GX-351™ Radar Interface Unit Technical Description

1 PRODUCT DESCRIPTION

1.1 PRODUCT OVERVIEW

The GX-351™ accepts a variety of navigation radar inputs and provides a scan-converted digital radar image and tracks to a network connection. As shown in Figure 1, the GX-351™'s compact 1U size and rugged design make it ideal for a variety of harsh environments.

Figure 1, UrsaNav GX-351™

1.2 FUNCTIONAL DESCRIPTION/BLOCK DIAGRAM

The GX-351™ accepts radar images in several formats including analog, digital, or via a network connection. Analog radar signals pass through a high speed analog-to-digital converter on the radar interface card where they are converted to a digital format. The digital signal is then passed over the PCI bus to the radar processing and scan conversion software modules for clutter processing and conversion to an X-Y format for display. The radar signal is then passed to the network adaptor to be sent over an Ethernet connection. A general block diagram is shown in Figure 2.

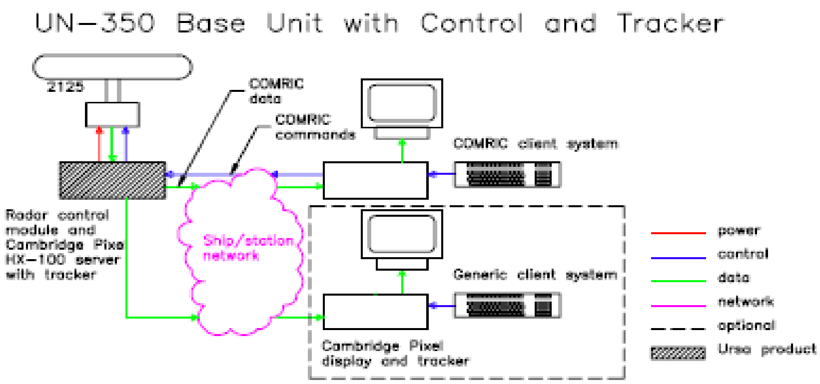

Figure 2, GX-351™ Block Diagram

The GX-351™ provides a range of processing options to reduce clutter and provide the best radar image possible. Radar images can be displayed in multiple windows simultaneously. They can also be displayed in different formats including Plan Position Indicator (PPI), A-scan, or B-scan. Additional features include tracking, radar recording, and playback. A typical multiple window, multiple format screen shot from a user application is shown in Figure 3.

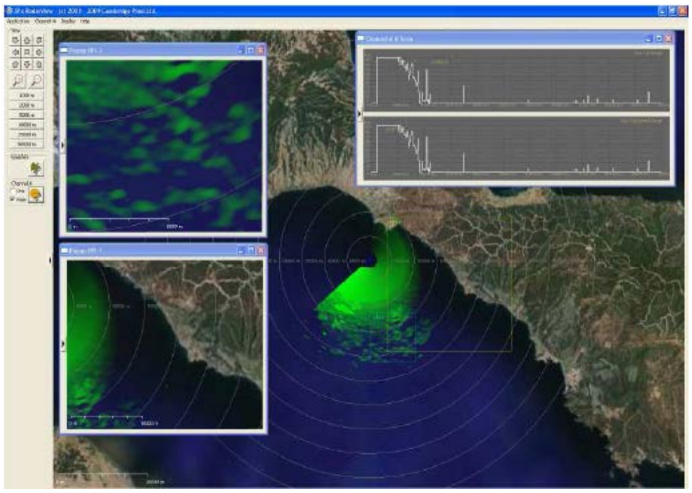

Figure 3, Sample Screen Shot

1.3 RADAR PROCESSING

The GX-351™ accepts a variety of radar inputs including azimuth change pulse (ACP), azimuth reset pulse (ARP), and parallel azimuth. It also accepts radar video from a network source or test/scenario generator. Analog radar video is digitized at sample rates up to 50 MHz with a 10-bit resolution. The digitized radar video is processed for display by the radar processing and scan-conversion software modules. The GX-351™ takes advantage of the processing power available from today's multi-core processors. All radar processing is done entirely in software. No additional special-purpose hardware is required.

