

# **Applications of Microwave Vacuum Tube Amplifiers in Earth and Space Science**

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Vacuum tubes have a long history in NASA's earth and space science programs, as well as those of the cognizant space agencies of various other governments. Within the NASA programs, helix and coupled-cavity Traveling Wave Tubes (TWTs) have formed the bulwark of microwave amplifiers and Extended Interaction Klystrons (EIKs) are beginning to see applications.

Over the course of several decades, NASA's earth and space science microwave tubes have transmitted telecommunications signals, radio science beacons and radar signals for many NASA missions. These tubes have operated at frequencies from 1 GHz to 94 GHz, and at power levels from a few Watts to a few Kilowatts. The NASA programs involved have encompassed earth science, planetary science and deep space missions.

Despite repeated past predictions to the contrary, microwave tubes will enjoy a healthy life in future earth and space science missions, as those missions evolve to operate at higher frequencies and higher effective radiated power in order to achieve greater data return. Evolution and extended capabilities of Solid State Power Amplifiers (SSPAs) have driven the evolution - not the extinction - of microwave tube amplifiers.

This talk will present a brief overview of the history of microwave tubes in NASA's earth and space science missions, a snap shot of where the application of these tubes finds itself today and a brief glimpse into the future direction of microwave amplifier requirements.

Challenges and risks unique to earth and space science applications will be discussed, as well as strategies to meet those challenges and mitigate those risks. The talk will describe the system trade space in which amplifier requirements are derived and how constraints on other system elements can affect amplifier requirements.