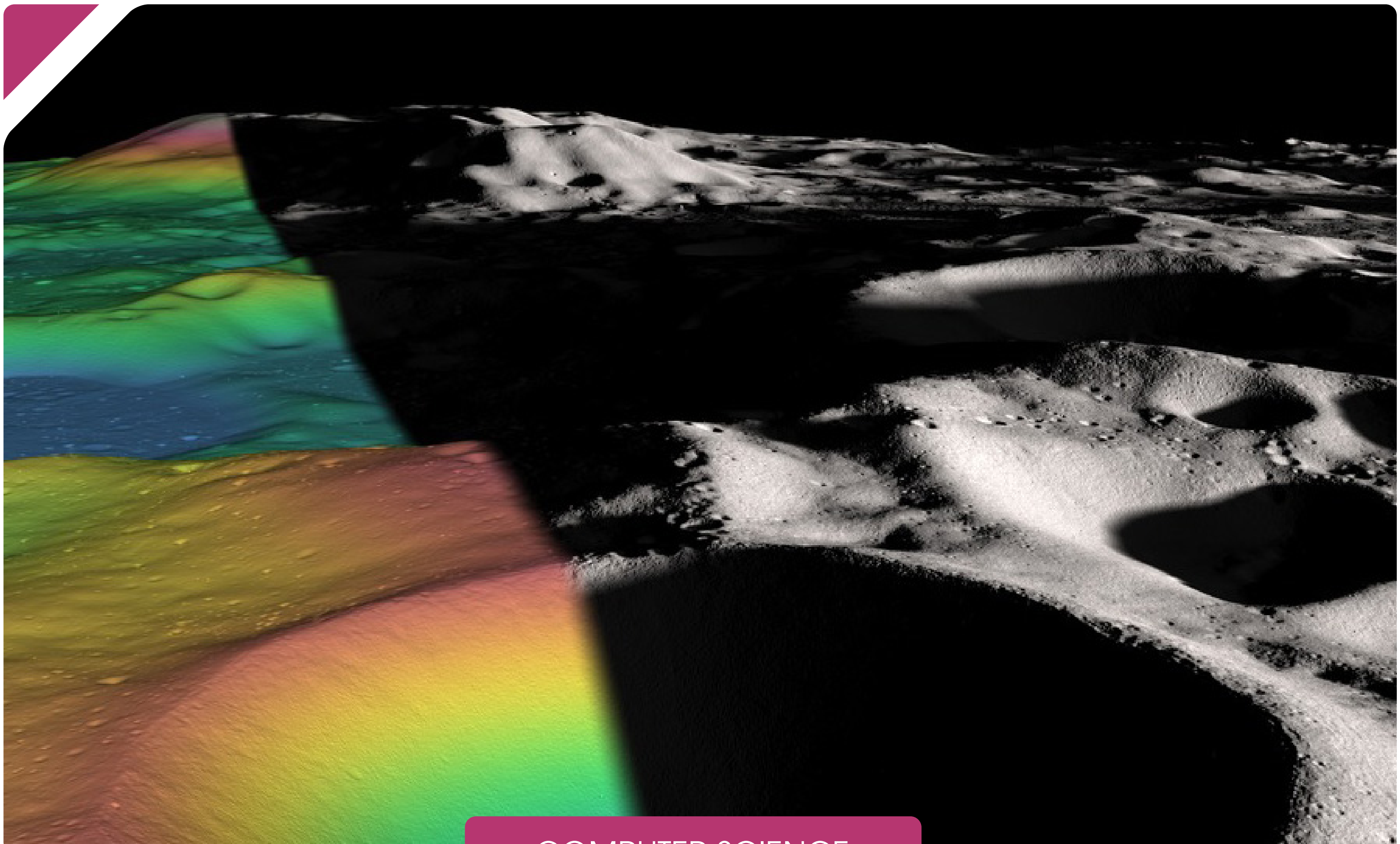
National Aeronautics and Space Administration

App Development Challenge

2023 Handbook



COMPUTER SCIENCE

Next Gen STEM – Moon

For more about Next Gen STEM visit https://www.nasa.gov/stem/moon

Education Product	
Educators and Students	Grades 5-12

Contents

Introduction

Welcome, middle and high school students and educators, to the NASA App Development Challenge (ADC)!

NASA needs YOU!

Are you someone who likes to code, create apps, or develop amazing visuals and graphics? Are you interested in coding or computer science but just haven't had a chance to learn more? If so, then it's time to join the ADC!

About This Handbook

The App Development Challenge Handbook provides all details for educators and students to develop a software application (app) in support of NASA's Space Communications and Navigation (SCaN) Team. New to programming? Check out NASA Computer Science Educational Resources.

Note: Information about the challenge will remain posted for use in educational settings beyond the challenge end date.

Illustration of astronauts on the lunar surface. (NASA)

Curriculum Standards Alignment

6th–8th Grade Next Generation Science Standards (NGSS)

(https://www.nextgenscience.org/search-standards)

Science and Engineering (NGSS)

Disciplinary Core Ideas

- MS-ETS1-1 Engineering Design: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
  - ETS1.A: The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- MS-ETS1-2 Engineering Design: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
  - ETS1.B: There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- MS-ETS1-3 Engineering Design: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
  - ETS1.B: Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
  - ETS1.C: Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- MS-ETS1-4 Engineering Design: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
  - ETS1.B: A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
  - ETS1.B: Models of all kinds are important for testing solutions.
  - ETS1.C: The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

Crosscutting Concepts

- Cause and Effect: Mechanisms and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
- Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
- Influence of Science, Engineering, and Technology on Society and the Natural World: The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

Science and Engineering Practices

- Asking Questions and Defining Problems: Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)
- Developing and Using Models: Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)
- Planning and Carrying Out Investigations: Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.
- Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)
- Using Mathematics and Computational Thinking: Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
- Constructing Explanations and Designing Solutions: Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Engaging in Argument From Evidence: Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)
- Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information (e.g., about a proposed object, tool, process, system) in writing and/or through oral presentations.

Common Core State Standards Connections

English Language Arts/Literacy

- RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ETS1-3)
- RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2, MS-ETS1-3)
- WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2)
- WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2)
- SL.8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ETS1-4)

Mathematics

- MP.2: Reason abstractly and quantitatively. (MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4)
- 7.EE.3: Solve multistep real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form, convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1, MS-ETS1-2, MS-ETS1-3)

9th–12th Grade Next Generation Science Standards (NGSS)

(https://www.nextgenscience.org/search-standards)

Science and Engineering (NGSS)

Disciplinary Core Ideas

- HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
  - ETS1.A: Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
- HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
  - ETS1.C: Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.
- HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
  - ETS1.B: When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
- HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
  - ETS1.B: Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Crosscutting Concepts

- Systems and System Models: Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-ETS1-4)
- Influence of Science, Engineering, and Technology on Society and the Natural World: New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1, HSETS1-3)

Science and Engineering Practices

- Asking Questions and Defining Problems: Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)
- Developing and Using Models: A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.
- Planning and Carrying Out Investigations: Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.
- Analyzing and Interpreting Data: Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.
- Using Mathematics and Computational Thinking: Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)
- Constructing Explanations and Designing Solutions: Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)
- Engage in Argument From Evidence: Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).
- Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Common Core State Standards Connections

