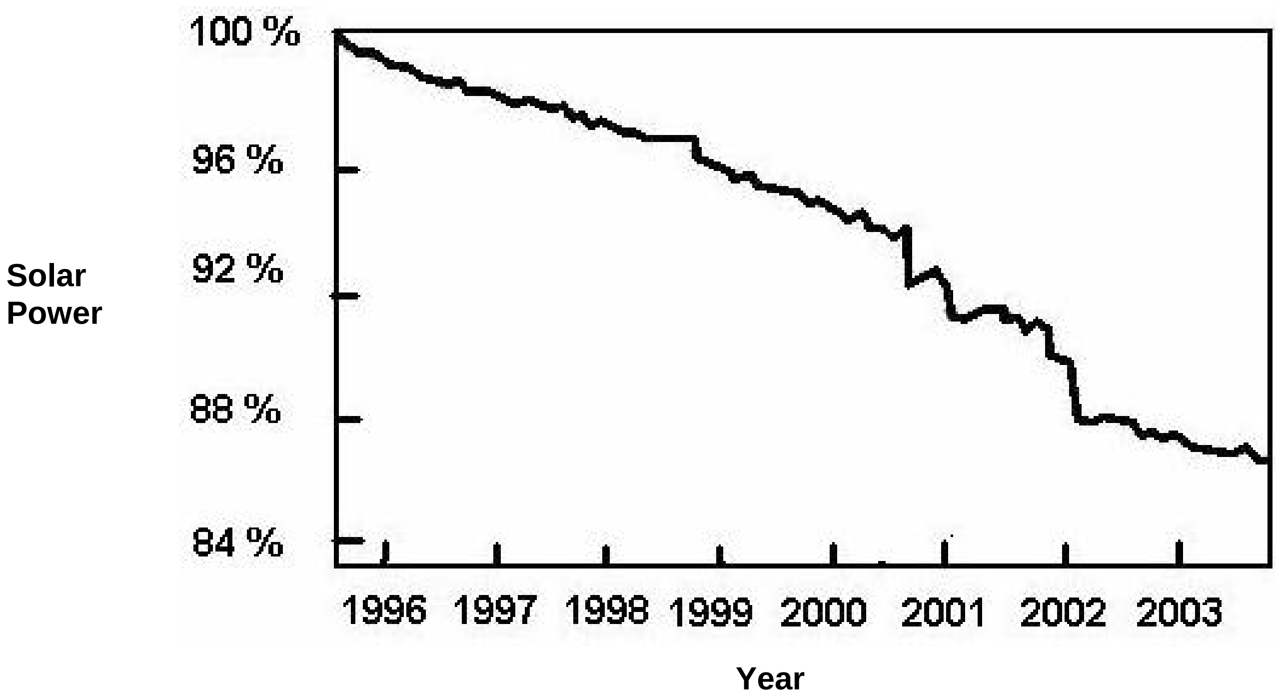
Name ______________________________

Soon after the first satellites were placed into orbit, engineers began to notice that the electrial power needed to operate the satellites was slowly declining. Very careful studies of the way that solar cells worked in space soon came up with a culprit: Cosmic rays! Cosmic rays are very high-speed ions, protons and electrons that travel through space. Some are produced by the sun during solar flares, while others come from space beyond the solar systems itself. Cosmic rays are deflected by strong magnetic fields. Fortunately, Earth has a very strong magnetic field that shields us from most of these cosmic rays, but enough get through that they collide with solar panels and solar cells on satellites orbiting Earth. Over time, these fast-moving particles cause changes in solar cells, making them less able to generate the electricity they are supposed to when sunlight falls on them. Thanks to decades of study, engineers can make very accurate models of these cosmic rays effects and incorporate them into the design of satellite power systems. Below is an actual graph prepared by Dr. Paul Brekke, the Project Scientist for the Solar Heliospheric Observatory. It shows how fast the satellite's solar arrays have changed their power output since 1995.

