APPENDICES

APPENDIX - A1: PROGRAMMING & CODING

CFRS POLSAR PRE-PROCESSING MATLAB CODING:

```
clear all;
clc;
%Read all real and imag images for Measured Matrix Mrh & Mrv in double
IMrh=double(imread('D:\workspace\NRSCdata\163424511\sarscape products\IMrh.tif'));
QMrh=double(imread('D:\workspace\NRSCdata\163424511\sarscape products\QMrh.tif'));
IMrv=double(imread('D:\workspace\NRSCdata\163424511\sarscape products\IMrv.tif'));
QMrv=double(imread('D:\workspace\NRSCdata\163424511\sarscape products\QMrv.tif'));

Mrh=[];Mrv=[];

Mrh=complex(IMrh,QMrh);
Mrv=complex(IMrv,QMrv);
%imtool(abs(Mrh));imtool(abs(Mrv));

[x y]=size(Mrh);
[m n]=size(Mrv);
FR=[];
MrhC=[];MrvC=[];
MrhC=conj(Mrh);
MrvC=conj(Mrv);

FR = 0.5.*atan(2.*(real(Mrh.*MrvC)./((Mrv.*MrvC)-(Mrh.*MrhC))));
[p q]=size(FR);
%imtool(abs(FR));
%Tiff true value conversion
t=Tiff('D:\workspace\NRSCdata\163424511\sarscape products\FR_matlab.tif', 'w');
tagstruct.ImageLength = size(FR,1);
tagstruct.ImageWidth = size(FR,2);
tagstruct.Photometric = Tiff.Photometric.MinIsBlack;
tagstruct.BitsPerSample = 64;
tagstruct.SampleFormat = 3;
tagstruct.SamplesPerPixel = 1;
tagstruct.RowsPerStrip = 16;
tagstruct.PlanarConfiguration = Tiff.PlanarConfiguration.Chunky;
tagstruct.Software = 'MATLAB';
t.setTag(tagstruct);
t.write(FR);
t.close();
figure;imagesc(imread('D:\workspace\NRSCdata\163424511\sarscape
products\FR_matlab.tif'));

Srh=[];Srv=[];

Srh = exp(1i.*FR).*(cos(FR).*Mrh - sin(FR).*Mrv);
Srv = exp(1i.*FR).*(sin(FR).*Mrh + cos(FR).*Mrv);
```

```matlab
%imtool(abs(Srh));imtool(abs(Srv));


ISrh = real(Srh);
QSrh = imag(Srh);
ISrv = real(Srv);
QSrv = imag(Srv);


%Tiff true value conversion
t=Tiff('D:\workspace\NRSCdata\163424511\sarscape products\ISrh.tif', 'w');
tagstruct.ImageLength = size(ISrh,1);
tagstruct.ImageWidth = size(ISrh,2);
tagstruct.Photometric = Tiff.Photometric.MinIsBlack;
tagstruct.BitsPerSample = 64;
tagstruct.SampleFormat = 3;
tagstruct.SamplesPerPixel = 1;
tagstruct.RowsPerStrip = 16;
tagstruct.PlanarConfiguration = Tiff.PlanarConfiguration.Chunky;
tagstruct.Software = 'MATLAB';
t.setTag(tagstruct);
t.write(ISrh);
t.close();
figure;imagesc(imread('D:\workspace\NRSCdata\163424511\sarscape products\ISrh.tif'));


%Tiff true value conversion
t=Tiff('D:\workspace\NRSCdata\163424511\sarscape products\QSrh.tif', 'w');
tagstruct.ImageLength = size(QSrh,1);
tagstruct.ImageWidth = size(QSrh,2);
tagstruct.Photometric = Tiff.Photometric.MinIsBlack;
tagstruct.BitsPerSample = 64;
tagstruct.SampleFormat = 3;
tagstruct.SamplesPerPixel = 1;
tagstruct.RowsPerStrip = 16;
tagstruct.PlanarConfiguration = Tiff.PlanarConfiguration.Chunky;
tagstruct.Software = 'MATLAB';
t.setTag(tagstruct);
t.write(QSrh);
t.close();
figure;imagesc(imread('D:\workspace\NRSCdata\163424511\sarscape products\QSrh.tif'));


%Tiff true value conversion
t=Tiff('D:\workspace\NRSCdata\163424511\sarscape products\ISrv.tif', 'w');
tagstruct.ImageLength = size(ISrv,1);
tagstruct.ImageWidth = size(ISrv,2);
tagstruct.Photometric = Tiff.Photometric.MinIsBlack;
tagstruct.BitsPerSample = 64;
tagstruct.SampleFormat = 3;
tagstruct.SamplesPerPixel = 1;
tagstruct.RowsPerStrip = 16;
tagstruct.PlanarConfiguration = Tiff.PlanarConfiguration.Chunky;
tagstruct.Software = 'MATLAB';
t.setTag(tagstruct);
t.write(ISrv);
t.close();
figure;imagesc(imread('D:\workspace\NRSCdata\163424511\sarscape products\ISrv.tif'));


%Tiff true value conversion
t=Tiff('D:\workspace\NRSCdata\163424511\sarscape products\QSrv.tif', 'w');
tagstruct.ImageLength = size(QSrv,1);
```

```matlab
tagstruct.ImageWidth = size(QSrv,2);
tagstruct.Photometric = Tiff.Photometric.MinIsBlack;
tagstruct.BitsPerSample = 64;
tagstruct.SampleFormat = 3;
tagstruct.SamplesPerPixel = 1;
tagstruct.RowsPerStrip = 16;
tagstruct.PlanarConfiguration = Tiff.PlanarConfiguration.Chunky;
tagstruct.Software = 'MATLAB';
t.setTag(tagstruct);
t.write(QSrv);
t.close();
imagesc(imread('D:\workspace\NRSCdata\163424511\sarscape products\QSrv.tif'));


%calculate conformity co-efficient mu
Mu=[];
SrhC = conj(Srh);
SrvC = conj(Srv);
Mu = 2.*imag(Srh.*SrvC)./((Srh.*SrhC)+(Srv.*SrvC));
%imtool(Mu);
%Tiff true value conversion
t=Tiff('D:\workspace\NRSCdata\163424511\sarscape products\Mu_matlab.tif', 'w');
tagstruct.ImageLength = size(Mu,1);
tagstruct.ImageWidth = size(Mu,2);
tagstruct.Photometric = Tiff.Photometric.MinIsBlack;
tagstruct.BitsPerSample = 64;
tagstruct.SampleFormat = 3;
tagstruct.SamplesPerPixel = 1;
tagstruct.RowsPerStrip = 16;
tagstruct.PlanarConfiguration = Tiff.PlanarConfiguration.Chunky;
tagstruct.Software = 'MATLAB';
t.setTag(tagstruct);
t.write(Mu);
t.close();
imagesc(imread('D:\workspace\NRSCdata\163424511\sarscape products\Mu_matlab.tif'));
```

