



## MKV<sup>e</sup> OVERVIEW

ECS presents the gold standard in instrumentation radar systems. The MkV<sup>e</sup> radar is a multifrequency, ultra-wideband, coherent, step-chirp measurement system that uses Doppler processing to provide synthetic aperture radar (SAR) and inverse SAR (ISAR) images. The MkV<sup>e</sup> is a sophisticated measurement instrument used to support production and operational testing in either ground-based or airborne configurations.

**Ultra-Wideband  
Instrumentation Radar Systems**

**Full Search and Track Capability**

**Mobile and Airborne Configurations**

**RCS Quality Control and Diagnostics**

**Real-Time SAR and ISAR Imaging**

**EW Simulations**

**Stealth Platform Evaluation**



## MkV<sup>e</sup> Enhancements

The MkV<sup>e</sup> enhancement centers around the MkV DSP and vastly improves many aspects of an already very successful MkV product line. In short, the MkV<sup>e</sup> enhancement improves:

- Processing speed
- Memory size
- Data throughput
- Software/firmware flexibility

The capability enhancements that result from these improvements are far-reaching and are described in further detail herein.

## MkV<sup>e</sup> Key Benefits

- 100:1 processing speed improvement resulting in faster real-time data processing and image display
- 10:1 I/O speed enhancement in support of accelerated data transfers to auxiliary equipment
- 10 dB more background subtraction through enhanced, real-time compensation
- The ability to modulate an RF carrier within a pulse
- Real-time capture and 16-bit digitization of analog data at rates up to 100 MB/sec
- 16 bit digital resolution -- full utilization of available RF/IF dynamic range with overhead to support future enhancements
- Expanded DSP memory supporting improved ability to deal with ambiguous clutter at higher PRFs
- Enhanced longevity and reliability by replacing several legacy boards/components with a modern COTS DSP board running ECS firmware

## Upgrading to MkV<sup>e</sup>

The high speed MkV<sup>e</sup> digital processing enhancement is available with all new MkV radars or as an affordable upgrade to existing MkV systems. All enhancements described herein are available whether the MkV<sup>e</sup> components are purchased with a new radar or via an upgrade. Upgrade cost varies slightly from system to system. Please contact ECS for a firm quotation.

## What Does the "e" in MkV<sup>e</sup> Stand for?

If only one thing, the "e" in MkV<sup>e</sup> stands for enhanced. But it represents so much more: evolution, exponential growth in capability and a truly excellent choice for RCS and other instrumentation radar needs.

## Industry-Leading 3-Year Warranty

Reliability experience with the MkV radar product line led ECS to increase the standard system warranty from one year to an industry-leading optional three-year period for the MkV<sup>e</sup>.

## Dual-Channel Receive Now Standard

Dual channel receive now comes standard with all new MkV<sup>e</sup> radar systems; discounts are available for single channel systems.

## MkV<sup>e</sup> Flexibility

The MkV<sup>e</sup> architecture is based on the legacy MkV architecture. This legacy architecture was created with the potential for satisfying nearly every conceivable instrumentation radar application within the limits of available component hardware. This inherent flexibility combined with additional digital capabilities now enables the MkV<sup>e</sup> to meet an exceedingly wide range of application needs. Such needs cover:

- Traditional instrumentation radar applications
- Airborne Generic Threat Simulation (GTS)
- High-speed analog to digital data recording
- ECM, ECCM, and a host of other applications involving arbitrary waveform generation

About 90 percent of the time a MkV customer's needs can be satisfied with a fairly modest waveform capability. However, it is rare when two customers require the same limited set. Because of this, ECS chose to incorporate a digital design that allows for unlimited flexibility within a table memory of one million elements. This allows pulse to pulse variation of:

- Frequency
- Pulse width
- Phase
- RF port selection
- PRI
- Attenuation
- Range delay

Pulse-to-pulse RF port selection flexibility enables:

- Instantaneous polarization diversity
- Real-time system monitoring via built-in diagnostic loop modes

## MkV<sup>e</sup> Reliability

Perhaps the MkV's greatest claim to fame is its reliability and maintainability. Without question, the MkV line provides industry-leading availability in a production environment. But this achievement requires more than just a highly reliable radar; it requires a well orchestrated, cradle-to-grave approach from the company behind the radar. ECS founded the instrumentation radar market over 35 years ago, and we have more experience maintaining production line instrumentation radars than anybody in the industry. This experience makes a real difference in achieving greater than 90% radar availability as demanded by our customers who operate in a production environment.

## MkV<sup>e</sup> Longevity

ECS ensures that upgrades are backward compatible with existing systems. This is our philosophy because we recognize the importance of system longevity. Our customers have been known to insist on 10+ years of service life, and there's no reason they shouldn't!

