Reducing the Network Bandwidth of an SSR System

Certain measures can be taken to reduce the COMRIC Message traffic on the network. The following recommendations are rated in priority based on simplicity of implementation and bandwidth reduction.

These recommendations are based on an architecture where a remote site is communicating back to a central site. The remote site contains a PC-RP (or multiple PC-RPs), Camera Manger and AIS Receiver. The central site contains one or more RDOP Stations and a Composite Tracker.

It is assumed the remote site is providing coastal surveillance coverage, where there is partial coverage of the terrestrial environment and partial coverage of the marine environment.

A real-life example with measured bandwidth reductions is provided at the end of this study. The baseline average bandwidth from the site is approximately 2474 kbps; this study will show how to reduce this bandwidth to 197 kbps without significant degradation to the operational nature of the system. This is over a 92% reduction in bandwidth.

Note: All values are subject to change based on environment, at a minimum a 20% overhead should be included for status and control message communication.

PC-RP / Tracker Recommendations:

Base Bandwidth for Radar Image: 623 kbps (~4000 Centroids)

Base Bandwidth for Tracks: 53 kbps (~120 Tracks)

1. Blanking Sectors:
   - Description:
     - Since the focus is on the marine environment one can blank radar transmissions over land. This will eliminate data transmission of the Radar Image, Contacts and Centroids over land. The drawback is that land is typically not defined by a starting and ending azimuth because of the contours of the coastline.
   - Implementation:
     - From RDOP, select System→Maintenance→RP Config→Port Config. Under Port Config enter in the beginning and ending azimuth of the land coverage in the Blanking Fields.
   - Percent Reduction:
     - 40% Reduction from Base (60% of Base Radar Image) [160° Blanked]

2. Landmask Graphics:
   - Description:
     - Since the focus is on the marine environment one can remove radar processing over specific unnecessary regions. Landmask graphics allow one to better define contours and can include other areas such as islands and high clutter regions. This will eliminate data transmission of the Radar Image, Contacts and Centroids within the defined regions. The drawback is the regions drawn by the operator are usually coarse and each mask is limited to 32 points. Areas of interest close to land may be masked.
   - Implementation:
     - From RDOP, Right-Click and create a Polygon Graphic. Right-Click on the graphic and associate it with an Image Landmask. Create Landmask Graphics for each land section, island, and high clutter region.
   - Percent Reduction:
     - 81% Reduction from Base (19% of Base Radar Image)

3. Landmask File:
   - Description:
     - This is the most effective means of removing radar data in unnecessary land regions. Landmask files can be generated by SSR from Unencrypted S57 Charts and are not limited to 32 points. These files will provide the best masking resolution. These files are loaded up by the PC-RP at runtime. This will eliminate data transmission of the Radar Image, Contacts and Centroids within the defined regions. The drawback is that a specific file format is required and may be difficult to obtain.
   - Implementation:
     - One must provide SSR with an Unencrypted S57 Chart of the region. SSR will provide a file named 'rp_landmask.txt' which needs to be placed on the PC-RP under /data/landmask/. Landmask Graphics may still be required for unnecessary high clutter regions.
   - Percent Reduction:
     - 55% Reduction from Base (45% of Base Radar Image)

4. Image Contrast:
   - Description:
     - The image contrast should be set to 100, which will reduce the amount of resolution each radar image cell provides. By default the PC-RP should have its image contrast set to 100.
   - Implementation:
     - From RDOP, select System→Maintenance→Image_Control. Verify the Image Contrast Slider is set to 100.
   - Percent Reduction:
     - N/A, this should already be implemented.

