NAVY EODB
ARMY TM 60A-2-1-74
AIR FORCE TO

Revision 0
29 May 1998

TECHNICAL MANUAL

EXPLOSIVE ORDNANCE DISPOSAL PROCEDURES
MK 32 MOD 2 ADVANCED RADIOGRAPHIC SYSTEM (ARS) OPERATOR'S MANUAL

Published under authority of the Secretaries of the Army, Navy, and Air Force.
(Prepared by the Naval Explosive Ordnance Disposal Technology Division, 2008 Stump Neck Road, Indian Head, MD 20640-5070)

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Chapter 1 - Before You Begin

1.0 Introduction

The MK 32 MOD 2 Advanced Radiographic System, (hereafter referred to as ARS) is a fully digital X-ray imaging system designed to rapidly acquire radioscopic images in the field and provide image enhancement tools to facilitate image evaluation.
The system consists of a controller, an imager, and interconnecting cables. Though image acquisition is fast and uncomplicated, image quality is excellent. Image manipulation capabilities range from simple to sophisticated and accommodate a variety of applications. Images are stored on disk in an industry-standard format that can be readily manipulated and annotated by third party software.

1.1 Safety Information

OPERATING PRECAUTIONS

The X-ray generator used with the ARS produces radiation that can be harmful to personnel. It is the responsibility of the user to ensure that the ARS is properly used by trained personnel who follow recommended operating procedures and applicable regulations. The following safety precautions are recommended by the X-ray generator supplier and SAIC: *Operating personnel should review and follow applicable regulations (see Appendix C)*Personnel in the vicinity of the system may be required to wear an approved radiation monitoring device when the system is being operated (see Appendix C)*Personnel should stand at a safe distance from the X-ray generator, and remain outside the direct beam during image acquisition. However, if personnel cannot be kept outside of the beam angle, they should at least remain 5 meters away from the X-ray generator (see Figure 1.1).*Although the X-ray beam angle is only 40 degrees, as a safety precaution all personnel should stand at least 1.5 meters away from the X-ray generator outside the beam angle. The radiation dose measured outside the direct X-ray generator beam is negligible (see Figure 1.1).*The Control Unit's interlock key should be turned to the "OFF" position when not acquiring. The X-ray generator cannot

fire when the Control Unit's key is in the "OFF" position. *The X-ray generator's power key should be turned to the "OFF" position when not acquiring images. The X-ray generator cannot fire when the key is in the "OFF" position. The system operator should remove the Control Unit and X-ray generator keys when not operating the system, to ensure that the system is not accidentally or improperly operated.

FCC COMPLIANCE

This equipment has been tested and found in compliance with the limits for a Class "A" digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates and can radiate frequency energy and, if not installed and used in accordance with the instruction manual, may cause interference to radio communications. Operation of this equipment in a residential area may cause interference, which is the responsibility of the user to correct. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This product was FCC verified under test conditions that included the use of shielded and/or filtered I/O cables and connectors between system components. To comply with FCC regulations, the user must use shielded cables and connectors and install them properly.

Chapter 2 - Setup and Operation

Setup of the ARS Figure 2.1 is a simple task that can be accomplished by a single individual in less than five minutes. The compact size of the versatile ARS allows it to be used as a portable system (with the system set up around the target object), or as a stationary system (with items placed in front of the imager). Once the system has been assembled, images can be acquired and viewed immediately. Cabling is provided with the standard system that allows for the Control Unit to be located as far as 100-meters away from the imaging area.

2.1 COMPONENT OVERVIEW

CONTROL UNIT

The Control Unit Figure 2.2, Figure 2.3 and Figure 2.4 is a fully integrated system comprised of a Pentium processor, flat panel display with a power-save feature, internal hard drive, 1.4 Mbyte floppy disk drive, and modem packaged in a lightweight carrying case.

X-RAY GENERATOR AND IMAGER

When acquiring an image, the Imager and X-ray generator should be positioned as shown in Figure 2.5 or Figure 2.6 below. The target object should be positioned so that it is as close as possible to the Imager's conversion screen (face), which is denoted by the white rectangular outline on the flat side of the Imager. The X-ray generator should be positioned approximately 60 cm from the Imager with its beam centered on and perpendicular to the Imager face.

CAUTION: The knobs on the imager MUST BE loosened prior to moving the handle. If the knobs are not loosened prior to adjusting or moving the handle, the imager may be damaged. This would require return of the unit for repair. This configuration may be appropriate when evaluating objects on the ground that cannot or should not be moved. The Imager is oriented so that its face is located as close to the ground as possible. The Imager handle is used to support the Imager so that its face is nearly vertical. The X-ray generator is set on the ground (or slightly elevated) so that the X-ray generator's beam is centered on the Imager's conversion screen. In Figure 2.6, the imager is oriented so that the bottom of the conversion screen is11cm above the ground surface. The X-ray generator must be elevated for the X-ray generator's beam to be centered on the screen.

2.2 Set-Up Procedures

1. Remove the ARS components from the shipping containers.

2. Place the Control Unit on a desktop (or other stable work area) as far from the imaging area as is practical.

3. Place the Imager as close to the object to be imaged as possible. Refer to the previous X-RAY GENERATOR AND IMAGER section for more information.

4. Place the X-ray Generator level with, and perpendicular to, the Imager's screen. Verify the X-ray Generator's Exposure Selector (LED at the back of the Inspector 200handle) is 99 pulses.

5. Run the 3-meter gray cable from the appropriate connector on the X-ray Generator to the appropriate connector on the Imager. This gray cable passes signals from the Imager to the Generator.

6. Run the 20-meter black color-coded cable from the appropriate connector on the Imager to the connector identified as "Imager" on the Control Unit. This cable supplies power to the Imager, carries the X-ray generator control signal and routes the image back to the Control Unit.

CAUTION: When unreeling the cable, be sure to grasp the cable rather than the connector and unreel the cable before connecting the cable to either the Imager or the Control Unit.

7. The Golden Engineering Inspector 200 X-ray generator is battery operated; insert an operable battery.

8. The ARS Control Unit can plugged into a 110 VAC, 60 Hz or 220 VAC, 50 Hz power outlet using the power cable provided, to an external 9.5-28 VDC generator, or can be battery operated.

9. The X-ray generator power key must be turned to the "ON" position before X-rays can be produced.

10. The Control Unit's interlock key must be turned to "STANDBY" before any X-rays can be produced.

11. Make sure that all personnel adhere to applicable radiation safety distance recommendations for field operation (see Chapter 1 for more information).

2.3 Power Considerations

The ARS is configured with a power-saving feature that will make the screen blank after a period of two to four minutes of non-usage of the system. Pressing the shift key or moving the mouse will reactivate the screen. Do not press any other key as it may perform an undesirable function. The ARS Control Unit will automatically switch between internal battery, US standard110 VAC, and international standard 220 VAC line power. The system is frequency insensitive between 45 and 65 Hertz. The Control Unit also powers the ARS Imager, therefore no special power consideration is required for the Imager. The ARS Control Unit can directly accept external DC power input that is connected to the Control Unit's connector labeled DC IN see Figure 2.3. Also, An optional 3 meter cable (Part VBC-12) is available that connects the Control Unit to a 12 VDC automobile cigarette lighter receptacle. Lastly, an optional cable with battery clip ends is available for connecting the Control Unit to an external battery. The Golden Engineering Inspector 200 X-ray generator is powered by a rechargeable14.4 VDC internal battery pack. Refer to the manufacturer's operation manual for more information.

2.4 Battery Power Considerations

A 10.8-Volt rechargeable battery is located in the hinged compartment below the keyboard of the Control Unit. A fully charged battery permits about 60 minutes of operation. The battery in the Control Unit will automatically begin recharging as soon as the unit is plugged into a line power outlet, and will take approximately 8 hours to completely recharge. (For instructions on using the Span DRC22-1535 recharger, see Appendix A. The Control Unit does not need to be powered on for the battery to recharge. To access the battery compartment, first loosen (do not remove) the two thumb screws in the front of the hinged battery compartment panel see Figure 2.4. The compartment swings open from the top. To remove the battery, pull the fabric battery lifting strap and the battery will lift out. To install a battery, first note the slots in the battery and align them with the metal flanges in the battery compartment. Put the slotted end of the battery in first, then glide the battery horizontally until the flanges enter the slots and the battery drops into the recessed battery holder.

CAUTION: Improper insertion of the battery, while difficult, is possible and can render the system useless if the battery connector is bent. Please be careful when inserting the battery. The external battery charger can charge optional spare batteries outside the Control Unit. Fully recharging a discharged battery with an external rapid charger takes about 3 hours. Table 2.2 provides information about the battery charge indicator and the LED charge status of the battery:

CAUTION: When the red LED starts to flash, images should be saved and the system should be shut down immediately.

2.5 The Main Menu
When power to the Control Unit is turned on, the computer will automatically enter the ARS software's Main Menu, which is in a familiar Windows-based style shown in Figure 2.7. The system is then ready for imaging.

2.6 Acquiring an Image To acquire an image, click on Acquire on the Main Menu. This activates the pull-down menu shown in Figure 2.8. Figure 2.9 shows a dialog box that contains a warning "Ensure the radiation area is clear before proceeding!" to remind the user to clear the imaging area of personnel before proceeding.

2.7 Editing an Image
After acquiring an image, the user can then select other pull-down menu options to enhance or edit the image. If the image just acquired is under- or over-exposed, or the features of interest in the image are not properly oriented for definitive evaluation, another image may be acquired after adjusting the exposure duration, or rearranging the placement of the X-ray generator or Imager relative to the target object. Resetting the X-Ray Pulses option in the Acquire dialog box (refer to Chapter4 on Imaging Techniques) will help with acquiring a better image. An acquired image can be visually enhanced using the functions found in the Modify pull-down menu. Most images will benefit from the Modify enhancements offered in the Modify menu. The options under the Annotate pull-down menu can be used to label or comment on features of interest, or to date and title the image. Note that image data and time are kept with the image header, visible via the Show Header Info menu option. Once the quality of the image is satisfactory, the image can be stored to hard disk or floppy disk using the options found in the File pull-down menu.

Chapter 3 - The ARS Menu Options

3.1 The Main Menu
As each menu bar function is selected, the definition of each selection is displayed left of the status bar at the bottom of the screen. Refer back to figure 2.7 to review the diagram of the control unit display screen. The left side of the status bar shows specific function keys or key combinations and the action they initiate. The middle of the status bar indicates which of the two images (Original or Modified buffers) is currently displayed. The right side provides information on cursor location in pixels, and pixel gray scale value (image brightness) at that location. Many of the functions on the Menu Bar and pull-down menus have corresponding icons located in the icon toolbar (along the right side of the screen). Table 3.1 lists the functions, starting from the first menu item, and the corresponding options for accessing that particular function.

3.2 The Acquire...Function
ACQUIRE...
An Acquire... request can be canceled at any point by selecting Cancel or pressing the ESC key twice. This will return the user to the Main Menu. When the Acquire option table 3.2 is selected, the X-ray Generator pulses after the preset time delay and an image is acquired. The system then returns to the Main Menu and the image is displayed on the screen (Figure 3.1).When a Delay Timer value other than 0 seconds has been set, a message box appears on the display with a counter that counts down

the preset number of seconds, see Figure3.2. Cancel may be selected to abort image acquisition at any point during the count down. Once the Delay Timer has been changed that value becomes the new default. The Delay Timer value automatically resets to 0 when the program is restarted. *Golden Engineering recommends not firing more than 99 pulses in a five-minute period to minimize the likelihood of the X-ray tube overheating in the Inspector 200 or theXR200 X-ray generators.

