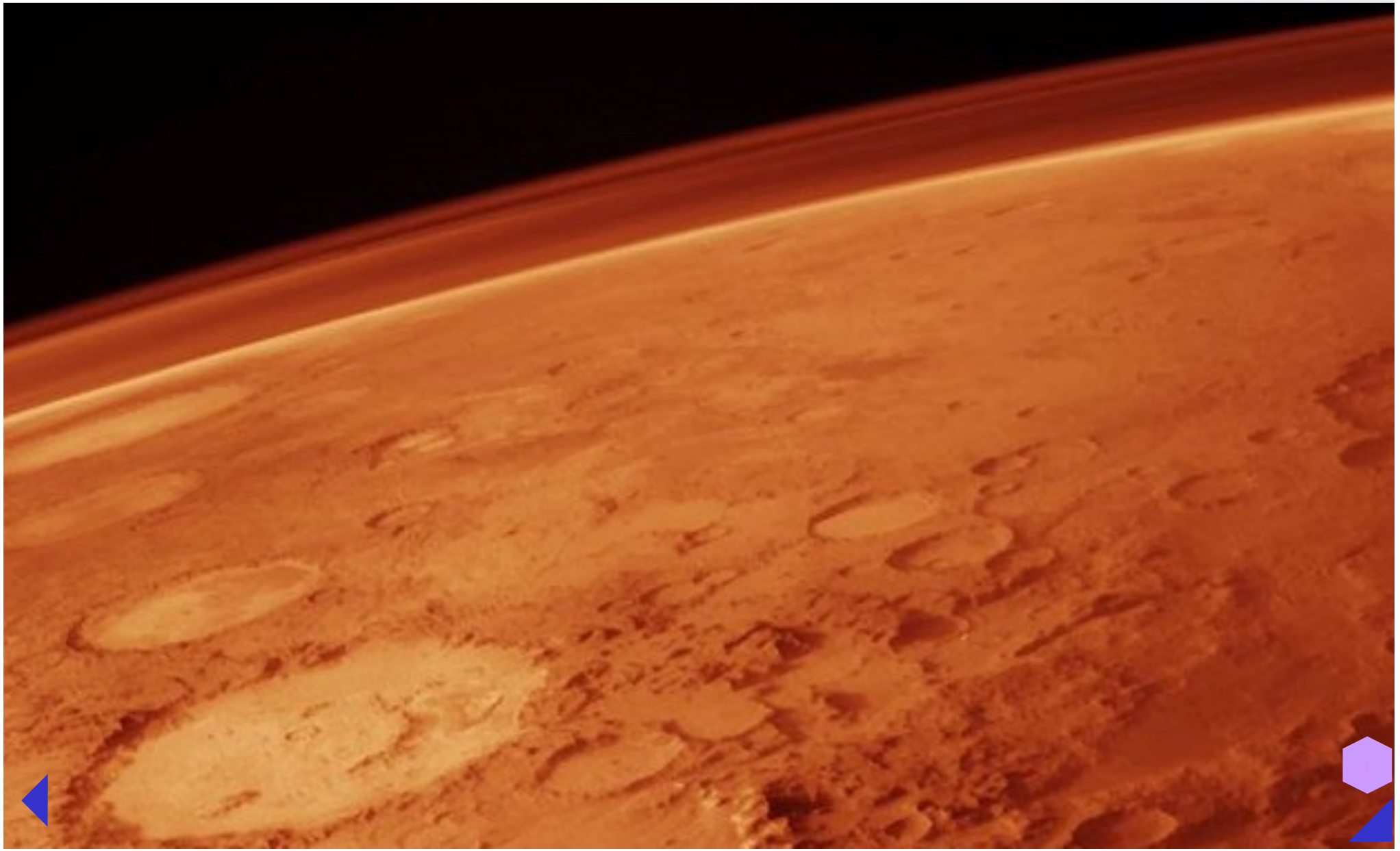
Case Study: Mars



Dashboard

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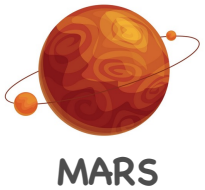
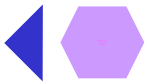
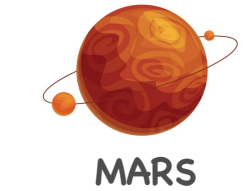


