Mythbusting: Exploring Common Misconceptions about the Ambiguity Function

Dylan Eustice[(1)], Charles Baylis[(1)], Larry Cohen [(2)], and Robert Marks II[(1)]
(1) Wireless and Micowave Circuits and Systems Program, Baylor University, Waco, TX, USA
(2) Naval Research Laboratory, Washington, DC, USA

The ambiguity function is a commonly used multidimensional function that describes the range and Doppler resolution capability of a radar waveform. Despite a pervasive presence within the radar community, the literature describing the fundamentals of the ambiguity function is often inconsistent. This presentation presents and clarifies five myths which have arisen from explicit and implicit treatment of the ambiguity function in the literature. Understanding these issues augments working knowledge of the ambiguity function and its applications.

Myth 1: *The ambiguity function is uniquely defined*. There are several different definitions, notably, two variations used by Woodward, who first proposed the ambiguity function. One definition of the ambiguity function is

$$\chi(\tau,u)=\int_{-\infty}^{\infty}x(t)x^{*}(t-\tau)e^{-j2\pi ut}\,dt$$

Additionally, some works alternately define the $|\chi|$ as the ambiguity function, while others use a normalized $|\chi|$ definition.

Myth 2: *The magnitudes of the various definitions of the ambiguity function are the same*. The magnitudes of the various definitions are not equal, but are related by transpositions along the τ and u axes. Imposing ambiguity function magnitude equality in some cases can impose an undesired realness constraint on the signal used.

Myth 3: *The maximum magnitude of the ambiguity function determines the optimal Doppler and range*. For complex signals, the optimum Doppler and range is determined by the real part of the ambiguity function, not the magnitude. For RF signals, the two values are nearly identical.

Myth 4: *The ambiguity function of a baseband signal is the same as the ambiguity function of the modulated RF signal*. The ambiguity function of the RF signal has additional harmonic frequency components which are shifted along the u axis by twice the RF frequency, which is high enough to allow these components to be ignored. The remaining baseband portion of the ambiguity function will have a similar envelope to that of the baseband ambiguity function, but will be modulated by the RF frequency sinusoid used.

Myth 5: *The ambiguity function is not invertible*. The ambiguity function may be inverted to within a scaling constant, i.e., given the ambiguity function, we can compute to within a proportionality constant the underlying temporal signal that produced it.