1.3.1 Scan Conversion

Radar scan conversion is the process of converting polar coordinates from the radar processor into Cartesian (x,y) coordinates that can be displayed on a monitor. Traditionally, hardware-based radar scan conversion has been the only solution for a high quality radar video display. However, the development of higher performance graphics cards, combined with widely available low-cost multi-core processors, has enabled affordable software-based solutions.

The GX-351™ is a software-based scan conversion solution that offers flexibility, performance, and the ability to meet current and evolving requirements—all at a lower cost with higher reliability and ease of maintenance. This solution bypasses hardware integration problems and the high initial costs associated with hardware-based scan converters. By eliminating the hardware scan converters, maintenance costs and the overall cost of ownership are greatly reduced.

The scan-conversion software module converts polar-format radar video into a number of possible display formats including PPI (Plan Position Indicator), A-Scan, and B-Scan. It operates on incoming radar video to create real-time updating images. These images are then passed to the COMRIC interface for transmission to the customer's application.

A unique feature of the scan conversion module is its ability to display multiple channels of radar video simultaneously on the same screen. These radar channels may be selected in any display combination, such as multiple radars at different locations or different videos from the same radar. These videos may represent the actual radar image or changes in the radar image. For example, a moving target in the input video may be identified by comparing current data with a time-averaged history. The data identified as changed is displayed in a different color, providing display emphasis, as shown in Figure 4.

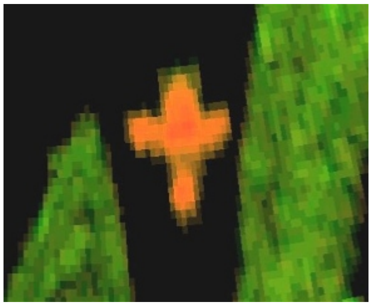

Figure 4, Moving Target Highlighted

The automatic generation of a moving target indicator (MTI) facilitates rapid identification of changes in the radar display images. In a complex, rapidly changing environment, such as a busy port, moving contacts can readily be seen in a color that contrasts with the normal video.

Another area of improvement over traditional scan converters is the retention of trail history when the view is changed. With older scan converters, when the view displayed changes, the trail history is typically lost. The GX-351™ scan conversion module, however, automatically retains trail history. This allows the display to zoom or scroll with no loss of trail history.

The GX-351™ scan conversion module provides a range of benefits and features that combine to provide a powerful and feature-rich set of tools for the display and analysis of radar data. The key features are summarized in Table 1.

GX-351™ Scan Conversion Summary Specifications
Software radar scan-conversion
PPI, B-Scan, and A-Scan display
Up to 256 levels of smooth fade
Radars up to 120 rpm
High accuracy conversion - full double-precision calculations with validated accuracy test results
Multiple radars in a window - multiple videos or different radars in the same window
Multiple colors - show different videos in different colors for clarity
Hole-free, spoke-free - considers all source and all destination samples
Trail retention on view change - keeps display of trail history on view change
Test pattern generator - flexible test and scenario generator module for testing
Continuous zoom and centering - Fully programmable range scaling and view centering
Real-time updates - Updates at display for real-time appearance of sweep
Time-based or sweep-based fading - Flexible fading modes for balancing realism and CPU load
Highly configurable - Easy to use, but also flexible to accommodate special requirements
Optional radar recording

Table 1, Scan Conversion Specifications

1.3.2 Clutter Processing

The GX-351™ offers a wide range of clutter processing functions that enables tailoring of the radar information display to mission needs, weather conditions, or location. The functions can be pre-configured to run in the background or adjusted through a set of intuitive controls. The GX-351™ clutter processing functions are described in Table 2.

