

Wind Driven Power Generation On Titan

Windmills – *In Space!*

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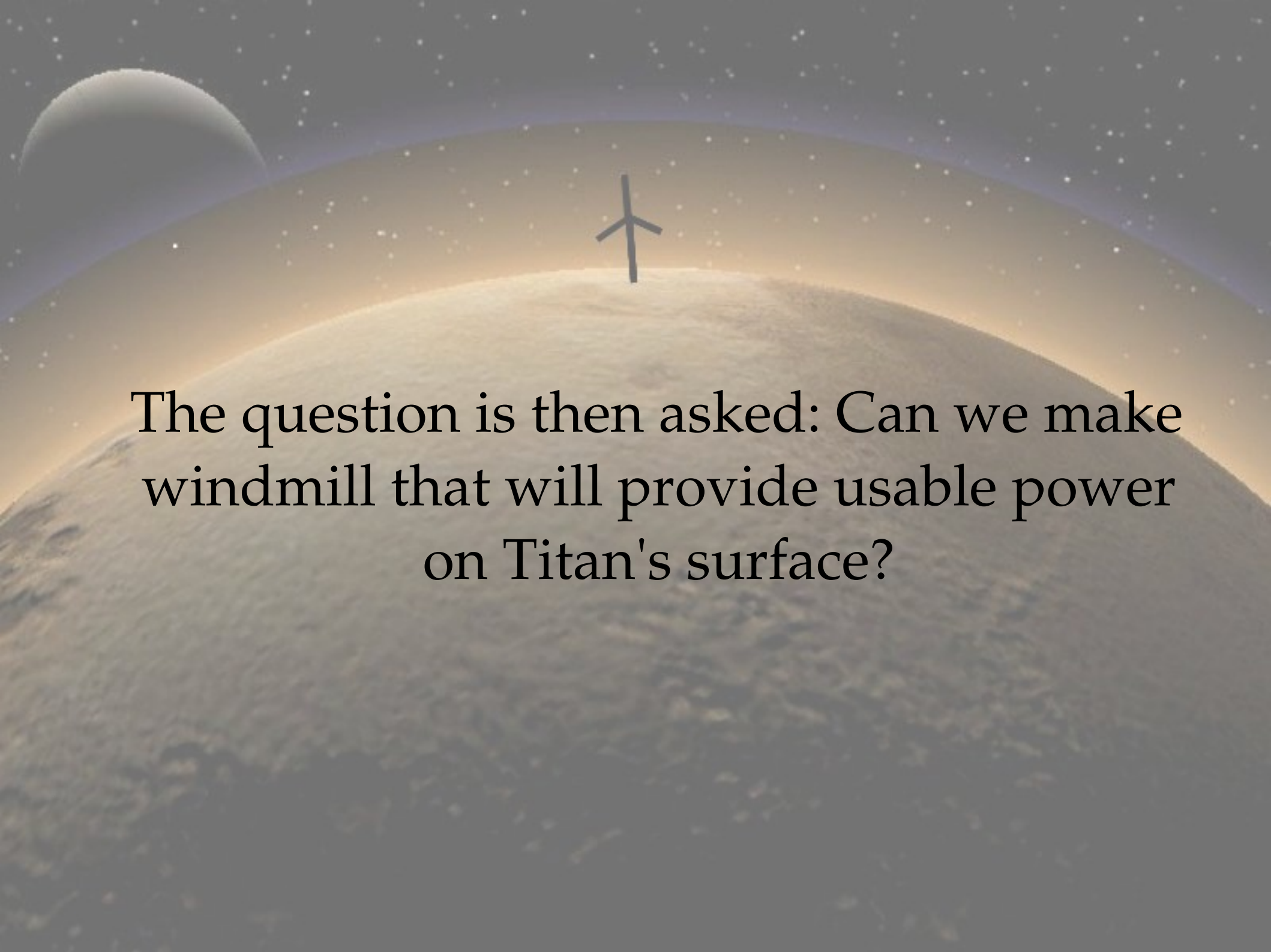
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Overview

- Introduction to Concept
- Background Information
- Overview of Calculations
- Advantages
- Disadvantages
- The Big Picture©
- Loose Ends
- Questions

Introduction to Concept

- Started by noticing several key points:
 - Power generation is always a concern in space exploration
 - Titan is a scientifically fascinating location, and will no doubt be a focus of extended research
 - Titan's atmosphere is very dense
 - Wind Turbines work extremely well in a dense atmosphere

