Naval Research Laboratory
Stennis Space Center, MS 39529-5004

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Ice Processing System Software Support Documentation

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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

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SPECIFICATIONS:

None.

STANDARDS:

None.

DRAWINGS:

None.

OTHER PUBLICATIONS:

Sverdrup Technology, Inc. September 1993	Software Requirements Specification for the Ice Processing System
Sverdrup Technology, Inc. September 1993	Software Design Description for the Ice Processing System
Sverdrup Technology, Inc. September 1993	Software Test Document for the Ice Processing System
Sverdrup Technology, Inc. September 1993	Software User's Manual for the NRL Satellite Image Processing System (NSIPS)

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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 <u>Screen Clouds/Land</u>

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

PROMPT	RESPONSE	INPUT DEVICE
NSIPS Menu	User Functions	Mouse Button
Select User Function Menu	Ice Processing	Mouse Button
Ice Processing Options Menu	AVHRR/OLS Lead Analysis	Mouse Button
Ice Processing Choices Menu	Screen Clouds/Land	Mouse Button
Message Window	Select an Image Window	Mouse Button 1
Message Window	Select Blank Squares	Mouse Button 1
Message Window	Select Square to Clear	Mouse Button 1
Message Window	Exit	Mouse Button 3
Ice Processing Choices Menu	Return to Main Menu	Mouse Button
Ice Processing Options Menu	Exit	Mouse Button
Select User Function Menu	Exit	Mouse Button
NSIPS Menu	Files	Mouse Button
Files Menu	Write an Image to a File	Mouse Button

TABLE 3.1.2-1. Screen Clouds/Land Inputs (cont.)

PROMPT	RESPONSE	INPUT DEVICE
Message Window	Select an Image Window	Mouse Button 1
File Type to Write Menu	Row/Column File	Mouse Button
Amount of Window Menu	Whole Window	Mouse Button
Message Window (New file name:)	Enter File name	Keyboard
Message Window	Click	Mouse Button 1
Files Menu	Return to Main Menu	Mouse Button
NSIPS Menu	Quit	Mouse Button

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: **$MACHINE/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

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

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

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

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:

"... **hava cupa java** ..."

Lead Statistics produces an output statistics file. Example file name: **ice_std_01.stats**.

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

PROMPT	RESPONSE	INPUT DEVICE
NSIPS Menu	User Functions	Mouse Button
Select User Function Menu	Ice Processing	Mouse Button
Ice Processing Options Menu	AVHRR/OLS Lead Analysis	Mouse Button
Ice Processing Choices Menu	Lead Statistics	Mouse Button
Message Window (.rc file list)	Select file name (Ex: ice_std_01.rc)	Mouse Button
Message Window (.stats file)	Enter file name (Ex: ice_std_01)	Keyboard
Ice Processing Choices Menu	Return to Main Menu	Mouse Button
Ice Processing Options Menu	Exit	Mouse Button
Select User Function Menu	Exit	Mouse Button
NSIPS Menu	Quit	Mouse Button

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 3.5.2-1. Motion Detect/Filter Inputs

PROMPT	RESPONSE	INPUT DEVICE
NSIPS Menu	User Functions	Mouse Button
Select User Function Menu	Ice Processing	Mouse Button
Ice Processing Options Menu	AVHRR/OLS Ice Motion Analysis	Mouse Button
Motion Processing Choices Menu	Motion Detect/Filter	Mouse Button
Message Window (.rc file list)	Select a .rc file (Ex: 26mar92_1410_n11.rc)	Mouse Button
Message Window (.rc file list)	Select a .rc file (Ex: 26mar92_1336_n11.rc)	Mouse Button
Message Window (.vec file)	Enter a .vec file (Ex: ice_std_01)	Keyboard
Message Window (Image Size)	Enter Image Size (Ex: 512)	Keyboard
Message Window (Chip Subimage Size)	Enter Chip Subimage Size (Ex: 10)	Keyboard
Message Window (Maximum Motion)	Enter Maximum Motion (Ex: 20)	Keyboard
Message Window (Minimum Intensity Value)	Enter Minimum Intensity Value (Ex: 0)	Keyboard

TABLE 3.5.2-1. Motion Detect/Filter Inputs (cont.)