English Language Arts/Literacy

- RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9: Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)

Mathematics

- MP.2: Reason abstractly and quantitatively. (HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)
- MP.4: Model with mathematics. (HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

6th–8th Grade Computer Science Teachers Association (CSTA) Standards
(https://www.csteachers.org/page/standards)

Computer Science Teachers Association (CSTA) K–12 Computer Science Standards	
• 2-CS-03: Systematically identify and fix problems with computing devices and their components. • 2-DA-07: Represent data using multiple encoding schemes. • 2-DA-08: Collect data using computational tools and transform the data to make it more useful and reliable. • 2-DA-09: Refine computational models based on the data they have generated. • 2-AP-10: Use flowcharts and/or pseudocode to address complex problems as algorithms. • 2-AP-11: Create clearly named variables that represent different data types and perform operations on their values.	• 2-AP-13: Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs. • 2-AP-14: Create procedures with parameters to organize code and make it easier to reuse. • 2-AP-15: Seek and incorporate feedback from team members and users to refine a solution that meets user needs. • 2-AP-16: Incorporate existing code, media, and libraries into original programs, and give attribution. • 2-AP-18: Distribute tasks and maintain a project timeline when collaboratively developing computational artifacts.

9th–12th Grade Computer Science Teachers Association (CSTA) Standards
(https://www.csteachers.org/page/standards)

Computer Science Teachers Association (CSTA) K–12 Computer Science Standards	
• 3A-CS-02: Compare levels of abstraction and interactions between application software, system software, and hardware layers. • 3A-CS-03: Develop guidelines that convey systematic troubleshooting strategies that others can use to identify and fix errors. • 3A-DA-11: Create interactive data visualizations using software tools to help others better understand real-world phenomena. • 3A-DA-12: Create computational models that represent the relationships among different elements of data collected from a phenomenon or process. • 3A-AP-17: Decompose problems into smaller components through systematic analysis, using constructs such as procedures, modules, and/or objects. • 3A-AP-18: Create artifacts by using procedures within a program, combinations of data and procedures, or independent but interrelated programs. • 3A-AP-21: Evaluate and refine computational artifacts to make them more usable and accessible. • 3A-AP-22: Design and develop computational artifacts working in team roles using collaborative tools.	• 3A-AP-23: Document design decisions using text, graphics, presentations, and/or demonstrations in the development of complex programs. • 3A-IC-24: Evaluate the ways computing impacts personal, ethical, social, economic, and cultural practices. • 3A-IC-27: Use tools and methods for collaboration on a project to increase connectivity of people in different cultures and career fields. • 3B-DA-06: Select data collection tools and techniques to generate data sets that support a claim or communicate information. • 3B-AP-14: Construct solutions to problems using student-created components, such as procedures, modules, and/or objects. • 3B-AP-20: Use version control systems, integrated development environments (IDEs), and collaborative tools and practices (code documentation) in a group software project. • 3B-AP-24: Compare multiple programming languages and discuss how their features make them suitable for solving different types of problems.

K–12 Computer Science Framework—Core Practices
(https://k12cs.org/navigating-the-practices/)

See examples of what will be completed by students for each of the Core Practices in the Supplemental Information and Resources section of this guide (under Learning Objectives).

Artemis Missions

Artemis is NASA's path to the Moon and the next step in human exploration. All lunar activities, including robotic and human exploration, fall under the Artemis missions and are a part of the Agency's broader Moon to Mars exploration approach.

There are many reasons to go back to the Moon. With our Artemis missions we will demonstrate new technologies, capabilities, and business approaches needed for future exploration, including Mars. We will establish American leadership and a strategic presence at the Moon while expanding our U.S. global economic impact and broadening our exploration partnerships. At the same time, we will inspire a new generation and encourage careers in science, technology, engineering, and mathematics (STEM).

How Do We Get to the Moon?

NASA's powerful new rocket, the Space Launch System (SLS), will send astronauts aboard the Orion spacecraft a quarter million miles from Earth to lunar orbit. From there, Orion will dock at the Gateway, a multipurpose outpost orbiting the Moon, or a commercial human landing system that will carry crew to the surface. Gateway will serve as a platform for science and a staging point for lunar surface missions, and crew will ultimately return to Earth aboard Orion. The early Artemis human missions include

- Artemis I: NASA is working toward the first test flight of the SLS rocket and Orion spacecraft as an integrated system.
- Artemis II: First flight of crew to the vicinity of the Moon aboard SLS and Orion.
- Artemis III and beyond: NASA will land the first woman and the first person of color on the Moon and prepare for human missions to Mars.

What Will We Do on the Moon?

While Mars remains our horizon goal, we have first set our sights on exploring more of the Moon than ever before with human and robotic explorers. Ahead of a human return, we will send a suite of science instruments and technology demonstrations to the lunar surface through commercial Moon deliveries.

We will send astronauts to new locations, starting with the lunar South Pole. At the Moon, we will

- Find and use water and other critical resources needed for long-term exploration.
- Investigate the Moon's mysteries and learn more about our home planet and the universe.
- Learn how to live and operate on the surface of another celestial body where astronauts are just 3 days from home.
- Prove the technologies we need before sending astronauts on missions to Mars, which can take up to 3 years round trip.

NASA App Development Challenge

The NASA App Development Challenge (ADC) is a coding challenge in which NASA presents technical problems to middle and high school students seeking student contributions to deep space exploration missions. The App Development Challenge is one of NASA's Artemis Student Challenges, whose mission is to build foundational knowledge and introduce students to topics, techniques, and technologies critical to the success of the agency's Artemis program. By responding to the ADC, students take a part directly in the Artemis Generation endeavors to land American astronauts, including the first woman and first person of color on the Moon.

NASA's Space Communications and Navigation (SCaN) program serves as the program office for all of NASA's space communications activities, presently enabling the success of more than 100 NASA and non-NASA missions. SCaN manages the Near Space Network and the Deep Space Network and ensures the availability and allocation of the radiofrequency spectrum for all NASA programs. Additionally, SCaN supports the research and development of cutting-edge space communications technologies, such as optical and quantum communications, and is responsible for developing an integrated space communications and navigation architecture to support science and human exploration programs through 2040.

Challenge Overview

In this year's challenge, teams will code a visualization of the South Pole region of the Moon to assist in mission planning and exploration activities. Teams will utilize lunar terrain data to create a visualization that displays essential information for navigation and communication. These student app solutions will visualize both height and slope variations on the lunar surface to help better aide in route planning. High school teams will calculate elevation and azimuth angles to include in their visualization as well as identify and defend a selection for landing and destination/exploration sites. Teams will also utilize wayfinding to plot the best path between a landing site and a destination site, and they will identify 10 communication link checkpoints for communication with Earth.

Teams will be separated into two categories, one for middle school and one for high school.

Teams ***must use coding*** to complete development of their app. Teams are encouraged to be creative and think outside of the box. Anyone seeing their solution should be smarter about the mission and should have fun while learning. These student team app solutions can be utilized by SCaN for mission planning and training activities. In future Artemis missions, data obtained directly on the lunar surface can be used to validate this previously collected data from the local perspective.

