**NEOShield Final Report: Figures, Tables, Appendices 1 and 2**

**Figure 1.** The trail left by the Chelyabinsk bolide. The left part of the image shows two contrarotating vortices formed by heating and buoyancy effects in the horizontal cylinder of air in which kinetic energy of the asteroid was deposited. The asteroid had a diameter of only 18 m yet produced a blast wave in the atmosphere that damaged thousands of buildings and caused injuries to some 1500 people. The high altitude of the airburst (> 20 km) and the shallow entry angle (about 17° from the horizon) combined to prevent a potentially far worse outcome. (Credit: Nikita Plekhanov; Wikimedia Commons.)

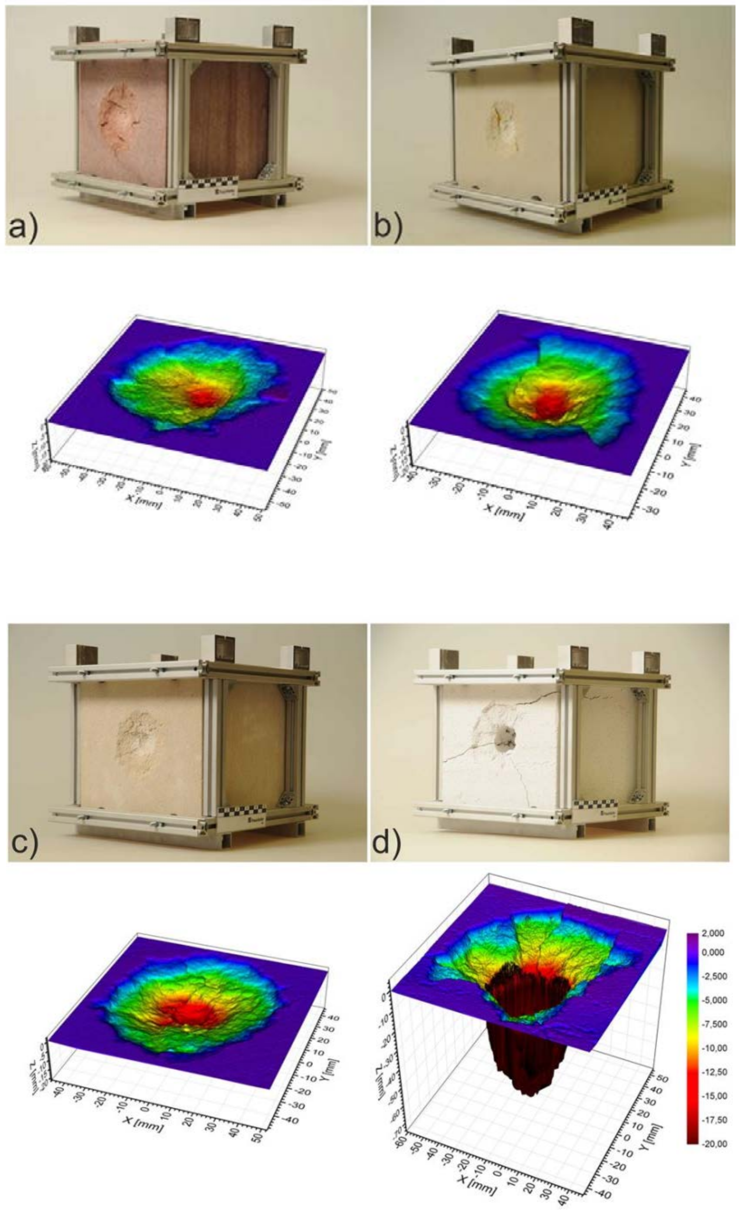


**Figure 2a.** Examples of the results of gas-gun experiments on asteroid surface analog materials carried out by NEOShield partner Fraunhofer Ernst Mach Institute, Freiburg, Germany. The impact craters in different target materials with porosities, ϕ, were formed by projectiles with approximately the same impact velocity: a. Quartzite (ϕ ~ 3 %); b. sandstone (ϕ ~ 25 %); c. limestone (ϕ ~ 31 %); d. aerated concrete (ϕ ~ 87 %). In each case a photograph of the target after the impact is shown above a three-dimensional model of the crater morphology. The colour code shown adjacent to the bottom right crater model applies to all four models. The experiments demonstrate that large craters are formed in highly porous material but in contrast, the ejected mass is small. (Credit: Fraunhofer EMI.)

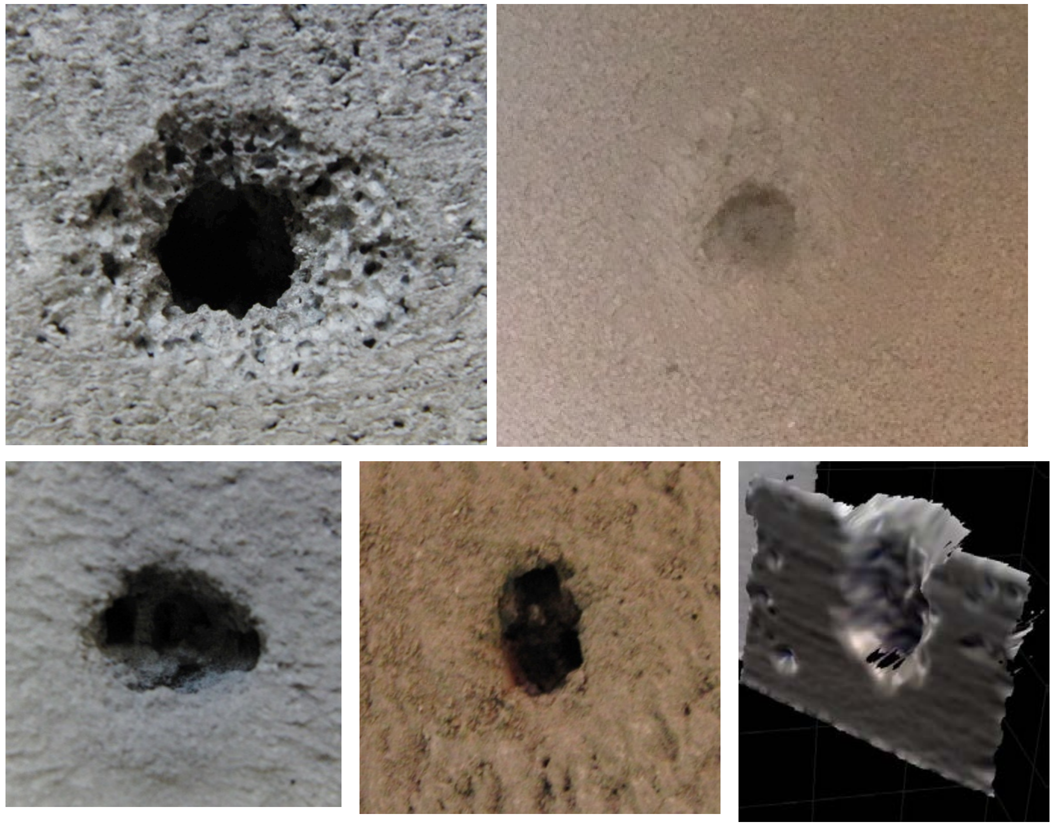

**Figure 2b.** Examples of the results of experiments with the all-angle gas gun operated by NEOShield partner Open University. The frames show craters in solid aerated concrete (top left), and with 5 mm (top right), 10 mm (lower left) and 20 mm (lower centre) overlying layers of regolith. Lower right: scan of the cross-section of the top left hand crater showing large depth/diameter ratio. The depth of the core crater is smaller for impacts with a regolith layer present but, for the small data set available, does not change with increasing regolith layer depth. This is true for regolith layers at least as thick as the crater depth in the solid target, indicating that particles penetrate much deeper in the regolith than they do in the solid. (Credit: Open University.)