5. Image Update Rate:
   - Description:
     - The image update rate for Range/Azimuth Image Types can be adjusted so that images are only transmitted once every X number of scans (Up to 3 Scans). Assuming this value is set to 3 Scans, a 2.5 Second Scan Rate Radar (24 RPM) will refresh on the RDOP every 7.5 seconds. In normal operation the image sectors are continually outputted, in this manner the entire image will burst every 3 Scans. The drawback is that if bursts cannot be handled, some of the image data may be dropped.
   - Implementation:
     - From RDOP, select System→Maintenance→Image_Control. Change the Update Rate to 3 Scans.
   - Percent Reduction:
     - 68% Reduction from Base (32% of Base Radar Image) [3 Scans]

6. Throttled Track Output:
   - Description:
     - **Note:** This assumes that the Composite Tracker is located at the remote site (See Alternate Site Configuration); if the Composite Tracker is instead located at the central site and tracks are only viewed at the central site then this is Not Applicable.
       By throttling the track output rate, tracks that are not moving quickly will output less frequently while high velocity tracks will maintain a fast update rate.
   - Implementation:
     - From the Composite Tracker's Desktop, Right-Click and select Sys Cfg. Under the Tracker Type selection a prompt will appear to add additional tracker options. Type Y to confirm, then type '-O 4 60 50'. These arguments will output the fastest tracks at a 4 second rate, the slowest tracks at a 60 second rate and medium velocity tracks at a rate between 4 and 60 seconds. Save the Sys Cfg changes and reboot the Composite Tracker.
   - Percent Reduction:
     - 62% Reduction from Base (38% of Base Track Output)

7. Centroids Only (No Contacts or Radar Image):
   - Description:
     - A Centroid is a data point which defines a cluster of radar returns. The position and shape of the cluster is transmitted through this Centroid Message. The RDOP can be configured to show the position and shape of these Centroids. The drawback is image data will not be viewable, however Centroids provide a very good representation of the radar image.
   - Implementation:
     - Reserved.
       [Future Implementation, Contact SSR Engineering]
   - Percent Reduction:
     - 73% Reduction from Base (27% of Base Radar Image)

8. Contacts Only (No Centroids or Radar Image):
    - Description:
        o A Contact is a data point which defines a cluster of radar returns. As opposed to the Centroid, only position data is provided (no shape data). The RDOP can be configured to show the position of these Contacts. The drawback is that image data will not be visible; Contacts provide limited information about the underlying radar data.
    - Implementation:
        o From the central site's RDOPs (must be performed on each RDOP Station), open the Composite Image Selector and deselect all Radar Images (select only Plots). From the RDOP, select Display and enable the checkbox labeled 'Contacts'.
    - Percent Reduction:
        o 82% Reduction from Base (18% of Base Radar Image)

9. Track Only (No Centroids, Contacts, or Radar Image):
    - Description:
        On RDOP there will be no presentation of the underlying radar data, only tracks will be presented to the operator. By default the RDOP shows the track data. The drawback is image data will not be viewable; the operator will not have an understanding of the underlying data that created the tracks.
    - Implementation:
        o From the central site's RDOPs (must be performed on each RDOP Station), select the Desktop, Right-Click and select X-Term. Change Directory (cd) to /usr/local/ssreng/rdop/. Under this directory open the file called rdop_priv.cfg.sample. The file provides instructions on how to use this file. You must enter in 'DISABLE_RADAR_IMAGE_VIEWING = all'. Follow the in-file instructions on saving the modified file in the proper location. Save changes and reboot the RDOP.
    - Percent Reduction:
        o 100% Reduction from Base (0% of Base Radar Image)

Camera Recommendations:

Base Bandwidth for Camera: 43 kbps
         (1 Second Update Rate, 704x480 Resolution, 30% Compression)

1. Reduce Update Rate on RDOP:
   - Description:
     - The RDOP Camera Client requests image snapshots from the Camera Manager. This update rate is configurable from the Camera Client. Increasing the rate will greatly reduce the bandwidth of the camera images. The drawback is that some infrequent critical information may appear and leave before the update occurs.
   - Implementation:
     - From the RDOP's Camera Client, set the Update Rate to the highest rate available (4 Seconds).
   - Percent Reduction:
     - 75% Reduction from Base (25% of Base Camera Image) [4 Seconds]