SVM MATLAB CODE:

```matlab
clear all;
clc;

folder = 'D:\workspace\NRSCdata\163424521\SVMtestData\';
dirImage = dir( folder );

numData = size(dirImage,1);

M={};

% Read Images
for i=1:numData
    nama = dirImage(i).name;
    if regexp(nama, '(ship|water)-[0-9]{1,2}.tif')
        B = cell(1,2);
        if regexp(nama, 'ship-[0-9]{1,2}.tif')
            B{1,1} = double(imread([folder, '/', nama]));
            B{1,2} =1;
```

```matlab
      elseif regexp(nama, 'water-[0-9]{1,2}.tif')
         B{1,1} = double(imread([folder, '/', nama]));
         B{1,2} = -1;
      end
      M = cat(1,M,B);
   end
end


% Convert image holder from cell to array
numDataTrain = size(M,1);
%[orginalImage, R] = geotiffread('D:\workspace\Sentinel 1\testData\ship-test.tif');
shipTest = double(imread('D:\workspace\NRSCdata\163424521\SVMtestData\ship-test.tif'));


[x y] = size(shipTest);
class = zeros(x*y*numDataTrain,1);
arrayImage=[];

for i=1:numDataTrain
   im = M{i,1};
   %im = rgb2gray(im);
   im = imresize(im, [x y]); %imtool(im);
   im = reshape(im', x*y, 1);
   arrayImage = cat(1, arrayImage, im);
   for ii=1: x*y
      class((x*y*(i-1))+ii) = M{i,2};
   end
end

arrayImage = cat(2, arrayImage, class);


SVMStruct = svmtrain(arrayImage, class, 'Kernel_Function', 'rbf');


% test for ship
%shipTest = double(imread('D:\workspace\NRSCdata\163424521\SVMtestData\ship-
test.tif'));
%shipTest = rgb2gray(shipTest);
shipTest = imresize(shipTest, [x y]);
shipTest = reshape(shipTest', x*y, 1);
testClass = zeros(x*y, 1);
shipTest = cat(2, shipTest, testClass);
result = svmclassify(SVMStruct, shipTest);


% classified image formation
resultImage =[];
for rows=1: x
   for cols=1: y
      resultImage (rows,cols) = result (((((rows-1)*y)+cols),1);
   end
end

imtool(resultImage);
imwrite(resultImage,'D:\workspace\NRSCdata\163424521\SVMresults\cond_svmrbf_HH.tif';
%geotiffwrite('D:\workspace\Sentinel 1\SVMresults\cond_svm_mlp.tif', resultImage, R);
%figure, geoshow('D:\workspace\Sentinel 1\testData\cond_svm.tif');
```