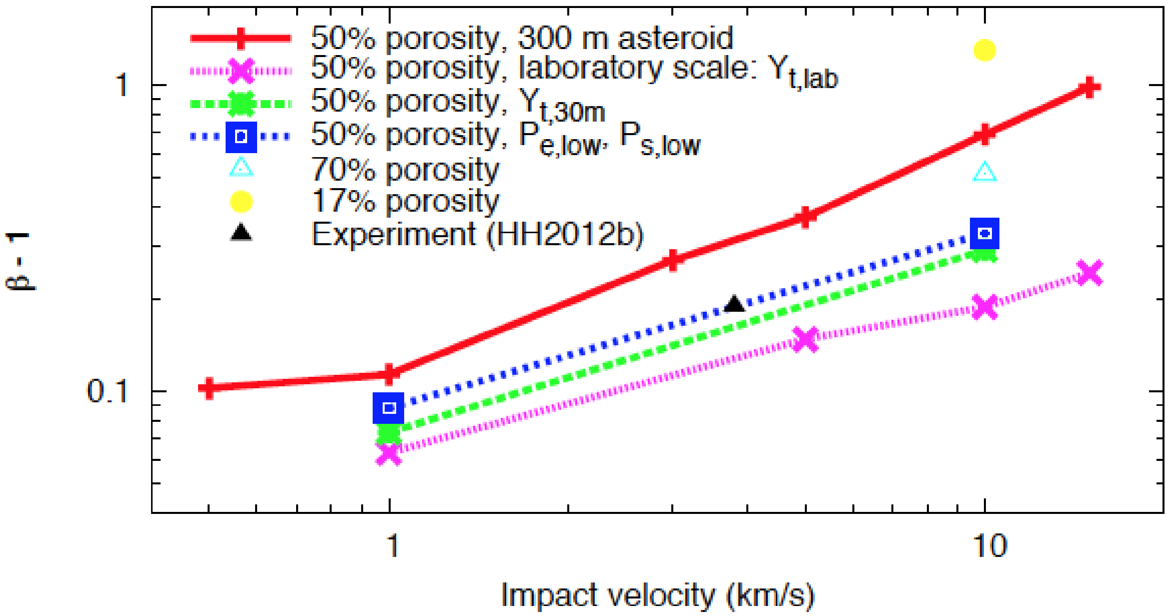


**Figure 3.** Momentum multiplication factor β-1 as a function of impact velocity, considering various strengths and porosities. The result of an impact experiment using a pumice target (Housen and Holsapple, 2012) is also shown. High tensile strengths, $Y_t$, corresponding to a 30 m ($Y_{t,30m}$) and a 3 cm ($Y_{t,lab}$) sized body, lead to less ejecta and therefore a smaller β. On the other hand, using a lower crushing strength (i.e., smaller crush-curve parameters Pe, Ps) leads to more compaction and therefore also less ejecta and smaller β. Increasing the porosity, while keeping the strength parameters constant, leads to a decreased β. Overall, our results are in reasonable agreement with the laboratory measurements of β in the case of a porous pumice target (Housen and Holsapple, 2012, 43rd LPSC, LPI Contribution No. 1659). Figure from Jutzi and Michel, 2014, Icarus 229:247-253.

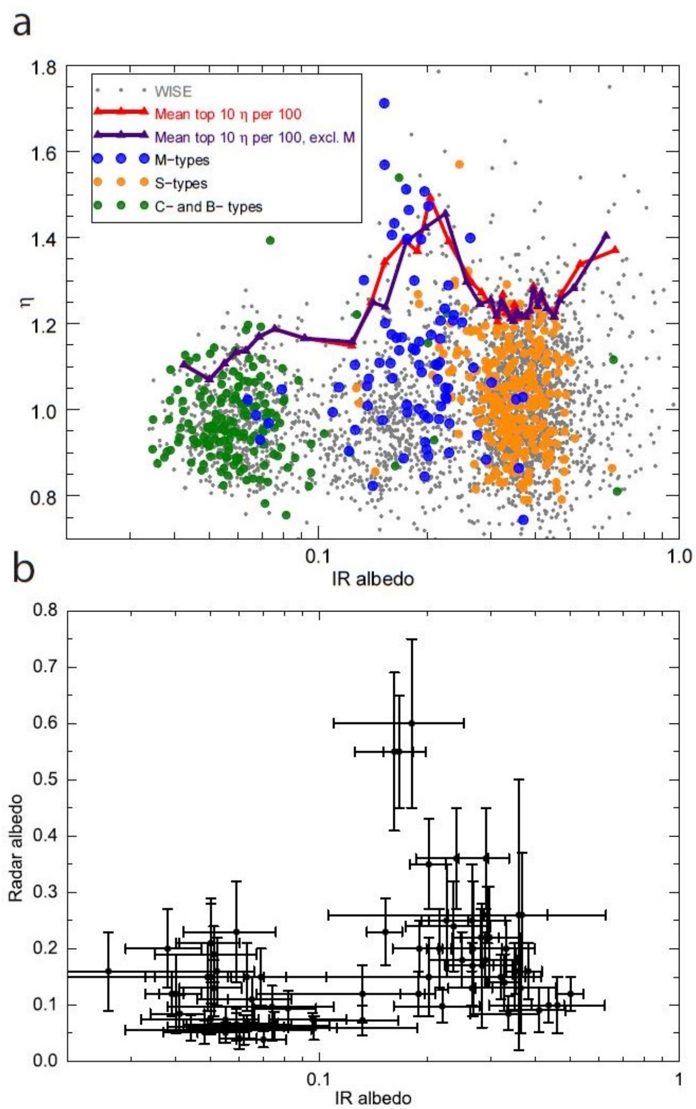


**Figure 4.**

a. WISE η values versus infrared albedo. η is a model fitting parameter derived by finding the model thermal continuum that best fits the measured infrared fluxes of a NEO; in general, η increases with thermal conductivity. Basic taxonomic types are shown as coloured bullets. The red curve is a plot of the mean of the highest 10 η values in bins of 100 data points; the purple curve is the same after removal of all the currently identified and suspected M (metallic) types from the dataset. The fact that the peak persists implies that many more metallic asteroids exist but remain unidentified to date.

b. Radar albedo versus WISE near-infrared albedo for main-belt asteroids. The broad clustering into 3 groups seen in (a) is also evident here, whereby the central group here corresponds to high radar albedo, and in (a) to a peak in η and the location of the M types.

Figure from Harris and Drube, 2014, Ap.J. Letters, 785:L4.