2. Modify Compression Factor on Axis Server:
   - Description:
     - The Axis Server provides jpeg snapshots of the camera's image. The compression factor of these jpeg images can be adjusted; this will reduce the size of the image. The drawback is that the quality of the image will be reduced; typically compression can be applied to a certain point before noticeable reduction in quality is present. The drawback is that if the compression factor is set too high, some of the image may be distorted and identification will become difficult.
   - Implementation:
     - Log into the Axis server from a Web Browser (Default Login is root and Password is root). Under Video & Image Settings, increase the Compression value. This value is typically set to 30; a range of 50-60 should still provide acceptable image quality.
   - Percent Reduction:
     - 25% Reduction from Base (75% of Base Camera Image) [50% Compr]

3. Modify Resolution on Axis Server:
   - Description:
     - The Axis Server provides jpeg snapshots of the camera's image. The resolution of this image can be adjusted; this will reduce the size of the image. The drawback is that if the resolution factor is too low, some of the image may be distorted and identification will become difficult.
   - Implementation:
     - Log into the Axis server from a Web Browser (Default Login is root and Password is root). Under Video & Image Settings change the Resolution value. This value is typically set to 704x480; this can be reduced to 352x240 or 176x120.
   - Percent Reduction:
     - 63% Reduction from Base (37% of Base Camera Image) [352x240]

Network Recommendations:

1. Implement Multicast:

   - Description:
     - o By default the SSR COMRIC Messages are transmitted via Unicast. If multiple RDOP Stations are viewing the same data at the central site, the remote site will send multiple copies of the data (one for each requesting RDOP Station). By implementing Multicast, only a single copy of the data will be transmitted from the remote site to the central site. This could dramatically reduce the bandwidth. The drawback is the difficulty of implementation – only an experienced Network Administrator should implement Multicast.

   - Implementation:
     - o **Note:** Only an experienced Network Administrator should implement Multicast. On all SSR Equipment, remote and central sites, open up Net Cfg. In Net Cfg, enter in the Multicast Base value under 'Multicast Base (Complete)'. Save the changes and reboot the system. Continue to perform this action on all the equipment.

   - Percent Reduction:
     - o 1- (1 / Num_Of_Stations) % Reduction from Base

Real-World Bandwidth Study

In this study, a PC-RP, AIS Receiver and Camera Manager at a remote site send data to a local RDOP. The baseline average bandwidth from this site is approximately 2474 kbps; this study will show how to reduce this bandwidth to 197 kbps without significant degradation to the operational nature of the system. This is over a 92% reduction in bandwidth.

