

SONAR THEORY AND APPLICATIONS

**EXCERPT FROM IMAGENEX MODEL 855
COLOR IMAGING SONAR USER'S MANUAL**

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ABOUT YOUR SONAR

TERMINOLOGY:

The following is an explanation of the basic terms used by Imagenex to describe their sonar techniques.

Color: The different colors used to represent the varying echo return strengths.

Echo: The reflected sound wave

Echo Return: The time required for the echo to return to the source of the sound

Sonar: The principle used to measure the distance between a source and a reflector (target) based on the echo return time

Target: The object that you wish to obtain information about.

IMAGING:

Fan shaped beam

Scans surfaces at shallow angles, usually through a horizontal angle

Displays color images or pictures

Complete echo strength information for each point

Primarily for visual interpretation

In **Imaging** a fan-shaped sonar beam scans a given area, by either rotating or moving in a straight line, through a series of small steps, (see **Figure 1**). The beam's movement through the water generates points that form a sonar image of the given area. The different colored points, representing the time (or slant range) of each echo return, plot a line on a video display screen. The image, consisting of the different colored lines, depicts the various echo return strengths. The following characteristics are necessary to produce a visual or video image of the sonar image:

- the angle through which the beam is moved is small
- the fan-shaped beam has a narrow angle
- the transmitted pulse is short
- the echo return information is accurately treated

These visual images provide the viewer with enough data to draw conclusions about the environment being scanned. The operator should be able to recognize sizes, shapes and surface reflecting characteristics of the chosen target. The primary purpose of the imaging sonar is as a viewing tool.

PROFILING:

Narrow pencil shaped beams

Scans surfaces at a steep angle usually on a vertical plane

Displays individual points or lines

Accurately cross-sections a surface

Echo strength for each point higher than a set threshold

Digitizes a data set for interfacing with external devices

Data set is small enough to be manipulated in a small computer

Primarily a measurement tool

In **Profiling** a narrow pencil-shaped sonar beam scans across the surface of a given area generating a single profile line on the display monitor, (see **Figure 2**). This line, consisting of a few thousand points, accurately describes the cross-section of the targeted area. A key to the

Profiling process is the selection of the echo returns for plotting. The sonar selects the echo returns, typically one or two returns for each "shot", based on a given criterion for the echo return strength and the minimum profiling range. The information gathered from the selection criteria forms a data set containing the range and bearing figures. An external device, such as a personal computer or data logger, accesses the data set through an RS-232 interface with the sonar.

The profile data is useful for making pen plots of bottom profiles, trench profiles, internal and external pipeline profiles. The primary purpose of the profiling sonar is as a quantitative measuring tool.

USING AN IMAGING SONAR ON AN ROV

The imaging sonar is a useful substitute for a positioning system on an ROV. Without an imaging sonar, an ROV relies on traveling underwater to bring new targets into view. With an imaging sonar, instead of traveling it is more useful to spend some time with the vehicle sitting on the bottom while the sonar scans the surrounding area. Scanning a large area takes only a short time, and the vehicle pilot can quickly assess the nature of the surrounding area. The ability to "see" a long distance underwater allows the pilot to use natural or man-made features and targets as position references.

The combination of an imaging sonar and an ROV leads to fast and effective training in sonar interpretation. If the ROV pilot is searching for a particular object, recognition can take place directly from the sonar image. In other cases a number of potential targets may be seen. A pilot can sharpen his sonar interpretation skills by viewing these targets with the vehicle's video camera and correctly identify them.

INTERPRETATION OF SONAR IMAGES

In many cases the sonar image of a target will closely resemble an optical image of the same object. In other cases, the sonar image may be difficult to interpret and quite unlike the expected optical image. The scanning process used to create a sonar image is different from the process used by the human eye or a camera to produce optical images. A sonar image will always have less resolution than an optical image, due to the nature of the ultrasonic signals used to generate it.

