Ice Processing System Software
Support Documentation

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Prepared for Remote Sensing Division

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I

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The Ice Processing System is a digital image processing function that performs sea-ice lead statistics analysis functions and ice-motion estimations. The menu-driven process permits the user to utilize Advanced Very High Resolution Radiometer and/or Operational Line Scan infrared or visible satellite imagery. The lead analysis software utilizes a Hough transform technique to determine lead orientation statistics. The function also provides/displays lead size, lead orientation, and lead spacing information in various forms to the user. Ice-motion vectors are obtained automatically from image pairs using a cross-correlation technique. The resultant motion vectors are then displayed over a screen image. Together, these techniques provide analysts with near-real-time indications of sea-ice conditions over regions of interest.

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SOFTWARE USER'S MANUAL
FOR THE
ICE PROCESSING SYSTEM

1.0 SCOPE

1.1 Identification

This Software User's Manual establishes the execution requirements for the Computer Software Configuration Item (CSCI) identified as the Ice Processing System. The Naval Research Laboratory (NRL) has requested the National Aeronautics and Space Administration (NASA)/Stennis Space Center (SSC) Technical Support Services Contractor's Data Services Department (DSD) to provide technical support to develop the Ice Processing System software.

1.2 System Overview

The Ice Processing System provides a user-friendly, menu-driven system to perform sea ice lead analysis functions as well as sea ice motion detection through Advanced Very High Resolution Radiometer (AVHRR)/Operational Line Scan (OLS) infrared (IR) and/or visible satellite imagery.

The lead analysis functions provide interactive cloud and land screening, transformation of images into Hough space (which is necessary for production of useful statistics), generation of high-resolution accumulator space scan lines, execution of Hough transform space peak neighborhood analysis, display of rose plots, and calculation of lead spacing statistics.

The motion detection functions calculate ice motion vectors of two time-sequential images, filter the vectors, and display the vectors over a screen image.

1.3 Document Overview

This document contains a description of the procedures necessary to execute the Ice Processing System.

2.0 APPLICABLE DOCUMENTS

2.1 Government Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification will be considered a superseding requirement.
SPECIFICATIONS:
None.

STANDARDS:
DoD-STD-2167A  
29 February 1988
Military Standard Defense  
System Software Development

DRAWINGS:
None.

OTHER PUBLICATIONS:
NOARL Technical Note 50  
Spring 1990
Sea Ice Lead Statistics from  
Satellite Imagery of the  
Lincoln Sea During ICESHELF  
Acoustic Exercise

NRL Memorandum Report  
NRL/MR/7240--93-7072
The Hough Transform Algorithm  
for Sea Ice Lead Analysis: An  
Evaluation

Copies of specifications, standards, drawings, and publications  
required by DSD in connection with the software development  
functions should be obtained from NRL or as directed by NRL.

2.2 Non-Government Documents

The following documents of the exact issue shown form a part of  
this specification to the extent specified herein. In the event  
of conflict between the documents referenced herein and the  
contents of this specification, the contents of this  
specification will be considered a superseding requirement.

SPECIFICATIONS:
None.

STANDARDS:
None.

DRAWINGS:
None.
OTHER PUBLICATIONS:

Sverdrup Technology, Inc.  
Software Requirements  
September 1993  
Specification for the Ice  
Processing System

Sverdrup Technology, Inc.  
Software Design  
September 1993  
Description for the Ice  
Processing System

Sverdrup Technology, Inc.  
Software Test  
September 1993  
Document for the Ice  
Processing System

Sverdrup Technology, Inc.  
Software User’s Manual  
September 1993  
for the NRL Satellite Image  
Processing System (NSIPS)

Copies of specifications, standards, drawings, and publications required by DSD in connection with the software development functions should be obtained from NRL or as directed by NRL.
3.0 DETAILED DESCRIPTION

The Ice Processing software executes one function at a time. The general flow of execution is as follows:

a. Perform cloud and land screening on the selected image, saving the modified image to a binary file.

b. Execute the Hough transform to determine the ice lead characteristics and orientations.

c. Display the lead information via a rose plot of orientation vs. length for the image.

d. Compute the lead spacing and width statistics.

e. Compute and filter the motion vectors for two time-sequential images.

f. Display the motion vectors on the image.

User input for the Ice Processing System is provided through the use of a 3 button mouse. The mouse buttons, from left to right, will be referred to as "1," "2," and "3," respectively. Unless otherwise specified, either mouse button may be used. Information regarding the user input to the Ice Processing System will be provided in table format in the following sections. The tables will indicate the menu or window prior to selection (PROMPT), the item to be selected (RESPONSE), and the method of selection or entry (INPUT DEVICE).

Upon login, the user will execute NSIPS by entering "wave" or "waveadv" at the system prompt (See Appendix A).

3.1 Screen Clouds/Land

Screen Clouds/Land performs cloud and land screening on the selected image. This function provides a mechanism for selecting various 64 x 64 grid elements (or blocks) in which clouds or land appear. These blocks are blanked out and not used in the lead analysis. The resulting image must be saved to a binary file.

3.1.1 Screen Clouds/Land Input Requirements

NSIPS must first be executed as directed in Appendix A. Image files must be available in the directory $MACHINE/run/images. The Image file must already be displayed using the NSIPS option described in Appendix B so that it may be chosen for input.
3.1.2 **Screen Clouds/Land Example Input**

Table 3.1.2-1 provides the prompts and example responses required to run Screen Clouds/Land.

**TABLE 3.1.2-1. Screen Clouds/Land Inputs**

<table>
<thead>
<tr>
<th>PROMPT</th>
<th>RESPONSE</th>
<th>INPUT DEVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSIPS Menu</td>
<td>User Functions</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Ice Processing</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>AVHRR/OLS Lead Analysis</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Choices Menu</td>
<td>Screen Clouds/Land</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window</td>
<td>Select an Image Window</td>
<td>Mouse Button 1</td>
</tr>
<tr>
<td>Message Window</td>
<td>Select Blank Squares</td>
<td>Mouse Button 1</td>
</tr>
<tr>
<td>Message Window</td>
<td>Select Square to Clear</td>
<td>Mouse Button 1</td>
</tr>
<tr>
<td>Message Window</td>
<td>Exit</td>
<td>Mouse Button 3</td>
</tr>
<tr>
<td>Ice Processing Choices Menu</td>
<td>Return to Main Menu</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Files</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Files Menu</td>
<td>Write an Image to a File</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>PROMPT</td>
<td>RESPONSE</td>
<td>INPUT DEVICE</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Message Window</td>
<td>Select an Image Window</td>
<td>Mouse Button 1</td>
</tr>
<tr>
<td>File Type to Write Menu</td>
<td>Row/Column File</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Amount of Window Menu</td>
<td>Whole Window</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window (New file name:)</td>
<td>Enter File name</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window</td>
<td>Click</td>
<td>Mouse Button 1</td>
</tr>
<tr>
<td>Files Menu</td>
<td>Return to Main Menu</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Quit</td>
<td>Mouse Button</td>
</tr>
</tbody>
</table>

### 3.1.3 Screen Clouds/Land Output

An output image is generated and displayed showing the selected 64 x 64 grid elements (or blocks) blanked out. The output image is then written to a binary file.

### 3.1.4 Screen Clouds/Land Example Output

During execution of the Screen Clouds/Land function messages will be displayed to the message window.

Each time an area is selected to be blanked during the image editing, both the image with the grid and the image without the grid will be updated to reflect the selection. Upon termination, the original image will reappear on the screen along with the image with blanked areas.

After execution, the output image will be written to binary disk file.

An example file name is: `SMACHINE/run/images/ice_std_01.rc`. 
3.1.5 Screen Clouds/Land Error Conditions

In the event that an error occurs, the following steps should be taken:

1. Verify that the user environment variable $MACHINE has been initialized to contain the computer designator and the assigned directory path.

2. Make sure that the requirements stated in Section 3.1.1 have been met.

3. Reenter inputs by referring to Table 3.1.2-1.
3.2 **Hough Transform**

Hough Transform obtains lead orientation within each 64 x 64 pixel block of a cloud-free image. The Hough Transform technique automatically finds lines and their orientation (0 - 179) as well as the number of pixels along each line.

3.2.1 **Hough Transform Input Requirements**

NSIPS must first be executed as directed in Appendix A. Screen Clouds/Land must have completed normally and created output files located in the directory $MACHINE/run/images.

3.2.2 **Hough Transform Example Input**

Table 3.2.2-1 provides the prompts and example responses required to run Hough Transform.

3.2.3 **Hough Transform Output**

Hough Transform will create accumulator, rose plot and lead summary files.

3.2.4 **Hough Transform Example Output**

After all file names and the minimum length are input, the following text is displayed during a program execution wait of approximately four (4) minutes:

"... hava cupa java ..."

Hough Transform produces an accumulator file, a rose plot file and a lead summary file. These files may be revised or plotted for determination of the transformation results.

Example file names:

$MACHINE/run/images/ice_std_01.acc
$MACHINE/run/images/ice_std_01.rose
$MACHINE/run/images/ice_std_01.lss
### TABLE 3.2.2-1. Hough Transform Inputs

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<tr>
<th>PROMPT</th>
<th>RESPONSE</th>
<th>INPUT DEVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSIPS Menu</td>
<td>User Functions</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function</td>
<td>Ice Processing</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Menu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice Processing</td>
<td>AVHRR/OLS Lead Analysis</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Options Menu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice Processing</td>
<td>Hough Transform</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Choices Menu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Message Window (.rc file list)</td>
<td>Select file name</td>
<td>Mouse Button</td>
</tr>
<tr>
<td></td>
<td>(Ex: ice_std_01.rc)</td>
<td></td>
</tr>
<tr>
<td>Message Window (.acc file)</td>
<td>Enter file name</td>
<td>Keyboard</td>
</tr>
<tr>
<td></td>
<td>(Ex: ice_std_01)</td>
<td></td>
</tr>
<tr>
<td>Message Window (.rose file)</td>
<td>Enter file name</td>
<td>Keyboard</td>
</tr>
<tr>
<td></td>
<td>(Ex: ice_std_01)</td>
<td></td>
</tr>
<tr>
<td>Message Window (.lss file)</td>
<td>Enter file name</td>
<td>Keyboard</td>
</tr>
<tr>
<td></td>
<td>(Ex: ice_std_01)</td>
<td></td>
</tr>
<tr>
<td>Message Window (Minimum Length)</td>
<td>Enter Minimum Length</td>
<td>Keyboard</td>
</tr>
<tr>
<td></td>
<td>(Ex: 50)</td>
<td></td>
</tr>
<tr>
<td>Ice Processing</td>
<td>Return to Main Menu</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Choices Menu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice Processing</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Options Menu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select User Function</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Menu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Quit</td>
<td>Mouse Button</td>
</tr>
</tbody>
</table>

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3.2.5 Hough Transform Error Conditions

In the event that an error occurs, the following steps should be taken:

1. Verify that the user environment variable $MACHINE has been initialize to contain the computer designator and the assigned directory path.
2. Make sure that the requirements stated in Section 3.2.1 have been met.
3. Reenter inputs by referring to Table 3.2.2-1.
3.3 **Display Rose Plot**

Display Rose Plot displays the rose patterns of the accumulator array on the original image as well as on a blank window.

### 3.3.1 Display Rose Plot Input Requirements

NSIPS must first be executed as directed in Appendix A. Hough Transform must have completed normally and created an output rose plot file located in the directory $MACHINE/run/images. An Image file must already be displayed using the NSIPS option described in Appendix B so that it may be chosen for input.

### 3.3.2 Display Rose Plot Example Input

Table 3.3.2-1 provides the prompts and example responses required to run Display Rose Plot.

### 3.3.3 Display Rose Plot Output

Display Rose Plot creates an image display overlaid by the rose plots for each of the 64 x 64 pixel squares. The function also creates a blank window with the rose plots displayed.

### 3.3.4 Display Rose Plot Example Output

During execution of the Display Rose Plot function, messages will be displayed to the message window.

### 3.3.5 Display Rose Plot Error Conditions

In the event that an error occurs, the following steps should be taken:

1. Verify that the user environment variable $MACHINE has been initialized to contain the computer designator and the assigned directory path.

2. Make sure that the requirements stated in Section 3.3.1 have been met.

3. Reenter inputs by referring to Table 3.3.2-1.
**TABLE 3.3.2-1. Display Rose Plot Inputs**

<table>
<thead>
<tr>
<th>PROMPT</th>
<th>RESPONSE</th>
<th>INPUT DEVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSIPS Menu</td>
<td>User Functions</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Ice Processing</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>AVHRR/OLS Lead Analysis</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Choices Menu</td>
<td>Display Rose Plot</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window (*.rose file list)</td>
<td>Select file name (Ex: ice_std_01.rose)</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window</td>
<td>Select an Image Window</td>
<td>Mouse Button 1</td>
</tr>
<tr>
<td>Message Window (km per 32 pixels)</td>
<td>Enter km value (Ex: 100)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Ice Processing Choices Menu</td>
<td>Return to Main Menu</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Quit</td>
<td>Mouse Button</td>
</tr>
</tbody>
</table>
3.4 Lead Statistics

Lead Statistics calculates the fractional lead area, lead spacing and lead width statistics for a cloud-free binary lead image. These values are presented in table form in the output file.

3.4.1 Lead Statistics Input Requirements

NSIPS must first be executed as directed in Appendix A. Image files must be available in the directory $MACHINE/run/images.

3.4.2 Lead Statistics Example Input

Table 3.4.2-1 provides the prompts and example responses required to run Lead Statistics.

3.4.3 Lead Statistics Output

Lead Statistics produces an output statistics file.

3.4.4 Lead Statistics Example Output

After all file names are input, the following text is displayed during a program execution wait of approximately 30 seconds:

"... bava cupa java ...


3.4.5 Lead Statistics Error Conditions

In the event that an error occurs, the following steps should be taken:

1. Verify that the user environment variable $MACHINE has been initialized to contain the computer designator and the assigned directory path.

2. Make sure that the requirements stated in Section 3.4.1 have been met.

3. Reenter inputs by referring to Table 3.4.2-1.
### TABLE 3.4.2-1. **Lead Statistics Inputs**

<table>
<thead>
<tr>
<th>PROMPT</th>
<th>RESPONSE</th>
<th>INPUT DEVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSIPS Menu</td>
<td>User Functions</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Ice Processing</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>AVHRR/OLS Lead Analysis</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Choices Menu</td>
<td>Lead Statistics</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window (.rc file list)</td>
<td>Select file name (Ex: ice_std_01.rc)</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window (.stats file)</td>
<td>Enter file name (Ex: ice_std_01)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Ice Processing Choices Menu</td>
<td>Return to Main Menu</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Quit</td>
<td>Mouse Button</td>
</tr>
</tbody>
</table>
3.5 **Motion Detect/Filter**

Motion Detect/Filter computes ice motion vectors for an image pair using a cross correlation technique. Vectors are computed on a 10-km grid. Confidence in a resulting vector is given by its correlation coefficient. The vector filtering depends on the correlation coefficient and the variation of the vector from its neighboring vectors.

3.5.1 **Motion Detect/Filter Input Requirements**

NSIPS must first be executed as directed in Appendix A. Image files must be available in the directory $MACHINE/run/images.

3.5.2 **Motion Detect/Filter Example Input**

Table 3.5.2-1 provides the prompts and example responses required to run Motion Detect/Filter.

3.5.3 **Motion Detect/Filter Output**

Motion Detect/Filter produces an output vector file.

3.5.4 **Motion Detect/Filter Example Output**

After all file names and parameters are input, the following text is displayed during a program execution wait of approximately 40 minutes:

"... go get lunch ..."

Motion Detect/Filter produces a vector file. Example file name: $MACHINE/run/images/ice_std_01.vec.

