2011-173
REQUEST FOR PROPPOSAL
LIDAR DATA ACQUISITION
IN THE CONTERMINOUS UNITED STATES

REQUEST FOR PROPOSAL 2011-173

LIDAR DATA ACQUISITION

Consulting Services Solicited by
Kitsap County, Washington
On behalf of the
Puget Sound LIDAR Consortium

Release Date: January 17, 2012

Proposal Submittal Deadline: February 17, 2012 at 12:00 Noon

Submit Proposals to:
R'Lene Orr, Purchasing and Records Manager
Kitsap County Purchasing Department
614 Division Street MS-7
Port Orchard, WA 98366

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REQUEST FOR PROPOSALS, LIDAR DATA ACQUISITION AND PROCESSING

DEADLINE: NOON, FEBRUARY 17, 2012, PACIFIC STANDARD TIME

I. REQUEST

The Puget Sound LIDAR Consortium (PSLC) is a loose consortium of parties interested in obtaining public-domain high-resolution LIDAR topographic survey data. Since 2000 the PSLC has acquired such data for more than 12,864 square miles of Washington and Oregon. The PSLC here solicits proposals to carry out further surveys. The resulting contract will be between Kitsap County and the chosen vendor. Staff at the Puget Sound Regional Council, with funding and assistance from staff at the U.S. Geological Survey, will provide contract management, data quality assurance, and data distribution.

For winter 2012-2013 the PSLC expects to have at least $300,000 available to purchase LIDAR surveys. Similar amounts may be available in following years, depending in large part on Federal appropriations. Most of these funds will be expended by Kitsap County via the contract that results from this RFP, but some Consortium partners may not find it feasible to purchase data via this contract and will choose to execute similar contracts with the vendor.

If the PSLC continues to receive support from the U.S. Geological Survey at near-present levels, the PSLC will provide quality assurance and distribution services for any LIDAR survey data obtained in Washington and Oregon that meets or exceeds the specifications outlined in this Request for Proposals and that is to be in the public domain.

II. PROPOSED SCOPE OF WORK

A. Technical Specifications

I. Data Acquisition

Returns per pulse	LIDAR instrument shall be capable of recording at least **3** returns per pulse, including 1st and last returns
On-ground laser beam diameter	Between 10 cm and 40 cm
Scan angle	**≤ 15 degrees** from nadir (±30 degrees overall). Note that this may require that the instrument be roll-compensated.
Swath overlap	Nominal 50% sidelap on adjoining swaths, i.e., survey shall be designed for 100% double coverage at planned aircraft height above ground
Design pulse density	**≥ 8 pulses/m^2** (includes swath overlap; e.g., with 50% sidelap, ≥ 4 pulse/m^2 in each swath)
GPS procedures	See **Appendix A. GPS procedures** and section **II B Difficult ground**.
Survey conditions	Leaf-off, no significant snow cover, no standing water in fields, and no flooding are desirable. In many wet parts of the Pacific

Northwest there is little chance of meeting these constraints. See **Appendix B. Survey conditions**. The PSLC, in consultation with the LIDAR contractor, shall judge whether conditions are suitable for LIDAR acquisition

II. Spatial Reference Framework

Vertical Datum	NAVD88, using latest geoid model available from the National Geodetic Survey, unless otherwise specified by the PSLC
Horizontal Datum	Data referenced to NAD83 (CORS96), data labeled NAD83-HARN for GIS purposes
Projection	UTM, State Plane, or Oregon Lambert (as requested by PSLC)
Units	Meters (UTM) or survey/international feet (State Plane, Oregon Lambert)

III. Accuracy

Absolute LIDAR measurement accuracy as reported by contractor

≤ 9 cm vertical (RMSE), measured on planar, near-horizontal surfaces. See **Appendix A. GPS procedures.**

Consortium will review contractor's analysis of measurement accuracy. If independent, pre-existing ground control points are available, the Consortium may evaluate data against these points as well.

Intra-survey reproducibility Barring true surface change (e.g., tides, changes in river level, active construction, moving vehicles),

≤ 6 cm vertical (RMSE) for project as a whole

≤ 40 cm horizontal (RMSE) for project as a whole

Within any 500m x 500m area, **≤ 10 cm** vertical (RMSE) on near-horizontal surfaces

Evaluated by comparison of overlapping swaths.

Reproducibility of range measurements Within any 10m x 10m area, **≤ 3 cm** (RMSE)

Evaluated by measuring departures from planarity of single-swath 1st returns from hard planar surfaces, e.g., building roofs.

IV. Completeness

Local relief, turbulence, and inability to maintain an exact flying height routinely lead to departures from survey design. For this reason minimum acceptable swath overlap and aggregate 1st-return density are specified here. Data will routinely be evaluated for completeness.

Coverage No voids between swaths. No voids because of cloud cover or instrument failure

Swath overlap	≤ 20% no-overlap area per project. No arbitrary 1 km x 1 km square with ≥ 50% no-overlap area
Aggregate 1st return density	Barring non-scattering areas (e.g., water, wet asphalt): For entire project area, ≥ 85% design pulse density. Within any 30m x 30m area within areas of swath overlap, ≥ 50% design pulse density

1st-return density is easily evaluated automatically. However target conditions commonly lead to permissible dropouts that result in low return densities. Areas of suspected too-low return density will be inspected by a human to ensure that they are the result of target conditions and not poor survey practices.

V. Usability

Files shall be named as described in **Appendix E. File names**.

Files shall have consistent internal formats.

Contractor shall propose all details of file names and file formats that are not specified here. Proposed names and formats must be approved by PSLC.

Files may be gzip or zip compressed. Use of compression and compression type shall be uniform across a given data layer.