# NEOShield mission target selection lists

SEVENTH FRAMEWORK PROGRAMME

| Rendezvous targets | | | Fly-by targets | | |
|---|---|---|---|---|---|
| Selected | All (Delta-v) | All (Name) | Selected | All (Delta-v) | All (Name) |

## All NEOs with Rendezvous delta-v < 6 km/sec, ordered by delta-v

| Colour | MPC Orbital Uncertainty Code |
|---|---|
| White | 0 - 1 |
| Green | 2 - 3 |
| Orange | 4 - 6 |

Warnings: CEU is an RMS uncertainty, the error ellipse may be significantly larger along the major axis.
Numbers in brackets () are inferred from other parameters and have not been directly measured.

| | Number | Name | H | delta-v (km/s) | U (MPC) | CEU ('') | D (km) | a/b | Albedo | Taxonomy | Period (hr) | Tumbling? | Binary? | PHA? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2006RH120 | 29.5 | 3.94 | 1 | 8.4 | | 3.0 | | | 0.0458;0.03 | | | |
| 2 | | 2012TF79 | 27.4 | 3.94 | 3 | 165 | | | | | | | | |
| 3 | | 2009BD | 28.1 | 3.95 | 0 | 1.65 | 0.004 | | .45 | | | | | |
| 4 | | 2010UE51 | 28.3 | 4.00 | 2 | 96 | | | | | | | | |
| 5 | | 2007UN12 | 28.7 | 4.00 | 3 | 246 | | | | | | | | |
| 6 | | 2008HU4 | 28.2 | 4.02 | 3 | 570 | | | | | | | | |
| 7 | | 2010VQ98 | 28.2 | 4.09 | 3 | 129 | | | | | | | | |
| 8 | | 2013XY20 | 25.5 | 4.12 | 3 | 60 | | | | | | | | |
| 9 | | 2012EC | 23.4 | 4.13 | 2 | 39 | | | | | | | | |
| 10 | | 2013DA1 | 27.3 | 4.13 | 6 | 1470 | | | | | | | | |
| 11 | | 2008EA9 | 27.7 | 4.13 | 5 | 810 | | | | | | | | |
| 12 | | 1991VG | 28.5 | 4.18 | 2 | 273 | | | | | | | | |
| 13 | | 2013EC20 | 29.0 | 4.20 | 5 | 135 | | | | | | | | |
| 14 | | 2012WR10 | 28.7 | 4.24 | 5 | 510 | | | | | | | | |
| 15 | | 2013BS45 | 25.9 | 4.25 | 0 | 2.4 | | | | | | | | |
| 16 | | 2014SU1 | 25.0 | 4.26 | 4 | 87 | | | | | | | | |
| 17 | | 2010AN61 | 27.0 | 4.26 | 5 | 14700 | | | | | | | | |

**Figure 5.** Screenshot of the first 17 entries in the target selection list, here in order of increasing rendezvous $dv$ for NEOs likely to be in the size range ~100 m to ~600 m. The total number of entries at the time of writing was 1163. The online list, which was updated regularly during the course of the project with new NEO discoveries and measurements of physical parameters, is currently located at http://star.pst.qub.ac.uk/~af/lowdv_neos/. (Credit: Queen's University, Belfast).

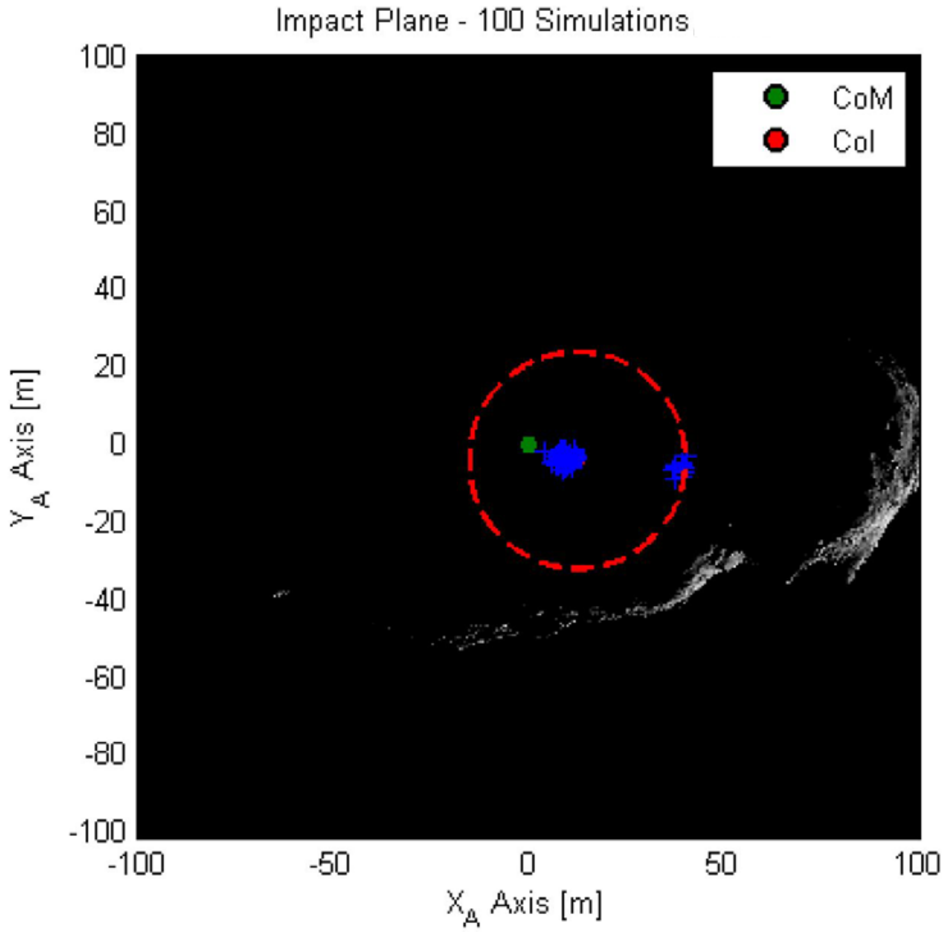


**Figure 6.** The results of 100 simulated impacts of a kinetic impactor into the NEO 2001 $QC_{34}$. Note that due to the very high phase angle at impact (roughly 140 degrees), only a very small sunlit horizon of the asteroid is visible. The last measurement and manoeuvre were 100 s prior to impact. The shape of the NEO Itokawa was assumed since the shape of 2001 $QC_{34}$ is unknown. The largest diameter of the ellipsoid was taken to be 190 m, which was computed to be the smallest possible value given current knowledge and pessimistic uncertainty assumptions. The smallest diameter of the ellipsoid is around 100 m. A larger area would reduce the risk of missing the target and enhance the quality of the information provided by the vision-based navigation. The green bullet is the center of mass (CoM) of the asteroid, chosen as the reference target point. The red-dashed circle is a projection onto the image of the navigation error standard deviation envelope. The blue crosses are the individual points of impact of each of the 100 Monte Carlo runs. The red dot (just visible at the edge of the main cluster of blue crosses) is the averaged point of impact (centre of Impact, CoI). For most (~ 85%) of the impacts the performance is very good (within 12 m), with only a very small bias of some 5 - 7 m in the direction of the centre of brightness (CoB). The remaining 15% of impacts fell in a tight cluster 40 m away in the direction of the CoB, suggesting that the timing of the final measurement and manoeuvre (100 s before impact) may require revision. A preliminary investigation considered a last manoeuvre at 50 s prior to impact instead of 100 s which increased the performance by a factor of 2 and reduced the number of offset points from 15% to 3%. The overall performance of the system is well within the goal and commensurate with analytical expectations. See Deliverable 8.2 for further details.