SUM...
The Sum function can be used to accumulate more than 99 pulses for an image. The first image is taken, then Sum is used to collect a subsequent image, and then it is added to the existing image, and may be repeated as the operator desires. This is useful when the object being imaged is thick or made of a material denser than typical objects. Selecting Fire and Sum X-Ray captures the first image. The Acquire dialog box appears again automatically. If the first image was adequate, select Cancel. If not, set the option values and select Fire and Sum X-Ray again. This will add the two images together.

CAUTION: Golden Engineering recommends not firing more than 99 pulses in a five-minute period to minimize the likelihood of the X-ray tube overheating in the Inspector 200 or the XR200 X-ray generators.

3.3 The File Menu
OPEN...
To retrieve a previously stored image from the hard drive or a floppy disk, select Open...from the File menu. When Open... is selected, a dialog box is displayed on the screen as shown in Figure 3.3. Select the desired file by double clicking on the filename, or by clicking on the filename, then clicking Open... The file may also be selected via the tab, arrow, and return keys. When the Enable Preview box is selected, a thumbnail image of the file will be displayed.

QUICK SAVE
The Quick Save option allows images to be stored without specifying a filename. The system selects an automatic filename, which is a function of the system date and time. Specifically, the first two numbers in the filename will refer to the day of the month, the next two will be the hour of the day, the next two will be the minute, and the final two will be the second. This is done to minimize the possibility that two images will have the same name. It is recommended that the image files be renamed as soon as possible after they have been stored so that they can be given filenames that are more descriptive than the computer generated names. Select Quick Save. A dialog box appears with the automatic filename and the option to save or cancel by selecting Yes or No. (Figure 3.4).

SAVE AS... To store an image (see table 3.3) on the hard drive or a floppy disk under a user-specified filename, select Save As... When this option is selected, a dialog box is displayed on the screen as shown in Figure 3.5. Select the desired location for the file and provide a descriptive name. Then select OK or Cancel.

Note: The new directories may be created within this window via the icon with the folder and the asterisk. The folder with the arrow ascends a directory, and the icon

on the right shows the dates and time for the tests listed. Please save all files in TIFF format to maintain compatibility and to preserve all the ancillary data with the images.

PRINT
Selecting the Print function activates the print dialog box. Set options for printing as in normal Windows applications. (Figure 3.6)

PRINT SETUP
The Print Setup dialog box provides the user with format options for the printed output. Options for printing setup are as in normal Windows, applications. (Figure 3.7)

EXIT
When Exit is selected, the ARS program is terminated. All unsaved buffers are discarded.

3.4 The Display Menu
The options provided in the Display menu allow images to be enhanced so that evaluation is easier. None of the functions in the Display menu will change the image permanently. Figure 3.8 shows the Main Menu with the Display pull-down menu activated.

ZOOM
When Zoom is selected, a dialogue box appears with three sizing options. Selecting the options x1, x2 or x4, will enlarge the image by a factor of one or two or four. Scroll bars will appear on the right and bottom of the screen for panning and scrolling through the image. To zoom back or un-zoom, the user has three options: select Zoom and x1, select the magnifying glass icon containing the minus sign and click on the image, or use the Page Down key on the key board.

PALETTES
Selecting any of the Palette options changes the display colors of the images. These color schemes may improve the appearance of details and, therefore, make the evaluation of the image easier (Figure 3.9).

DEFAULT
This option return the image to a positive view of the image.

INVERTED GRAYSCALE
This option provides a negative view of the image (Figure 3.10).

INVERTED RAINBOW
This option provides a reversed-color view of the image.

RAINBOW
This option provides a colored view of the image.

AUTO-STRETCH
This option allows the ARS processor to adjust automatically the brightness and contrast of the image. It will select settings that frequently maximize image clarity.

CONTRAST STRETCH
This function is used to change the distribution of the color or gray-levels of the image. A dialog box will appear on the screen over the image. This will contain a histogram with two thin blue bars located along its left and right sides. The histogram is a graphical display showing intensity (along the horizontal axis) and their corresponding number of pixels with that intensity (along the vertical axis). Image contrast and brightness can be altered by adjusting the location of the blue bars within the histogram (Figure 3.11). The blue bars can be repositioned along the horizontal axis using several methods. The position of an individual blue bar can be changed by clicking once on the bar, moving the mouse to the left or right to the desired position, and then clicking a second time. Both bars can be moved simultaneously (to capture a more precise array within the histogram) by clicking once within the blue bars and then using the arrow keys to move the selected area along the horizontal axis. Contrast Stretch does not change the original data in the display memory buffer. This allows the user to exit the Contrast Stretch function with the appropriate contrast values still in effect, and continue to acquire new images and perform other tasks.

Note: Contrast Stretch and Grayscale Invert act only on the displayed image. When images are stored to disk, the underlying data will not be stretched or inverted, and the original appearance may be restored by selecting the "Default" pallet.

GRID OVERLAY
ARS provides two methods for measuring the size and location of features of interest in the displayed image. The Grid overlay function overlays a one-cm square grid on the screen over the image (Figure 3.12). This allows the user to quickly estimate device dimensions and determine the positioning of device components within a package.

DISTANCE MEASUREMENT
The Distance Measurement function allows the user to place two points, and measures the distance between the cursors in inches or centimeters. By selecting Distance, a crosshair cursor appears. Move this cursor to the desired first location, and click to set the position. Next, moves the cursor to the second location. As the cursor is moved to the second point, a mobile line is displayed. A second click sets the second mark and the distance between the two set points is displayed in a message box as shown in Figure 3.13

SHOW
This function gives two options: By selecting Image Header, a box appears on the screen that displays the date and time that the particular image was acquired. It also shows the serial number of the Control Unit used, and whether the image has been modified or not (Figure 3.14).Cumulative Pulse Count displays the total number of pulses fired by the X-ray generator since the last reset (Figure 3.15). This can be used

to give an indication of remaining battery, or X-ray tube life. There is an option to reset the count. This should be used when a new X-ray tube is installed. See the X-ray generator operator's manual for more details. The expected life of the tube in the Golden Engineering XR200 is 35,000 pulses.

Note: The Cumulative Pulse Count function records the number of pulses requested, not the number actually fired.

SWITCH BUFFERS

There are two image memory buffers in ARS. The original image data acquired by the system are stored in the Original Buffer. The image resulting from processing is stored in the Modified Buffer. Alternating between the two buffers is done with the Switch Buffers function. The current buffer on the display is highlighted in the Status Bar

CLEAR BUFFER

This function erases the image located in the display buffer, clearing the display.

3.5 The Modify Menu

The processing functions in the Modify menu irreversibly change the data in the images. These functions act on the original image data located in the Original Buffer, and produce a modified image, which is in turn stored in the Modified Buffer. The buffer being displayed is automatically switched from the displayed Buffer to the displayed Buffer when these functions are performed. A modified image can be saved to floppy disk independent of the original raw data (Figure 3.16)

REGION OF INTEREST (ROI) PROCESSING

When ROI Processing is activated, the cursor changes to a crosshair. Clicking, moving the crosshair and clicking again on the image defines the region-of-interest (ROI). Enhancement functions can then be applied and will only affect the ROI. When this function is selected, the Display and Modify functions are applied to the data in the selected ROI, rather than on the whole image. (Figure 3.17) shows the ROI Toolbar below. Title labels have been provided here to identify the icons.)

ANNOTATE

The Annotate function allows for the addition of text and lines to the displayed image. When Text is selected, another submenu appears which gives the option of selecting either Black or White text. A dialog box is then displayed allowing text to be entered. A rectangle showing the text is then displayed together with a hand cursor. This cursor allows positioning of the text rectangle. The text is placed in a white or black rectangle (background) so that it is always visible, independent of the shade of the background. An example of black text on a white background is shown in Figure 3.18 below. The Lines option allows straight lines to be drawn on the displayed image. Once Lines is selected, the same color option of Black or White can be made, and across hair cursor appears. Move this cursor to the desired first location and set the first point by clicking once. Next, move the cursor to the second location. As the cursor is moved to the second point, a rubber-band line is displayed between the first point and the current location of the cursor. A second click sets the second mark and the line is drawn between the two set points as shown in Figure 3.19.

SHARPEN
This operation makes edges pronounced and can improve the resolution of the image. It makes lines and edges in an image much more defined. There are three options to this function: Fine, Moderate, and Extreme. The Fine option will slightly sharpen the image and can be used when a subtle adjustment is necessary. The Moderate option is more obvious and improves the clarity of the image without drastically increasing the apparent noise level (for an explanation of noise, see the following page). The Extreme filter will dramatically increase the sharpness of the image but because the noise will also be increased in the processed image, it produces a "grainy" effect.(Figure 3.20).

SMOOTH
These filters essentially produce the opposite effect of the Sharp functions. The filters smooth out edges, producing a slightly smoother, softer image, reducing speckle and noise. As with the Sharpen function, there are three options: Fine, Moderate, and Extreme. The Moderate option also has an icon button and function key. Applying one of the Smooth filters will slightly reduce the resolution of an image. (Figure 3.21).

NOISE REDUCTION
This function has three options in its submenu: Average, Median, and Despeckle. Noise in an image is pixels with randomly distributed brightness levels. Noise Reduction will help filter out problem areas such as spots in an image. Average replaces the center pixel of a three-by-three array with the average of those nine pixels. Median replaces the center pixel of the three-by-three array with the median value of those nine pixels. Despeckle removes 1-pixel speckle from the image and shrinks some larger speckles (Figure 3.22).

EDGE DETECT
This function has three options: Horizontal, Vertical and Diagonal. As each option is selected those particular edges in the image will be displayed as white lines on a black background. This tool may be helpful in locating items with characteristic shapes in a cluttered image by removing the shading and features. Figure 3.23 shows the same image of a pipe bomb with the horizontal edges in the image shown in white. The menu is also selected to show its location and options.

EMBOSS
This function will make an image appear raised or stamped by suppressing the shading within the image and tracing its edges with black or white (Figure 3.24).

ADD IMAGES
The Add Images feature allows the user to add images together to enhance the user's ability to discern objects within dense containers or housings. This feature is useful when the highest pulse rate setting (99) provides a dim image. This feature allows the user to add multiple 99, pulse images together. The user must begin the Add Images process with the original image located within the Original Buffer and the image to be added located within the Modified Buffer. (The user may switch between the

buffers using the F7 key.) While viewing the Original Buffer, select the Add Images function to add the images together. The resulting image appears in the Modified Buffer. To view the combined images, select the Automatic Stretch function from the Display menu. Automatic Stretch should make the image viewable, most of the time.
Note: The Add Images function clips the maximum pixel intensity to 255.

SUBTRACT IMAGES
The complement of the Add Images function, the Subtract Images feature allows the user to subtract images from one another. This feature can be used to remove system-induced artifacts in images by taking a background image and subtracting the image of the object. The user must begin the Subtract Images process with the original image located within the Original Buffer and the image to be subtracted located within the Modified Buffer. (The user may switch between the buffers using the F7 key.) While viewing the Original Buffer, select the Subtract Images function to subtract the images. The resulting image appears in the Modified Buffer. To view the combined images, select the Automatic Stretch function from the Display menu. Automatic Stretch should make the image viewable, most of the time.