Clutter Processing Module Specifications	
Thresholding	Video is thresholded by comparing each sample with a fixed or dynamically-calculated threshold level. In dynamic thresholding the signal level is analyzed around the sample and a threshold value is calculated. This allows the clutter reduction to adapt in real time to differing noise levels throughout the surveillance area.
Low-pass filter	A low-pass filter removes high-frequency effects using a filter of programmable cut-off frequency. This may be used in conjunction with a high-pass filter to select (or reject) signal information in a specific frequency band.
Sensitivity Time Control (STC)	The STC filter provides a time- (equivalent to range) dependent gain function that can be used to eliminate near-range noise.
Fast Time Constant (FTC) filter	The FTC filter provides a fast-time constant (high-pass) filter that may be used to remove large areas of constant-level video (e.g., from weather effects).
Range Ring Insertion	The range ring insertion process inserts range rings into the video. The spacing and width of the rings is programmable. Rings may be inserted at regular intervals or at user-defined intervals.
Azimuth sector blank	A sector of video is blanked. A number of these processes may be cascaded to eliminate multiple sectors of video. The parameters of the process control the azimuth position and width of the sector.
Range blank	Video is blanked from range zero through to a programmed interval and/or from a programmed range to the end of the radar coverage.
Polygon blanking	This is a more general form of the sector/range blanking process, which allows one or more complex polygons to define an area for manipulation. The polygons could be used to eliminate a coastline, or video in runways, for an aircraft ground-movement application.
Azimuth offset	This process implements an azimuth offset on the incoming video to rotate it by a programmed amount. The process may be used to re-align radar video or rotate it to provide a heading-relative display.
Scan-to-scan integration	This process allows multiple scans of video to be processed. Up to 15 scans of history data are considered along with the current video. The output is a programmable function of the history and new data.
Gain and offset adjustment	Video may be manipulated with a general-purpose gain and offset adjustment programmed with a look-up table.
Contrast stretching	A general look-up table may be programmed to provide mapping from input values to desired outputs.
Static clutter removal and MTI	A clutter map may be calculated by integration of input video with a programmable time-constant. The clutter map shows the correlation of video from scan-to-scan so that stationary clutter is emphasized. By removing the stationary clutter from the input video moving targets are emphasized.

Table 2, Clutter Processing Specifications

1.3.3 Tracking

SPx Server, a component of the Cambridge Pixel SPx radar processing family, is a Commercial-Off-The-Shelf (COTS) primary radar data extractor and target tracker.

Interfacing to hardware or network radar video, SPx Server accepts polar-format radar video and processes it to identify targets which are then correlated from scan to scan to output positional and motion updates. The software is highly configurable and identifies target-like shapes according to defined rules. These candidate tracks may be output directly after detection, for example into an existing correlator, or may be further processed by SPx Server using a track filter.

The SPx Server software module is integrated with the SPx Processing library, which provides a comprehensive range of radar processing capabilities. After acquisition, and prior to data processing, the video may be passed through the standard SPx processing functions to implement gain control, area-based video removal, thresholding, interference suppression, or other functions. Additionally, user-defined processes may be incorporated into the processing chain to form a custom solution using SPx as the integrating framework.

When extracted data is correlated from scan to scan, the track correlator uses multiple hypotheses to support ambiguous interpretations of the radar video. The filter uses position, size, shape, and historical measurements to correlate existing tracks with new data—providing updated positions and dynamics, as well as a confidence estimate. The behavior of historical track data is analyzed to aid interpretation and provide a first-level classification capability.

Optional video recording capabilities are available in the compatible SPx Record module that records the polar radar video to support, for example, incident recording or training applications.

Target Extraction

The SPx Extraction process examines the processed video to search for target-like returns that form a connected target-like shape. A set of configurable parameters define the target size of interest, making it possible for small noise returns or larger clutter or land masses to be eliminated early in the processing.

The Extraction process begins by creating a set of spans that represent intervals of video above a threshold for each processed return. These spans are then combined across returns to form connected two-dimensional shapes. The weighted center of gravity, bounding box, and total weight of the plot shape are calculated and entered into a plot database along with a timestamp. At this stage of the processing, no merging occurs of close plots that are likely to be derived from the same target. This means partial plots can be reported on the network, if desired, and allows the tracking process to consider the merits of merging in the context of the local tracks.