Generally, rough objects reflect sound well in many directions and are therefore good sonar targets. Smooth angular surfaces may give a very strong reflection in one particular direction, but almost none at all in other directions. Some objects, such as smooth plane surfaces, may be difficult to see with a sonar. They can act as a perfect mirror (so called specular reflectors), reflecting the sonar pulse off in unexpected directions, never to return. This happens to people visually, when they see an object reflected in a window. The human eye deals with such reflections daily but it is surprising to see the same thing occur with a sonar image. As with normal vision, it is often useful to scan targets from different positions, to help identify them. A target which is unrecognizable from one direction may be quite easy to identify from another.

It is very important to note that the ranges shown to the targets on the sonar image are "slant" ranges. Usually the relative elevations of the targets are not known, only the range from the transducer. This means that two targets, which are displayed in the same location on the screen may be at different elevations. For example, you might see a target on the bottom, and a target

floating on the surface in the same place. By analyzing the shadows you can estimate the height of objects above the bottom. An example of this calculation is shown in **Figure 4**.

The diagrams following this chapter are examples of the sonar scanning process. Studying the diagrams will help you to better understand the images that you see. A basic knowledge of this process will help users to interpret what otherwise might be confusing images.

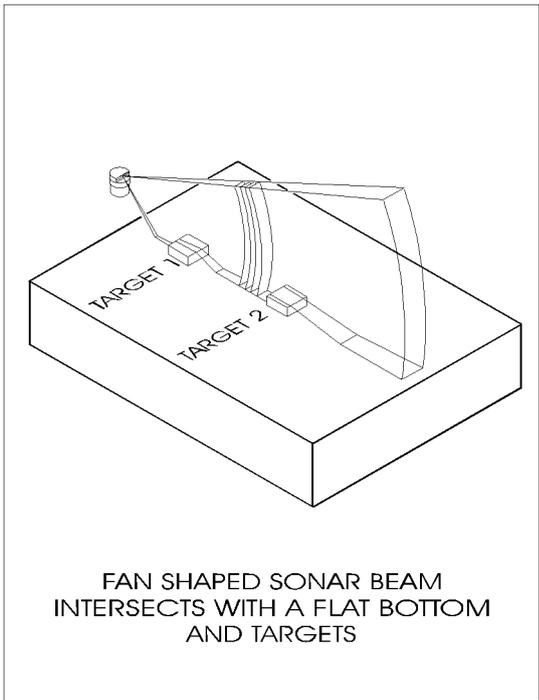
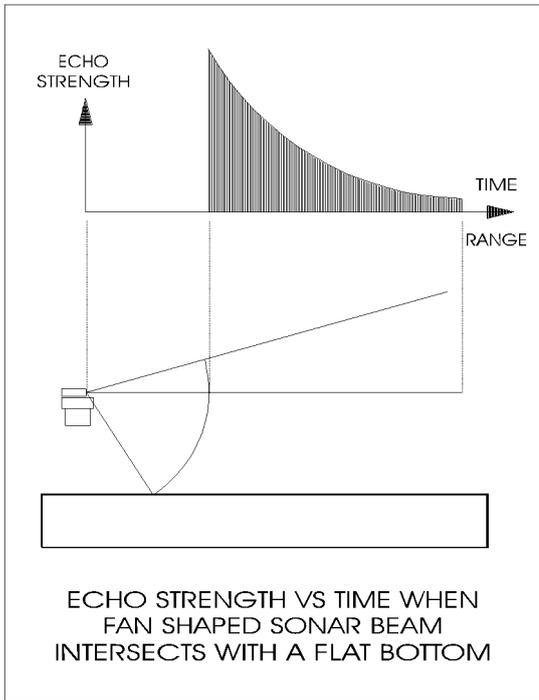
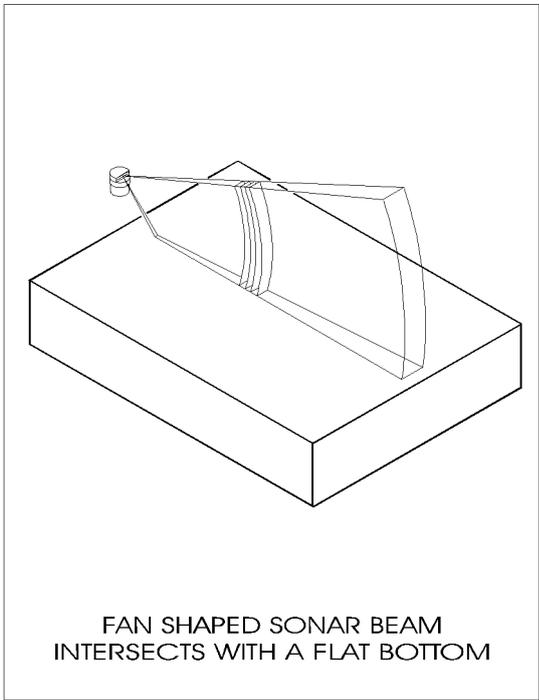
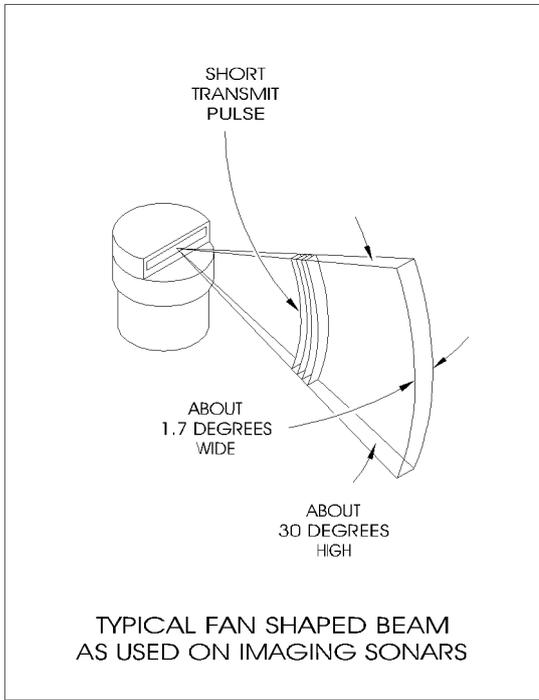