PROMPT	RESPONSE	INPUT DEVICE
Message Window (Maximum Intensity Value)	Enter Maximum Intensity Value (Ex: 255)	Keyboard Keyboard
Message Window (Chip Overlap)	Enter Chip Overlap (Ex: 0)	Keyboard
Message Window (Time Difference Between Images)	Enter Time Difference Between Images (Ex: 71.5)	Keyboard
Message Window (km/pixel)	Enter km/pixel (Ex: 1.1)	Keyboard
Message Window (Correlation Cutoff)	Enter Correlation Cutoff (Ex: .4)	Keyboard
Message Window (Maximum Pixel Difference)	Enter Maximum Pixel Difference) (Ex: 1)	Keyboard
Motion Processing Choices Menu	Return to Main Menu	Mouse Button
Ice Processing Options Menu	Exit	Mouse Button
Select User Function Menu	Exit	Mouse Button
NSIPS Menu	Quit	Mouse Button

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 3.6.2-1. Motion Vector Display Inputs

PROMPT	RESPONSE	INPUT DEVICE
NSIPS Menu	User Functions	Mouse Button
Select User Function Menu	Ice Processing	Mouse Button
Ice Processing Options Menu	AVHRR/OLS Ice Motion	Mouse Button
Motion Processing Choices Menu	Motion Vector Display	Mouse Button
Message Window	Select an Image Window	Mouse Button 1
Message Window (.vec file)	Select a .vec file (Ex: ice_std_01.vec)	Mouse Button
Pencil (displayed on image)	Move the pencil to where the legend is desired and Left Click	Mouse Button 1
Motion Processing Choices Menu	Return to Main Menu	Mouse Button
Ice Processing Options Menu	Exit	Mouse Button
Select User Function Menu	Exit	Mouse Button
NSIPS Menu	Exit	Mouse Button

4.0 NOTES

4.1 Glossary

ACRONYM	Definition
AVHRR	Advanced Very High Resolution Radiometer
CSCI	Computer Software Configuration Item
DSD	Data Services Department
IR	Infrared
NASA	National Aeronautics and Space Administration
NRL	Naval Research Laboratory
NSIPS	NRL Satellite Image Processing System
OLS	Operational Line Scan
SSC	Stennis Space Center
SUM	Software User's Manual

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 dircetories 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

CONTENTS

FIGURES

TABLES

APPENDICES

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.

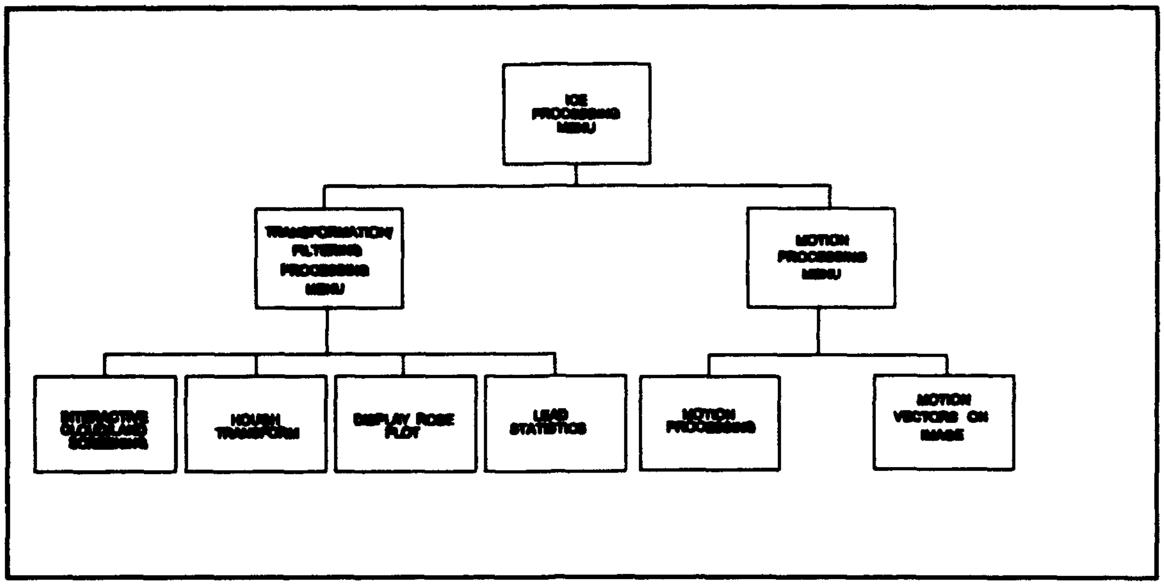

Figure 1.2-1. Ice Processing Architecture

2.0 APPLICABLE DOCUMENTS

2.1 Government Documents

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

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None.

DRAWINGS:

None.

OTHER PUBLICATIONS:

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

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.

f. Display the motion vectors on the image.

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

- FORTRAN 77+ 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

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

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 4.1.3-1. Screen Clouds/Land Mouse/Keyboard Inputs

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

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 $MACHINE/run/images/ice_std_01.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.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).