Track Creation

The tracker maintains an active track database. The contents of the database are updated with new plot data derived from the data extraction stage. New tracks are added to the database from either a manual request (perhaps derived from an operator or an external process), or automatically.

The automatic track creation occurs when plots entered into the database are identified as uncorrelated, or ungated, with any existing known target. A new preliminary track is created and updated with future detections until confidence that the track is likely to be a target of interest is established.

The time a track is held in the preliminary stage as a programmable option and needs to be set to balance the speed of detection with the likelihood of a false alarm. In a low-clutter environment, where extracted plots are likely derived from real targets, the acquisition time may be as short as two detections. For noisy situations, where the plot extractor is reporting false detections, the integration time in the preliminary stage may be extended.

Multi Hypothesis Tracking (MHT)

The SPx Tracker uses multi-hypothesis association. This offers significant improvements in perfomance over simpler single-hypothesis trackers. The role of a tracker is to interpret radar observations to distinguish real targets from noise and to construct models that describe the motion of true targets. The tracker is provided with data, typically in the form of plots, derived from processing of the radar video. These plots are connected regions of radar video that satisfy some rules of position, amplitude, size, and signal strength. Unfortunately, measurements from the radar are imperfect. There will be noise from the measurement process, clutter from the environment, and unpredicted maneuvers of the targets of interest. Therefore, the tracker will be presented with noisy and possibly multiple measurements from the target of interest. The tracker's responsibility is to provide the best interpretation of the data using assumed or calculated statistics for the noise and the likelihood of change.

In the single hypothesis situation, the tracker is forced to make the best interpretation based on the data available at each update. For some updates, where there is a clear interpretation of the measurement, the best interpretation may be obvious and the single hypothesis offers a satisfactory solution. Problems arise, however, if the interpretation of the measurements is not obvious. In this case it may be desirable to defer a decision until the next update when additional information will help in deciphering the correct interpretation. The ability to simultaneously consider multiple interpretations of the system is the key to the multi hypothesis tracker.

Track Filter

For each hypothesis, the tracker updates the current estimated position with the new measurement. If the measurement were known as completely accurate, the update process would believe the measurement and the new estimate would be exactly the measured value.

For various reasons, the measurement is inaccurate so the update process must take a weighted combination of the expected position and the measured position. This is track filtering, and SPx offers a number of track filtering modes. The simplest mode uses fixed gains in the components of the measurement. This can be successful for tracking applications where the target is clearly identified and relatively clutter free.

The filter works by computing a dynamic filter gain, K, based on estimated system noise and measurement noise models. The system noise is used to model uncertainty in the known dynamics of the target, including its ability to maneuver. As system noise increases, or equivalently, as measurement noise decreases, the filter places more weight on the measurement so the filter gains increase. As system noise decreases or as measurement noise increases, the filter gains decreases causing less emphasis on the new measurement. The filter gains are continually changing and provide, under certain assumptions of the noise characteristics and linearity, an optimal estimation of the true target position. As part of the update process, the track filter also provides a convenient measure of the estimation accuracy through the covariance matrix. This provides a useful confidence assessment of the estimation.

Tracking Parameters

The behavior of the tracker may be configured through a set of tracking parameters. These parameters may be set initially from a configuration file and adjusted during operation of the tracker using using either a customer GUI or network interface. The parameters control many aspects of the tracker's performance including:

- Minimum/maximum speed of the target to be tracked
- Multi or single hypothesis association modes
- Fixed-gain and adapative gain
- Expected target dynamics
- Size limitations on targets to be tracked
- Measurement noise estimates

SPx Track Product Options

SPx Track can be supplied in a PC-based server configuration, a cPCI/VME single-board computer configuration, or as software modules for custom installation. The tracker works with Cambridge Pixel's own HPx series of radar interface cards, or it can be used with network radar formats.

1.3.4 Radar record and playback

The GX-351 has a radar video record and playback feature that may be initiated independently for two channels of video. Incoming radar video is compressed, using a loss-less coding format, and stored on an internal 500 GB hard drive. The recorded file can be copied and moved as a normal Windows file; the file can also be broken into smaller files based on file size or recording time. The recorded files can be replayed into RadarView.

