MEMORANDUM OF UNDERSTANDING

REGARDING PERMISSION TO USE A SOFTWARE FOR SCIENTIFIC PURPOSES

BETWEEN:

The Department of Natural Resources
(hereinafter referred to as "NRCan")

- and -

The Department of Agriculture and Agri-Food
(hereinafter referred to as "AAFC")

(Referred to individually as the "Party" and collectively as the "Parties")

WHEREAS NRCan claims to have the right to grant a licence for the software described in Schedule A;

AND WHEREAS AAFC has requested that NRCan grant a non-exclusive permission to use the software;

NOW, THEREFORE, the Parties have reached the following understanding:

1. DEFINITION

1.1(a) "*Memorandum of Understanding*" or "*MOU*" means the present document and Schedule A attached hereto;

1.1(b) "*Confidential Information*" means all information, documents, techniques, methods, processes, know-how, designs and inventions related to the Software;

1.1(c) "*Minister*" means the Minister of Natural Resources and any duly authorized representative of that Minister;

1.1(d) "*Software*" means the software described in Schedule A, or any part thereof; and

1.1(e) Grammatical variations of the above terms have similar meanings. Words used in this Agreement importing the singular number only shall include the plural and vice versa.

2. PERMISSION TO USE SOFTWARE

2.1 Subject to the terms and conditions of this MOU, NRCan hereby provides AAFC with a non-transferable and non-exclusive worldwide permission to use the Software.

2.3.1 NRCan claims to be the sole proprietor of the Software and shall retain all copyright and other rights pertaining in any way to the Software.

2.4 This MOU will come into force on the last date of signature of the present document by the Parties.

3. DISTRIBUTION

3.1 AAFC will not duplicate or distribute the Software in any manner whatsoever, except as provided by the terms of this MOU.

4. CONFIDENTIALITY

4.1 All Confidential Information will be treated in the strictest confidence by AAFC and AAFC will take all reasonable security measures to ensure that any employee, agent or consultant to whom it discloses Confidential Information will retain such information in confidence.

4.2 Only the executable code of the software is covered by the present MOU. AAFC will not decompile, disassemble, reverse engineer or derive any source code from the Software or create a derivative work, except with the prior written consent of NRCan.

5 ASSIGNMENT

5.1 This MOU will not be assigned in whole or in part by AAFC without the prior written consent of the Minister and any assignment made without that consent is void and of no effect.

5.2 Where an assignment of the MOU made pursuant to Article 9.1, such assignment shall not relieve AAFC of any obligation under this Agreement or impose any liability upon NRCan.

6. ACKNOWLEDGEMENTS

6.1 Any publications or publicity by AAFC referring to the Software shall duly acknowledge NRCan ownership of the Software.

7. EXCLUSION AND INDEMNITY

7.1 The permission to use the Software is provided on an "as is" basis and NRCan makes no guarantees, representations or warranties respecting the Software, either expressed or implied, arising by law or otherwise, including but not limited to, effectiveness, completeness, accuracy or fitness for a particular purpose.

7.2 NRCan will not be liable in respect of any claim, demand or action, irrespective of the nature of the cause of the claim, demand or action alleging any loss, injury or damages, direct or indirect, which may result from AAFC's use or possession of the Software. NRCan will not be liable in any way for loss of revenue or contracts, or any other consequential loss of any kind resulting from any defect in the Software.

7.3 NRCan will not provide support for installation, conversion, training, upgrade or maintenance of the Software.

8. DESTRUCTION

8.1 Prior to disposing of any media, AAFC will ensure that any Software contained by such media has been completely erased or otherwise destroyed.

9.1 Notwithstanding Article 19, the Minister may, by written notice given to AAFC, terminate, at any time, the whole or any part of this MOU in the event that AAFC fails, refuses, neglects or is unable to perform or discharge its undertakings under this MOU.

9.2 Notwithstanding any other provision of this MOU, after the initial five (5) year period, the MOU may be terminated by either party on ninety (90) days notice in writing.

9.3 If this MOU is terminated pursuant to Article 10, AAFC will immediately return to the Minister all copies of the Software in its possession.

10. LANGUAGE

10.1 The parties have agreed that this MOU be drawn up in English. Les parties ont convenu que la présente convention soit rédigée en anglais.