Note: This bandwidth study does not include bandwidth reduction for implementing Multicast. It is assumed only one RDOP station is requesting the remote site's information.
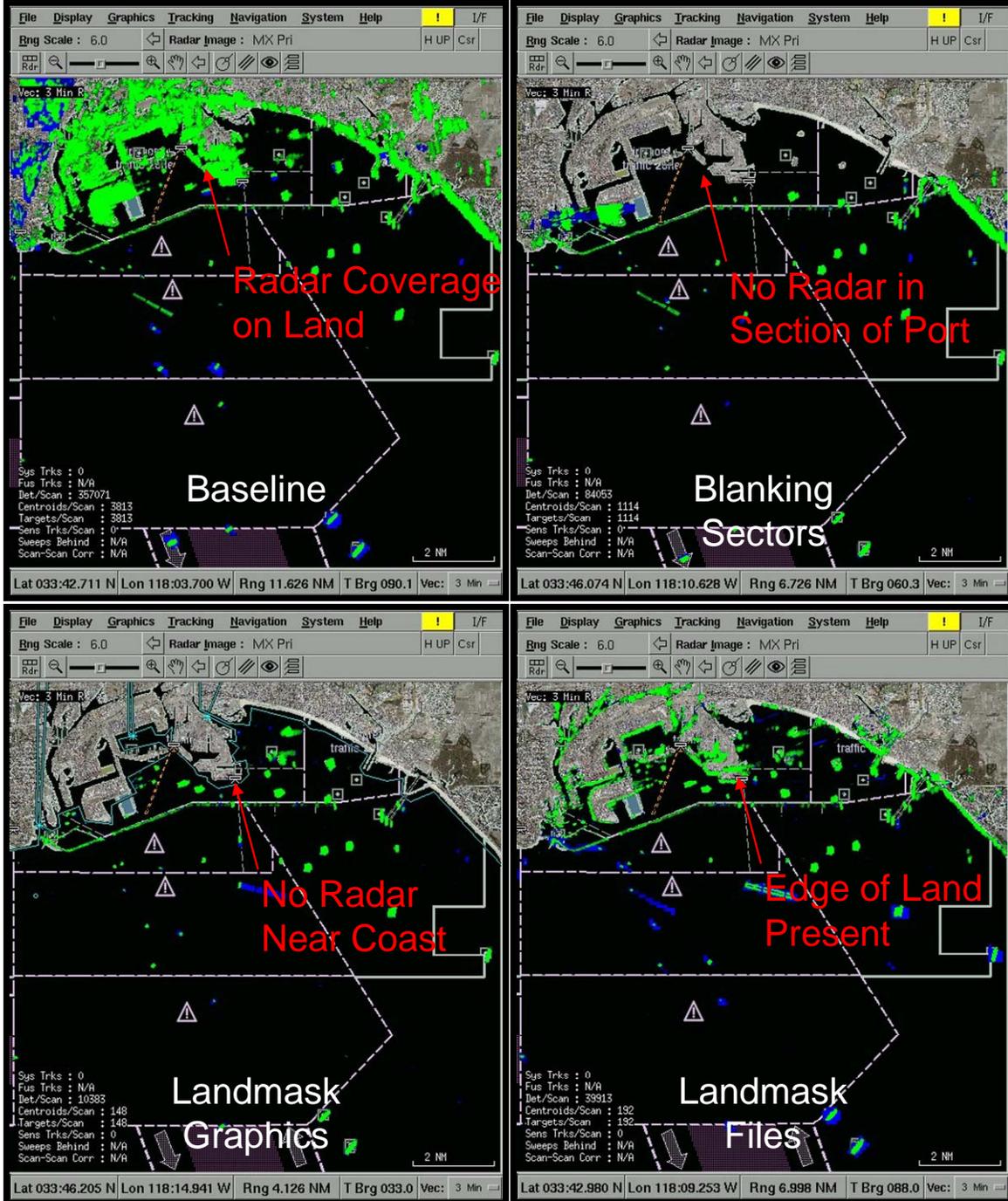
Radar Image Masking:

The first step is to remove radar data in unnecessary regions of land and clutter. The following table shows the reduction in bandwidth from the base image by using the approaches recommended above.

Note: Centroids do not directly correlate to the size of radar image, but do provide a certain order of magnitude when comparing against other installations.

Description	Centroids	Bandwidth (kbps)	Percent Reduction
Baseline	4000	623	N/A
Blanking Sectors	1100	375	40%
Landmask Graphics	150	120	81%
Landmask File	200	280	55%

These images compare the radar image using the reduction techniques. If the littoral waters or ports are of interest then Blanking Sectors and Landmask Graphics alone may not be prudent. The best reduction without losing coverage of any areas of interest is to upload a Landmask file. If the Landmask file cannot be obtained, then well developed Landmask graphics is the best alternative.

Reducing the Radar Image Further:

In this study, the Landmask File became the new base, and will be reduced further by taking additional actions recommended in this study. The following table shows the reduction in bandwidth from the new base image by using these previously mentioned techniques.

Description	Bandwidth (kbps)	Percent Reduction
Baseline - Landmasked	280	
Image Update Rate	90	68%
Centroids Only	75	73%
Contacts Only	50	82%

Although running with 'Centroids Only' or 'Contacts Only' provides an additional Percent Reduction over adjusting the update rate, the drop in quality is significant. Unless the bandwidth limitations make it absolutely necessary, adjusting the Image Update Rate to 3 Scans should be enough. The figure below shows what 'Centroids Only' and 'Contacts Only' looks like to the operator.