The GX-351 features two removeable drive bays; 500 GB hard drives are standard however; larger capacity drives are avaviable to meet your storage capacity requirements. An optional drive controller that supports hot-swap is also available.

1.4 COMRIC INTERFACE

1.4.1 COMRIC Overview

The Common Radar Information Communication (COMRIC) protocol was designed and developed for the United States Coast Guard to provide a standard Application Programming Interface (API) that would allow distribution of Radar and other sensor information to various display systems on a network. For example, COMRIC allows External Tactical Systems to control and view Radar information from the AN/SPS-73 radar. The GX-350 is available with a COMRIC interface for government customers to allow it to seamlessly interface with existing systems which utilize this interface.

2 PRODUCT SPECIFICATIONS

2.1 PHYSICAL CHARACTERISTICS

The GX-351™ is hosted on a rugged industrial-grade server that features the latest in processing power packaged for demanding environments. Its compact size, rugged steel chassis, and state-of-the-art cooling features make it ideal for extreme applications. The GX-351™'s physical characteristics are summarized in Table 3.

Military Standards (*designed to or tested to)	
Operational Temperature, MIL-STD-810F, Method 501.5	
Mechanical (1U)	
Height Width Depth Weight	1.75" (4.45 cm) 17.75" (45.1 cm) 20.125" (51.11 cm) 15-21 lbs. (6.80-9/52 kg)
CPU	
Intel® CPU architecture from Intel- Nehalem-EP and Westmere-EX dual Core, dual Quad Core or dual Hexa Core embedded long-life roadmap options	
External Bays (2)	
Option 1 (std) Option 2 Option 3	Two (2) removable SATA or SAS 2.5" or 3.5 HDD Four (4) 2.5" SATA or SAS HDDs One (1) CD/DVD (R/W) or Blue Ray
Expansion Slots (1)	
Option 1	One (1) full-height, ¾ length slot; combination is configuration-dependent

Cooling	
Option 1 (std)	High spped, high volume fans (6 + 2 PS) thermostatically controlled
Mounitng Options	
Option 1 (std) Option 2 Option 3	Mounted on Delrin glides Fixed mount, front and rear Jonathan rails
Power Supply	
Option 1 (std) Option 2	120/240VAC w/PFC 24VDC
System Board	
Option 1—One PCI-e 2.0 x 16 (x8 signals)	X8DTL-3F, Socket 1366, 2-48 GB ECC Reg. DDR3, PS/2 KB/M, DB9 Serial, VGA, 2-USB, 2-GBLAN, On-board SAS, IPMI w/KVM over IP

Table 3, GX-351™ Physical Characteristics

2.2 RADAR INTERFACE

The GX-351™ uses the HPx-100 Radar Interface Card from Cambridge Pixel. The HPx-100 is a highly cost-effective PCI-based primary radar acquisition card that captures and processes one or two analogue or digital radar video signals. The Hpx-100 is a half-length PCI card, as shown in Figure 5.