FIGURE 1

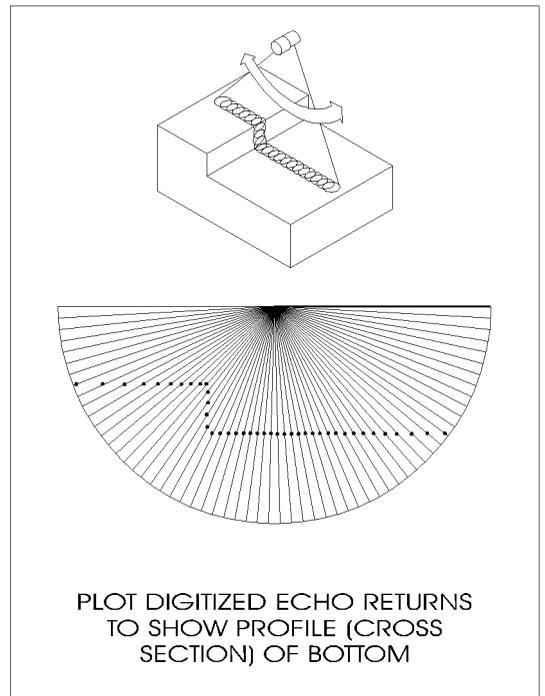
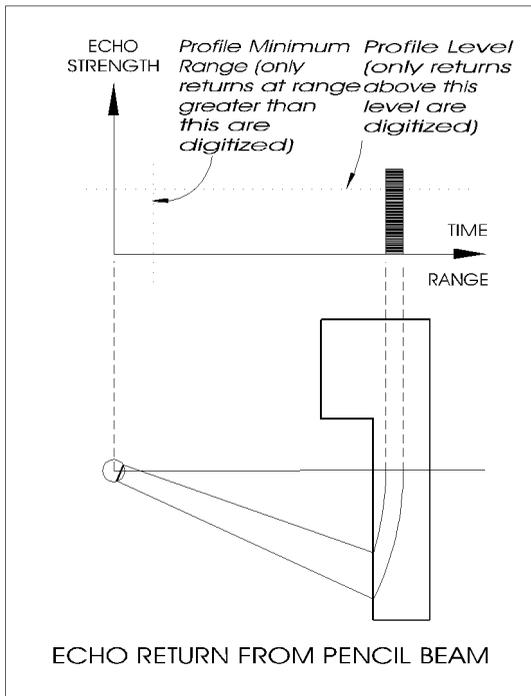
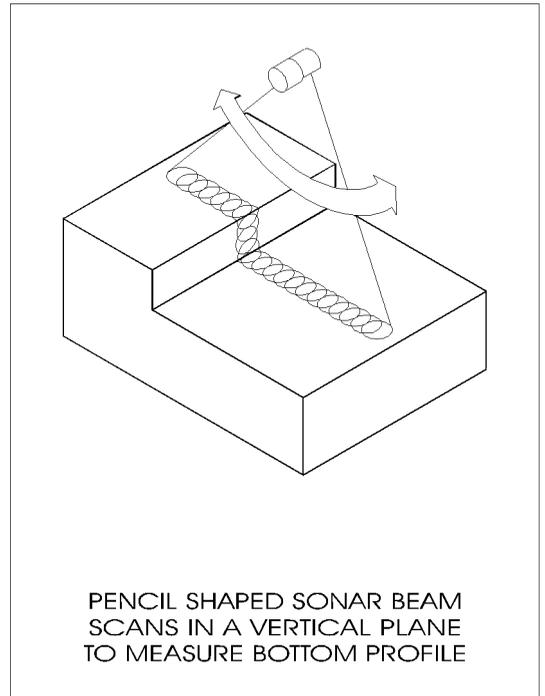
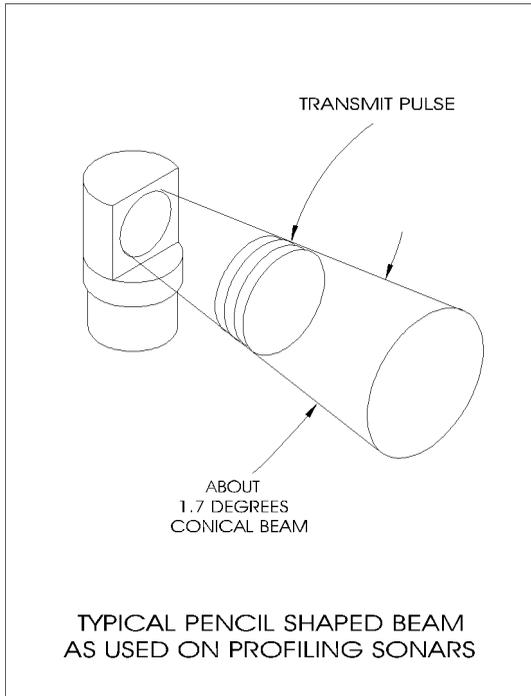