3.5.5 **Motion Detect/Filter Error Conditions**

In the event that an error occurs, the following steps should be taken:

1. Verify that the user environment variable $MACHINE has been initialized to contain the computer designator and the assigned directory path.

2. Make sure that the requirements stated in Section 3.5.1 have been met.

3. Reenter inputs by referring to Table 3.5.2-1.
<table>
<thead>
<tr>
<th>PROMPT</th>
<th>RESPONSE</th>
<th>INPUT DEVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSIPS Menu</td>
<td>User Functions</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Ice Processing</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>AVHRR/OLS Ice Motion Analysis</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Motion Processing Choices Menu</td>
<td>Motion Detect/Filter</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window (.rc file list)</td>
<td>Select a .rc file (Ex: 26mar92_1410_n11.rc)</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window (.rc file list)</td>
<td>Select a .rc file (Ex: 26mar92_1336_n11.rc)</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window (.vec file)</td>
<td>Enter a .vec file (Ex: ice_std_01)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (Image Size)</td>
<td>Enter Image Size (Ex: 512)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (Chip Subimage Size)</td>
<td>Enter Chip Subimage Size (Ex: 10)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (Maximum Motion)</td>
<td>Enter Maximum Motion (Ex: 20)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (Minimum Intensity Value)</td>
<td>Enter Minimum Intensity Value (Ex: 0)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>PROMPT</td>
<td>RESPONSE</td>
<td>INPUT DEVICE</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>--------------</td>
</tr>
<tr>
<td>Message Window (Maximum Intensity Value)</td>
<td>Enter Maximum Intensity Value (Ex: 255)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (Chip Overlap)</td>
<td>Enter Chip Overlap (Ex: 0)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (Time Difference Between Images)</td>
<td>Enter Time Difference Between Images (Ex: 71.5)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (km/pixel)</td>
<td>Enter km/pixel (Ex: 1.1)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (Correlation Cutoff)</td>
<td>Enter Correlation Cutoff (Ex: .4)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Message Window (Maximum Pixel Difference)</td>
<td>Enter Maximum Pixel Difference (Ex: 1)</td>
<td>Keyboard</td>
</tr>
<tr>
<td>Motion Processing Choices Menu</td>
<td>Return to Main Menu</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Quit</td>
<td>Mouse Button</td>
</tr>
</tbody>
</table>
3.6 **Motion Vector Display**

Motion Vector Display overlays the ice motion vectors on an image display.

3.6.1 **Motion Vector Display Input Requirements**

NSIPS must first be executed as directed in Appendix A. Motion Detect/Filter must have completed normally and created an output vector file located in the directory $MACHINE/run/images. An image file must already be displayed using the NSIPS option described in Appendix B so that it may be chosen for input.

3.6.2 **Motion Vector Display Example Input**

Table 3.1.2-1 provides the prompts and example responses required to run Motion Vector Display.

3.6.3 **Motion Vector Display Output**

After the execution of Motion Vector Display, the ice motion vectors are displayed on the selected image window.

3.6.4 **Motion Vector Display Example Output**

During execution of the Lead Statistics function, messages will be displayed to the message window.

3.6.5 **Motion Vector Display Error Conditions**

In the event that an error occurs, the following steps should be taken:

1. Verify that the user environment variable $MACHINE has been initialized to contain the computer designator and the assigned directory path.

2. Make sure that the requirements stated in Section 3.6.1 have been met.

3. Reenter inputs by referring to Table 3.6.2-1.
<table>
<thead>
<tr>
<th>PROMPT</th>
<th>RESPONSE</th>
<th>INPUT DEVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSIPS Menu</td>
<td>User Functions</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Ice Processing</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>AVHRR/OLS Ice Motion</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Motion Processing Choices Menu</td>
<td>Motion Vector Display</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Message Window</td>
<td>Select an Image Window</td>
<td>Mouse Button 1</td>
</tr>
<tr>
<td>Message Window (.vec file)</td>
<td>Select a .vec file (Ex: ice_std_01.vec)</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Pencil (displayed on image)</td>
<td>Move the pencil to where the legend is desired and Left Click</td>
<td>Mouse Button 1</td>
</tr>
<tr>
<td>Motion Processing Choices Menu</td>
<td>Return to Main Menu</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Exit</td>
<td>Mouse Button</td>
</tr>
</tbody>
</table>
### 4.0 NOTES

### 4.1 Glossary

<table>
<thead>
<tr>
<th>ACRONYM</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVHRR</td>
<td>Advanced Very High Resolution Radiometer</td>
</tr>
<tr>
<td>CSCI</td>
<td>Computer Software Configuration Item</td>
</tr>
<tr>
<td>DSD</td>
<td>Data Services Department</td>
</tr>
<tr>
<td>IR</td>
<td>Infrared</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NRL</td>
<td>Naval Research Laboratory</td>
</tr>
<tr>
<td>NSIPS</td>
<td>NRL Satellite Image Processing System</td>
</tr>
<tr>
<td>OLS</td>
<td>Operational Line Scan</td>
</tr>
<tr>
<td>SSC</td>
<td>Stennis Space Center</td>
</tr>
<tr>
<td>SUM</td>
<td>Software User’s Manual</td>
</tr>
</tbody>
</table>
Appendix A. NSIPS Execution Sequence

The execution sequence for NSIPS is as follows:

1. Change directories to the /run directory.
2. Source the .run file.
3. Change directories to the /imagepro directory.
4. Enter the command wave.
Appendix B. NSIPS Image Display Option

The execution sequence for the NSIPS Image Display option is as follows:

1. Execute NSIPS (See Appendix A).
2. Select Files from the NSIPS Menu.
3. Select List Files and Display Them from the Files Menu.
4. Select Image from the File Type Menu.
5. Select w_test.img from the Select File Name Menu.
6. Select Automatic from the Scale Type Menu.
7. Select Standard (512x512) from the Display Size Menu.
8. Select Continue from the Overlay Option Menu.
SOFTWARE TEST DOCUMENT

FOR THE

ICE PROCESSING SYSTEM
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SOFTWARE TEST DOCUMENT FOR THE ICE PROCESSING SYSTEM

1.0 SCOPE

1.1 Identification

This Software Test Document establishes the test requirements for the Computer Software Configuration Item (CSCI) identified as the Ice Processing System. The Naval Research Laboratory (NRL) has requested the National Aeronautics and Space Administration (NASA)/Stennis Space Center (SSC) Technical Support Services Contractor’s Data Services Department (DSD) to provide technical support to develop the Ice Processing System software.

1.2 System Overview

The Ice Processing System provides a user-friendly, menu-driven system performing data transformation and filtering functions as well as motion detection on glacial ice masses detected through Advanced Very High Resolution Radiometer (AVHRR)/Operational Line Scan (OLS) infrared (IR) satellite imagery.

The transformation and filtering functions provide interactive cloud and land screening, transformation of images into Hough space, generation of high-resolution accumulator space scan lines, execution of Hough transform space peak neighborhood analysis, display of rose plots, and calculation of ice lead statistics.

The motion detection functions calculate ice motion vectors of two time-sequential images, filter the vectors, and display the vectors over a screen image.

The Ice Processing System software architecture identifying the Computer Software Components (CSCs) and related Computer Software Units (CSUs) is given in Figure 1.2-1.

1.3 Document Overview

This document contains a description of the test cases and test procedures necessary to perform the formal qualification testing of the Ice Processing System.
2.0 APPLICABLE DOCUMENTS

2.1 Government Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification will be considered a superseding requirement.

SPECIFICATIONS:
None.

STANDARDS:
DoD-STD-2167A
29 February 1988
Military Standard Defense
System Software Development

DRAWINGS:
None.

OTHER PUBLICATIONS:
NOARL Technical Note 50
Spring 1990

NRL/MR/7240--93-7072
Summer 1993
The Hough Transform Technique for Sea Ice Lead Analysis: An Evaluation

Figure 1.2-1. Ice Processing Architecture
Copies of specifications, standards, drawings, and publications required by DSD in connection with the software development functions should be obtained from NRL or as directed by NRL.

2.2 Non-Government Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification will be considered a superseding requirement.

SPECIFICATIONS:
None.

STANDARDS:
None.

DRAWINGS:
None.

OTHER PUBLICATIONS:
Sverdrup Technology, Inc. Software Requirements Specification for the Ice Processing System September 1993
Sverdrup Technology, Inc. Software Design Description for the Ice Processing System September 1993

Copies of specifications, standards, drawings, and publications required by DSD in connection with the software development functions should be obtained from NRL or as directed by NRL.

3.0 FORMAL QUALIFICATION TEST PREPARATION

The Ice Processing software was designed to execute one function at a time and will be tested in that manner. The general flow of execution would be to:

a. Perform cloud and land screening on the selected image.

b. Execute the Hough transform to determine the ice lead characteristics and orientations.

c. Display the lead information via a rose plot of orientation vs. length for the image.

d. Compute the lead spacing and width statistics.

e. Compute and filter the motion vectors for two time-sequential images.
The following sections describe the test schedule and pre-test procedures for each formal qualification test of the Ice Processing System.

3.1 Screen Clouds/Land

This section describes the test schedule and pre-test procedures for the qualification tests of the Screen Clouds/Land CSU which is part of the Transformation/Filtering Processing CSC. This CSU provides a mechanism for selecting various 64 x 64 grid elements (or blocks) in which clouds or land appear. These blocks are blanked out and not used in the lead analysis.

3.1.1 Screen Clouds/Land Schedule

The qualification test will be performed during Fiscal Year (FY) 94 by NRL personnel.

3.1.2 Screen Clouds/Land Pre-Test Procedures

3.1.2.1 Hardware Preparation

The following hardware will be required to perform the test:

a. SUN SPARCStation
   -  SUN OS 4.1.X Operating System
   -  32 Megabytes (MB) of Random Access Memory (RAM)
   -  600 MB Hard Disk
   -  Keyboard
   -  Mouse
   -  Color Graphic Display Device

b. Silicon Graphics, Inc. (SGI) Workstation
   -  IRIX 4.0.X Operating System
   -  32 MB of RAM
   -  600 MB Hard Disk
   -  Keyboard
   -  Mouse
   -  Color Graphic Display Device

Prior to the test, the hardware will be checked to verify that the systems are operating normally. The hardware verification will be performed the day prior to the qualification test.

3.1.2.2 Software Preparation

The following support software must be resident on the SUN and the SGI to perform the test:

-  X Window System
-  Precision Visuals - Workstation Analysis and Visualization Environment (PV-WAVE) Graphics System
-  C Programming Language
Prior to loading the Ice Processing System, the NRL Satellite Imagery Processing System (NSIPS) software system and support files must be installed and certain directories must be created on the SUN and the SGI.

The UNIX environment variable $MACHINE must be initialized to contain the computer designator and the assigned directory path.

### 3.1.2.3 Other Pre-Test Preparations

The image files (.rc) should be copied from the distribution disk to the $MACHINE/run/images/ directory prior to performing the qualification test.

#### 3.2 Hough Transform

This section describes the test schedule and pre-test procedures for the qualification tests of the Hough Transform CSU which is part of the Transformation/Filtering Processing CSC. Lead orientation is obtained within each 64 x 64 pixel block of a cloud-free image using the Hough transform. The Hough transform technique automatically finds lines and their orientation (0 - 179), as well as the number of pixels along each line.

##### 3.2.1 Hough Transform Schedule

The schedule for the Hough Transform qualification test will be identical to that presented in Section 3.1.1.

##### 3.2.2 Hough Transform Pre-Test Procedures

#### 3.2.2.1 Hardware Preparation

The hardware preparation for the Hough Transform qualification test will be identical to that presented in Section 3.1.2.1.

#### 3.2.2.2 Software Preparation

The software preparation for the Hough Transform qualification test will be identical to that presented in Section 3.1.2.2.

#### 3.2.2.3 Other Pre-Test Preparation

The other pre-test preparation for the Hough Transform qualification test will be identical to that presented in Section 3.1.2.3.

#### 3.3 Display Rose Plot

This section describes the test schedule and pre-test procedures for the qualification tests of the Display Rose Plot CSU which is part of the Transformation/Filtering Processing CSC. This CSU displays the rose patterns of the accumulator array on the original image as well as on a blank window.
3.3.1 Display Rose Plot Schedule
The schedule for the Display Rose Plot qualification test will be identical to that presented in Section 3.1.1.

3.3.2 Display Rose Plot Pre-Test Procedures

3.3.2.1 Hardware Preparation
The hardware preparation for the Display Rose Plot qualification test will be identical to that presented in Section 3.1.2.1.

3.3.2.2 Software Preparation
The software preparation for the Display Rose Plot qualification test will be identical to that presented in Section 3.1.2.2.

3.3.2.3 Other Pre-Test Preparation
The other pre-test preparation for the Display Rose Plot qualification test will be identical to that presented in Section 3.1.2.3.

3.4 Lead Statistics
This section describes the test schedule and pre-test procedures for the qualification tests of the Lead Statistics CSU which is part of the Transformation/Filtering Processing CSC. This CSU calculates the fractional lead area, lead spacing and lead width statistics for a cloud-free binary lead image. These values are presented in a table form in the output file.

3.4.1 Lead Statistics Schedule
The schedule for the Lead Statistics qualification test will be identical to that presented in Section 3.1.1.

3.4.2 Lead Statistics Pre-Test Procedures

3.4.2.1 Hardware Preparation
The hardware preparation for the Lead Statistics qualification test will be identical to that presented in Section 3.1.2.1.

3.4.2.2 Software Preparation
The software preparation for the Lead Statistics qualification test will be identical to that presented in Section 3.1.2.2.

3.4.2.3 Other Pre-Test Preparation
The other pre-test preparation for the Lead Statistics qualification test will be identical to that presented in Section 3.1.2.3.
3.5 Motion Detect/Filter

This section describes the test schedule and pre-test procedures for the qualification tests of the Motion Detect/Filter CSU which is part of the Motion Processing CSC. This CSU computes ice motion vectors for an image pair using a cross correlation technique. Vectors are computed on a 10 km grid. Confidence in a resulting vector is given by its correlation coefficient. The vector filtering depends on the correlation coefficient and the variation of the vector from its neighboring vectors.

3.5.1 Motion Detect/Filter Schedule

The schedule for the Motion Detect/Filter qualification test will be identical to that presented in Section 3.1.1.

3.5.2 Motion Detect/Filter Pre-Test Procedures

3.5.2.1 Hardware Preparation

The hardware preparation for the Motion Detect/Filter qualification test will be identical to that presented in Section 3.1.2.1.

3.5.2.2 Software Preparation

The software preparation for the Motion Detect/Filter qualification test will be identical to that presented in Section 3.1.2.2.

3.5.2.3 Other Pre-Test Preparation

The other pre-test preparation for the Motion Detect/Filter qualification test will be identical to that presented in Section 3.1.2.3.

3.6 Motion Vector Display

This section describes the test schedule and pre-test procedures for the qualification tests of the Motion Vector Display CSU which is part of the Motion Processing CSC. This CSU overlays the ice motion vectors on an image display.

3.6.1 Motion Vector Display Schedule

The schedule for the Motion Vector Display qualification test will be identical to that presented in Section 3.1.1.

3.6.2 Motion Vector Display Pre-Test Procedures

3.6.2.1 Hardware Preparation

The hardware preparation for the Motion Vector Display qualification test will be identical to that presented in Section 3.1.2.1.
3.6.2.2 Software Preparation

The software preparation for the Motion Vector Display qualification test will be identical to that presented in Section 3.1.2.2.

3.6.2.3 Other Pre-Test Preparation

The other pre-test preparation for the Motion Vector Display qualification test will be identical to that presented in Section 3.1.2.3.

4.0 FORMAL QUALIFICATION TEST DESCRIPTION

The following sections identify the test cases, test procedures, and related information associated with each formal qualification test of the Ice Processing System. An Ice Processing System Cross-Reference Table is given in Table 4.0-1.

