“Seismic Imaging by Next-generation BAsis-function Decomposition (SINBAD)”

**** Phase II ****

CONSORTIUM MEMBERSHIP AGREEMENT
FOR @<OIL COMPANIES> @<SERVICE PROVIDERS>

THIS AGREEMENT is made the 1st day of December, 2008.

BETWEEN

THE UNIVERSITY OF BRITISH COLUMBIA, a corporation continued under the *University Act* of British Columbia with offices at Suite 103 – 6190 Agronomy Road, Vancouver, British Columbia, V6T 1Z3; (the "University");

AND

<@>_____, a corporation incorporated under the laws of **<@>**_____, with a registered office at **<@>**_____; (the "Participant")

(University and Participant are referred to in this Agreement individually as a "**Party**" and collectively as the "**Parties**")

WHEREAS

(1) It is the University's objective to exploit its technology for the public benefit, in harmony with its Global Access Principles launched by the University in November 2007 and as outlined at www.uilo.ubc.ca/global.asp, and to generate further research in a manner consistent with the University's status as a non-profit, tax exempt educational institution;

(2) The University has been engaged in research and development in the field of seismic imaging and has undertaken research into a project referred to as Seismic Imaging by Next-generation BAsis-function Decomposition **("SINBAD");**

(3) Software developed through SINBAD has incorporated software developed by the California Institute of Technology ("**Caltech**"), and to which the University has secured the rights to sublicense such software to Participant; and

(4) The Participant wishes to participate in continued research in and development of SINBAD (the "**Research**"), and the University wishes to undertake such research.

NOW, THEREFORE, the Parties agree as follows:

1. DEFINITIONS and INTERPRETATION

1.1 (a) "**Advisory Committee**" means the committee established to provide advice to the University on matters regarding the Research in accordance with Clause 4;

(b) "**Affiliate**" means any corporation, Limited Liability Company or other legal entity directly or indirectly controlled by Participant or its successors or assigns, or any successor or assign of such an entity. For the purpose of this Agreement, "control" shall mean the direct or indirect ownership of at least fifty percent (50%) of the outstanding shares or other voting rights of the subject entity to elect directors, or if not meeting the preceding, any entity owned or controlled by or owning or controlling at the maximum control or ownership right permitted in the country where such entity exists;

(c) “**California Institute of Technology**” means a not-for-profit California corporation, located at 1200 E. California Blvd., Pasadena, CA 91125.

(d) “**Caltech Software**” shall mean the curvelet software libraries and source code that: i) are available for download at www.curvelet.org or ii) may be obtained from Caltech by negotiating a commercial license.

(e) “**Caltech Patent**” shall mean the rights in and to any and all inventions which are disclosed in the U.S. and foreign patents and patent applications identified in Schedule 3 with respect to the Caltech Software and all counterparts, corresponding international and foreign patent applications, and patents resulting therefrom;

(f) **"Confidential Information**" means all information, regardless of its form that is disclosed by the University to the Participant or its Affiliates and which is clearly identified in writing as "Confidential" at the time of disclosure. If identified orally, a written notice must be sent to the Participant within ten (10) business days thereafter. “Confidential Information” does not include information:

(i) possessed by the Participant or its Affiliates prior to receipt from the University, other than through prior confidential disclosure by the University, as evidenced by the Participant`s business records;

(ii) published or available to the general public otherwise than through a breach of this Agreement;

(iii) obtained by the Participant or its Affiliates from a third party with a valid right to disclose it, provided that the third party is not under a confidentiality obligation to the University in respect of the same; or

(iv) independently developed by employees, agents or consultants of the Participant or its Affiliates who did not use the Confidential Information as evidenced by the Participant`s business records; or

(v) that must be disclosed pursuant to an order or a subpoena.

(g) “**Curvelet Transform Technology**” means the suite of programs, scripts, and procedures, including Executable Code and Source Code, which perform the Fast Digital Curvelet Transform referred to in Schedule 2, and that was developed at the California Institute of Technology;

(h) **“Derivative Works”** means any work consisting of revisions, annotations, elaborations, or other modifications to Software which, as a whole, represent an original work of authorship. Derivative Works includes any updates and new releases of the FDCT Software developed at the California Institute of Technology during the term of this Agreement, inclusive of backups, updates, or merged copies permitted hereunder including the file structures, programming instructions, user interfaces and screen formats and sequences;

(i) “**Effective Date**” means <@>_____;

(j) “**Executable Code**” means computer software programs, not readily perceivable by humans, and suitable for machine execution without the intervening steps of interpretation or compilation.

(k) **"Field"** means signal and image processing, including seismic data processing;

(l) "**Fast Digital Curvelet Transform"** means the transform described in Schedule 2 attached hereto. ;

(m) "**FDCT Software**" means the suite of programs, scripts, and procedures, including Executable Code and Source Code, received by Participant, which perform the Fast Digital Curvelet Transform;

(n) "**Foreground IP**" means the copyright (including the source code), design rights, trademarks and patents (whether registered or not and all applications for any of them) and other forms of intellectual property rights made or generated solely as a result of the research;

(o) "**Principal Investigator**" means Dr. Felix J. Herrmann of the Department of Earth and Ocean Sciences at The University of British Columbia;

(p) "**Software**" means copyright rights, as defined by United States copyright laws and applicable international treaties and/or conventions;

(q) "**Source Code**" means computer software programs, not in machine-readable format and not suitable for machine execution without the intervening steps of interpretation or compilation; and

(r) "**Start Date**" means April 1, 2009.