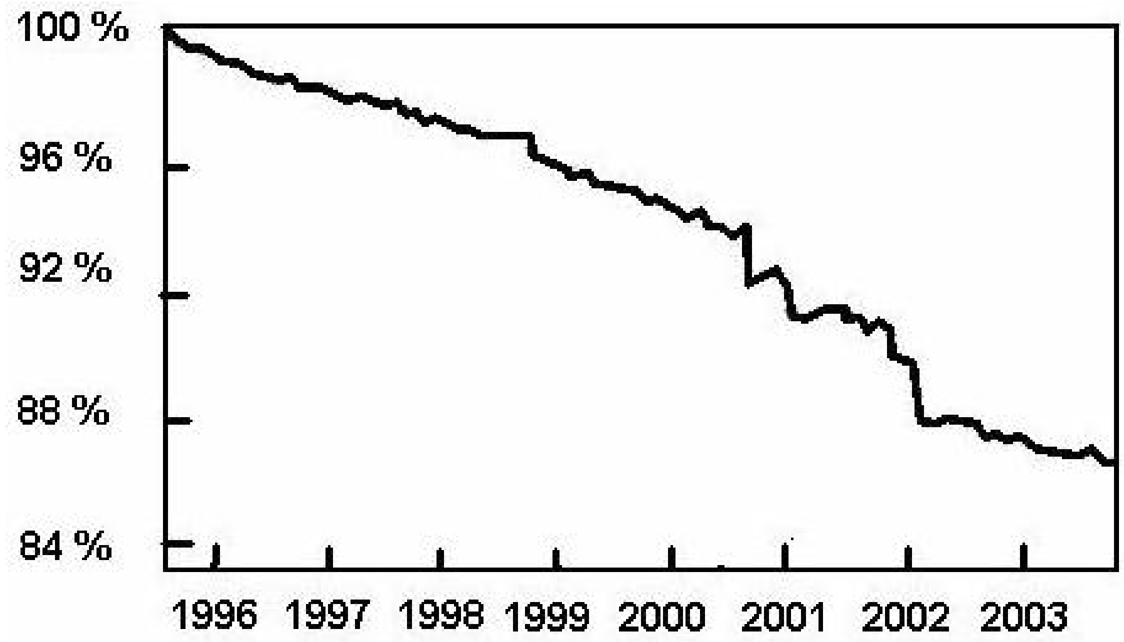


Question 1: By how much has the SOHO satellite power declined by 2002?

Question 2: Satellites often remain usable for 15 years. By what percentage will the electricity from the SOHO solar panels have declined by that time?

Question 3: The instruments on a satellite require 850 watts of power to operate. If a scientist wants her instrument to continue working for 15 years, how large should the satellite power supply be at the time of launch?

Question 4: The surface of a satellite has an area of 1000 square centimeters. The solar cells can generate about 0.03 watts per square centimeter. A) What is the total power available to the satellite by covering its surface with solar cells? B) If the satellite is to last 15 years, what is the maximum power that the instruments can draw and still work after 15 years?



Question 1: By how much has the SOHO satellite power declined by 2002?
Answer: From the plot, the power has declined to 88% of its original 100% at launch.

Question 2: Satellites often remain usable for 15 years. By what percentage will the electricity from the SOHO solar panels have declined by that time? **Answer:** From the previous answer, the decline was 12% in 6 years, so after 15 years the decline will be (15/6) x 12% = 30%.

Question 3: The instruments on a satellite require 850 watts of power to operate. If a scientist wants her instrument to continue working for 15 years, how large should the satellite power supply be at the time of launch? **Answer:** From the previous answer, if the experiments need 850 watts to operate after 15 years, the solar panels have to be designed to produce 30% more than 850 watts at the start of the mission or (1.30) x 850 watts = 1105 watts.

Question 4: The surface of a satellite has an area of 1000 square centimeters. The solar cells can generate about 0.03 watts per square centimeter. A) What is the total power available to the satellite by covering its surface with solar cells? B) If the satellite is to last 15 years, what is the maximum power that the instruments can draw and still work after 15 years?
Answer:
A) The total power will be 3000 square cm x 0.03 watts per square cm = 90 watts.
B) Because the solar panels will degrade by 30% during the 15 years, this means that after 15 years you will only have 90 watts x 0.70 = 63 watts to run your instruments!!
Scientists typically take advantage of the surplus of energy at the start of a mission to run the most energy-consuming instruments, then shut them down one at a time until the satellite finally stops being a useful scientific instrument.