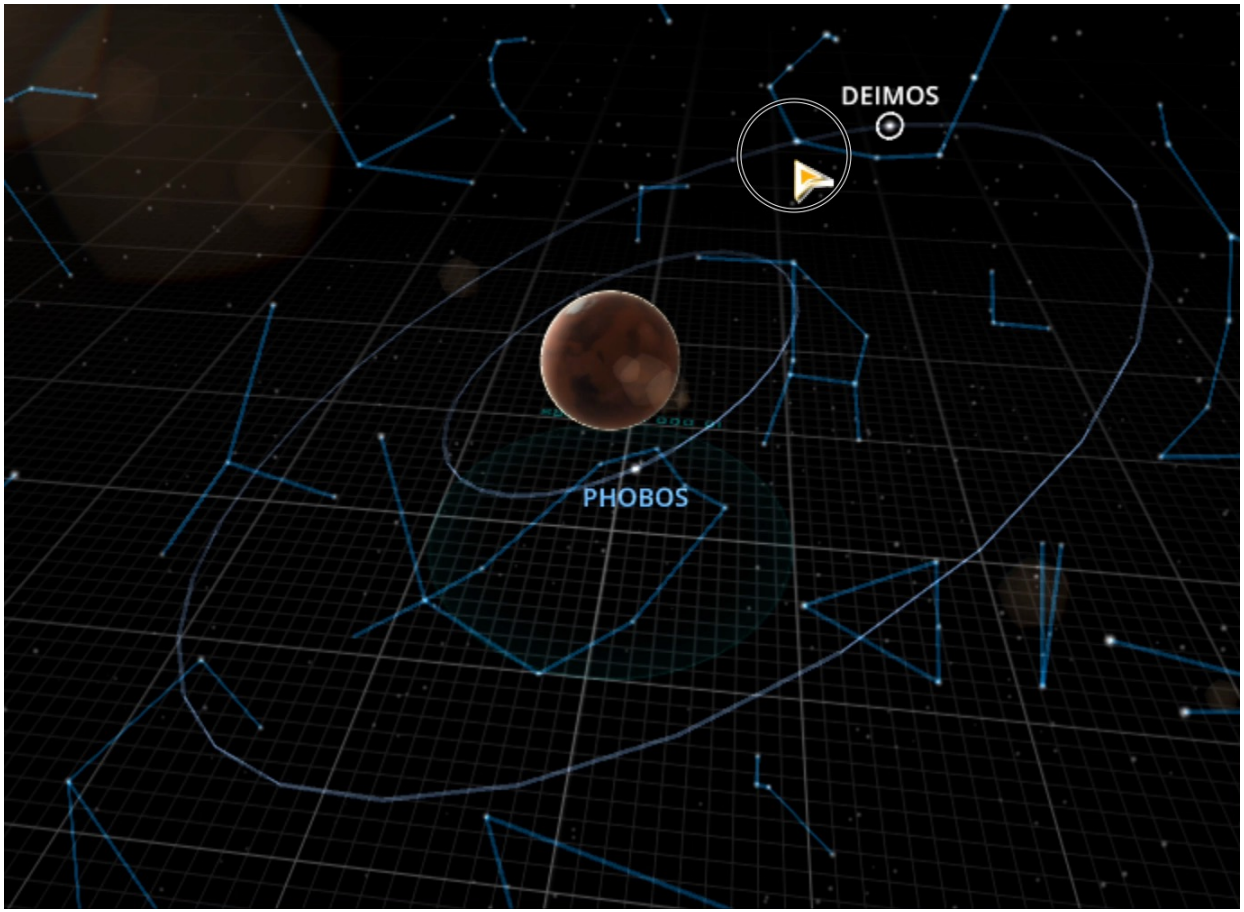
Project Description



Mars: The Project Description

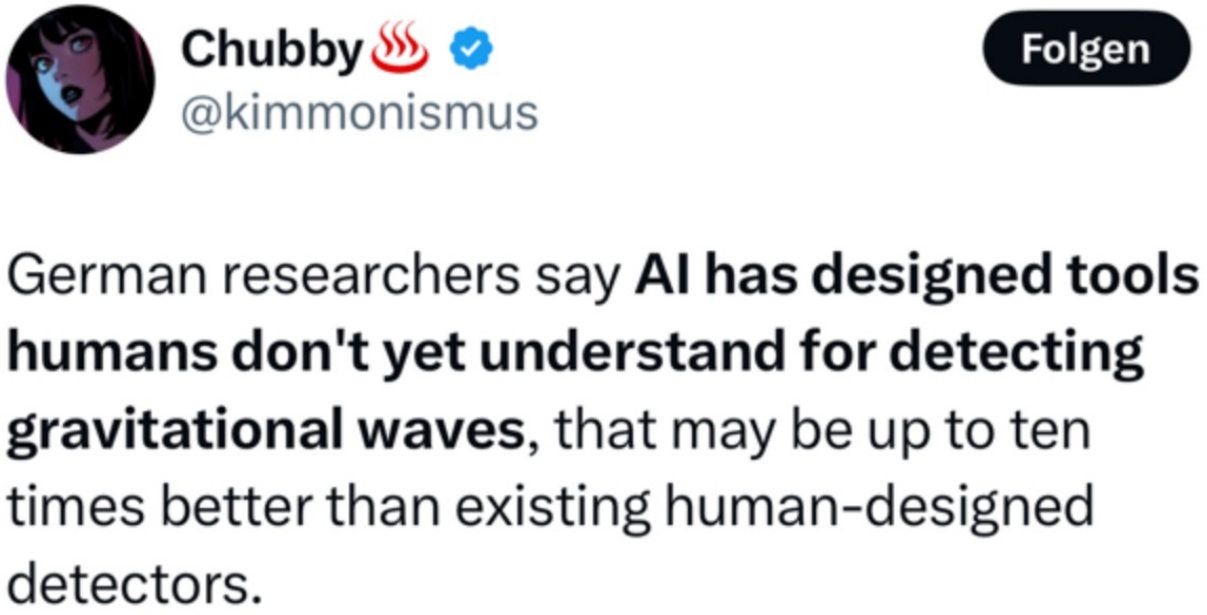
Mars has **two moons: Deimos and Phobos**. Every day, each of them rises and sets at certain points in time.



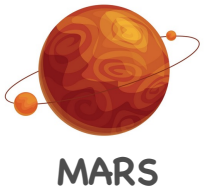


Mars: The Project Description

The purpose of the Mars project is to **measure the interference of gravitational waves using a neural network**.



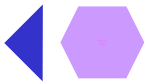
Mars: The Project Description



For the measurements on Mars to work, **both** moons must be visible, as they act as gravitational lenses.

To perform the measurement, the measuring device must be powered up every day. This costs a lot of energy, which is why it will only be done if the total time span both moons are visible is long enough.

It is therefore necessary to have a software function *Moon* that takes two time-intervals (one for Deimos being visible, one for Phobos being visible) as input and **counts the number of minutes they overlap**.



Mars: The Software Engineering Method

NASA Procedural Requirements

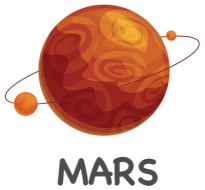
NPR 7150.2D
Effective Date: March 08, 2022
Expiration Date: March 08, 2027

COMPLIANCE IS MANDATORY FOR NASA EMPLOYEES

MARS

NASA Software Engineering Requirements

Sources: https://lws.larc.nasa.gov/vfmo/pdf_files/N_PR_7150_002D_.pdf, https://www.nasa.gov/wp-content/uploads/2018/09/nasa_systems_engineering_handbook_0.pdf, 2025



Assumptions

Mars: Assumptions

AS1: A mars day (a.k.a. **sol**) is approximately 24 earth hours, 39 earth minutes and 35 earth seconds long (= 88775 earth seconds in total).