Table 4.0-1. Ice Processing System Cross-Reference Matrix

<table>
<thead>
<tr>
<th>REQUIREMENT NAME</th>
<th>SRS SECTION 3 PARAGRAPH</th>
<th>SDD SECTION 4 PARAGRAPH</th>
<th>STD SECTION 4 PARAGRAPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware/Software Suite</td>
<td>3.0</td>
<td>4.1</td>
<td>4.0</td>
</tr>
<tr>
<td>NSIPS Option</td>
<td>3.0</td>
<td>4.1</td>
<td>4.0</td>
</tr>
<tr>
<td>User-Friendly, Menu Driven</td>
<td>3.2</td>
<td>4.1</td>
<td>4.0</td>
</tr>
<tr>
<td>Perform Transformation and Filtering</td>
<td>3.2.2</td>
<td>4.2</td>
<td>4.1 - 4.4</td>
</tr>
<tr>
<td>Motion Detection/Display</td>
<td>3.2.3</td>
<td>4.3</td>
<td>4.5 - 4.6</td>
</tr>
</tbody>
</table>

Each test within this STD will verify the first three requirements in Table 4.0-1 via mere execution of the test.

In the test descriptions, the following convention on input device is used: "select" or "click" refer to mouse input and "enter" refers to keyboard input.

4.1 Screen Clouds/Land

The purpose of this test is to verify selection of the image, division of the image into 8 x 8 64 pixel squares, blanking out the selected areas of clouds/land and saving the resultant image to a file.

4.1.1 Screen Clouds/Land Requirements Traceability

This test will fulfill the engineering requirements in Section 3.2.2 in the Ice Processing System Software Requirements Specification (SRS).

4.1.2 Screen Clouds/Land Initialization
This test requires that the hardware and software configuration be identical to that presented in Section 3.1.

4.1.3 **Screen Clouds/Land Test Inputs**

The test inputs will be entered by the mouse or keyboard in response to prompts displayed on the screen. Table 4.1.3-1 provides the prompts and responses required for this test.

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Window</td>
<td>Select an Image Window (Left Click)</td>
</tr>
<tr>
<td>Message Window</td>
<td>Left Click to Select Blank Squares</td>
</tr>
<tr>
<td>Message Window</td>
<td>Left Click on Square to Clear (repeat 13 times to blank all areas shown in Figure 4.1.6-1)</td>
</tr>
<tr>
<td>Message Window</td>
<td>Right Click to Exit</td>
</tr>
<tr>
<td>Ice Processing Choices Menu</td>
<td>Select Return to Main Menu</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>Select Exit</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Select Exit</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Select Files</td>
</tr>
<tr>
<td>Files Menu</td>
<td>Select Write an Image to a File</td>
</tr>
<tr>
<td>Message Window</td>
<td>Select an Image Window (Left Click)</td>
</tr>
<tr>
<td>File Type to Write Menu</td>
<td>Select Row/Column File</td>
</tr>
<tr>
<td>Amount of Window Menu</td>
<td>Select Whole Window</td>
</tr>
<tr>
<td>Message Window</td>
<td>Enter Name: ice_std_01</td>
</tr>
<tr>
<td>Message Window</td>
<td>Left Click</td>
</tr>
<tr>
<td>Files Menu</td>
<td>Select Return to Main Menu</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Select Quit</td>
</tr>
</tbody>
</table>

4.1.4 **Screen Clouds/Land Expected Test Results**

During the image editing, each time an area is selected for being blanked, both the image with the grid and the one without the grid should be updated to reflect the selection. Upon termination of the CSU, the original image should reappear on the screen along with the image with the blanked areas.
After the test of this CSU has completed execution normally, there should be an image file residing on the disk. The name of the file should be $\text{MACHINE}/\text{run}/\text{images}/\text{ice\_std\_01.\text{rc}}$.

### 4.1.5 Screen Clouds/Land Test Evaluation Criteria

The criteria for evaluating the test are as follows:

- The CSU terminated normally
- The ice\_std\_01.\text{rc} file was created

### 4.1.6 Screen Clouds/Land Test Procedure

The following steps define the test procedure for performing the test:

1. Execute NSIPS by entering "wave" or "waveadv" at the system prompt.
2. Execute Ice Processing by first entering "User Functions" at the NSIPS Menu, and then choosing "Ice Processing" from the "Select User Function" Menu.
3. Execute the CSC by selecting the "AVHRR/OLS Lead Analysis" option from the "Ice Processing Options" menu.
4. Execute the CSU by selecting the Screen Clouds/Land option from the "Ice Processing Choices" menu.
5. Enter responses, given in Table 4.1.3-1, in response to the CSU and following NSIPS prompts.
6. Upon termination of the CSU, verify that saved file exists.
7. Through NSIPS redisplay the Image to assure the blanked portions are indeed blank (see Figure 4.1.6-1).
In the event that the test terminates other than normally, the test will have to be performed again. Error conditions can occur on the open/close or read/write operations on the files which would cause the CSU to terminate. Prior to performing the test again, make sure that the required file(s) resides on the SUN/SGI.

4.1.7 Screen Clouds/Land Assumptions and Constraints

It is assumed that the user is logged on the system with the default image directory set to $MACHINE/run/images/ and the following file exists on the system:

- Image File - $MACHINE/run/images/07apr92.rc

It is also assumed that the Image file has already been displayed through an NSIPS option so that it may get clicked on (or chosen) for input to this test (see Figure 4.1.7-1 for the original image display).
4.2 Hough Transform

The purpose of this test is to perform the Hough Transform on the cloud/land screened image and to verify the resultant output files.

4.2.1 Hough Transform Requirements Traceability

This test will fulfill the engineering requirements in Section 3.2.2 in the Ice Processing System SRS.

4.2.2 Hough Transform Initialization

This test requires that the hardware and software configuration be identical to that presented in Section 3.1.

4.2.3 Hough Transform Test Inputs

The test inputs will be entered by the mouse or keyboard in response to prompts displayed on the screen. Table 4.2.3-1 provides the prompts and responses required for this test.
Table 4.2.3-1. Hough Transform Mouse/Keyboard Inputs

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Window - .rc file</td>
<td>Select: ice_std_01.rc</td>
</tr>
<tr>
<td>list</td>
<td></td>
</tr>
<tr>
<td>Message Window - .acc file</td>
<td>Enter: ice_std_01</td>
</tr>
<tr>
<td>Message Window - .rose file</td>
<td>Enter: ice_std_01</td>
</tr>
<tr>
<td>Message Window - .lss file</td>
<td>Enter: ice_std_01</td>
</tr>
<tr>
<td>Message Window - minimum</td>
<td>Enter: 50.</td>
</tr>
<tr>
<td>length</td>
<td></td>
</tr>
<tr>
<td>Message Window -</td>
<td>N/A. There is an approximate 4 minute</td>
</tr>
<tr>
<td></td>
<td>wait for program execution during</td>
</tr>
<tr>
<td></td>
<td>which time the following text is</td>
</tr>
<tr>
<td></td>
<td>displayed:</td>
</tr>
<tr>
<td></td>
<td>&quot;... hava cupa java ...&quot;</td>
</tr>
</tbody>
</table>

Ice Processing Choices Menu Select Return to Main Menu

Ice Processing Options Menu Select Exit

Select User Function Menu Select Exit

NSIPS Menu Select Quit

4.2.4 Hough Transform Expected Test Results

After the test of this CSU has completed execution normally, there should be an accumulator file, rose plot file and lead summary file. The names of these files should be:

$MACHINE/run/images/ice_std_01.acc
$MACHINE/run/images/ice_std_01.rose
$MACHINE/run/images/ice_std_01.lss

4.2.5 Hough Transform Test Evaluation Criteria

The criteria for evaluating the test are as follows:

- The CSU terminated normally
- The accumulator, rose plot and lead summary files were created
4.2.6 Hough Transform Test Procedure

The following steps define the test procedure for performing the test:

1. Execute NSIPS by entering "wave" or "waveadv" at the system prompt.

2. Execute Ice Processing by first entering "User Functions" at the NSIPS Menu, and then choosing "Ice Processing" from the "Select User Function" Menu.

3. Execute the CSC by selecting the "AVHRR/OLS Lead Analysis" option from the "Ice Processing Options" menu.

4. Execute the CSU by selecting the Hough Transform option from the "Ice Processing Choices" menu.

5. Enter responses, given in Table 4.2.3-1, in response to the CSU and following NSIPS prompts.

6. Upon termination of the CSU, verify that the three output files exist.

7. Perform an ASCII dump on the rose plot and lead summary files to verify the numbers versus Tables 4.2.6-1 and 4.2.6-2.

<table>
<thead>
<tr>
<th>Table 4.2.6-1. Rose Plot File</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rose Plot File Sample</td>
</tr>
<tr>
<td>of First 25 Lines</td>
</tr>
<tr>
<td>0.0  0.0</td>
</tr>
<tr>
<td>0.0  1.0</td>
</tr>
<tr>
<td>21.0  2.0</td>
</tr>
<tr>
<td>23.0  3.0</td>
</tr>
<tr>
<td>0.0  4.0</td>
</tr>
<tr>
<td>0.0  5.0</td>
</tr>
<tr>
<td>0.0  6.0</td>
</tr>
<tr>
<td>0.0  7.0</td>
</tr>
<tr>
<td>0.0  8.0</td>
</tr>
<tr>
<td>0.0  9.0</td>
</tr>
<tr>
<td>0.0 10.0</td>
</tr>
<tr>
<td>0.0 11.0</td>
</tr>
<tr>
<td>0.0 12.0</td>
</tr>
<tr>
<td>0.0 13.0</td>
</tr>
<tr>
<td>0.0 14.0</td>
</tr>
<tr>
<td>0.0 15.0</td>
</tr>
<tr>
<td>0.0 16.0</td>
</tr>
<tr>
<td>0.0 17.0</td>
</tr>
<tr>
<td>0.0 18.0</td>
</tr>
<tr>
<td>26.0 19.0</td>
</tr>
<tr>
<td>0.0 20.0</td>
</tr>
<tr>
<td>0.0 21.0</td>
</tr>
<tr>
<td>0.0 22.0</td>
</tr>
<tr>
<td>0.0 23.0</td>
</tr>
<tr>
<td>0.0 24.0</td>
</tr>
</tbody>
</table>
Table 4.2.6-2. Lead Summary File

Lead Summary File Sample of Header and First 25 Data Records

Input file name = /sid2/run/images/07apr92.rc

<table>
<thead>
<tr>
<th>Block Number</th>
<th>Direction</th>
<th>km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.0</td>
<td>21.0</td>
</tr>
<tr>
<td>1</td>
<td>3.0</td>
<td>23.0</td>
</tr>
<tr>
<td>1</td>
<td>19.0</td>
<td>26.0</td>
</tr>
<tr>
<td>1</td>
<td>28.0</td>
<td>16.0</td>
</tr>
<tr>
<td>1</td>
<td>43.0</td>
<td>56.0</td>
</tr>
<tr>
<td>1</td>
<td>50.0</td>
<td>31.0</td>
</tr>
<tr>
<td>1</td>
<td>64.0</td>
<td>10.0</td>
</tr>
<tr>
<td>1</td>
<td>68.0</td>
<td>23.0</td>
</tr>
<tr>
<td>1</td>
<td>77.0</td>
<td>11.0</td>
</tr>
<tr>
<td>1</td>
<td>113.0</td>
<td>11.0</td>
</tr>
<tr>
<td>1</td>
<td>126.0</td>
<td>29.0</td>
</tr>
<tr>
<td>1</td>
<td>159.0</td>
<td>12.0</td>
</tr>
<tr>
<td>2</td>
<td>42.0</td>
<td>16.0</td>
</tr>
<tr>
<td>2</td>
<td>45.0</td>
<td>16.0</td>
</tr>
<tr>
<td>2</td>
<td>56.0</td>
<td>11.0</td>
</tr>
<tr>
<td>2</td>
<td>68.0</td>
<td>78.0</td>
</tr>
<tr>
<td>2</td>
<td>76.0</td>
<td>17.0</td>
</tr>
<tr>
<td>2</td>
<td>82.0</td>
<td>9.0</td>
</tr>
<tr>
<td>2</td>
<td>87.0</td>
<td>9.0</td>
</tr>
<tr>
<td>3</td>
<td>28.0</td>
<td>10.0</td>
</tr>
<tr>
<td>3</td>
<td>32.0</td>
<td>12.0</td>
</tr>
<tr>
<td>3</td>
<td>42.0</td>
<td>20.0</td>
</tr>
<tr>
<td>3</td>
<td>43.0</td>
<td>8.0</td>
</tr>
<tr>
<td>3</td>
<td>51.0</td>
<td>24.0</td>
</tr>
<tr>
<td>3</td>
<td>58.0</td>
<td>30.0</td>
</tr>
</tbody>
</table>

In the event that the test terminates other than normally, the test will have to be performed again. Error conditions can occur on the open/close or read/write operations on the files which would cause the CSU to terminate. Prior to performing the test again, make sure that the required file(s) resides on the SUN/SGI.

4.2.7 Hough Transform Assumptions and Constraints

It is assumed that the user is logged on the system with the default image directory set to $MACHINE/run/images/ and the following file exists on the system:

- Image File - $MACHINE/run/images/ice_std_01.rc

4.3 Display Rose Plot

The purpose of this test is to display the rose patterns of the orientations and lengths for the leads in each of the 64 x 64 pixel blocks on the image and as a separate display window (rose plot).
4.3.1 **Display Rose Plot Requirements Traceability**

This test will fulfill the engineering requirements in Section 3.2.2 in the Ice Processing System SRS.

4.3.2 **Display Rose Plot Initialization**

This test requires that the hardware and software configuration be identical to that presented in Section 3.1.

4.3.3 **Display Rose Plot Test Inputs**

The test inputs will be entered by the mouse or keyboard in response to prompts displayed on the screen. Table 4.3.3-1 provides the prompts and responses required for this test.

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Window - .rose file Select: ice_std_01.rose</td>
<td></td>
</tr>
<tr>
<td>list</td>
<td></td>
</tr>
<tr>
<td>Message Window Select an Image Window (Left Click)</td>
<td></td>
</tr>
<tr>
<td>Message Window - km per Enter: 100.</td>
<td></td>
</tr>
<tr>
<td>32 pixels</td>
<td></td>
</tr>
<tr>
<td>Ice Processing Choices Menu Select Return to Main Menu</td>
<td></td>
</tr>
<tr>
<td>Ice Processing Options Menu Select Exit</td>
<td></td>
</tr>
<tr>
<td>Select User Function Menu Select Exit</td>
<td></td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Select Quit</td>
</tr>
</tbody>
</table>

4.3.4 **Display Rose Plot Expected Test Results**

After the test of this CSU has completed execution normally, there should be an image display overlaid by the rose plots for each of the 64 x 64 pixel squares to compare with Figure 4.3.4-1. There should also be a blank window with the rose plots displayed.

4.3.5 **Display Rose Plot Test Evaluation Criteria**

The criteria for evaluating the test are as follows:

- The CSU terminated normally
- The rose plot on the display screen matches that shown in Figure 4.3.4-1
4.3.6 Display Rose Plot Test Procedure

The following steps define the test procedure for performing the test:

1. Execute NSIPS by entering "wave" or "waveadv" at the system prompt.

2. Execute Ice Processing by first entering "User Functions" at the NSIPS Menu, and then choosing "Ice Processing" from the "Select User Function" Menu.