(s) "**University Background IP**" means any Intellectual Property Rights owned or under the control of the University prior to the date of this Agreement relating to the technology which is described in Schedule 1 attached to this Agreement, and excludes Caltech Patent and Curvelet Transform Technology;

2. RESEARCH WORK AND PUBLICATION

2.1 Subject to compliance by the Participant with its obligations under this Agreement, the University shall:

(a) carry out the Research in accordance with those policies, standards, procedures, conventions and techniques that are of a high recognized and acceptable professional standard in the scientific community and in accordance with the requirements of this Agreement;

(b) comply with all health and safety regulations applicable to any work carried out as part of the Research and otherwise comply with all relevant laws and regulations in the conduct of the Research;

(c) supply all equipment, materials and facilities as may be required to conduct the Research, which shall remain the property of the University after termination of this Agreement;

2.2 The University shall provide a representative to attend all meetings of the Advisory Committee, who shall be a person engaged in the management of the Research on behalf of the University.

2.3 The Participant acknowledges that the policies of the University require that the results of the Research be publishable. The Parties therefore agree that the Principal Investigator and other researchers engaged in the Research shall not be restricted from presenting at symposia, national, or regional professional meetings, or from publishing in abstracts, journals, theses, or dissertations, or otherwise, whether in printed or in electronic media, methods and results of the Research, provided however that the Principal Investigator provides the Participant with a copy of any proposed publication or presentation forty-five days in advance of publication or presentation, or in the case of software 12 months prior to a public release.

2.4 During the term of this Agreement, The University will keep the Participant informed, orally or in writing, as to the progress of the Research.

2.5 Any funds received by the University from the Participant under this Agreement are non-refundable, unless the University terminates this Agreement before its expiration.

3. OBLIGATIONS OF THE PARTICIPANTS

3.1 Subject to the University's compliance with the terms of this Agreement, the Participant shall pay the University funds in accordance with the schedule below (all funds in Canadian dollars):

<@OIL COMPANIES>

<@SINBAD I Member:

- <$72,500 Canadian due on or before _____;>
- <$72,500 Canadian on each anniversary of the Start Date until termination.>

OR

<@NON-SINBAD I Member:

- <$78,500 Canadian due on or before _____;>
- <$78,500 Canadian on each anniversary of the Start Date for the first four years (*i.e.* five payments of $78,500), and $72,500 per annum on each anniversary of the Start Date thereafter until termination.

OR

- <$72,500 Canadian due on or before _____;>
- <$72,500 Canadian on each anniversary of the Start date until termination
- <a one-time fee of $25,000 due on or before _____;>

- <**@LATE ENTRY FEE**> AND $36,250 one-time late entry fee due on or before the Start Date.

<@SERVICE PROVIDERS>

- <$83,500 Canadian due on or before _____; >
- <$83,500 Canadian on each anniversary of the Start Date until termination.>

<**@LATE ENTRY FEE**> <AND $36,250 one-time late entry fee due on or before the Start Date.

3.2 The Participant may, at its own cost, provide a representative to attend meetings of the Advisory Committee.

3.3 Performance of the Research is dependent on the amount of funds received from Participants. The University reserves the right to suspend work on the Research or to terminate the Research and this Agreement by delivering written notice of same to the Participant if funds are not sufficient to carry out the Research.

3.4 The Participant may make payments by wire transfer to:

Pay Via: SWIFT MT100
Pay to: HSBC Bank Canada, Main Branch, Vancouver, BC – SWIFT Address HKBCCATT
Account number for Canadian dollars: 016-10020-437218-002
Beneficiary: The University of British Columbia
Payment Details: RTA, FAS #F08-0456

3.5 The University will retain title to any equipment purchased with funds provided by the Participant under this Agreement.

4. ADVISORY COMMITTEE

4.1 The Advisory Committee shall:

(a) provide advice to the University relating to the conduct of the Research;

(b) review the results and recommendations of any University Research reports;

4.2 The Advisory Committee shall consist of no more than one representative from Participant and at least one University representative.

4.3 Meetings of the Advisory Committee shall be held at Vancouver, British Columbia. Meetings shall be regulated as the University may decide from time to time.

4.4 The University shall call all such meetings and shall give at least 10 days' prior written notice thereof to the Participant.

5. CONFIDENTIALITY

5.1 Except as expressly provided herein, each Party agrees not to disclose any terms of this Agreement to any third party without the consent of the other Party; provided, however, that disclosures may be made as required by securities laws or other applicable laws, or to actual or prospective investors or corporate partners, or to a Party's accountants, attorneys or to the United States Government and or other professional advisors or to Affiliates, or to Caltech for the purpose of the University satisfying its obligations to Caltech under its license agreement for the Caltech Software and Caltech Patents.

5.2 The Participant will keep and use University Confidential Information in confidence and will not, without the University's prior written consent, disclose the University`s Confidential Information to any person or entity.

5.3 If the Participant is required by judicial or administrative process to disclose the University`s Confidential Information, it will promptly notify the University and allow it reasonable time to oppose the process before disclosing the Confidential Information.

5.4 Notwithstanding any termination or expiration of this Agreement, the obligations set out in this Article 5 survive and continue to bind the Parties, their successors and assigns until 7 years after such termination or expiration.

