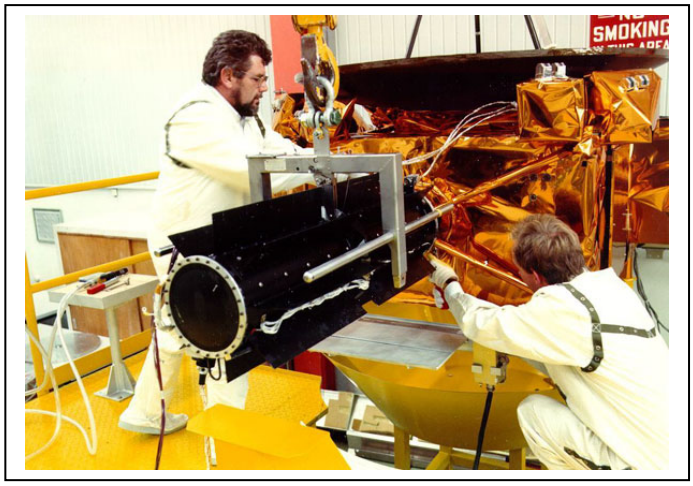
Designing a Power System for Juno



The Juno spacecraft is traveling to Jupiter and will go into orbit around 2017. The engineers that designed the spacecraft had to choose between using solar panels and RTGs to generate the electricity.

The advantage of the RTG (see photo) is that it delivers the same amount of power whether there is sunlight or not. The advantage of solar panels is that they are much more efficient in producing electricity per kilogram of mass.

The efficiency of a satellite power system can be measured by comparing the number of watts generated by the physical mass of the power system. For example, a system that generates 1000 watts and has a mass of 50 kilograms has a rating of 20 watts/kg. Another system that generates 200 watts with a mass of 5 kilograms has a rating of 40 watts/kg. The second system is more efficient.

Problem 1 – Juno engineers compared a solar panel system and RTG when deciding which was better to generate the 500 watts of electricity needed to travel to Jupiter. The mass of each system was an important factor. It costs $5,000 per kilogram to send things to Jupiter. The engineers used the two equations below to determine the watts per kilogram for the solar and RTG systems:

Solar: $P - 7M = 129$ RTG: $15M - P = 295$

For what power will the masses of the two systems be the same?

Problem 2 – The Cassini mission orbiting Saturn uses RTGs to generate the 300 watts of electricity it needs. From the equations in Problem 1, what is the mass of the RTG system used by Cassini?

Problem 3 - If Cassini had used a solar panel system, the equation for the power and mass would be $P - 2M = 129$. What would be the mass of a solar panel system for Cassini?

Answer Key

Problem 1 – Juno engineers compared a solar panel system and RTG when deciding which was better to generate the 500 watts of electricity needed to travel to Jupiter. The mass of each system was an important factor. It costs $5,000 per kilogram to send things to Jupiter. The engineers used the two equations below to determine the watts per kilogram for the solar and RTG systems:

Solar: $P - 7M = 129$ RTG: $15M - P = 295$

For what power will the masses of the two systems be the same?

$P - 7M = 129$
$-P + 15M = 295$ substitution: $P = 15M - 295$,
then $(15M-295) - 7M = 129$
so $8M = 424$ and
M = 53 kg and
P = 500 watts

Problem 2 – The Cassini mission orbiting Saturn uses RTGs to generate the 300 watts of electricity it needs. From the equations in Problem 1, what is the mass of the RTG system used by Cassini?

Answer: $15M - 300 = 295$ so **M = 39 kilograms**.

Problem 3 - If Cassini had used a solar panel system, the equation for the power and mass would be $P - 2M = 129$. What would be the mass of a solar panel system for Cassini?

Answer: $300 - 2M = 129$ so $M =$ **85 kilograms**.

The Solar panel system at Saturn would have to be over twice as massive as the RTG.