

AEC 2022

PROGRAMMING COMPETITION CASE

# BACKGROUND

Since landing in early 2021, the Perseverance Rover and Ingenuity Helicopter have been exploring Mars to further our understanding of the planet and help prepare the way for future human exploration. [Canadian researchers and engineers](https://www.ctvnews.ca/sci-tech/nasa-is-about-to-land-on-mars-and-these-canadians-are-part-of-the-mission-1.5313516) continue to play an important role in this mission by conducting experiments and helping to operate the complex systems involved.

As part of the mission team, a [Canadian Systems engineer](https://www.ctvnews.ca/sci-tech/perseverance-is-on-mars-and-now-this-canadian-born-engineer-s-work-really-begins-1.5332219) was tasked with determining when the team will be able to communicate directly with the Perseverance Rover using its High Gain Antenna. This calculation is affected by a range of variables including the location of Perseverance on the Martian surface, the relative positions of Earth and Mars as they orbit the sun and the rotation period for each planet.

# THE CASE

Your team has been asked to create a software tool that calculates the distance and transmission latency between two planets orbiting the Sun. As the planets are in constant motion, the tool must take into consideration their relative positions in orbit at a specific point in time.

The software should also warn users if the specified point in time coincides with a solar conjunction when one planet passes directly behind the Sun relative to the other planet. During this time, transmissions are typically minimized for a few weeks due to the potential for radio signal interference.

The tool does not need to consider either planet’s rotation or the position of antennae on the surface of the planets as these factors will be calculated by another team.

## Input Requirements

The software will have two modes of execution: Configuration and Calculation.

In Configuration mode, users enter data about the planets. This information is required to generate the [required output](#_Output_Requirements) and includes:

* Planet Name
* Orbital Radius
* Orbital Period
* Date/time of Last Opposition with Earth (This value only applies to planets other than Earth)

The data may be stored in a file or database, and it should be easy to add, view, update and delete entries using the software tool. Invalid input (like specifying “giraffe” as the orbital radius) should be rejected. Configuration data for Earth, Mars and Saturn may be found in the [table below](#_Data_Requirements).

In Calculation mode, the software will accept the following inputs from the users:

* The name of the planets for which the calculations will be performed (eg. Earth and Mars). Obviously, the users will not be able to perform calculations for planets that haven’t yet been entered through the configuration interface.
* The Earth date for which the calculations are to be performed. The specified date must not occur in the past or be more than 100 years in the future. This value should default to the current date.

## Data Requirements

The following data may be used to calculate the desired outputs for Earth, Mars and Saturn:

|  |  |  |
| --- | --- | --- |
| Data Category | Data Point | Value |
| General | Speed of light in a vacuum | 299 792 458 m/s |
| Earth Data | Average distance to Sun | 149.6M km |
| 1 year | 365.24 Earth days |
| Mars Data | Date & Time of last opposition (relative to Earth) | 2020-10-13 23:20 UTC |
| Average distance to Sun | 228.9M km |
| 1 year | 686.98 Earth days |
| Saturn Data | Date & Time of last opposition (relative to Earth) | 2021-08-02 06:00 UTC |
| Average distance to Sun | 1 482.2 M km |
| 1 year | 10 759.22 Earth days |

To simplify calculations, you may assume the following:

* The planets orbit in the same plane (non-inclined)
* The orbits of the planets are circular (non-elliptical)

## 

## Output Requirements

The following outputs must be returned for the date and planets specified:

* 1. Distance separating the two planets
  2. Latency associated with transmitting a signal between the planets
  3. Whether the specified date falls within the moratorium on transmitting commands due to solar conjunction. (Assume that the moratorium extends to a 7° angle on each side of the sun.)
  4. Date of the next planetary opposition (when the planets are closest)
  5. A graph illustrating daily signal latency over the next 24 months from the date specified
  6. BONUS: A visualization illustrating the positions of both planets in their orbits on the date specified

There are no restrictions on the format of the output data, however, the results must be clearly communicated. Note that small margins of error are acceptable.

## Additional Considerations

Usability of the tool is important, and the software should be intuitive. However, teams can decide whether to present users with a graphical user interface or a command line interface.

Your team may identify additional data sources, outputs or enhancements that would benefit the users of this tool. You are encouraged to include additional features in your software if time permits.

# LOGISTICS

Your team will be given eight hours to complete this task. All deliverables, including source code, must be submitted electronically prior to the end of the provided time. Please note that your team may choose to develop the software solution using the programming languages, IDEs and libraries of your choice.

# REFERENCES AND SOURCES

[Perseverance is on Mars, and now this Canadian-born engineer's work really begins | CTV News](https://www.ctvnews.ca/sci-tech/perseverance-is-on-mars-and-now-this-canadian-born-engineer-s-work-really-begins-1.5332219)

[NASA is about to land on Mars, and these Canadians are part of the mission | CTV News](https://www.ctvnews.ca/sci-tech/nasa-is-about-to-land-on-mars-and-these-canadians-are-part-of-the-mission-1.5313516)

[Communications - NASA Mars](https://mars.nasa.gov/mars2020/spacecraft/rover/communications/#High-Gain-Antenna)

[NASA's Mars Fleet Lies Low with Sun Between Earth and Red Planet – NASA’s Mars Exploration Program](https://mars.nasa.gov/news/9051/nasas-mars-fleet-lies-low-with-sun-between-earth-and-red-planet/)