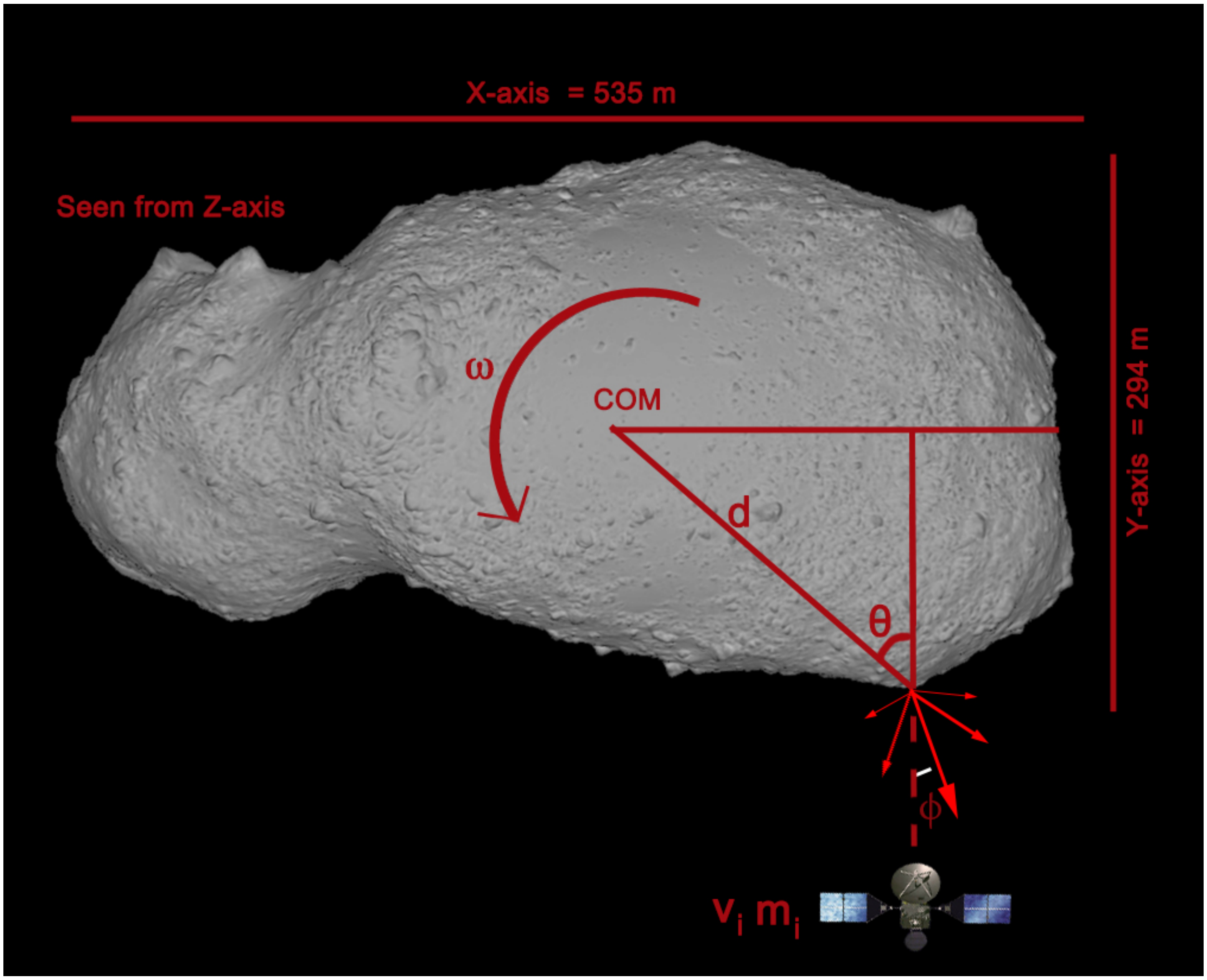


**Figure 7.** A kinetic impactor impacts off-center on Itokawa thereby changing its rotational period. Itokawa's dimensions are 535 x 294 x 209 m and it rotates around the Z-axis, which is perpendicular to the image. See Deliverable 9.6b for further details. Credit: Robert Gaskell produced the shape-model of Itokawa used.

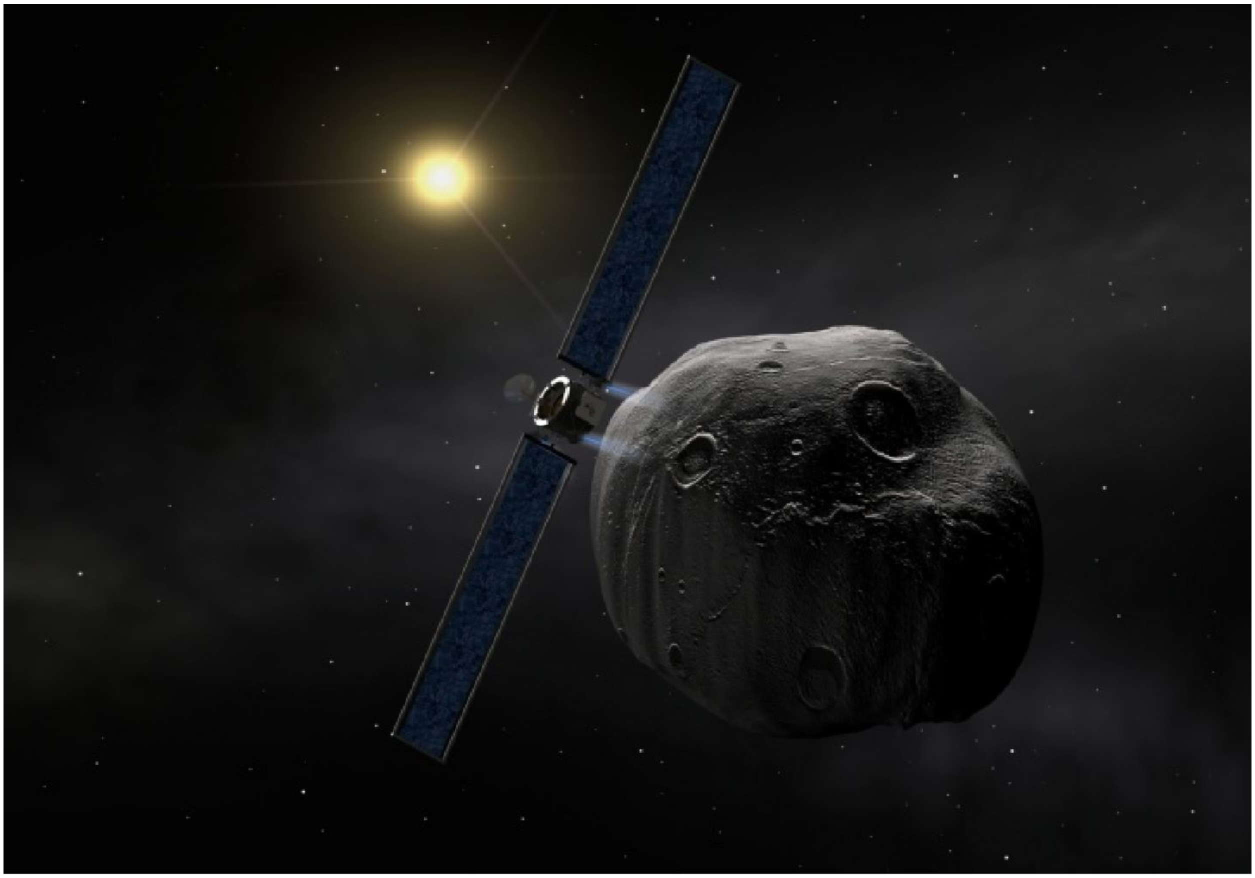

**Figure 8.** Artist's impression of NEO deflection by means of a gravity tractor (from Deliverable 8.3, background image credit: ESO).