In support of longevity, the MkV<sup>e</sup> Digital Processor Unit incorporates the latest in integrated FPGA and Intel processing hardware, making use of an architecture widely adopted in commercial and military digital data processing systems. Because of the widespread use of this digital backbone we anticipate availability and vendor support well into the next decade.

ECS selects product improvement paths with a great deal of thought. Selected paths lead to incremental but significant increases in overall performance while maintaining backward compatibility. As such, the MkV<sup>e</sup> will not be subject to planned or unplanned obsolescence. MkV<sup>e</sup> customers will always have the ability to maintain or enhance their systems with upgrades at a reasonable cost well into the future. It will not be necessary to budget for a complete replacement system a few years hence.



## A/D Resolution vs. True Instantaneous Dynamic Range

The instantaneous dynamic range of modern instrumentation radars is limited by the RF/IF chain and not by the A/D converter. Neither the MkV<sup>e</sup> nor any known competitor's instrumentation radar represents an exception to this rule. The legacy MkV incorporates 14 bit A/D converters, and the new MkV<sup>e</sup> includes 16-bit A/D converters. The 16-bit MkV<sup>e</sup> A/D converters extend the upper limit of supported instantaneous dynamic range from 72 dB to 84 dB, where one bit has been reserved for sign and one for noise modulation. The RF/IF chain in both the MkV and MkV<sup>e</sup> support >70 dB instantaneous dynamic range. The additional dynamic range supported by the A/D converters is desirable for the following reasons:

- Future RF/IF improvements can be readily incorporated into an existing architecture
- The dynamic range may be augmented with coherent integration to typical levels of 100 dB or more.

## High-Speed Frequency Switching

Achieving reliable, high-speed frequency switching has been a long-standing concern within the instrumentation radar community. In the past, only a single synthesizer vendor could support switching at 1 MHz and above. These units are known for reliability issues. Recently a number of vendors developed matching or superior synthesizers operating at speeds up to 5 MHz. The MkV<sup>e</sup> takes advantage of this enhancement.

## Dynamic Target Tracking

Dynamic tracking of targets is an important issue in some applications. The MkV<sup>e</sup> has implemented the inherent MkV capability to provide for up to three channels of signals and/or monopulse tracking. Included in this capability is the ability to track targets in range and angle while simultaneously performing RCS measurements. This version of tracking is flexible in that the target can be tracked in both dimensions using a variety of techniques. Targets can be tracked manually in both range and angle. Automatic tracking techniques include split-gate range and centroid optical tracking, and/or auxiliary GPS target position reporting to track both range and angle.

## 10 dB Improvement in Background Subtraction

The MkV<sup>e</sup> increases the background subtraction capability from a very good 30 dB to an outstanding 40+ dB. Temperature, phase stability, and system calibration are important to precise radar measurements. The MkV<sup>e</sup> adds the ability to actively compensate for changes in the environment during calibration and data collection. The improved background subtraction is a direct result of this active compensation.

## Enhanced Application Flexibility

ECS's MkV<sup>e</sup> enhancement enables applications that go beyond those traditionally associated with instrumentation radars, including:

### ECM/ECCM Monitoring

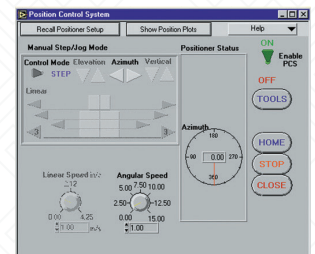
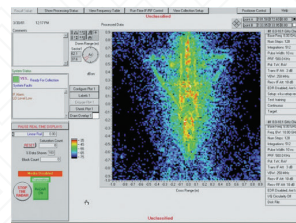
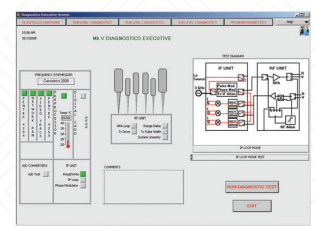
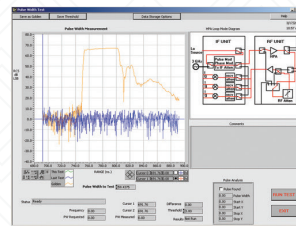
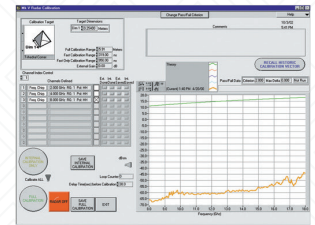
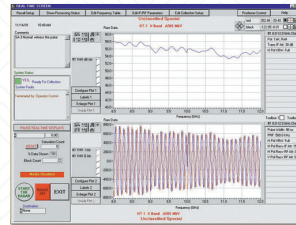
The MkV<sup>e</sup> supports *High-speed Analog to Digital Data Recording* -- the ability to capture and digitize extended lengths of streaming analog data at rates > 200 MB/sec. This capability is available over the full RF bandwidth of the radar. This enables the MkV<sup>e</sup> to record the active, real-time response of a target under test to stimulation by a radar. Likewise, any electromagnetic ECM or ECCM response issued by an asset may also be recorded for analysis or diagnostic purposes. These represent just a few of the possible uses for the MkV<sup>e</sup>'s High-speed Analog to Digital Data Recording capability.