Note: The Subtract Images function truncates resultant pixels that would be less than zero to zero.

HISTOGRAM EQUALIZE
This function makes a non-linear change to the image, to enhance more subtle details than Auto Contrast. It automatically adjusts the brightness of pixels to balance the brightness across the range of brightness within an image to enhance visual interpretation (Figure 3.25). In some cases, Histogram Equalize may provide a better enhancement of the image than Auto Contrast.

ROTATE IMAGE
This function allows the image to be rotated. Three options are available within Rotate Image. +180 Degrees allows the image to be rotated 180 deg.and is useful when the image was acquired with the Imager set upside down (Figure 3.26). Flip Left-Right and Flip Top-Bottom are additional options to reflect the image left-to-right or top-to-bottom.

3.6 The Preferences Menu
The Preferences pull-down menu allows the user to alter the behavior of the user interfaces. Figure 3.27 shows the Preferences pull-down menu. A checkmark next to each menu item indicates whether or not the item is activated Checks next to the menu items indicate they are selected as preferences.

ICON BAR
This option shows or hides the Icon Toolbar located at the top of the screen, just below the Main Menu bar. Removal of this toolbar allows more of the image to be viewed without scrolling or panning. The system will revert to showing the icon bar when the application is restarted.

STATUS BAR
This option shows or hides the Status Bar, which is located across the bottom of the

screen. The system will revert to showing the icon bar when the application is restarted.

DISTANCE IN CM
This option toggles between measurement units in centimeters or inches to suit user preference. The system will retain this user preference when the application is restarted. The Distance Measurement and Grid Overlay are affected by this setting.

BUFFER PROTECTION
This option turns the buffer protection on and off. A check mark indicates its status. When on, the system will prompt when a buffer is about to be discarded before that buffer has been saved. When not on; no warnings are given. The system will retain the buffer protection on when the system is restarted.

INVERT ALL IMAGES
This option allows the user to select a negative or positive view of the images. A check mark indicates its status. The system will revert to non-invert function when the system is restarted.

AUTOMATIC STRETCH ALL
Choosing this option sets ARS preferences to automatically optimize the contrast of the all displayed images. (To manually set the contrast for individual images, use Contrast Stretch under the menu option.) The system reverts to the non-automatic stretch when the system is restarted.

3.7 The Help Menu
The Help pull-down menu allows the user to display information on system operation.

HELP
Selecting the Help function brings up a dialogue box containing the contents of this user manual.(Figure 3.28).

KEY MAP
Key Map: When this function is selected, a message box containing a list of the function keys with their corresponding functions is displayed on the screen as shown in Figure 3.29.

ABOUT
This function activates a message box containing information on the ARS software version installed on the system (Figure 3.30).

Chapter 4 - Imaging Techniques

4.1 Target Density and Exposure Duration
EXPOSURE DURATION
The ARS (figure 4.1) allows the user to adjust the X-ray exposure duration (number of pulses) before acquiring an image. This is useful when the target objects vary by

thickness and composition. The X-ray Generator's exposure duration is adjusted using the X-Ray Pulses input field of the Acquire... function dialog box as described in Chapter 2. The default acquisition of 7 pulses should be used when imaging very thin or light-weight objects which do not readily absorb X-rays. Longer exposure time settings (a higher number of pulses) should be used if the target object is not

sufficiently penetrated with 17 pulses. The X-Ray Pulses feature allows the operator to gradually add pulses to a captured image until the object is sufficiently penetrated (refer to Chapter 3 for more information about the SUM function). Setting the X-Ray Pulses higher than necessary will result in a saturated (pure white) image, or saturated areas of the image. To avoid this, set the X-Ray Pulses to a lower exposure setting, then increase or decrease it as necessary to achieve a bright image that is free of saturation. An insufficiently long exposure time for an object will result in a dark image that provides little or no information about the internal structure or content of the object.

Note: The best way to achieve a satisfactory image is to refer to the histogram Contrast Stretch feature under the Display... menu. If the histogram graph is bunched to the left, the number of pulses should be increased. If the histogram graph is bunched to the right, it is likely that the number of pulses was set too high.

DISTANCE

Another more subtle method for adjusting the target X-ray illumination is to vary the distance between the X-ray Generator and the Imager. Although a distance of approximately 60 to 90 cm between the X-ray Generator and Imager is recommended to provide a sharp, proportional image, this separation distance can be decreased to penetrate thicker or denser materials. Regardless of the distance between the X-ray Generator and Imager, it is always best to place the object as close to the center of the Imager screen as possible, which will result in maximum penetration and resolution.

Note: An object located between the X-ray Generator and Imager will produce an enlarged image. This is because X-rays are emitted radially out from a small spot (diverging), and the X-ray "shadow" of the object is projected onto the Imager screen. Therefore, the further the object is away from the Imager and the closer it is to the Generator, the larger its projection, and, consequently, the larger its features will appear in the acquired image. Objects that are closer to the Imager will more closely reflect their true dimensions. Objects that are further from the Imager will measure larger than they actually are. Objects such as thick wood and aluminum, thin steel, thin plastic or card board enclosures can be imaged easily by adjusting the distance between Generator and Imager and varying the exposure duration settings. The Add Images function allows the operator to add separately acquired images together, to overcome the X-ray generator's limit of 99 pulses. This increases the system's ability to image steel and other denser materials.

4.2 X-Ray Beam Filtering

X-ray generator beam filters may be used to enhance the quality (resolution and

contrast) of the image, thus improving the visibility of subtle features. A filter is generally a thin metal sheet placed over the X-ray generator's beam aperture. This filter, by absorption and scatter, removes a fraction of the low energy X-rays that may be contributing to image noise due to scattering. The type and thickness of the filter used depends on the thickness and composition of the imaged object. Examples of recommended beam filters for thin or lightweight objects: * 0.12 - 0.25 mm copper filter * 0.51 - 0.762 mm a1uminum filter. Examples of recommended beam filters for denser materials: * 0.51 mm copper filter* 1.27 mm aluminum filter

Chapter 5 - Procedures for Modem Use

5.1 Sending and Receiving Files On the Receiving Machine:

Start Communications Center
Start Terminal (AA TR and MR lights will glow on the Control Unit)
The system is now ready to receive
On the sending machine:
Start Communications Center
Start Terminal (AA TR and MR lights will glow on the Control Unit)
The system is now ready to send
To dial, press the ALT and D keys simultaneously, type the extension and press Enter
The following information will appear on the screen:
Sending: ATDT9255
Receiving: RING
ATA
CONNECT 336600/ARQ
Sending: CONNECT 336600/ARQ
On the sending machine, selecting Pg Up initiates a transfer
Click OK for z modem transfer
Move to the directory where the images are to be sent
Double click on each image to be sent
Click Send List
Both machines will track the file transfer. Each file transfer will take approximately one minute.
Choose the Terminate Current Session and reset modem button on the sending machine.
Both machines will disconnect.
Files should appear in c:\images\download on the receiving machine. It is possible, under rare circumstances, to damage the phone system when connecting an analog device, such as this modem, to the phone system. Please check with the local technician to very operability.
Be sure to shutdown, restart, and verify sending and receiving from both machines.

Appendix A - Maintenance

A1. Preventative Maintenance

SYSTEM CARE AND CLEANING

The ARS should be stored and transported in the transit cases provided with the system. The ARS has no special periodic maintenance requirements other than battery charging and image quality checking. The unit may be cleaned using a damp cloth and mild detergent, but care must be taken to prevent water from entering sensitive electronic areas. The flat panel display may be wiped off using a damp, lint-free cloth while the power is off.

BATTERY MAINTENANCE

The ARS internal battery must remain charged to ensure that the system is ready for deployment at a moment's notice. The ARS incorporates a built-in battery charger that will recharge a fully discharged internal battery in approximately 8 hours.
The battery may be easily removed and replaced by the user. (See section 2.4 for details on battery access.) Over time, batteries on the shelf will gradually lose their charge. It is recommended that spare batteries be recharged every two months of storage. Spare batteries may be charged/recharged using the external charger (instructions follow below).Replacement batteries must conform to the specification for an DR-35S 10.8 V 3800mA-hr battery. A 3800 m A-hr charger is acceptable, but NiMH is the only chemistry that is acceptable.

OPERATING THE SPAN RECHARGER

Plug the wall adapter into an outlet and insert the plug end of the power cable into the jack on the rear of the DRC22-1535 Recharger. Insert one or two DR35 batteries into the pocket(s) on the top of the Recharger. Lights near the pockets will illuminate to indicate the status of the batteries as
follows:

Off No battery detected
Red Charging
Green Fully charged
Yellow Standby
Red Flashing Error

The DRC22-1535 Recharger will completely charge a DR35 in about 75 minutes.) If two batteries are inserted, they will be charged sequentially. The light of the second battery will be yellow, indicating a standby condition. The second battery will automatically commence charging once the first battery is completed. he DRC22-1535 monitors battery temperature and will not commence charging a pack if it is outside a temperature range of 10deg.C - 45deg.C. Any pack that is outside this range will also be indicated by a yellow light. An error indication will be given if the battery terminals are shorted or if the battery fails to properly take a charge. If your DRC22-1535 charger does not function as expected, check the following: Make sure the wall adapter is properly connected. Make sure there are no foreign objects lodged in the pockets. Make sure the batteries are installed so that they properly mate with the connector in the bottom of the pocket.

IMAGE QUALITY MEASUREMENT AND CHECK
Included with each system at shipment is a calibration image, in the directory: C:\images\calibration This is an image of some small wires and a resolution "star" gauge. It is suggested that the user periodically check system operation by duplicating this image. The image is 60 cm away from the X-ray source, and the image is taken using 7 pulses with the items taped to the front of the imager.

DISK SPACE
Hard disk and floppy disk file space can be recovered by deleting old images that are no longer needed, or ones that have been backed up to an external hard drive. Use the Delete option in the Windows Explorer application that can be accessed through a right-click on the Start button on the bottom of he screen. See Table A1.1 for ARS Spare Parts Maintenance Procedures.

Appendix B - Troubleshooting

B1. Repair Instructions
The ARS is warranted for one year from the time the unit is shipped from SAIC. Return inoperative Control Units, Imagers, and/or cables including a description of the symptoms and authorization for repair service to:

Science Applications International Corporation (SAIC)
Attn: ARS Manufacturing Manager
16701 West Bernardo Drive
San Diego, California 92127 (800) 962-1632
For system support or information:
E-Mail Radeco@cpmx.saic.com, or Call (800) 962-1632.

B2. Troubleshooting Guide
see Table B2.1. If none of these corrective actions fix the problem, send an E-mail or call for system support (see Paragraph B1).

B3. Potential Error Messages
see Table B3.1. Review the Following Text Messages to locate the reason for the error message. If none of these definitions assist in determining the problem, send and E-mail or call for system support (see ParagraphB1).

B4. Variable Text Messages
see Table B4.1.Review the following Variable Text Messages to locate the reason for the error message. If none of definitions assist in determining the problem, send an E-mail or call for system support.