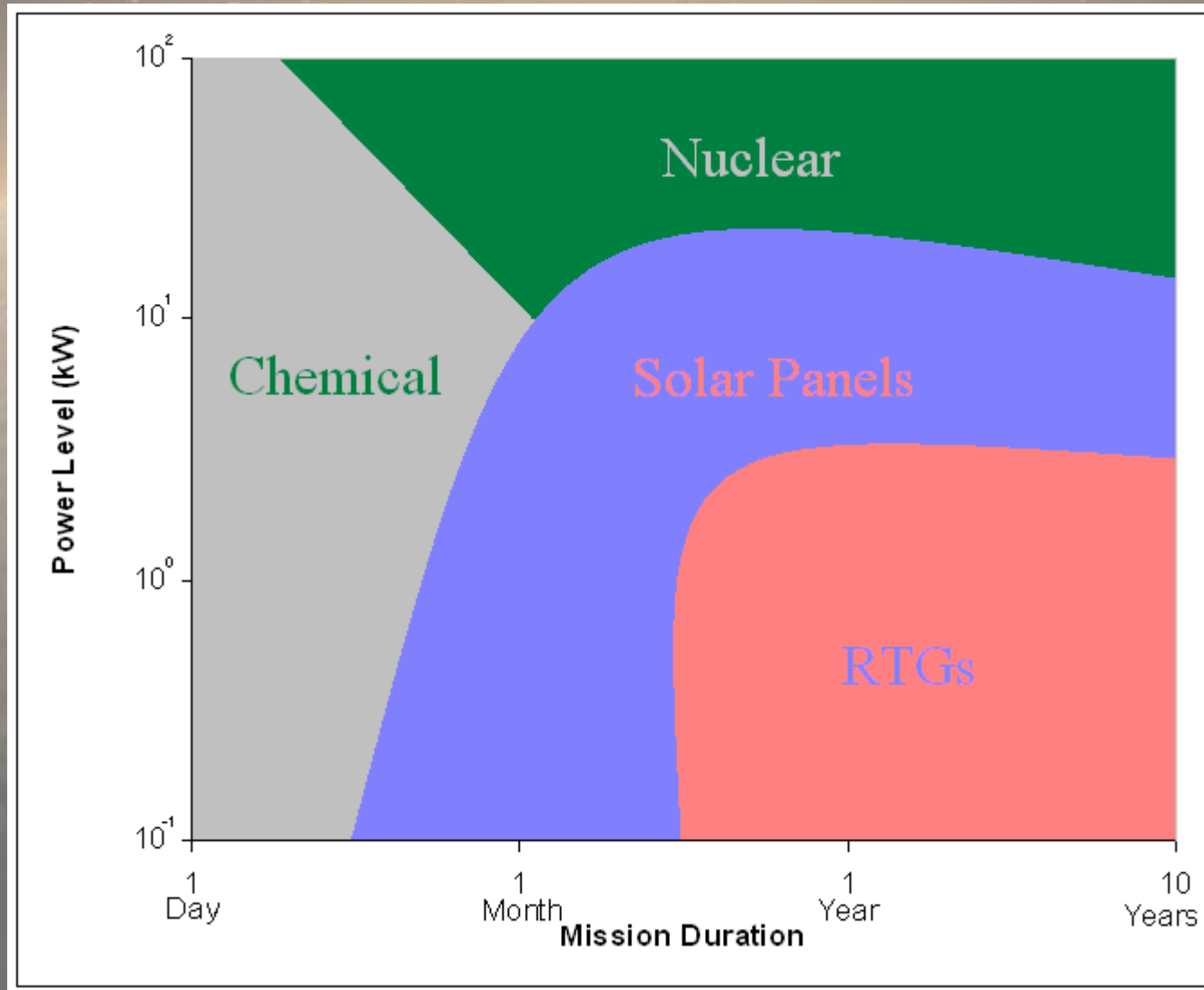
The image is a stylized illustration of Titan's surface. In the foreground, a large, rounded, light-colored mound represents the ground, with a simple silhouette of a three-bladed windmill standing on its peak. The background shows a dark, starry sky with a large, pale, crescent moon in the upper left corner. The overall scene is dimly lit, suggesting a twilight or dawn atmosphere.

The question is then asked: Can we make
windmill that will provide usable power
on Titan's surface?