Note: If necessary the site can be configured to transmit 'Tracks Only' which will completely eliminate the bandwidth of the Radar Image (See Alternate Site Configuration).
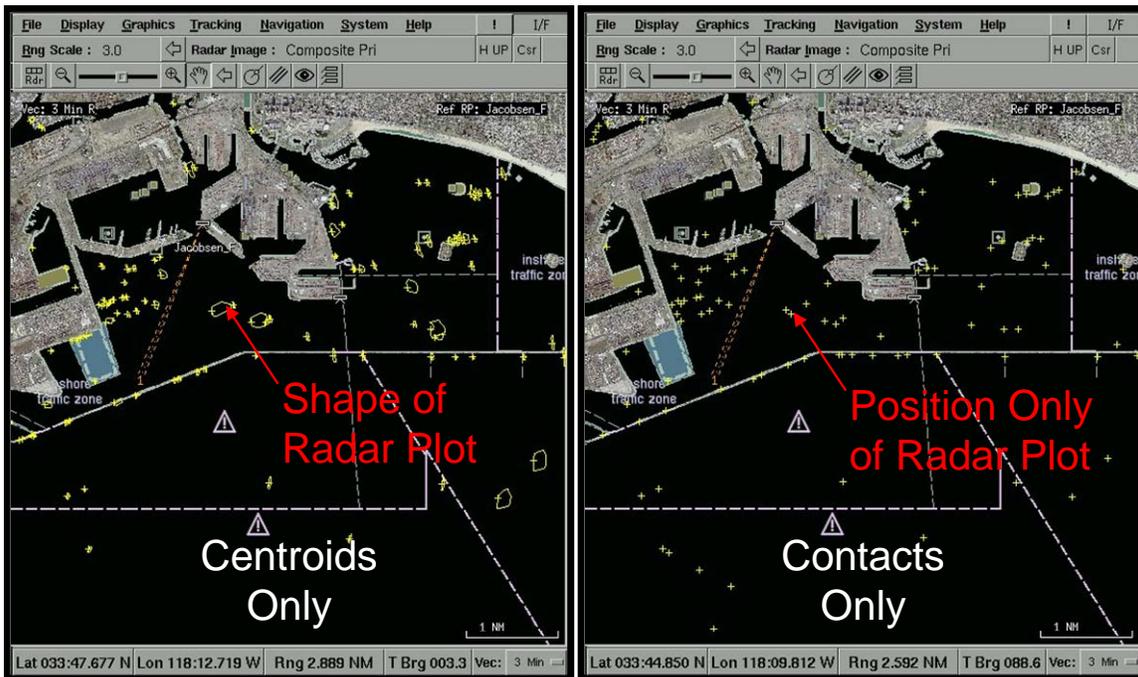
In this bandwidth study, the Image Update Rate was extended to 3 Scans, which reduced the Landmasked radar image from 280 kbps to 90 kbps.

From the original baseline radar image of 623 kbps these actions reduced the radar image to 90 kbps (or 86% reduction), without losing significant quality of the coverage area.

AIS Targets

In the area of coverage used during this study 80 of the 120 tracks were transmitting AIS. The transmission of AIS data is subject to certain conditions:

- Class A [Dynamic Data]: Every 2-10 seconds while underway.
- Class B [Dynamic Data]: Every 30 seconds while underway (<14 knots).
- Class A & B [Dynamic Data]: Every 3 minutes while at anchor.
- Class A & B [Static Data]: Every 6 minutes.

Given the mix of fast moving, slow moving and parked ships on average each target transmits 3.5 – 4 messages per second. This resulted in an average AIS Target Message bandwidth of 7 kbps.

AIS Target Messages cannot be compressed or throttled.