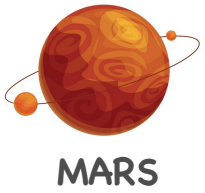
MARS

Several approaches have been proposed to divide the mars day into mars hours, mars minutes and mars seconds.

One uses the fact that 88775 = 25x67x53, dividing each mars day into 25 mars hours, each mars hour into 67 mars minutes and each mars minute into 53 mars seconds.

We will take a simpler approach here, **dividing each mars day into 25 mars hours and each mars hour into 100 mars minutes**.

Mars: Assumptions / 2



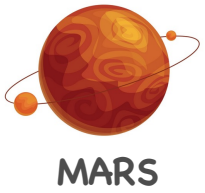
AS2: Every day, each Mars moon rises and sets at certain points in time. Both points in time are expressed as *Mars-timestamps*, together forming a *Mars-interval*. Deimos, for instance, could rise at 4:97 and set at 12:02. That day, Phobos could rise at 24:44 and set at 7:50 the next day.

AS3: This example of [24:44, 7:50] shows that the first Mars-timestamp in a Mars-interval need not be smaller than the second Mars-timestamp. If the second one is smaller, it is about a point in time the next Mars-day.

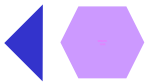
AS4: It may be assumed that a moon rises and sets exactly in the middle of a Mars-minute.

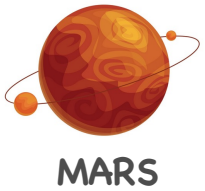
Mars: Assumptions / 3

AS5: It may also be assumed that if a certain interval is valid for a Mars-day, it was also valid for the previous Mars-day and will be valid for the following one (although this is slightly wrong, but we can neglect the error it introduces).

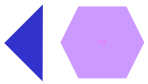


AS6: On Mars, *Moon* will not be called via GUI, but by the experiment coordination software which was programmed by NASA developers.

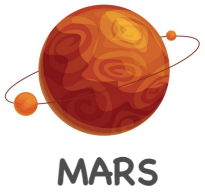




Requirements



Mars: Requirements



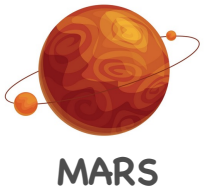
REQ1: Input to *Moon* should be two Mars-intervals – one for Deimos, one for Phobos.

REQ2: Output should be an integer, namely the number of Mars-minutes the intervals overlap.

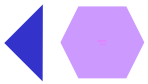
For instance, D[13:91, 23:05] P[22:05, 24:45]
(D = Deimos, P = Phobos) leads to the result 100,
because there are 100 Mars minutes from 22:05 to 23:05.
Another example: D[24:53, 7:12], P[5:12, 8:45] leads to the result 200, because the intervals overlap for the 200 minutes from 5:12 to 7:12.

REQ3: If the two intervals have only one point in common
(example D[12:32, 17:06] P[17:06, 19:78]),
another example D[22:11, 0:36] P[7:00, 22:11])
then the result should not be zero minutes, but one minute (*„twilight rule*").

REQ4: In order to be able to test *Moon* properly **on Earth**, a human-computer interface (not necessarily a GUI) should be added. It will not be needed on Mars.