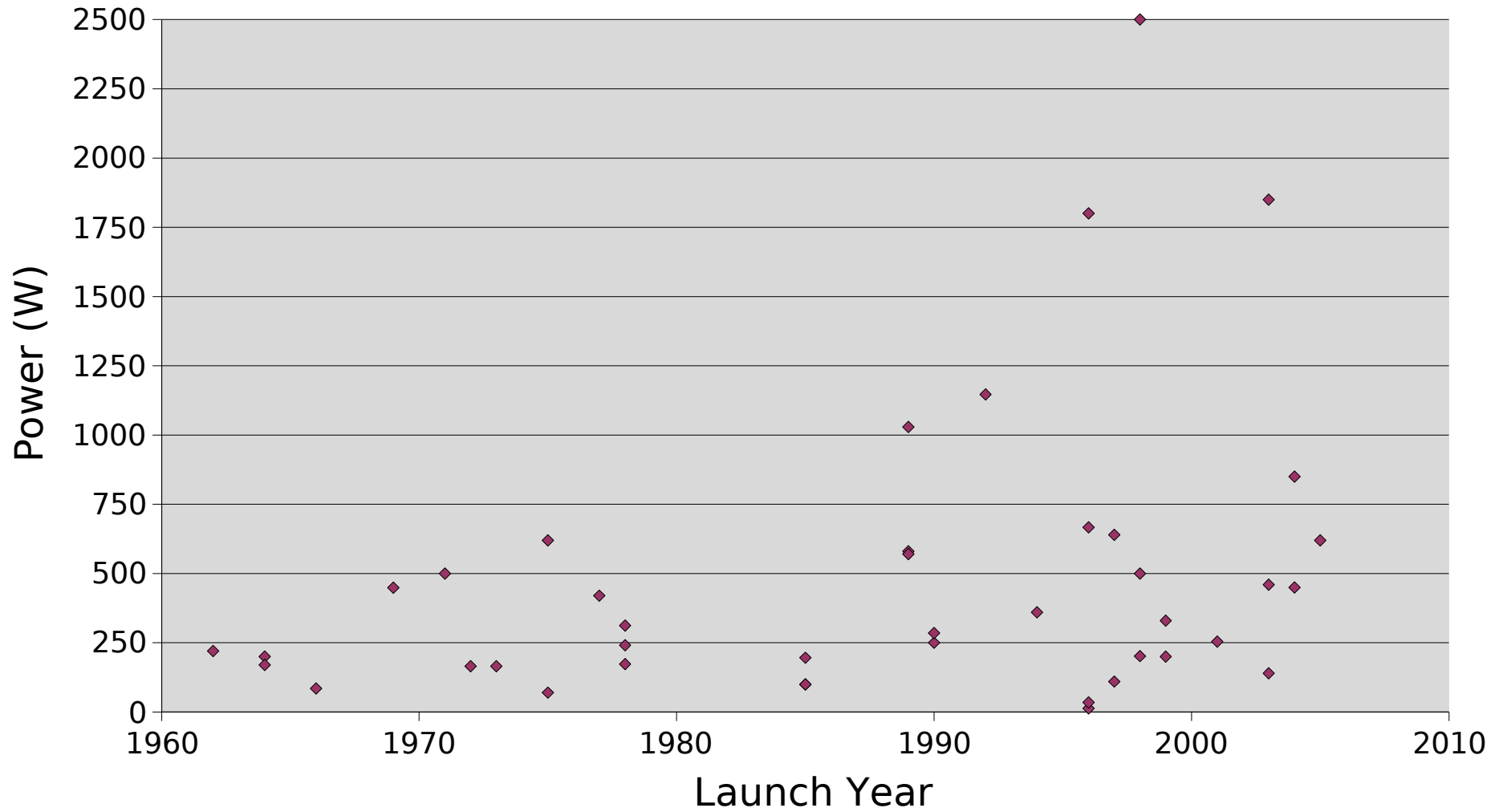
Background Information

- Titan's atmospheric density – 5.44kg/m^3
 - Over 4.5 times that of Earth
- Power output scales proportionately to density
- Titan's thick, hazy atmosphere and distance from the sun rules out solar power