5.5 The Participant and its Affiliates will ensure that the Source Code to any Software or Confidential Information is not disclosed to any other third party. In the event of an unauthorized or accidental disclosure of the Source Code the Participant will immediately:

(a) notify the University and will provide to the University full particulars of all information in the Participant's possession or control regarding the circumstances of such unauthorized use or disclosure;

(b) take (in full consultation with the University) and at the Participant's sole cost and expense all reasonable steps deemed necessary to remedy any such unauthorized use or disclosure, and take all reasonable steps necessary to recover the Source Code and to prevent its unauthorized use by any third party.

6. INTELLECTUAL PROPERTY, INDEMNIFICATION & LIMITATION OF LIABILITY

6.1 All Foreground IP shall be the property of the University from the date of its creation.

6.2 The Participant indemnifies, holds harmless and defends the University, its Board of Governors, directors, officers, employees, faculty, students, invitees and agents against any and all claims (including all reasonable legal fees and disbursements) arising out of the receipt or use by the Participant or its Affiliates of any of the University's Confidential Information, University Background IP, Foreground IP, or any data or other results arising from such use including, without limitation, any damages or losses, consequential or otherwise, arising from or out of the Research.

6.3 The California Institute of Technology shall not be liable for any use of the FDCT Software or related know-how, and Participant hereby agrees to defend, indemnify and hold the California Institute of Technology and its employees harmless from any loss, claim, damage or liability, or whatever kind of nature, which may arise from this Agreement, or the use by Participant or its Affiliates of the Curvelet Transform Technology, FDCT Software, or any related know-how transferrred to the Participant or its Affiliates hereunder.

6.4 The University's total liability, whether under the express or implied terms of this Agreement, in tort (including negligence) or at common law, for any loss or damage suffered by the Participant or its Affiliates, whether direct, indirect or special, or any other similar damage that may arise or does arise from any breaches of this Agreement by the University, its Board of Governors, officers, employees, faculty, students or agents, is limited to $5,000.

6.5 Neither party will be liable for consequential or incidental damages arising from any breach or breaches of this Agreement.

6.6 Notwithstanding the termination or expiration of this Agreement, the rights and obligations in this Section 6 will survive and continue to bind the Participant and its successors and assigns.

7. GRANT OF RIGHTS

@ OIL COMPANY

7.1 <Subject to Section 6.2 (Indemnity), the University grants the Participant and its Affiliates a perpetual, worldwide, non-exclusive, non-transferable, royalty-free license to use and exploit University Background IP and Foreground IP for internal use only in the Field. Such internal use shall not include the provision of services or products to third parties. Internal use includes uses by Participant and its Affiliates as an "operator" in the field of oil and gas production and exploration.

7.2 Subject to Section 6.2 (Indemnity) and Section 6.3, the University grants the Participant and its Affiliates a worldwide, non-exclusive, non-transferable, royalty-free license to use and exploit the Caltech Patent, Caltech Software and the Curvelet Transform Technology for internal use in the Field and in conjunction with the University Background IP and/or Foreground IP, during the term of this Agreement.>

@ SERVICE PROVIDER

7.3 <Subject to Section 6.2 (Indemnity), the University grants the Participant and its Affiliates a perpetual, worldwide, non-exclusive, non-transferable, royalty-free license to use and exploit University Background IP and Foreground IP for internal use only in the Field, during the term of this Agreement. Such internal use shall not include the provision of products to third parties but may include the provision of services to third parties, provided that neither the Source Code nor Executable Code is disclosed to such third parties.

7.4 Subject to Section 6.2 (Indemnity) and Section 6.3, the University grants the Participant and its Affiliates a worldwide, non-exclusive, non-transferable, royalty-free license to use and exploit the Caltech Patent, Caltech Software and the Curvelet Transform Technology for internal use in the Field, and solely in conjunction with the University Background IP and/or Foreground IP, during the term of this Agreement.>

7.5 Neither the Participant nor its Affiliates will grant sublicenses of the University Background IP, Foreground IP or California Institute of Technology IP to any third party.

7.6 The Participant acknowledges and agrees that the University may use University Background IP and Foreground IP without charge in any manner for any purpose.

7.7 California Institute of Technology retains ownership of FDCT Software and Caltech Patent licensed under this Agreement.

7.8 Participant may not remove or obscure any visible copyright or trademark notices.

7.9 The FDCT Software shall not become subject to application for patent or copyright by Participant.

7.10 Participant may not install any copies of FDCT Software on computers that are not owned or leased by Participant or its Affiliates.

7.11 Participant agrees that it may make a reasonable number of copies of Software for archival and backup purposes.

7.12 Participant shall be the sole owner of any data output in any format or media derived from or obtained by use of the FDCT Software and may freely use and disclose such output to any third party.