3. Execute the CSC by selecting the "AVHRR/OLS Lead Analysis" option from the "Ice Processing Options" menu.

4. Execute the CSU by selecting the Display Rose Plot option from the "Ice Processing Choices" menu.

5. Enter responses, given in Table 4.3.3-1, in response to the CSU and following NSIPS prompts.

6. Upon termination of the CSU, verify that the rose plots match.
In the event that the test terminates other than normally, the test will have to be performed again. Error conditions can occur on the open/close or read/write operations on the files which would cause the CSU to terminate. Prior to performing the test again, make sure that the required file(s) resides on the SUN/SGI.

4.3.7 Display Rose Plot Assumptions and Constraints

It is assumed that the user is logged on the system with the default image directory set to $MACHINE/run/images/ and the following file exists on the system:

- Rose Plot File - $MACHINE/run/images/ice_std_01.rose

The appropriate Image (same used in Test 4.1, see Figure 4.1.7-1) must be displayed before starting the test.

4.4 Lead Statistics

The purpose of this test is to compute lead spacing and lead width statistics.

4.4.1 Lead Statistics Requirements Traceability

This test will fulfill the engineering requirements in Section 3.2.2 in the Ice Processing System SRS.

4.4.2 Lead Statistics Initialization

This test requires that the hardware and software configuration be identical to that presented in Section 3.1.

4.4.3 Lead Statistics Test Inputs

The test inputs will be entered by the mouse or keyboard in response to prompts displayed on the screen. Table 4.4.3-1 provides the prompts and responses required for this test.

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Window - .rc file list</td>
<td>Select: ice_std_01.rc</td>
</tr>
<tr>
<td>Message Window - .stats file</td>
<td>Enter: ice_std_01</td>
</tr>
<tr>
<td>Message Window - N/A.</td>
<td>N/A. There is an approximate 30 second wait for program execution during which time the following text appears:</td>
</tr>
</tbody>
</table>

2-18
is displayed:

"... hava cupa java ..."

Ice Processing Choices Menu Select Return to Main Menu
Ice Processing Options Menu Select Exit
Select User Function Menu Select Exit
NSIPS Menu Select Quit

4.4.4 Lead Statistics Expected Test Results

After the test of this CSU has completed execution normally, there should be a statistics file. The name of the file should be ice_std_01.stats

4.4.5 Lead Statistics Test Evaluation Criteria

The criteria for evaluating the test are as follows:

- The CSU terminated normally
- The Statistics file was created

4.4.6 Lead Statistics Test Procedure

The following steps define the test procedure for performing the test:

1. Execute NSIPS by entering "wave" or "waveadv" at the system prompt.
2. Execute Ice Processing by first entering "User Functions" at the NSIPS Menu, and then choosing "Ice Processing" from the "Select User Function" Menu.
3. Execute the CSC by selecting the "AVHRR/OLS Lead Analysis" option from the "Ice Processing Options" menu.
4. Execute the CSU by selecting the Lead Statistics option from the "Ice Processing Choices" menu.
5. Enter responses, given in Table 4.4.3-1, in response to the CSU and following NSIPS prompts.
6. Upon termination of the CSU, verify that the statistics file exists.
7. Perform an ASCII dump of the ice_std_01.stats file and verify the contents with Table 4.4.6-1.
Table 4.4.6-1. Statistics File

Sample Statistics File

File:/sid2/run/images/07apr92.rc

Image size (km in one dimension): 512
Percent covered by leads: 7.2

<table>
<thead>
<tr>
<th>orientation (deg)</th>
<th># of lead crossings</th>
<th>mean spacing (km)</th>
<th>std spacing (km)</th>
<th>mn width (km)</th>
<th>std width (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.</td>
<td>1249</td>
<td>16.8</td>
<td>16.2</td>
<td>1.9</td>
<td>1.2</td>
</tr>
<tr>
<td>15.</td>
<td>1178</td>
<td>17.1</td>
<td>18.0</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>30.</td>
<td>1043</td>
<td>19.5</td>
<td>21.9</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>45.</td>
<td>843</td>
<td>23.8</td>
<td>29.0</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>60.</td>
<td>1036</td>
<td>20.1</td>
<td>28.5</td>
<td>2.0</td>
<td>1.7</td>
</tr>
<tr>
<td>75.</td>
<td>1090</td>
<td>19.4</td>
<td>25.4</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>90.</td>
<td>1146</td>
<td>18.6</td>
<td>19.7</td>
<td>2.0</td>
<td>1.4</td>
</tr>
<tr>
<td>105.</td>
<td>1226</td>
<td>17.4</td>
<td>18.9</td>
<td>1.8</td>
<td>1.2</td>
</tr>
<tr>
<td>120.</td>
<td>1209</td>
<td>17.4</td>
<td>17.0</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td>135.</td>
<td>1127</td>
<td>17.9</td>
<td>17.1</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>150.</td>
<td>1252</td>
<td>16.1</td>
<td>16.0</td>
<td>1.6</td>
<td>0.9</td>
</tr>
<tr>
<td>165.</td>
<td>1368</td>
<td>14.9</td>
<td>14.4</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td>180.</td>
<td>1249</td>
<td>16.8</td>
<td>16.2</td>
<td>1.9</td>
<td>1.2</td>
</tr>
</tbody>
</table>

In the event that the test terminates other than normally, the test will have to be performed again. Error conditions can occur on the open/close or read/write operations on the files which would cause the CSU to terminate. Prior to performing the test again, make sure that the required file(s) resides on the SUN/SGI.

4.4.7 Lead Statistics Assumptions and Constraints

It is assumed that the user is logged on the system with the default image directory set to $MACHINE/run/images/ and the following file exists on the system:

- Image File - $MACHINE/run/images/ice_std_01.rc

4.5 Motion Detect/Filter

The purpose of this test is to select two images of the same area but different times, determine the ice motion vectors and to filter the vectors.

4.5.1 Motion Detect/Filter Requirements Traceability

This test will fulfill the engineering requirements in Section 3.2.3 in the Ice Processing System SRS.

4.5.2 Motion Detect/Filter Initialization

This test requires that the hardware and software configuration be identical to that presented in Section 3.1.
4.5.3 Motion Detect/Filter Test Inputs

The test inputs will be entered by the mouse or keyboard in response to prompts displayed on the screen. Table 4.5.3-1 provides the prompts and responses required for this test.

Table 4.5.3-1. Motion Detect/Filter Mouse/Keyboard Inputs

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Window - .rc file Select:</td>
<td>26mar92_1410_n11.rc</td>
</tr>
<tr>
<td>list</td>
<td></td>
</tr>
<tr>
<td>Message Window - .rc file Select:</td>
<td>29mar92_1336_n11.rc</td>
</tr>
<tr>
<td>list</td>
<td></td>
</tr>
<tr>
<td>Message Window - .vec file Enter:</td>
<td>ice_std_01</td>
</tr>
<tr>
<td>Message Window - image size Enter:</td>
<td>512.</td>
</tr>
<tr>
<td>Message Window - chip Enter:</td>
<td>10.</td>
</tr>
<tr>
<td>subimage size</td>
<td></td>
</tr>
<tr>
<td>motion</td>
<td></td>
</tr>
<tr>
<td>Message Window - Minimum Enter:</td>
<td>0.</td>
</tr>
<tr>
<td>intensity value</td>
<td></td>
</tr>
<tr>
<td>Message Window - Maximum Enter:</td>
<td>255.</td>
</tr>
<tr>
<td>intensity value</td>
<td></td>
</tr>
<tr>
<td>Message Window - Chip Enter:</td>
<td>0.</td>
</tr>
<tr>
<td>overlap</td>
<td></td>
</tr>
<tr>
<td>Message Window - Time Enter:</td>
<td>71.5</td>
</tr>
<tr>
<td>difference between images</td>
<td></td>
</tr>
<tr>
<td>Message Window - km/pixel Enter:</td>
<td>1.1</td>
</tr>
<tr>
<td>Message Window - Enter:</td>
<td>.4</td>
</tr>
<tr>
<td>Correlation cutoff</td>
<td></td>
</tr>
<tr>
<td>Message Window - Maximum Enter:</td>
<td>1.</td>
</tr>
</tbody>
</table>
pixel difference

Message Window - N/A. There is an approximate 40 minute wait for program execution during which time the following text is displayed:

"... go get lunch ...

Motion Processing Choices Select Return to Main Menu

Menu

Ice Processing Options Menu Select Exit

Select User Function Menu Select Exit

NSIPS Menu Select Quit

4.5.4 Motion Detect/Filter Expected Test Results

After the test of this CSU has completed execution normally, there should be a vector file. The name of this file should be $MACHINE/run/images/ice_std_01.vec.

4.5.5 Motion Detect/Filter Test Evaluation Criteria

The criteria for evaluating the test are as follows:

- The CSU terminated normally
- The vector file was created

4.5.6 Motion Detect/Filter Test Procedure

The following steps define the test procedure for performing the test:

1. Execute NSIPS by entering "wave" or "waveadv" at the system prompt.

2. Execute Ice Processing by first entering "User Functions" at the NSIPS Menu, and then choosing "Ice Processing" from the "Select User Function" Menu.

3. Execute the CSC by selecting the "AVHRR/OLS Ice Motion Analysis" option from the "Ice Processing Options" menu.

4. Execute the CSU by selecting the Motion Detect/Filter option from the "Motion Processing Choices" menu.

5. Enter responses, given in Table 4.5.3-1, in response to the CSU and following NSIPS prompts.

2-22
6. Upon termination of the CSU, verify that the vector file was generated (See Table 4.5.6-1).