Getting Started

The handbook provides challenge components, directions, timelines, handouts, resources to help teams create an app, and links to other useful resources that can serve as supplemental materials to this ADC Handbook. Lead Teachers and team members should read the entire handbook to understand the challenge expectations and requirements. The Mission Resources section near the end of this handbook provides links to important fact sheets, program overviews, and videos.

Challenge Summary

Student teams will have 10 weeks to create and post their app designs online for consideration by NASA to use in future mission planning activities. Teams with favorable submissions advance to present their app in an interview with NASA subject matter experts from the SCaN team. On conclusion of the interviews, NASA will select student team(s) for a culminating event. The challenge begins on October 5, 2022, and concludes with video submissions on December 14, 2022.

Review the Challenge

Student teams must

- Use any programming language (Java, Scratch, etc.) and/or operating system (Windows, Android, etc.) to complete development of an app
- Adhere to the policies of their school districts or organizations regarding participation in the challenge
- Submit a video of original student-led work on the completed app
- Complete program requirements as identified by the ADC team

Middle school teams must

- Be able to process and read all provided position and slope data of the lunar South Pole region
- Display all position and slope data in some meaningful form beyond text
- Visualize a path that accounts for mission planning goals and identify communication link checkpoints

High school teams must

- Be able to process and read all provided position and slope data of the lunar South Pole region
- Display all position and slope data in some meaningful form beyond text
- Identify and explain a selection for a landing and destination site as well as areas of interest along the path
- Visualize a path that accounts for mission planning goals and identify communication link checkpoints
- Calculate and display elevation and azimuth angles

Review the Timeline

- September 28: STEM Gateway Registration Closes
- October 5: Live Virtual Kickoff Event
- October 12: Live Virtual Connection: App Development and Game Engine Scripting
- November 9: Live Virtual Connection: App Visualizations and Human Factors
- November 30: Live Virtual Connection: Student Team Interviews, Virtual Reality Applications, and Employee Profile
- December 14: ADC Video Submission Deadline

Review the Eligibility Requirements and Form a Team

- Formal or informal U.S. education organizations may participate.
- Signed letter of support from principal or administrator of your organization must be submitted during registration to confirm participation.
- Teams may be a middle school team or a high school team. Student participants must be on one team only.
  - All members of a middle school team must be in grades 5–8 during the 2022–2023 school year.
  - All members of a high school team must be in grades 9–12 during the 2022–2023 school year.
- Teams must be led by a sponsor or educator (i.e., Lead Teacher) from an informal or formal U.S. education organization
- The minimum team size is 5 students and 1 Lead Teacher. There is no maximum team size. However, Top Teams who are invited to a NASA field center may only send 5 students, the Lead Teacher, and one chaperone. The additional chaperone must be a part of the organization and must be the opposite gender of the Lead Teacher if both genders are represented within the student team.
- The Lead Teacher must complete an Educator Professional Development Collaborative (EPDC) Moon webinar and submit a certificate of completion before the video submission deadline.
- If selected to visit a NASA center:
  - All participants that travel to a NASA center must be U.S. citizens.
  - Student members must be aged 13 or above during travel to a NASA center.
  - Traveling teams must include two chaperones, age 21 years or older, who represent the gender mix of the student team (see above).
  - Organization chaperones are fully responsible for their students during the culminating event.
  - Traveling team members will use housing and transportation provided.
  - Team members will participate in all scheduled events or planned activities during the culminating event.
  - Teams will conduct a technical presentation for NASA personnel.
  - Comingling of personal travel arrangements or travel arrangements for nonparticipants is not permitted.
  - If the event is changed to a virtual culminating event, all participants must be U.S. citizens.
  - All team members must participate fully according to the challenge guidelines.

Notify NASA and Register Your Team

After a thorough review of all of the above, each Lead Teacher must

- Register their team in NASA STEM Gateway
- Include a signed letter of support from the principal or administrator of the team's school or organization

Lead Teachers must complete their registration in NASA STEM Gateway and include their signed letter of support no later than end of day on September 28, 2022.

Lead Teachers, note that by submitting an intent to participate, the team is confirming full participation through the end of the culminating event, if selected to attend. Dates are subject to change.

Click to access the NASA STEM Gateway ADC 2023 opportunity and register your team.

Email NASA's ADC team at JSC-ADC@mail.nasa.gov with any questions.

Challenge Timeline

The following timeline provides details on all major activities for the App Development Challenge (ADC).

The start date is Wednesday, October 5, 2022. Video submissions are due on Wednesday, December 14, by 2 p.m. central time. This will conclude teams' participation in the ADC unless selected to participate in interviews. Teams not selected for interviews will be notified by email.

Teams are encouraged to participate in all live virtual connections to receive information about coding and app development. If there are any questions about this timeline, please contact the team at JSC-ADC@mail.nasa.gov.

Reminder: Lead Teachers must register their team in NASA STEM Gateway before registration closes on September 28, 2022.

App Development Challenge Timeline*

Start Date	End Date	NASA ADC Activity*
10/5/2022	**12/14/2022**	**App Development Challenge (10 weeks)**
10/5/2022	10/5/2022	LVC† 1: LIVE VIRTUAL KICKOFF EVENT
10/12/2022	10/12/2022	LVC 2: App Development and Game Engine Scripting
11/9/2022	11/9/2022	LVC 3: App Visualizations and Human Factors
11/30/2022	11/30/2022	LVC 4: Student Team Interviews, Virtual Reality Applications, and Employee Profile
1/25/2023	1/25/2023	ADC Special Virtual Event, "Join the Artemis Generation"
2/1/2023	2/15/2023	Selected Team Interviews With SCaN Team
2/22/2023	2/22/2023	Announcement of Top Teams for Culminating Event
4/12/2023	**4/14/2023**	**NASA ADC Culminating Event**

*Timeline is subject to change.
†LVC = Live Virtual Connection.

Live Virtual Connections

Student teams will be supported during the challenge with Live Virtual Connections from NASA subject matter experts. Virtual connections will present information essential for completing the challenge. These events will include ADC updates, app development presentations, any schedule changes, and information on future events. Each virtual connection will include a question-and-answer session with the subject matter expert providing the presentation.

Virtual Connection Schedule

Ideally, teams will gather in one location to participate in these events. Teachers should lead this effort and encourage students not to connect individually from another location. However, based on current guidelines at the time of publication, team members may have to connect individually and should follow school and organization guidelines as well as social distancing guidelines.

The ADC Virtual Connection schedule is as follows. Live virtual connections will last 60 to 75 minutes. Dates and times are subject to change.

Live Virtual Connection 1

Date: Wednesday, October 5, 2022

Topic: ADC Live Virtual Kickoff Event

Live Virtual Connection 2

Date: Wednesday, October 12, 2022

Topic: App Development and Game Engine Scripting

Live Virtual Connection 3

Date: Wednesday, November 9, 2022

Topic: App Visualizations and Human Factors

Live Virtual Connection 4

Date: Wednesday, November 30, 2022

Topic: Student Team Interviews, Virtual Reality Applications, and Employee Profile

Challenge Requirements and App Components

Teams will be challenged to create an app that the Space Communications and Navigation (SCaN) team could use to visualize lunar terrain data for future mission planning and training activities.