8. **DISCLAIMER OF WARRANTY**

8.1 THE UNIVERSITY MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, REGARDING DATA OR SOFTWARE OR OTHER RESULTS ARISING FROM THE RESEARCH OR REGARDING CONFIDENTIAL INFORMATION THE UNIVERSITY MAY DISCLOSE TO THE PARTICIPANT. THE UNIVERSITY SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTY OF NON-INFRINGEMENT OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND THE UNIVERSITY WILL, IN NO EVENT, BE LIABLE FOR ANY LOSS OF PROFITS, BE THEY DIRECT, CONSEQUENTIAL, INCIDENTAL, OR SPECIAL OR OTHER SIMILAR DAMAGES ARISING FROM ANY DEFECT, ERROR OR FAILURE TO PERFORM, EVEN IF THE UNIVERSITY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THE PARTICIPANT ACKNOWLEDGES THAT THE RESEARCH IS OF AN EXPERIMENTAL AND EXPLORATORY NATURE, THAT NO PARTICULAR RESULTS CAN BE GUARANTEED, AND THAT THE PARTICIPANT HAS BEEN ADVISED BY THE UNIVERSITY TO UNDERTAKE ITS OWN DUE DILIGENCE WITH RESPECT TO ALL MATTERS ARISING FROM THIS AGREEMENT.

8.2 NOTHING IN THIS AGREEMENT:

(A) CONSTITUTES A WARRANTY OR REPRESENTATION BY THE UNIVERSITY AS TO TITLE TO THE INTELLECTUAL PROPERTY LICENSED HEREUNDER, OR THAT ANYTHING MADE, USED, SOLD OR OTHERWISE DISPOSED OF UNDER THE LICENSE GRANTED IN THIS AGREEMENT WILL NOT INFRINGE THE PATENTS, COPYRIGHTS, TRADE-MARKS, INDUSTRIAL DESIGNS OR OTHER INTELLECTUAL PROPERTY RIGHTS OF ANY THIRD PARTIES, OR ANY PATENTS, COPYRIGHTS, TRADE-MARKS, INDUSTRIAL DESIGN OR OTHER INTELLECTUAL PROPERTY RIGHTS OWNED, IN WHOLE OR IN PART, BY THE UNIVERSITY, OR LICENSED BY THE UNIVERSITY TO ANY THIRD PARTIES;

(B) CONSTITUTES AN EXPRESS OR IMPLIED WARRANTY OR REPRESENTATION BY THE UNIVERSITY THAT THE PARTICIPANT HAS, OR WILL HAVE THE FREEDOM TO OPERATE OR PRACTICE THE INTELLECTUAL PROPERTY LICENSED HEREUNDER, OR THE FREEDOM TO MAKE, HAVE MADE, USE, SELL OR OTHERWISE DISPOSE OF ANY PRODUCTS; OR

(C) IMPOSES AN OBLIGATION ON THE UNIVERSITY TO BRING, PROSECUTE OR DEFEND ACTIONS OR SUITS AGAINST THIRD PARTIES FOR INFRINGEMENT OF PATENTS, COPYRIGHTS, TRADE-MARKS, INDUSTRIAL DESIGNS OR OTHER INTELLECTUAL PROPERTY OR CONTRACTUAL RIGHTS.

8.3 THE FDCT SOFTWARE IS EXPERIMENTAL IN NATURE AND IS BEING LICENSED “AS IS.” IT IS PART OF AN ONGOING EXPERIMENTAL RESEARCH PROGRAM. THE LICENSE OF THE FDCT SOFTWARE DOES NOT INCLUDE ANY TECHNICAL SUPPORT. THE CALIFORNIA INSTITUTE OF TECHNOLOGY AND UNIVERSITY MAKE NO WARRANTIES, REPRESENTATION OR UNDERTAKING WITH RESPECT TO THE UTILITY, EFFICACY, SAFETY, OR APPROPRIATENESS OF USING THE FDCT SOFTWARE.

8.4 THE FDCT SOFTWARE IS PROVIDED “AS-IS” WITHOUT WARRANTY OF ANY KIND INCLUDING ANY WARRANTIES OF PERFORMANCE OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE OR PURPOSE (as set forth in UCC §§23212-2313) OR FOR ANY PURPOSE WHATSOEVER HOWEVER USED.

8.5 IN NO EVENT SHALL THE CALIFORNIA INSTITUTE OF TECHNOLOGY BE LIABLE FOR ANY DAMAGES AND/OR COSTS, INCLUDING BUT NOT LIMITED TO INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND, INCLUDING ECONOMIC DAMAGE OR INJURY TO PROPERTY AND LOST PROFITS, REGARDLESS OF WHETHER THE CALIFORNIA INSTITUTE OF TECHNOLOGY SHALL BE ADVISED, HAVE REASON TO KNOW, OR IN FACT SHALL KNOW OF THE POSSIBILITY.

8.6 PARTICIPANT BEARS ALL RISK RELATING TO QUALITY AND PERFORMANCE OF THE FDCT SOFTWARE USED BY THE PARTICIPANT OR ITS AFFILIATES.

9. **INSURANCE**

9.1 The Participant acknowledges the University's representation that it has liability insurance applicable to its directors, officers, employees, faculty, students and agents while acting within the scope of their employment by the University and that it has no liability insurance policy that can extend protection to any other person. Therefore, the Participant assumes the risks of personal injury and property damage attributable to the negligent acts or omissions of the Participant and its Affiliates and their directors, officers, employees and agents.

10. **TERM, TERMINATION AND WITHDRAWAL**

10.1 This Agreement starts on the Effective Date and continues for twelve months. This Agreement will be renewed automatically for further twelve-month periods, unless a notice of termination is given in writing by one Party to the other at least three (3) months before the end of this Agreement or the end of the latest renewal. If such a notice of termination is given, this Agreement will terminate with effect from the end of the twelve-month period during which the notice of termination was given.