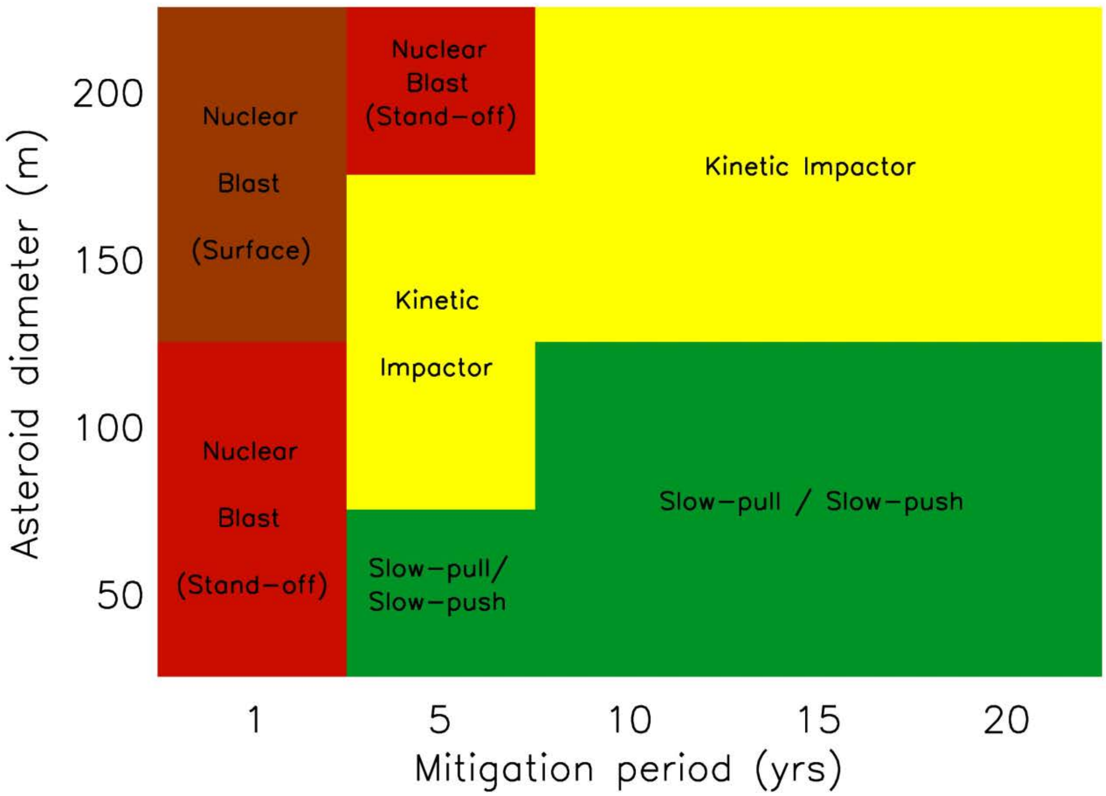


**Figure 9.** The best choice of space-mission deflection method, according to the results of the NEOShield trade-off study (Deliverable 7.5), is shown for realistic ranges of potential impactor size and time available for deflection of the NEO. "Mitigation period" is defined as the time between the start of the spacecraft's interaction with the asteroid and the predicted date of the impact of the NEO on the Earth. Accurately controllable slow-pull and slow-push techniques include the gravity tractor in addition to alternative approaches studied in less detail within NEOShield, such as the ion-beam shepherd and laser ablation. For very rare threatening NEOs much larger than 200 m, or mitigation periods shorter than a few years, nuclear blast deflection is deemed the best option. For objects smaller than 50 m, no space missions are foreseen, and "civil defence" actions (i.e., sheltering and evacuation measures) would probably be most appropriate. For intermediate scenarios, given current technology, the kinetic impactor appears to be the most viable deflection option. Figure credit: S. Eckersley (NEOShield, Airbus DS Limited, UK) and D. Perna (NEOShield, Observatoire de Paris, LESIA).

**Table 1.** NEOShield partner organisations

| Partner name | Country | Role/main contributions<br>WP = work package involvement<br>(see Table 2) |
|---|---|---|
| German Aerospace Center (DLR) Institute of Planetary Research, Berlin | Germany | NEOShield project coordinator; NEO science: data analysis, modeling; global mitigation strategy; public outreach.<br>WP 1, 2, 5, 9, 10 |
| Airbus Defence & Space | Germany | Supervision of technical work; space mission design; public outreach.<br>WP 1, 7, 8, 9, 10 |
| Paris Observatory | France | NEO science: orbital dynamics, space-mission instrumentation; global mitigation strategy.<br>WP 2, 5, 9 |
| Centre National de la Recherche Scientifique (CNRS), Côte d’Azur Observatory | France | NEO science: computer modeling of NEO material and structural properties.<br>WP 2, 3 |
| The Open University | UK | NEO science: all-angle gas-gun experiments.<br>WP 4 |
| Fraunhofer Ernst Mach Institute, Freiburg | Germany | NEO science: horizontal gas-gun experiments, computer modeling of NEO material properties.<br>WP 2, 3, 4 |
| Queen’s University Belfast | UK | NEO science: observations, data analysis, deflection test-mission target selection.<br>WP 2, 5 |
| Airbus Defence & Space | UK | NEO deflection techniques trade-off study; global mitigation strategy.<br>WP 7, 8, 9 |
| Airbus Defence & Space | France | Kinetic-impactor concept; space mission design.<br>WP 6, 8 |
| Elecnor Deimos | Spain | Kinetic-impactor concept; space mission design; global mitigation strategy.<br>WP 6, 8, 9 |
| Carl Sagan Center, SETI Institute, Mountain View, California | USA | Gravity tractor concept; space mission design.<br>WP 7, 8, 9 |
| TsNIIMash, Russian Federal Space Agency | Russia | Blast deflection concept; space mission design; global mitigation strategy.<br>WP 7, 8, 9 |
| University of Surrey | UK | Gravity tractor concept.<br>WP 7 |

**Table 2.** NEOShield work packages

| Work package no. | Description | Type of activity<br>MGT = management<br>RTD = Research/ technological development | Lead partner | Person-months |
|---|---|---|---|---|
| 1 | Consortium administrative and financial management. | MGT | DLR | 30 |
| 2 | NEO Physical properties. | RTD | Obs. Paris | 76 |
| 3 | Modelling/numerical simulations. | RTD | CNRS | 73 |
| 4 | Laboratory experiments. | RTD | Open University | 57 |
| 5 | Deflection demonstration mission target NEOs. | RTD | DLR | 48 |
| 6 | Kinetic impactor concept. | RTD | Elecnor Deimos | 45 |
| 7 | Alternative mitigation approaches. | RTD | Airbus DS UK | 68 |
| 8 | Design of appropriate demonstration missions for realistic scenarios. | RTD | Airbus DS Germany | 63.5 |
| 9 | Global response campaign roadmap. | RTD | Obs. Paris | 51.5 |
| 10 | Dissemination of results/Public outreach. | OTHER | DLR | 21 |

**Table 3.** NEOShield results suggest that the listed NEOs, half of which are categorised as potentially hazardous, are relatively metal rich (from Harris and Drube, 2014, Ap.J. Letters, 785:L4)