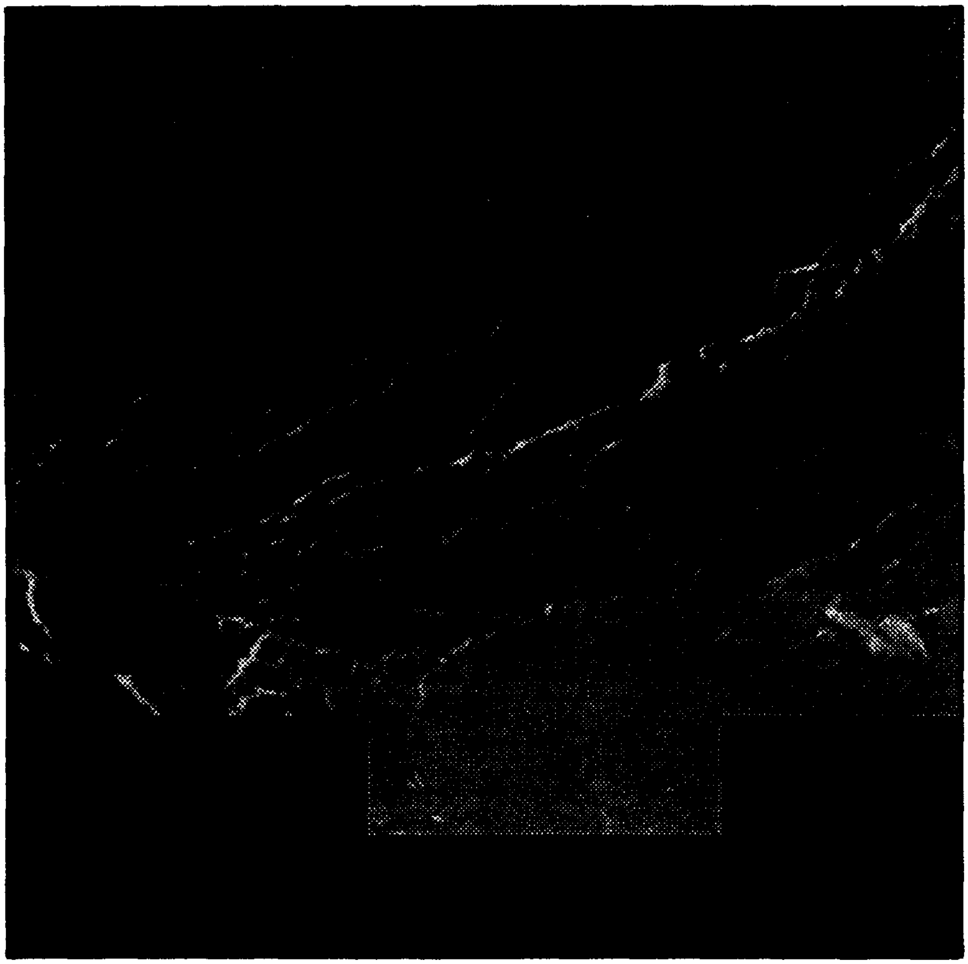

Figure 4.1.6-1. Image with Cloud/Land Edit Applied

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).

Figure 4.1.7-1. 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

Prompt	Response
Message Window - .rc file list	Select: ice_std_01.rc
Message Window - .acc file	Enter: ice_std_01
Message Window - .rose file	Enter: ice_std_01
Message Window - .lss file	Enter: ice_std_01
Message Window - minimum length	Enter: 50.
Message Window -	N/A. There is an approximate 4 minute wait for program execution during which time the following text 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

4.2.4 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 4.2.6-1. Rose Plot File

Rose Plot File Sample
<u>of First 25 Lines</u>

0.0	0.0
0.0	1.0
21.0	2.0
23.0	3.0
0.0	4.0
0.0	5.0
0.0	6.0
0.0	7.0
0.0	8.0
0.0	9.0
0.0	10.0
0.0	11.0
0.0	12.0
0.0	13.0
0.0	14.0
0.0	15.0
0.0	16.0
0.0	17.0
0.0	18.0
26.0	19.0
0.0	20.0
0.0	21.0
0.0	22.0
0.0	23.0
0.0	24.0

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

Block Number	Direction	km^2
1	2.0	21.0
1	3.0	23.0
1	19.0	26.0
1	28.0	16.0
1	43.0	56.0
1	50.0	31.0
1	64.0	10.0
1	68.0	23.0
1	77.0	11.0
1	113.0	11.0
1	126.0	29.0
1	159.0	12.0
2	42.0	16.0
2	45.0	16.0
2	56.0	11.0
2	68.0	78.0
2	76.0	17.0
2	82.0	9.0
2	87.0	9.0
3	28.0	10.0
3	32.0	12.0
3	42.0	20.0
3	43.0	8.0
3	51.0	24.0
3	58.0	30.0

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 4.3.3-1. Display Rose Plot Mouse/Keyboard Inputs

Prompt	Response
Message Window - .rose file list	Select: ice_std_01.rose
Message Window	Select an Image Window (Left Click)
Message Window - km per 32 pixels	Enter: 100.
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