GIS data (ESRI grids, shapefiles) shall have complete and correct associated projection files.

All files must be readable.

B. Deliverables

Report of Survey	Text report that describes survey methods; results; contractor's accuracy assessments, including internal reproducibility and absolute accuracy; file formats; file-naming schemes; tiling schemes. *.pdf, .odt, or .doc format*
Aircraft trajectories	Aircraft position (easting, northing, elevation) and attitude (heading, pitch, roll) and GPS time recorded at regular intervals of 1 second or less. May include additional attributes, including PDOP and estimated positional and velocity errors. May be clipped to project area. *ASCII text or shapefile+.dbf format*
Ground control points	List of all ground control points (GCPs) and their positions as determined by the contractor. For each GCP: ID, easting, northing, orthometric height, and survey method. May include additional attributes such as ellipsoidal height and description of the ground surface (e.g., asphalt, short grass, forest floor). *Shapefile+.dbf format*
All-return point cloud	List of all valid returns. For each return: Posix time, easting, northing, elevation, intensity, return#, return classification. May include additional attributes. No duplicate entries. Time shall be reported to the nearest microsecond or better. Easting, northing, and elevation shall be reported to nearest 0.01 m (nearest 0.01 ft). **Classification of returns shall be as complete as is feasible and**

without avoidable return misclassification; see **Appendix D. Return classification**.
LAS 1.2 or greater, using Point Data Record format 1 or 3. LAS files shall have all fields populated, including all return attributes identified above.
Conformance to return classification requirement will be evaluated by visual inspection of large-scale shaded-relief images of ground surface model.
*1/100th USGS 7.5-minute quadrangle (0.75 minute by 0.75 minute) tiles; see **Appendix C. Tiling scheme***

Ground point list List of X,Y,Z coordinates of all identified ground points.
*ASCII text. 1/4th USGS 7.5-minute quadrangle (3.75 minute by 3.75 minute) tiles; see **Appendix C. Tiling scheme***

Ground (bare-earth) surface model Raster of ground surface, interpolated via triangulated irregular network from identified ground points. Surface models shall have no tiling artifacts and no gaps at tile boundaries. Areas outside survey boundary shall be coded as NoData. Internal voids (e.g., open water areas) may be coded as NoData.
Idealization of the landscape in the course of constructing surface models should be avoided. In particular, the triangulated irregular networks from which ground surface raster models are interpolated should not include breaklines derived from other data sources.
*ESRI floating point grid, 3 ft (1m) cell size, snapped to (0,0), 1/4th USGS 7.5-minute quadrangle (3.75 minute by 3.75 minute) tile, Z values shall not be rounded or truncated; see **Appendix C. Tiling scheme.***

First-return (highest-hit) surface model Raster of first-return surface, cell heights are highest first return within that cell, cells without first returns shall be coded as NoData.
*ESRI floating point grid, 3 ft (1m) cell size, snapped to (0,0), 1/4th USGS 7.5-minute quadrangle (3.75 minute by 3.75 minute) tile, Z values shall not be rounded or truncated; see **Appendix C. Tiling scheme***

Formal metadata See **Appendix F. Instructions on formal metadata**

C. Optional Deliverables

Intensity image Raster image of 1st-return intensity.
TIFF, 3 ft (1m) pixel size, 1/4th USGS 7.5-minute quadrangle (3.75 minute by 3.75 minute) tiles; see Appendix C. Tiling scheme

Contours 1-ft or 2-ft contours. AutoCAD .dxf or ESRI shapefile format.
1/4th USGS 7.5-minute quadrangle (3.75 minute by 3.75 minute) tiles; *see **Appendix C. Tiling scheme***

D. Exceptional costs

Upon arrangement, data for intertidal areas shall be acquired at low tide stages. If this requirement significantly restricts permissible survey times, contractor and PSLC may negotiate a surcharge, not to exceed 100% of the per-area cost, for such surveys.

Hydroflattening (removal of elevation artifacts in water bodies in bare-earth DEMs) may be specified for some surveys. PSLC shall specify in detail how hydro-flattening will be performed, including the treatment of longitudinal and lateral gradients in stream-surface elevations and the treatment of tidal water bodies that have multiple true elevations. Deliverables for hydroflattening shall include breaklines and a 2nd, hydroflattened bare-earth DEM. Contractor and PSLC will negotiate a surcharge for hydroflattening.

E. Difficult ground

Areas of extreme local relief and (or) poor access are more difficult to survey because of (1) inability to maintain a near-constant aircraft height above ground, (2) occasional occultation of the GPS satellite constellation, (3) difficulty in adequately distributing GPS base stations and ground control points, and (4) within-swath variations in ground elevation that exceed the depth of field of the LIDAR instrument. In such circumstances it may be advisable to relax the specifications laid out in this Request for Proposals. Any such relaxation must be approved by the PSLC and may be associated with a lower price to be negotiated between the PSLC and the Contractor.

F. Delivery Schedule (review carefully)

The final delivery shall be made no later than 110 working days from end of data acquisition. Contractor is encouraged to deliver products sequentially as they become available rather than all at one time. The PSLC will review and accept/reject products within 30 days of delivery. The contractor should propose a preferred delivery schedule.

Following a thorough Quality Assessment by PSLC staff, data will be accepted or rejected based on specifications in this RFP. If it is determined that the delivered LIDAR data are insufficient to meet the RFP specifications, the contractor will be required to reprocess and/or re-fly problem areas.

G. Intellectual Property Rights

The PSLC shall have unrestricted rights to all delivered reports and data. The PSLC expects to place reports and data in the public domain. This specification places no restrictions on the contractor's rights to resell data or derivative products as the contractor sees fit.

