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TEAMING FOR ASTEROID DEFLECTION

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Extended Abstract—

The objective of defending Earth from a collision with an asteroid calls for informed and cooperative efforts to effectively deflect the object away from the planet. That process starts with educating students, teachers, and the public about the asteroid threat and inspiring them to become the next generation of planetary defenders. By providing tools to engage in science, technology, engineering, and mathematics (STEM) education, the goal is to motivate the students not only to be informed citizens but potentially to select a STEM field as their career choice. STEM education seeks to build competencies necessary to succeed in a global economy as it prepares our youth to work together to address global challenges by employing critical thinking, creativity, collaboration, and problem solving. Additionally, STEM education not only promotes 21st century skills but also reinforces behavioral competencies that require perseverance, cooperation, organization, and adaptability in order to succeed.

A simple tool for introducing students to the physics of asteroid deflection is an online web application called the Near-Earth Objects (NEO) Deflection App (NDA) developed collaboratively by The Aerospace Corporation and NASA's Jet Propulsion Laboratory (JPL). The NDA simulates hypothetical realistic asteroids on collision courses with Earth and allows the design of missions to kinetically strike and deflect the asteroid with a spacecraft launched from Earth. The NDA is accessible on JPL's website: https://cneos.jpl.nasa.gov/nda/. The NDA is aligned to the current set of adopted teaching standards in the United States. The Next Generation Science Standards (NGSS) framework provides guidance for educators on a three-dimensional level by incorporating science and engineering practices, cross-cutting concepts, and disciplinary core ideas to concepts taught in public schools. The NDA uses simplified mathematical and computational representations applying Kepler's gravitational laws to describe the motion of objects in orbit to analyze, represent, and model data by running simple computational simulations. The participants explore the scale, proportion, and quantity of collisions with celestial objects and their interdependence of science and engineering to conduct research and develop new solutions to potential problems.

The intent of the app is to demonstrate to individual users the basics of asteroid deflection mission design. The Aerospace Corporation has added a collaborative educational context to the app and developed an educational program to conduct asteroid deflection teaming exercises with the NDA (Figure 1). During the program, participants learn about asteroids and comets and how they have affected our planet. The participants learn about significant past impacts that have been recorded, then engage in discussion about the potential of a future impact and the likelihood of it causing disruptions to our lives. The participants navigate several public websites to find current information about objects that have the potential to impact Earth and explore how large the objects are, how close to Earth they will travel, and how long ago they were discovered. After exploring facts about the asteroid hazard, the participants access the teaming app available on Aerospace's website and become familiar with it by engaging in a guided simulation. Several participants are then grouped into teams and given a hypothetical asteroid collision scenario to solve. The teams are given a designated time frame to deflect the asteroid. Each team aims to win the exercise by maximizing the scale of deflection with minimum usage of launch vehicles. Because there could be many solutions to the problem, each team may arrive at a different performance metric. The team with the highest performance metric wins the competition. The teaming NDA is accessible on Aerospace's website: https://planetary-defense.aerospace.org/. The teaming app helps participants investigate a world problem beyond their immediate environment, stimulating different

perspectives by developing skills and engaging in collaboration with other team members. Moreover, the app encourages participants to take action and take part in problem-solving situations that can affect many and work together to communicate potential solutions to a broader, diverse audience.

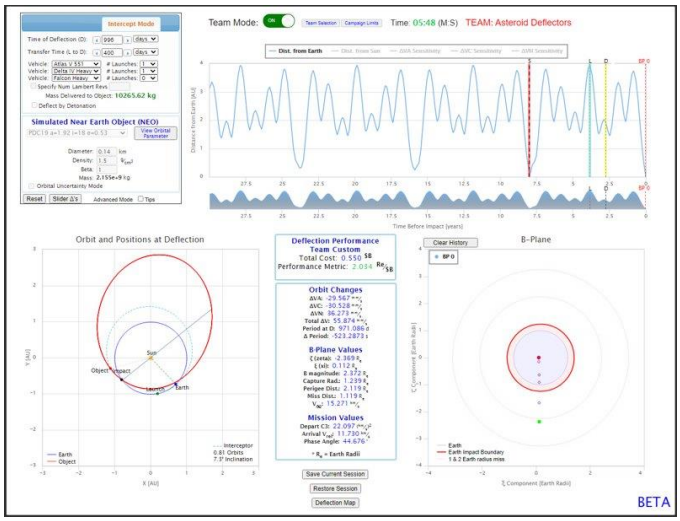

Figure 1 Parts of the Teaming NDA

Typical asteroid deflection sessions consist of two (2) to four (4) rounds of increasing challenge. The first scenario affords the participants a healthy budget, enough time from discovery to deflection of the object, and the choice of multiple launch vehicles. As the exercise progresses, the time to accomplish the task is shortened and the object gets tougher to deflect. In subsequent rounds, the incoming objects can be larger or heavier at each level, and the teams must work together to come up with the most feasible solution while adhering to the constraints. After each session, all teams come together and discuss their findings; a winner is selected based on the best performance metric.

The teaming NDA has been employed in in-person events as well as on virtual platforms. The app is fully supported and accessible via both formats. The benefit of the virtual events is that it can be run across regions and more students can be reached. Moreover, because the teaming NDA is accessible to all, it works well for in-person events that can be run postpandemic in classrooms. Over the past few years, The Aerospace Corporation has run nine (9) workshops for teachers, students, and the public. Three (3) of the workshops were in person and six (6) were virtual. About ninety (90) percent of participants in our workshops, both teachers and students, have expressed that their experience with the teaming app was “excellent,” and all have indicated that they would participate in a future workshop.

Future work using the teaming app includes continuing to offer STEM outreach events on a quarterly basis. Teacher training on how to run sessions to increase student usage of the app is critical, as teachers have greater access to students in our target areas. The developed program strives to bridge the ethnic, gender, and socioeconomic gaps that exist in our educational system by providing these events free of charge for participants and highlighting that diversity breeds success. In an attempt to expand the reach of the teaming app to the greater community, Aerospace is partnering with other nonprofit organizations to deliver the programming to a wider field on specific occasions such as Asteroid Day and during Engineering Week, and creating an online request for education groups that would like a classroom experience. Furthermore, Aerospace has created lessons that furnish activities to educators to use in their classrooms in tandem with the teaming app. Teaching aids are available on Aerospace’s website: https://aerospace.org/asteroids.