4.3.4 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

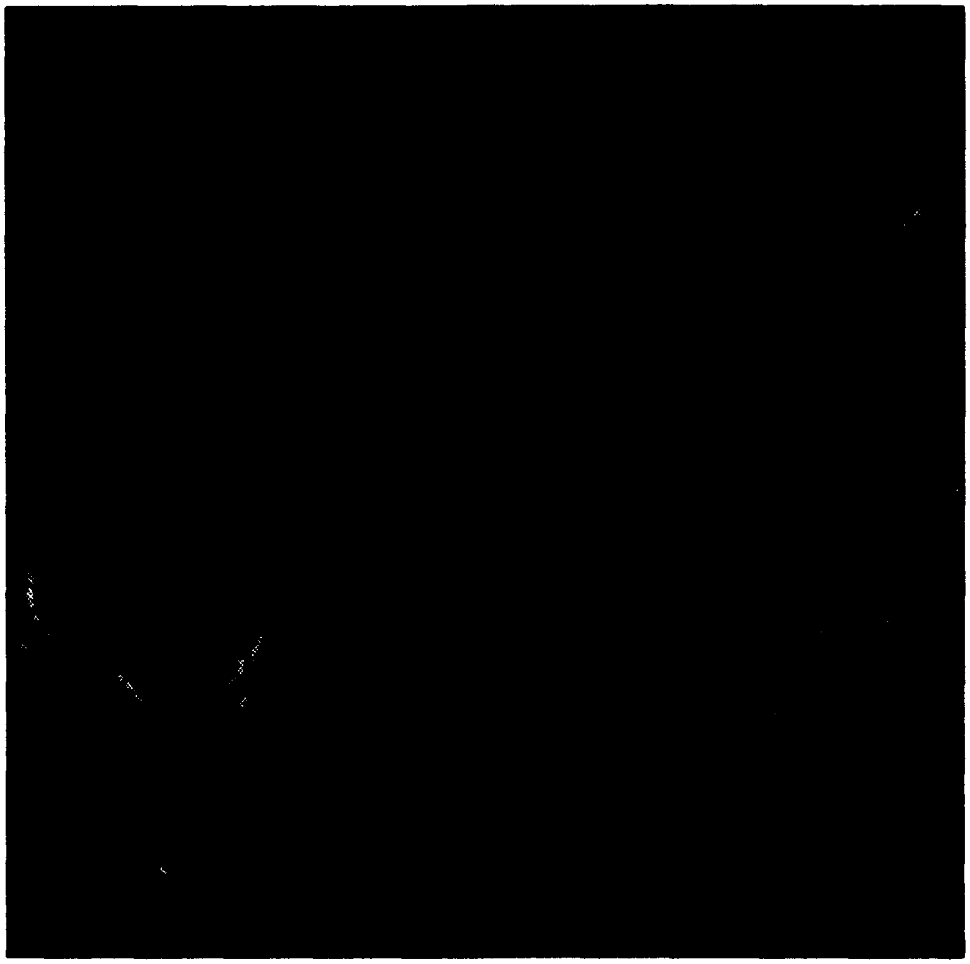

Figure 4.3.4-1. Rose Plot Image Display

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 4.4.3-1. Lead Statistics Mouse/Keyboard Inputs

Prompt	Response
Message Window - .rc file list	Select: ice_std_01.rc
Message Window - .stats file	Enter: ice_std_01
Message Window -	N/A. There is an approximate 30 second wait for program execution during which time the following text

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

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

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

Prompt	Response
Message Window - .rc file list	Select: 26mar92_1410_n11.rc
Message Window - .rc file list	Select: 29mar92_1336_n11.rc
Message Window - .vec file	Enter: ice_std_01
Message Window - image size	Enter: 512.
Message Window - chip subimage size	Enter: 10.
Message Window - Maximum motion	Enter: 20.
Message Window - Minimum intensity value	Enter: 0.
Message Window - Maximum intensity value	Enter: 255.
Message Window - Chip overlap	Enter: 0.
Message Window - Time difference between images	Enter: 71.5
Message Window - km/pixel	Enter: 1.1
Message Window - Correlation cutoff	Enter: .4
Message Window - Maximum	Enter: 1.

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 Menu	Select Return to Main 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.