THE ASTROPHYSICAL JOURNAL LETTERS, 785:L4 (5pp), 2014 April 10

**Table 1**
Candidate High Metal Content NEOs Passing the Filter $0.15 < p_{IR} \leqslant 0.3$; $\eta > 2.0$

| NEO | Tax. | PHA? | $D$ (km) | $p_v$ | $\eta$ | $\eta_{err}$ | $p_{IR}$ |
|---|---|---|---|---|---|---|---|
| 138359 | | N | 1.09 | 0.10 | 2.931 | 0.105 | 0.19 |
| 1865 | S | N | 1.61 | 0.14 | 2.902 | 0.036 | 0.27 |
| 152931 | Q | N | 1.65 | 0.24 | 2.884 | 0.138 | 0.24 |
| 152978 | S: | Y | 0.53 | 0.11 | 2.641 | 0.116 | 0.19 |
| 365071 | | Y | 0.87 | 0.15 | 2.559 | 0.117 | 0.28 |
| 3554 | X, M, D | N | 3.05 | 0.09 | 2.411 | 0.072 | 0.19 |
| 215442 | | N | 0.79 | 0.15 | 2.328 | 0.325 | 0.17 |
| 152558 | S | N | 1.36 | 0.18 | 2.284 | 0.051 | 0.28 |
| 366774 | AS | Y | 0.86 | 0.20 | 2.284 | 0.059 | 0.29 |
| 250680 | | Y | 0.40 | 0.15 | 2.279 | 0.075 | 0.30 |
| 7822 | S | Y | 1.21 | 0.13 | 2.261 | 0.049 | 0.30 |
| 163243 | S, Q | Y | 1.68 | 0.17 | 2.191 | 0.061 | 0.23 |
| 263976 | L | Y | 0.79 | 0.13 | 2.165 | 0.043 | 0.18 |
| 142464 | | N | 0.89 | 0.12 | 2.139 | 0.044 | 0.22 |
| 2002 NW16 | | N | 0.85 | 0.16 | 2.118 | 0.066 | 0.26 |
| 103067 | S | Y | 1.28 | 0.25 | 2.114 | 0.056 | 0.29 |
| 363024 | | Y | 0.56 | 0.10 | 2.055 | 0.067 | 0.24 |
| 325102 | | N | 0.36 | 0.12 | 2.048 | 0.063 | 0.18 |

**Notes.** Taxonomic classifications are taken from the EARN database (http://earn.dlr.de/). A colon following the taxonomic class signifies an uncertain classification. All *WISE* sightings in the catalog, including multiple sightings of the same object, have been considered for the purposes of this table; due to measurement errors or different observational circumstances one record in the *WISE* catalog may pass the filter while another for the same object may not. The uncertainties in values of diameter and albedo derived from NEATM fitting are of the order of 15% and 30%, respectively (Mainzer et al. 2011a; Delbo' et al. 2003). For details of the NEO*WISE* data see Mainzer et al. (2011a).

**NEOShield Final Report: Appendix 1**

**A Selection of NEOShield Public Outreach Items**

## Newspapers, internet (selection)

http://www.bbc.co.uk/news/science-environment-16651642 20 Jan. 2012

http://www.allesoversterrenkunde.nl/artikelen/1194-Europa-wil-voorbereid-zijn-als-de-hemel-omlaagvalt.html 21 Jan. 2012

http://www.lefigaro.fr/sciences/2012/01/24/01008-20120124ARTFIG00690-proteger-la-terre-contre-la-chute-d-un-asteroide.php 24 Jan. 2012

http://www.dw-world.de/dw/article/0,,6703710,00.html 25 Jan. 2012

http://www.francetv.fr/info/des-scientifiques-planchent-sur-la-deviation-d-asteroides-au-cas-ou_54551.html 25 Jan. 2012

http://www.spiegel.de/wissenschaft/weltall/0,1518,811368,00.html 26 Jan. 2012

http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-2536/ 26 Jan. 2012

http://www.space.com/14370-asteroid-shield-earth-threat-protection-meeting.html 27 Jan. 2012

http://www.sueddeutsche.de/wissen/asteroidenabwehr-vorbild-armageddon-1.1268537 27 Jan. 2012

http://www.dailymail.co.uk/sciencetech/article-2092626/Asteroid-shield-wont-time-19-mile-wide-monster-hurtling-past-Earth-week.html 27 Jan. 2012

http://news.yahoo.com/asteroid-threat-earth-sparks-global-neoshield-project-155016535.html

27 Jan. 2012

http://www.mirror.co.uk/news/technology-science/scientists-race-to-build-asteroid-shield-304366 28 Jan. 2012

http://www.nrk.no/vitenskap-og-teknologi/1.7965575 28 Jan. 2012

http://www.francesoir.fr/actualite/scienceecologie/asteroides-des-solutions-a-l-etude-pour-eviter-la-collision-178970.html 29 Jan. 2012

http://www.24heures.ch/savoirs/sciences/Bientot-un-bouclier-antiasteroides-pour-proteger-la-Terre/story/13281508 30 Jan. 2012

http://german.china.org.cn/international/2012-01/30/content_24508259.htm 31 Jan. 2012 http://www.astrium.eads.net/node.php?articleid=8210 31 Jan. 2012

http://www.lexpress.fr/actualite/sciences/comment-detourner-un-asteroide-qui-menace-la-terre_1076349.html 31 Jan. 2012

http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-2640/ 3 Feb. 2012

http://www.welt.de/wissenschaft/weltraum/article13849960/NEO-Shield-als-Abwehr-gegen-kosmische-Bomben.html 4 Feb. 2012

http://www.augsburger-allgemeine.de/wissenschaft/Schutzschild-gegen-den-Gott-der-Zerstoerung-id18634306.html 4 Feb. 2012

http://www.franceinfo.fr/sciences-sante/du-cote-des-etoiles/comment-se-proteger-des-asteroides-511667-2012-02-04 4 Feb. 2012

http://www.raumfahrer.net/news/astronomie/05022012181158.shtml 5 Feb. 2012

http://www.bild.de/news/ausland/asteroiden/forscher-wollen-asteroiden-sprengen-neu-22454458.bild.html 6 Feb. 2012

http://www.rp-online.de/wissen/weltraum/schutzschild-gegen-bomben-aus-dem-all-1.2701621

6 Feb. 2012

http://www.sciencepresse.qc.ca/blogue/2012/02/06/projet-neoshield-pour-ne-finir-dinosaures

6 Feb. 2012

http://www.spacedaily.com/reports/Project_NEOShield_Asteroid_defence_systems_999.html

7 Feb. 2012

http://www.sanfinna.com/?p=52685 7 Feb. 2012

http://www.morgenpost.de/web-wissen/article1903270/Wie-die-Erde-vor-Asteroiden-geschuetzt-werden-soll.html 11 Feb. 2012

http://www.welt.de/print/wams/vermischtes/article13863879/Rettung-vor-dem-grossen-Crash.html

12 Feb. 2012

http://www.universetoday.com/93595/neoshield-a-preemptive-strike-against-asteroids/

15 Feb. 2012

http://www.dw.de/dw/article/0,,15751387,00.html 19 Feb. 2012 http://www.news.ch/Forscher+Netzwerk+untersucht+Asteroidenabwehr/530515/detail.htm

21 Feb. 2012

http://www.rp-online.de/digitales/rp-plus/die-angst-vor-dem-einschlag-1.2733312 28 Feb. 2012

http://www.faz.net/aktuell/feuilleton/debatten/asteroidenabwehr-vom-ende-her-11709851.html

24 Apr. 2012

http://www.badische-zeitung.de/nachrichten/panorama/die-kosmische-bombe-aus-der-bahn-werfen

7 Jul. 2012

http://www.oberbipp.ch/documents/NZZ_2.pdf 26 Aug. 2012

http://www.welt.de/print/wams/article112043724/Davon-geht-die-Welt-nicht-unter.html