The challenge requires teams to create an app that

1. Visualizes the lunar data in some useful form
2. Plots a route from a landing site location to a destination site location
3. Identifies 10 communication link checkpoints for optimal communication

Coding Components

The ADC team will provide teams with a Lunar Data File (Regional), Lunar Surface Texture image, and lunar terrain map information to create an app. **The Lunar Data File and Lunar Surface Texture image will be available at the start of the challenge, October 5, 2022, on the ADC website.**

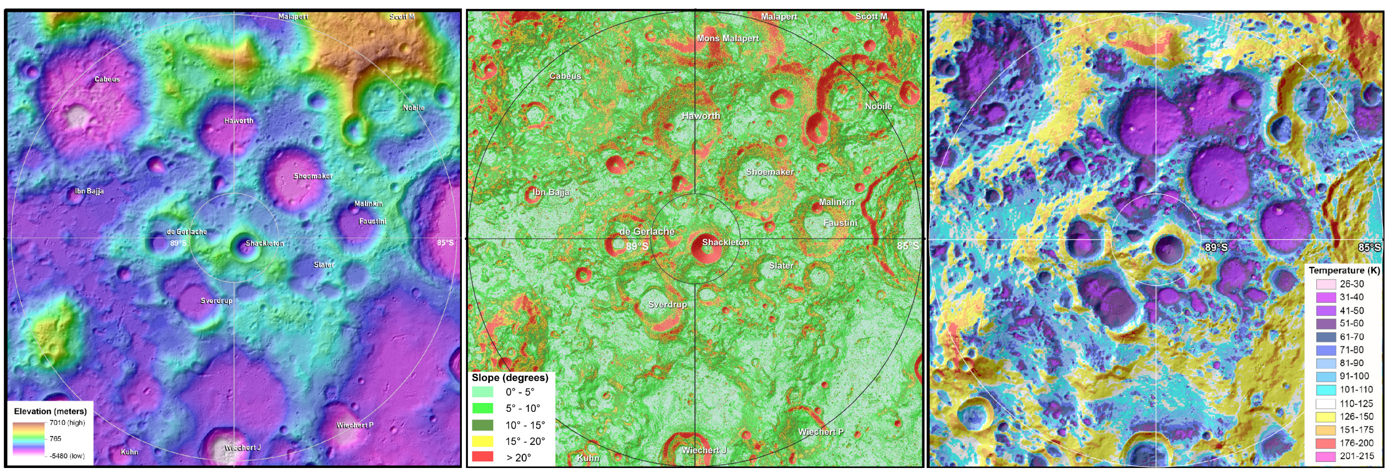
1. Lunar Data File: An excel spreadsheet (CSV file) with four aspects of the lunar South Pole region
   - The file displays latitude, longitude, height, and slope in a traditional Cartesian coordinate format.
   - Data is calculated from –88.0° to –90.0° north latitude at a lateral separation of 40 m.
   - High school teams are required to calculate elevation and azimuth angles from the astronaut's position to the Earth and include this information as part of the app's visualization. High school teams are required to identify and explain a selection for a landing and destination site as well as areas of interest along the path.
2. Lunar Surface Texture Image
   - An example of lunar regolith surface texture (PNG file) has been provided to make Moon rendering more realistic.
   - Teams can create their own surface texture and are encouraged to do so.
3. Lunar Terrain Maps
   - Publicly available lunar maps, images, and illustrations are available online at various locations. The provided Lunar Data File was created from data released from the Lunar Reconnaissance Orbiter Lunar Orbiter Laser Altimeter (LOLA). This data can be found as part of the Lunar South Pole Atlas of maps, images, and illustrations from the Lunar and Planetary Institute, Houston. Additional resources are available in the Mission Resources section at the end of this guide.

Each team is responsible for processing this information and creating an app to visualize this data. The following section provides a step-by-step guide through this process.

App Creation Requirements: Visualization and Navigation

All teams must create an app that visualizes the lunar surface and plots a path from the identified landing site to the destination site, identifying the location of 10 communication link checkpoints. Team apps will be evaluated based on criteria identified here and presented in greater detail in this guide's Video Presentation Criteria and Scoring Rubrics.

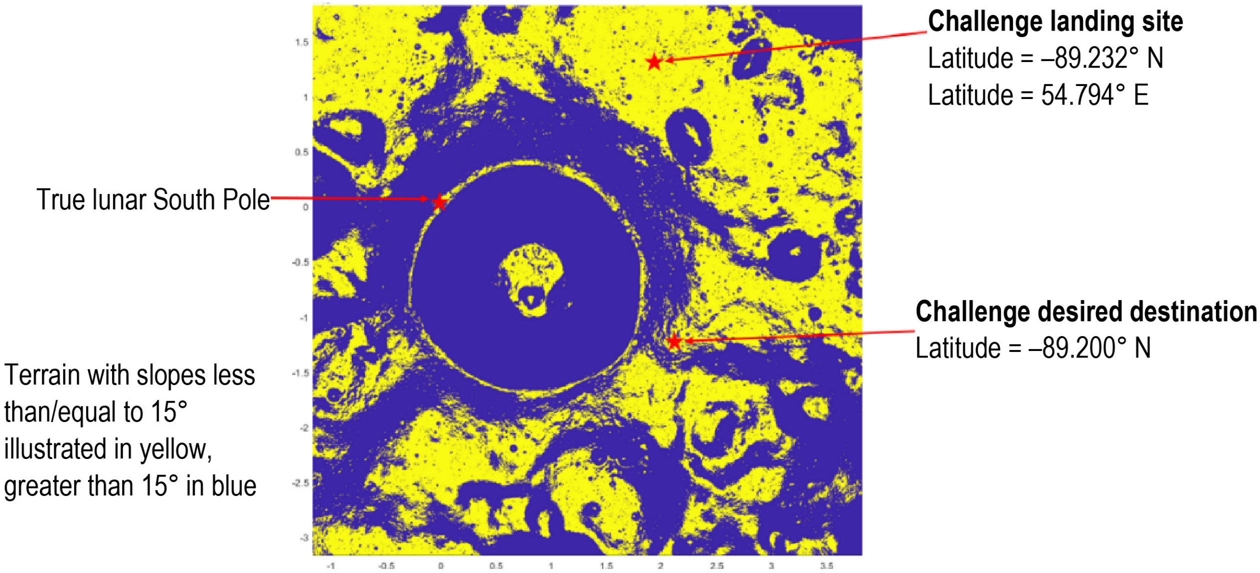
1. The first thing each team needs to do is download the **Regional Lunar Data File** from the ADC website. **The Regional Lunar Data File and Lunar Surface Texture Image will be available at the start of the challenge, October 5, 2022.**
2. Teams experiencing problems accessing these files should contact JSC-ADC@mail.nasa.gov.
3. Teams must then import the data into an app development platform.
    a. There are a variety of ways to create a visualization of the lunar terrain surface. The ADC team has provided a Regional Data File that, upon conversion, imports well into a game engine such as Unity or Unreal.
4. Create a visualization of the lunar surface using the data provided.
    a. Height (meters, m) and slope (degrees, °) data should be visualized in some useful way.
        (1) High school teams must calculate and display elevation and azimuth angles from the astronaut's position to the Earth as part of their visualization.
    b. Apply a texture and use color to convey information to scale.
        (1) Color should be used to communicate height and slope data. Example lunar terrain maps using color are publicly available from the Lunar and Planetary Institute's Lunar South Pole Atlas. Teams should consider a toggle feature to differentiate information, for example, between false color and true color.
        (2) An example surface texture is provided on the ADC website. Teams are free to create their own texture. Note: A smooth surface is not as realistic as a textured surface.



