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ASTEROID IMPACT MISSION: DIDYMOS REFERENCE MODEL

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1 INTRODUCTION

1.1 Scope

This document shall serve as the reference model of the asteroid 65803 Didymos 1996 GT and shall be used by the Contractor throughout the AIM phase-A/B1 study tasks.

Any missing or conflicting information deemed necessary for the AIM spacecraft design shall be reported to the Agency, which will maintain this model and make available updates as necessary in the context of the AIM Phase A/B1 work.

2 REFERENCES

[1] Minor Planet Center:
[2] PDS, radar (Lance Benner) and lightcurve (Petr Pravec) observations.
[4] Pravec, P., et al., 2006, Photometric survey of binary near-Earth asteroids, Icarus, 181:63-93.
[5] Fang, J., and J.-L. Margot, 2012, Near-Earth binaries and triples: Origin and evolution of spin-orbital properties, Astron. J., 143:24.
[6] Scheirich, P., and P. Pravec, 2009, Modeling of lightcurves of binary asteroids, Icarus, 200:531-547.
[7] JPL Small-Body Database Browser: http://ssd.jpl.nasa.gov/sbdb.cgi
[8] Asteroid Lightcurve DataBase, rev. 2014-Mar-01
[9] AIM Advisory Team Final Report: https://www.oca.eu/michel/AIMReport_Final.pdf

3 TERMINOLOGY & ACRONYMS

+/-	Refers to the uncertainty of the reported value without giving the nature of the uncertainty.
[#]	Reference, as detailed in section 2.
P	period
a	semi-major axis
e	eccentricity
ρ	mass density
MPC	Minor Planet Center

4 MAIN DYNAMICAL AND OBSERVATIONAL VALUES

Parameter	Value	Reference / comments
Official minor planet number of primary	65803	[1]
Official name of primary	Didymos	[1]
Provisional designation of primary	1996 GT	[1]
Dynamical type	Apollo	[1]
Method of discovery of companion	photometric lightcurve	[1]
Last update in MPC database	2013	[1]
Diameter of Primary	0.8 km	
Diameter of Secondary	0.17 km	[see D2/D1 below]
Bulk density of the secondary (assumed)[1]	2 g/cc	
Distance between the centre of primary and secondary	1.1 km	
Total mass of system	5.27e11 kg	[5]
Geometric Albedo	0.147	
Rotation period of the primary	2.2593 h	[8]
Radar albedo	0.24 +/-25%	

[1] The bulk density of the secondary is not known. However, based on the estimated mass density of the system as well as the bulk density known for S-type objects (about 2 to 2.7 g/cc), we assume a value of 2 g/cc for the secondary. In effect, even if the secondary may be a rubble pile, it should be relatively compact because indications are that it is tidally locked along its major axis -- this implies internal dissipation that may have helped drive the system to a lower energy state commensurate with compaction. If true, then the minimum density of the secondary should be close (but no necessarily identical) to the primary density, hence the assumed value of 2 g/cc. This results in an escape speed of the secondary about 7.7 cm/s.

Heliocentric eccentricity (e)	e = 0.383752494 +/- 9e-9	[7]
Heliocentric semimajor axis (a)	1.64443277 +/- 1e-8 AU[2]	[7]
Heliocentric inclination to the ecliptic (i)	3.407650° +/- 2e-6°	[7]
Absolute magnitude of the primary (H)	18.0	[7]

5 BINARY ORBIT SOLUTIONS

The values in the table below show that there are two possible solutions for the binary orbit with two pole orientations that are both compatible with existing observations. Which one of the two is the real one is not known at the time of writing. Observations in April 2015 should allow the pole orientation to be better constrained. Figure 1 shows the two possible values.

Synchronous rotation of secondary is compatible with existing observations. This would imply the secondary rotational period P_s is the same as the secondary orbital period P.