III. ADMINISTRATIVE REQUIREMENTS

A. Objective of Request for Proposal (RFP)

The objective of this RFP is to provide sufficient information for qualified Contractors to submit written proposals. The RFP is not a contractual offer or commitment to purchase services. Contractors must be bona-fide providers of the services requested using installed and operating systems open for inspection by representatives of the PSLC. To be responsive to this request, proposals must conform to the procedures, format, and content requirements outlined in this RFP. Deviations may be grounds for disqualification.

B. Proposal Submission Deadline

An original and all copies of the RFP response must be received no later than **12:00 PM (PST) February 17, 2012 by the Consortium members noted in Section IV, C.**

C. Addenda to the Request for Proposals

If it becomes necessary to revise any part of this RFP, an addendum will be provided to all who have been mailed or have picked-up this RFP. Respondents should contact the PSLC, following the instructions in Section D below, if they find inconsistencies or ambiguities. Any clarification given may become an addendum.

D. Requests for Information

Any requests for clarification or additional information regarding this RFP shall be submitted via e-mail to Diana Martinez or Ralph Haugerud at the following addresses by **4:00 PM (PST) February 3, 2012**:

Diana Martinez	Ralph Haugerud
dmartinez@psrc.org	rhaugerud@usgs.gov
206.971.3052	206.713.7453

All requests received prior to the deadline will be answered via e-mail and copies of the questions and answers will be forwarded to all prospective contractors who have formally requested a copy of this RFP and have provided their e-mail address.

E. Duly Authorized Signature

The original proposal must contain the signature of a duly authorized officer or agent of the company.

F. Respondent Responsibility for Proposal Costs

The Contractor shall be fully responsible for all proposal development and submission costs. The PSLC does not assume any contractual obligations as a result of the issuance of this RFP, the preparation or submission of a proposal by a Contractor, the evaluation of an accepted proposal, or the selection of any finalists.

G. Economy of Proposal

Proposals should be prepared simply and economically and give a straightforward and concise description of the Contractor's capabilities to satisfy the requirements of the project. Special bindings, colored displays, etc., are not necessary. Emphasis should be placed on completeness and clarity of content.

H. Substantive Proposals

The Contractor's duly authorized officer or agent shall certify in writing that:

- The Contractor's proposal is genuine; not made in the interest of, or on behalf of, any undisclosed person, firm, or corporation; and is not submitted in conformity with and agreement of rules of any group, association, organization, or corporation.
- The Contractor has not directly or indirectly induced or solicited any other proposer to put in a false or sham proposal.
- The Contractor has not solicited or induced any other person, firm, or corporation to refrain from proposing.
- The Contractor has not sought by collusion to obtain for himself/herself any advantage over any other proposer or the Consortium.

I. Proposal Changes or Withdrawal

A proposer may withdraw or modify its proposal any time before the proposal due date by a written request, signed in the same manner and by the same person who signed the proposal.

J. Acceptance of Request for Proposal Content

Provisions of the RFP and the contents of the successful response are considered available for inclusion in final contractual obligations. The Consortium retains the option of canceling the award or selecting another offer if the successful Contractor fails to accept such obligations.

K. Contractor Qualifications

Contractors must submit evidence that they have relevant past experience and have previously delivered services similar to the ones required. Each firm may also be required to show that it has satisfactorily performed similar work in the past and that no claims of any kind are pending against such work. No proposal will be accepted from a firm that is engaged in any work that would impair its ability to perform or finance this work.

L. Estimate of costs

Respondents shall provide an estimated cost breakdown to perform all work requested in this RFP. Final cost will be negotiated with the selected contractor. In the event an agreement on cost cannot be negotiated, the Consortium reserves the right to negotiate with an alternative contractor.

The estimated cost breakdown should identify the following:

- Price for mobilization
- Price for partial mobilization, i.e. movement from survey to survey within the Washington-Oregon area.
- Per-area price for data acquisition and subsequent processing, exclusive of mobilization. At the Contractor's discretion, per-area price may vary with elevation and/or local relief. ***The Consortium recognizes that larger projects can be significantly less costly on a per-area basis to acquire and thus invites proposals and pricing schedules that reflect these economies of scale.***
- Per-area price for optional contours and per-area price for optional intensity images.

Should the proposal offer value-added products and/or services in excess of those requested in the Scope of Work (e.g., additional imagery), cost estimates for those products and/or services should be separated from those associated with the requested scope of work.

M. Right to Reject Proposals

The Consortium reserves the right to reject any and all proposals and to waive any formality in proposals received, to accept or reject any or all the items in the proposal, and award the contract in whole or in part if it is deemed in the Consortium's best interest.

N. Sub-consulting and Equipment Purchases Responsibility

Proposals must indicate all items of work or service that will be performed by sub-contractors and identify the sub-contractors and service they will perform. Proposals shall also describe the sub-consulting organization and the contractual arrangements made therewith. All sub-contractors will be subject to approval by the Consortium. The selected Contractor will also furnish the corporate or company name and the names of officers or principals of said companies proposed as sub-contractors. The Consortium will consider the selected Contractor to be solely responsible in all contractual matters, including payment of any and all charges resulting from sub-contractor contracts. The selected Contractor shall cause appropriate provision of its proposal to be inserted in all ensuing subcontracts to ensure fulfillment of all contractual provisions by sub-contractors. The Consortium will hold the selected Contractor directly responsible for the quality, integrity, and delivery of all product deliverables specified in this RFP

O. Access Agreements (read carefully)

The Contractor shall provide written notification to the PSLC on the number and locations of ground control points used in this project. The contractor shall determine land ownership encompassing those locations and as required, obtain site access permission. The contractor shall notify landowners and coordinate with the appropriate personnel prior to on-site or over-site activities. The contractor shall be solely responsible for the requisite filing of flight plans and obtaining appropriate permissions from the FAA and other agencies as necessary.