Surface Height (Elevation) Surface Slope Surface Temperature

Different ways to color code the lunar South Pole. (Source: https://www.lpi.usra.edu/lunar/lunar-south-pole-atlas/)

    c. Middle school teams must plot a path from the landing site to the destination site that does not exceed 15 degrees of slope. High school teams must identify their own landing and destination sites and plot a path not exceeding 15 degrees of slope.
        (1) Landing Site:
            (a) Latitude: −89.232° N
            (b) Longitude: 54.794° E
            (c) Data File Row Number 5029279
        (2) Destination Site:
            (a) Latitude: −89.200° N
            (b) Longitude: 120.690° E
            (c) Data File Row Number 5161666



d. Identify 10 communication link checkpoints along the path based on navigation and communication parameters.
    (1) Middle school: Highest height (m)
    (2) High school (see the Video Presentation Scoring Rubric section for more information):
        (a) Azimuth and elevation angles from the astronaut's position to the Earth. The equations for calculating these angles can be found in the Appendix in the Azimuth and Elevation Angle Equations section.
        (b) Earth Cartesian Position with respect to Lunar Fixed Frame at a single time instant is [X, Y, Z] = [361000, 0, –42100] km.

5. Create and submit a video highlighting student-led work on the lunar visualization app.

Additional information on how teams will be evaluated on their lunar visualization app can be found in the Video Presentation Criteria and Scoring Rubrics section.

Challenge Mentorship

Teams should reach out to universities, local organizations, businesses, and subject matter experts to seek guidance on coding and app development. As part of their video presentation, teams must include a short narrative on the connections made and how these discussions helped in development of the app.

Teams needing additional assistance in developing an app can request a mentor from the ADC team. Mentors are not guaranteed to be available and will be provided on a first-come, first-served basis.

Storyboard Handout

The Storyboard Handout is for conceptualizing development of the app. A completed storyboard conveys what a team envisions as the final app design. During the ADC, teams will encounter challenges that require them to define problems, brainstorm options, and choose the best possible solution for achieving a completed app design. As part of the video presentation, teams must include a narrative on the challenges they encountered and how the challenges were solved. Teams will also use the Storyboard Handout to draw their main app in color, and then use the outer bubbles for additional details or descriptions of the app parts. The final app design is subject to change based on challenges encountered throughout the development process.

The Storyboard Handout can be found in the Appendix.

Deep Space Network antennas in Madrid, Spain. (NASA)

Video Presentation Criteria and Scoring Rubrics

Each team will submit a 5- to 7-minute video highlighting student-led work on the development of the team's app. **All videos should be posted to YouTube in the "unlisted" setting; video submissions should not be available to the public. Videos should only include students aged 13 and older and must be in accordance with the media policies of the team's school or organization.** The video presentation will showcase student-led work from the design phase through completion of the app. The Video Presentation Scoring Rubrics in this guide will be used to assess and score each team's video submission.

Once the video is posted to YouTube, each Lead Teacher must email the ADC team a link to the video by **2 p.m. central time on Wednesday, December 14, 2022,** at JSC-ADC@mail.nasa.gov.

Video Presentation Criteria

Each team must use the following script for their 5- to 7-minute video submission.

1. Introductory statement:
   - "This is team (team name) and we worked on NASA's App Development Challenge…."
   - Do not identify the name of any student, teacher, school, group, city, or region in the presentation.
   - Identify what coding language was utilized, what data points the app visualizes, and how successful the team was in creating a useful app.
2. Run the app, visually showing highlights of the terrain visualization and path navigation.
3. Provide narration on each aspect of the app's visualizations.
4. Identify challenges the team encountered and how they were solved along the way.
5. Identify what skills the team learned and how these were acquired during the challenge.
6. Identify any guidance the team received from mentors and subject matter experts that assisted in the learning process.
7. Based on the results, explain what the team would do differently in the future to improve the app.
8. Highlight completed community engagement events and those planned for the future.

Note: See the Video Presentation Scoring Rubrics for detailed presentation criteria.

Video Presentation Scoring Rubrics*

There are two separate rubrics, one for middle school and one for high school. The Video Presentation Scoring Rubrics will be used by members of the ADC team, the SCaN team, and NASA subject matter experts to evaluate video submissions. Remember to follow the script and provide details on each of the Video Presentation Criteria. Teams are encouraged to use the rubric to self-score their video in advance of final submission. The video presentation score will be part of the selection process. The Video Presentation Criteria and Scoring Rubrics can be found in the Appendix.

***Information about the challenge will remain posted for use in educational setting beyond the challenge end date.**

Selected Team Interviews

Video submissions are due by 2 p.m. central time on Wednesday, December 14, 2022. The ADC team will spend the next few weeks reviewing and evaluating submissions. Teams selected to participate in live virtual interviews can expect to be notified by close of business on January 26, 2023 (schedule subject to change).

Selected teams will receive questions and comments regarding their app and video presentation from NASA's ADC and SCaN teams. When teams receive these questions, they should prepare written responses in preparation for a live virtual connection with NASA personnel and the ADC team. Lead Teachers must submit their written responses prior to their interview at a date and time set by the ADC team. All submissions should be emailed to JSC-ADC@mail.nasa.gov.

Live virtual connections will be facilitated through video conference. The date and time of the event will be emailed to the Lead Teacher by the ADC team. The live virtual connection will be 30 to 45 minutes long and will give teams the opportunity to speak to both the SCaN and ADC teams. Teams will provide answers to the questions and respond to additional comments. Technical suggestions to improve app functionality will be discussed.

Each team's written submission and live connection will be evaluated to help determine which team(s) will be selected for the culminating event. Teams will be ranked by the NASA technical team. **In case of a tie score, preference will be determined by the NASA technical team**. The Top Teams must work with ADC mentors and team members to adjust any required items, based on technical suggestion by NASA, prior to attending the culminating event.

Top Team(s) selected to attend the culminating event can expect to be notified by close of business on February 22, 2023.

Near Space Network antennas AS–3 (foreground) and AS–1 (background) in Alaska. (NASA)

Community Engagement

Teams are expected to share their work in space exploration with a wider audience. Community engagement efforts should be planned and implemented. Teams can share their efforts whether they are working in a formal or informal setting. A school-based team could share their app with a younger grade or as part of a virtual or in-person STEM day or science fair. A museum-based team might set up a display at the museum for a day to share their work with the public, or they might participate in a virtual presentation to highlight their work. An after-school program could host a virtual open house to highlight their work for parents along with other after-school activities. Each team has unique opportunities to share their work in space exploration with a wider audience. **Lead Teachers and students should follow their school or organization's guidelines for these types of events.** Any community engagement should follow local social distancing guidelines or be virtual. Be sure to include images and video of outreach events in the team video submission. Teams selected to participate in the culminating event will need to plan additional outreach leading up to the culminating event.