<table>
<thead>
<tr>
<th>Table 4.5.6-1. Motion Vector File</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample of the Vector File Header and First 25 Data Records</td>
</tr>
</tbody>
</table>

```
/sid2/run/images/26mar92_n1l.rc
/sid2/run/images/29mar92_n1l.rc

<table>
<thead>
<tr>
<th>47 47 0.3888811171</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 0 71.4300000000 1.0000000000</td>
</tr>
<tr>
<td>25.5000000000 25.5000000000 0.3888811171 -2.7221677303 0.8212952018</td>
</tr>
<tr>
<td>35.5000000000 25.5000000000 0.3888811171 -2.7221677303 0.7998079062</td>
</tr>
<tr>
<td>45.5000000000 25.5000000000 -7.7776222229 3.1110489368 0.0000000000</td>
</tr>
<tr>
<td>55.5000000000 25.5000000000 1.1666433811 -3.1110489368 0.7471593022</td>
</tr>
<tr>
<td>65.5000000000 25.5000000000 0.3888811171 -2.7221677303 0.8294126391</td>
</tr>
<tr>
<td>75.5000000000 25.5000000000 0.3888811171 -3.1110489368 0.7998079062</td>
</tr>
<tr>
<td>85.5000000000 25.5000000000 0.3888811171 -3.1110489368 0.8294126391</td>
</tr>
<tr>
<td>95.5000000000 25.5000000000 0.3888811171 -3.1110489368 0.8051504493</td>
</tr>
<tr>
<td>105.5000000000 25.5000000000 0.3888811171 -3.1110489368 0.6919284463</td>
</tr>
<tr>
<td>115.5000000000 25.5000000000 0.3888811171 -3.1110489368 0.6345492230</td>
</tr>
<tr>
<td>125.5000000000 25.5000000000 0.7777622342 -3.4999301434 0.7546359301</td>
</tr>
<tr>
<td>135.5000000000 25.5000000000 -6.6109790802 -7.7776222229 0.0000000000</td>
</tr>
<tr>
<td>145.5000000000 25.5000000000 0.7777622342 -3.4999301434 0.7866768837</td>
</tr>
<tr>
<td>155.5000000000 25.5000000000 0.7777622342 -3.4999301434 0.8094323277</td>
</tr>
<tr>
<td>165.5000000000 25.5000000000 -5.4443354607 -3.4999301434 0.0000000000</td>
</tr>
<tr>
<td>175.5000000000 25.5000000000 0.7777622342 -3.1110489368 0.0000000000</td>
</tr>
<tr>
<td>185.5000000000 25.5000000000 1.1666433811 -3.8888111115 0.0000000000</td>
</tr>
<tr>
<td>195.5000000000 25.5000000000 0.7777622342 -3.4999301434 0.0000000000</td>
</tr>
<tr>
<td>205.5000000000 25.5000000000 -5.8332166672 2.3332867622 0.0000000000</td>
</tr>
<tr>
<td>215.5000000000 25.5000000000 3.8888111115 -7.7776222229 0.0000000000</td>
</tr>
<tr>
<td>225.5000000000 25.5000000000 0.0000000000 -7.7776222229 0.0000000000</td>
</tr>
<tr>
<td>235.5000000000 25.5000000000 -3.4999301434 -7.7776222229 0.0000000000</td>
</tr>
<tr>
<td>245.5000000000 25.5000000000 1.1666433811 -0.7777622342 0.0000000000</td>
</tr>
<tr>
<td>255.5000000000 25.5000000000 7.7776222229 -4.2776923180 0.0000000000</td>
</tr>
<tr>
<td>265.5000000000 25.5000000000 1.9444055557 -7.7776222229 0.0000000000</td>
</tr>
</tbody>
</table>

In the event that the test terminates other than normally, the test will have to be performed again. Error conditions can occur on the open/close or read/write operations on the files which would cause the CSU to terminate. Prior to performing the test again, make sure that the required file(s) resides on the SUN/SGI.

4.5.7 Motion Detect/Filter Assumptions and Constraints

It is assumed that the user is logged on the system with the default image directory set to $MACHINE/run/images/ and the following files exist on the system:

- Image File 1 - $MACHINE/run/images/26mar92_1440_n1l.rc
- Image File 2 - $MACHINE/run/images/29mar92_1336_n1l.rc
4.6  **Motion Vector Display**

The purpose of this test is to display the ice motion vectors on the image for which they were calculated.

4.6.1  **Motion Vector Display Requirements Traceability**

This test will fulfill the engineering requirements in Section 3.2.3 in the Ice Processing System SRS.

4.6.2  **Motion Vector Display Initialization**

This test requires that the hardware and software configuration be identical to that presented in Section 3.1.

4.6.3  **Motion Vector Display Test Inputs**

The test inputs will be entered by the mouse or keyboard in response to prompts displayed on the screen. Table 4.6.3-1 provides the prompts and responses required for this test.

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Window - Image 1</td>
<td>Select an Image Window (Left Click)</td>
</tr>
<tr>
<td>Message Window - .vec file</td>
<td>Select: ice_std_01.vec</td>
</tr>
<tr>
<td>Pencil (displayed on image)</td>
<td>Move the pencil to where the legend is desired and Left Click</td>
</tr>
<tr>
<td>Motion Processing Choices</td>
<td>Select Return to Main Menu</td>
</tr>
<tr>
<td>Ice Processing Options Menu</td>
<td>Select Exit</td>
</tr>
<tr>
<td>Select User Function Menu</td>
<td>Select Exit</td>
</tr>
<tr>
<td>NSIPS Menu</td>
<td>Select Quit</td>
</tr>
</tbody>
</table>

4.6.4  **Motion Vector Display Expected Test Results**

After the test of this CSU has completed execution normally, the ice motion vectors should be displayed on the selected image window.
4.6.5 Motion Vector Display Test Evaluation Criteria

The criteria for evaluating the test are as follows:

- The CSU terminated normally
- The vectors are correct

4.6.6 Motion Vector Display Test Procedure

The following steps define the test procedure for performing the test:

1. Execute NSIPS by entering "wave" or "waveadv" at the system prompt.

2. Execute Ice Processing by first entering "User Functions" at the NSIPS Menu, and then choosing "Ice Processing" from the "Select User Function" Menu.

3. Execute the CSC by selecting the "AVHRR/OLS Ice Motion Analysis" option from the "Ice Processing Options" menu.

4. Execute the CSU by selecting the Motion Vector Display option from the "Motion Processing Choices" menu.

5. Enter responses, given in Table 4.6.3-1, in response to the CSU and following NSIPS prompts.

6. Upon termination of the CSU, verify that the vectors have been displayed on the image window.

In the event that the test terminates other than normally, the test will have to be performed again. Error conditions can occur on the open/close or read/write operations on the files which would cause the CSU to terminate. Prior to performing the test again, make sure that the required file(s) resides on the SUN/SGI.

4.6.7 Motion Vector Display Assumptions and Constraints

It is assumed that the user is logged on the system with the default image directory set to $MACHINE/run/images/ and the following file exists on the system:

- Motion Vector File - $MACHINE/run/images/ice_std_01.vec

It is also assumed that the Image file has already been displayed through an NSIPS option so that it may get clicked on (or chosen) for input to this test.
5.0 NOTES

5.1 Glossary

AVHRR  Advanced Very High Resolution Radiometer
CSCI  Computer Software Configuration Item
CSC  Computer Software Component
CSU  Computer Software Unit
DSD  Data Services Department
FY  Fiscal Year
IR  Infrared
MB  Megabytes
NASA  National Aeronautics and Space Administration
NRL  Naval Research Laboratory
OLS  Operational Line Scan
PV-WAVE  Precision Visuals - Workstation Analysis and Visualization Environment
RAM  Random Access Memory
SDD  Software Design Document
SGI  Silicon Graphics, Inc.
SRS  Software Requirements Specification
SSC  Stennis Space Center
STD  Software Test Document
Appendix A - Image File Format

512 x 512 (262144) - values 0 to 255 stored as byte (a1)
(.rc extension) Data stored columnwise.

Appendix B - Accumulator File Format

Set of 181 (-90 to 90) records for each 64 x 64 block (64 sets). Each record has 181 accumulator values stored as byte (a1).

Values = 0 or are set at lead centroid (index in array) to the size of the image scan space line (in pixels).

Appendix C - Rose Plot File Format

For each of the 64 blocks and each angle (0 - 179):

Data: Total length and angle (f6, f5)

Appendix D - Lead Summary File Format

Header:
1. "Input File Name = ", a
2. "Block Number Direction km^2"

Data:
Block Number, angle, Length
(5X, I2, 11X, F5, 4X, F5)

Appendix E - Lead Statistics File Format

Header:
1. "File:", 40a
2. "Image size (km in one direction):", I4
   "Percent Covered by Leads:", F8
3. "Orientation # of lead mean spacing std spacing mn width std width"
   "(deg) crossings (km) (km) (km) (km)"

Data: angle, numleads, rmeanspace, stdspace, rmeanwidth, stdwidth
(4X, F4.0, 8X, I6, 5X, F6, 7X, F6, 5X, F6, 3X, F6)
Appendix F - Motion Vector File Format

Header:
1. Input image file 1 - 1x, a80
2. Input image file 2 - 1x, a80
3. Number of vectors in the x direction, number of vectors in the y direction, scale for pixel to velocity - i4, i4, f15.10
4. Number of samples in chip (or window), chip_overlap, time difference in minutes, kilometers per pixel (usually 1.0 or 1.1) - 2i10, 2f15.10

Data: x and y pixel numbers of the vector’s starting point, x and y directional velocities, correlation coefficient (0.0 to 1.0) - 5f15.10
Appendix G - Temporary Files Formats

G.1 Hough Transformation

File Name: h64chj.dat

<table>
<thead>
<tr>
<th>Record</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Image File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2</td>
<td>Accumulator File Name</td>
<td>a80</td>
</tr>
<tr>
<td>3</td>
<td>Rose Plot File Name</td>
<td>a80</td>
</tr>
<tr>
<td>4</td>
<td>Lead Summary File Name</td>
<td>a80</td>
</tr>
<tr>
<td>5</td>
<td>Minimum Length</td>
<td>f10.5</td>
</tr>
</tbody>
</table>

G.2 Lead Statistics

File Name: tempstats.dat

<table>
<thead>
<tr>
<th>Record</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Image File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2</td>
<td>Lead Statistics File Name</td>
<td>a80</td>
</tr>
</tbody>
</table>

G.3 Motion

File Name: xmotion.inp

<table>
<thead>
<tr>
<th>Record</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Image1 File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2</td>
<td>Image2 File Name</td>
<td>a80</td>
</tr>
<tr>
<td>3</td>
<td>Image Size</td>
<td>i10</td>
</tr>
<tr>
<td>4</td>
<td>Chip subimage size</td>
<td>i10</td>
</tr>
<tr>
<td>5</td>
<td>Maximum Motion</td>
<td>i10</td>
</tr>
<tr>
<td>6</td>
<td>Minimum Intensity Value</td>
<td>i10</td>
</tr>
<tr>
<td>7</td>
<td>Maximum Intensity Value</td>
<td>i10</td>
</tr>
<tr>
<td>8</td>
<td>Chip Overlap</td>
<td>i10</td>
</tr>
<tr>
<td>9</td>
<td>Time Between Images</td>
<td>f15.10</td>
</tr>
<tr>
<td>10</td>
<td>Km/Pixel</td>
<td>f15.10</td>
</tr>
</tbody>
</table>

G.4 Motion Filter

File Name: motion_filter.inp

<table>
<thead>
<tr>
<th>Record</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vector File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2</td>
<td>Correlation Cutoff</td>
<td>f15.10</td>
</tr>
<tr>
<td>3</td>
<td>Maximum Pixel Difference</td>
<td>f15.10</td>
</tr>
</tbody>
</table>
SOFTWARE DESIGN DOCUMENT

FOR THE

ICE PROCESSING SYSTEM
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SOFTWARE DESIGN DOCUMENT
FOR THE
ICE PROCESSING SYSTEM

1.0 SCOPE

1.1 Identification

This Software Design Document establishes the design for the Computer Software Configuration Item (CSCI) identified as the Ice Processing System. The Naval Research Laboratory (NRL) has requested the National Aeronautics and Space Administration (NASA)/Stennis Space Center (SSC) Technical Support Services Contractor's Data Services Department (DSD) to provide technical support to develop the Ice Processing System software.

1.2 System Overview

The Ice Processing System will provide a user-friendly, menu-driven system performing data transformation and filtering functions as well as motion detection on glacial ice masses detected through Advanced Very High Resolution Radiometer (AVHRR)/Operational Line Scan (OLS) infrared (IR) satellite imagery.

The transformation and filtering functions will provide interactive cloud and land screening, transformation of images into Hough space, generation of high-resolution accumulator space scan lines, execution of Hough transform space peak neighborhood analysis, display of rose plots, and calculation of ice lead statistics.

The motion detection functions will calculate ice motion vectors of two time-sequential images, filter the vectors, and display the vectors over a screen image.

1.3 Document Overview

This document defines the design of the Ice Processing System and will be used as the basis for the implementation and testing of the software system.

2.0 APPLICABLE DOCUMENTS

2.1 Government Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification will be considered a superseding requirement.

SPECIFICATIONS:

None.
2.2 **Non-Government Documents**

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification will be considered a superseding requirement.

**SPECIFICATIONS:**

None.

**STANDARDS:**

None.

**DRAWINGS:**

None.

**OTHER PUBLICATIONS:**

Sverdrup Technology, Inc.  
Software Requirements Specification for the Ice Processing System  
September 1993

Other documentation to be used as reference for the SDD includes the SUN, SGI, FORTRAN, C and PV-WAVE User’s Manuals and Reference Guides.

Copies of specifications, standards, drawings, and publications required by DSD in connection with the software development functions should be obtained from NRL or as directed by NRL.
3.0 PRELIMINARY DESIGN

The Ice Processing System will be developed and maintained on the SUN SPARCStations and Silicon Graphics, Inc. (SGI) workstations using the X Window System, Precision Visuals - Workstation Analysis and Visualization Environment (PV-WAVE) graphics system, C programming language, and FORTRAN 77+ programming language.

The Ice Processing will run as an option of the NRL Satellite Image Processing System (NSIPS) software. After software startup, the user will interface with the system via mouse point-and-click inputs as well as keyboard commands.

3.1 CSCI Overview

Figure 3.1-1 provides an overview of the external interfaces of the Ice Processing System.

![Diagram of external interfaces]

**Figure 3.1-1. External Interface Overview**

The Image File (.rc) contains a standard 512 x 512 AVHRR IR satellite image. The format for the Image File is given in Appendix A.

The graphic display device is any of the various color monitors that can be interfaced to the SUN SPARCStation and/or the Silicon Graphics.

The mouse device is any of the various hand-held pointing devices that can be interfaced to the SUN SPARCStation and/or the Silicon Graphics.

3.1.1 CSCI Architecture

The Ice Processing System software architecture is shown in Figure 3.1.1-1.
The Ice Processing software is composed of three Computer Software Components (CSCs): Ice Processing Menu, Transformation/Filtering Processing and Motion Processing.

The Ice Processing Menu will allow the user to select a processing option or to terminate the processing and return control to NSIPS. Once a selection has been made, the appropriate subordinate processing software will be executed.

The Transformation/Filtering Processing software will be menu-driven for selection of the ice processing options. The Screen Clouds/Land portion of the processing will provide interactive editing of imagery data to blank out 64 x 64 pixel squares of clouds and/or land prior to performing the ice lead processing. The Hough Transform portion of the processing will perform the Hough 64 piece processing for leads. The Rose Plot portion of the processing will display the rose plots for the length of the leads in each direction (0 - 179°) as detected through the Hough 64 piece processing. The Lead Statistics portion of the processing will calculate fractional lead area; and lead spacing and lead width statistics for a binary lead image.

The Motion Processing software will be menu-driven for selection of the ice motion processing choices. The Motion Processing portion of the processing will calculate motion vectors of two time-sequential images and apply a filter to the vectors. The Motion Vectors portion of the processing will overlay the motion vectors on the display image.
Figure 3.1.1-2 provides an overview of the internal interfaces of the Ice Processing System.

The Accumulator file (.acc) will contain sizes of the image space lines (in pixels) by orientation (0 - 179°) for each of the 64 blocks. The format of this file is given in Appendix B.

The Rose Plot file (.rose) will contain the lead lengths and the angles for each of the 64 blocks of the image. The format of this file is given in Appendix C.

The Lead Summary file (.lss) will contain the image source header information followed by the lead size and orientation information in the form of block number, angle and length for each lead. The format of this file is given in Appendix D.

The Lead Statistics file (.stats) will contain the image source header information followed by a list of the the lead orientation (deg), the number of lead crossings, mean spacing (km), standard spacing (km), mean width (km) and standard width (km). The format of this file is given in Appendix E.

The Motion Vector file (.vec) will contain the image source and vector header information followed by the x and y pixel number of the vector’s starting point, the x and y directional velocities and the correlation coefficient (0.0 to 1.0) for each vector. The format of this file is given in Appendix F.
The temporary files will be used to pass such information as input file name(s), output file name, and program parameters from the main processing modules to the Hough transformation, lead statistics, motion and motion filter programs. The formats of these files are given in Appendix G.

3.1.2 System States and Modes

The Ice Processing software was designed to execute one function at a time. The general flow of execution would be to:

a. Perform cloud and land screening on the selected image.

b. Execute the Hough transform to determine the ice lead characteristics and orientations.

c. Display the lead information via a rose plot of orientation vs. length for the image.

d. Compute the lead spacing and width statistics.

e. Compute and filter the motion vectors for two time-sequential images.

f. Display the motion vectors on the image.

3.1.3 Sizing and Timing Requirements

Since the Ice Processing System will not be a real-time processing system, the system will not have strict processing time requirements. However, the system will be designed and implemented with the user response time being a vital concern.

The Ice Processing System software and associated files will be required to function within the target SUN computer system environment utilizing the SUN OS 4.1.X operating system, 32 Megabytes (MB) of Random Access Memory (RAM), and a 600 MB hard disk.

The Ice Processing System software and associated files will also be required to function within the target SGI computer system environment utilizing the IRIX 4.0.X operating system, 32 MB of RAM, and a 600 MB hard disk.

3.2 CSCI Design Description

The Ice Processing System will provide the capabilities for satellite imagery data edit, process, and display that are described in the following sections.

3.2.1 Ice Menu System

The Ice Processing System will provide a user-friendly menu system that will interact with all the subordinate processing software.
3.2.2 Transformation/Filtering Processing

The Transformation/Filtering Processing software will be menu-driven for selection of the ice processing options.

The Screen Clouds/Land portion of the processing will provide interactive editing of imagery data to blank out 64 x 64 pixel squares of clouds and/or land prior to performing the ice lead processing.

The Hough Transform portion of the processing will perform the Hough 64 piece processing for leads.

The Rose Plot portion of the processing will display the rose plots for the length of the leads in each direction (0 - 179°) as detected through the 64 piece processing.

The Lead Statistics portion of the processing will calculate fractional lead area, lead spacing and lead width statistics for a binary lead image.

3.2.3 Motion Processing

The Motion Processing software will be menu-driven for selection of the ice motion processing choices.

The Motion Processing portion of the processing will calculate motion vectors of two time-sequential images and apply a filter to the vectors.

The Motion Vectors portion of the processing will display the motion vectors on the display image.
4.0 DETAILED DESIGN

4.1 Ice Menu System

This CSC will display a menu for user selection of a processing option or to return to the NSIPS menu (or exit).

4.1.1 Ice Menu Design Specification/Constraints

The Ice Menu System CSC displays the "Ice Processing Options" menu for user selection of the desired menu option. If a processing option is selected, the appropriate processing CSC will be activated and, upon its completion, the menu will be re-displayed. This will continue until the "Exit" option is selected. At this time the CSC will terminate and control will return to the NSIPS menu (or the system prompt).

4.1.2 Ice Menu Design

This section of the SDD contains the detailed design information for this CSC.

a. Input/Output Data Elements

Input: File(s): None
Keyboard/Mouse: Processing Option

Output: File(s): None
Screen: Ice Processing Menu

b. Local Data Elements

Option Number (sel)

c. Error Handling

N/A

d. Logic Flow

The Program Design Language (PDL) for the logic flow of this CSC is as follows:

```
Loop until option = exit
   Display Menu
   If option = AVHRR/OLS Lead Analysis - start NRL_IceMenu
   If option = AVHRR/OLS Ice Motion Analysis - start MotionMenu
End loop
Exit
```
4.2 Transformation/Filtering Processing

This CSC provides the "Ice Processing Choices" menu for selecting the function to be performed. The available functions are:

a. Screen Clouds/Land
b. Run Hough Transform for Orientation and Size
c. Display Rose Plot
d. Run Lead Space and Width Algorithm
e. Return to Main Menu

The first four of the functions correspond to the four CSUs in this CSC and the last one will return control to the Ice Menu System CSC.

4.2.1 Screen Clouds/Land

This CSU provides a mechanism for selecting various 64 x 64 grid elements (or blocks) in which clouds or land appear. These blocks are blanked out and not used in the lead analysis.

4.2.1.1 Screen Clouds/Land Design Specification/Constraints

The commonly used, automatic methods for masking clouds in IR images of the ocean are not successful over ice-covered seas, where clouds may be either warmer or cooler than underlying ice. Clouds are often distinguishable from leads only by their shape. Therefore, a manual selection of cloud and land areas has been chosen.

The CSU divides the selected image into 8 x 8 64 pixel squares and then the user can select the areas containing the clouds and land. Once all the desired areas have been blanked, the user must double click in a blanked out square to exit the function.

4.2.1.2 Screen Clouds/Land Design

This section of the SDD contains the detailed design information for this CSU.

a. Input/Output Data Elements

Input: File(s): 512 x 512 Image
       Keyboard/ Mouse: Image Selection
                      Block Selection

Output: File(s): None
       Screen: 512 x 512 Image with a 64 x 64 grid overlaid and blocks blanked out
b. **Local Data Elements**

Selected Image Window Number (curr1)
Window Number for Copy of Image (window_num)

c. **Error Handling**

This CSU checks the status of the mouse throughout to process. If the status is normal (=1), the CSU continues with the block blanking process. If it is for a double click (=4), the CSU terminates the selection process. If it is anything else, the CSU waits for another response.

d. **Logic Flow**

The PDL for the logic flow of this CSU is as follows:

- **Input:** 512 x 512 Image
  - Mouse - Image selection and square(s) selection
- **Output:** 512 x 512 Image with 64 x 64 pixel areas blanked out

Select Image 1 - via placing cursor on the image and clicking
Get Window Number
Initialize window information
Draw grid lines on the image to make it 8 x 8 of 64 pixel squares