16 Dec. 2012

http://www.washingtonpost.com/national/health-science/nasa-asteroid-fly-by-next-week-closest-ever-of-its-size/2013/02/07/ff47b876-714d-11e2-ac36-3d8d9dcaa2e2_story_1.html 8 Feb. 2013

http://www.berliner-zeitung.de/raumfahrt/begegnung-im-weltall-asteroid-kommt-der-erde-extrem-nah,10808910,21685052.html 8 Feb. 2013

http://www.fr-online.de/raumfahrt/begegnung-im-weltall-asteroid-kommt-der-erde-extrem-nah,1473248,21685052.html 8 Feb. 2013

http://www.nzz.ch/wissen/wissenschaft/globale-antworten-auf-eine-globale-bedrohung-1.17997976

14 Feb. 2013

http://www.faz.net/aktuell/wissen/weltraum/asteroid-2012-da14-rendezvous-mit-einem-kosmischen-besucher-12080808.html 15 Feb. 2013

http://www.faz.net/aktuell/wissen/weltraum/weltraum-forschung-der-asteroidenjaeger-12081900.html 15 Feb. 2013

**[Countless TV, radio, and newspaper reports cited NEOShield on the occasion of the close approach of 2012 DA14 and the Russian fireball over Chelyabinsk. 15 Feb. 2013]**

http://www.guardian.co.uk/science/across-the-universe/2013/feb/18/asteroids-how-deflect-dangerous

18 Feb. 2013

http://www.faz.net/aktuell/wissen/weltraum/interview-ueber-asteroidenabwehr-wenn-sie-uns-zu-nahe-kommen-12085485.html 20 Feb. 2013 http://www.dw.de/meteorite-explosion-puts-space-on-un-agenda/a-16622302 22 Feb. 2013

http://www.pbs.org/wgbh/nova/next/space/risk-of-an-asteroid-strike/ 27 Mar. 2013

http://lci.tf1.fr/science/nouvelles-technologies/risque-d-asteroide-on-est-loin-de-savoir-quoi-faire-et-quelle-decision-7934438.html 23 Apr. 2013

http://www.morgenweb.de/nachrichten/welt-und-wissen/kosmische-bomben-strategien-gegen-eine-todliche-gefahr-1.1131111 25 Jul. 2013

http://www.spiegel.de/wissenschaft/weltall/tscheljabinsk-meteorit-anatomie-einer-beinahe-katastrophe-a-932197.html 6 Nov. 2013

http://www.berliner-zeitung.de/wissen/glueck-im-unglueck-meteorit-von-tscheljabinsk-hatte-gewaltige-wucht,10808894,24921716.html 6 Nov. 2013

http://www.tagesspiegel.de/wissen/asteroiden-sie-koennten-eine-ganzestadt-zerstoeren/9050734.html 9 Nov. 2013

http://www.focus.de/wissen/diverses/wissenschaft-billard-im-all-tests-fuer-asteroiden-abwehr-mit-satelliten_id_3617557.html 15 Feb. 2014

http://www.badische-zeitung.de/nachrichten/panorama/ihn-vorherzusehen-war-unmoeglich--80776323.html 15 Feb. 2014

http://www.morgenpost.de/newsticker/dpa_nt/infoline_nt/wissenschaft_nt/article124881277/Tests-fuer-Asteroiden-Abwehr-mit-Satelliten.html 15 Feb. 2014

http://penzanews.ru/en/opinion/55135-2014 18 Feb. 2014

http://www.esa.int/ger/ESA_in_your_country/Germany/Experten_beraten_ueber_Asteroidenabwehr 18 Feb. 2014

http://www.spiegel.de/wissenschaft/weltall/asteroiden-gefahr-erde-ist-auf-einschlaege-aus-all-schlecht-vorbereitet-a-955924.html 11 Mar. 2014

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# NEOShield Final Report: Appendix 2. Tables of Deliverables and Milestones

| Del. no. | Deliverable name | Version | WP no. | Lead beneficiary | Nature | Dissemination level | Delivery date from Annex I (proj month) | Actual / Forecast delivery date | Status | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Initial progress repo rt to the REA. | 1.0 | 1 | DEUTSCHES ZENTRUM FU ER LUFT - UND RAUMFAHRT E V | Report | CO | 6 | 06/07/2012 | Submitted | |
| 2 | Periodic progress rep ort to the REA. | 1.0 | 1 | DEUTSCHES ZENTRUM FU ER LUFT - UND RAUMFAHRT E V | Report | CO | 16 | 30/05/2013 | Submitted | |
| 3 | Periodic progress rep ort to the REA. | 2.0 | 1 | DEUTSCHES ZENTRUM FU ER LUFT - UND RAUMFAHRT E V | Report | CO | 32 | 21/10/2014 | Submitted | |
| 4 | Final project report to the REA. | 1.0 | 1 | DEUTSCHES ZENTRUM FU ER LUFT - UND RAUMFAHRT E V | Report | CO | 41 | 31/05/2015 | Submitted | |
| 1 | Report on frequency o f mitigation-relevant pr operties. | 1.0 | 2 | DEUTSCHES ZENTRUM FU ER LUFT - UND RAUMFAHRT E V | Report | PU | 24 | 10/01/2014 | Submitted | |
| 2 | requirements for miti gati on precursor reco nna issance. | 1.0 | 2 | OBSERVATOI RE DE PARIS | Report | CO | 31 | 08/08/2014 | Submitted | |
| 3 | Instrumentation design s. | 1.0 | 2 | OBSERVATOI RE DE PARIS | Report | CO | 24 | 10/01/2014 | Submitted | |
| 4 | Requirements modellin g/simulation work and la b. experiments. | 1.0 | 2 | CENTRE NAT IONAL DE LA RECHERCHE SCIENTIFIQUE | Report | CO | 2 | 21/03/2012 | Submitted | |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Experiments requireme nts. | 1.0 | 3 | CENTRE NAT IONAL DE LA RECHERCHE SCIENTIFIQUE | Report | CO | 5 | 03/07/2012 | Submitted | |
| 2 | Modeling/simulations o f laboratory results. | 1.0 | 3 | CENTRE NAT IONAL DE LA RECHERCHE SCIENTIFIQUE | Report | CO | 24 | 13/01/2014 | Submitted | |
| 3 | Scaled-up modelling: m omentum gain and NEO deflection efficiency . | 2.0 | 3 | CENTRE NAT IONAL DE LA RECHERCHE SCIENTIFIQUE | Report | CO | 31 | 19/05/2015 | Submitted | |
| 4 | Potential for re-accu mula tion of hazardous large b odies from impa ct ejecta. | 2.0 | 3 | CENTRE NAT IONAL DE LA RECHERCHE SCIENTIFIQUE | Report | PU | 31 | 05/06/2015 | Submitted | |
| 1 | Results of momentum-tr ansfer experiments on u nconsolidated materi als. | 2.0 | 4 | THE OPEN U NIVERSITY | Report | CO | 27 | 09/06/2015 | Submitted | |
| 2 | Material properties o f the regolith analogu e sampl es. | 1.0 | 4 | FRAUNHOFER -GESELLSCH AFT ZUR FO ERDERUNG D ER ANGEWAN DTEN FORSC HUNG E.V | Report | CO | 12 | 28/06/2013 | Submitted | |
| 3 | Results of impact expe riments on consolidat ed samples. | 1.0 | 4 | FRAUNHOFER -GESELLSCH AFT ZUR FO ERDERUNG D ER ANGEWAN DTEN FORSC HUNG E.V | Report | CO | 27 | 10/04/2014 | Submitted | |
| 1 | Dynam.- and phys.-pro perty requirements fo r N EOs as targets in mitigat ion demo missi ons. | 1.0 | 5 | DEUTSCHES ZENTRUM FU ER LUFT - UND RAUMFAHRT E V | Report | CO | 15 | 21/05/2013 | Submitted | |
| 2 | List of potential tar get NEOs and their pr ope rties relevant to m itigat ion demo missio ns. | 1.0 | 5 | THE QUEEN'S UNIVERSITY OF BELFAST | Report | PU | 11 | 10/12/2012 | Submitted | |