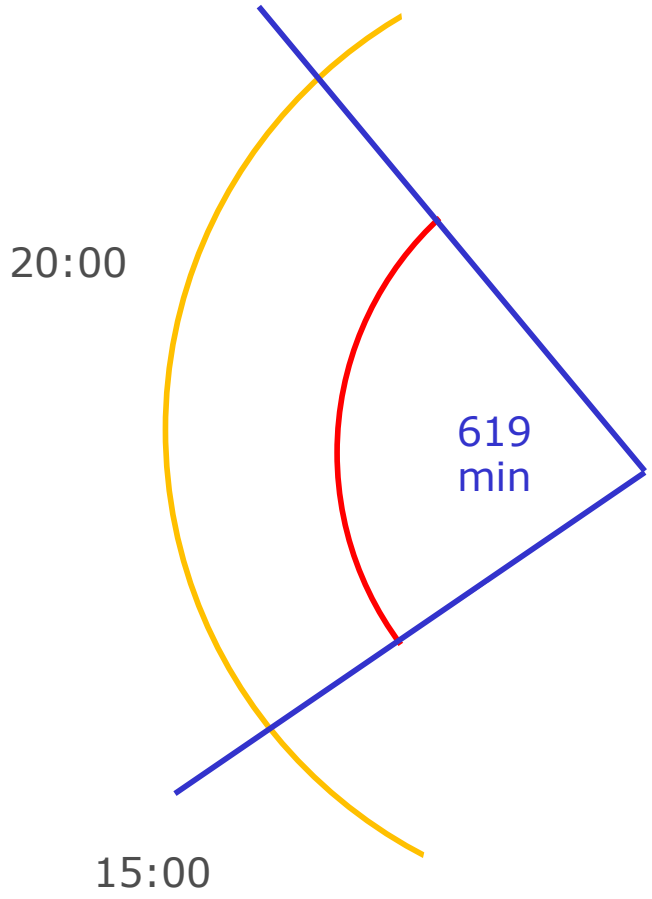
Examples

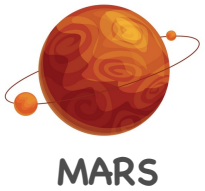


Mars: An Example

Deimos (14:00, 22:40)

Phobos (15:88, 22:07)

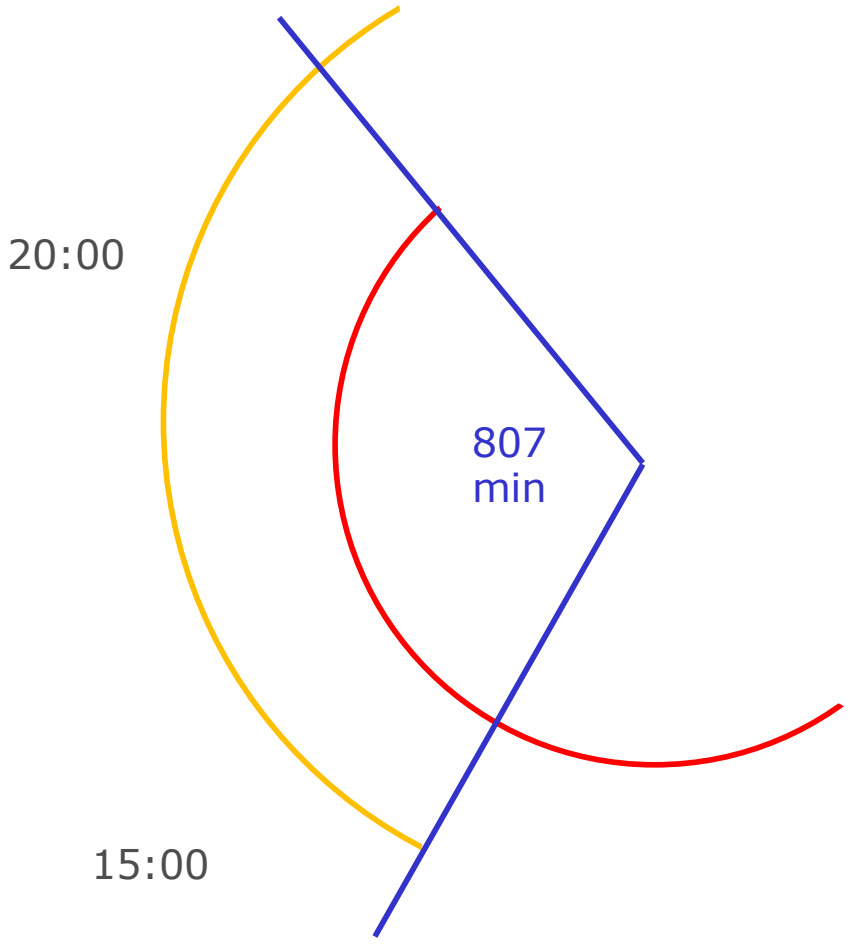


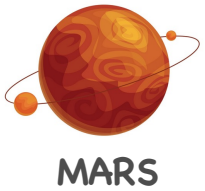


Mars: Another Example

Deimos (14:00, 22:40)

Phobos (10:20, 22:07)