Appendix C - ARS Radiation Survey Measurements

C1. Introduction
SAIC's ARS X-ray Inspection System uses a Golden Engineering Inspector 200 X-ray generator. This device emits X-Radiation, which can be harmful to people if they

receive excessive exposures. The use of such systems is regulated by both state and federal regulations. The use of X-ray generators outside of cabinets and shielded rooms to form images of objects is termed Field Radiography. Most states require operators of such systems to be trained in, and demonstrate an understanding of, the following subjects: Characteristics of X-Radiation Units of radiation dose Radiation hazards Radiation levels from radiation machines Methods of controlling radiation exposure: Time, Distance and Shielding Use of Radiation Survey Instruments: Operation, Calibration, and Limitations Radiation Survey Techniques Characteristics and use of personnel monitoring equipment Use of radiation machines in radiography

C2. Dose Measurements

Inspector 200 X-ray Generator dose measurements CAN be made using: Integrating ionization chambers Film badges Pocket ionization chambers (PICs)Thermo-luminescent dosimeters (TLDs) because these measure the energy liberated in the detector from the time the instrument was zeroed. Inspector 200 X-ray Generator dose measurements CANNOT be made using: Pulse counting instruments such as a Geiger-Mueller (GM) tube. These instruments will only count one event in the short time (50 nanoseconds) of the X-ray pulse. Survey meters such as an ion chamber operating in a dose rate mode. The time responses of these survey meters are too slow to measure the dose delivered to the instrument in the relevant time frame. Radiation dose measurements were made around the ARS X-ray inspection system using a Victoreen 450B survey meter operated in the integration mode. An Inspector 200 X-ray generator, the processor to the Inspector -200, was used for these measurements. The X-ray unit was set to capture images at the default 17 pulses per image. The generator and imager were separated by 69 cm. Images were taken to assess the dose rate received by the survey meter while it was directly in the beam. In addition, scattered dose was measured while a 10 x 10 cm oak timber was directly in the beam. The oak timber provides a reasonable upper estimate of the scattered radiation. Metallic objects will produce roughly the same amount of scattered radiation but will absorb more of it, giving a smaller amount of scattered radiation than the high-density oak. The survey meter was first zeroed by turning the unit off. The meter was then turned on and the instrument placed in the integrate mode. When the meter reached a dose of more than 1 mR, it was re-zeroed by turning the meter off. (The incremental dose recorded in the integrate mode is 10 R for readings less than 1 mR and 1 mR for readings greater than 1 mR.)The dose per exposure was calculated by subtracting the reading before the exposure from the reading after the exposure. Measurements made in the beam resulted in a dose of 10 mR per image at a distance of69 cm from the generator and 17 pulses per image. This corresponds to a dose rate of3.1 mR per pulse at 30 cm from the generator. This dose is consistent with the dose of 3.5 mR per pulse at 30 cm from the generator reported by GEI. This agreement confirms that the survey meter, operated in the integrate mode, is measuring the dose correctly. (The meter is normally calibrated while operating in the dose rate configuration.) (It should be noted that a Victoreen 450P survey meter cannot be used to measure doses out of the beam.)The dose rate outside of the beam was measured by exposing a 10 x 10 cm oak timber directly in front of the imager to produce scattered radiation. Data were obtained by forming images of the wood and using the dosimeter in the integrate mode. It appears that the radiation scattered from the wood dominates the measured dose. To investigate the shielding effectiveness of normal interior walls to the penetration of the scattered radiation, the dose was first measured with no shielding present. Two 1.27 cm thick

sheets of drywall material were then inserted between the generator and scatterer and the detector. The dose per image decreased by a factor of 2. Normal walls will also include wood framing and other interior material such as electrical cabling and normally will be at an angle to the scattered radiation. A factor of 2 reduction in the scattered dose caused by normal interior walls should be a conservative estimate. Concrete walls will provide much greater attenuation. One can estimate that a 10 cm thick concrete wall will reduce the transmitted dose by a factor of 50 (Attenuation A = 0.02).

C3. Legal Dose Limitations

OCCUPATIONAL EXPOSURES

An occupationally exposed individual is limited to receiving 5 Rem of radiation per year. If the operator remains over 1.8 meters from the objects being inspected it, the operator would need to take more than 1,000,000 images in a year to reach the legal limit for occupationally exposed personnel. For minors, the occupational dose limits are 10% of the annual dose limits for adult workers. For declared pregnant workers, the dose to an embryo/fetus during the entire pregnancy must not exceed 500 mRem. Furthermore, a reasonable effort must be made to ensure that exposures to declared pregnant workers are essentially uniform throughout the pregnancy.

GENERAL PUBLIC

The dose limit for uncontrolled areas is 2 mRem in any one hour and 100 mRem in a year. It was shown above that it is fairly easy to obtain 2 mRem in the beam in short periods of time. It was also shown that it would only take 5 images at a distance of 3 meters, or 10 images if there is an intervening interior wall, to reach this level. At a distance of 1.8 meters from the scatterer, out of the main beam, it would take 2300 images to reach the 2 mR dose limit see (table 5).

ALARA

In addition to the legal limits mentioned above, both state and federal laws require that radiation doses to both occupationally exposed individuals and to the general public be held to levels that are as low as reasonably achievable (ALARA). If it is reasonably easy for an operator to stand behind a wall when he is making exposures, this must be done. In addition, if a shield is reasonably easy to incorporate into a setup, it must be included. It should be noted however, that the operator must maintain control of the region of the X-ray beam out to a distance of at least 1.5 meters from the generator when the generator is fired. This will impose some limits on where the operator can be positioned.

C4. Monitoring

All of the states in the US control the use of X-ray generators. Additionally, the FDA regulates the use of X-ray generators in cabinets and shielded rooms. Most states require that personnel radiation dosimeters be provided to, and used by, all personnel who conduct Field Radiography. Most states also require that physical radiation surveys be performed for each set up and that the results of these surveys be recorded. It is likely that a two-point radiation survey would be sufficient if one has a survey meter like the Victoreen450B.

C5. Utilization Log

Each user must maintain records of the use of the X-ray source. This utilization log

must include: * The name and serial number of the machine. * The location, date, and the identity of the individual operator for each use. * The number of images produced or the number of pulses produced for each use. Refer to the sample (Utilization Log) shown on the following page.

C6. Source Registration

Most US states require that users of X-ray sources, such as the Inspector 200 X-ray generator used in the ARS, register these sources with the Department of Health. SAIC strongly recommends that all purchasers of X-ray sources, regardless of the state or country where they are located, pursue registration of these devices with the appropriate local agency.

C7. References

A1. Radiological Health Handbook, Bureau of Radiological Health, 1970, U.S. Department of Health, Education, and Welfare, Bureau of Radiological Health, Rockville, Maryland, p 151, 152.

C8. Dose Control Tables

Table C8.1 lists the conditions that are necessary to restrict the dose at the indicated positions to less than 2 mR. Column 1 gives the number of images that the operator expects to take in a given location. The second column lists the distance along the beam path (and a +/-20deg.cone around the beam centerline) that must be controlled to ensure that all regions outside of this region receive less than 2 mR. The third column lists the thickness of concrete that one would need to have behind the imager, .9 meters from the generator, for the region in back of the wall to be considered as uncontrolled. The fifth column yields the thickness of lead that would have to be placed over an interior wall to allow the area behind the wall to be considered as uncontrolled. Table C8.2 is similar to (Tables C8.1) except it lists the conditions that are necessary to restrict the dose at the indicated positions to less than 100 mR. FigureC.1shows the ARS Safety Zones.

C9. State Radiation Safety Contact List

Alabama: Kirk Whatley, Director
Division of Radiation Control
State Department of Public Health
RSA Tower
PO Box 303017
Montgomery, AL 36130-3017
Phone: (334) 206-5391
Fax: (334) 613-5387
Email: kwhatley.adph.state.al.us

Alaska: Kate Coleman, Chief
Radiological Health Program
AK Dept. of Health & Social Services
P. O. Box 110613
Juneau, AK 99811-0613
Phone: (907) 465-3256

Fax: (907) 465-2088
Email: katec%health@state.ak.us

Arizona: Aubrey V. Godwin, Director
Arizona Radiation Regulatory Agency
4814 South 40th Street
Phoenix, AZ 85040
Phone: (602) 255-4845
Fax: (602) 437-0705
Email: gdwa23a@prodigy.com

Arkansas: David D. Snellings, Jr., Director
Division of Radiation Control
Arkansas Department of Health
4815 W. Markham, Slot #30
Little Rock, AR 72205-3867
Phone: (501) 661-2301
Fax: (501) 661-2468

California: Edgar D. Bailey, Chief
Radiologic Health Branch
Dept. of Health Services
P.O. Box 942732
Sacramento, CA 94234-7320
Phone: (916) 322-3482
Fax: (916) 324-3610
Email: ebailey@hw1.cahwnet.gov

Colorado: Robert M. Quillin, Director
Laboratory and Radiation Services Division
CO Department of Public Health & Environment
8100 Lowry Blvd.
Denver, CO 80220-6928
Phone: (303) 692-3038
Fax: (303) 343-3697
Email: robert.quillin@state.co.us

Connecticut: Radiation Control Division
Dept. of Environmental Protection
165 Capitol Avenue
Hartford, CT 03106
Phone: (203) 566-5668

Delaware: Allan Tapert, Program Administrator
Office of Radiation Control
Division of Public Health
P.O. Box 637
Dover, DE 19903
Phone: (302) 739-3787

Fax: (302) 739-3839
Email: atapert@bangate.state.de.us

Florida: William A. Passetti, Chief
Florida Department of Health
Bureau of Radiation Control
1317 Winewood Blvd.
Tallahasse, FL 32399-0700
Phone: (850) 487-1004
Fax: (850) 487-0435
Email: bill_passetti@hcsgwy.hcs.net

Georgia: Thomas E. Hill, Manager
Radioactive Materials Program
Department of Natural Resources
4244 International Parkway, STE 114
Atlanta, GA 30354
Phone: (404) 362-2675
Fax: (404) 362-2653
Email: tom_hill@mail.dnr.state.ga.us

Hawaii: Noise and Radiation Branch,
Environmental Protection and Health Services Division
Department of Health
591 Ala Moana Blvd.
Honolulu, HI 96813
Phone: (808) 548-4383

Idaho: Grant Klokeid, Senior Radiation Physicist
X-Ray and Electronic Products
Laboratory Improvement Section
Division of Health
2220 Old Penitentiary RD.
Boise, ID 83712
Phone: (208) 334-2235
Fax: (208) 334-2382
Email: klokeidg(dhwtowers/towers3/klokeidg)@dhw.state.id.us

Illinois: Paul Eastvold, Manager
Office of Radiation Safety
Department of Nuclear Safety
1035 Outer Park Drive
Springfield, IL 62704
Phone: (217) 785-9918
Fax: (217) 782-1328
Email: eastvold@idns.state.il.us

Indiana: John H. Ruyack, Director
Indoor and Radiologic Health Division

Indiana Department of Health
2 North Meridian Street, 5F
Indianapolis, IN 46204-3003
Phone: (317) 233-7146
Fax: (317) 233-7154
Email: jruyack@isdh.state.in.us

Iowa: Donald A. Flater, Chief
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Iowa Department of Public Health
Lucas State Office Building
Des Moines, IA 50319
Phone: (515) 281-3478
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Email: dflater@idph.state.ia.us

Kansas: Vick L. Cooper, Chief
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Bureau of Air and Radiation
Forbes Field, Bldg. 283
Topeka, KS 66620-0001
Phone: (785) 296-1560
Fax: (785) 296-0984
Email: vcooper@kdhe.state.ks.us

