Combined Optimization of Aircraft Maneuvers and RF Measurements for Passive Air-Air Ranging

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When a tactical aircraft sets out on a mission in dense airborne and surface RF (radio frequency) emitter environment, the pilot desires to minimize the use of the onboard fire control radar to remain "silent". Consequently, the pilot heavily relies on the onboard passive sensors and offboard reports received from wingmen and other sources. The onboard sensors may include a RWR (radar warning receiver) and an IRST (infrared search and track) sensor. The RWR detects RF (radio frequency) emissions from airborne target fire control radars and land/sea radars that are a part of complex weapon systems – such as SAM (surface-to-air missiles) and AAA (anti-aircraft- artillery) guns. The IRST detects hot emissions from airborne targets – such as target aircraft exhaust and thermal airframe heating. The critical need for the pilot is to have timely "situation awareness" of the targets (friendly or unfriendly) within a certain airspace (upper and lower hemispherical coverage) around the aircraft. Key target parameters to aid situation awareness include ID (identification) features, slant range, intent, mode (if the target has RF transmitters), and an assessment of the target's near-term and far-term lethality (its weapon's envelope). Timely, accurate range estimates provide information to the onboard flight path management system to compute route plans to avoid targets and vital information to the fire control computer when onboard standoff weapons are to be deployed. To estimate range passively for air-to-air target engagements is one of the most challenging research areas for the military tactical fighter aircraft industry today, and is the focus of this paper. Research has shown that 10 percent range estimates in 10 seconds are achievable under certain RF measurement and scenario (initial conditions and sensing aircraft maneuvers) conditions. The presentation reviews the mathematical models used, the Cramer-Rao lower bound formulation and range estimate errors for a typical air-air scenario. We conclude with a review of the complex relationship between the sensing aircraft maneuvers, required RF measurements, and initial uncertainties in emitter aircraft range, speed and heading angle; and the high-level requirements for fielding a real-time passive ranging system.