Centroids for Composite Tracker

In this study a central Composite Tracker was receiving Radar Centroids and AIS Targets from the remote stations. As shown above, a Landmasked environment with ~200 Centroids present will consume a bandwidth of 75 kbps. To reduce the bandwidth further one can install the Composite Tracker at the remote site (See Alternate Site Configuration).

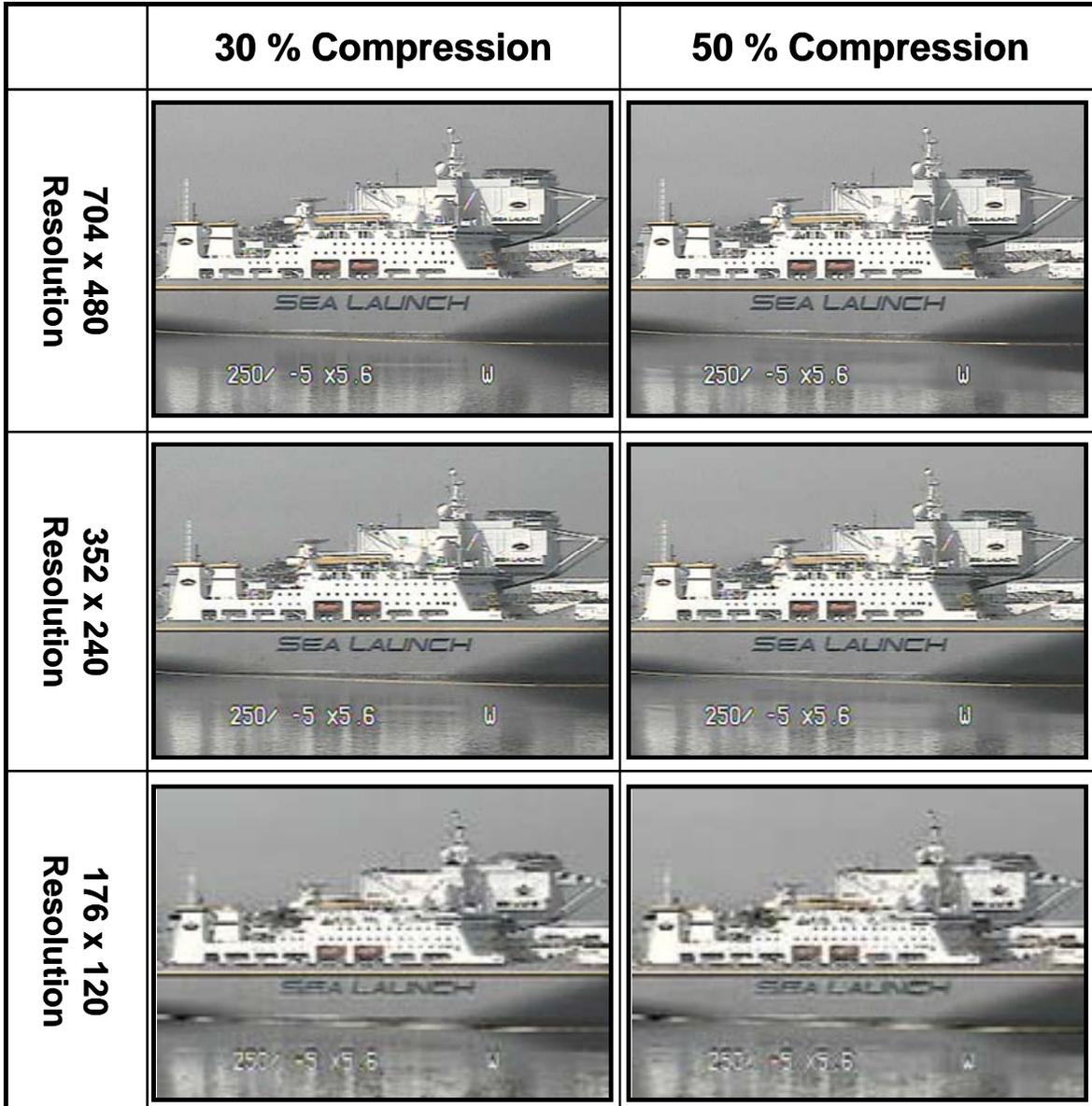## Reducing the Camera Bandwidth

The Axis Server interface for the camera is based on jpeg technology and is therefore highly dependent on the camera's field of view. The figure below shows how significantly the size of the image can change depending on the range of colors and their spatial dispersion within the image. For most cameras overlooking the water, the size of the image should be relatively small.