```
:-----------------------:  
<p>| 1 2 3 4 5 6 7 8      |
| 9 . . .              |
|                      |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
</tr>
</tbody>
</table>
```

Message - "Click select to blank squares"
  "Click menu to continue"
Set up loop to blank the squares containing land and clouds
Message - "Click select on square to clear"
  "Click menu on square to exit"
Set column and row values for the 64 pixel square
Replot the selected square (or block) blanked out
End loop
When done, deallocate array space

e. **Local Data Files/Data Bases**

N/A

f. **Limitations**

To successfully execute the CSU, at least one image must have previously been displayed.

To save the edited image, the NSIPS Write an Image to a File function must be executed.
4.2.2 Hough Transform

Lead orientation is obtained within each 64 x 64 pixel block of a cloud-free image using the Hough transform. The Hough transform technique automatically finds lines and their orientation (0 - 179°), as well as the number of pixels along each line.

4.2.2.1 Hough Transform Design Specification/Constraints

This CSU prompts the user to select an image, assign the output file names, and enter the minimum length of the threshold inside the transform. The input image (0 - 255) is then converted to a binary image (0 or 255). The Hough transform works on pixels which have already been tentatively classified as lead pixels. Each pixel in "image space" is mapped into a curve in "parameter space". Parameter space is represented as an accumulator array of discrete rho (distance from the image origin to a line) and theta (orientation). The Geric accumulator optimization technique is then applied, followed by accumulator space clustering. Because each column in the accumulator array has the size of a lead with that column's orientation, the array is then used to create the rose plot file of lead size for orientations between 0 and 179° for each of the 64 blocks.

4.2.2.2 Hough Transform Design

This section of the SDD contains the detailed design information for this CSU.

a. Input/Output Data Elements

Input: File(s): 512 x 512 Image File
Keyboard/
Mouse: File Names
Threshold Minimum Length
Overwrite Option
File Selection

Output: File(s): Accumulator File (.acc)
Rose Plot File (.rose)
Lead Summary File (.lss)
Screen: File Assignment/Overwrite Messages

b. Local Data Elements

Image File Name (infile)
Accumulator File Name (outfile)
Rose Plot File Name (outrosefil)
Lead Summary File Name (outlssfil)
Threshold Minimum Length (minlen)
Image Size (imsize)
Accumulator Size (numac)
Image Data Array (image)
Accumulator Array (accumulator)
Accumulator Indexes (ib1 = 1, ib2 = 8, jb1 = 1, jb2)
Geric Accumulator Array (accugeric)
Angle (theta)
Distance from Origin (rho)
c. Error Handling

If there is no Image file(s) available, a message stating "Sorry, no files found" will be displayed and the "Ice Processing Choices" menu will be redisplayed.

d. Logic Flow

The PDL for the logic flow of this CSU is as follows:

Input: File names for .rc, .acc, .rose and .lss files
Keyboard - Length value and Overwrite option
Mouse - for File selection
Output: .rc file list
Messages
Temporary file (file names and parameter for "pvwh64chj")

Get and display list of Row/Column (.rc) files
Choose file via placing cursor on desired file and clicking mouse button.
Assign accumulator file name (.acc)
If file exists - overwrite Y/N - if N, exit
Assign rose plot file name (.rose)
If file exists - overwrite Y/N - if N, exit
Assign Lead summary file name (.lss)
If file exists - overwrite Y/N - if N, exit
Assign minimum length of the threshold inside the transform (Default = 5)
Write input and output file names and parameter via "printf"
Spawn "pvwh64chj" to compute for each of the 64 blocks the lead orientations and lengths

Program pvwh64ch.f:

Get the temporary directory
Open input file (*h64chj)
Read file names and minimum length of threshold inside the transform
Perform initialization
Call trigo
Open the Image file and the Accumulator file
Read the Image file - store the data in 512 x 512 array (input)
Fill Image array: input (i,j) > 128; image (i,j) = 255
else; image (i,j) = 0
Zero the Accumulator array
Loop thru data blocks (8 x 8)
*** Pass I - Transformation to Parameter Space
Loop thru 64 x 64 blocks
  If image (x,y) = 255
    Do 0, 179, 1 ; Lead angles
    Theta = angle
    Rho = distance from origin
    Call Quant ; Quanticize Rho
    Increment accumulator array
  End do

End if

3-12
Pass II - Geric Accumulator Optimization
Zero the Accumulator geric array (accugeric)
Loop thru 64 x 64 blocks
  If image (x,y) = 255
    Initialize counters
    Do 0, 179, 1 ; Lead angles
    Call Quant ; Quanticize Rho
    If Accumulator (rho,theta) > maxscn
      Set Max. scn, rho & theta
    End if
    End do
  If rhomax .ge. -irholen
    Increment accugeric
    LINK = rho & theta max.
  End if
End if
End loop

Pass III - Accumulator Space Clustering
Initialize Img array with geric accumulator values
Call CLUS
Zero Img and Accumulator arrays
Do 1, number of clusters
  Accumulator (centroid) = size of image space line (in pixels)
End do
Write accumulator file (0 to 179 angles per record - each character is al format; -90 to 90 records)
End loop
Close Input and accumulator files
Call cjrose
Stop

Subroutine Clus:
  Zero Cluster array and ledg and nedg arrays
  Find clusters in hough accumulator space
  Determine size of image space line (in pixels) which corresponds to each cluster as well as the cluster's centroid
  Return

Subroutine Quant:
  Set integer and fractional parts of (rho/irhostep)
  Set irho depending on the fractional part
  Return

Subroutine Trigo:
  Set arrays for sine and cosine values for 0 - 179 degrees
Subroutine CJrose:

Open Accumulator, Rose Plot and Summary files
Loop on the 64 blocks (8 x 8)
  Read a set of accumulator data (input)
  Zero frequency for the angle array and frequency rho
  Cycle through the accumulator data summing size
  of image space line sections by angle (or
  orientation) (freqang)
  Write Rose Plot file
  If freq > minimum, write Summary file
End Loop

e. Local Data Files/Data Bases

The following local data files are accessed by this CSU:

Accumulator File (.acc) - See Appendix B for the file format and content.
Rose Plot File (.rose) - See Appendix C for the file format and content.
Lead Summary File (.lss) - See Appendix D for the file format and content.
Temporary Input File for Program pvwh64ch (pvwh64chj.dat) - See Appendix G.1 for the file format and content.

f. Limitations

If any of the output files exist and the user chooses not to overwrite the current file information, this option terminates and the "Ice Processing Choices* menu is redisplayed.

4.2.3 Display Rose Plot

This CSU displays the rose patterns of the accumulator array on the original image as well as on a blank window.

4.2.3.1 Display Rose Plot Design Specification/Constraints

Initially, the user must select the image and rose plot file along with the radius of the circle (how many km for the 32 pixel radius). The rose plot file is read for each of the 64 pixel square blocks. In each applicable block, the length or size of the lead is displayed at the given orientation on the image and the blank window.

4.2.3.2 Display Rose Plot Design

This section of the SDD contains the detailed design information for this CSU.

3-14
a. Input/Output Data Elements

Input: File(s): Rose Plot File (.rose)
Keyboard/
Mouse: Circle Radius (km/32 pixel radius)
Rose File Name
Image Selection

Output: File(s): None
Screen: Rose Plots on the Selected Image
Rose Plots on the Blank Window

b. Local Data Elements

km/32 Pixel Radius (pixperkm)
Image Window Number on Which to Display Rose Plots (curr1)
Window Number of Blank Window (window_num)
Orientation Array (ang)
Length Array (times)

c. Error Handling

If there is no .rose file(s), display a message and return to display of the "Ice Processing Choices" menu.

d. Logic Flow

The PDL for the logic flow of this CSU is as follows:

Input: Rose file to plot (.rose)
Image on which to plot the rose file info
Keyboard - Radius of circle (how many km for the 32 pixel radius)
Mouse - File name and Image selections

Output: The rose plot on the image - lengths are plotted in red unless they are longer than the radius and then they are in yellow
The rose plot on a new window with no image

Get and display list of rose plot (.rose) files
Choose file via putting cursor on file name and clicking
Select Imagel by placing cursor on it and clicking
Get Window Number of Imagel
Get new window number for blank screen
Draw 8 x 8 grid on both windows
Loop through 8 x 8 blocks
Read orientations and lengths
Plot rose vectors
End loop

e. Local Data Files/Data Bases

The following local data file is accessed by this CSU:

Rose Plot File (.rose) - See Appendix C for the file format and content.
f. **Limitations**

To successfully execute this CSU, at least one image must have previously been displayed.

### 4.2.4 Lead Statistics

This CSU calculates the fractional lead area, lead spacing and lead width statistics for a cloud-free binary lead image. These values are presented in a table form in the output file.

#### 4.2.4.1 Lead Statistics Design Specification/Constraints

Once the Image and Statistics file names have been assigned, the files are opened. The Image file is read and the "suspected" lead pixels are counted. The final value is then used to calculate the percent of the image that is covered by leads. A "comb" of 64 lines is passed through the image to find the average spacing between encounters with leads along each line of the comb. The main processing loop goes from 0 to 180° in increments of 15°, in order to obtain lead spacing as a function of compass direction. The CSU processes through the image for each directional group and then computes the mean width and its standard deviation along with the mean spacing and its standard deviation. The values are then written to the Statistics file.

#### 4.2.4.2 Lead Statistics Design

This section of the SDD contains the detailed design information for this CSU.

**a. Input/Output Data Elements**

<table>
<thead>
<tr>
<th>Input: File(s):</th>
<th>512 x 512 Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyboard/ Mouse:</td>
<td>Image Selection</td>
</tr>
<tr>
<td></td>
<td>Statistics File Name</td>
</tr>
<tr>
<td></td>
<td>Overwrite Option</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output: File(s):</th>
<th>Statistics File</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temporary File</td>
</tr>
<tr>
<td>Screen:</td>
<td>Assignment and Overwrite Messages</td>
</tr>
</tbody>
</table>

**b. Local Data Elements**

- Image File Name (temp)
- Statistics File Name (templ)
- 512 x 512 Image Array (input)
- Image Size in One Dimension (imsize)
- Number of Lines in Comb (maxlines)
- Lead Spacing Array (leadspace) and Index (numspace)
- Lead Width Array (widthlead) and Index (numleads)

**c. Error Handling**

If no Image file is available, the message "Sorry, no files found" will be displayed and the "Ice Processing Choices" menu will be redisplayed.
d. **Logic Flow**

The PDL for the logic flow of this CSU is as follows:

**Input:**
- Input file name (.rc)
- Output file name (.stats)
- Mouse - File name selection
- Keyboard - Overwrite option

**Output:**
- Statistics File (.stats)
- Temp file (file names and parameters for "leadstats")

Get list of Row/Column (.rc) files
Choose file via putting cursor on file name and clicking
Assign lead statistics file name (.stats)
If file exists - overwrite Y/N - if N, exit
Write input and output file names via "printf"
Spawn "leadstats"

**Program leadstat.f:**

Get the temporary directory
Open input file ("tempstats.dat")
Read file names
Open Image file and Statistics file
Read the Image file - store the data in 512 x 512 array (image)
If image (i,j) > 200; Increment lead pixel counter
Compute fractional lead area
Write header info in Statistics file
Loop through angles 0 thru 180 with increments of 15 degrees
Initialize parameters
Depending on angle compute "step", "columnfac" and "rowfac"
Figure out how many lines should be in comb due to inclination from vertical (it is 64 for vertical and horizontal)
Subtract fudge factor
Loop on maxlines
Set up starting point of chord through the image
Call TESTNEXT
Do calculation of parameters depending on if:
- at the end of the chord
- hit a lead point on the chord
- just come off a lead point
- point on the chord is not a lead point
- the point on the chord is not a lead point and a lead has not yet been hit on the chord

End do
End loop
Compute width mean and standard deviation
Compute space mean and standard deviation
Write statistics to the .stats file
End loop
Stop
Subroutine testnext:

Test each point along chord through image

e. Local Data Files/Data Bases

The following local data files are accessed by this CSU:

Statistics File (.stats) - See Appendix E for the file format and content.

Temporary Input File for Program leadstat.f (tempstats.dat) - See Appendix G.2 for the file format and content.

f. Limitations

If the output file exists and the user chooses not to overwrite the current file information, this option terminates and the "Ice Processing Choices" menu is redisplayed.
4.3 **Motion Processing**

This CSC provides the "Motion Processing Choices" menu for selecting the function to be performed. The available functions are:

a. Motion Processing  
b. Motion Vectors on an Image  
c. Return to Main Menu

The first two of the functions correspond to the two CSUs in this CSC and the last one will return control to the Ice Menu System CSC.

4.3.1 **Motion Detect/Filter**

This CSU computes ice motion vectors for an image pair using a cross correlation technique. Vectors are computed on a 10 km grid. Confidence in a resulting vector is given by its correlation coefficient. The vector filtering depends on the correlation coefficient and the variation of the vector from its neighboring vectors.

4.3.1.1 **Motion Detect/Filter Design Specification/Constraints**

The two Image files, the Vector file and several motion detection and filtering parameters are assigned. Once the Image data are read, this CSU determines the number of vectors to be calculated in the x and y directions. The Vector file header information is written; and the coordinates for the upper-left corner for the first windows to be correlated, the increment used to compute all other windows and the vector origin for the first window are computed. A loop is initiated to process through all the windows of the input images and write the vector information to the output file.

The vector filtering process is controlled by the input parameters "cut value" and "pixel_diff". Vectors with correlation coefficient values less than the cut value are filtered from the output vector file. Those vectors with correlation values greater than or equal to the cut value are compared to the nine (9) or less neighboring vectors with correlation values greater than or equal to the cut value. The center vector must be within pixel_diff in the x and y dimensions of at least two (2) of its neighboring vectors or the vector is considered to be a bad vector and is not written to the output file.

4.3.1.2 **Motion Detect/Filter Design**

This section of the SDD contains the detailed design information for this CSU.
a. Input/Output Data Elements

Input: File(s): Two 512 x 512 Images
      Keyboard/
      Mouse: Image File Selections
             Vector File Name
             Parameters
             Overwrite Option

Output: File(s): Vector File
         Two Temporary Files
         Screen: Several File and Parameter Assignment Messages

b. Local Data Elements

Image File Names (file1, file2)
Vector File Name (file3)
Image Size (imsize)
Chip Subimage Size (csimage)
Maximum Motion (mmsize)
Minimum Intensity Value (minintsize)
Maximum Intensity Value (maxintsize)
Chip Overlap (cosize)
Time Difference Between Images (timedif)
Km/Pixel (kmpix)
Correlation Cutoff (cutoff)
Maximum Pixel Difference (pixdiff)
x and y Pixel Numbers of the Vector’s Starting Point (xcenter,
ycenter)
x and y Directional Velocities (vel_x, vel_y)
Correlation Coefficient (corr_coef)

c. Error Handling

If no Image is available, the message "Sorry, no files found" will
be displayed and the "Motion Processing Choices" menu will be
redisplayed.

The status of each input process is checked and if there is an
input error detected, the CSU terminates and control is returned to
the "Motion Processing Choices" menu.

d. Logic Flow

The PDL for the logic flow of this CSU is as follows:

Input: AVHRR image file names (.rc) NOTE: They must be of
the same area just different times.
      Output vector file name (.vec)
      Keyboard - Parameters, vector file name, Overwrite