10.2 If the Participant commits any breach or default of any terms or conditions of this Agreement and also fails to remedy such breach or default within thirty (30) days after receipt of a written notice from the University, the University may terminate this Agreement by sending a notice of termination in writing to the Participant. This termination will be effective as of the date of the receipt of such notice. The termination may be in addition to any other remedies available at law or in equity.

10.3 Upon the termination of this Agreement, the Participant will cease to use the University's Confidential Information and Curvelet Transform Technology in any manner whatsoever and upon the written request by the University, Participant agrees to destroy all of the University's Confidential Information in Participant's possession or control and certify the same to the University. In the event that such Confidential Information must not be destroyed pursuant to judicial proceedings, Participant will promptly notify the University.

10.4 Termination of this Agreement for any reason shall neither release any Party hereto from any liability which, at the time of such termination, has already accrued to the other Party or which is attributable to a period prior to such termination, nor preclude either Party from pursing any rights and remedies that it may have hereunder, at law or in equity and which accrued or is based upon any event occurring prior to such termination.

10.5 No termination of this Agreement, however effectuated, will release Participant from its rights and obligations under this Agreement including: Sections 1.0 (Definitions and Interpretations), 5.0 (Confidentiality), 8 (Disclaimer of Warranty), 10.3 (cessation of use of Confidential Information), 6 (Indemnity) and 10.4 (accrued liability).

11. GOVERNING LAW

11.1 This Agreement is governed by, and will be construed in accordance with, the laws of British Columbia and the laws of Canada in force in that province, without regard to its conflict of law rules. The Parties agree that by executing this Agreement, they have attorned to the exclusive jurisdiction of the Supreme Court of British Columbia.

12. ASSIGNMENT

12.1 Except by operation of law or the sale of that part of business to which the Research pertains, a Party may not assign this Agreement without the prior written consent of the other Party, which consent will not be unreasonably withheld or delayed.

13. TAXES

13.1 The Participant shall be responsible for payment of all applicable Value Added Taxes chargeable on goods or services supplied by the University.

14. NOTICES

14.1 All payments, reports and notices or other documents that a Party is required or may want to deliver to any other Party will be delivered:

(a) in writing; and

(b) either by personal delivery or by registered or certified mail (with all postage and other charges prepaid) at the address for the receiving Party as set out in Article 14.2 or as varied by any notice.

Any notice personally delivered is deemed to have been received at the time of delivery. Any notice mailed in accordance with this Article 14.1 is deemed to have been received at the end of the fifth day after it is posted.

14.2 Addresses for delivery of notices:

Participant	The University
<@> <@> <@> <@> <@> Telephone: <@> Fax: <@>	Managing Director University-Industry Liaison Office #103 – 6190 Agronomy Road The University of British Columbia Vancouver, British Columbia Canada V6T 1Z3 Telephone: (604) 822-8580 Fax: (604) 822-8589

14.3 The Participant may direct questions of a scientific nature or regarding financial matters to the University through the following contacts:

Scientific Matters:

Dr. Felix J. Herrmann
The University of British Columbia
Department of Earth and Ocean Sciences
6339 Stores Road
Vancouver, British Columbia
V6T 1Z4 CANADA
Telephone: (604) 822-8628
Facsimile: (604) 822-6088

Financial Matters:

Manager, Research and Trust Accounting
Office of Financial of Services
University of British Columbia

General Services Administration Building
2075 Wesbrook Mall
Vancouver, British Columbia
V6T 1Z1 CANADA
Telephone: (604) 822-6883
Telecopier: (604) 822-2417

15. COPYRIGHT MARKING

15.1 Participant will mark, in at least one conspicuous location, a notice that the some of the Software licensed hereunder are owned by California Institute of Technology and The University of British Columbia. All marking should include: © 2008 California Institute of Technology, Pasadena, California. ALL RIGHTS RESERVED. Based on Government Sponsored Research NAS7-03001 and © 2008 The University of British Columbia, British Columbia, Canada.

16. USES NOT PERMITTED

16.1 Participant agrees to utilize FDCT Software solely for the business purposes of Participant and its Affiliates. Any other uses are not permitted.

16.2 Except for distribution to its Affiliates, Participant agrees not to distribute the FDCT Software to any person external to Participant.

17. FORCE MAJEURE

17.1 Neither Party shall lose any rights hereunder or be liable to the other Party for damages or losses (except for payment obligations) on account of failure of performance by the defaulting Party if the failure is occasioned by war, strike, fire, Act of God, earthquake, flood, lockout, embargo, governmental acts or orders or restrictions, failure of suppliers, act of terrorism, or any other reason where failure to perform is beyond the reasonable control and not caused by the negligence or intentional conduct or misconduct of the nonperforming Party, and such Party has exerted all reasonable efforts to avoid or remedy such force majeure; provided, however, that in no event shall a Party be required to settle any labor dispute or disturbance.

18. EXPORT REGULATION

18.1 FDCT Software including technical data, are subject to U.S. export control laws, including the U.S. Export Administration Act as well as the Export Regulations in Participant's country and its associated regulations, and may be subject to export or import regulations in other countries. Participant agrees to strictly comply with all U.S. Export Control Regulations and acknowledges that it has the responsibility to obtain such licenses for FDCT Software as may be required after delivery to Participant. Participant agrees not to disclose or re-export any part of the FDCT Software received under this Agreement.

