SCIENCE INVESTIGATIONS AND PAYLOAD FOR THE DON QUIJOTE MISSION – RESULTS OF THE PHASE A STUDY. S. D. Wolters[1], A. J. Ball[1] and N. McBride[1], [1]Planetary and Space Sciences Research Institute, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK, email: s.d.wolters@open.ac.uk

Introduction: *Don Quijote* (DQ) is an Impact Mitigation Preparation Mission. The concept is to send two spacecraft to a Near-Earth Asteroid (NEA), an Orbiter and an Impactor. The Impactor smashes into the asteroid while the Orbiter measures the change in the asteroid's orbit, by means of a Radio Science Experiment (RSE) carried out before and after impact. Three target asteroids were chosen for the study: 2002 AT4, (10302) 1989 ML, and (99942) Apophis. Parallel Phase A studies were carried out by industrial consortia in 2006/2007. The Open University defined the payload and science operations for the QinetiQ-led study, and the results of this are reported here. The Executive Summary of the study can be downloaded from [1].

Mission Objectives: ESA defined two mission objectives for the DQ study. The *Primary Objective* is to determine momentum transfer from the impact by measuring the asteroid's mass, size, bulk density and rotation state. The *Secondary Objective* is to perform multi-spectral mapping of the asteroid. We proposed an additional objective, intermediate in priority. The *Impact Interpretation Objective* is to calibrate the impact through measurement of relevant near-surface properties and observation of the impact so that the momentum enhancement factor that results from the impact can be extrapolated for the general population of NEOs.

Table 1: Experiment types, prioritised left to right

		Radio Science	Mapping Camera	Thermal IR Spec.	Laser Altimeter	NIR Spec.	Impact Camera	X-Ray Spec.
Primary	Mass	Y						
	Semimajor axis change	Y		Y				
	Gravity field	Y			Y			
	Rotation state		Y					
	Size/Shape		Y		Y			
Impact Interpretation	Near-surface density	Y						
	Impact cloud particle size			Y			Y	
	Near-surface porosity limits					Y		
	Near-surface grain size limits		Y	Y				
	Near-surface shear strength						Y	
Secondary	Topography /Morphology		Y		Y			
	Mineralogy			Y		Y		
	Elemental Composition							Y

Thermal IR Spectrometer: We assessed the possible range of semimajor axis drift rate due to the Yarkovsky effect: e.g. for (10302) 1989 ML, assuming that the possible surface thermal inertia is between 40 and 2200 J m^{-2} K^{-1} $s^{-1/2}$, the drift could range from 70 to 4000 m/yr. A trade-off vs. a thermal IR radiometer indicated that high spectral resolution is required to measure surface temperature to the required accuracy. *Therefore we concluded that a thermal IR spectrometer is mandatory.* We defined a requirement that the surface thermal inertia must be measured to an accuracy of 1 m^{-2} K^{-1} $s^{-1/2}$, corresponding to 4 m/yr in the drift rate. Additionally, the spectrometer could derive limits on near-surface particle sizes down to a thermal skin depth of 9 cm and a thermal IR spectrometer with a high spectral resolution can be used to determine silicate mineralogy.

Table 2: Instrument resources

Instrument	Heritage	Mass w/ Margin (kg)	Power w/ Margin (W)	FoV (°)
Mapping Camera	AMIE (SMART-1)	2.3	2.2	5.3
Thermal IR Spectrometer	MERTIS (BepiColombo)	2.6	9.4	4
Laser Altimeter	NLR (NEAR)	5.3	17.3	0.17
NIR spectrometer	SIR-2 (Chandrayaan-1)	2.4	3.6	0.4
Impact Camera	AMIE (SMART-1)	2.1	2.3	40
X-ray spectrometer	D-CIXS (SMART-1)	5.0	29.4	7
TOTAL		**19.7**	**60.6**	

Laser Altimeter: This has a number of advantages, particularly for a target with smooth terrain or areas of or permanent shadow, as well as allowing ~5× higher spatial resolution. Therefore the laser altimeter is highly prioritised.

Impact Camera: We produced simple models of the ejecta cloud and concluded that an impact camera with a 40° field of view that covers ~30 km during the impact would help acheive the Impact Interpretation Objective. We also recommended including a polarimetry filter for measuring grain sizes.

Gravity Attraction vs. SRP Uncertainty: We also considered the changing uncertainty in optical properties of the surface of a SMART-1 chassis during the mission lifetime, and its effect on the solar radiation pressure uncertainty. We found that to measure above J2 for 2002 AT4, RSE drift-bys for measuring gravity field must be done as early as possible or there must be a campaign to measure SRP in orbit.

References: [1] http://esa-mm.esa.int/docs/NEO/QinetiqDQExecSum.pdf