      option
      Mouse - Image file selections

Output: Vector File (.vec)
      2 Temp files (file names and parameters for "xmotion"
      and "motion_filter")

Get list of Row/Column (.rc) files
Choose file via putting cursor on file name and clicking -
Image 1
Get list of Row/Column (.rc) files
Choose file via putting cursor on file name and clicking -
Image 2
Assign vector output file name (.vec)
If file exists - overwrite Y/N - if N, exit
Assign Image size
Assign Chip Subimage Size (the size of the square)
Assign Maximum motion expected
Assign Minimum intensity value (0)
Assign Maximum intensity value (255)
Assign Chip Overlay - default = 0
Assign Time Difference Between Images in hours
Assign Km/pixel (1.0)
Assign Correlation Cutoff (anything less than the cutoff will not be considered)
Assign Maximum Pixel Difference
Write out parameters for xmotion - via printf
Write out parameters for motion_filter - via printf
Spawn xmotion
Spawn motion_filter

Program xmotion.f:

Get the temporary directory
Open input file (*xmotion.inp*)
Read input into "in" and "rin" arrays
Open output vector file
Process images - Call usrxmotion_corr
Close output file

Subroutine usrxmotion_corr:

Compute scale for converting vectors from pixels to centimeters per second
Create pixel shift to velocity table
Create table of squared byte values (0 - 255)
Read the two images - Call usrxm_cread
Calculate the number of windows to be processed - Call usrxm_windst
Write vector file header info
Get coordinates of first window - Call usrxm_window
Loop to process all windows of the input images
Call usrxm_correlate
Write vector record
End loop

Subroutine usrxm_cread:

Open input image file
Read image (in bytes) into "dater" array
Close input file
Loop to convert data
   Convert from byte to integer (itemp)
   If itemp < min or > max: Buff (i, j) = 999
   else: Buff (i, j) = itemp
End loop
**Subroutine usrxm_windst:**

Determine how many vectors will be calculated in the X and Y directions

**Subroutine usrxm_window:**

Find starting upper-left corner of first imagel window
Calculate the increment to be used to compute all other windows
Compute the vector origin for the first window
Find starting upper-left corner of first image2 window

**Subroutine usrxm_correlate:**

Initialize displacement and correlation coefficient
Loop on maximum pixel shift (in x and y)
  call usrxm_chipcomp
    If number of values used in the sums > minimum
      Compute sum of squares - sum squared (val1, val2)
      If val1 & val2 > 0.0
        Compute correlation coefficient (corr_coef)
        If corr_coef > peak
          peak = corr_coef
          save x and y indices
      End if
    End if
End loop

**Subroutine usrxm_chipcomp:**

If mode = 0
  Initialize save values to 0.0
  Loop through the number of samples in the chip (or window or sub-image)
    If imagel value < 256 (or is it non-masked)
      Increment number of values counter
      Add value to the sum of the Imagel values (sum1)
      Add value squared to the sum of the Image 1 values squared (sum3)
    End if
  End loop
Set mode = 1
End if

Initialize all sum values (1 - 5) and number of values
Loop through the number of samples in the chip (or window or sub-image)
  If imagel value < 256 (or is it non-masked)
    If image2 value < 256 (or is it non-masked)
      Add value to the sum of the Image2 values (sum2)
      Add value squared to the sum of the Image4 values squared (sum4)
      Add Imagel value * Image2 value to sum5
Else
  Decrement number of values counter
  Subtract value to the sum of the Image1 values (sum1)
  Subtract value squared to the sum of the Image1 values squared (sum3)
End if
End if
End loop

Program motion_filter.f:

Get the temporary directory
Open input file ("motion_filter.inp")
Read vector file name, correlation cut off, pixel difference
Open input vector file (chj.out)
Read the names of original input image files (records 1 & 2)
Read number of vectors in the x and y directions and km to pixel scale factor (record 3)
Read number of samples in chip (or window), Chip overlap in Image1, time difference between images and km/pixel (record 4)
Open output vector file
Write the first four records just read from input
Read all vectors from the input file (vect array)
Initialize number vectors filtered counter to 0
Loop through all the vectors
  Set vecta = vect
  Initialize good vector counter to 0
  If correlation value => cutoff
    Loop on neighboring vectors (maximum 9)
      If correlation value => cutoff
        If vector x & y differences < pixel difference
          Increment good vector counter
        End if
      End if
    End loop
  End if
  If good vector counter < 2
    Set correlation value to 0.0
    Increment number vectors filtered counter
  End if
End loop
Write console message with number vectors filtered counter
Write output vector file
Close files

e. Local Data Files/Data Bases

The following local data files are accessed by this CSU:

Vector File (.vec) - See Appendix F for the file format and content.

Temporary Input File for Program xmotion.f (xmotion.inp) - See Appendix G.3 for the file format and content.
Temporary Input File for Program motion_filter.f (motion_filter.inp) - See Appendix G.4 for the file format and content.

f. Limitations

The two selected images must be of the same area but of different times.

If the output file exists and the user chooses not to overwrite the current file information, this option terminates and the "Motion Processing Choices" menu is redisplayed.

4.3.2 Motion Vector Display

This CSU overlays the ice motion vectors on an image display.

4.3.2.1 Motion Vector Display Design Specification/Constraints

After the Image and the Vector file are assigned, the number of vectors in the x direction and the y direction are read from the Vector file. A loop is then set up to read the vectors and display them on the image. Finally, the legend along with the length in km/hour are displayed.

4.3.2.2 Motion Vector Display Design

This section of the SDD contains the detailed design information for this CSU.

a. Input/Output Data Elements

Input: File(s): 512 x 512 Image File
       Vector File
       Keyboard/
       Mouse: Image and Vector File Selections

Output: File(s): None
        Screen: Motion Vectors Displayed on the Image

b. Local Data Elements

Window of Selected Image (curr1)
Vector File Name (file1)
Number of Vectors in the x Direction (ia)
Number of Vectors in the y Direction (jb)
Scale for Pixel to Velocity (con)
Number of Samples in Chip (inl3)
Chip Overlap (inl8)
Time Difference in Minutes (rin1)
Kilometers per Pixel (rin2)
X Pixel Number of Vector’s Starting Point (a)
Y Pixel Number of Vector’s Starting Point (b)
X Directional Velocity (u)
Y Directional Velocity (v)
Correlation Coefficient (e)
c. **Error Handling**

If there is no image already displayed on which to overlay the vectors, control will return to the "Motion Processing Choices" menu.

If no vector files are found, a message stating "Sorry, no files found" will be displayed and control will return to the "Motion Processing Choices" menu.

d. **Logic Flow**

The PDL for the logic flow of this CSU is as follows:

- **Input:** Vector file name (.vec)
  - Vector file
- **Output:** Vectors displayed on the image
  - Vector scale on image

Select Image via placing cursor on the image window and clicking
Initialize parameters
Select vector input file name (.vec)
Read header information from vector file
Double loop from 1 to jb and ia (jb & ia are from .vec file)
  - Read vector file record
  - Compute vector display parameters
  - Display vector
End loop
Draw legend
Write length in km/hour (vector scale)

e. **Local Data Files/Data Bases**

The following local data file is accessed by this CSU:

- Vector File (.vec) - See Appendix F for the file format and content.

f. **Limitations**

N/A
5.0 CSCI DATA

5.1 CSCI Internal Data Elements

The data elements described in this section correspond to the internal interfaces described in Section 3.1.1.

The data elements in the Accumulator file will be grouped into one main category: Data. The format and description of the data elements in the file are given in Appendix B.

The data elements in the Rose Plot file will be grouped into one main categories: Data. The format and description of the data elements in the file are given in Appendix C.

The data elements in the Lead Summary file will be grouped into two main categories: Header and Data. The format and description of the data elements in the file are given in Appendix D.

The data elements in the Lead Statistics file will be grouped into two main categories: Header and Data. The format and description of the data elements in the file are given in Appendix E.

The data elements in the Motion Vector file will be grouped into two main categories: Header and Data. The format and description of the data elements in the file are given in Appendix F.

The data elements in the Temporary files will be grouped into two main categories: Header and Data. The format and description of the data elements in the files are given in Appendix G.

5.2 CSCI External Data Elements

The data elements described in this section correspond to the external interfaces described in Section 3.1.

The data elements in the Image file will be grouped into one main category: Data. The format and description of the data elements in the file are given in Appendix A.
6.0 CSCI DATA FILES

6.1 Data File to CSC/CSU Cross Reference

The following data file versus CSC/CSU cross-reference is annotated with an "I" for input and an "O" for output. The CSC/CSU references correspond to the Detailed Design as specified in Section 4.0.

<table>
<thead>
<tr>
<th>File Name</th>
<th>4.1</th>
<th>4.2.1</th>
<th>4.2.2</th>
<th>4.2.3</th>
<th>4.2.4</th>
<th>4.3.1</th>
<th>4.3.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>xxxxxxx.xrc</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xxxxxxx.acc</td>
<td></td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xxxxxxx.rose</td>
<td></td>
<td>O</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xxxxxxx.lss</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>xxxxxxx.stats</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>xxxxxxx.vec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>I</td>
</tr>
<tr>
<td>h64chj.dat</td>
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<td></td>
<td></td>
<td></td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td>tempstats.dat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td>xmotion.inp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td>motion_filter.inp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O</td>
<td></td>
</tr>
</tbody>
</table>

6.2 Image File

The file structure and data elements for the Image file are given in Appendix A.

6.3 Accumulator File

The file structure and data elements for the Accumulator file are given in Appendix B.

6.4 Rose Plot File

The file structure and data elements for the Rose Plot file are given in Appendix C.

6.5 Lead Summary File

The file structure and data elements for the Lead Summary file are given in Appendix D.
6.6 **Lead Statistics File**

The file structure and data elements for the Lead Statistics file are given in Appendix E.

6.7 **Motion Vector File**

The file structure and data elements for the Motion Vector file are given in Appendix F.

6.8 **Temporary Files**

The file structure and data elements for the Temporary files are given in Appendix G.
7.0 REQUIREMENTS TRACEABILITY

Table 7.0-1 provides the software requirements versus software design cross-reference matrix. The matrix shows each requirement as noted in the Ice Processing System Software Requirements Specification and which CSC/CSU fulfills all or part of each requirement, along with the test method and level used to verify that each requirement has been satisfied.

<table>
<thead>
<tr>
<th>REQUIREMENT NAME</th>
<th>SRS SECTION 3 PARAGRAPH</th>
<th>QUALIFICATION</th>
<th>SDD SECTION 4 PARAGRAPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware/Software Suite</td>
<td>3.0</td>
<td>A, D</td>
<td>CSCI 4.1</td>
</tr>
<tr>
<td>NSIPS Option</td>
<td>3.0</td>
<td>D</td>
<td>CSCI 4.1</td>
</tr>
<tr>
<td>User-Friendly, Menu Driven</td>
<td>3.2</td>
<td>D</td>
<td>CSCI 4.1</td>
</tr>
<tr>
<td>Perform Transformation and Filtering</td>
<td>3.2.2</td>
<td>A, D</td>
<td>CSCI 4.2</td>
</tr>
<tr>
<td>Motion Detection/Display</td>
<td>3.2.3</td>
<td>A, D</td>
<td>CSCI 4.3</td>
</tr>
</tbody>
</table>

Qualification Method: A - Analysis    D - Demonstration
8.0 NOTES

8.1 Glossary

AVHRR  Advanced Very High Resolution Radiometer
CSCI  Computer Software Configuration Item
CSC  Computer Software Component
CSU  Computer Software Unit
DSD  Data Services Department
IR  Infrared
MB  Megabytes
NASA  National Aeronautics and Space Administration
NRL  Naval Research Laboratory
OLS  Operational Line Scan
PDL  Program Design Language
PV-WAVE  Precision Visuals - Workstation Analysis and Visualization Environment
RAM  Random Access Memory
SDD  Software Design Document
SGI  Silicon Graphics, Inc.
SRS  Software Requirements Specification
SSC  Stennis Space Center
Appendix A - Image File Format

512 x 512 (262144) - values 0 to 255 stored as byte (al) (.rc extension) Data stored columnwise.

Appendix B - Accumulator File Format

Set of 181 (-90 to 90) records for each 64 x 64 block (64 sets). Each record has 181 accumulator values stored as byte (al).

Values = 0 or are set at lead centroid (index in array) to the size of the image scan space line (in pixels).

Appendix C - Rose Plot File Format

For each of the 64 blocks and each angle (0 - 179):

Data: Total length and angle (f6, f5)

Appendix D - Lead Summary File Format

Header:
1. "Input File Name = ", a
2. "Block Number  Direction  km^2"

Data:
Block Number, angle, Length (5X, I2, 11X, F5, 4X, F5)

Appendix E - Lead Statistics File Format

Header:
1. "File: ", 40a
2. "Image size (km in one direction): ", I4
   "Percent Covered by Leads: ", F8
3. "Orientation  # of lead mean spacing std spacing mn width std width"
   (deg)  crossings (km) (km) (km) (km)

Data: angle, numleads, rmeanspace, stdspace, rmeanwidth, stdwidth (4X, F4.0, 8X, I6, 5X, F6, 7X, F6, 5X, F6, 3X, F6)
Appendix F - Motion Vector File Format

Header:
1. Input image file 1 - 1x, a80
2. Input image file 2 - 1x, a80
3. Number of vectors in the x direction, number of vectors in the y direction, scale for pixel to velocity - i4, i4, f15.10
4. Number of samples in chip (or window), chip_overlap, time difference in minutes, kilometers per pixel (usually 1.0 or 1) - 2i10, 2f15.10

Data: x and y pixel numbers of the vector's starting point, x and y directional velocities, correlation coefficient (0.0 to 1.0) - 5f15.10
Appendix G - Temporary Files Formats

G.1 Hough Transformation

File Name: h64chj.dat

<table>
<thead>
<tr>
<th>Record</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Image File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2</td>
<td>Accumulator File Name</td>
<td>a80</td>
</tr>
<tr>
<td>3</td>
<td>Rose Plot File Name</td>
<td>a80</td>
</tr>
<tr>
<td>4</td>
<td>Lead Summary File Name</td>
<td>a80</td>
</tr>
<tr>
<td>5</td>
<td>Minimum Length</td>
<td>f10.5</td>
</tr>
</tbody>
</table>

G.2 Lead Statistics

File Name: tempstats.dat

<table>
<thead>
<tr>
<th>Record</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Image File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2</td>
<td>Lead Statistics File Name</td>
<td>a80</td>
</tr>
</tbody>
</table>

G.3 Motion

File Name: xmotion.inp

<table>
<thead>
<tr>
<th>Record</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Image1 File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2</td>
<td>Image2 File Name</td>
<td>a80</td>
</tr>
<tr>
<td>3</td>
<td>Image Size</td>
<td>i10</td>
</tr>
<tr>
<td>4</td>
<td>Chip subimage size</td>
<td>i10</td>
</tr>
<tr>
<td>5</td>
<td>Maximum Motion</td>
<td>i10</td>
</tr>
<tr>
<td>6</td>
<td>Minimum Intensity Value</td>
<td>i10</td>
</tr>
<tr>
<td>7</td>
<td>Maximum Intensity Value</td>
<td>i10</td>
</tr>
<tr>
<td>8</td>
<td>Chip Overlap</td>
<td>i10</td>
</tr>
<tr>
<td>9</td>
<td>Time Between Images</td>
<td>f15.10</td>
</tr>
<tr>
<td>10</td>
<td>Km/ Pixel</td>
<td>f15.10</td>
</tr>
</tbody>
</table>

G.4 Motion Filter

File Name: motion_filter.inp

<table>
<thead>
<tr>
<th>Record</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vector File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2</td>
<td>Correlation Cutoff</td>
<td>f15.10</td>
</tr>
<tr>
<td>3</td>
<td>Maximum Pixel Difference</td>
<td>f15.10</td>
</tr>
</tbody>
</table>
SOFTWARE REQUIREMENTS SPECIFICATION

FOR THE

ICE PROCESSING SYSTEM
APPENDICES

Appendix A - Image File Format ................................................. 4-11