HFS MATLAB CODING:

```matlab
clear all;
clc;

%[a, R] = geotiffread('D:\workspace\NRSCdata\163424521\results\clump sieve in
envi\poly2_seg_c4s5_hv.tif');
a = double(imread('D:\workspace\NRSCdata\163424521\results\clump sieve in
envi\rbf_seg_c4s5_hv.tif'));
[x y]=size(a);
% fprintf(x,y);
imtool(a);
figure, imhist(a);

binRange= 0:(max(a(:)));
[binCounts] = histc(a, binRange);

[i j] = size(binCounts);

histNo=[];
for rows=1: i
    histNo(rows,1)=0;
    for cols=1:j
        histNo(rows,1)= binCounts(rows,cols) + histNo(rows,1);
    end
end

histRange=[min(histNo(:)),5,10,20,30,40,50,100,200,300,max(histNo(:))];
[histCounts, ind] = histc(histNo, histRange);

classImage=[];

for rows=1: x
    for cols=1: y
        for dnValue=1:i
        if a(rows,cols)==dnValue-1
            classImage(rows,cols) = ind (dnValue,1);
        end
        end
    end
end

%Tiff true value conversion
t=Tiff('D:\workspace\NRSCdata\163424521\results\clump sieve in
envi\HistoSlice_rbf_seg_c4s5_hv.tif', 'w');
tagstruct.ImageLength = size(classImage,1);
tagstruct.ImageWidth = size(classImage,2);
tagstruct.Photometric = Tiff.Photometric.MinIsBlack;
tagstruct.BitsPerSample = 64;
tagstruct.SampleFormat = 3;
tagstruct.SamplesPerPixel = 1;
tagstruct.RowsPerStrip = 16;
tagstruct.PlanarConfiguration = Tiff.PlanarConfiguration.Chunky;
tagstruct.Software = 'MATLAB';
t.setTag(tagstruct);
```

```
t.write(classImage);
t.close();
figure;imagesc(imread('D:\workspace\NRSCdata\163424521\results\clump sieve in
envi\HistoSlice_rbf_seg_c4s5_hv.tif'));


%imwrite(outImage,'D:\workspace\NRSCdata\163424521\results\clump sieve in
envi\HistoSlice_sigm_seg_c4s5_hv.tif');
%geotiffwrite('D:\workspace\NRSCdata\163424521\results\histoSlice_C4S5_hv.tif',
outImage, R);
%figure, geoshow('D:\workspace\NRSCdata\163424521\results\histoSlice_C4S5_hv.tif');
```

APPENDIX - A2: SENTINEL-1A POSITION DATA ON 24 FEB 2016 (SOURCE: BIGOCEANDATA)

