Executive summary

This report provides results from a preliminary analysis of a potentially hazardous asteroid scenario carried out at the Jet Propulsion Laboratory from March 26 – April 26, 2012.

Current knowledge and uncertainty

Near-Earth asteroid 2011 AG5 was discovered on January 8, 2011, at Mt. Lemmon, Arizona, by the NASA-sponsored Catalina Sky Survey, a component of NASA's Near-Earth Object (NEO) Observation Program. The asteroid was most recently observed on September 21, 2011, but has since been unobservable due to its proximity to the Sun's position in the sky as observed from Earth. To date, 2011 AG5 has only been observed through about half of its 625-day orbit. As a result, its orbital motion is not known well enough to accurately predict its position decades from now.

Extensive analysis of the current orbit parameters of 2011 AG5 indicates that the asteroid shows that it currently has a 1-in-500 (0.2 percent) chance of impacting the Earth on February 5, 2040. In order for the chance of a 2040 impact to increase, 2011 AG5 will need to pass through a small, 365-kilometer-wide, region in space (called a "keyhole"), about 1.8 million km from Earth, during a close Earth encounter predicted to occur on February 3, 2023. The most likely trajectory of 2011 AG5 as currently understood does not indicate that the asteroid will pass through this keyhole in 2023. However, the current extent of uncertainty embedded in trajectory prediction does allow for a 1-in-500 (0.2 percent) chance of passage through the keyhole. If 2011 AG5 should pass through the keyhole in 2023, the orbit change caused by the close encounter with Earth could put the asteroid on a trajectory leading to a collision with Earth on February 5, 2040. With an estimated diameter of about 140 meters and a calculated impact velocity of 15 kilometers per second, the asteroid would release about 100 megatons of energy if it should impact.

It is important to note that the current extent of uncertainty embedded in these predictions is large. A significant reduction in orbital uncertainty for 2011 AG5 is necessary to determine definitively whether the asteroid could be on an impacting trajectory. This reduction can be accomplished by making additional observations and measuring the asteroid's position over time. 2011 AG5 is currently on the opposite side of the Sun from the Earth and hence unobservable. When it becomes observable again in 2013, its orbit will be recalculated, its orbital motion will become much better defined, and, in all likelihood, the chance of Earth impact will drop to essentially zero. However, it is currently not possible to state with absolute certainty that the chance 2011 AG5 will impact with Earth in 2040 will disappear. There is a small chance that the asteroid's updated predicted position in 2040 could end up being even closer to the Earth, in which case the chance of impact could rise as high as 10-15 percent.

Reducing uncertainty

Several observing opportunities are available for 2011 AG5 starting in Fall 2012, some markedly more challenging than others. For the 2012 opportunity, the asteroid will be extremely faint, and imaging will only be possible during morning twilight and near the horizon. While these observations are possible to obtain, they would require very favorable observing circumstances, even using the largest telescope available, at the Keck Observatory. A Hubble Space Telescope (HST) observation opportunity in April 2013 would require an ancillary ground-based effort in advance of the HST observing period. These opportunities would require significant effort to arrange and approve, probably requiring direct intervention from NASA HQ. If NASA were to plan the April 2013 HST observations, it would be expected to also award the Keck time in 2012.

However, very favorable opportunities for observing the asteroid start in September 2013. The 2013 observations are 95 percent likely to eliminate the possibility of a 2040 impact altogether. With the addition of 2015–2016 observations, this likelihood increases to about 99 percent. Conversely, if the asteroid turns out to really be on an Earth impacting trajectory, 2013 observations could raise the chance of impact to 10–15 percent, and observations in 2015–2016 could raise the chance of impact to around 70 percent. These more precise calculations would be completed well in advance of a 2040 impact encounter.

Options for deflection

Our studies focus on using the most mature technology for deflection, a kinetic-impactor spacecraft that would hit the asteroid with enough mass and at a high enough velocity to change the asteroid's trajectory so that it misses Earth by a wide margin in 2040. While most of our analyses focus on pre-keyhole deflections to prevent the asteroid from passing through the keyhole in 2023, we also examine options for deflecting the asteroid after keyhole passage.

While further study would be required to design optimal pre- and post-keyhole rendezvous and impact missions, this short study demonstrates that numerous viable deflection mission options are available in the event that 2011 AG5 turns out to be on a trajectory leading to a 2040 Earth impact. In the unlikely event that observations made in September 2013 show a significant increase in the chance of Earth impact, there would still be sufficient time to plan and carry out a successful deflection campaign.