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| The work described in this report was done under ESA Contract. Responsibility for the contents resides in the author or organisation that prepared it. | | | | |
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TN1A TIRA Mission Requirements document

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1. Introduction
   1. Scope

This document describes the TIRA scientific and technological objectives & requirements as outcome of task 1200 “Requirements analysis of the HERA mission and Iteration with planetary experts and navigation experts” executed by ROB and VITO.

* 1. Applicability

This document applies to the TIRA project only.

1. References
   1. Applicable project documents

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| --- | --- |
|  | Statement of work - ESA-GSTP-TECMMO-SOW-010535, 26/07/2018  + revision of functional and performance requirements (based on revised version provided by Alessandro Zuccaro Marchi; email 19/12/2018)  [GSTP CHYTI] requirements with descoping to TIR\_v2). |
|  | Hera Mission Requirements Document (Issue 1, Revision 2), 14/05/2019 |

* 1. Reference documents

|  |  |
| --- | --- |
|  | Didymos Reference Model; 01/09/2016 |
|  | Thermal Asteroid Impact Mission (TAIM); CR-TAIM-D1; 07/07/2017 |
|  | MarcoPolo-R Science Requirements Document ; MPR-RSSD-RS-001; 08/10/2011 |
|  | Thermal Infrared Imaging Experiments of C-Type Asteroid 162173 Ryugu on Hayabusha2; Space Sci Rev (2017) **208**: 255 – 286  DOI 10.1007/s11214-016-0286-8 |
|  | Autonomous vision‑based navigation for proximity operations around binary asteroids  CEAS Space Journal; https://doi.org/10.1007/s12567-018-0197-5 |
|  | Science case for the Asteroid Impact Mission (AIM): S component of the Asteroid Impact & Deflection Assessment (AIDA) mission (Michel et al . 2016, Advances in Space Research 57, 2529-2547 |
|  | European component of the AIDA mission to a binary asteroid: Characterization and interpretation of the impact of the DART mission. (Michel et al . 2018 Advances in Space Research 62 (8), 2561-2272 |
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1. Terms, definitions and abbreviated terms

Specific terms and definitions, abbreviations and acronyms are listed in Table 1

|  |  |
| --- | --- |
| GNC | Guidance, Navigation and Control |
| YORP | Yarkovsky–O'Keefe–Radzievskii–Paddack effect |
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**Table 1: Specific terms and definitions**

1. TIRA OBjectives

TIRA will be used for both scientific and GNC purposes on board of the Hera platform. The requirements are based on AD1 and

* 1. Scientific objectives

The Hera mission is part of the “Planetary Defence” programme of ESA. This mission has as goal to study the asteroid deflection by kinetic impact, as will be performed in the NASA’s DART mission [RD7]. Scientific requirements resulting from this demonstration study are the primary requirements. However, asteroid science can also greatly benefit from the Hera mission and will thus also be considered in the instrument study of TIRA. These are however secondary and will only pursued in case that the need of resources is not significantly increased.

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| # | Priority | Objective | Description | Reference |
| TIRA\_SO1 | Primary | Surface properties & materials: | Characterize the regolith structure and cohesion. Discriminate between different possible surface properties of Didymoon (e.g. bare rock versus granular surfaces) that have great influence on the momentum transfer efficiency of a kinetic impactor. | D5 from AD2 |
| TIRA\_SO2 | Primary | Orbital and spin state evolution | Determine the global thermo-physical properties of the asteroid surface that contribute to the orbit/rotation evolution, in particular Yarkovsky and YORP effects. | D6 from AD2 |
| TIRA\_SO3 | Secondary | Subsurface properties & materials | Characterize the subsurface material exposed by the DART impact. | D4 from AD2 |

* 1. Technology objectives

The Hera mission will also be used for technology demonstrations. These technologies could be needed to enable future deep-space mission concepts. These are however not considered mission drivers for Hera. In case of the TIRA instrument it is intended to investigate to use TIR imaging for GNC purposes.

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| # | Objective | Description | Reference |
| TIRA\_TO1 | Demonstrate the benefits of an TIR instrument to support the asteroid rendezvous phase, by enabling the acquisition of complementary data for autonomous navigation: | Acquisition of images in Thermal Infrared with high contrast and at a sufficiently high pace to allow the determination of asteroid centroid and tracking of surface features. | T2.1, T2.2, T2.3, T2.4 (AD2) |

1. Requirements
   1. Scientific requirements

In order to meet the above-mentioned scientific objectives, we need to be able to use TIRA for the following measurements:

* TIRA shall enable the retrieval of the surface temperature of Didymoon.
* TIRA shall enable the retrieval of the asteroid surface thermal inertia
* TIRA shall have enough spatial resolution to resolve interior of a 10m crater from a distance of 10 km.
* TIRA shall observe the surface at a range of local times and phase angles.

Leading to the following requirements:

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| TIRA\_SCI\_REQ001 | TIRA shall enable the retrieval of the surface temperature with an accuracy of < 5K over the range of 200K <T<420K |
| TIRA\_SCI\_REQ002 | TIRA shall enable the retrieval of the asteroid surface thermal inertia with an accuracy of < 100 (TBD) W m−2 K−1 s1/2 |
| TIRA\_SCI\_REQ003 | TIRA shall have spatial resolution < 3m from 10 km at 8 µm . |

* 1. Technological requirements

For the GNC purpose of TIRA the following performances are needed:

* TIRA shall enable the use of TI images at high enough frequency for onboard GNC processing
* TIRA shall cover the whole Didymoon surface in its FOV for Centre-of-brightness determination and limb extraction
* TIRA shall enable the use of TI image with sufficient contrast and spatial resolution for Pattern recognition and tracking
* TIRA shall be able to observe the night side of Didymoon at least partially

Leading to the following requirements:

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| TIRA\_TEC\_REQ001 | TIRA shall retrieve images at a frequency > 1 frame/s |
| TIRA\_TEC\_REQ002 | TIRA shall enable the retrieval of the asteroid surface thermal inertia with an accuracy of < 100 (TBD) W m−2 K−1 s1/2 |
| TIRA\_TEC\_REQ003 | TIRA shall have a spatial resolution < 3m from 10 km at 8 m |
| TIRA\_TEC\_REQ004 | TIRA shall have a FOV > 5.5ox5.5o to have the whole Didymoon for Centre-of-brightness determination at a distance of ~ 2 km. |