MV SUMAYLA ONE 8216552	18° 56.476' N	072° 50.559' E	24/02/2016 01:28:35 UTC	NNW	332	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.942' N	072° 52.125' E	24/02/2016 01:25:59 UTC	NNW	347	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.477' N	072° 50.559' E	24/02/2016 01:25:35 UTC	NNW	332	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.940' N	072° 52.124' E	24/02/2016 01:22:19 UTC	NE	35	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.475' N	072° 50.558' E	24/02/2016 01:19:35 UTC	WNW	283	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.937' N	072° 52.125' E	24/02/2016 01:16:48 UTC	S	182	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.475' N	072° 50.560' E	24/02/2016 01:16:35 UTC	WNW	283	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.939' N	072° 52.121' E	24/02/2016 01:11:28 UTC	SE	133	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.479' N	072° 50.559' E	24/02/2016 01:10:35 UTC	WNW	283	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.936' N	072° 52.121' E	24/02/2016 01:05:39 UTC	E	94	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.478' N	072° 50.559' E	24/02/2016 01:04:35 UTC	WNW	283	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.937' N	072° 52.121' E	24/02/2016 01:02:09 UTC	E	90	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.476' N	072° 50.558' E	24/02/2016 01:01:35 UTC	WNW	283	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.935' N	072° 52.120' E	24/02/2016 00:56:48 UTC	SE	134	0	Source:T-AIS

Vessel	Latitude	Longitude	Timestamp				Source
MV SUMAYLA ONE 8216552	18° 56.478' N	072° 50.559' E	24/02/2016 00:55:35 UTC	WNW	288	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.936' N	072° 52.120' E	24/02/2016 00:51:29 UTC	SSE	168	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.479' N	072° 50.558' E	24/02/2016 00:49:34 UTC	WNW	288	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.936' N	072° 52.120' E	24/02/2016 00:45:59 UTC	N	0	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.475' N	072° 50.560' E	24/02/2016 00:43:34 UTC	W	280	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.476' N	072° 50.559' E	24/02/2016 00:40:34 UTC	W	280	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.934' N	072° 52.120' E	24/02/2016 00:40:28 UTC	SW	229	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.935' N	072° 52.119' E	24/02/2016 00:36:48 UTC	NNW	342	0	Source:T-AIS
MV SUMAYLA ONE 8216552	18° 56.476' N	072° 50.559' E	24/02/2016 00:34:34 UTC	W	280	0	Source:T-AIS
M.V.NAND PANNA 8219140	18° 55.933' N	072° 52.120' E	24/02/2016 00:31:08 UTC	NNW	332	0	Source:T-AIS

Asset	Lat	Long	Date	Dir	Deg	Speed	Temp	Pressure	Visibility	u-comp of wind	v-comp of wind	Water Temp	height of combined wind	Dir of wind waves	height of wind waves	Mean period of wind waves	Dir of swell waves	height of swell waves	Mean period of swell waves
MV SUMAYLA ONE 8216552	18° 56.476' N	072° 50.559'E	24/02/2016 01:28:35 UTC	NNW	332	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAND PANNA 8219140	18° 55.942' N	072° 52.125'E	24/02/2016 01:25:59 UTC	NNW	347	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYLA ONE 8216552	18° 56.477' N	072° 50.559'E	24/02/2016 01:25:35 UTC	NNW	332	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAND PANNA 8219140	18° 55.940' N	072° 52.124'E	24/02/2016 01:22:19 UTC	NE	35	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYLA ONE 8216552	18° 56.475' N	072° 50.558'E	24/02/2016 01:19:35 UTC	WNW	283	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAND PANNA 8219140	18° 55.937' N	072° 52.125'E	24/02/2016 01:16:48 UTC	S	182	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s

Vessel	Latitude	Longitude	Timestamp	Dir															
MV SUMAYL A ONE 8216552	18° 56.475' N	072° 50.56 0'E	24/02/20 16 01:16:35 UTC	WNW	283	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAN D PANNA 8219140	18° 55.939' N	072° 52.12 1'E	24/02/20 16 01:11:28 UTC	SE	133	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYL A ONE 8216552	18° 56.479' N	072° 50.55 9'E	24/02/20 16 01:10:35 UTC	WNW	283	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAN D PANNA 8219140	18° 55.936' N	072° 52.12 1'E	24/02/20 16 01:05:39 UTC	E	94	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYL A ONE 8216552	18° 56.478' N	072° 50.55 9'E	24/02/20 16 01:04:35 UTC	WNW	283	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAN D PANNA 8219140	18° 55.937' N	072° 52.12 1'E	24/02/20 16 01:02:09 UTC	E	90	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYL A ONE 8216552	18° 56.476' N	072° 50.55 8'E	24/02/20 16 01:01:35 UTC	WNW	283	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s