Appendix B - Accumulator File Format ....................................... 4-11
Appendix C - Rose Plot File Format .......................................... 4-11
Appendix D - Lead Summary File Format .................................... 4-11
Appendix E - Lead Statistics File Format ................................... 4-11
Appendix F - Motion Vector File Format .................................... 4-12
Appendix G - Temporary Files Formats ...................................... 4-13
SOFTWARE REQUIREMENTS SPECIFICATION
FOR THE
ICE PROCESSING SYSTEM

1.0 SCOPE

1.1 Identification

This Software Requirements Specification establishes the requirements for the Computer Software Configuration Item (CSCI) identified as the Ice Processing System. The Naval Research Laboratory (NRL) has requested the National Aeronautics and Space Administration (NASA)/Stennis Space Center (SSC) Technical Support Services Contractor's Data Services Department (DSD) to provide technical support to develop the Ice Processing System software.

1.2 CSCI Overview

The Ice Processing System shall provide a user-friendly, menu-driven system performing data transformation and filtering functions as well as motion detection on glacial ice masses detected through Advanced Very High Resolution Radiometer (AVHRR)/Operational Line Scan (OLS) infrared (IR) satellite imagery.

The transformation and filtering functions shall provide interactive cloud and land screening, transformation of images into Hough space, generation of high-resolution accumulator space scan lines, execution of Hough transform space peak neighborhood analysis, display of rose plots, and calculation of ice lead statistics.

The motion detection functions shall calculate ice motion vectors of two time-sequential images, filter the vectors, and plot the vectors over a screen image.

1.3 Document Overview

This specification defines the engineering and qualification requirements for the Ice Processing System and shall be used as the basis for the design and testing of the system.

2.0 APPLICABLE DOCUMENTS

2.1 Government Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS:

None.
STANDARDS:

DoD-STD-2167A Military Standard Defense System Software Development
29 February 1988

DRAWINGS:
None.

OTHER PUBLICATIONS:


Copies of specifications, standards, drawings, and publications required by DSD in connection with the software development functions should be obtained from NRL or as directed by NRL.

2.2 Non-Government Documents
None.

3.0 ENGINEERING REQUIREMENTS

The Ice Processing System shall be developed and maintained on the SUN SPARCStations and Silicon Graphics, Inc. (SGI) workstations using the X Window System, Precision Visuals - Workstation Analysis and Visualization Environment (PV-WAVE) graphics system, C programming language, and FORTRAN 77+ programming language.

The Ice Processing shall run as an option of the NRL Satellite Image Processing System (NSIPS) software. After software startup, the user shall interface with the system via mouse point-and-click inputs as well as optional keyboard commands.

3.1 CSCI External Interface Requirements

Figure 3.1-1 provides an overview of the external interfaces of the Ice Processing System.
The Image File (.rc) contains a standard 512x512 AVHRR IR satellite image. The format for the Image File is given in Appendix A.

The graphic display device is any of the various color monitors that can be interfaced to the SUN SPARCStation and/or the Silicon Graphics.

The mouse device is any of the various hand-held pointing devices that can be interfaced to the SUN SPARCStation and/or the Silicon Graphics.

3.2 CSCI Capability Requirements

The Ice Processing System shall provide the capabilities for satellite imagery data edit, process, and display that are described in the following sections.

3.2.1 Ice Menu System

The Ice Processing System shall provide a user-friendly menu system that will interact with all the subordinate processing software.

3.2.2 Transformation/Filtering Processing

The Transformation/Filtering Processing software shall be menu-driven for selection of the ice processing options.
The Screen Clouds/Land portion of the processing shall provide interactive editing of imagery data to blank out 64 x 64 pixel squares of clouds and/or land prior to performing the ice lead processing.

The Hough Transform portion of the processing shall perform the Hough 64 piece processing for leads.

The Rose Plot portion of the processing shall display the rose plots for the length of the leads in each direction (0 - 179°) as detected through the 64 piece processing.

The Lead Statistics portion of the processing shall calculate fractional lead area, lead spacing and lead width statistics for a binary lead image.

3.2.3 Motion Processing

The Motion Processing software shall be menu-driven for selection of the ice motion processing choices.

The Motion Processing portion of the processing shall calculate motion vectors of two time-sequential images and apply a filter to the vectors.

The Motion Vectors portion of the processing shall display the motion vectors on the display image.

3.3 CSCI Internal Interfaces

Figure 3.3-1 provides an overview of the internal interfaces of the Ice Processing System.
The Accumulator file (.acc) shall contain sizes of the image space lines (in pixels) by orientation (0 - 179°) for each of the 64 blocks. The format of this file is given in Appendix B.

The Rose Plot file (.rose) shall contain the lead lengths and the angles for each of the 64 blocks of the image. The format of this file is given in Appendix C.

The Lead Summary file (.lss) shall contain the image source header information followed by the lead size and orientation information in the form of block number, angle and length for each lead. The format of this file is given in Appendix D.

The Lead Statistics file (.stats) shall contain the image source header information followed by a list of the lead orientation (deg), the number of lead crossings, mean spacing (km), standard spacing (km), mean width (km) and standard width (km). The format of this file is given in Appendix E.

The Motion Vector file (.vec) shall contain the image source and vector header information followed by the x and y pixel number of the vector's starting point, the x and y directional velocities and the correlation coefficient (0.0 to 1.0) for each vector. The format of this file is given in Appendix F.
The temporary files shall be used to pass such information as input file name(s), output file name, and program parameters from the main processing modules to the Hough transformation, lead statistics, motion and motion filter programs. The formats of these files are given in Appendix G.

3.4 **CSCI Data Element Requirements**

3.4.1 **Internal Interfaces Data Elements**

The data elements described in this section correspond to the internal interfaces described in Section 3.3.

The data elements in the Accumulator file shall be grouped into one main category: Data. The format and description of the data elements in the file are given in Appendix B.

The data elements in the Rose Plot file shall be grouped into one main categories: Data. The format and description of the data elements in the file are given in Appendix C.

The data elements in the Lead Summary file shall be grouped into two main categories: Header and Data. The format and description of the data elements in the file are given in Appendix D.

The data elements in the Lead Statistics file shall be grouped into two main categories: Header and Data. The format and description of the data elements in the file are given in Appendix E.

The data elements in the Motion Vector file shall be grouped into two main categories: Header and Data. The format and description of the data elements in the file are given in Appendix F.

The data elements in the Temporary files shall be grouped into two main categories: Header and Data. The format and description of the data elements in the files are given in Appendix G.

3.4.2 **External Interfaces Data Elements**

The data elements described in this section correspond to the external interfaces described in Section 3.1.

The data elements in the Image file shall be grouped into one main category: Data. The format and description of the data elements in the file are given in Appendix A.

3.5 **Adaptation Requirements**

3.5.1 **Installation-Dependent Data**

Not applicable.

3.5.2 **Operational Parameters**

Not applicable.
3.6 **Sizing and Timing Requirements**

Since the Ice Processing System shall not be a real-time processing system, the system shall not have strict processing time requirements. However, the system shall be designed and implemented with the user response time being a vital concern.

The Ice Processing System software and associated files shall be required to function within the target SUN computer system environment utilizing the SUN OS 4.1.X operating system, 32 Megabytes (MB) of Random Access Memory (RAM), and a 600 MB hard disk.

The Ice Processing System software and associated files shall also be required to function within the target SGI computer system environment utilizing the IRIX 4.0.X operating system, 32 MB of RAM, and a 600 MB hard disk.

3.7 **Safety Requirements**

Not applicable.

3.8 **Security Requirements**

All data and software within the Ice Processing System shall not have a security classification or shall not be considered proprietary. Therefore, no security requirements shall be associated with the system.

3.9 **Design Constraints**

The design constraints on the Ice Processing System shall be that it must fit within the capabilities of the C and FORTRAN 77+ programming languages, X Window System, and PV-WAVE graphics system as available and installed on the SUN SPARCStation and Silicon Graphics workstation systems. The Ice Processing System shall be designed in a modular fashion to easily support incorporation of additional sources and formats of satellite altimeter data. In addition, the implementation of the software shall conform to the coding standards given in DoD-STD-2167A.

3.10 **Software Quality Factors**

Not applicable.

3.11 **Human Performance/Human Engineering Requirements**

The system shall be menu driven with full error recovery from erroneous operator inputs. All displays (including print on legends) shall be large enough and clear enough to be distinguished by an average operator during poor viewing and maximum stress conditions.

3.12 **Requirements Traceability**

Not applicable.
4.0 QUALIFICATION REQUIREMENTS

The qualification testing or acceptance testing will require use of the SUN SPARCStation and SGI workstation outputs to verify the software implementation.

4.1 Qualification Methods

Table 4.1-1 specifies the qualification methods and levels that shall be used to ensure that the Ice Processing System requirements in Section 3 have been satisfied.

Table 4.1-1. Qualification Cross-Reference Table

<table>
<thead>
<tr>
<th>REQUIREMENT NAME</th>
<th>SECTION 3 PARAGRAPH</th>
<th>QUALIFICATION METHOD(S)*</th>
<th>LEVEL</th>
<th>SECTION 4 TEST PARAGRAPH</th>
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<tbody>
<tr>
<td>Hardware/Software Suite</td>
<td>3.0</td>
<td>A, D</td>
<td>CSCI</td>
<td>N/A</td>
</tr>
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<td>NSIPS Option</td>
<td>3.0</td>
<td>D</td>
<td>CSCI</td>
<td>N/A</td>
</tr>
<tr>
<td>User-Friendly, Menu Driven</td>
<td>3.2.1</td>
<td>D</td>
<td>CSCI</td>
<td>N/A</td>
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<td>Perform Transformation and Filtering</td>
<td>3.2.2</td>
<td>A, D</td>
<td>CSCI</td>
<td>4.2.1</td>
</tr>
<tr>
<td>Motion Detection/Display</td>
<td>3.2.3</td>
<td>A, D</td>
<td>CSCI</td>
<td>4.2.2</td>
</tr>
</tbody>
</table>

Qualification Method: A - Analysis  D - Demonstration

4.2 Special Qualification Requirements

This section specifies the special requirements associated with the qualification of the Ice Processing System.

4.2.1 Transformation and Filtering

The qualification of the Transformation and Filtering, Section 3.2.2, will require the following:

- One standard 512 x 512 AVHRR IR satellite image file

The test will be performed at the CSCI level.

4.2.2 Motion Detection/Display

The qualification of the Motion Detection/Display, Section 3.2.3, will require the following:

- Two standard 512 x 512 AVHRR IR satellite image files containing information for the same area but at different times

The test will be performed at the CSCI level.
5.0  PREPARATION FOR DELIVERY

The completed software system shall reside on the NRL SUN SPARCStation disk and SGI. All software will be copied to 150 MB cartridge tape for delivery and backup purposes.
6.0 NOTES

6.1 Glossary

AVHRR Advanced Very High Resolution Radiometer
CSCI Computer Software Configuration Item
DSD Data Services Department
IR Infrared
MB Megabytes
NASA National Aeronautics and Space Administration
NRL Naval Research Laboratory
OLS Operational Line Scan
PV-WAVE Precision Visuals - Workstation Analysis and Visualization Environment
RAM Random Access Memory
SGI Silicon Graphics, Inc.
SRS Software Requirements Specification
SSC Stennis Space Center
Appendix A - Image File Format

512 x 512 (262144) - values 0 to 255 stored as byte (al) (.rc extension) Data stored columnwise.

Appendix B - Accumulator File Format

Set of 181 (-90 to 90) records for each 64 x 64 block (64 sets). Each record has 181 accumulator values stored as byte (al).

Values = 0 or are set at lead centroid (index in array) to the size of the image scan space line (in pixels).

Appendix C - Rose Plot File Format

For each of the 64 blocks and each angle (0 - 179):

Data: Total length and angle (f6.1, f5.1)

Appendix D - Lead Summary File Format

Header:
1. "Input File Name = ", a
2. "Block Number   Direction  km^2"

Data:
Block Number, angle, Length (5X, I2, 11X, F5.1, 4X, F5.1)

Appendix E - Lead Statistics File Format

Header:
1. "File: ", 40a
2. "Image size (km in one direction): ", I4
   "Percent Covered by Leads: ", F8.1
3. "Orientation  # of lead  mean spacing  std spacing  mn width  std width"
   " (deg)  crossings     (km)     (km)    (km)     (km)"

Data: angle, numleads, rmeanspace, stdspace, rmeanwidth, stdwidth (4X, F4.0, 8X, I6, 5X, F6.1, 7X, F6.1, 5X, F6.1, 3X, F6.1)
Appendix F - Motion Vector File Format

Header:
1. Input image file 1 - 1x, a80
2. Input image file 2 - 1x, a80
3. Number of vectors in the x direction, number of vectors in the y direction, scale for pixel to velocity - i4, i4, f15.10
4. Number of samples in chip (or window), chip_overlap, time difference in minutes, kilometers per pixel (usually 1.0 or 1.1) - 2i10, 2f15.10

Data: x and y pixel numbers of the vector’s starting point, x and y directional velocities, correlation coefficient (0.0 to 1.0) - 5f15.10
Appendix G - Temporary Files Formats

G.1 Hough Transformation

File Name: h64chj.dat

<table>
<thead>
<tr>
<th>Record Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Image File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2 Accumulator File Name</td>
<td>a80</td>
</tr>
<tr>
<td>3 Rose Plot File Name</td>
<td>a80</td>
</tr>
<tr>
<td>4 Lead Summary File Name</td>
<td>a80</td>
</tr>
<tr>
<td>5 Minimum Length</td>
<td>f10.5</td>
</tr>
</tbody>
</table>

G.2 Lead Statistics

File Name: tempstats.dat

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<th>Record Description</th>
<th>Format</th>
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</thead>
<tbody>
<tr>
<td>1 Image File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2 Lead Statistics File Name</td>
<td>a80</td>
</tr>
</tbody>
</table>

G.3 Motion

File Name: xmotion.inp

<table>
<thead>
<tr>
<th>Record Description</th>
<th>Format</th>
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</thead>
<tbody>
<tr>
<td>1 Image1 File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2 Image2 File Name</td>
<td>a80</td>
</tr>
<tr>
<td>3 Image Size</td>
<td>i10</td>
</tr>
<tr>
<td>4 Chip subimage size</td>
<td>i10</td>
</tr>
<tr>
<td>5 Maximum Motion</td>
<td>i10</td>
</tr>
<tr>
<td>6 Minimum Intensity Value</td>
<td>i10</td>
</tr>
<tr>
<td>7 Maximum Intensity Value</td>
<td>i10</td>
</tr>
<tr>
<td>8 Chip Overlap</td>
<td>i10</td>
</tr>
<tr>
<td>9 Time Between Images</td>
<td>f15.10</td>
</tr>
<tr>
<td>10 Km/Pixel</td>
<td>f15.10</td>
</tr>
</tbody>
</table>

G.4 Motion Filter

File Name: motion_filter.inp

<table>
<thead>
<tr>
<th>Record Description</th>
<th>Format</th>
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<tbody>
<tr>
<td>1 Vector File Name</td>
<td>a80</td>
</tr>
<tr>
<td>2 Correlation Cutoff</td>
<td>f15.10</td>
</tr>
<tr>
<td>3 Maximum Pixel Difference</td>
<td>f15.10</td>
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</tbody>
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