Quantum Information Science and Technology (QIST)

Future ADCs will look to incorporate QIST elements as part of the coding challenge. Student teams are expected to share information on QIST, specifically Quantum Day 2023 and QuanTime resources, as part of community engagement efforts. Information regarding both items can be found on their respective websites: World Quantum Day 2023 is April 14, and QuanTime provides activities, lessons, and games for students and educators. Information regarding inclusion of QIST elements as part of the ADC can be found in the Appendix as part of the scoring rubrics. Additional information and resources can be found at NASA SCaN World Quantum Day.

Social Media

The ADC team is interested in learning how each team is progressing and would like updates when available. Social media allows teams the opportunity to share their NASA unique experience with the public and promote the challenge. Teams are encouraged to create a web presence using platforms of their choice. Use **#NextGenSTEM** and **#NASA_ADC** when posting so the ADC team can follow your progress. Teams must follow their school or organization's guidelines related to social media.

Media Relations

As teams share their experiences with the public, they may have opportunities to interact with the media. The ADC team would like to know when a team is highlighted in the media. Each team should keep a list of these media interactions and share any links to newspaper postings, online stories, videos, live events, etc., with JSC-ADC@mail.nasa.gov.

Press Releases

The ADC team will provide press releases to registered teams as part of the challenge to share with the media. An additional press release will be provided to the Top Teams selected to attend the culminating event.

Media Releases

NASA media releases will be required for all members (student and adult) of selected teams. The media release form will cover challenge video submissions, team interviews, and any media covering participation in the culminating event. NASA media releases will ***ONLY*** be utilized by teams participating in team interviews. Please check with your organization for any guidance on media releases.

Top Team(s) selected to the culminating event might be asked to complete additional documentation regarding their app submission and use by NASA.

Conclusion and Contact Information

The ADC team hopes participation in NASA's App Development Challenge is a beneficial and rewarding learning experience for each team. The ADC team will work to provide timely updates to Lead Teachers via email. Questions can be directed to JSC-ADC@mail.nasa.gov.

NASA's Optical Ground Station 1 in Table Mountain, California. (NASA)

Supplemental Information and Resources

Learning Objectives (Computational Thinking Model)

The following illustration depicts the K–12 Computer Science Framework's 7 Core Practices model. NASA's App Development Challenge (ADC) was designed to incorporate these core practices into the learning experience.

K–12 Computer Science Framework's 7 Core Practices.
(Adapted from K–12 Computer Science Framework, Creative Commons license CC BY-NC-SA 4.0)

App Development Challenge

The following descriptions show examples of what will be completed for each practice by students participating in the ADC:

1. Fostering an inclusive computing culture
   - Identify a variety of people who can provide ideas, mentorship, and feedback
   - Identify a variety of people who might be end users for the product
   - Create functions to broaden accessibility and use
2. Collaborating around computing
   - Select the programming language, operating system environment, and development environment to be used based upon the team's skill set and experience
   - Identify roles and responsibilities for team members, as well as norms for ensuring everyone has a voice
   - Solicit and incorporate feedback from various stakeholders
3. Recognizing and defining computational problems
   - Explain the challenge
   - Break the challenge into smaller chunks
   - Develop storyboards for visualizing a final app
4. Developing and using abstractions
   - Identify and incorporate existing libraries, modules, images, and three-dimensional (3D) models that may provide useful features in visualizing an app
   - Code useful subroutines (e.g., recognizing keyboard and mouse input) that may be used multiple times in the final app
5. Creating computational artifacts
   - Develop some pseudocode to guide development of the app
   - Code ways to visualize the height and slope of the lunar South Pole
   - Code ways to communicate information via color
   - Code ways to visualize a path and identify communication link checkpoints
   - Code other useful features
6. Testing and refining computational artifacts
   - Run the app with the NASA-provided data
   - Run an entire mission visualizing the provided data and plotting a path from the start point to the destination point
   - Let other people beta test the app and provide feedback
   - Add useful functions for communicating information and ensure the app can handle these additions
7. Communicating about computing
   - Script and deliver a presentation on how the team's app works, what they learned making it, and what ideas they have for future improvements
   - Record a video of the team presentation and submit it to NASA
   - Share your experience with others in the community

Digital Badges for Students and Educators

The NASA STEM Engagement & Educator Professional Development Collaborative (EPDC) is a national educator professional development and STEM engagement organization designed to partner with NASA in service to STEM educators and their students across the country. NASA STEM EPDC provides professional learning services via online webinars and activities for educators and students. These lessons are directly aligned to NASA mission objectives. An electronic badge (i.e., completion certificate) is awarded to any student or educator upon completion of the course. Educators can use this badge for professional development hours with their school districts. Educators are encouraged to visit the website and utilize these lessons in their classroom. Lead Teachers must complete an EPDC Moon webinar and submit a certificate of completion.

Next Gen STEM Educator Guides

NASA's Office of STEM Engagement Next Gen STEM initiative provides a platform for students to contribute to NASA's endeavors in exploration and discovery. These mission-driven activities include over 20 evidence-based products and opportunities to engage students in authentic STEM experiences. The following six educator guides contain standards-aligned activities that help students learn about NASA's mission to send humans to the Moon.

- Crew Transportation With Orion
- Propulsion With the Space Launch System
- Habitation With Gateway
- Hazards to Deep Space Astronauts
- Deep Space Communications
- Landing Humans on the Moon

  The following YouTube videos demonstrate activities from the Landing Humans on the Moon educator guide:

  – Sculpting Lunar Geology with Deb Baggett
  – Priority Packing with Lynn Dotson
  – Safe Landing on the Moon with Seth Johnson

Mission Resources

- NASA's Space Communications and Navigation (SCaN) – SCaN home page
- SCaN Now – Real-time status display for NASA's ground stations
- SCaN Sponsored Outreach Programs and Exhibits – Projects or programs sponsored by SCaN for the public
- Moon: NASA Science – Interactive Moon landing and geography map, news, and articles
- Moon Trek – Application to view imagery and perform analysis on Moon data
- NASA 3D Resources – NASA 3D models, images, and textures on GitHub
- Computer-Generated Imagery (CGI) Moon Kit—Scientific Visualization Studio (SVS) – Color and elevation maps for 3D rendering software
- United States Geological Survey (USGS) Astrogeology Science Center – Resource website for lunar maps and data
- Lunar South Pole Atlas – Online atlas that consists of maps, images, and illustrations of the lunar South Pole region from the Lunar Planetary Institute, Houston
- Lunar Orbital Data Explorer – The data file provided to teams was collected using NASA's Planetary Data System Lunar Orbital Data Explorer
- NASA Lunar Reconnaissance Orbiter (LRO) – NASA LRO home page
- Lunar Reconnaissance Orbiter (LRO) Goddard – NASA LRO website from Goddard Space Flight Center (GSFC)
- Lunar Reconnaissance Orbiter Camera – Interactive map to explore the lunar surface
- NASA LOLA Data Node – Primary source for Lunar Orbiter Laser Altimeter (LOLA) data products
- Moon LRO LOLA Digital Elevation Model (DEM) – Specific DEM on the Moon
- We Are NASA – NASA's next great leap video – the next chapter in space exploration
- Moon to Mars: SLS and Orion – Sustainable program of exploration
- NASA Orion Spacecraft – NASA Orion website
- Space Launch System – NASA Space Launch System (SLS) website
- NASA Moon to Mars – News report, sustainable campaign to return to the Moon