Kentucky: John A. Volpe, Ph.D., Manager
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Cabinet for Human Resources
Mail Stop HS 2E-D
275 East Main Street
Frankfort, KY 40621-0001
Phone: (502) 564-3700
Fax: (502) 564-6533
Email: jvolpe1@mail.state.ky.us

Louisiana: William H. Spell, Administrator
Radiation Protection Division
Office of Air Quality & Radiation Protection
P. O. Box 82135
Baton Rouge, LA 70884-2135
Phone: (504) 765-0160
Fax: (504) 765-0220
Email: bills@deq.state.la.us

Maryland: Roland G. Fletcher, Administrator
Radiological Health Program
Air & Radiation Mgmt. Admin.
Department of the Environment

2500 Broening Highway
Baltimore, MD 21224
Phone: (410) 631-3300
Fax: (410) 631-3198
Email: rf0033@mail.state.md.us

Maine: Acting Manager
Radiation Control Program
Division of Health Engineering
10 State House Station
Augusta, ME 04333
Phone: (207) 287-5698
Fax: (207) 287-4172

Massachusetts: Robert M. Hallisey, Director
Radiation Control Program
Department of Public Health
305 South Street, 7th Floor
Jamaica Plain, MA 02130
Phone: (617) 727-6214
Fax: (617) 767-2098
Email: hallisey@world.std.com

Michigan: David W. Minnaar, Chief,
Radiological Protection Section
MI DEQ, Drinking Water and Radiological Protection Division
Radiological Protection Section
3423 N. Martin Luther King, Jr. Boulevard
P.O. Box 30630
Lansing, MI 48909-8130
Phone: (517) 335-8197
Fax: (517) 335-8706
Email: minnaard@state.mi.us

Minnesota: Judith Ball, Manager
Section of Asbestos, Indoor Air, Lead and Radiation
Division of Environmental Health
PO Box 64975
Minneapolis, MN 55164-0975
Phone: (612) 215-0945
Fax: (612) 215-0976
Email: ballj@mdh-envh.health.state.mn.us

Mississippi: Robert W. Goff, Director
Division of Radiological Health
Department of Health
P. O. Box 1700
Jackson, MS 39215-1700
Phone: (601) 354-6657

Fax: (601) 354-6167
Email: rgoff@msdh.state.ms.us

Missouri: Gary McNutt, Rad. Hlth. Analyst III
Environmental Public Health
Department of Health
P. O. Box 570
Jefferson City, MO 65102-0570
Phone: (573) 751-6160
Fax: (573) 526-6946
Email: gmcnutt@mail.state.mo.us

Montana: George Eicholtz, Coordinator, Radiological Health Program
MT Dept of Public Health and Human Services
Cogswell Building
Licensure Bureau
P.O. Box 202951
Helena, MT 59620-2951
Phone: (406) 444-5266
Fax: (406) 444-1742

Nebraska: Division of Radiological Health
Department of Health
Centennial Mall, South,
Box 95007
Lincoln, NE 68509
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Nevada: Stanley R. Marshall, Supervisor
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Nevada State Health Division
1179 Fairview Drive, STE 102
Carson City, NV 89701-5405
Phone: (702) 687-5394
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Email: smarshal@gov.mail.state.nv.us

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6 Hazen Drive Concord, NH 03301-6527
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New Jersey: Jill Lipoti, Ph.D., Asst. Director
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P.O. Box 415
Trenton, NJ 08625-0415
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New Mexico: William M. Floyd, Program Manager
NM Environment Department
Hazardous and Radioactive Materials Division
P.O. Box 26110
Santa Fe, NM 87502-6110
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New York: Karim Rimawi, Ph.D., Director
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NYS Health Department
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Albany, NY 12203
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North Carolina: Richard M. Fry, Director
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Raleigh, NC 27609-7221
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Email: mel_fry@mail.ehnr.state.nc.us

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P. O. Box 5520
Bismarck, ND 58506-5520
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P.O. Box 118
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Oklahoma: Mike Broderick, Env. Program Administrator
Radiation Management Section
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Fax: (717) 783-8965
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Rhode Island: Marie Stoeckel, MPH, CIH, Chief
Office of Occup. & Rad. Health
Department of Health
3 Capitol Hill, Room 206
Providence, RI 02908-5097
Phone: (401) 222-2438
Fax: (401) 222-2456

South Carolina: Max K. Batavia, P.E., Chief
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DHEC 2600 Bull Street
Columbia, SC 29201
Phone: (803) 737-7400
Fax: (803) 737-7412
Email: batavimk@columb54.dhec.state.sc.us

South Dakota: John Robertson, Medical Facilities Engineer
Office of Health Care Facilities
Licensure and Certification
615 East 4th Street
c/o 500 Capitol

Pierre, SD 57501-5070
Phone: (605) 773-3356
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Fax: (801) 533-4097
Email: eqrad.bsinclai@email.state.ut.us

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Occupational & Radiological Health
Department of Health
P. O. Box 70
Burlington, VT 05402
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Fax: (802) 865-7745

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Main Street Station
1500 E. Main, Rm. 240
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Phone: (804) 786-5932
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Email: lfoldesi@vdh.state.va.us

Washington: John L. Erickson, Director
Division of Radiation Protection
Washington Department of Health
Airdustrial Center Bldg. #5
P.O. Box 47827
Olympia, WA 98504-7827
Phone: (360) 236-3210
Fax: (360) 236-2255
Email: jle0303@hub.doh.wa.gov

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815 Quarrier Street
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Wisconsin: Paul S. Schmidt, Manager
Radiation Protection Unit
Bureau of Public Health
Dept. of Health & Family Services
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Madison, WI 53701-0309
Phone: (608) 267-4792
Fax: (608) 267-4799
Email: schmips@dhfs.state.wi.us

Wyoming: Radiological Health Services
Division of Health and Medical Services
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Appendix D - ARS Components

D1. Standard Components

see Figure D1 for ARS Standard Components Diagram.

Table A1.1 ARS Spare Parts Maintenance Procedures			
Cage Code	**Part Number**	**Component**	**Maintenance Procedures**
32101	120361	Control Unit	Replace Control Unit, return defective part to depot for repair
32101	120312	X-ray Imager	Replace X-ray Imager, return defective part to depot for repair
OBLZ9	DRC22-1535U	Battery Charger Kit	Replace battery charger kit
007V7	DR-35S	Battery	Recharge or replace battery
75915	239002	2Amp Fuse	Replace fuse
OEHX4	MDL-8	8 Amp Fuse	Replace fuse
32101	120211	Controller Transport Case	Replace transport case
32101	120210	Imager Transport Case	Replace transport case
32101	120258	Cable with Cigarette lighter end	Replace cable

Table A1.1

NANCE

Table A1.1 ARS Spare Parts Maintenance Procedures (Cont.)			
Cage Code	**Part Number**	**Component**	**Maintenance Procedures**
32101	120254	Cable that connects the imager to the X-ray generator	Replace cable
8K411	17566	AC Power Cable	Replace cable
32101	120257	12 VDC Power Cable	Replace cable
32101	120217	Cable Reel Assembly	Replace cable and/or reel assembly
32101	120218	Extension Cable Reel Assembly	Replace extension cable and/or reel assembly
n/a	MN3734	Modem	Replace modem

Table A1.1

Table B2.1 Troubleshooting Actions		
Symptom/Indication	**Test**	**Corrective Action**
AC power applied, green battery LED not illuminated but system boots on battery power, red battery LED illuminates	Check source voltage Check AC fuse Check power cable	Verify there is AC power. If necessary replace AC fuse. Replace power cable.
System won't operate on internal battery power, red battery LED not illuminated	Connect to external AC or DC power source, if green battery LED illuminates, take corrective action	Replace or recharge internal battery.
External DC power applied, green battery LED not illuminated, system won't boot	Check source voltage Check 12 VDC fuse	Verify there is DC power. If no, wait for DC thermal fuse to reset (5 min. with no power).
System halts while booting or while operating	Cycle power switch to the "OFF" position for 10 seconds, reboot system	If symptom does not clear, reload system software.
Power LED illuminated, no display		Restart unit and retry
Display present, but no image acquired. X-ray source not firing	Check cabling between the Imager and X-ray source Ensure both the X-ray source and the Controller interlock keys are in the "ON" position. Verify that the LCD display on the X-ray source is set to 99. Attempt to fire the X-ray source.	Imager to X-ray Source cable may need replacing.
Display present, but no image acquired. X-ray source fires	Replace X-ray Source.	Check cumulative pulses, X-ray tube may need replacing.
Display present but image is dark	Position the X-ray source 61 cm from the Imager screen with the beam centered to the screen. Fire the X-ray source for 7 pulses, the highest screen intensity should read between 190 and 255 at the intensity indicator on the Status Bar	Replace the X-ray tube if intensity is lower than 190. Retest, if still low, X-ray Source may be malfunctioning.
Screen is blank	This is probably the battery saving feature that goes into effect after two to four minutes of non-use.	To reactivate the screen, move the mouse of press the shift key. NOTE: DO NOT press any other key as it may perform an undesirable function.
Two-thirds of image appears on screen with one-third of image black on the right-hand side.	Check computer desktop settings.	Go to Control Panel Display Properties and choose Settings; set Font size to Small Fonts.

Table B2.1

Table B3.1 Potential Error Messages	
Potential Error Messages	**Definition**
BMP Header size exceeds Var Buffer - TCP Error.	This message occurs whenever an attempt to convert received data into a BITMAP (*.bmp) image file would cause the receive buffer (variant array) to be overrun. This is caused by the amount of data received being less than the size of the bitmap header (1070 bytes) indicating that the received data is not image data.
Computer Not Connected! – TCP Error Message.	This message is displayed whenever the control unit is not connected and an attempt was made to send a command to the imager.
Connection Timeout! - TCP Error.	Socket connection 20-second timeout elapsed, socket failed to connect.
Can't Allocate Memory – Error.	Attempt to allocate memory for Rainbow Image data failed.
Can't Copy to Memory - Error.	Attempt to copy Rainbow Image data to local memory failed.
Can't Lock Memory - Error.	Attempt to lock allocated memory for Rainbow Image data failed.
Contrast Method Error - Error Message.	HistoEqualize function failed to perform ROI contrast adjustment.
Destination Window Must Have an Image	Add Error or Subtract Error.
Error in Directory Name! - Error.	Invalid directory name.
FeedLoad Error - TCP Error.	The FeedLoad function failed. This function is used to load image data over the network into the image buffer.
File Open Error - Error Message.	Log file, Hidden.log or ROIStats.log could not be opened. Result is that log file is not updated with selected TCP Receive data (formatted), I/O Data (unformatted) or ROI statistics.
File Write Error - Error Message.	Log file, Hidden.log or ROIStats.log write operation failed. Result is that log file is not updated with selected TCP Receive data (formatted), I/O Data (unformatted), or ROI statistics.
Fire X-Ray cannot execute with Key switch off! - Acquire X-Ray Message.	This message is displayed whenever an attempt is made to Fire the X-Ray source without the safety key switch is in the off position.
Original Number SaveMemory Error - Error Message.	This message is displayed whenever the SaveMemory function fails. This function is used to save image bitmap data into a temporary memory buffer. The temporary memory buffer is used to speed up the Original Number calculation.
Post-Connect Delay cannot be less than 1 - TCP Message.	Response to invalid parameter input to "Input Post-Connect Delay" dialog box.
Power Up Delay cannot be less than 1 - TCP Message.	Response to invalid parameter input to "Input Power Up Delay" dialog box.