P. Complete Services/Products

The selected Contractor shall be required to:

- Furnish all tools, equipment, supplies, supervision, transportation, and other accessories, services and facilities.
- Furnish all materials, supplies, and equipment specified and required to be incorporated in, and form a permanent part of, the completed work.
- Provide and perform all necessary labor.
- Allow the PSLC to inspect the Contractors facilities and equipment.
- Execute and complete all specified work with due diligence, in accordance with good technical practice and the requirements, stipulations, provisions, and conditions of this RFP and the resultant contract.

R. Non-Washington Corporations

If a contract or subcontract is awarded to a non-Washington corporation, such corporation shall obtain authorization to do business in the State of Washington prior to final execution. The laws of the State of Washington shall govern the contract executed between the selected Contractor and the Consortium, and any interpretations or constructions thereof. Further, the place of performance and transaction of business shall be deemed to be the County of Kitsap, State of Washington; in the event of litigation, the exclusive venue and place of jurisdiction shall be the Superior Court for Kitsap County, Washington.

S. Invoicing and Payment Schedule

Products deliverable under the agreement shall be submitted to the PSLC according to a schedule to be agreed upon with the Consortium. Upon acceptance of each product submission by the PSLC, the Contractor may submit invoices for payments in accordance with a schedule to be negotiated.

Invoices shall be submitted to:

Phyllis Mann, Program Administrator
Kitsap County Department of Emergency Management
911 Carver Street
Bremerton, WA 98312

T. Insurance Requirements

The selected Contractor will be required to provide proof of insurance, and to have the County of Kitsap, State of Washington named as additional insured on their General Liability Insurance policy. Specific insurance coverage and amounts will be determined during negotiations.

U. Ownership of Data

All products, data, information, findings and documents prepared or obtained under the terms of this RFP shall become the exclusive property of the Consortium.

IV. SELECTION, CONTRACTING PROCESS, AND ESTIMATED SCHEDULE

A. Advertisement

The Consortium will advertise this in the Seattle Journal of Commerce, National Journals during the week of January 17, 2012. Those firms that the PSLC is aware of as providing LIDAR services will be notified via e-mail of the availability of the RFP.

B. Evaluation Criteria

All proposals will be evaluated by a Contractor Evaluation Committee (CEC) made up of qualified persons from the PSLC and others. Additional technical input may be used from an independent consultant. Selection will be made based on technical qualifications and approach as well as overall project cost. Rating criteria will include:

1. Meeting or exceeding specific requirements in this RFP noted in Section IIA, Technical Specifications
2. Relevant experience of firm in similar projects
3. Relevant experience of assigned staff in similar projects
4. References responses
5. Schedule to acquire and process the data
6. Project Cost
7. Accessibility of Contractor's data processing staff. The PSLC has found that easy conversation with data processing staff is desirable. It is undesirable that these staff be located in a time zone more than 5 hours different from the Pacific Northwest, or within a management structure that renders them inaccessible.

C. Contractor Response

Proposals must be submitted directly to the following PSLC members and must be received no later than 12:00 PM (PST) February 17, 2012.

Original (hard-copy) to

R'Lene Orr
Kitsap County Purchasing Division
614 Division Street
Port Orchard, WA 98366

Copies to

Diana Martinez, Senior GIS Analyst
Puget Sound Regional Council
1011 Western Avenue, Suite 500
Seattle, WA 98104-1035
dmartinez@psrc.org

Craig Weaver, Pacific Northwest Regional Coordinator
Earthquake Hazard Program
U.S. Geological Survey
Department of Earth & Space Sciences
University of Washington, Box 351310
Seattle, Washington 98195-1310
craig@ess.washington.edu

Ralph Haugerud, Research Geologist
U.S. Geological Survey
Department of Earth & Space Sciences
University of Washington, Box 351310
Seattle, Washington 98195-1310
rhaugerud@usgs.gov

These copies may be in digital (PDF) form and may be emailed to the recipients.

All proposal materials submitted will automatically become the property of the PSLC, which reserves the right in its sole discretion to use without limitation any and all information, concepts, and data contained therein.

Respondents should contact only those persons specifically designated for information about the status of this procurement following proposal submission. Disregarding this directive may disqualify the proposal involved.

D. Contractor Evaluation Committee Recommendations

The CEC will use the Evaluation Criteria listed in Section IV B herein, to rate and rank the proposals that are found to be responsive to all major requirements of this RFP. Quality of response to each RFP point as set forth herein will be rated and a comparative qualitative ranking of all proposals will be developed based on a composite rating of each one.

The rating and ranking results will be reported to the members of the Consortium along by selection by March 30, 2012

E. Selection and Notification

After the Consortium has made the final selection, all firms submitting proposals shall be notified of the results of the selection process on or near April 16, 2012.

F. Agreement Preparation

After the contractor has been chosen and notified, Kitsap County will prepare two copies of the contractor agreement. The contractor will review and sign both originals and return both to Kitsap County. Kitsap County will sign both originals and return one to the contractor.

V. PROPOSAL FORMAT AND CONTENT

To speed and simplify the proposal evaluation and to ensure that each proposal receives the same orderly review, all proposals must follow the format described in this section. Proposals shall contain all elements of information requested. Exceptions must be noted as described in Section V.B.6 below.

Proposals shall include the following sections:

I. Executive Summary

II. Administrative Questions

III. Summary of Technical Process

IV. Related Experience and References

V. Project Equipment Description

VI. Project Staff

VII. Schedule

VII. Costs

Detailed requirements and directions for preparation of each section are outlined below

A. Section I: Executive Summary

In the Executive Summary, highlight the major facts and features of the Proposal, including any conclusions, assumptions, and recommendations you desire to make. The Executive Summary should be specifically designed for review by executives who may not possess a technical background. It must be no more than three pages in length.