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

Table 4.5.6-1. Motion Vector File

Sample of the Vector File Header
<u>and First 25 Data Records</u>

```
/sid2/run/images/26mar92_n11.rc

/sid2/run/images/29mar92_n11.rc

47  47    0.3888811171
      10          0  71.4300003052   1.0000000000
 25.5000000000  25.5000000000   0.3888811171  -2.7221677303   0.8212952018
 35.5000000000  25.5000000000   0.3888811171  -2.7221677303   0.7199681401
 45.5000000000  25.5000000000   0.3888811171  -2.7221677303   0.7998079062
 55.5000000000  25.5000000000  -7.7776222229   3.1110489368   0.0000000000
 65.5000000000  25.5000000000   1.1666433811  -3.1110489368   0.0000000000
 75.5000000000  25.5000000000   0.3888811171  -3.1110489368   0.7471593022
 85.5000000000  25.5000000000   0.3888811171  -2.7221677303   0.8294126391
 95.5000000000  25.5000000000   0.3888811171  -3.1110489368   0.8051504493
105.5000000000  25.5000000000   0.3888811171  -3.1110489368   0.6919284463
115.5000000000  25.5000000000   0.3888811171  -3.1110489368   0.6345459223
125.5000000000  25.5000000000   0.7777622342  -3.4999301434   0.7546359301
135.5000000000  25.5000000000  -6.6109790802  -7.7776222229   0.0000000000
145.5000000000  25.5000000000   0.7777622342  -3.4999301434   0.7866768837
155.5000000000  25.5000000000   0.7777622342  -3.4999301434   0.8094323277
165.5000000000  25.5000000000  -5.4443354607  -3.4999301434   0.0000000000
175.5000000000  25.5000000000   0.7777622342  -3.1110489368   0.0000000000
185.5000000000  25.5000000000   1.1666433811  -3.3888111115   0.0000000000
195.5000000000  25.5000000000   0.7777622342  -3.4999301434   0.0000000000
205.5000000000  25.5000000000  -5.8332166672   2.3332867622   0.0000000000
215.5000000000  25.5000000000   3.8888111115  -7.7776222229   0.0000000000
225.5000000000  25.5000000000   0.0000000000  -7.7776222229   0.0000000000
235.5000000000  25.5000000000  -3.4999301434  -7.7776222229   0.0000000000
245.5000000000  25.5000000000   1.1666433811  -0.7777622342   0.0000000000
255.5000000000  25.5000000000   7.7776222229  -4.2776923180   0.0000000000
265.5000000000  25.5000000000   1.9444055557  -7.7776222229   0.0000000000
```

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_n11.rc
- Image File 2 - $MACHINE/run/images/29mar92_1336_n11.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 4.6.3-1. Motion Vector Display Mouse/Keyboard Inputs

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

4.6.4 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

Record	Description	Format
1	Image File Name	a80
2	Accumulator File Name	a80
3	Rose Plot File Name	a80
4	Lead Summary File Name	a80
5	Minimum Length	f10.5

G.2 Lead Statistics

File Name: tempstats.dat

Record	Description	Format
1	Image File Name	a80
2	Lead Statistics File Name	a80

G.3 Motion

File Name: xmotion.inp

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

G.4 Motion Filter

File Name: motion_filter.inp

Record	Description	Format
1	Vector File Name	a80
2	Correlation Cutoff	f15.10
3	Maximum Pixel Difference	f15.10

SOFTWARE DESIGN DOCUMENT

FOR THE

ICE PROCESSING SYSTEM

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FIGURES

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APPENDICES

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.

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/MR/7240--93-7072 Summer 1993	The Hough Transform Technique 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. September 1993	Software Requirements Specification for the Ice Processing System

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.

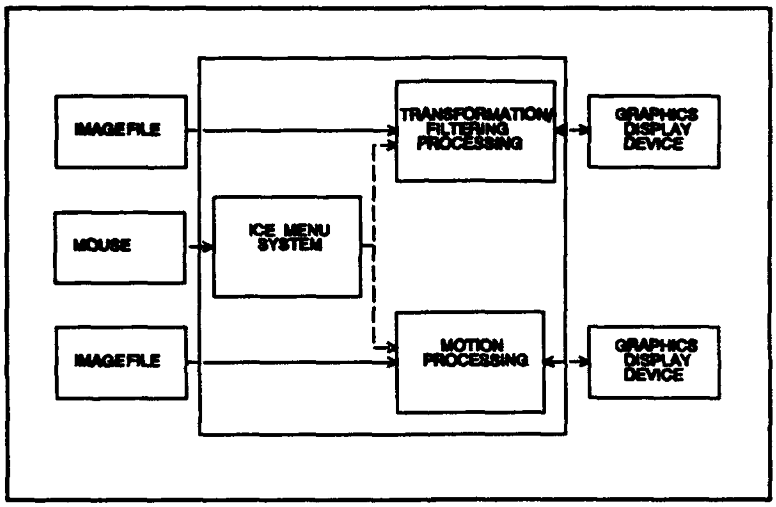

Figure 3.1-1. External Interface Overview

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.