Binary Orbit Solution 1		
Pole solution 1 (3σ)	λ=157° +4°/-7°, β=19° +45°/-15°	[6] (ecliptic coordinates)
Diameter ratio D2/D1	0.22 +/- 0.01	[6] (ecliptic coordinates)
Secondary orbital period (P)	11.906h +0.004/-0.1	[6] (ecliptic coordinates)
Secondary eccentricity (e)	0.09 +0.07/-0.09	[6] (ecliptic coordinates)
Mass density (ρ)	1.7 +0.6/-0.4 g/cc	[6] (ecliptic coordinates)

[2] The uncertainties of the orbital parameters will be translated in a next phase into the ¨uncertainty region at AIM arrival to Didymos vicinity; e.g. the approximate maximum linear dimension of the ¨uncertainty region¨ (i.e. the longest semi axis if it is an ellipsoid) will be estimated.

Binary Orbit Solution 2		
Pole solution 2 (3σ)	λ=329 +11°/-194°, β=-70 °+25°/-15°	[6] (ecliptic coordinates)
Diameter ratio D2/D1	0.21 +/- 0.01	[6] (ecliptic coordinates)
Secondary orbital period (P)	11.920h +0.004/-0.006	[6] (ecliptic coordinates)
Secondary eccentricity (e)	0.02 +0.01/-0.02	[6] (ecliptic coordinates)
Mass density (ρ)	2.1 +0.8/-0.5 g/cc	[6] (ecliptic coordinates)

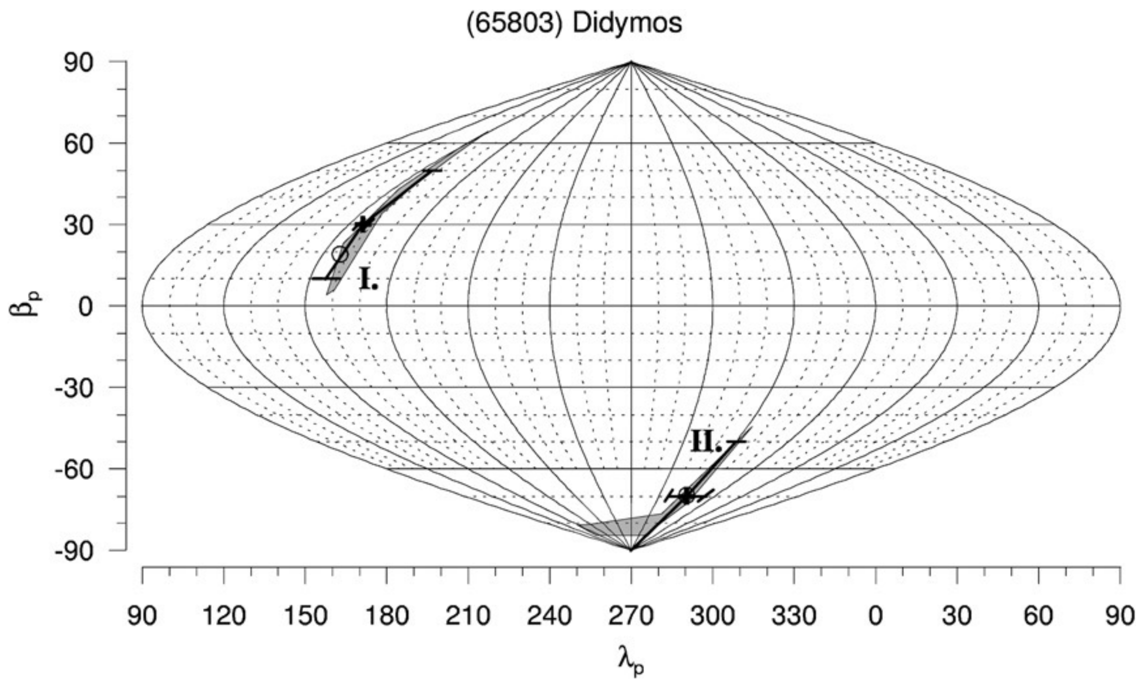

Figure 1: Range of plausible poles of the mutual orbit of (65803) Didymos in ecliptic coordinates (Pravec et al. (2006)) [6].