B. Section II. Administrative Questions

Provide following information relative to your firm. Similar information must be provided for each sub-contractor.

1. Firm name and business address, including telephone number, FAX and e-mail address.
2. Year established (include former firm names and year established, if applicable).
3. Type of ownership and parent company, if any.
4. Indication of whether the firm(s) is/are licensed to do business in the State of Washington.
5. Project manager's and authorized negotiator's names, mailing address, telephone number and e-mail address if different from Item 1. The authorized negotiator would be the person that is empowered to make binding commitments for the prime and its sub-contractors.
6. What exceptions are taken to the requirements of this RFP? If exceptions are taken, cite the activity involved, the exception taken and alternate language. If no exceptions are taken, so state.
7. What is the current financial status and condition of the respondent? This query will be best satisfied by submission of the prime contractor's latest annual financial statement or equivalent.

C. Section III. Summary of Technical Process

Discuss and clearly explain the methodology that your firm proposes to use to satisfactorily achieve the required results on this project. Include all aspects of survey control, data acquisition & analysis and quality control procedures. Describe the attributes of the data as it is to be acquired, including: laser pulse repetition rate; scan pattern, angle and rate; laser footprint diameter on the ground; number of returns per

shot collected (i.e., first and last, or multiple); swath width, overlap between adjacent swaths, average and worst-case spacing of laser shots cross and along-track within a swath; number of GPS base stations used and maximum distance to a station. For first and last, or multiple returns per shot, state the minimum resolvable distance between returns. State if the intensity of the laser return and off-nadir angle are to be included as a part of the delivered data. List the software used to process the data, include the publisher name, version used and platform/operating system. Proposals that stress activities that will exceed the requirements of this project at additional costs are not desired and will be rated negatively. This discussion should not be any longer than 12 pages.

D. Section IV: Related Experience and References

Provide a list of projects of similar magnitude and complexity that the prime Contractor has performed in the last five years. Include a brief description (no more than one page per project) of the projects. The descriptions should specify the services provided, type of terrain including vegetation, contract amount, geographic extent, accuracy or scale, and any other pertinent information. In addition, the name, address, and phone number of the client's project manager must be provided as a reference.

Submit one sample of a LIDAR product your firm has produced in similar terrain and of a similar quality level anticipated for this project. This shall be in digital format. Note any professional and technical activities in societies and institutes that are used to maintain current state of the art expertise and contribute to the betterment of standard of practice. This discussion should not exceed 2 pages.

E. Section V: Project Equipment Description

List all equipment, hardware, and software that your firm intends to use during the course of this project. This shall include at a minimum: Aircraft (fixed wing or helicopter), laser equipment, IMU, GPS equipment, processing software, etc. Please indicate specifics as to availability of equipment (as a function of time) for this project, as well as compatibility of your firm's internal software to accommodate this project's requirements in terms of deliverables. This discussion should not be longer than 4 pages.

F. Section VI: Project Staff

Provide a complete project staff description in the form of a graphic organization chart, a staff summary that addresses individual roles and responsibilities, and resumes for all project participants. It is critical that Contractors commit to particular levels of individual staff members' time to be applied to work on this project. Variance from these commitments must be requested in writing from the Consortium and reviewed/approved in terms of project quality or schedule impact.

G. Section VII: Schedule

Identify any issues with meeting the schedule as outlined in section IIC.

H. Costs

Provide complete cost schedule, as outlined in section IIIL.

APPENDIX A. GPS PROCEDURES

All GPS measurements shall be made with dual frequency L1-L2 receivers with carrier-phase correction. All GPS measurements shall be made during periods with PDOP $\leq$3.0 and with at least 6 satellites in common view of both a stationary reference receiver and the roving receiver.

Stationary reference receivers shall be located at existing National Geodetic Survey (NGS) marks or at new marks. Marks shall be established and certified to the appropriate State standards and statutes, shall be tied to monuments published through NGS, and the monuments shall have been surveyed or re-surveyed within 2 years of the LIDAR survey. In the case of an existing mark, its location shall be

verified by processing one GPS session of at least two hours duration and comparing the computed position with the position published by NGS. Each new mark shall be located by tying to one or more NGS Continuously Operating Reference Stations (CORS) by static GPS methods. If the distance to the nearest CORS is less than 80 km, use at least 2 independent GPS sessions, each at least 2 hours long. If the distance to the nearest CORS is greater than 80 km, use at least 2 sessions each at least 4 hours long.

At least two GPS reference receivers shall be in operation during all LIDAR missions, sampling positions at ≥1 Hz. The roving GPS receiver in the aircraft shall sample positions at ≥2 Hz. Differential GPS baseline lengths shall be no longer than 30 km.

Ground control points (GCPs), used for both survey calibration and assessment of absolute vertical accuracy, shall be established using GPS and (or) other techniques that are expected to result in accuracies of 1.5 cm (RMSE) or better. Strongly clustered GCPs are useful, perhaps even desirable, for calibration. Vertical accuracy shall be assessed by calculating and averaging the distances between a subset of at least 30 GCPs that are not clustered and a surface interpolated from LIDAR 1st returns. At least 20% of flight line swaths should contain points in this subset and the maximum distance between these GCPs should be no less than one-half the maximum distance across the survey area.

The *Report of Survey* shall document the identity, published position, and measured position of all existing NGS marks used for reference stations. The locations of new marks shall be described, along with their measured positions and the identity and published positions of CORS to which their locations were tied. The *Report of Survey* shall describe the technique(s) used to establish GCPs and document the positions and residuals of all GCPs used to evaluate survey accuracy.