Table B3.1

Table B3.1 Potential Error Messages (Cont.)	
Potential Error Messages	**Definition**
The displayed image is about to be overwritten! Do you want to save this data before continuing? - Buffer Protection.	This message is used to prevent accidental overwriting of the current image buffer.
Please Disable Shrink-To-Fit Mode before attempting to add Annotation. - Disable Shrink Mode.	Warning message used to prevent an illegal operation, i.e., Shrink-To-Fit Mode and Annotation are not compatible. The image should be set to 1:1 zoom before annotating with either white or black text or lines.
Please Disable Shrink-To-Fit Mode before attempting to select a Region of Interest. - Disable Shrink Mode.	Warning message used to prevent an illegal operation, (i.e., Shrink-To-Fit Mode and Region-0f-Interest (ROI) processing are not compatible.) The image should be set to 1:1 zoom before using the ROI tools.
TCP Receive Timeout! - TCP Error.	20-seconds has elapsed since a command was sent to the imager without a corresponding response.
Please Disable Shrink-To-Fit Mode before attempting to measure Distance. - Disable Shrink Mode.	Warning message used to prevent an illegal operation, (i.e., Shrink-To-Fit Mode and Distance Measurement processing are not compatible.) The image should be set to 1:1 zoom before performing Distance Measurements.
Failed to connect with Imager. Please check cable. - TCP Error.	An error occurred during socket connection that indicates the server could not be found. The cable connection between the control unit and the imager should be checked to insure proper connection.
GetFileInfo Failed - Cannot Read Header - Error Message.	The GetFileInfo function failed during attempt to read the comment fields in TIFF file format.
Get Histogram Failed – Error Message.	GetHistogram function failed to provide ROI Histogram for statistics calculations.
Horizontal Edge Detect Error - Error Message.	SpatialFilter function failed to perform ROI Horizontal Edge Detection operation.
Horiz. Res. Value Out of Range - Error Message.	Horizontal resolution value input is out of the range for the current imager.
LAN Connection TimeOut! - TCP Error.	A five second timeout occurred during the power-up initialization sequence for the control unit due to LAN connection failure with the imager.
Message Parse Error! - TCP Error.	A error occurred trying to decode the message reply from the iamger.
Original Buffer Required As Source Window - Add Error or Subtract Error.	Try function again, starting with Original buffer.
Original Number SaveMemory Error - TCP Error.	The SaveMemory function failed during a copy of image data into a local memory buffer used to calculate the Original Number.
Server Closed Connection - TCP Error.	The socket connection was closed by the server (or imager).
Source Window Must Have an Image - Add Error or Subtract Error.	Add or subtract error. Check initial conditions for function.
Start FeedLoad Error - TCP Error.	The StartFeedLoad function failed. This function is used to start the loading of image data over the network into the image buffer.

Table B3.1

Table B3.1 Potential Error Messages (Cont.)	
Potential Error Messages	**Definition**
StopLoading Error – TCP Error.	An attempt to continue loading image data over the network after the total file size was received occurred.
Unknown File Format - TCP Error.	Received image data cannot be identified as either a TIFF file or raw image data file.
Vertical Edge Detect Error - Error Message.	SpatialFilter function failed to perform ROI Vertical Edge Detection operation.
Vert. Res. Value Out of Range - Error Message.	Vertical resolution value input is out of the range for the current imager.
Lead Error – Error Writing File	Disk is full, no room for image.
Fire X-ray cannot execute with key switch off – Error	To fire image, rotate key.

Table B3.1

Table B4.1 Variable Text Messages	
Variable Text Messages	**Definition**
TCP Error message header data, TCPUnit.	This error message will have the following format. **ERROR_MSG<first characters of received message>** The received message can be one of: GET_IMAGER_CAPAB SET_IMAGER_PARAM GET_IMAGE GET_TESTIMAGE GET_STATUS SET_IO RESET SEND_STRING GET_STRING Any of the errors shown here indicate a failed imager or a new version of the Insight software that is not working properly.

Table B4.1

Table C8.1 Metric Requirements for Control of Main Beam to Produce a Dose of Less than 2 mR				
# of Images	Controlled Distance in Beam Path (m)	Thickness of Concrete Shielding at .9 m (cm)	Thickness of Concrete Shielding at 3 m (cm)	Thickness of Lead Shielding on Drywall at 3 m (cm)
1	1.5	3.6	0	0
5	3.35	4.6	0	0
10	4.94	6.4	3.6	0.64
20	6.98	8.6	4.1	0.71
50	11.0	10.4	4.6	0.89
100	15.5	13.7	6.4	1.3
200	21.9	17.8	8.6	1.9
500	34.7	20.8	10.4	2.4
1000	49.4	23.1	13.7	3.2

Table C8.1

Table C8.2 Metric Requirements for Control of Main Beam to Produce a Dose of Less than 100 mR				
# of Images	Controlled Distance in Beam (m)	Thickness of Concrete Shielding at .9 m (cm)	Thickness of Concrete Shielding at 3 m (cm)	Thickness of Lead Shielding on Drywall at 3 m (cm)
1	1.8	0	0	0
5	4.1	0	0	0
10	5.82	0	0	0
20	8.23	.51	0	0
50	13.0	3.0	0	0
100	18.4	4.1	0	0
200	25.9	5.6	.3	0
500	41.1	8.1	3.0	.43
1000	58.2	10.2	4.1	.69

Table C8.2

Table 1.1 ARS Volume and Weight

Components	Volume and Weight
Everything but the x-ray generator in two transport cases	✓ Volume .24 m^3 ✓ Weight: 45.2 kg
On-target equipment (imager, x-ray cable, two 50 meter cables)	✓ Volume: 0.039 m^3 ✓ Weight: 11.8 kg

Table 1.1

Table 1.2 ARS Standard System Components

Components	Description
Control Unit	✓ Lightweight, ruggedized aluminum housing with a fully integrated Pentium 133 MHz (or faster) processor, 26 cm (10.4") active matrix color flat panel display, custom software, over 2 Gbyte internal hard drive, 1.4 Mbyte floppy disk drive, two PCMCIA (Personal Computer Memory Card International Association) slots, 28.8 kbaud removable PCMCIA modem card.
	✓ 110/220 VAC 60/50 Hz, 9.5 to 28 VDC auto-sensing, auto-switching
	✓ One internal 10.8 VDC rechargeable smart battery (DR35S compatible)
	✓ Dimensions: 32 cm x 13 cm x 26.5 cm (12.5" W x 5" H x 10.5" D)
	✓ Weight: 6.8 kg (15 lbs.) including smart battery pack
X-ray Imager	✓ Compact solid-state camera with 20 x 25 cm (8" x 10") field-of-view. Electro-optical system records images formed on the Imager's X-ray conversion screen and transmits the images to the Control Unit.
	✓ Dimensions: 30 cm x 34 cm x 18 cm (11.75" W x 13.25" H x 7" D)
	✓ Weight: 4.4 kg (9.4 lbs.)
	✓ Power: 12 VDC (supplied by link to Control Unit)
Cables	✓ One 50 m (164 ft) cable on a reel assembly supplies power from the Control Unit to the Imager
	✓ One 50 m extension cable on a reel assembly connects the 50 m cable above with the Imager
	✓ 7 m (22 ft) control cable connects the Inspector 200 X-ray generator to the Imager
	✓ 2 m (7 ft) AC power cable supplies power to the Control Unit
	✓ 2 m fused cable connects the Control Unit to a 12 VDC automobile cigarette lighter receptacle
	✓ 6 m (20 ft) cable with battery clip ends connects the Control Unit to an external battery generator
Battery Charger Kit	✓ External dual smart battery charger
	✓ Power transformer: 110 VAC, 60 Hz input
	✓ Standard 2 m (7 ft) AC power cord
Transport Cases	✓ Watertight, crushproof, foam-lined case for storing and transporting the Controller
	✓ Controller transport case weight (empty): 12.2 kg (27 lbs)
	✓ Imager transport case weight (empty): 12.4 kg (27.5 lbs)
Keys	✓ Control Unit Interlock Key

Table 1.2

Table 1.3 ARS Accessory Items	
Components	**Description**
Cables (Optional)	✓ Optional: 2 m (7 ft) country-specific power cable ✓ Optional: 2 m power cable to connect the Golden Engineering XR200 ✓ Optional: 2 m power cable to connect the Golden Engineering Inspector 200
Golden Engineering XR200 X-ray generator* (Optional)	✓ Single-package, pulsed 150 kV device with a 40-degree beam angle. Produces extremely short bursts of X-rays capable of penetrating several centimeters of most materials. ✓ Dimensions: 11.5 cm x 19 cm x 32 cm (4.5" W x 7.5" H x 12.5" D), the front half is a canister with a diameter of 4 cm (1.6") ✓ Weight: 5.5 kg (12 lbs.) including battery ✓ Tube life: 100,000 pulses ✓ Power: self-contained, 14.4 VDC removable, rechargeable nickel-cadmium battery pack (provided) ✓ Battery charger *Please refer to the Golden Engineering Operator's Manual for more information.
Golden Engineering Inspector 200* (Optional)	✓ Tube life: 35,000 pulses ✓ Power: 110/220 VAC or 12 VDC self contained, removable rechargeable lead-acid battery *Please refer to the Golden Engineering Operator's Manual for more information.

Table 1.3

Table 1.4 ARS SPARE Items			
Cage Code	**Part Number**	**Component**	**Description**
32101	120361	Control Unit	✓ Lightweight, ruggedized aluminum housing with a fully integrated Pentium 133 MHz (or faster) processor, 26 cm (10.4") active matrix color flat panel display, custom software, over 2 Gbyte internal hard drive, 1.4 Mbyte floppy disk drive, two PCMCIA slots, 28.8 kbaud removable PCMCIA modem card. ✓ 110/220 VAC 60/50 Hz, 9.5 to 28 VDC auto-sensing, auto-switching ✓ One internal 10.8 VDC rechargeable smart battery (DR35S compatible) ✓ Dimensions: 32 cm x 13 cm x 26.5 cm (12.5" W x 5" H x 10.5" D) ✓ Weight: 6.8 kg (15 lbs.) including smart battery pack
32101	120312	X-ray Imager	✓ Compact solid-state camera with 20 x 25 cm (8" x 10") field-of-view. ✓ Dimensions: 30 cm x 34 cm x 18 cm (11.75" W x 13.25" H x 7" D) ✓ Weight: 4.4 kg (9.4 lbs.) ✓ Power: 12 VDC (supplied by link to Control Unit)
OBLZ9	DRC22-1535U	Battery Charger Kit	✓ External dual battery charger ✓ Power transformer: 100 – 240 VAC, 47 – 63 Hz input ✓ Standard 2 m (7 ft) AC power cord
007V7	DR-35S	Battery	✓ 10.8 VDC rechargeable battery
75915	239002	2Amp Fuse	✓ 2 Amp, 250V fuse for the Controller
OEHX4	MDL-8	8 Amp Fuse	✓ 8 Amp, 250V fuse for the cigarette lighter adapter
32101	120211	Controller Transport Case	✓ Watertight, crushproof, foam-lined case for storing and transporting the Controller
32101	120210	Imager Transport Case	✓ Watertight, crushproof, foam-lined case for storing and transporting the Imager
32101	120258	Cable	✓ 3 m (10 ft) fused cable connects the Control Unit to a 12 VDC automobile cigarette lighter receptacle
32101	120254	Cable	✓ Imager to X-ray generator

