Light Travel Times

NASA satellites and space probes are so far away from Earth that serious time delays happen when radio signals are sent to them. This is because radio signals travel at the speed of light, 300,000 kilometers/sec, and the distances from Earth to the spacecraft are huge!!

Spacecraft	Distance (km)	Seconds
Themis P2	30,000	
LRO	382,000	
ACE	1.5 million	
MESSENGER	50 million	
STEREO-A	111 million	
Mars Orbiter	220 million	
Ulysses	800 million	
Cassini	1.8 billion	
Voyager 2	13 billion	

This image was taken by the Hubble Space Telescope and shows the satellite Io The moon is the small disk to the left, and its shadow appears to the right of center. (Courtesy J. Spenser, Lowell Observatory and NASA).

Problem 1 - How long will it take for a radio signal to travel from the satellites to Earth, one-way, in the above table? Complete the last column to find out!

Problem 2 - Suppose a radio message needs to be sent at 01:20 on February 15, 2008. To the nearest minute, what time would it be when the message arrived at each spacecraft, and when the data arrived back at Earth?

Problem 3 - When Jupiter was located farthest from the Sun (aphelion), it was at a distance of 667 million kilometers from Earth. When it was closest to the sun (perihelion) it was 590.5 million kilometers from Earth. Suppose you are calculating a schedule for when the satellite Io will be exactly at dead-center of Jupiter's disk based on when you saw the transit at perihelion. How much of a schedule change will you see when you observe the transit at aphelion, and will the transit occur sooner or later than you predicted?

Answer Key

Problem 1 – Answer:

Spacecraft	Distance (km)	Seconds
Themis P2	30,000	**0.1**
LRO	382,000	**1.3**
ACE	1.5 million	**5.0**
MESSENGER	50 million	**167**
STEREO-A	111 million	**370**
Mars Orbiter	220 million	**733**
Ulysses	800 million	**2,667**
Cassini	1.8 billion	**6,000**
Voyager 2	13 billion	**43,333**

Problem 2 - Answer: see table below:

Spacecraft	Distance (km)	Arrival at satellite	Arrival at Earth	One-way time
Themis P2	30,000	**01:20**	**01:20**	**0.2 sec**
LRO	382,000	**01:20**	**01:20**	**2.6 sec**
ACE	1.5 million	**01:20**	**01:20**	**10 sec**
MESSENGER	50 million	**01:23**	**01:26**	**2.8 minutes**
STEREO-A	111 million	**01:26**	**01:32**	**6.2 minutes**
Mars Orbiter	220 million	**01:32**	**01:44**	**12.2 minutes**
Ulysses	800 million	**02:04**	**02:49**	**44.4 minutes**
Cassini	1.8 billion	**03:00**	**04:44**	**1.7 hours**
Voyager 2	13 billion	**13:20**	**01:20 on Feb 16th**	**12.0 hours**

Problem 3 - When Jupiter was located farthest from the sun (aphelion), it was at a distance of 667 million kilometers from Earth. When it was closest to the sun (perihelion) it was 590.5 million kilometers from Earth. Suppose you are calculating a schedule for when the satellite Io will be exactly at dead-center of Jupiter's disk based on when you saw the transit at perihelion. How much of a schedule change will you see when you observe the transit at aphelion, and will the transit occur sooner or later than you predicted?

Answer: The difference between Jupiter's distance in each case is 667 million - 590.5 million = 76.5 million kilometers. At the speed of light, this equals a time difference of 76500000/300000 = 255 seconds or 4.25 minutes. At the time the transit occurs at aphelion, the event will be seen about 4.25 minutes later than the predicted time.