Ka-Band Upgrade of TIRA: The Future of Radar Space Observation in Europe

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ABSTRACT

The Tracking and Imaging Radar (TIRA) of Fraunhofer FHR is one of the most capable ground-based sensors for space domain awareness in Europe. To meet the challenges posed by the trend toward ever-smaller satellites, by dense mega-constellations and increasing space debris, TIRA is undergoing major upgrades. One of it is a new Ka band imaging radar with integrated tracking capabilities [1]. Moving from the current Ku band imaging radar to the new system operating at Ka band, enables a substantially larger resolution in the range and cross-range direction by increasing the bandwidth and center frequency, respectively.

The new Ka-band system will be powered by two coupled-cavity TWTs from Microwave Power Products (MPP) integrated in a quasi-optical power-combining front end. The front end uses free-space Gaussian beam propagation, polarization-selective wire-grids, and Faraday-rotator-based duplexers to provide low-loss transmission, high isolation between transmit and receive paths, and full polarization ability.

Given the critical role of the Ka-band TWTs and the RF front end in overall system performance, FHR is building a dedicated Ka-band test stand. This facility allows safe and flexible experimentation with the RF, high-voltage, cooling, control, and protection system of the future TIRA installation in a laboratory setting. It will support detailed characterization of single TWTs and the combined chain in terms of output power, efficiency, gain and phase flatness over bandwidth, pulse shape, stability, and long-term drift. The test stand will also be used to validate the quasi-optical components under high-power operation, verify polarization switching and modulation schemes, and qualify interlock and monitoring concepts for reliable unattended operation.

The presentation will describe the Ka-band transmitter architecture, the quasi-optical power-combining and duplexing concept, and the design and role of the new test stand, highlighting how advanced vacuum-tube technology underpins the next generation of radar space observation in Europe.

References

[1] KLARE, Jens, et al. The future of radar space observation in Europe—Major upgrade of the tracking and imaging radar (TIRA). *Remote Sensing*, 2024, 16. Jg., Nr. 22, S. 4197.