PP Plan and follow the PP processes as was done for EMM; All bodies are Cat II at this time, except Mars


Thank you!