## Arbitrary Waveform Generation

The MkV<sup>e</sup> is capable of generating very exotic waveforms, including modulation within the radar pulse itself. Examples of this are single pulse frequency chirps, phase coded sequences and AM/FM/PM modulation, to name a few. This arbitrary waveform capability combined with the legacy MkV waveform table truly leads to an unlimited number of waveform possibilities.

## MkV History

The MkV represents the fifth generation of a line of instrumentation radars that began with the MkI in 1979. The MkV<sup>e</sup> is the latest **enhanced** version within that successful radar product line. Since 1979 ECS has delivered over 75 instrumentation radar systems covering a wide range of complexities. The first MkV was produced in 1996, and the year 2016 marked the production of the 40<sup>th</sup> MkV. The most recent MkV radars include the powerful MkV<sup>e</sup> enhancement.



FEATURE	SPECIFICATION
Control computer	Intel CPU or equivalent
Operating system	Windows
Frequency coverage	0.1-18 GHz continuous or selected bands
Frequency expansion	18 - 100 GHz
Frequency switching time	200 ns min
Frequency waveform table	1 million entries
Frequency step-chirp	Pulse-to-pulse sequential or pseudorandom
Phase code	Mono, bi, poly-phase, PN and other low sidelobe sequences
Waveform flexibility	Variable PRF, phase, frequency, pulse width, etc
Antenna polarization ports	Linear, circular
Polarization	Full matrix pulse-to-pulse (with dual channel)
Transmit pulse width	3.0 ns to 1.3 ms in 0.156-ns steps
Instantaneous RF bandwidth	500 MHz
Selectable video bandwidth	up to 250 MHz
PRF/sample rates	up to 5 MHz
Range delay	0 to 1.3 ms in 0.156-ns steps
Range sampling jitter	3.5 ps
A/D quantization	14 or 16 bits
Signal integration	1 to 1 million, integer variable
Dynamic range	> 70 dB instantaneous (@ 100 MHz bandwidth) plus integration
I/Q circularity	0.02dB RMS corrected
System stability	+/- 0.1 dB and +/-1 deg
System drift	Monitored and corrected (offline or real-time)
System linearity	+/- 0.2 dB (-12 to -82 dBsat); 1.0 dB overall
Online diagnostics	Stability; statistics; loop tests
Built-in test	RF and digital board level

FEATURE	SPECIFICATION
Calibration	Automatic external reference and internal loop
Bias subtraction	Bi and polyphase processing
Background subtraction	-40 dB or better
Data collection rate	up to 100 MB/sec
Range gates	1, 2, 4, 8 or continuous; range gates may be moved dynamically
Range Gate Placement	Move RGs dynamically according to target sector
Real-time processing	SAR, ISAR, RCS, 1D transforms
Dynamic tracking	Monopulse, range, Doppler, angle
Pulsing modes	Single, double, triplets, burst
Waveform interleaving	Single frequency, step-chirp, range walk; all can be stored
Tx/Rc modes	Monostatic, co-located bistatic, separated bistatic
Phase codes	Up to 65536 arbitrary code sequence; separate TX and RX, sequential, PRN, custom
Transmitter leveling	64 levels, 1-dB resolution, programmable for each frequency entry
Raw data access port (non-integrated)	Digitized separately at max rates determined by available ADCs and storage throughput
Remote control	Limited or full control via network and WiFi connections; PDA control and monitoring
System monitoring and logging	Subsystems monitored for thermal, voltage and other variations
Positioner control	Control and record any set of positioners for antennas and targets
Motion measurement monitoring	Via inertial and GPS mechanisms
Auxiliary range sampling and recording	> 200 MHz sample rates
Packaging	For fixed or mobile operations
Noise figure (at receiver input)	2.5 dB (typical)
Receive channels	1, 2, 3 (two standard)
Broadcast memory	Data sent to multiple processing points