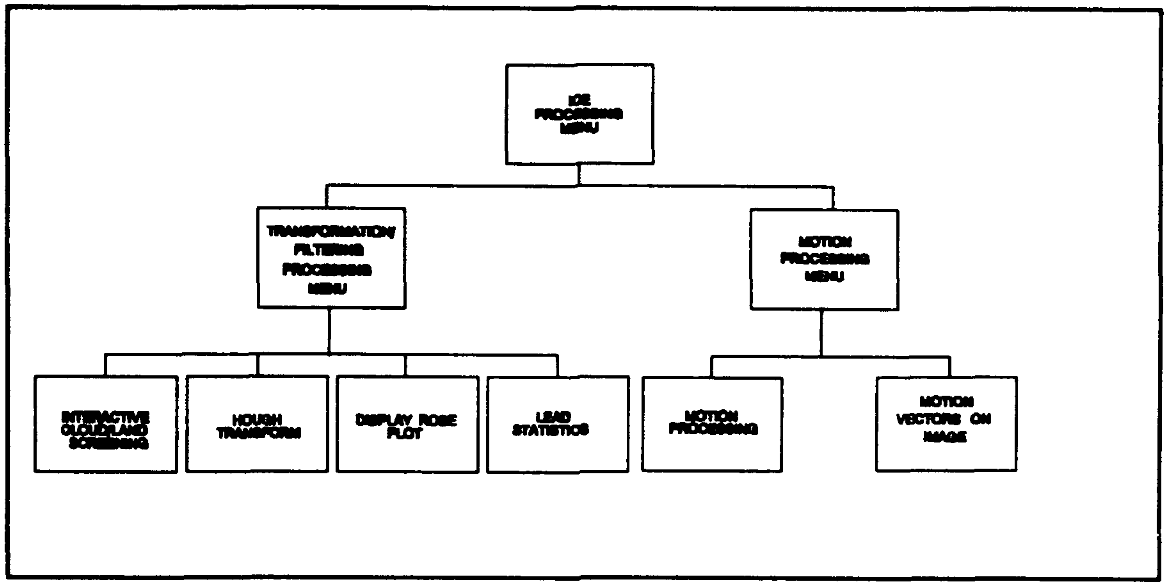

Figure 3.1.1-1. Ice Processing Architecture

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.

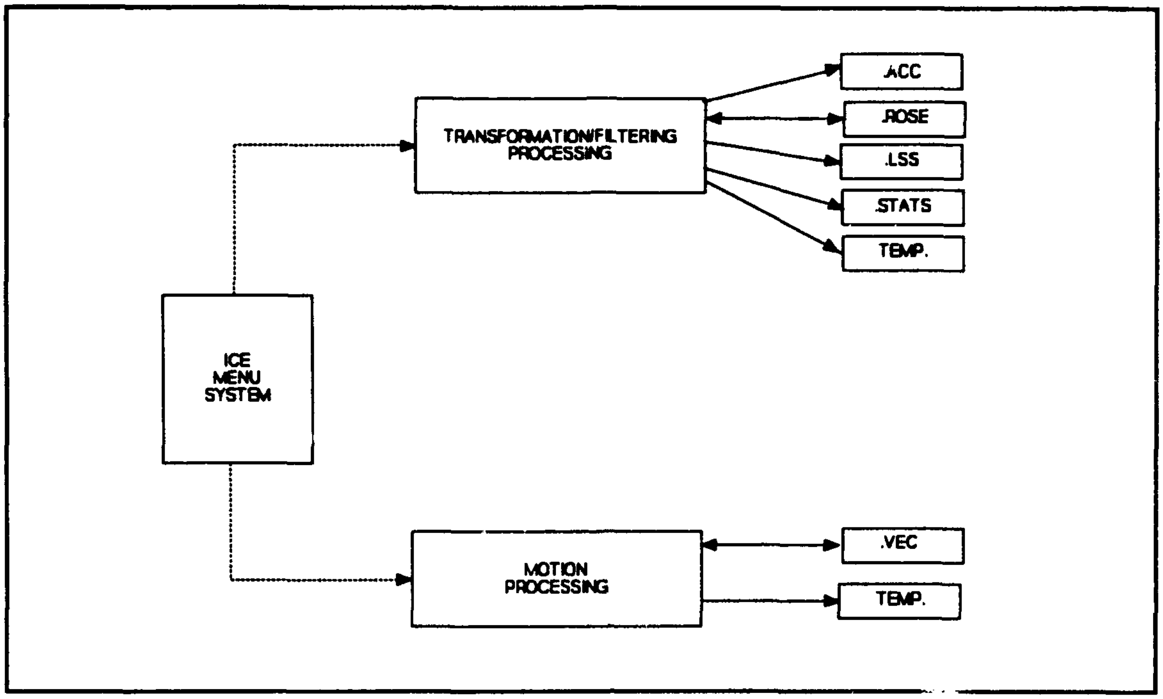

Figure 3.1.1-2. Internal Interface Overview

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 sucn 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 <u>Ice Menu System</u>