19. SUPPORT AND UPGRADES

19.1 No software maintenance support or training is provided as part of this Agreement.

20. GENERAL LEGAL PROVISIONS

20.1 Nothing contained in this Agreement is to be deemed or construed to create between the Parties a partnership or joint venture. No Party has the authority to act on behalf of any other Party, or to commit any other Party in any manner at all or cause any other Party's name to be used in any way not specifically authorized by this Agreement.

20.2 Subject to the limitations in this Agreement, this Agreement operates for the benefit of and is binding on the Parties and their respective successors and permitted assigns.

20.3 No condoning, excusing or overlooking by any Party of any default, breach or non-observance by any other Party at any time or times regarding any terms of this Agreement operates as a waiver of that Party's rights under this Agreement. A waiver of any term or right under this Agreement will be in writing signed by the Party entitled to the benefit of that term or right, and is effective only to the extent set out in the written waiver.

20.4 No exercise of a specific right or remedy by any Party precludes it from or prejudices it in exercising another right or pursuing another remedy or maintaining an action to which it may otherwise be entitled either at law or in equity.

20.5 Headings in this Agreement are for reference only and do not form a part of this Agreement and are not be used in the interpretation of this Agreement.

20.6 All terms in this Agreement which require performance by the Parties after the expiry or termination of this Agreement, will remain in force despite this Agreement's expiry or termination for any reason.

20.7 Part or all of any Article that is indefinite, invalid, illegal or otherwise voidable or unenforceable, may be severed from this Agreement and the balance of this Agreement will continue in full force and effect.

20.8 At the request of the University or Participant, the other Party will obtain the execution of any agreement or instrument (including from its employees, agents, contractors, consultants or representatives) that may be reasonably required to consummate the transactions contemplated in this Agreement, including assigning any rights, waiving any rights or perfecting any rights in such requesting Party's name.

20.9 This Agreement and the Schedules set out the entire understanding between the Parties and no changes to this Agreement are binding unless in writing and signed by the Parties to this Agreement. The Parties will be bound by the Schedules, except to the extent that they may conflict with the terms and conditions contained in this Agreement, in which case the terms and conditions of this Agreement will govern.

20.10 In this Agreement, unless the contrary intention appears, the singular includes the plural and vice versa and words importing a gender include other genders.

20.11 This Agreement may be executed in counterparts by the Parties, either through original copies or by facsimile. An executed copy of this Agreement delivered by facsimile will constitute valid execution and delivery of this Agreement.

20.12 Participant agrees that it shall not use the name of the California Institute of Technology, Jet Propulsion Laboratory, or JPL in any advertising or publicity material or make any form of representation or statement, which would constitute an express or implied endorsement by the California Institute of Technology of any licensed product, and that it shall not authorize others to do so, without first having obtained written approval from the California Institute of Technology, except as may be required by governmental law, rule or regulation.

20.13 University agrees that it will not use the name of Participant in any advertising or publicity material or make any form of representation or statement, which would constitute an express or implied endorsement by the Participant of any licensed product, and that University shall not authorize others to do so, without first having obtained written approval from Participant, except as may be required by governmental law, rule or regulation.

IN WITNESS WHEREOF the Parties have executed this Agreement on the day and year first above written.

SIGNED FOR AND ON BEHALF of
THE UNIVERSITY OF BRITISH COLUMBIA
by its authorized signatories:

_____
Authorized Signatory

_____
Authorized Signatory

SIGNED FOR AND ON BEHALF of
@<PARTICIPANT>
by its authorized signatories:

_____
Authorized Signatory

I have read and understood the foregoing Agreement and understand my responsibilities as the Principal Investigator:

Signature: _____
Dr. Felix J. Herrmann
Dept: Earth and Ocean Sciences, The University of British Columbia

Date: _____

SCHEDULE 1

UNIVERSITY BACKGROUND IP

1 Wavefield reconstruction

1.1 Curvelet-based focal transform

Description: Seismic wavefield reconstruction based on the combination of the non-adaptive curvelet transform and the data-adaptive focal transform. This method involves the inversion of the curvelet-regularized focusing operator by a sparsity-promoting program that solves a large-scale norm-one optimization problem.

Packages:

SLIMpy.apps : source code

SLIMpy.demos : demo

1.2 Jittered undersampling

Description: In this paper, we present a new discrete undersampling scheme designed to favor wavefield reconstruction by sparsity-promoting inversion with transform elements that are localized in the Fourier domain. Our work is motivated by empirical observations in the seismic community, corroborated by recent results from compressive sampling, which indicate favorable (wavefield) reconstructions from random as opposed to regular undersampling. As predicted by theory, random undersampling renders coherent aliases into harmless incoherent random noise, effectively turning the interpolation problem into a much simpler denoising problem.

A practical requirement of wavefield reconstruction with localized sparsifying transforms is the control on the maximum gap size. Unfortunately, random undersampling does not provide such a control and the main purpose of this paper is to introduce a sampling scheme, coined jittered undersampling, that shares the benefits of random sampling, while offering control on the maximum gap size. Our contribution of jittered sub-Nyquist sampling proofs to be key in the formulation of a versatile wavefield sparsity-promoting recovery scheme that follows the principles of compressive sampling.

After studying the behavior of the jittered-undersampling scheme in the Fourier domain, its performance is studied for curvelet recovery by sparsity-promoting inversion (CRSI). Our findings on synthetic and real seismic data indicate an improvement of several decibels over recovery from regularly-undersampled data for the same amount of data collected.