11. NOTICES

11.1 Where in this MOU any notice is required to be given or made by either party, it shall be in writing and is effective if it is sent by registered mail, by telegram, by telex, by facsimile or delivered in person, addressed as follows:

(a) To NRCan:

Department of Natural Resources
Earth Sciences Sector
615 Booth Street, Room 518
Ottawa, Ontario
K1A 0E9

Attention: Licensing Officer
Business Development
Telephone No.: (613) 996-6171
Facsimile No.: (613) 995-8737

(b) To AAFC:

Research Branch
Agriculture and Agri-Food Canada
Sir John Carling Bldg
960 Carling Avenue
Ottawa, Ontario
K1A OC5

Attention: Johanne Boisvert
Program Director
Telephone No.: (613) 759-7832
Facsimile No.: (613) 759-7771

and any notice shall have been given if, by registered mail when the postal receipt is acknowledged by the other party; by telegram, when transmitted by the carrier; by telex or facsimile, when transmitted and receipt is confirmed; and by messenger or specialized courier agency, when delivered.

11.2 A party may change its representative or its address by giving a notice of change to the other party in accordance with Article 12.1.

12. AMENDMENTS

12.1 No amendment of this MOU will be valid unless effected by a written amendment signed by both parties.

13. DISPUTE RESOLUTION

13.1 The parties agree to negotiate all disagreement arising fom this MOU in good faith by referring the matter to the management oftheir respective Departments for resolution.

IN WITNESS WHEREOF each of the parties has caused this MOU to be signed in duplicate as of the day and year written below.

HER MAJESTY THE QUEEN IN RIGHT OF CANADA

Signatures were removed for privacy

Date: 12/9/02 Per: ______________________

Dr. Marc D'Iorio
Director, Applications Division
Canada Centre for Remote Sensing
Natural Resources Canada

Date: 24.9.2 Per: ______________________

Mr. Bruce ~~Michell~~ MITCHELL
Director general
Research Planning and Coordination
Agriculture and Agri-Food Canada

SCHEDULE A

THE POLARIMETRIC WORKSTATION
PRODUCT DESCRIPTION

Product Description:

Only the executable code of the polarimetric workstation is covered by the present MOU.

Software Description:

Objective

The original purpose of the development of the polarimetric workstation (PWS) is to provide an efficient and friendly tool for analysis of polarimetric images

Description of the PWS

To promote the unique polarimetric capabilities of RADARSAT 2, CCRS has investigated various applications using fully polarimetric data collected by Convair-580 C-SARs. The results obtained depend a lot on the tool used for polarimetric information extraction. The polarimetric workstation (PWS) is the fruit of about ten years experience in polarimetric image analysis. PWS includes a set of effective tools selected from the wide set of tools published in the open literature. Extensive effort resulted with an efficient and friendly workstation that will help users in the exploration of the very promizing and exciting technique of polarimetry. PWS permits the analysis of data collected with various polarimeters, such as the Convair-580 SAR, as well as SIR-C and NASA-JPL AIRSAR data.

1. Requirements

- PC platform
- Windows NT and 2000
- Graphic display is optimized for 21" monitors
- standard video card

2. Installation

1 Create a directory PWS on your local disc.
2 Copy the content of the CD to that directory.
3 To install the libraries in the current directory, double-click on mglinstaller.exe.
4 Set your system path variable (PATH) to the C:\PWS directory and C:\PWS\bin\win32 (if your local hard disk is C). To set the PATH, go to control panel -> system -> environment and add "; C:\PWS; C:\PWS\bin\win32 " without the quotes to the end of the PATH line.
5 Restart computer
6 Double-click on PWS to start running the PWS or type PWS under "RUN" tool of the "START" Windows-menu (second option is more stable on some computer).

3. PWS Function Description

3.1 Tools panel

When you execute PWS, the tools panel appears on the desktop. The tools panel contains

- Load Image
- Local Area Analysis
- Image Synthesis
- View data
- Demo

3.2 Data Format

The PWS can read the following data:

Convair 580:

Single-Look Complex (SLC) : 4 channels of complex values HH, VV, HV, and VH
Geocor product: Geocoded data under Mueller matrix format. The JPL compressed format was used to save data volume, under target and system reciprocity assumption (HV=VH).