FIGURE 2

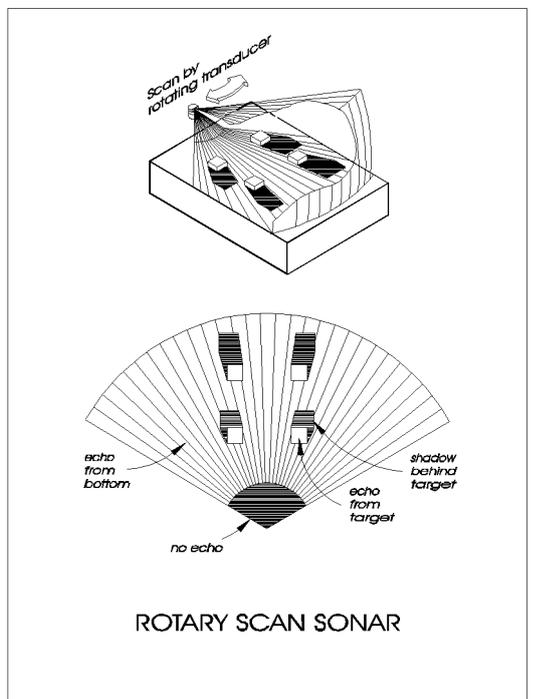
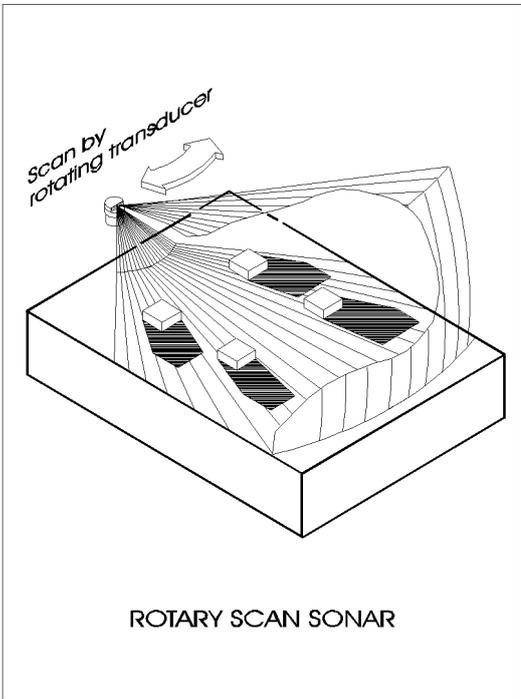
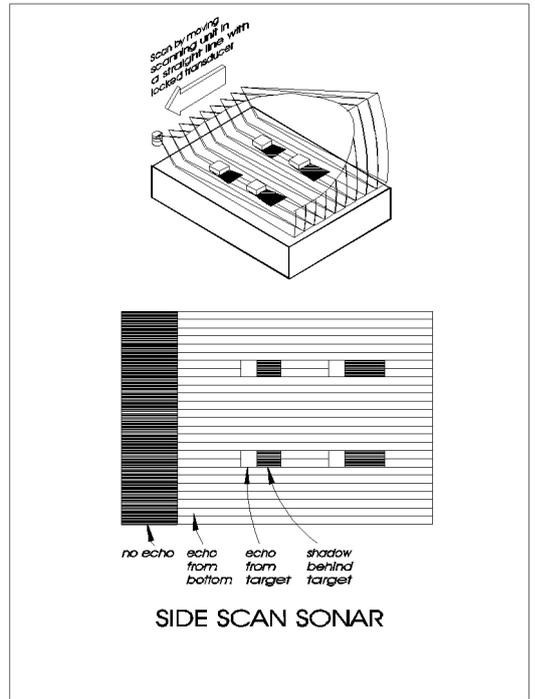
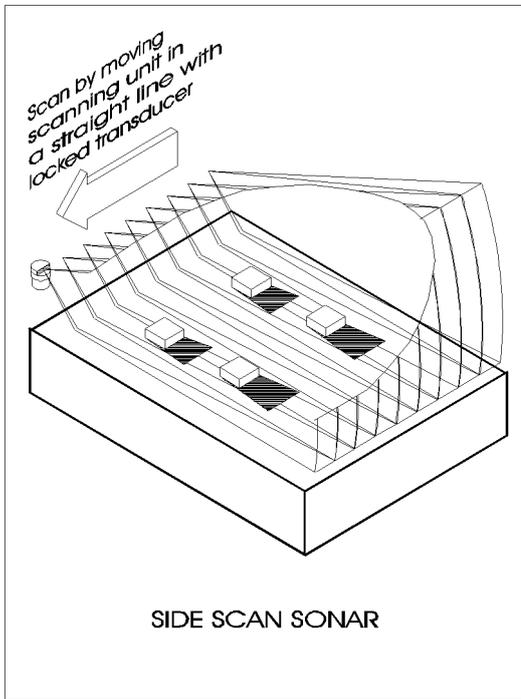
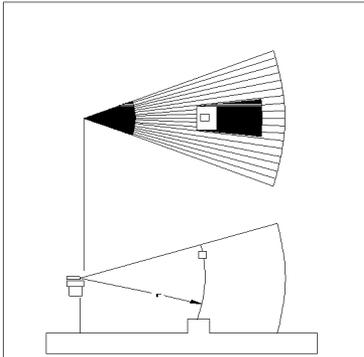
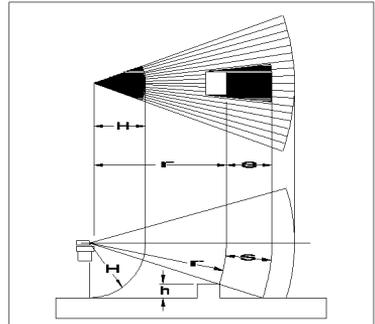