Packages:

SoftReleaseSept07 : demo in Papers/Jitter

1.3 Surfacelet transform

Description: Here we compare the transform domain interpolation results on seismic data with missing traces. The two transform domains are curvelets and surfacelets. The interpolation algorithm is performed on two different examples, one synthetic, and one with real marine data. The interpolation problem is resolved via a large-scale solver with iterative cooling and soft thresholding for the -regularization minimization involved in the recovery.

Packages:

SoftReleaseSept07 : demo in MATLAB/SURFinterp

1.4 Seismic denoising with 3-D transform-domain sparsity

Description: The code performs Seismic denoising exploiting 3D-curvelet transform domain sparsity. The 3D curvelet transform exploits the three-dimensional structure of seismic data thereby yielding better results. The denoising problem is formed as an optimization problem and is solved by iterative Landweber method.

Packages:

SLIMpy.user_demos : demo in vkumar/denoise3d

2 Wavefield separation

2.1 Curvelet-based primary-multiple separation from a Bayesian perspective

Description: A new primary-multiple separation scheme which makes use of the sparsity of both primaries and multiples in a transform domain, such as the curvelet transform to provide estimates of each. The proposed algorithm utilizes seismic data as well as the output of a preliminary step that provides erroneous predictions of the multiples. The algorithm separates the signal components, i.e., the primaries and multiples by solving an optimization problem that assumes noisy input data and can be derived from a Bayesian interpretation. More precisely, the optimization problem can be arrived at via an assumption of a weighted Laplacian distribution for the primary and multiple coefficients in the curvelet domain and of white Gaussian noise contaminating both the seismic data and the preliminary prediction of the multiples, which both serve as input to the algorithm.

Packages:

SLIMpy.ANAs : source code
SLIMpy.apps : source code
SLIMpy.demos : demo

2.2 3D Curvelet-based primary-multiple separation from a Bayesian perspective

Description: Primaries multiples separation use the sparsity of both primaries and multiples in curvelet domain by solving an optimization problem that assumes noisy input data and can be derived from a Bayesian perspective.

Packages:

SLIMpy.ANAs : source code
SLIMpy.user_demos : demo in dwang/pms-bayes3D

2.3 Adaptive curvelet-domain primary-multiple separation

Description: In this paper we developed a new adaptive curvelet-domain matching filter in primary-multiple separation problem instead of using conventional least-squares windowed amplitude matching,we propose a data-adaptive method that corrects amplitude errors, which vary smoothly as a function of location, scale (frequency band) and angle. In that case, the amplitudes can be corrected by an element-wise curvelet-domain scaling of the predicted multiples.

Packages:

SLIMpy.ANAs : source code
SLIMpy.apps : source code
SoftReleaseFeb08 : paper in Papers/CurveMatchRep

2.4 Surfacelet-based primary-multiple separation

Description: Here we compare the transform domain primary-multiple separation on seismic data with simple thresholding in a transform domain. The transform domains

are curvelets and surfacelets. Simple thresholding is performed on the SRME predicted multiples and the subtraction is performed on a full 2D SAGA dataset, and the curvelet / surfacelet results are compared. It is important to note that this method highly relies on the accurate prediction of primaries / multiples, since inaccurate predictions will cause residual multiple energy in the result or may lead to a distortion of the primaries, or both.

Packages:

SoftReleaseSept07 : demo in MATLAB/SURF-Mult-Predict

2.5 Surfacelet-based primary-multiple separation from Bayesian perspective

Description: Here we compare the Bayesian wave-field separation algorithm in a transform domain. The transform domains are curvelets and surfacelets. The purpose of this demo is to compare which transform domain is better suited for the problem of primary-multiple separation from a Bayesian perspective. The algorithm is tested on a 2-dimensional dataset.

References: wang07rri

Packages:

SLIMpy.ANAs : source code

SLIMpy.apps : source code

SLIMpy.user_demos : demo in elebed/curv-surf

2.6 Ground-roll removal based on Curvelet Transform

Description: The demonstration of surface wave identification and separation through SLIMpy and pyct tools developed at SLIM. Two examples will be shown with real data to highlight the use of these tools relating to ground roll noise prediction, separation and the ability to perform multiple separations in sequence. This demo is fully reproducible through use of Madagascar and contains the appropriate tools, which can be modified to fit specific projects.

Packages:

SoftReleaseSept07 : demo in PYTHON/GroundRoll

2.7 Block coordinate relaxation and Bayesian surface wave separation

Description: This is a demonstration of surface wave identification and separation through SLIMpy and pyct tools developed at SLIM. Two examples will be shown with synthetic and real data to highlight the use of these tools relating to ground roll noise prediction, separation methods and their performance. Two different signal separation methods developed at SLIM will be used and the results can be compared. This demo is fully reproducible through use of Madagascar and contains the appropriate tools, which can be modified to fit specific projects.

Packages:

SLIMpy.ANAs : source code

SLIMpy.apps : source code

SLIMpy.user_demos : demo in cyarham/GroundRoll

3 Imaging

3.1 Curvelet Match Filtering for True Migration Amplitude Recovery

Description: This code estimates and applies the inverse of the diagonal of the normal operator in curvelet domain to the migrated image in the context of true amplitude recovery migration In these demos the migrated and de-migrated image are fetch from

ftp-server. These images should be generated before using this software.
The images in these examples are obtained using reverse-time migration-demigration, provided by William Symes at Rice university Inversion Lab and TOTAL E&P, Houston and are subjected to term and condition of these institutes.