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
```

e. Local Data Files/Data Bases

N/A

f. Limitations

N/A

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 Image1 - 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

                  :-------------------------:
                  : 1  2  3  4  5  6  7  8  :
                  : 9 . . .                 :

                  :_____________________64__:

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 director
Open input file ("h64chj     )
Read file names and min      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
```

```
          End Loop
***       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 a1 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.

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 Image1 by placing cursor on it and clicking
Get Window Number of Image1
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

Input:	File(s):	512 x 512 Image
	Keyboard/ Mouse:	Image Selection
		Statistics File Name
		Overwrite Option
Output:	File(s):	Statistics File
		Temporary File
	Screen:	Assignment and Overwrite Messages

b. Local Data Elements

Image File Name (temp)
Statistics File Name (temp1)
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-leftcorner 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 greated 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 image1 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 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 image1 value < 256 (or is it non-masked)
                  Increment number of values counter
                  Add value to the sum of the Image1 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 image1 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 Image1 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 (in13)
Chip Overlap (in18)
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.

	CSC/CSU						
File Name	4.1	4.2.1	4.2.2	4.2.3	4.2.4	4.3.1	4.3.2
xxxxxxxx.rc		I	I		I	I	I
xxxxxxxx.acc			O				
xxxxxxxx.rose			O	I			
xxxxxxxx.lss			O				
xxxxxxxx.stats					O		
xxxxxxxx.vec						O	I
h64chj.dat			I/O				
tempstats.dat					I/O		
xmotion.inp						I/O	
motion_filter.inp						I/O	

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 7.0-1. Requirements Cross-Reference Matrix

REQUIREMENT NAME	SRS SECTION 3 PARAGRAPH	QUALIFICATION		SDD SECTION 4 PARAGRAPH