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|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Prioritized demo-miss ion target suggestion s. | 1.0 | 5 | THE QUEEN'S UNIVERSITY OF BELFAST | Report | PU | 15 | 31/05/2013 | Submitted | |
| 4 | Orbit refinement and re connaissance observati ons as required. | 1.0 | 5 | THE QUEEN'S UNIVERSITY OF BELFAST | Report | PU | 31 | 18/09/2014 | Submitted | |
| 1 | Significant open issu es w ith regard to the kinetic -impactor conc ept. | 1.0 | 6 | DEIMOS SPACE SOCIEDAD LIM ITADA UNIP ERSONAL | Report | CO | 5 | 18/06/2012 | Submitted | |
| 2 | Impactor GNC technolo gies. | 1.0 | 6 | AIRBUS DEF ENCE AND S PACE SAS | Report | RE | 31 | 22/09/2014 | Submitted | |
| 3 | Orbitor GNC technolog ies. | 2.0 | 6 | DEIMOS SPACE SOCIEDAD LIM ITADA UNIP ERSONAL | Report | CO | 31 | 21/01/2015 | Submitted | |
| 1 | Assessment of gravity tra ctor and other mit igation concepts. | 1.0 | 7 | SETI INSTI TUTE CORPO RATION | Report | PU | 15 | 06/05/2013 | Submitted | |
| 2 | Assessment of gravity tra ctor with multiple -spacec raft tractors. | 1.0 | 7 | UNIVERSITY OF SURREY | Report | PU | 15 | 22/05/2013 | Submitted | |
| 3 | Assessment of blast de fle ction and other miti gatio n concepts. | 3.0 | 7 | FEDERALNOE GOSUDARST VENNOE UNI TARNOPREDP RIYATIE TS ENTRALNY N AUCHNO- IS SLEDOVATEL SKY INSTITUT MACHINO STROENIYA | Report | PU | 15 | 05/05/2014 | Submitted | |
| 4 | Potential benefits of hum an missions for mi tigatio n strategies. | 1.0 | 7 | AIRBUS DS GMBH | Report | PU | 15 | 03/04/2013 | Submitted | |
| 5 | Trade-offs of viable al te rnative mitigation concep ts. | 1.0 | 7 | AIRBUS DEF ENCE AND S PACE LTD | Report | PU | 18 | 24/09/2013 | Submitted | |
| 1 | Requirements on NEO ta | 1.0 | 8 | AIRBUS DS | Report | PU | 4 | 28/06/2012 | Submitted | |

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|---|---|---|---|---|---|---|---|---|---|---|
| | rget selection. | | | GMBH | | | | | | |
| 2 | Detailed demo-mission design, kinetic impa ctor. | 1.0 | 8 | AIRBUS DS GMBH | Report | CO | 36 | 25/02/2015 | Submitted | |
| 3 | Detailed demo-mission design, gravity trac tor. | 1.0 | 8 | SETI INSTI TUTE CORPO RATION | Report | CO | 36 | 29/05/2015 | Submitted | |
| 4 | Detailed demo-mission design, blast deflect ion. | 1.0 | 8 | FEDERALNOE GOSUDARST VENNOE UNI TARNOPREDP RIYATIE TS ENTRALNY N AUCHNO- IS SLEDOVATEL SKY INSTITUT MACHINO STROENIYA | Report | CO | 36 | 16/03/2015 | Submitted | |
| 5 | Assessment of demo-mis sion variants. | 1.0 | 8 | AIRBUS DEF ENCE AND S PACE LTD | Report | PU | 36 | 07/04/2015 | Submitted | |
| 1 | Preliminary roadmap o utline. | 1.0 | 9 | OBSERVATOI RE DE PARIS | Report | CO | 31 | 08/08/2014 | Submitted | |
| 2 | Required reconnaissan ce observations. | 1.0 | 9 | OBSERVATOI RE DE PARIS | Report | PU | 36 | 08/06/2015 | Submitted | |
| 3 | Description of decisi on-making tool. | 1.0 | 9 | DEIMOS SPACE SOCIEDAD LIM ITADA UNIP ERSONAL | Report | CO | 36 | 19/01/2015 | Submitted | |
| 4 | Atmospheric trajector y analysis and ground- da mage limitation. | 1.0 | 9 | FEDERALNOE GOSUDARST VENNOE UNI TARNOPREDP RIYATIE TS ENTRALNY N AUCHNO- IS SLEDOVATEL SKY INSTITUT MACHINO STROENIYA | Report | PU | 31 | 18/09/2014 | Submitted | |
| 5 | Final roadmap, includi ng political decision -making | 1.0 | 9 | AIRBUS DEF ENCE AND S | Report | PU | 36 | 24/04/2015 | Submitted | |

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|---|---|---|---|---|---|---|---|---|---|---|
| | , reconnaissan ce, decisio n tool. | | | PACE LTD | | | | | | |
| 6 | Options for future im plementation of propo sed demo missions. | 1.0 | 9 | AIRBUS DS GMBH | Report | CO | 41 | 31/05/2015 | Submitted | |
| 1 | Presentation of web de sig ns to project. | 1.0 | 10 | AIRBUS DS GMBH | Report | CO | 3 | 30/04/2013 | Submitted | |
| 2 | Public web site online. | 1.0 | 10 | AIRBUS DS GMBH | Other | PU | 6 | 29/05/2015 | Submitted | |
| 3 | Project web site. | 1.0 | 10 | AIRBUS DS GMBH | Other | CO | 6 | 29/05/2015 | Submitted | |
| 4 | Outreach events. | 1.0 | 10 | DEUTSCHES ZENTRUM FU ER LUFT - UND RAUMFAHRT E V | Other | PU | 41 | 27/05/2015 | Submitted | |

## Milestones

| Milestone no. | Milestone name | Work package no | Lead beneficiary | Delivery date from Annex I | Achieved Yes/No | Actual / Forecast achievement date | Comments |
|---|---|---|---|---|---|---|---|
| 1 | Kick-Off meeting. | All | DLR | 16/01/2012 | Yes | 16/01/2012 | |
| 2 | Initial progress assessme nt. | 1,2,3,4,5,6,7,8,10 | DLR | 31/05/2012 | Yes | 31/05/2012 | |
| 3 | Preparation for mission designs complete. | 1,2,4,5,6,7 | DLR | 31/03/2013 | Yes | 30/06/2013 | Delays in submission of s ome deliverables have only minor impact on ov erall schedule. |
| 4 | Outline designs of demo missions complete. | 1,2,3,4,7,8 | Astrium-DE | 31/12/2013 | Yes | 31/12/2013 | |
| 5 | Research work packages wrap up. | 1,2,3,4,5,6,9 | DLR | 31/07/2014 | Yes | 31/07/2014 | Delays in submission of s ome deliverables have only minor impact on ov erall schedule. |
| 6 | Final presentation. | All | DLR | 31/05/2015 | Yes | 25/06/2015 | |