APPENDIX B. SURVEY CONDITIONS

For almost all purposes, including description of the forest canopy, the best possible ground model is of paramount importance. LIDAR data should be acquired in conditions that maximize the potential quality of the ground model.

The acquisition period should reflect a balance between several constraints:

- Low PDOP and visibility of a sufficient number of satellites.
- *No snow cover with average thickness greater than 6 inches or with thickness variations greater than 1 foot.* In areas of winter snow cover, the melting snow pack in late Spring and early Summer has large thickness variations. Spring acquisitions are thus rarely acceptable. Light early-season snowfall (no more than a few inches) often improves ground model quality by knocking down low brush and improving ground reflectivity. Late Fall acquisitions can provide excellent results. Data should not be acquired in Winter when there is significant snow pack. This constraint may dictate acquisition during leaf-on conditions.

  High mountain areas with permanent snow cover cannot meet this constraint and typically have severe weather and access (for ground GPS work) constraints. The optimal acquisition time for such areas is likely to be late Summer or early Fall. If high mountains are interspersed with large low-elevation valleys, much of the target area may have to be flown twice, once in late Summer (minimal snow cover and good weather) and once in the late Fall and Winter leaf-off period.
- *Adequate chance of sufficient intervals without rain, fog, or low clouds within the specified acquisition period.* Weather records for the target area should demonstrate that, within the planned acquisition period, there is an acceptable chance that the aggregate duration of clear periods (each of sufficient duration to field a LIDAR flight) will be sufficient to complete planned acquisition flights with the available crews and equipment. Many parts of the Pacific Northwest have such frequent rain, fog, and (or) low clouds that this constraint trumps all others.

- *No tall grain.* Discrete-return LIDAR instruments will not obtain ground returns beneath closed-cover green corn or small grains. Data should be acquired after harvest or before grains reach significant closure (for corn) and height (for small grains). Row crops are less problematic.
- *No extensive standing water.* In rainy, low-relief areas, this constraint may rule out acquisition during much of the leaf-off season. In low-relief valleys, data should not be acquired when overbank areas are flooded.
- *Low stream flow.* For low-relief valleys with unconfined streams, it is very useful to have ground models which support accurate prediction of the wetted area at various river stages. This dictates acquisition of LIDAR data in low-flow conditions. If this constraint is operable, permissible gauge heights should be specified for each major stream in the target area. In streams that have steep banks (including most leveed streams) or that lie in confined valleys, changes in river stage cause little change in the underwater area and there is little benefit to requiring acquisition in low-flow conditions.
- *No significant deciduous leaf cover.* Deciduous foliage substantially reduces the fraction of laser pulses that yield ground returns. In lowlands west of the Cascade Range, this typically restricts acquisition to the months of December, January, February, and March. In some years, and in some locales, earlier or later acquisitions may be acceptable. Even where the forest is almost entirely evergreen there is usually significant deciduous vegetation along streams, where there is usually the greatest need for accurate ground models.
- *Low tide.* In nearshore areas it may be desirable to restrict acquisition of data for intertidal areas to periods when the predicted (or observed) water level is less than some defined value; or to require collection of data for all areas down to a defined elevation. This will significantly contract the available acquisition window and thus usually increase the cost of survey.
- *Availability of funding.* Public agency funding often disappears at the end of the fiscal year or biennium. This may drive acquisition in less than optimal conditions.
- *Immediate need for data.*

In many parts of the Pacific Northwest all of these constraints cannot be met and some compromise is necessary. Compromises in acquisition conditions *will* compromise data quality, but it should be remembered that a less-than-perfect LIDAR bare-earth model is likely to be far better than a model derived from any other data source. Where an adequate ground model already exists and the primary survey target is the forest canopy it may be appropriate to acquire LIDAR data during flooded, snow-covered, and (or) leaf-on conditions.

RFPs, proposals, and contracts for acquisition of LIDAR data should clearly specify acceptable acquisition conditions, including their likely calendar duration and probability of occurrence, as these greatly impact the cost of obtaining data.

We suggest that realistic constraints for the Pacific Northwest are:

- All areas: adequate PDOP and satellite visibility, no flooding
- High mountains (above 6,000 feet elevation): After August 15 and without significant new snow cover (see above) below 8,000 feet elevation. Earlier surveys permissible if all winter snow is melted.
- Puget Lowland, southern Georgia Basin, east slope Coast Range, eastern and northern Olympic Mountains: Leaf off, no significant snow cover
- Willamette Valley (with extensive flats and extensive agriculture): No extensive standing water, no tall grains.

- Columbia Plateau: No tall grains, no significant snow cover.
- Interior mountains (east slope Cascades, Okanogan Highlands, Blue Mountains): No significant snow cover, no tall grains
- Northern Basin and Range: No significant snow cover

The windward, wet west slope of the Coast Range, western Olympic Mountains, and western Cascade foothills present a special problem. At low elevations (below ~3,000 feet), large fractions of these regions are covered with deciduous forest in logged areas and along valley bottoms and do not have a high probability of clear weather during the leaf-off season. Above ~3,000 feet there may be little chance of leaf-off conditions without significant snow cover during any given year. High- and low-elevation areas are intermixed and are not economically surveyed at different times. We suggest requiring leaf-off, no snow cover acquisition with a high likelihood that a survey cannot be completed in any given year unless—and this will commonly be the case—funding requirements and data needs require the planning of leaf-on, no snow cover acquisition.