		METHOD(S)*	LEVEL	
Hardware/Software Suite	3.0	A, D	CSCI	4.1
NSIPS Option	3.0	D	CSCI	4.1
User-Friendly, Menu Driven	3.2	D	CSCI	4.1
Perform Transformation and Filtering	3.2.2	A, D	CSC	4.2
Motion Detection/Display	3.2.3	A, D	CSC	4.3

*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 (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) - 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

Record	Description	Format
1	Image File Name	a80
2	Accumulator File Name	a80
3	Rose Plot File Name	a80
4	Lead Summary File Name	a80
5	Minimum Length	f10.5

G.2 Lead Statistics

File Name: tempstats.dat

Record	Description	Format
1	Image File Name	a80
2	Lead Statistics File Name	a80

G.3 Motion

File Name: xmotion.inp

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

G.4 Motion Filter

File Name: motion_filter.inp

Record	Description	Format
1	Vector File Name	a80
2	Correlation Cutoff	f15.10
3	Maximum Pixel Difference	f15.10

SOFTWARE REQUIREMENTS SPECIFICATION

FOR THE

ICE PROCESSING SYSTEM

CONTENTS

FIGURES

TABLES

APPENDICES

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 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.

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.

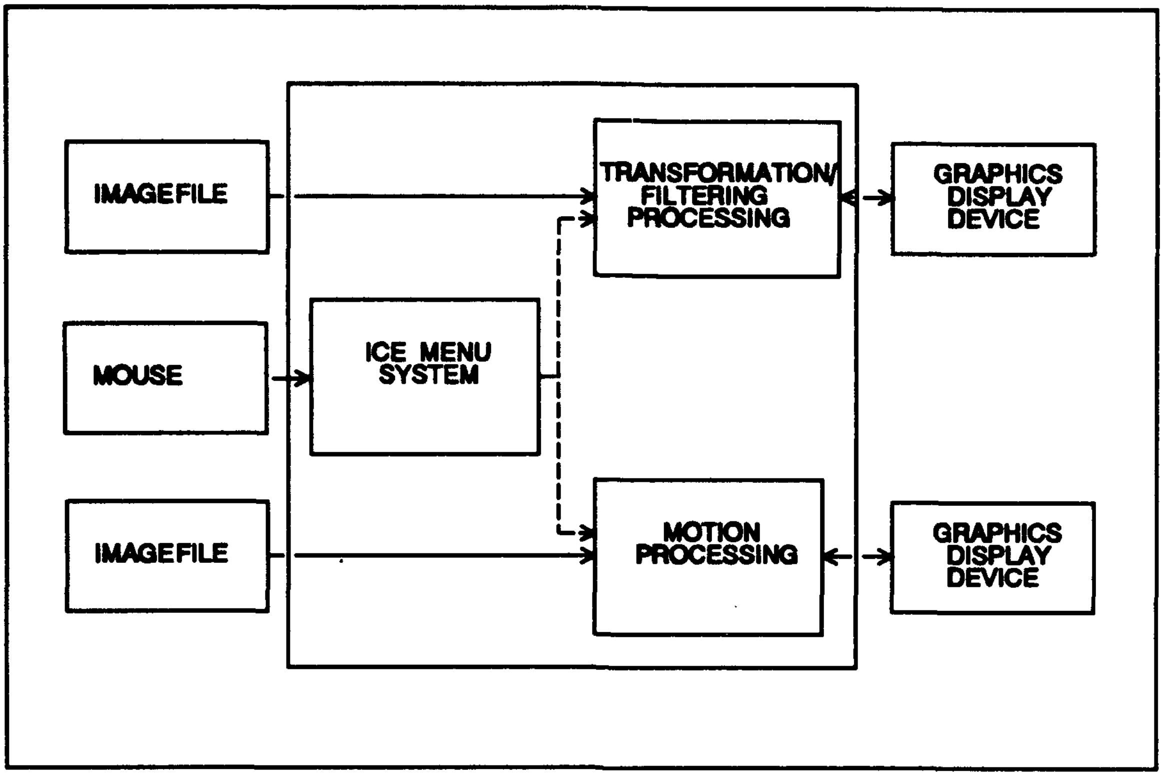

Figure 3.1-1. External Interface Overview

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.

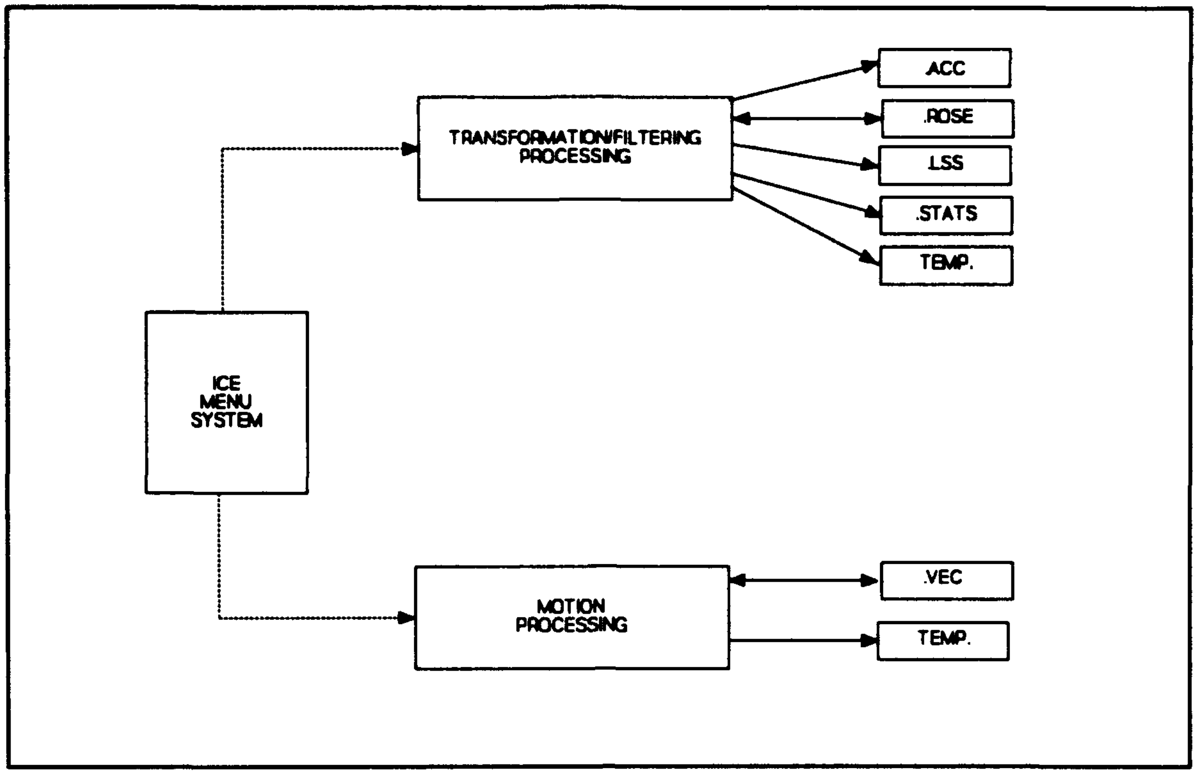

Figure 3.3-1. Internal Interface Overview

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 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

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

*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 (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
(f6.1, 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

Record	Description	Format
1	Image File Name	a80
2	Accumulator File Name	a80
3	Rose Plot File Name	a80
4	Lead Summary File Name	a80
5	Minimum Length	f10.5

G.2 Lead Statistics

File Name: tempstats.dat

Record	Description	Format
1	Image File Name	a80
2	Lead Statistics File Name	a80

G.3 Motion

File Name: xmotion.inp

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

G.4 Motion Filter

File Name: motion_filter.inp

Record	Description	Format
1	Vector File Name	a80
2	Correlation Cutoff	f15.10
3	Maximum Pixel Difference	f15.10