Vessel	Latitude	Longitude	Time	Dir	Col1	Col2	Temp	Pressure	Col3	Wind1	Wind2	Temp2	Col4	Col5	Col6	Col7	Col8	Col9	Col10
M.V.NAND PANNA 8219140	18° 55.935' N	072° 52.120' E	24/02/20 16 00:56:48 UTC	SE	134	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYLA ONE 8216552	18° 56.478' N	072° 50.559' E	24/02/20 16 00:55:35 UTC	WNW	288	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAND PANNA 8219140	18° 55.936' N	072° 52.120' E	24/02/20 16 00:51:29 UTC	SSE	168	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYLA ONE 8216552	18° 56.479' N	072° 50.558' E	24/02/20 16 00:49:34 UTC	WNW	288	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAND PANNA 8219140	18° 55.936' N	072° 52.120' E	24/02/20 16 00:45:59 UTC	N	0	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYLA ONE 8216552	18° 56.475' N	072° 50.560' E	24/02/20 16 00:43:34 UTC	W	280	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYLA ONE 8216552	18° 56.476' N	072° 50.559' E	24/02/20 16 00:40:34 UTC	W	280	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s

Vessel	Latitude	Longitude	Time																
M.V.NAND PANNA 8219140	18° 55.934' N	072° 52.120'E	24/02/2016 00:40:28 UTC	SW	229	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAND PANNA 8219140	18° 55.935' N	072° 52.119'E	24/02/2016 00:36:48 UTC	NNW	342	0	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
MV SUMAYLA ONE 8216552	18° 56.476' N	072° 50.559'E	24/02/2016 00:34:34 UTC	W	280	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s
M.V.NAND PANNA 8219140	18° 55.933' N	072° 52.120'E	24/02/2016 00:31:08 UTC	NNW	332	0.1	26.5 °C	1010 50 Pa	32600 m	3.64 m/s	-4.33 m/s	27.1 °C	0.9 m	320°	0.3 m	2 s	235°	0.8 m	8 s

APPENDIX - A4: SENTINEL-1A CLASSIFIED DATA BASED ON AIS / PORT CALL DATA (SOURCE: SEAWEB)

Ship	Gross tonnage	Port_of_Call	Country_of_Call	Arrival_Date	Sailed_Date	Hours_in_Port	Arrival_Date
ADWITA (9231523) 1,706gt Anchor Handling Tug Supply	1706	Mumbai Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 00:28
BRIGHT WORLD (9125114) 19,299dwt Chemical Tanker	19299	Mumbai Anchorage	India	24-02-2016	24-02-2016	8	24-02-2016 07:43
CREST MERCURY TWO (9724403) 2,301gt Anchor Handling Tug Supply	2301	Mumbai Bravo (East) Anchorage	India	24-02-2016	24-02-2016	4	24-02-2016 19:58
CS SORAYA (9569932) 57,000dwt Bulk Carrier	32984	Mumbai Outer Anchorage	India	24-02-2016	24-02-2016	5	24-02-2016 14:38
DALI (9697428) 9,962teu Container Ship (Fully Cellular)	94730	Mumbai Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 18:07
EMERALD (9471941) 2,443gt Platform Supply Ship	2443	Mumbai Anchorage	India	24-02-2016	24-02-2016	4	24-02-2016 00:53
EMIRATES WAFA (9306160) 6,539teu Container Ship (Fully Cellular)	73934	Mumbai Bravo (West) Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 15:58
FLAMBOYAN (8223256) 424gt Research Survey Vessel	424	Mumbai Bravo (East) Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 19:57
FUGRO MAPPER (9529047) 581gt Offshore Tug/Supply Ship	581	Mumbai Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 00:28
GURU KRIPA (9129512) 1,592gt General Cargo Ship	1592	Mumbai Outer Anchorage	India	24-02-2016	24-02-2016	6	24-02-2016 16:56
LOUISE (9565974) 962gt Anchor Handling Tug Supply	962	Mumbai Bravo (West) Anchorage	India	24-02-2016	24-02-2016	16	24-02-2016 03:23
MEENAKSHI (8924563) 199gt Utility Vessel	199	Mumbai Anchorage	India	24-02-2016	24-02-2016	4	24-02-2016 16:56
OCEAN AMETHYST (9561227) 2,418gt Platform Supply Ship	2418	Mumbai Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 20:56
OCEAN CROWN (9325582) 394gt Tug	394	Jawahar Dweep	India	24-02-2016	24-02-2016	<2	24-02-2016