Unless acquisition contracts specifically require collection of data within a certain time period, data collection shall be deferred until conditions are suitable and there shall be no penalties for failure to acquire data because of the lack of suitable conditions. **Unless otherwise specified, the PSLC (in consultation with the LIDAR contractor) shall judge whether conditions are suitable for LIDAR acquisition.**

APPENDIX C. TILING SCHEME

A good tiling scheme has the following attributes: (1) tile boundaries can be computed readily, (2) adjacent tiles can be identified easily, (3) and tile names have meaning to the casual user. Tiles based on the Public Land Survey System meet attribute (3) but fail (1) miserably. Arbitrary tiling schemes (numbering from left to right and top to bottom, river miles, etc.) typically fail (1), often fail (2), and usually fail (3). Square tiles with boundaries at, for example, 1000 m intervals and named by northing and easting values of the SW corner meet (1) and (2) nicely, fail (3), and have the additional defect of being tied to a particular coordinate system—if the dataset is reprojected much of the utility of this naming scheme is lost. We thus specify a tiling scheme based on USGS 7.5-minute quadrangles, as tile boundaries can be computed without additional information, the names of adjacent tiles can be computed (though with difficulty), and tile names have some meaning.

Data shall be delivered in tiles that are rectangular in geographic coordinates, correspond to standard USGS 7.5-minute quadrangles and divisions thereof, and are named according to the scheme

qAAOOORCQ	(quarter-quadrangle, 3.75 minute by 3.75 minute region)
qAAOOORCQNN	(1/100th quadrangle, 0.75 minute by 0.75 minute region)

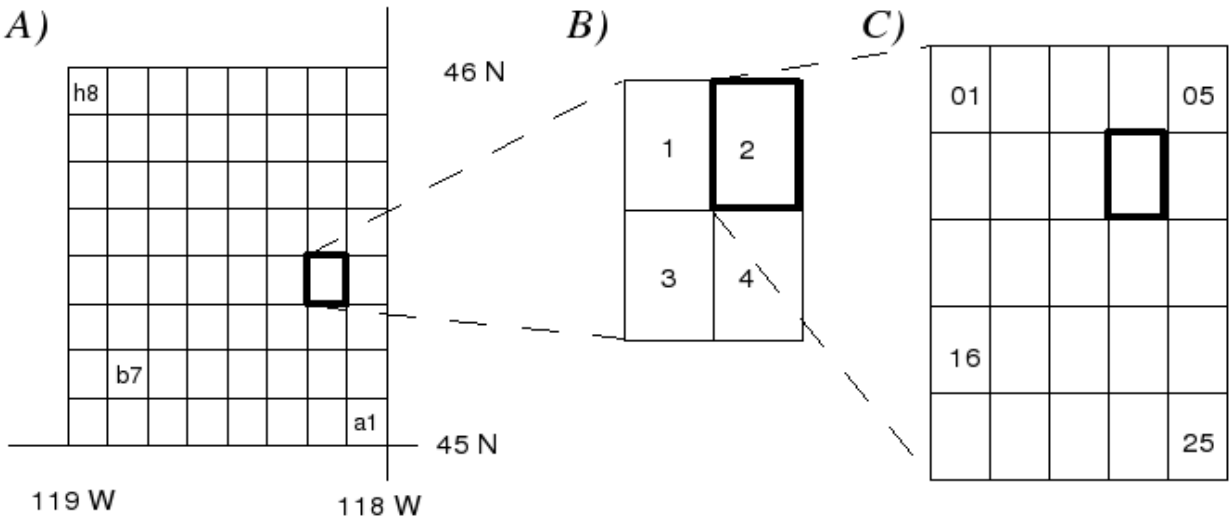
where

AA is the integer north latitude of the SE corner of the 1° x 1° region that contains the quadrangle,

OOO is the integer west longitude of the SE corner of the 1° x 1° region, R is the row, labeled from a to h, south to north, and C is the column, labeled from 1 to 8, east to west. That is, in diagram A below of the 1° x 1° region with a southeast corner at latitude 45N, longitude 118W, the highlighted quadrangle is q45118d2.

Q is the quadrangle quadrant, which shall be numbered west-to-east, north-to-south, as is shown in diagram B. That is, the highlighted quarter-quadrangle tile in diagram B is q45118d22.

QNN identifies the 1/100th quadrangle, which shall be labeled by numbering the 25 divisions of each quarter-quadrangle west-to-east, north-to-south, as shown in diagram C. That is, the highlighted tile in diagram C is q45118d2209.



APPENDIX D. RETURN CLASSIFICATION

We are unaware of any method for cheaply and accurately quantifying the accuracy of LIDAR return classification. In the absence of such a method, we specify that "Classification of returns shall be as complete as is feasible and without avoidable misclassification." We recognize that this specification is weak and look forward to discovery of a method for routinely quantifying the accuracy of return classification.

Definition of "feasible" and "avoidable" may require dialog between the contractor and the PSLC. Dialog may also be necessary to establish the appropriate trade-off between automatic identification of most vegetation returns and failure to identify ground returns at landscape corners.

Returns from burn piles, stumps, downed logs, and almost all buildings shall be classified as vegetation, structure, not-ground, or left unclassified. Returns from highway embankments, retaining walls, bridge abutments, earthen berms, boulders, and plow ridges and furrows shall be classified as ground or left unclassified. Automatic return classification procedures tend to not identify bridges and overpasses as ground and this is encouraged, for the resulting ground models will be more hydrologically correct.

Return classification procedures shall be documented in the Report of Survey and in formal metadata insofar as is possible without revealing trade secrets. Classification codes shall be defined in the Report of Survey and in formal metadata, with careful attention to the distinction between not-ground and unclassified.

APPENDIX E. FILE NAMES

Names of data files shall be composed of the tile name followed, in some cases, by a suffix that denotes the data layer and (or) the file format. In some cases this name shall have additional suffixes that denote an export file and (or) file compression.