App Development and Design Resources

- Unity® (Unity Technologies) – A cross-platform game engine used to develop games and simulations for use on various devices
- Unreal® Engine (Epic Games, Inc.) – A suite of integrated tools for game developers to design and build games, simulations, and visualizations
- Blender® (Blender Foundation) – Free and open-source 3D creation suite
- Code.org® – Nonprofit dedicated to expanding access to computer science
- QuanTime – Activities designed for K–12 to introduce middle and high school students to quantum information science

Artemis Mission Resources

- Artemis – Humanity's return to the Moon
- Artemis Missions – Artemis home page
- Join Artemis – Learn more about the Artemis missions and how to get involved
- What is Artemis? – Article and video link answering questions about Artemis
- Artemis Fact Sheet (PDF) – Artemis handout with important facts
- Artemis I – Artemis I mission overview
- Artemis I Map – One-page infographic of Artemis I mission
- Artemis I: Pushing Farther into Deep Space – Artemis I mission video
- Artemis I: We Are Capable – Artemis I mission video
- Artemis Mission Maps – Artemis I through Artemis V infographics

STEM Engagement Resources

- NASA's Next Gen STEM – Office of STEM Engagement initiative to provide STEM products and opportunities to engage students in NASA missions
- NASA Computer Science Educational Resources – Computer science resources for K–12 educators and students
- NASA at Home – Activities, resources, books, apps, and much more for bringing NASA into your home
- SCaN Kids Zone – Activities, handouts, and resources for K–12 students
- STEM Classroom Activities – Lesson plans and educational resources for grades 5–8
- NASA Space Apps Challenge – Annual international hackathon
- NASA eClips™ – Short educational videos

Informal Education Resources

- NASA STEM Engagement Informal Education Resources – Home page for informal education institutions and organizations to explore NASA resources, activities, and programs
- NASA Museum and Informal Education Alliance – Alliance for informal education professionals providing free NASA educational resources and services
- NASA Space STEM – Site designed to enhance students' understanding of and engagement with STEM

Student Challenges

- Artemis Student Challenges – Selection of NASA student challenges engaging middle school through graduate school students as part of the Artemis generation

Career Connections and Internship Opportunities

- NASA Internships – NASA home page for internships, fellowships, and Pathways opportunities
- NASA Careers – NASA home page for career information and links to job searches and recruitment events
- NASA Employee Profiles – Selection of individual NASA employee stories from across the Agency
- Exploring Careers @ NASA – Students – Resources for students interested in working at NASA including links to internship and fellowship opportunities
- NASA People – Articles and videos highlighting various NASA careers
- NASA People (YouTube) – Videos of NASA employees highlighting their work across the Agency

Appendix

Middle School Rubric

Category	Best = 3 points	Better = 2 points	Good = 1 point	Missing = 0 points	TOTAL POINTS
App Creation – Modeling	App visualizes both height and slope from the provided data and accurately displays it from a first-person perspective. Data is smoothed, looking like natural terrain.	App visualizes both height and slope from the provided data and displays it from a first-person perspective. 40-m data separation has not been smoothed or interpolated.	App visualizes both height and slope using some of the provided data and visualizes this data in some useful 2D form.	App fails to visualize data in some useful form beyond text.	Raw Score Multiplier × 3
App Creation – Color and Texture	App displays texture and uses color to convey information to scale with corresponding color key and allows user to toggle between different color coding.	App displays texture and uses color to convey either height (meters) or slope information with corresponding color key.	App displays either color or texture, but not both.	App fails to apply a texture or to use color to convey information.	Raw Score Multiplier × 2
App Creation – Wayfinding	App plots and clearly identifies complete path from the landing site to destination site that does not exceed 15 degrees of slope and has some sort of optimization, e.g., shortest distance or least amount of hill climbing.	App plots a path from the landing site to the destination site that does not exceed 15 degrees of slope.	App displays any path from the landing site to the destination site.	App fails to identify a path.	Raw Score Multiplier × 3
App Creation – Communication Link Checkpoints	App identifies and provides evidence supporting the selection of 10 locations for communication link checkpoints at a location of high elevation at regular intervals along the path.	App identifies and explains the selection of 10 locations for communication link checkpoints at some important location along the path, e.g., a place where you would turn.	App arbitrarily places 10 communication link checkpoints.	App fails to identify any place for communication checkpoints.	Raw Score Multiplier × 3
Communicating Computing	All app components are fully described, with detailed information on the work required to complete each component and how the team worked collaboratively to complete the app. Description includes mention of the 7 Core Practices of the K–12 Computer Science Framework.	More than one app component is described, but the components or how the team worked to complete the app are not completely identified, OR a single app component is described with detailed information and how the team worked to complete it.	At least one app component is described, but its function, and how the team worked to complete it, is not fully described.	Identification of app components and how the team worked to complete them is not included.	
Troubleshooting	Challenges encountered are clearly identified, with explanations of how the team solved or planned to solve each challenge and the results of these actions.	Challenges encountered are identified, with limited explanations of how the team solved or planned to solve each challenge and the results of these actions.	Challenges are implied or not fully stated. It is not identified if any action was taken to solve the challenges.	Narrative of challenges encountered is not included or is incomplete.	
Student-Acquired Skills	Key skills learned and acquired through participation in the challenge are identified with detailed information and technical terms and are supported with visible app components.	Key skills learned are stated, but with limited details of how they were acquired or incorporated into the app development.	Key skills learned are stated, but no additional narrative on how they were acquired or incorporated into the development of the app is provided.	Narrative on student-acquired skills is not included or is incomplete.	
Subject Matter Experts (SMEs) and Mentors	Interactions with scientists, engineers, or other relevant SMEs are fully described, including how their guidance and feedback is incorporated into the app design.	Interactions with scientists, engineers, or other relevant SMEs are described, and details are included on guidance they provided.	Interactions with scientists, engineers, or other relevant SMEs are acknowledged in general terms, but no specific details are included.	Interactions with scientists, engineers, or other relevant SMEs are not acknowledged.	
Community Engagement	Evidence of completed events and social media outreach is included, with additional outreach planned. Evidence of shared Quantum Day information and activities provided to promote participant engagement. Social media outreach includes resources links. Evidence of completion of QuanTime activities.	Evidence of completed events and social media outreach is included. Inclusion of Quantum Day information and activities provided to participants or linked in social media outreach.	Evidence of only future planned events or social media is included.	No evidence of events or outreach is included.	
			SCORE	(out of 48)	
Extras	Teams can receive up to 5 additional points for aspects that enhance the app in terms of displayed data, visualizations, functionality, ease of use, or accessibility for users needing special accommodations. Examples include the following: 1. Create and display an accurate mini map in a corner of the visualization to show progress or 2D perspective. 2. Compare potential route if slope constraint was relaxed to a maximum of 20 degrees. 3. Compare terrain height differences of adjacent points to slope data of current points. 4. Determine the smallest maximum number of degrees of slope that must be allowed for a path from the normal starting point to the top of the rim of the large crater to the southwest of it. 5. Demonstrate a limitation of classical radio/laser communication and discuss how quantum communication might bypass that limitation.				
			FINAL SCORE	(out of 48)	
Team Name: ________________________________			FINAL % SCORE		