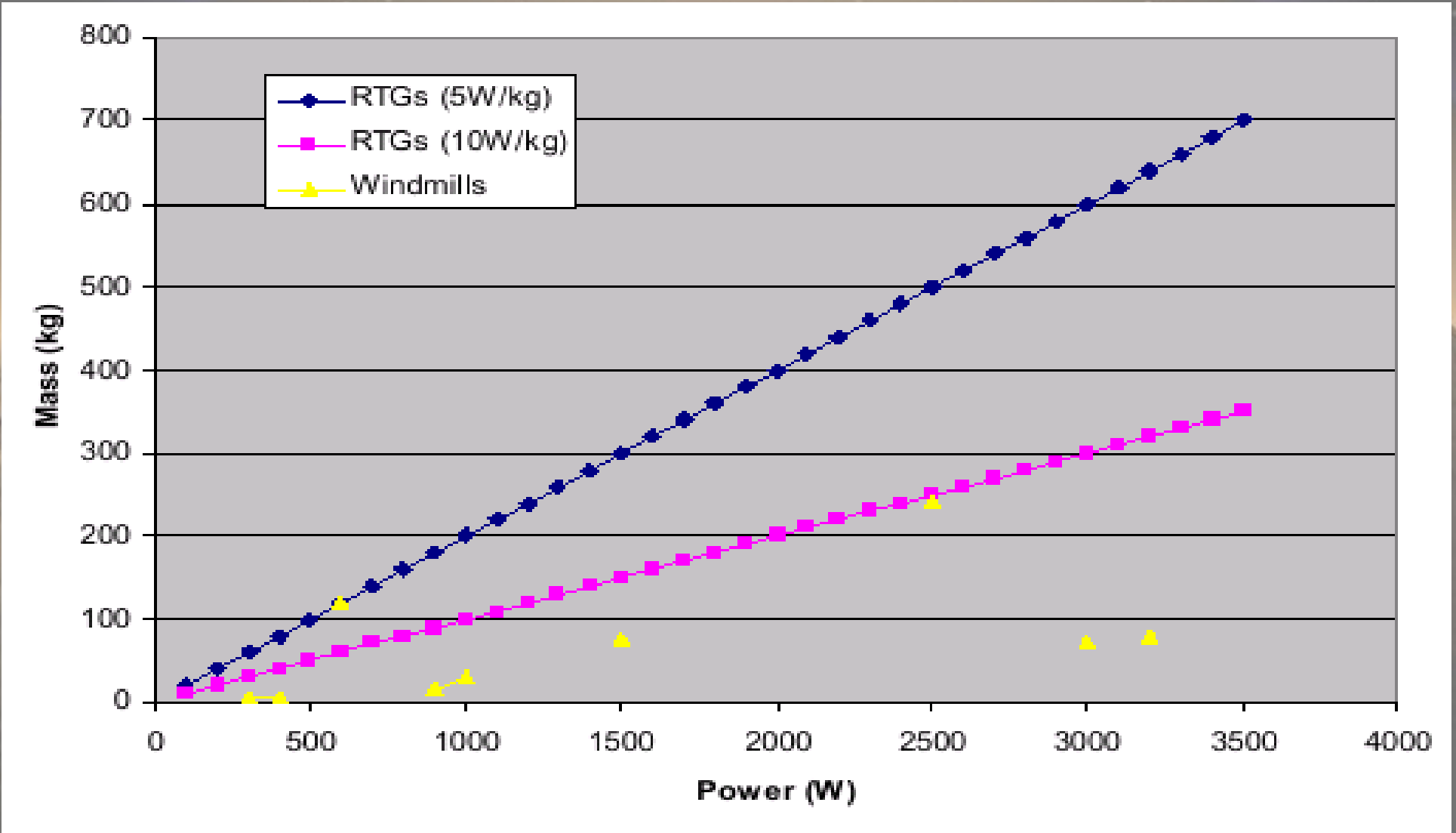
Design Space for RTGs, Solar Panels, & Nuclear Generation



Power Usage vs. Launch Year for US and European Space Probes



Specific Power for RTG's vs. Windmills



Overview of Calculations

- The most important equation of all:

$$P = \pi * r^2 * e * \left(\frac{1}{2}\right) * d * v^3$$

- Key relationships:
 - Power is directly proportional to efficiency and density
 - Power is directly proportional to square of windmill radius
 - Power is directly proportional to cube of wind speed

Overview of Calculations

- Efficiency is taken as 50%
- Density already seen to be 5.44 kg per cubic meter
- Only unknowns are windmill radius and wind speed

Advantages

- Power output
- Cost
 - \$125,000 per Watt for RTG's would cost almost 190 Million for 1.5kW
- Weight
 - RTG capable of 1.5kW would be 150-300kg
- Building on well-established technology

Disadvantages

- Technology is well established-but not in space
- Power output is (possibly) not constant

The Big Picture©

- Advances in space lead to advances on Earth
- Titan is a narrow application, but an important one

Loose Ends

- Actual atmospheric density is not yet released
- Surface wind speeds are unknown
- Turbines need to be designed for the environment



Questions?