For the quarter-quadrangle q45123a31 and constituent 1/100th-quadrangle tile q45123a3101, these are the names of data files:

all-return point cloud

q45123a3101.las	(LAS file)

ground (bare-earth) surface model

q45123a31be	(ESRI grid name)
q45123a31be.e00	(ESRI export file)
q45123a31be.e00.gz	(gzip compressed ESRI export file)
q45123a31be.e00.zip	(zip compressed ESRI export file)

first-return (highest-hit) surface model

q45123a31hh	(ESRI grid name)
q45123a31hh.e00	(ESRI export file)
q45123a31hh.e00.gz	(gzip compressed ESRI export file)
q45123a31hh.e00.zip	(zip compressed ESRI export file)

ground point list

q45123a3101.txt	(ASCII)
q45123a3101.txt.gz	(gzip compressed ASCII file)
q45123a3101.txt.zip	(zip compressed ASCII file)

first-return (highest-hit) intensity image

q45123a31hh.tif	(TIFF image; with accompanying .tfw file)

ground (bare-earth) contours

q45123a31.dxf	(CAD .dxf file)
q45123a31.dxf.gz	(gzip compressed .dxf file)
q45123a31.dxf.zip	(zip compressed .dxf file)
q45123a31.shp	(ESRI shapefile; with accompanying .dbf, .shx files)
q45123a31.shp.zip	(zip compressed ESRI shapefile: includes .shp, .shx, .dbf files)

All deliveries shall use the same format for similar data. The contractor shall not deliver grids on one occasion and equivalent .e00 files on another, or zipped files on one occasion and gzipped files on another.

APPENDIX F. INSTRUCTIONS ON FORMAL METADATA

GIS-compatible data and files shall be explained with XML format metadata that follows the Federal Geographic Data Committee's (FGDC) Content Standard for Digital Geospatial Data. Metadata may be a single file that describes an entire survey or multiple files each of which describes a constituent part (e.g., area A, area B, area C) of the survey. Metadata shall include, but are not limited to, the following:

Color key: To be completed by agency

To be completed by contractor

Under *Identification* Information

Description, Abstract

An abstract summarizing the datasets delivered. Include project area. Include general tiling scheme (e.g., USGS 7.5 quarter quad). For each data layer, describe

Data structure and attributes, including resolution and precision

Total number of files

Time Period

Date(s) of data capture (range of dates)

For these dates, use the Current Reference: ground condition.

Status

Statement regarding completeness Status.

Spatial Domain, Bounding Coordinates and G-Polygon

Project survey area bounding coordinates in decimal degrees

Data Set Credit

Title for the name and address of the contractor who captured the data

Originator for the names of the agencies who contributed funds and participated in the acquisition of the data.

Other Citation Details for explanation of the acquisition: Agencies who participated in the contract (e.g., Kitsap County Department of Emergency Management administered the contract; Puget Sound LIDAR Consortium served as technical resource and provided quality assessment, Oregon Department of Geology and Mineral Industries coordinated the participator requests; and agencies identified under Originator participated.)

Under *Data Quality*

Process Step

Process Description for manufacturer, model, and serial number of LIDAR instrument(s). May include separate specifications for scanning laser rangefinder, inertial navigation system, and GPS unit

Value(s) of instrument parameters during survey, including

Nominal on-ground beam diameter

pulse rate

maximum number of returns recorded

minimum separation between detected returns from a single pulse, expressed as a distance

laser output power

minimum return power required to produce a return

beam wavelength

frequency of GPS sampling

frequency of IMU sampling

Nominal swath width

Nominal height of instrument above ground

Nominal single-swath pulse density

Nominal aggregate pulse density

Identity and assumed coordinates of reference survey monument(s)

Nature of vertical control (e.g., RTK GPS or water surface + tidal observations)

Calibration procedures

Return classification procedures

Positional Accuracy

Vertical Accuracy Report. Accuracy may be specified as RMSE or 95% confidence (indicate which). Vertical accuracy shall be reported for LIDAR measurements and, optionally, for the derived ground (bare-earth) surface model. XY accuracy of LIDAR measurements may also be reported. Shall include one or more of the following sections:

Accuracy as predicted by creator of survey

Accuracy as measured by creator of survey

Accuracy as verified by Consortium or independent 3rd party

Under *Spatial Data Organization Information*

Indirect Spatial Reference

Tiling scheme (if any). (e.g. ASCII data is divided into 1/100th USGS 7.5" quad)

Under *Spatial Reference Information*

Horizontal Coordinate System Definition:

Geographic Coordinate System for the captured data

Projected Coordinate System for the delivered data

Horizontal Datum for the delivered data

Ellipsoid Name (identify both the ellipsoid and the geoid model used to translate from ellipsoid to orthometric heights)

Vertical Coordinate System Definition

Datum Name

Vertical units

Under *Entity and Attribute Information*

Overview Description, Entity and Attribute Overview

Attribute descriptions if applicable (e.g. return point attributes in ASCII data or user bit field in LAS format). For all-return data, definition of return classification codes. Whether time is specified as GPS week and GPS second or Posix time. Any other relevant attribute information.

Under *Distribution Information*

Distributor

Distribution point of contact

Standard Order Process

Ordering Instructions - web location, if applicable

Fees – "There are no fees. This product is in the public domain."

Distribution Liability

Absence of intellectual property restrictions

Under *Metadata Reference Information*

Metadata Contact

Details for author(s) of metadata

Metadata Standard Name

"FGDC Content Standards for Digital Geospatial Metadata"

Metadata Standard Version

"FGDC-STD-001-1998" unless updated or otherwise substituted