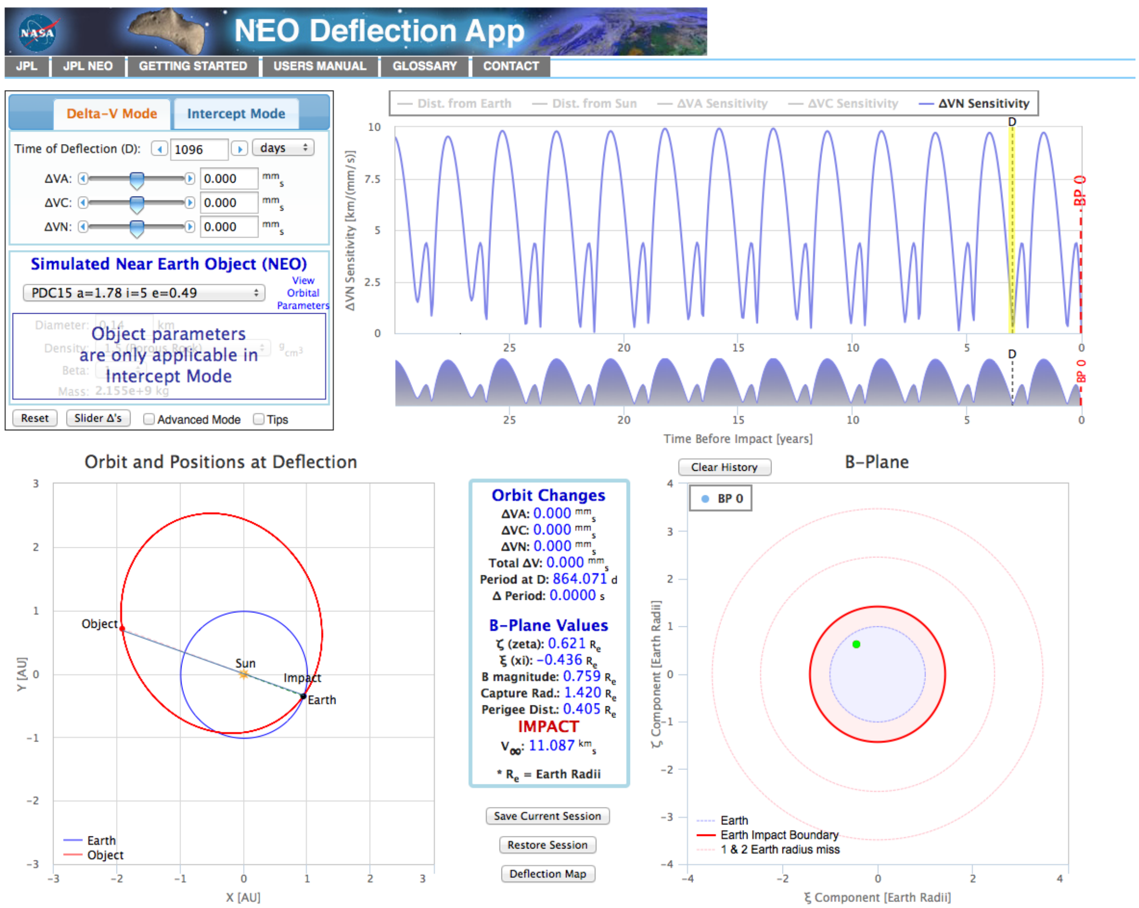
Quick Start Guide for the NASA/JPL NEO Deflection App

First time users of this site are strongly urged to read the far more comprehensive ***User's guide*** and follow the examples therein.



Main Panel (upper left)

Delta-V Mode: The user inputs the deflection Delta-V directly. The inputs are:

- The particular simulated Near Earth Object (NEO) to be dealt with.
- The time (D) of the deflection relative to the predicted time of the asteroid's impact with the Earth.
- The three components of the deflection velocity to be applied: ΔVA (along track), ΔVC (cross-track) and ΔVN (normal to the orbit plane).

The object parameters in the bottom half of the Main Panel are grayed out because they are not applicable in Delta-V mode.

Intercept Mode: The user designs an interceptor mission to deflect the NEO from a predicted Earth impact; the delta-v applied to the asteroid depends on the trajectory of the interceptor, the type and number of launch vehicles, the size and density of the asteroid, and the momentum multiplier factor Beta. The primary new inputs in this mode are:

- Transfer time interval (L to D) between the spacecraft launch and the time of deflection (D).
- Object mean diameter, bulk density and the momentum multiplier Beta.
- Launch vehicle and the number of launches.

Selecting "Advanced Mode" provides the user with more options for deflection, including multiple launches with different launch vehicles, general values for Beta, and specified numbers of spacecraft revolutions about the Sun for the interceptor prior to impact.

Plot Panel (upper right)

Displays plots of the following parameters as a function of time before impact:

- Earth-to-object distance in astronomical units (AU)
- Sun-to-object distance in astronomical units (AU)
- Sensitivities of the b-plane deflection to the ΔVA, ΔVC and ΔVN velocity change components, as a function of the deflection time (D).