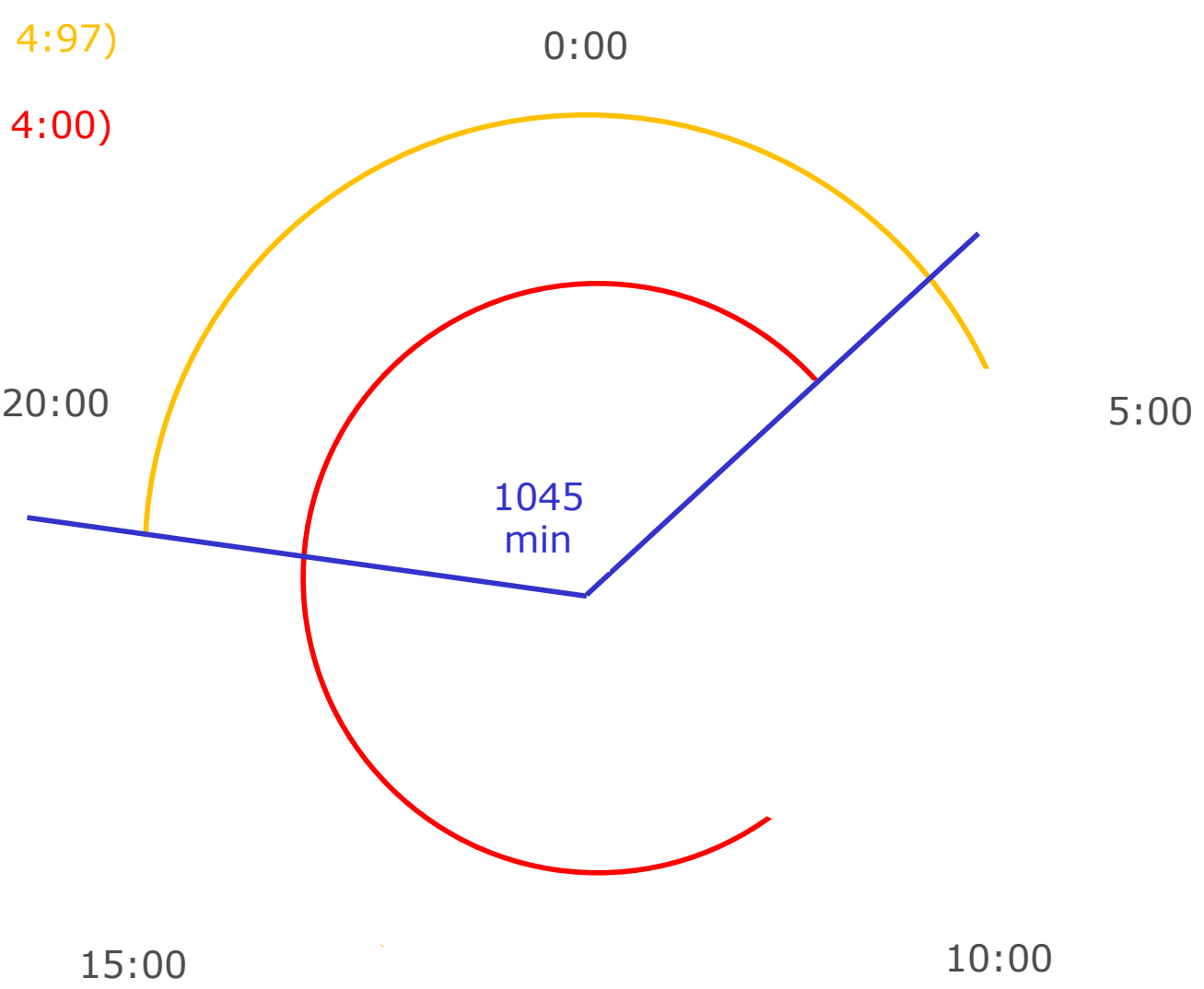




Mars: Yet Another Example

Deimos (18:55, 4:97)

Phobos (10:39, 4:00)



Mars: Twilight Rule Example

Deimos (18:55, 3:97)

Phobos (10:39, 18:55)