Note: Image Sizes are in Bytes not Bits (8 Bits = 1 Byte)

By implementing the recommendations laid out in this paper one can see the size and quality reductions of the camera image. In this study, it was determined that a 50% Compression and 352x240 Resolution was acceptable.

Resolution	Measured Values Compression		Percent Reduction Compression	
	30%	50%	30%	50%
704x480	344 kb	256 kb	0%	26%
352x240	128 kb	100 kb	63%	71%
176x120	40 kb	32 kb	88%	91%

In addition to the compression and resolution, the update rate was changed from 1 second to 4 seconds – further reducing the bandwidth by 75%. The bandwidth for this camera (on this image) was reduced from 344 kbps to 25 kbps (or 93% reduction).

Bandwidth Reduction Summary:

In this study the following techniques were implemented to reduce the bandwidth:

- Landmask File loaded on PC-RP
- Landmask Graphics enabled on high clutter non critical areas
- PC-RP Radar Image update rate change from 1 Scan to 3 Scans
- Camera Image compression changed from 30% to 50%
- Camera Image resolution changed from 704x480 to 352x240
- Camera Image update rate changed from 1 Second to 4 Seconds

Using these techniques the following bandwidth reductions were achieved without significant degradation to the operational nature of the system.

	Baseline (kbps)	Adjusted (kbps)	Reduction (%)
Radar Image	623	90	86%
Centroids	1500	75	95%
AIS Targets (80)	7	7	0%
Tracks (N/A)	0	0	0%
Camera Image	344	25	93%
Total Bandwidth	*2474*	*197*	*92%*

Note: All values are subject to change based on environment, at a minimum a 20% overhead should be included for status and control message communication.

Alternate Site Configuration:

In some configurations, with a single remote station, the bandwidth could be further reduced by locating the Composite Tracker at the remote site. The remote site no longer needs to send Radar Centroids and AIS Targets to this central site and instead only sends Composite Track data. This architecture modifies the above study's results. These tracks can also be throttled to reduce the bandwidth further, as described below.

Reducing the Track Output Rate

The output rate of each track can be throttled based on its kinematics. In this Alternate Site Study, the Tracker runtime arguments were modified as described in the above implementation (-O 4 60 50). These arguments will output the fastest tracks at a 4 second rate, the slowest tracks at a 60 second rate and medium velocity tracks at a rate between 4 and 60 seconds. The table below shows the output interval of targets given their various velocities. To further reduce the track bandwidth one can increase the value of the threshold (i.e. change from 50m to 100m).

Target	Velocity (Knots)	Velocity (m/s)	Time (s) to Threshold (50 m)	Output Interval (s)
1	1	0.51	97.19	60
2	5	2.57	19.44	19.44
3	10	5.14	9.72	9.72
4	15	7.72	6.48	6.48
5	20	10.29	4.86	5
Arguments (5s = min, 60s = max, 50m = threshold)				

In this study, 120 Composite Tracks were present and the baseline bandwidth was 53 kbps. By implementing the throttle mechanism as described above this bandwidth was reduced to an average of 20 kbps (or 62% reduction), without losing significant quality of real-time track data.

Alternate Site Bandwidth Summary:

The table below provides an updated analysis for a remotely located Composite Tracker.

	Baseline (kbps)	Adjusted (kbps)	Reduction (%)
Radar Image	623	90	86%
Centroids	1500	0	100%
AIS Targets (80)	7	0	100%
Tracks	53	20	62%
Camera Image	344	25	93%
Total Bandwidth (kbps)	*2527*	*135*	*95%*