The parameter plotted in this panel can be changed by clicking the desired parameter name in the legend along the top of the plot. The Deflection Time is indicated by the vertical dashed line highlighted in yellow and marked D. Dragging the line changes the deflection time, or you can just click on a plot point to set D to that time. In intercept mode, a second vertical dashed line is shown, highlighted in blue and marked L, for Launch Time. The yellow and teal (in Intercept mode) colored bars can also be moved with the mouse to select another time of deflection (D) or launch time (L); dragging it changes the Transfer Time (L to D). At the far right hand side of the plots, the vertical red dashed line marked BP 0 (for B-Plane 0) denotes the potential Earth impact time. If the object has earlier close approaches that produce keyholes, their times are shown as vertical red dashed lines denoted BP 1, BP 2, etc. Clicking and dragging across the background of a plot zooms in on the selected portion. The plot zoom can be reset to full-scale by clicking "Reset zoom" in the upper right corner.

Orbit Panel (lower left)

This panel displays the:

- Orbits of the object (in red) and the Earth (in dark blue)
- Positions of the object (red dot) and Earth (dark blue dot) at the time of deflection

- Position of the asteroid and Earth at their predicted impact (black dot).
- Deflection spacecraft orbit given as a dashed light blue path (Intercept Mode)
- Orbital inclination of the interceptor spacecraft
- Number of orbits about the sun the spacecraft takes prior to the asteroid impact

The NEO (labeled “Object”) can be dragged around its orbit to change the time of deflection (D) and, in intercept mode, the position of the Earth at time of launch (labeled “Launch”) can be dragged to change the Transfer Time.

Values Panel (lower middle)

Displays the following numerical quanitites:

Orbit Changes:

- Asteroid changes in the velocity components (ΔVA, ΔVC and ΔVN)
- Total velocity change (Total ΔV)
- Asteroid’s orbital period before the deflection
- Change in asteroid orbital period due to the deflection impact (Δ Period)

B-plane Values:

- ζ (zeta) and ξ (xi) coordinates of the b-vector (coordinates of the trajectory, represented by the green dot in the B-Plane Panel)
- Magnitude of b-vector (close approach distance if Earth’s gravity is neglected)
- Earth capture radius (radius of circle enclosing trajectories that will impact)
- Perigee distance (actual closest approach distance); values less than 1 Earth radius are possible because we treat the Earth as a point mass
- Miss distance (altitude) of close approach point (or the word IMPACT)
- V_∞: velocity of asteroid relative to Earth, neglecting the acceleration due to the Earth’s gravity

Mission Values (in Intercept Mode):

If no viable trajectory has been found that meets the constraints, this area displays the message “Infeasible Launch Window”. Otherwise it displays:

- Departure C3: launch energy-per-unit-mass required to achieve the spacecraft’s transfer trajectory
- Arrival V_{rel}: Velocity of the spacecraft relative to the asteroid at arrival
- Phase angle of the asteroid as viewed from the spacecraft at arrival (Sun-asteroid-spacecraft angle)

At the bottom of this panel are three buttons that allow the user to:

- Save and restore information on session scenarios
- Display a deflection map that can be used to help find optimal combinations of Deflection Time D and Transfer (L-to-D) times. The colors on the map indicate the relative size of the b-plane deflection as a function of the two times, with size of the deflection increasing from dark blue to red. The map is split into four images for 4 ranges of deflection times. Click Close to return to the main screen.

B-Plane Panel (lower right)

This panel displays a plot showing the location of the asteroid's trajectory in the Earth impact B-plane. The coordinate axes are called ξ (xi) and ζ (zeta), and the units are Earth radii. It turns out that the ζ (zeta) direction is the easier direction in which to move the asteroid because it is closely associated with the asteroid's heliocentric along-track direction, and that's the direction along which an orbiting body's motion most easily changes. The filled blue circle indicates the geometrical size of the Earth, and the red dotted circle indicates the "capture radius" for the encounter, which encompasses the trajectories that impact the Earth. The green dot indicates the current trajectory of the deflected asteroid, while the red dot indicates the undeflected trajectory of the asteroid, initially hidden behind the green dot. If the green dot is within the red circle, the asteroid will hit the Earth.

The view in this panel can be zoomed-in by clicking and dragging diagonally across the plot, and can be reset to the full Earth view by clicking "Reset zoom" in the upper right corner.

Some of the objects experience close Earth flybys during the 30 years before the potential impact. Additional b-planes (BP 1, BP 2, etc.) are defined for flybys that are close enough to produce keyholes. The legend in the upper left corner of the B-plane plot shows the available b-planes. If you choose a b-plane other than BP 0, the app zooms in on the keyhole in that b-plane. The boundaries of the keyhole are shown by the two solid purple lines. Trajectories going between these lines will impact the Earth in BP 0; to avoid impact, your KI mission must move the trajectory outside the line pair. If you click Reset zoom, you can see the location of the keyhole. See the User's Guide for more information about keyholes.

This app makes many simplifying assumptions, and therefore should not be used for real mission design. It is for educational purposes only. The app was designed and implemented by the Aerospace Corporation of El Segundo, CA, in close collaboration with the NASA/JPL NEO Program Office. JPL personnel devised the simulated impacting NEOs, generated the tables of trajectory positions, velocities and deflection sensitivity parameters used by the app to calculate deflections, and created the deflection maps.