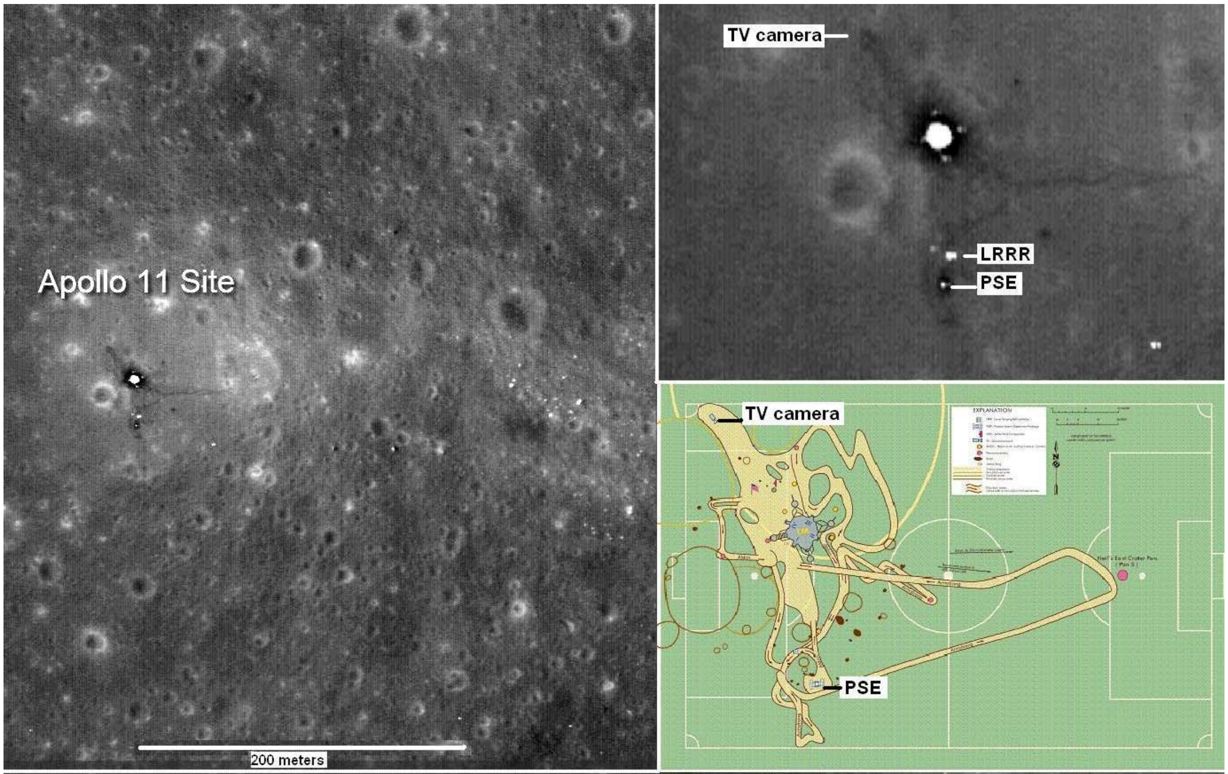

The Lunar Reconnaissance Orbiter (LRO) recently imaged the Apollo-11 landing area at high-resolution and obtained the image above (top left). An enlargement of the area is shown in the inset (top right) and a rough map of the area is also shown (bottom right). The landing pad with three of its four foot-pads is clearly seen, together with the Lunar Ranging Retro Reflector experiment (LRRR), the Passive Seismic Experiment (PSE) and the TV camera area. The additional white spots seen in the left image are boulders from the West Crater located just off the right edge of the image.

Problem 1 - Using a millimeter ruler and the '200 meter' metric bar, what is the scale of each of the two images and the map?

Problem 2 - About what is the distance between the TV camera and the PSE?

Problem 3 - From the left-hand image; A) What is the height and width of the field? B) What is the area of the field in square-kilometers?

Problem 4 - In the left-hand image, what is the diameter, in meters, of A) the largest crater, and B) the smallest crater?

Problem 5 - By counting craters in the left-hand image, what is the surface density of cratering in this region of the moon for craters between 10 meters and 50 meters in diameter, in units of craters per square kilometer?

Problem 6 - The number of tons of TNT required to excavate a crater with a diameter of D meters is approximately given by $E = 0.001 D^3$. How many tons of TNT were produced by the meteors that created the largest, and smallest craters identified in Problem 4?

Problem 1 - Using a millimeter ruler and the '200 meter' metric bar, what is the scale of each of the two images and the map?Answer: The main image has a '200 meter' bar that is about 42 millimeters long, so the scale is 200 meters/42mm = **4.8 meters/mm**. From this scale, the distance from the center of the launch module to the LRRR is 5 millimeters or 5 x 4.8 = 24 meters. The top left image is at a scale where the distance is 15 millimeters on the image, so the scale is 24 meters/15 mm = **1.6 meters/mm**. The corresponding distance on the map is 20 millimeters, so its scale is 24 meters/20 mm = **1.2 meters/mm**.

Problem 2 - About what is the distance between the TV camera and the PSE? Answer: In the top-right image, this distance is 15mm or 15 mm x (1.6 m/1mm) = **24 meters.**

Problem 3 - From the left-hand image; A) What is the height and width of the field? B) What is the area of the field in square-kilometers? Answer: A) Height x Width = 98mm x 84mm and at a scale of 4.8 meters/mm this becomes **470 meters x 403 meters**. B) The area is 0.47 km x 0.40 km = **0.19 km^2**

Problem 4 - In the left-hand image, what is the diameter, in meters, of A) the largest crater, and B) the smallest crater? Answer: The largest crater, the white area to the right of the Apollo-11 lander is 8mm in diameter, or 8 mm x (4.8 meters/mm) = **24 meters** in diameter. The smallest craters are about 1 mm across or **5 meters** in diameter.

Problem 5 - By counting craters in the left-hand image, what is the surface density of cratering in this region of the moon for craters between 10 meters and 50 meters in diameter, in units of craters per square kilometer? Answer: The range of crater diameters on the image corresponds to 2 mm to 10 mm. Students may variously count the number of circular markings in this range and obtain about 50 craters. The area of the image was calculated as 0.19 km^2, so the surface density will then be 450 craters/0.19 km^2 = **260 craters/km^2**.

Problem 6 - The number of tons of TNT required to excavate a crater with a diameter of D meters is approximately given by $E = 0.001 D^3$. How many tons of TNT were produced by the meteors that created the largest, and smallest craters identified in Problem 4? Answer: Largest crater diameter was D=24 meters, so $E = 0.001 \times (24)^3$ = **14 tons of TNT**. The smallest crater had D=5 meters so that $E = 0.001 \times (5)^3$ = **0.125 tons of TNT**. **Note to Teacher:** The actual size of the impacting meteorite is generally estimates to be about 1/10 the diameter of the crater it produces so for the smallest craters, the impactors were about 50 centimeters across (20-inches), while the largest was about 2.4 meters across (7-feet).