							24-02-2016 12:47
OFFSHORE HUNTER (8218287) 815gt Offshore Tug/Supply Ship	815	Mumbai Anchorage	India	24-02-2016	24-02-2016	4	24-02-2016 12:47
OSL GLORY (9720756) 3,583gt Platform Supply Ship	3583	Mumbai Bravo (West) Anchorage	India	24-02-2016	24-02-2016	2	24-02-2016 04:42
P. T. VENUGOPAL (9576399) 1,831gt Platform Supply Ship	1831	Mumbai Outer Anchorage	India	24-02-2016	24-02-2016	3	24-02-2016 16:43
P. T. VENUGOPAL (9576399) 1,831gt Platform Supply Ship	1831	Mumbai Bravo (East) Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 14:31
P. T. VENUGOPAL (9576399) 1,831gt Platform Supply Ship	1831	Mumbai Bravo (East) Anchorage	India	24-02-2016	24-02-2016	4	24-02-2016 07:42
SCI MUMBAI (9419539) 4,469teu Container Ship (Fully Cellular)	4469	Mumbai Anchorage	India	24-02-2016	24-02-2016	2	24-02-2016 17:20
SEA CHEETAH (8121159) 1,621gt Anchor Handling Tug Supply	1621	Mumbai Bravo (East) Anchorage	India	24-02-2016	24-02-2016	7	24-02-2016 12:55
TAG 16 (9191797) 1,734gt Anchor Handling Tug Supply	1734	Mumbai Cargo Transhipment Area	India	24-02-2016	24-02-2016	2	24-02-2016 20:46
VOLVOX DELTA (8304567) 8,089gt Trailing Suction Hopper Dredger	8089	Mumbai Anchorage	India	24-02-2016	24-02-2016	2	24-02-2016 19:59
VOLVOX DELTA (8304567) 8,089gt Trailing Suction Hopper Dredger	8089	Mumbai Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 18:12
VOLVOX DELTA (8304567) 8,089gt Trailing Suction Hopper Dredger	8089	Mumbai Anchorage	India	24-02-2016	24-02-2016	<2	24-02-2016 14:05
VOLVOX DELTA (8304567) 8,089gt Trailing Suction Hopper Dredger	8089	Mumbai Anchorage	India	24-02-2016	24-02-2016	5	24-02-2016 07:43
VOLVOX DELTA (8304567) 8,089gt Trailing Suction Hopper Dredger	8089	Mumbai	India	24-02-2016	24-02-2016	<2	24-02-2016 05:32
VOLVOX DELTA (8304567) 8,089gt Trailing Suction Hopper Dredger	8089	Mumbai	India	24-02-2016	24-02-2016	2	24-02-2016 01:19

APPENDIX - A5: RISAT-1 POSITION DATA (PROCESSED) ON 15 FEB 2012 (SOURCE: VT EXPLORER)

DATE TIME (UTC)	LAT	LONG	COURSE	SPEED	HDG	IMO	NAME	A	B	C	D	DRAUGHT	DESTINATION	GT
2012-11-15 02:15:34	19.41514	72.43293	349.8	7.6	354	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 02:21:22	19.42724	72.43065	349.6	7.6	353	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 02:44:03	19.47524	72.42147	349.8	7.7	353	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 02:51:25	19.49092	72.41849	349.7	7.8	353	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 02:58:48	19.50669	72.41551	350	7.8	353	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 03:01:53	19.51358	72.41424	350.3	7.9	353	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 03:18:45	19.55086	72.40748	350.9	8.2	353	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 03:21:46	19.55766	72.4063	350.9	8.3	352	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 03:41:55	19.60357	72.40055	350.5	8.4	352	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 03:44:54	19.61054	72.39933	350.7	8.4	351	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 04:01:23	19.64939	72.39138	348.5	8.7	349	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443
2012-11-15 04:07:36	19.66387	72.38829	348.3	8.8	349	9471941	EMERALD	13	57	5	7	4.6	GD CHETNA TAPTI	2443