6 RADAR SHAPE MODEL

A preliminary shape model on the Didymos primary based on the past radar observations is shown below in figure 2. Radar data cannot provide a model of the secondary: the SNR is too weak, echoes are not sufficiently resolved, and the rotation coverage is limited.

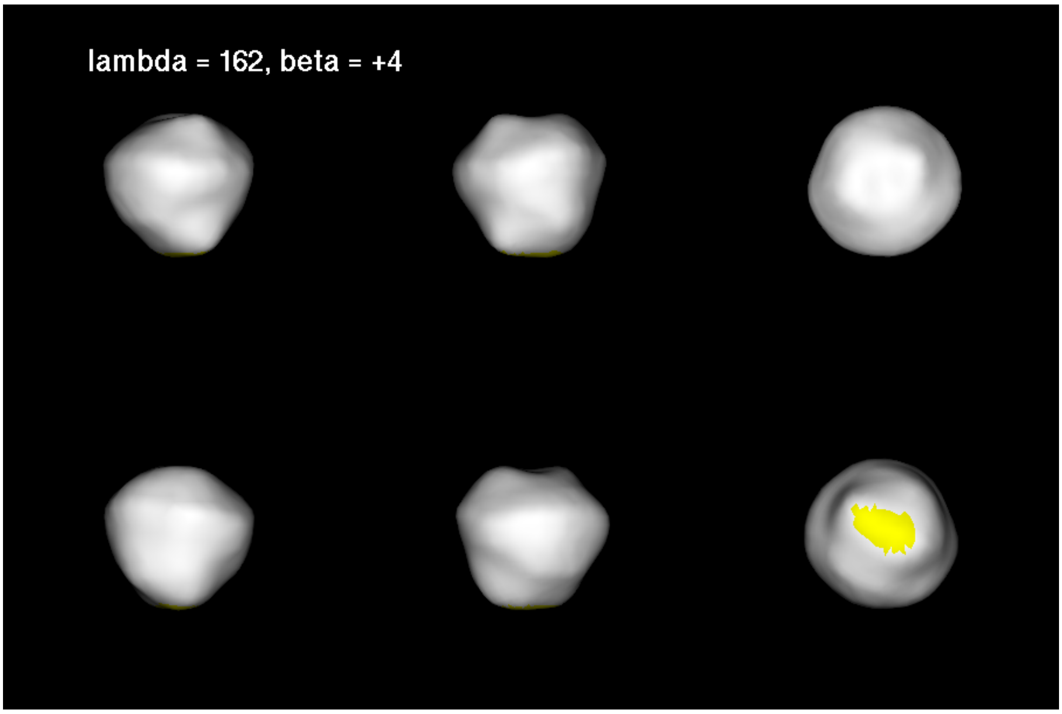

Figure 2: Preliminary shape model of the primary (principal axis view). The secondary (not imaged) estimated to be more elongated from other data (courtesy of Lance Benner).

7 THEORETICAL THERMAL MODEL

The thermal properties of the surface (e.g. thermal inertia) will not be known in advance. Figure 3 shows a preliminary temperature distribution at the surface of the asteroid Didymos (primary) calculated at 1.664 AU from the Sun for a thermal inertia of 100m^{-2} s$^{-0.5}$ K^{-1}, bolometric Bond albedo of 0.1, emissivity of 0.9 and assuming that the asteroid spins perpendicular to the direction toward the Sun, (which is not necessarily the case).