JPL:

SIR-C (quad-pol) SLC
SIR-C (quad-pol) MLC
AIRSAR

3.3 Load image

10 Click on "**Load image**" on the top of the GUI.

20 Select the header or image file that you want to display.

- The Convair 580 SLC files are generally named "l#p#??polgasp.hdr" for the header files and "l#p#??polgasp.img" for the image files. The 4 complex channel images HH, VV, HV, and VH are needed.
- JPL SIR-C data are provided on tape or CD. First you need to dump tape by using the JPL software or by using the UNIX command "dd". PWS uncompress and read directly the compress data. The SIR-C dumped files should be named as the JPL format pr#####_ldr_ceos and pr#####_img_ceos_image (leader and compressed image files respectively), where ##### is the JPL process number.

30 After selecting your file, specify which type of data it is: Convair 580 (SLC, or Geocor product), JPL (SIR-C SLC, SIR-C MLC, or AIRSAR)

40 An image size limit has been set to 50,000 columns. If the image is larger than the limit, you will be prompted to crop the image. If desired, a cropping function will start automatically.

50 The selected image will be displayed in a new window. The other polarizations can be visualized by clicking on the polarizations menu at the top of that window. If this is the first time the selected image/polarization has been loaded, a magnitude conversion process that converts the 32 bits Real complex data to 8 bits unsigned integers, is automatically launched.

3.4 Local Analysis Tools

Local analysis tools are functions that provide information on local areas like fields and forest.

3.4.1 Define polygons

To use one of the local analysis tools, first you need to define a polygon by clicking on the "define polygon" button. You won't be able to zoom on the image during the polygon selection, so zoom in your area, if needed, before clicking on define polygon.

1 To create your polygon, use the left mouse button to select a corner of your area.
2 To delete the last point, use "backpace" on your keyboard. Clicking the right button of your mouse sets the last point of your polygon.
3 If you accept this polygon, you will be prompt to provide a name for that area.
4 If some polygons have already been created, you can select one of them or create a new one. Created polygons are permanently saved when one of the local area tools have been run.

3.4.2 Local area tools

a0 **Polarimetric signature:** Generate the co-polarized and cross-polarized polarimetric signatures of the selected polygon. Select "Save" in the File menu if you wish to save the results. A minimum of 400 independent samples per polygon is required for accurate estimation of the polarimetric parameters.

b0 **Statistics:** Provide estimates of the polarimetric parameters that characterize the scattered and the received waves. The parameters computed for each selected polygon are saved in a Excel file. A minimum of 400 independent samples per polygon are required for accurate estimation of the polarimetric parameters. The following parameters are estimated for the polygon under study:

1 __ (=__ sin $_{inc}$, where $_{inc}$ is the incidence angle) in dB for the linear polarizations HH, VV, and HV.
2 __ in dB for the right (R) and left (L) circular polarizations RR, LL, and RL.
3 The span in dB; it represents the total scattered wave intensity.
4 The extrema in dB, R_o^{max} and R_o^{min}, of the scattered wave intensity.
5 The extrema in dB, p_{max} and p_{min}, of the degree of polarization. The combination of these two parameters with R_o^{max} and R_o^{min} permits an excellent characterization of the type of scattering mechanisms and its heterogeneity (Touzi et al. 1992).
6 The extrema in dB of the completely polarized wave intensity CP_{MAX} and CP_{MIN}.
7 The extrema (in dB) CUP_{MAX} and CUP_{MIN} of the completely unpolarized wave intensity.
8 The extrema (in dB) P_{MAX} and P_{MIN} of the received power; the scattered wave is maximized and the received antenna is matched to the scattered wave polarization
9 The extrema (in dB) of the cross-matched power PX_{MAX} and P_{XMIN} ; the scattered wave is maximized and the received antenna polarization is cross-matched to the scattered wave polarization
10 The Van Zyl coefficient P_{MIN}/P_{MAX}
11 Channel coherence amplitude _ and phase _ (in degree) for HH-VV, HH-HV, and VV-HV.
12 Polarization signature pedestals.
13 The number of pixels per polygon, as well as the incidence angle, are indicated

c0 **Histogram:** Generate the amplitude histogram of the 4 polarizations. Select "Save" in the File menu if you wish to save the results.

d0 Poincaré Sphere: Display (as a red dot) the polarization state of the scattered signal on the Poincaré sphere. All the polarization states generated from 1 look SLC data are on the surface of the Poincaré sphere. Multi-look data can also be generated, and the multi-look polarization states that correspond to partially polarized scattered wave are located within the Poincaré sphere. User can select the transmitted signal configuration and the number of looks (per pixel).