Date/Time														
2012-11-15 06:26:13	19.91009	72.43114	353	5.7	511	8127787	GAL ROSS SEA	13	34	3	9	4.2	MUMBAI	799
2012-11-15 07:00:38	18.87333	72.84101	216.7	11.4	511	0		0	0	0	0	0		
2012-11-15 07:19:26	18.84602	72.78826	258.7	7.5	511	0		0	0	0	0	0		
2012-11-15 07:33:00	18.87227	72.8522	173	0.4	511	0		0	0	0	0	0		
2012-11-15 07:50:51	18.92869	72.87213	252.1	0.1	63	9547233	S.C.I.PAWAN	20	46	5	11	5.5	MUMBAI	2048
2012-11-15 08:07:27	18.84388	72.84631	275.5	8.8	277	8845456	NAND HAZIRA	65	13	8	4	3.8	DHARAMTAR	1484
2012-11-15 08:08:48	18.88291	72.84111	119.5	0.1	511	0		0	0	0	0	0		
2012-11-15 08:55:12	18.92702	72.86128	238.1	0.1	511	7431961	KAMALXL	67	39	16	2	5.2	MUMBAI	5625
2012-11-15 08:58:29	19.05655	72.58676	196.7	0.1	110	8511653	MAHARASHTRA	0	0	0	0	6.5	MUMBAI	
2012-11-15 08:58:57	18.8409	72.71285	261.7	9.2	258	8845456	NAND HAZIRA	65	13	8	4	3.8	DHARAMTAR	1484
2012-11-15 09:00:00	19.01675	72.81694	360	0	511	0	MRCC MB	0	0	0	0	0		
2012-11-15 09:05:18	18.83853	72.69584	262.3	9.2	260	8845456	NAND HAZIRA	65	13	8	4	3.8	DHARAMTAR	1484
2012-11-15 09:32:36	18.85131	72.63726	338.6	8.4	339	8845456	NAND HAZIRA	65	13	8	4	3.8	DHARAMTAR	1484
2012-11-15 09:57:17	18.82326	72.68873	85.3	3.6	66	0		0	0	0	0	0		490
2012-11-15 11:10:38	19.02467	72.61173	95.9	0.1	511	7501819	PALMYRA I	94	23	11	7	5	MUMBAI	5306

APPENDIX - A6: RISAT-1A PORT CALL DATA ON 15 NOV 12 (SOURCE: VT EXPLORER)

Ship	LR/IMO_Ship_No.	Port_of_Call	Country_of_Call	Arrival_Date	Sailed_Date	Hours_in_Port	Arrival_Date
ACACIA STAR (9127631) 45,342dwt Bulk Carrier	9127631	Mumbai Anchorage	India	14-11-2012	14-11-2012	7	14-11-2012 04:30
ACRUX N (9433066) 1,740teu Container Ship (Fully Cellular)	9433066	Mundra	India	15-11-2012	15-11-2012	23	15-11-2012 06:16
AEL I (9361926) 3,116dwt Products Tanker	9361926	Mundra General Anchorage A	India	14-11-2012	15-11-2012	26	14-11-2012 15:09
ALPINE AMALIA (9460136) 105,304dwt Crude/Oil Products Tanker	9460136	Sikka Product Vessel Anchorage	India	16-11-2012	16-11-2012	4	16-11-2012 16:38
ALPINE MYSTERY (9392808) 47,128dwt Chemical/Products Tanker	9392808	Pipavav	India	15-11-2012	16-11-2012	6	15-11-2012 21:59
ARABIAN SEA (9448097) 3,261gt General Cargo/Passenger Ship	9448097	Cochin	India	14-11-2012	14-11-2012	62	14-11-2012 02:37
ARIETTA A (9554664) 56,947dwt Bulk Carrier	9554664	Kandla Outer Anchorage	India	14-11-2012	15-11-2012	31	14-11-2012 10:34
BANKIM CHANDRA CHATTERJEE (9045481) 45,134dwt Crude/Oil Products Tanker	9045481	Mundra General Anchorage A	India	14-11-2012	14-11-2012	8	14-11-2012 03:42
DESH GARIMA (9467756) 114,790dwt Crude/Oil Products Tanker	9467756	New Mangalore	India	14-11-2012	14-11-2012	18	14-11-2012 15:29
DIGNITY (9464687) 4,380teu Container Ship (Fully Cellular)	9464687	Pipavav	India	14-11-2012	14-11-2012	29	14-11-2012 02:02
E. R. PERTH (9152868) 2,825teu Container Ship (Fully Cellular)	9152868	Mundra	India	14-11-2012	14-11-2012	17	14-11-2012 16:30
GAL BEAUFORT SEA (8127775) 799gt Anchor Handling Tug Supply	8127775	Mumbai Anchorage	India	14-11-2012	15-11-2012	29	14-11-2012 04:28
GLOVIS CHALLENGE (9590591) 58,288gt Vehicles Carrier	9590591	Mumbai	India	15-11-2012	15-11-2012	21	15-11-2012 17:05
GRAND BRIDGE (9131046) 45,916dwt Bulk	9131046	Visakhapatnam	India	15-11-2012	15-11-2012	23	15-11-2012