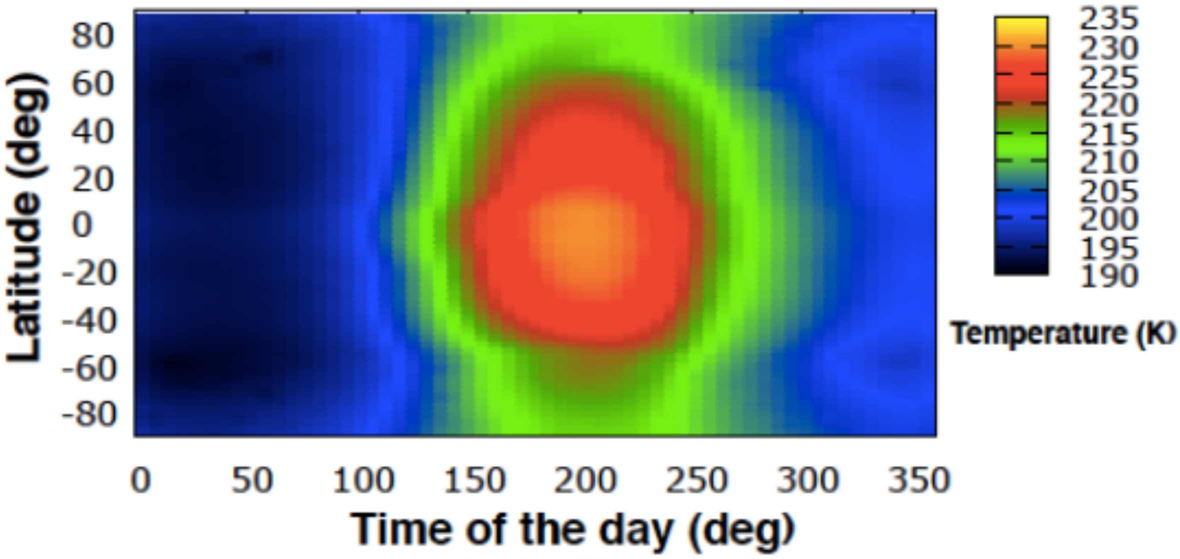

Figure 3: Preliminary temperature distribution at the surface of the asteroid Didymos calculated at 1.664 AU from the Sun.

Local midnight corresponds to 0 degrees. The hottest spot is not at 180 degrees (noon), but is slightly shifted because of the thermal inertia.

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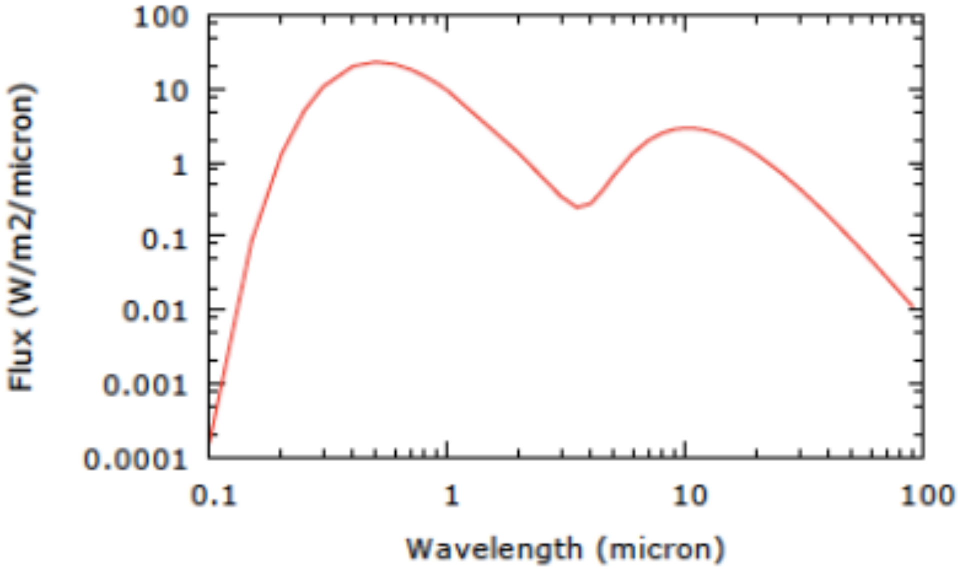

Figure 4: Spectral energy distribution (SED) at the distance of 1 km of the asteroid.

The total power from the asteroid and thus heating the spacecraft is given by the integral of the SED, shown in figure 4. This gives a flux of about 66 W/m^2

8 ADDITIONAL NOTES

- Regarding its spectral properties, Didymos is now classified as an S-type (DeLeon et al. 2010), even if it was originally classified as an Xk-type (Binzel et al. 2004) due to limited wavelength coverage.
- The radar albedo is consistent with silicates and inconsistent with pure metal.