App Development Challenge

High School Rubric

Category	Best = 3 points	Better = 2 points	Good = 1 point	Missing = 0 points	TOTAL POINTS
App Creation – Modeling	App accurately visualizes the following from a first-person perspective: height, slope, elevation angle from astronaut to Earth, and azimuth angle from astronaut to Earth. Data is smoothed, looking like natural terrain.	App accurately visualizes height and slope from a first-person perspective, but not elevation angle from astronaut to Earth or azimuth angle from astronaut to Earth. 40-m data separation has not been smoothed or interpolated.	App visualizes the lunar surface in some useful 3D form.	App fails to visualize data in some useful form beyond text.	Raw Score Multiplier × 3
App Creation – Color and Texture	App displays texture and uses color to convey information to scale with corresponding color key and allows user to toggle between height, slope, elevation angle, and azimuth angle.	App displays texture and uses color to convey information to scale with corresponding color key and allows user to toggle between height and slope.	App displays texture and uses color to convey either height or slope information with corresponding color key.	App fails to apply a texture or to use color to convey information.	Raw Score Multiplier × 2
App Creation – Wayfinding	App plots and clearly identifies a complete path from the landing site to the destination site that does not exceed 15 degrees of slope and allows user to toggle between different optimizations, e.g., shortest distance, least amount of hill climbing, or percentage of time Earth is visible.	App plots a complete path from the landing site to the destination site that does not exceed 15 degrees of slope and has some sort of optimization, e.g., shortest distance or least amount of hill climbing.	App plots a path from the landing site to the destination site that does not exceed 15 degrees of slope.	App fails to identify a path.	Raw Score Multiplier × 3
App Creation – Communication Link Checkpoints	App identifies 10 locations, along the path, for communication link checkpoints at a location where the elevation angle to Earth is greater than the elevation angle to the horizon at the same azimuth angle, with some sort of optimization, e.g., maximum distance between checkpoints.	App identifies 10 locations, along the path, for communication link checkpoints at a location where the elevation angle to Earth is greater than the elevation angle to the horizon at the same azimuth angle.	App identifies 10 locations, along the path, for communication link checkpoints at some important location, e.g., a place of high elevation.	App fails to identify any location for communication checkpoints.	Raw Score Multiplier × 3
App Creation – Lunar Site Selection	Landing and destination sites as well as areas of interest along the path are identified with scientific evidence/data/rationale for site selection.	Landing and destination sites as well as areas of interest along the path are identified with conversational explanation of site selection.	Identification of landing and destination sites but no explanation.	No identification or explanation of site selections.	Raw Score Multiplier x 2
Communicating Computing	All app components are fully described, with detailed information on the work required to complete each component and how the team worked collaboratively to complete the app. Description includes mention of the 7 Core Practices of the K–12 Computer Science Framework.	More than one app component is described, but the components or how the team worked to complete the app are not completely identified, OR a single app component is described with detailed information and how the team worked to complete it.	At least one app component is described, but its function, and how the team worked to complete it, is not fully described.	Identification of app components and how the team worked to complete them is not included.	
Troubleshooting	Challenges encountered are clearly identified, with explanations of how the team solved or planned to solve each challenge and the results of these actions.	Challenges encountered are identified, with limited explanations of how the team solved or planned to solve each challenge and the results of these actions.	Challenges are implied or not fully stated. It is not identified if any action was taken to solve the challenges.	Narrative of challenges encountered is not included or is incomplete.	
Student-Acquired Skills	Key skills learned and acquired through participation in the challenge are identified with detailed information and technical terms and are supported with visible app components.	Key skills learned are stated, but with limited details of how they were acquired or incorporated into the app development.	Key skills learned are stated, but no additional narrative on how they were acquired or incorporated into the development of the app is provided.	Narrative on student-acquired skills is not included or is incomplete.	
Subject Matter Experts (SMEs) and Mentors	Interactions with scientists, engineers, or other relevant SMEs are fully described, including how their guidance and feedback is incorporated into the app design.	Interactions with scientists, engineers, or other relevant SMEs are described, and details are included on guidance they provided.	Interactions with scientists, engineers, or other relevant SMEs are acknowledged in general terms, but no specific details are included.	Interactions with scientists, engineers, or other relevant SMEs are not acknowledged.	
Community Engagement	Evidence of completed events and social media outreach is included, with additional outreach planned. Evidence of shared Quantum Day information and activities provided to promote participant engagement. Social media outreach includes resources links. Evidence of completion of QuanTime activities.	Evidence of completed events and social media outreach is included. Evidence of shared Quantum Day information and activities provided to promote participant engagement. Social media outreach includes resources links. Evidence of completion of QuanTime activities.	Evidence of only future planned events or social media is included.	No evidence of events or outreach is included.	
			SCORE	(out of 54)	
Extras	Teams can receive up to 5 additional points for aspects that enhance the app in terms of displayed data, visualizations, functionality, ease of use, or accessibility for users needing special accommodations. Examples include the following: 1. Create and display an accurate mini map in a corner of the visualization to show progress or 2D perspective. 2. Compare potential routes if slope constraint was relaxed to a maximum of 20 degrees. 3. Compare terrain height differences of adjacent points to slope data of current points. 4. Determine the smallest maximum number of degrees of slope that must be allowed for a path from the normal starting point to the top of the rim of the large crater to the southwest of it. 5. Demonstrate a limitation of classical radio/laser communication and discuss how quantum communication might bypass that limitation.				
			FINAL SCORE	(out of 54)	
	Team Name: ______________________________		FINAL % SCORE		

Storyboard Handout

Azimuth and Elevation Angle Equations

The following equations should be used by high school student teams for completing azimuth and elevation angle calculations.

Azimuth from Reference Location A to Target Location B

- $Azimuth_{AB} = \text{atan2}\Big((\sin(Long_B - Long_A) * \cos(Lat_B)), \Big((\cos(Lat_A) * \sin(Lat_B)) - (\sin(Lat_A) * \cos(Lat_B) * \cos(Long_B - Long_A))\Big)\Big)$

Spherical to Cartesian Conversion

Radius = Lunar Radius + Terrain Height

Lunar Radius = 1737.4 km

- $x = Radius * (\cos(Lat)) * (\cos(Long))$
- $y = Radius * (\cos(Lat)) * (\sin(Long))$
- $z = Radius * (\sin(Lat))$

Elevation from Reference Location A to Target Location B

- $[x_{AB}, y_{AB}, z_{AB}] = [x_B, y_B, z_B] - [x_A, y_A, z_A]$
- $Range_{AB} = \sqrt{{x_{AB}}^2 + {y_{AB}}^2 + {z_{AB}}^2}$
- $rz = x_{AB}\cos(Lat_A)\cos(Long_A) + y_{AB}\cos(Lat_A)\sin(Long_A) + z_{AB}\sin(Lat_A)$
- $Elevation_{AB} = \text{asin}\left(\frac{rz}{Range_{AB}}\right)$

National Aeronautics and Space Administration
NASA Headquarters
E Street Southwest
Washington DC 20024-3210

www.nasa.gov

NP-2022-08-3066-HQ