Carrier							16:59
IVY (9475325) 336gt Tug	9475325	Sikka	India	14-11-2012	16-11-2012	55	14-11-2012 09:54
JBU OPAL (9400409) 19,864dwt Chemical/Products Tanker	9400409	Sikka Product Vessel Anchorage	India	14-11-2012	14-11-2012	3	14-11-2012 01:07
KALYMNOS (9203265) 299,089dwt Crude Oil Tanker	9203265	Jamnagar Terminal	India	14-11-2012	14-11-2012	51	14-11-2012 04:32
KOTA GEMBIRA (9252369) 2,607teu Container Ship (Fully Cellular)	9252369	Mundra	India	14-11-2012	14-11-2012	20	14-11-2012 10:18
KOTA GEMBIRA (9252369) 2,607teu Container Ship (Fully Cellular)	9252369	Mundra General Anchorage A	India	14-11-2012	14-11-2012	6	14-11-2012 04:47
MARE FOX (9248942) 1,200teu Container Ship (Fully Cellular)	9248942	Tuticorin	India	14-11-2012	14-11-2012	46	14-11-2012 11:51
NAND PANNA (8219140) 1,313gt Offshore Tug/Supply Ship	8219140	Mumbai Anchorage	India	14-11-2012	16-11-2012	46	14-11-2012 17:19
OLYMPIC CANYON (9340609) 4,787gt Offshore Tug/Supply Ship	9340609	Kakinada	India	14-11-2012	14-11-2012	8	14-11-2012 02:38
RIO BRAVO (9348091) 5,905teu Container Ship (Fully Cellular)	9348091	Mundra	India	14-11-2012	14-11-2012	25	14-11-2012 01:13
ROYAL EPIC (9339478) 56,026dwt Bulk Carrier	9339478	Mundra	India	14-11-2012	14-11-2012	35	14-11-2012 04:31
SAMUDRIKA-4 (8311728) 951gt Anchor Handling Tug Supply	8311728	Mumbai Bravo (West) Anchorage	India	14-11-2012	15-11-2012	26	14-11-2012 15:22
SCI RATNA (9524906) 2,039gt Anchor Handling Tug Supply	9524906	Chennai	India	14-11-2012	15-11-2012	18	14-11-2012 15:29
SUMAYLA ONE (8216552) 1,078gt Offshore Support Vessel	8216552	Mumbai Bravo (East) Anchorage	India	15-11-2012	16-11-2012	21	15-11-2012 17:03
X-PRESS HOOGLY (9399117) 917teu Container Ship (Fully Cellular)	9399117	Kolkata	India	14-11-2012	14-11-2012	54	14-11-2012 10:00
ZOYA (7423495) 775gt Offshore Tug/Supply Ship	7423495	Mumbai Anchorage	India	14-11-2012	15-11-2012	23	14-11-2012 10:02