FIGURE 3



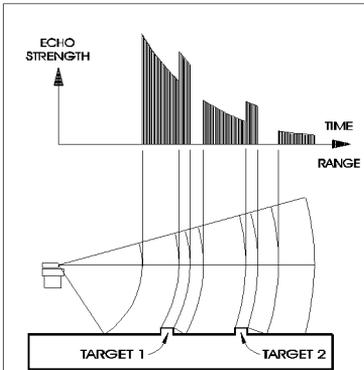
TARGETS AT THE SAME SLANT RANGE
BUT DIFFERENT ELEVATIONS PLOT AT THE
SAME LOCATION ON THE DISPLAY



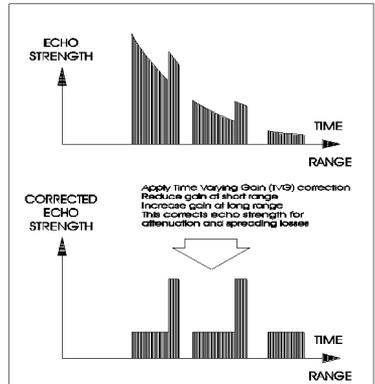
$$\text{Target Height } h = \frac{H \times s}{r + s}$$

(true only on flat, level bottom)

USE SHADOW LENGTH
TO CALCULATE TARGET HEIGHT

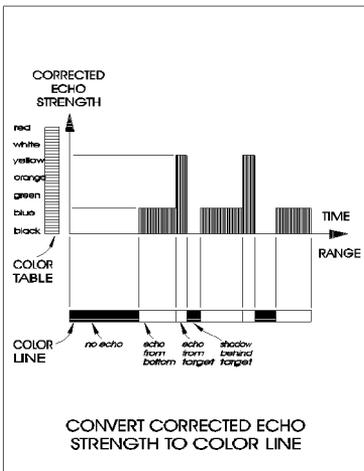


ECHO STRENGTH VS TIME WHEN
FAN SHAPED SONAR BEAM
INTERSECTS WITH A FLAT BOTTOM
AND TARGETS

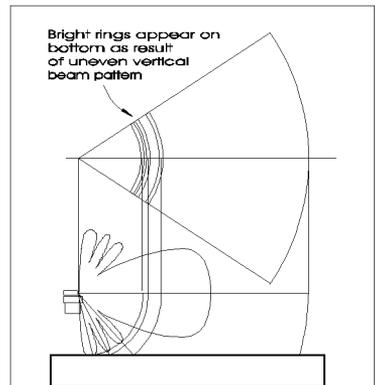


Apply Time Varying Gain (TVG) correction
Reduce gain of short range
Increase gain of long range
This corrects echo strength for
attenuation and spreading losses

CORRECT ECHO STRENGTH
FOR CHANGES DUE TO RANGE



CONVERT CORRECTED ECHO
STRENGTH TO COLOR LINE



ACTUAL SONAR BEAM WITH
UNEVEN PATTERN

FIGURE 4