To show the position of the polarization state within the sphere, a longitudinal section of the Poincaré sphere is presented. The longitude, as well as the thickness of the section can be selected using the slider control. Blue circles represent the longitudinal section intersection with the surface of the sphere. Red dots indicate the polarization states and their distance to the blue circles provides an indication of the degree of polarization. Select "Save" in the File menu if you wish to save the results.

e0 Phase difference: Display channel coherence for HH-VV, HH-HV and HV-VV. Polar representation is used; radius is the amplitude and angle is the phase of the complex coherence.

f0 Cloude decomposition: Derive Cloude's parameters (H), anisotropy (A), a and b, derived from Cloude's decomposition algorithm (Cloude and Pottier 1996). Two options is offered:

1. Estimate of the means of Cloude's parameters H, A, a and b. To obtain unbaised estimates, the averaged coherency matrix is calculated over the polygon area under study, and used to derive the parameters.
2. Display the histogram of a as a function of entropy H within Cloude's parabola. a and H are derived using coherency matrix derived from multi-look samples. The number of looks (i.e. number of independent samples per pixel) can be fixed in terms of pixel window size.

g0 Saving and viewing the results: Once the local area analysis tool is selected, select the "Apply" button to execute the function. Numerical output values are saved in a file such as "image_output.csv" (csv extension is for Comma Separated Values format). View the results by clicking on the "View data" button on the bottom-left of the control tools panel. Microsoft Excel, Corel QuattroPror, Lotus123 will automatically import the "image_output.csv" file.

3.5 Image Synthesis Tools

Image synthesis tools permits the synthesis of the received radar reflectivity images for any combination of transmitting-receiving antenna polarizations. The synthesis is performed on the portion of the image selected by the user. Define the coordinates of the sub-image before running the synthesis tool by selecting the "Define sub-image" button.

3.5.1 Define sub-image

You can define the sub-image in 3 ways:

a **Full image:** The synthesis will be performed on the entire image

b **Interactive:** With your left mouse button select a corner of your sub-image, hold and drag your cursor to generate the area. Release the button when the rectangle covers the desired area.

c **Coordinates:** The user is prompted to enter the top-left and bottom-right coordinates of the desired sub-image.

The user can specify the output sample spacing:

Full resolution: 1-look image.
Square samples: set automatically the size of the multi-look pixel to synthesize an image with square pixel. For example, a sample of 9x1 pixel is used with the Convair-580 1-look SLC data.
User defind: The user specifies the multi-look pixel size (number of pixels in azimuth and range per multi-look sample).

3.5.2 Tools

a **Beta naught (b_=__ sin _Inc):** Convert the selected sub-image, to a power image of the transmitting and receiving antenna polarizations defined by the user. The channel generated is saved using the 32 bits float format and a separate header file.

b **Correlation:** Evaluate the channel coherence (magnitude and phase) correlation and phase difference for a selected sub-image. The saved Outputs are two 32 bits Real float images (amplitude and phase) with corresponding header files. If "full resolution" is selected, only a phase image will be created (coherence magnitude is 1 in this case).

3.6 Demo

By selecting "Demo", on the top-left corner of the control tools panel, a demonstration movie will launch. The demo represents a sequence of b_ images synthesized for different configurations of the transmitting-receiving antenna polarizations. The transmitting and receiving polarization ellipses are displayed on each side of the synthesized image.

References

[Livingstone et al. 95]
Livingstone C. E., A. L. Gray, R. K. Hawkins, P. W. Vachon, T. I. Lukowski and M. LaLonde", "The CCRS airborne SAR systems: Radar for remote sensing research", *CJRS*, Vol. 21, No. 4, pp 468--491, Sep. 1995.

[Touzi et al. 92]
Touzi R., S. Goze, T. Le Toan , A. Lopes, and E. Mougin , "Polarimetric discriminators for SAR images" , *IEEE Trans. Geoscience Rem Sens.*, Vol. 30, No. 5, pp 973-980, Sep. 1992.

[Cloude and Pottier 96]
Cloude R. and E. Pottier, "A review of target decomposition theorems in radar polarimetry", *IEEE Trans. Geoscience Rem. Sens.*, Vol. 34, No. 2, pp. 498-518, March 1996