Packages:

SoftReleaseFeb08 : Demo in PYTHON/CrvltMtchFlt4TrueAmpRecovery

4 Solvers

4.1 solvers

4.1.1 Iterative Soft Thresholding with cooling (ISTc)

Description: ISTc is a solver for large-scale one-norm regularized least squares. It is designed to solve any of the following two problems:

1. Basis pursuit denoise:

2. Basis pursuit:

ISTc relies only on matrix-vector operations *Ax* and .

Packages:

… : [SLIMpy.ANAs]: source code

4.1.2 SPGL1: A solver for large-scale sparse reconstruction

Description: SPGL1 is a solver for large-scale one-norm regularized least squares. It is designed to solve any of the following three problems:

1. Basis pursuit denoise:

2. Basis pursuit:

3. Lasso:

SPGL1 relies only on matrix-vector operations *Ax* and accepts both explicit matrices and functions that evaluate these products. In addition, SPGL1 supports the complex-variables case, and can solve each of these problems in the complex domain.

Packages:

SoftReleaseSept07 : demo in PYTHON/SPGL1 directory

4.2 solvers

4.2.1 LSQR

Description: Attempts to solve the least squares problem that minimizes . If **A** is inconsistent, it attempts to solve the system of linear equations **Ax=y**.

Packages:

SLIMpy.ANAs : source code

5 Transforms

5.1 Surfacelet transform with RSF data interface

Description: The Surfacelet transform (SurfeBox) is adapted to provide an interface to

read/write data using RSF (MADAGASCAR) file format.

Packages:

SurfBox.slim : source code

SLIM2RSFext : MADAGASCAR extension

5.2 Curvelets

5.2.1 2D and 3D Curvelet Transform with RSF data interface

Description: Two extensions to CurveLab are provided:

1. The 2D and 3D Curvelet code (CurveLab) is adapted to provide an interface to read/write data using RSF (MADAGASCAR) file format. The original in-core curvelet transforms were recorded into out-off-core MADAGASCAR applications.
2. Python wrapper was written to access in-core curvelet transforms.

Packages:

CurveLab-2.0.2-SLIM : source code

SLIM2RSFext : MADAGASCAR extension

pyCurvelab : Python wrapper

5.2.2 3D MPI Curvelet Transform with RSF data interface

Description: The original 3D MPI Curvelet code is adapted to provide an interface to read/write data using RSF (MADAGASCAR) file format. The utilized curvelet transform is in-core and can write either single or distributed (processor owned) files. The enclosed demonstration allows to compare the performance of 3D MPI RSF Curvelet transform to performance of SLIM's out-off-core serial implementation of 3D Curvelet transform.

Packages:

CurveLab-2.0.2-SLIM : source code

SLIM2RSFext-MPI : MADAGASCAR extension

SoftReleaseSept07 : demo in Other/FDCT-3D_MPI directory

6 Utilities

6.1 Jitter sampling

Description: The basic idea behind jittered undersampling is to regularly decimate the interpolation grid and subsequently perturb according to a discrete uniform distribution the coarse-grid sample points on the fine grid.

Packages:

SLIM2RSFext : MADAGASCAR extension

7 SLIMpy development/programming environment

Description: SLIMpy is a tool that interfaces Abstract Numerical Algorithms (ANAs) with a variety of lower lever software packages. SLIMpy uses operator overloading to build an abstract computational tree which can be applied to many other software environments such as MADAGASCAR (formerly RSF).

The main development in this release is SLIMpy's embarrassingly parallel capability. SLIMpy now takes advantage of multi core processors by running each independent command on a given number of threads. A more intuitive interface for adding plugin commands (e.g. MADAGASCAR) has replaces the old plugin system. A number of bugs have been fixed, stdin/out commands that have no stdin or stdout may now be run from SLIMpy. Currently in the development branch there is a Beta version which

expands SLIMpy's multi core to multi processor functionality by using rsh and keeping track of local vs. global data.

Plans for the next release include a scalar class as a complement to the vector class. The scalar class will become a part of the AST (Abstract Syntax Tree) so it algorithms may be built in entirety before execution. This will help with the dependency problem SLIMpy has with scalars and also enable more efficient parallel utilities.

Packages:

SLIMpy.core : source code

SCHEDULE 2

FAST DIGITAL CURVELET TRANSFORM

The Fast Digital Curvelet Transform software takes as input a two-dimensional Cartesian array and returns a table of curvelet coefficients. Each curvelet coefficient essentially extracts information about the digital array at a specific scale, along a specific orientation, and at a specific location. (As an analogy, the Fourier transform extracts information at specified frequencies). There is an inverse transformation which allows reconstruction of the original array by recombining its curvelet coefficients. Both transformations, the forward and inverse mappings, are stable. In addition, the run time is almost linear in the number of pixel values. The package contains two distinct implementations of the same algorithm, and also includes an extension of the software to three-dimensional arrays.

SCHEDULE 3

LIST OF CALTECH PATENTS

Caltech File #	Inventor(s)	Description	Patent #
4349	Emmanuel Candes, Laurent Demanet, and David Donoho	Caltech curvelet	US Patent application #: 11/400,048, published 2/15/2007 (US-20070038691-A1)