Table 1.4

Table 1.4 ARS SPARE Items (Cont.)			
Cage Code	**Part Number**	**Component**	**Description**
8K411	17566	Cable	✓ AC power cord
32101	120257	Cable	✓ 12VDC power supply cable
32101	120217	Cable Reel Assembly	✓ 50 m power cable on a reel assembly connects the Control Unit to the Imager
32101	120218	Extension Cable Reel Assembly	✓ 50 m extension cable on a reel assembly connects the cable above to the Imager
n/a	MN3734	Modem	✓ PCMCIA format, removable ✓ Speed: 28.8 Kb/s ✓ Telephone connector: World

Table 1.4

Table 2.1 Standard ARS Components	
Container	**Contents**
Transport Case 1	ARS Control Unit, two 50-meter cables on reels, keys
Transport Case 2	X-ray Imager, 7 meter Imager to X-ray Generator cable, ARS Control Unit power cord (space is also provided for an X-ray Generator)

Table 2.1

Table 2.2 Battery Charge Indicator Light	
LED State	**Status**
Flashing green	Battery is being charged
Solid green	Battery is fully charged
Solid red	System is being run from internal battery
Flashing red	Battery is about to lose charge, and will shut down in less than 5 minutes

Table 2.2

Table 3.1 Function Options			
Pull-Down Menu Function	**Function Key**	**Key Combination**	**Icon**
Acquire	F1		
Quick Save	F2		
Open	F3		
Save As...	F4		
Print		<Ctrl-P>	
Exit		<Alt-X>	
Zoom		Zoom in – PgUp	
Grayscale Invert			
Contrast Stretch	F5		
Auto Stretch	F6		
Switch Buffers	F7		
ROI Processing			
Sharpen (Moderate)	F8		
Smooth (Moderate)	F9		
Help	F10	<Ctrl-H>	
Key Map		<Ctrl-K>	
Open File Menu		Alt-F	
Open Acquire Menu		Alt-A	

Table 3.1

Table 3.2 Acquire Options			
Command	**Description**	**Input Range**	**Default**
X-Ray Pulses	Sets the number of times that the generator will pulse on firing	5-99 pulses	7 pulses
Delay Timer	Sets the time delay before the generator fires	0-300 sec	0 sec

Table 3.2

Table 3.3 Image Storage Options		
Storage Method	**Maximum Capacity**	**Drive**
Internal Hard Drive	Over 2000 images	C:
1.4 Mbyte Floppy Disk Drive	4 Images per disk	A:
Optional PCMCIA Hard Drive	System-defined	D:

Table 3.3

Dose Limits	(See 10CFR for complete table)	
Population	**Limits**	
	Hourly	**Annual**
Occupational	2mR	5000mR
General Public	2mR	100mR

Table 5

Table 6

Utilization Log

Source Serial #	Use Location	Use Date	User	Voltage/ Current	Exposure Time (Pulses)	PIC#	PIC Initial Value	PIC Final Value	NET DOSE (mREM)

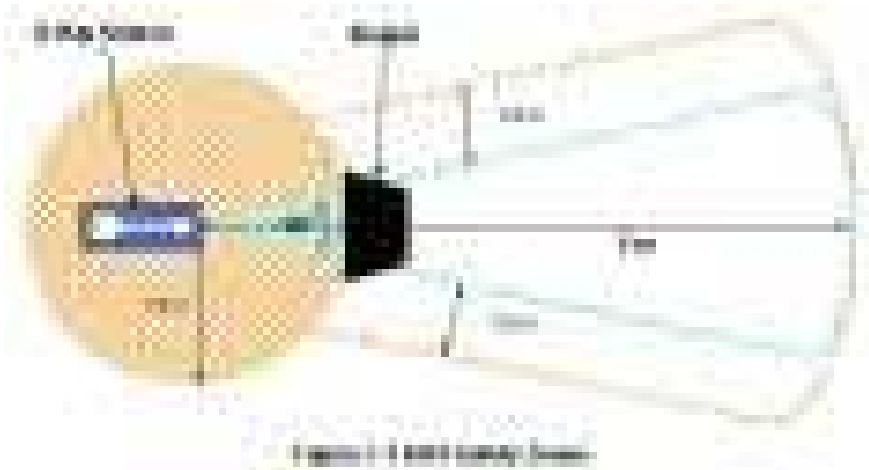

Figure C.1

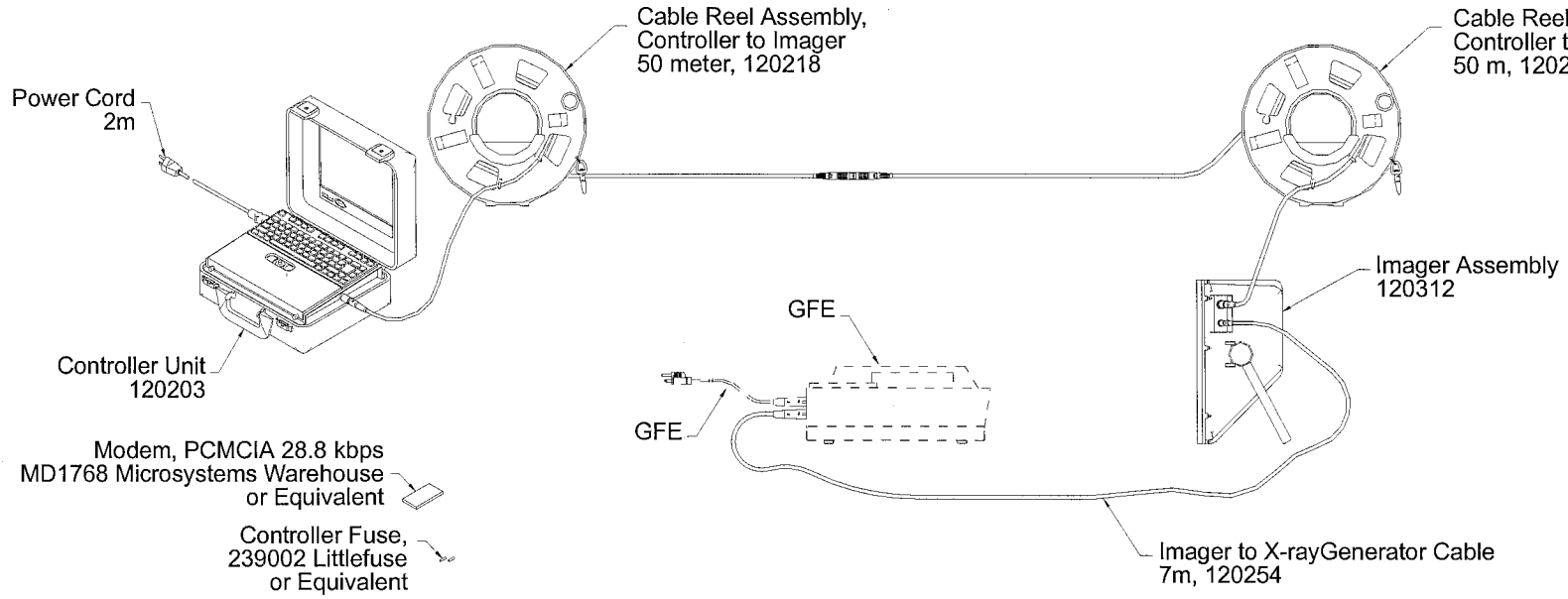

Figure D1 ARS Standard Components Diagram.

Figure D.1

ARS STANDARD COMPONENTS DIAGRAM

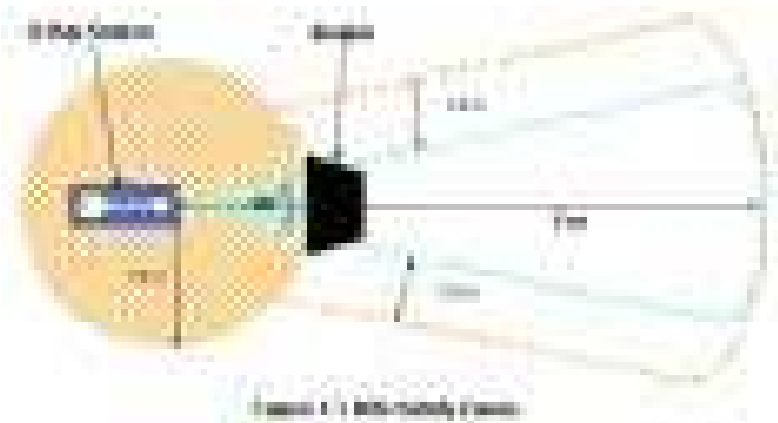

Figure 1.1

Figure 2.1 Fully assembled ARS showing the system components and cable interconnections.

Figure 2.1

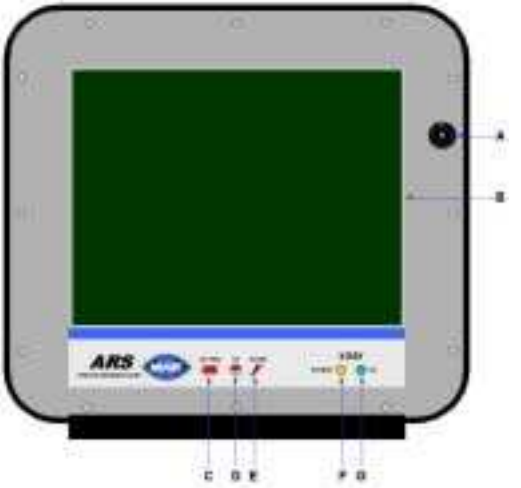

Figure 2.2

Figure 2.3

Figure 2.4 Key Pad opened revealing battery compartment.

Figure 2.4

Figure 2.5 ARS Imager and X-Ray Generator in position to image objects on the ground.

Figure 2.5

Figure 2.5 ARS Imager and X-Ray Generator in position to image objects off the ground.

