NASA's Deep Impact Mission: Decision Making

Earth-Based Observatories

STRATEGY INFORMATION SHEET

BACKGROUND INFORMATION

Earth-based observatories will be used for observations from Earth. The best case scenario would mean that the impact would take place when the comet is visible though the telescopes of more than one major observatory. Earth-based observing of the impact is a secondary source of data. Earth-based viewing allows scientists to observe the characteristics of the comet nucleus before impact. The types of observation from the Earth includes optical and infrared imaging, optical and infrared spectroscopy, and x-ray, optical, infrared and far infrared photometry.

Mauna Kea Observatory

The receipt of optical data from Earth-based observatories is constrained to night and only when the comet is above the horizon (i.e., in view). Clouds and bad weather can constrain ground observations. The Deep Impact mission design requires that impact occurs when more than one Deep Space Network antenna is in view of the comet.

Your group investigates the various possible observatories that may be involved with Earth-based observations of the impact by finding information about the observatories at various Web sites. Also, you will determine the locations of these observatories and the times at which the impact could be observed from these locations. Other factors like cost and requirements for the use of telescopes are considered.

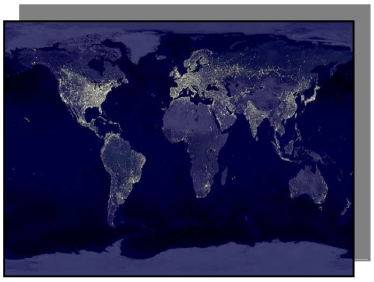
Deep Impact astronomer Karen Meech describes the proposal process below:

> *One of the biggest challenges for this mission is to obtain as much observing time as we will need to fully characterize the target before we get there. In order to obtain telescope time at any observatory, scientists must submit a proposal justifying their need. At all of the national observatories the proposal process is very regimented. For example, they dictate the margin size and font to be used in the proposal. Proposals not meeting the specifications are not even read. There is usually one page of scientific justification, explaining why your proposal should be accepted. These proposals are read by astronomers, but many with a different specialty area. Not all astronomers understand the importance of determining the rotation of a dirty snowball in space. So, in this one short page we have to inform them of the necessary background of the request and excite them about why this is the best thing to be done with the telescope. Another page is dedicated to justifying the request for a particular telescope, and why your science cannot be done with a smaller telescope.*
>
> *A committee of our peers reads hundreds of proposals, judges them, grades them, and ranks them. After they have decided which proposals are awarded time, someone else schedules the proposals with the highest ranking proposals getting their first choice of dates. A high-profile NASA mission like Deep Impact will get special considerations when it gets closer to the time of impact. Amateur astronomers can take Charged-Coupled Device (CCD) images and measure the brightness of Comet 9P/Tempel 1 at different times. Their limitation, however, is that they cannot observe very faint objects. During the time when the comet is bright, we should have almost continuous coverage from an enthusiastic, interested public who want to contribute to a real mission.*

Procedure:

1. The following observatories are being considered for use by the Deep Impact team for Earth-based observations. Use an atlas/globe and the Web to find information about these observatories in order to fill in the chart on the next page. Under "general comments" you may want to comment on the amount of darkness at each observatory. The Earth at night can be viewed at http://antwrp.gsfc.nasa.gov/apod/ap001127.html

United States
Haleakala (Maui)
http://www.ifa.hawaii.edu/haleakala/
Mauna Kea Observatory, Hawaii (the big island)
http://www.ifa.hawaii.edu/88inch/88inch.html
Palomar Observatory (Southern California)
http://www.astro.caltech.edu/palomarpublic/
Chile
Cerro Tololo Inter-American Observatory (Chile)
http://www.ctio.noao.edu
La Silla Observatory (Chile)
http://www.ls.eso.org/index.html
Paranal Observatory (Chile)
http://www.eso.org/paranal/



Observatory	Latitude/Longitude	Elevation	Weather Notes	General Comments
Haleakala, HI				
Mauna Kea, HI				
Palomar, CA				
Cerro Tololo, Chile				
La Silla, Chile				
Paranal, Chile				

2. There are certain pieces of information that are needed when requesting time for using telescopes at the various sites listed above. Look up some of the sites and make a list of some of the information that we would need to have in order to complete a research proposal. Include this information on a separate sheet of paper.
3. Use the European Southern Observatory Sky Calendar Tool to find the times that the impact could be observed from various observatories under consideration. That is, note the times of darkness and moon location for July 4, 2005 in the chart below. The tool provides sunrise and sunset times at each site, astronomical twilights, in local time and moon rise and set times and phase for each night in the month. In order to obtain the information to fill out this chart, select the site, for year select 2005, from July to July. Convert all times to Universal Time, using a time zone converter. The following site offers this tool: http://www.timezoneconverter.com/index.shtml

Observatory	Sunset	Sunrise	Moonrise	Moonset	% moon illumination
Haleakala, HI					
Mauna Kea, HI					
Palomar, CA					
Cerro Tololo, Chile					
La Silla, Chile					
Paranal, Chile					

4. Use an ephemeris generator to find the right ascension and declination of Comet 9P/Tempel 1. The Solar System Dynamics Groups at the Jet Propulsion Laboratory has an online solar system data and ephemeris computation service that provides access to highly accurate ephemerides for solar system objects. An ephemeris table gives the position of celestial objects at different times and from different observing sites. Use the following procedure to find the right ascension and declination of Comet 9P/Tempel 1 at the time of impact.
   a. On a computer with Internet access, go to: http://ssd.jpl.nasa.gov/cgi-bin/eph
   b. Click on the button that says "Target Body."
   c. Under "Select Small-Body," enter "9P/Tempel 1," then click "Search." Choose "9P/Tempel 1 [2005.5]" from the drop-down menu, then click on "Use Selected Asteroid/Comet."
   d. Click on "Observer Location."

e. Under “Lookup Named Location,” type in the name of the observatory. Then click on “Search.”
f. Click on “Time Span.”
g. Enter the start date and time as: “2005 – 07 – 04 - 00:00” for July 4, 2005.
h. Enter the stop date and time as: “2005 – 07 – 04 – 23:50” for the end of the same day.
i. Click on “Use Specific Settings.”
j. Click on “Output Quantities and Format.”
k. Choose Number 1, “Astrometric RA and DEC,” and de-select all other check boxes.
l. Click on “Use Specific Settings.”
m. Click on “Generate Ephemeris.”
n. Fill in this table:

Comet 9P/Tempel 1 on July 5, 2005	Right Ascension	Declination
Observatory		
Haleakala, HI		
Mauna Kea, HI		
Palomar, CA		
Cerro Tololo, Chile		
La Silla, Chile		
Paranal, Chile		

The following is information provided to you from the Deep Impact mission planning team.

There are two scenarios for time of impact under consideration. The first is July 4, 2005 at 00:00 UT. In this scenario, the prime Earth-based observation locations include Lasilla, Cerro Tololo and Paranal in Chile. The second scenario is July 4, 2005 at 06:00 UT. In this scenario the prime Earth-based observation locations are Mauna Kea, and Haleakala in Hawaii, with Palomar as a backup.

a. From what site will the comet be above the horizon for the longest time?

b. How does the moon affect observing?

c. From the sunrise and sunset information in your chart, determine the dark times at different sites.

From this information, which two observatories would you recommend to your group for observing the impact from the ground? Include the reasons for your choices.