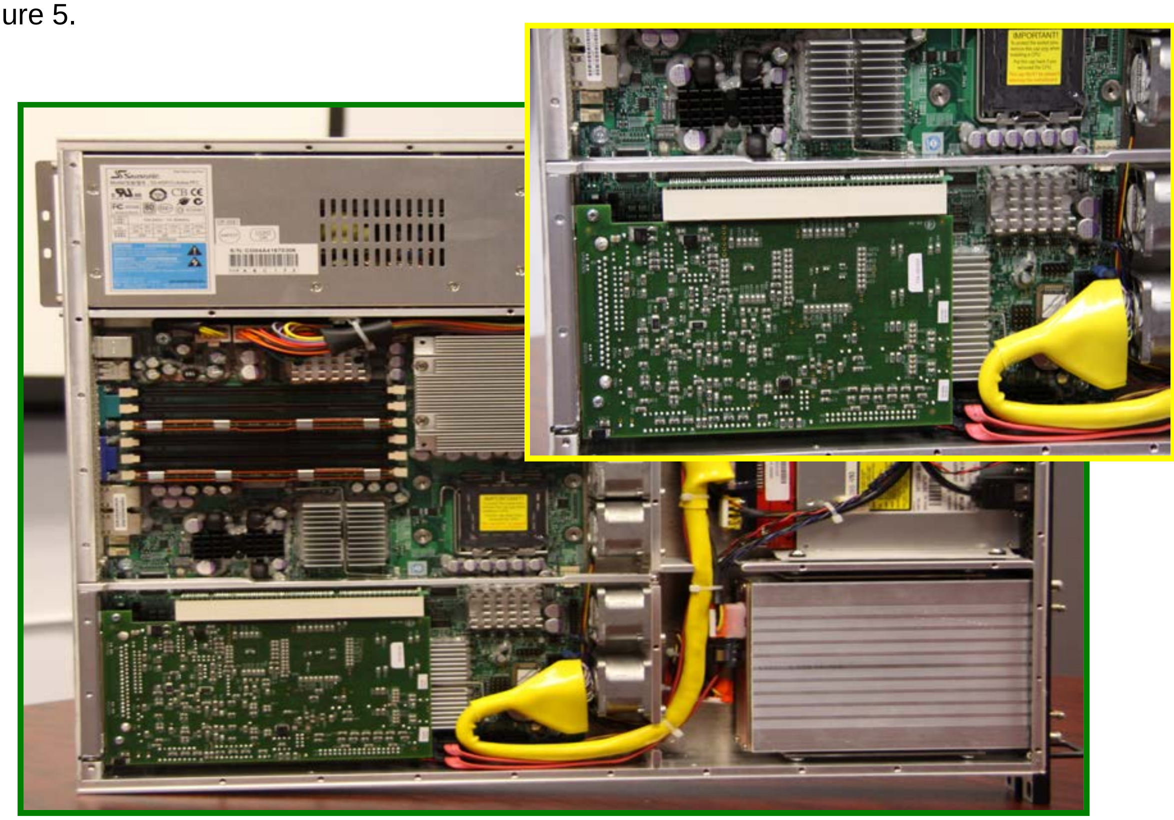

Figure 5, HPx-100

The HPx-100 interfaces to analog or digital radar signals and provides a flexible mixing capability to allow a combination of the inputs to be captured.

The dual analog input videos are captured at up to a 50 MHz sample rate using high-precision analog-to-digital converters at a 10 bits resolution. The captured video can be optionally down-sampled to reduce the data rate before transfer across the PCI bus using high-speed DMA. An on-board Virtex FPGA provides data processing and control and offers capability for expanding the data processing functions for customized applications.Detailed specifications of the HPx are listed in Table 4.

HPx Specifications		
Architecture	Form factor	PCI (half-length) Interface
	PCI Bus	32-bit, 33/66 MHz
Functional	Radar Inputs	2 x Analog (-5v to 5v), 75 Ohms
		8 x Digital (RS422) with external clock
		ACP/ARP (RS422, RS423, or 75 Ohm terminated discrete)
		Parallel azimuth input (12 bits + clock)
		Trigger (RS422, RS423, or up to 30v, 75 Ohms terminated discrete signal
		Optional composite trigger on video
	Radar Mixing	Programmable mixing of analogue and digital inputs
	Gain Control	Programmable gain and offset adjustment control
	Test Generator	Built in analogue and digital test generator
	Return Length	Programmable up to 64 k samples per return
	Bandwidth	25 MHz for each analog channel
	PRF	100 to 16 kHz
	Scan Rates	Up to 120 rpm
	Sample Rate	Programmable up to 50 MHz for each channel.
	Trigger delay	Programmable range zero trigger delay
	Range correlation	Programmable range decimation
	Output	Digitized radar video on PCI bus
	A to D	10 bits sampling reduced to 8 bits in processing LUT
	General Purpose IO	4 bits of programmable output for general control
		4 bits of input for general inputs
Connector	Front Panel	37W D connector for radar video and ACP/ARP azimuth inputs. Parallel azimuth is accessible through header connector on the card

Table 4, HPx Specifications