Figure 2.6

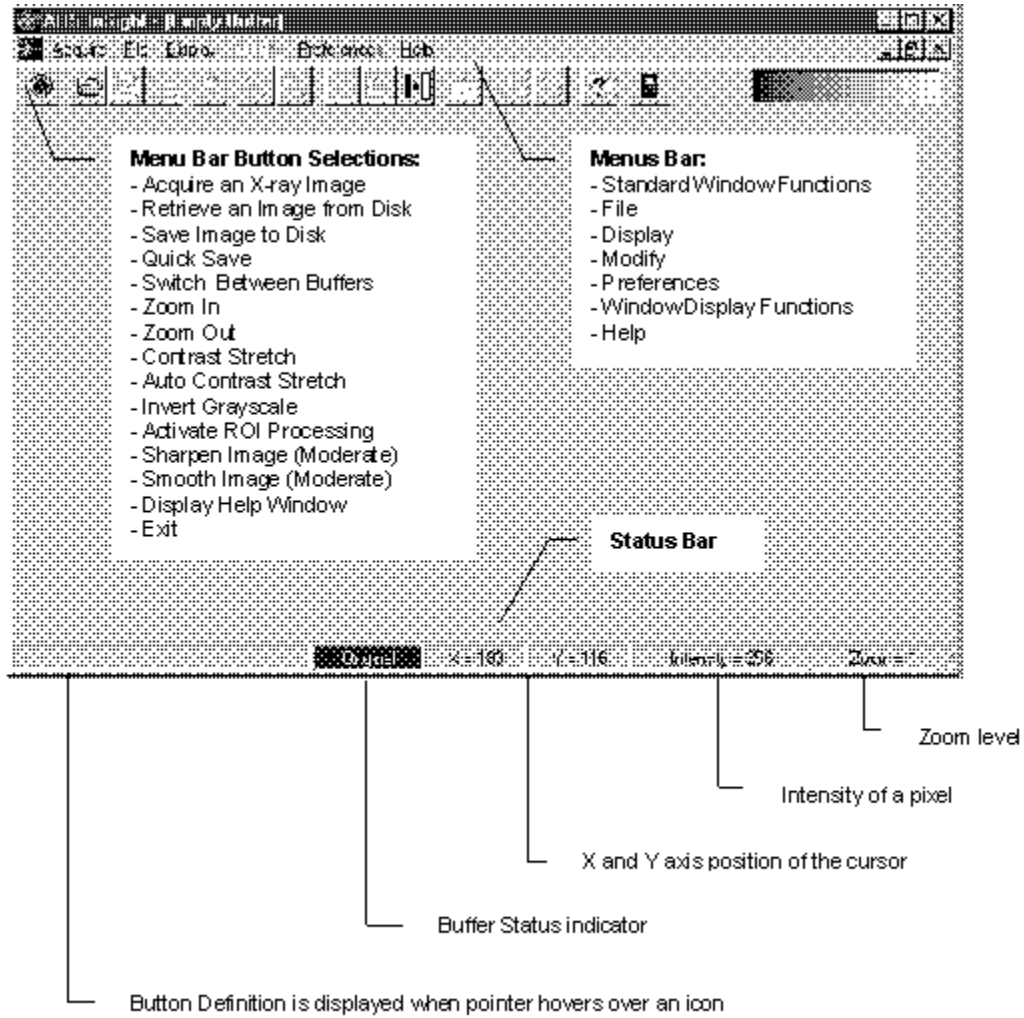

Figure 2.7 ARS User Interface Main Menu screen showing menu bar on the top, icons bar below, and status bar at the bottom.

Figure 2.7

Figure 2.8

Figure 2.9

Figure 3.1

Figure 3.2

Figure 3.3

Figure 3.4

Figure 3.5

Figure 3.6

Figure 3.7

3.3.3 DIALOG BOX

Figure 3.8

CHOOSING THE DISPLAY MENU

Figure 3.9

Figure 3.10

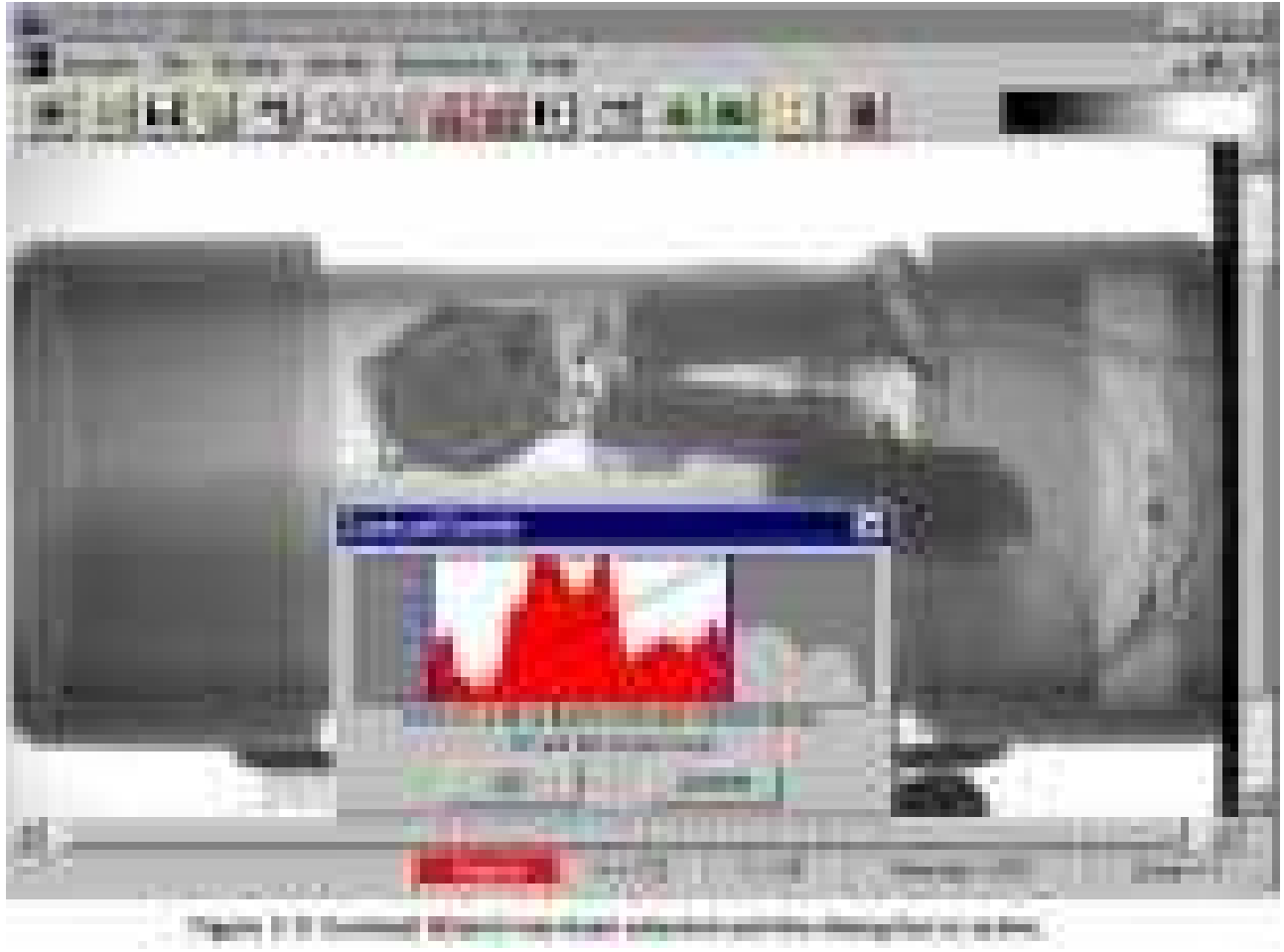

Figure 3.11

Figure 3.12

Figure 3.13

Figure 3.14

Figure 3.15

Figure 3.16

Figure 3.17

Figure 3.18

Figure 3.19

Figure 3.20

Figure 3.21

Figure 3.22

Figure 3.23

Figure 3.24

TO THE IMAGE

Figure 3.25

Figure 3.26

Figure 3.27

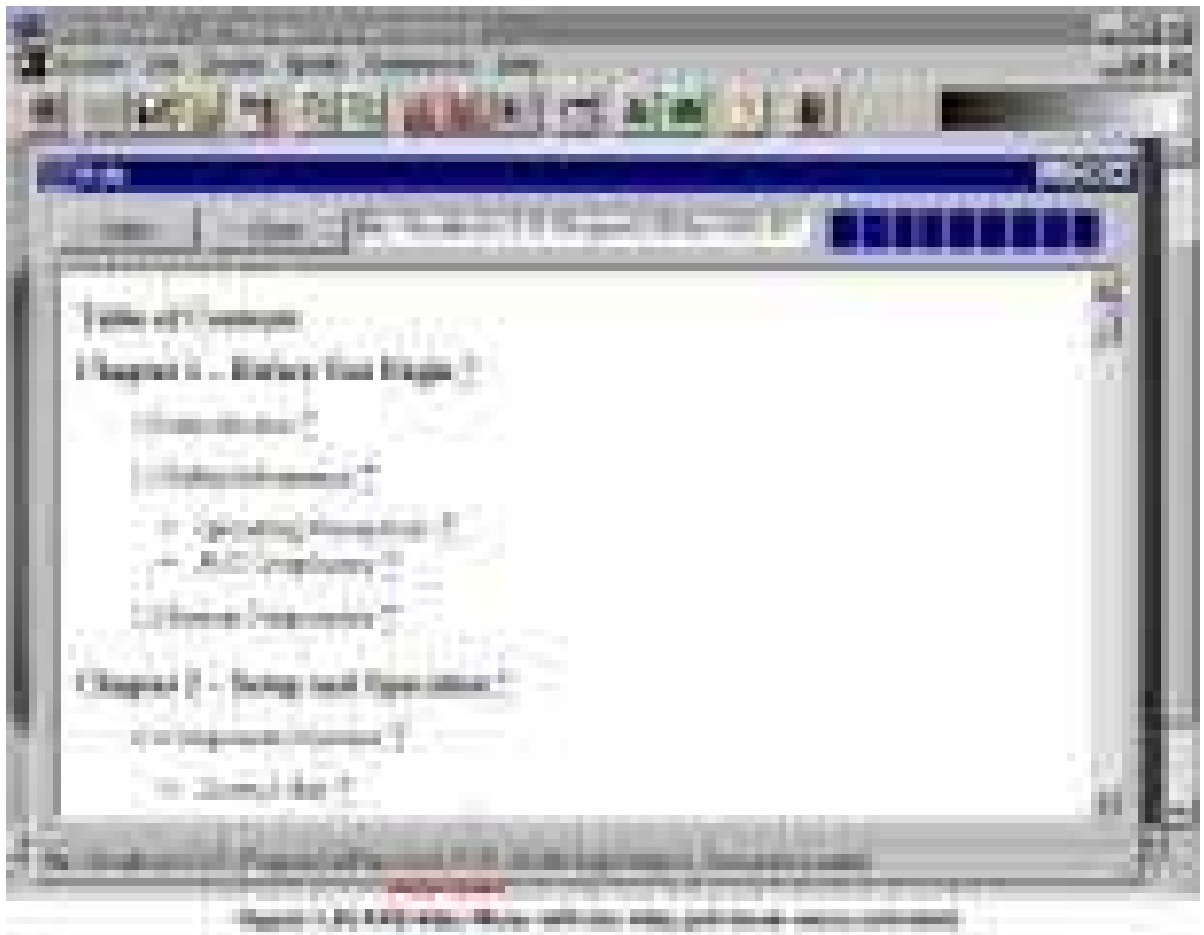

Figure 3.28

Figure 3.29

Figure 3.30

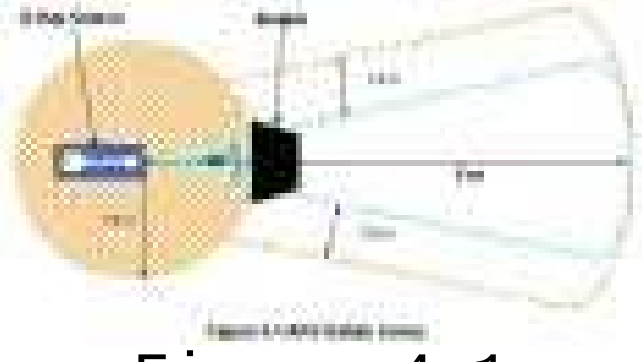

Figure 4.1