



UT-Battelle, LLC
 Acting under contract DE-AC05-00OR22725
 With the U.S. Department of Energy
 Internet: <https://web.ornl.gov/adm/contracts/index.shtml>

DRAFT
Basic Ordering Agreement

Section A - Agreement Form

1. Agreement Number:	2. Solicitation Number: 6400016227	3. Type of Agreement : Basic Ordering Agreement
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4a. Subcontract Administrator:
 W. R. Besancenez

4b. Email Address: BESANCENEZWR@ORNL.GOV	4c. Telephone: 865-576-1538	4d. Fax: 865-241-4082
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5. Issued By: UT-Battelle, LLC c/o Oak Ridge National Laboratory P.O. BOX 2008, BLDG. 5700 OAK RIDGE, TN 37831-6024	6. Submit Invoices To: UT-Battelle, LLC - Accounts Payable Email pdf file to ornlap@ornl.gov or Fax to 865-241-1080
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7. Name and Address of Seller	8. Ship To: UT Battelle, LLC for the Dept. of Energy c/o Oak Ridge National Laboratory 1 Bethel Valley Road, Bldg 7120 Oak Ridge TN 37830 Show subcontract number on all packages, B/L, and, if required, invoices.
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	E	Inspection and Acceptance			

10. Brief Description of Supplies or Services being acquired: GCC Accelerator Support

11. Ceiling amount of Agreement:

12. Seller's Agreement. Seller agrees to furnish and deliver the items or perform services to the extent stated in this document for the consideration stated in any resulting task orders. The rights and obligations of the parties to this agreement and any resultant task orders shall be subject to and governed by this document , task orders, and any document attached or incorporated by reference.	13. Award. UT-Battelle, LLC (Company) agrees to award this agreement to the Seller. The rights and obligations of the parties to this agreement are subject to and governed by this document, task orders, and any documents attached or incorporated by reference.
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() Seller is required to sign and return a copy of this document. (Checked if applicable)	UT-Battelle, LLC
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A. Signature of person authorized to sign for Seller DRAFT - DRAFT	A. Signature of person authorized to sign DRAFT - DRAFT
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B. Name of signer	B. Name of signer
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C: Title of signer	C. Title of signer
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D. Date	D. Date
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Section B - Supplies or Services and Prices/Costs

B.1 Description

- a. This Basic Ordering Agreement (BOA) is issued to simplify and expedite the purchase of the items or services specified in Section C - "Specifications/Statement of Work".
- b. The Seller agrees to provide such quantities of the items or services as specified in SECTION C - "Specifications/Statement of Work", as the Company may order in accordance with the provisions of this agreement.
- c. The total value of all task orders issued under this agreement shall not exceed \$_____ (To Be Determined (TBD)).
- d. Work to be performed under this agreement will be more specifically defined in written task orders issued by the Company to the Seller. Task orders will be fixed-price and may be fully or incrementally funded. All task orders will include:
 1. A technical description of the work.
 2. The BOA number and the task order number.
 3. The fixed price of the task order.
 4. The period of performance for the task order.
 5. The fixed-price terms and conditions.
 6. Clauses applicable to task order.
 7. Other pertinent information.
- e. No funds are being obligated under this Agreement. The Company is not obligated to release any funds or issue any task orders under this Agreement.

B.2 Ordering Procedures

- a. The Company may begin the task order process by issuing a solicitation to the Seller, describing the service to be ordered, setting forth a performance schedule, and identifying clauses that will be applicable to the task order.
- b. The solicitation will indicate the date the task order proposal is due. Seller's proposal shall contain the information and be in the format required by the solicitation. Pices shall be proposed using the hourly rates specified in "Pricing Information" in Section B. Task orders will be issued on the Company's task order form.
- c. Task order solicitations will be issued at the Company's discretion on a competitive or non-competitive basis. Seller's performance of previous task orders may be considered when making this determination.

B.3 Pricing Information



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Section B - Supplies or Services and Prices/Costs, continued

B.3.1 Task Pricing

<u>Item</u>	<u>Description</u>	<u>Qty</u>	<u>Unit</u>	<u>Delivery</u> <u>By</u>	<u>Total</u> <u>Price</u>
No.					
1	Task 1 as described in the SOW	1	Lot	_____	\$ _____
2	Task 2 as described in the SOW.	1	Lot	_____	\$ _____
3	Task 3 as described in the SOW	1	Lot	_____	\$ _____
4	Task 4 as described in the SOW	1	Lot	_____	\$ _____
5	Task 5 as described in the SOW	1	Lot	_____	\$ _____
6	Task 6 as described in the SOW	1	Lot	_____	\$ _____
7	Task 7 as described in the SOW	1	Lot	_____	\$ _____
8	Task 8 as described in the SOW	1	Lot	_____	\$ _____
9	Task 9 as described in the SOW	1	Lot	_____	\$ Do Not Price
10	Task 10 as described in the SOW.	1	Lot	_____	\$ _____

B.3.2 Fully Burdened Hourly Rates



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Section B - Supplies or Services and Prices/Costs, continued

Description

Rate

(List to be included here in the award documents.)

B.4 Incremental Funding

The following may be applied to Task Orders

This Agreement/Task Order is incrementally funded. The clause, Limitation of Company's Obligation (July 2006), is incorporated by reference and amended as follows: The first sentence of paragraph (a) is revised to read, "Of the total price or, as applicable, the ceiling price of the Agreement, \$_____ (TBD) is currently allotted and available for payment." The first sentence of paragraph (c) (1) is revised to read, "Funds currently allotted are expected to cover the work to be performed until _____ (TBD) ."

Section C - Specifications/Statement of Work

C.1 Statement of Work

The Seller shall furnish the items or services specified in this Section:

STATEMENT OF WORK
GCC Accelerator Support
17 July 2019

1. SCOPE

1.1. Introduction

The Oak Ridge Leadership Computing Facility (OLCF) at Oak Ridge National Laboratory fields some of the most powerful supercomputers in the world in support of the U.S. Department of Energy's scientific mission. The prior, current, and next-generation supercomputers (Titan, Summit, and Frontier) all utilize GPU accelerators to deliver this computational capability within an affordable power envelope.

The OLCF has strongly supported and promoted directive-based approaches for GPU programming in order to facilitate the portability of user code between systems with and without such accelerators, specifically, the OpenACC and OpenMP languages, which are layered on C, C++, and Fortran. The OLCF also finds it useful to offer multiple implementations (compilers) for each of the languages it makes available.

The GNU Compiler Collection (GCC) is an open source compiler suite that supports C, C++, and Fortran, as well as a number of other programming languages. It is widely used by OLCF users, on both OLCF and non-OLCF platforms. GCC currently includes some support for OpenACC and OpenMP, but there are capability and performance gaps, particularly on the GPU-accelerated platforms of interest to the OLCF (NVIDIA and AMD GPUs), that prevent it from being a viable tool for users needing those languages.

The primary purpose of this Statement of Work (SOW) is to bring the implementations of OpenACC and OpenMP in the GCC compiler suite up to the latest versions of the standards, and supporting the GPU-accelerators of interest to OLCF so that it becomes fully capable with respect to the needs of OLCF users on OLCF and other platforms. Secondly, there are some features from the most recent Fortran standard that we would like to be implemented in GCC, and we anticipate the need for maintenance and support of GCC (not limited to the new work described above) in terms of responding to bug reports and performance issues based on the guidance of designated Company staff.

The expectation is that this work will be completed as quickly as reasonably possible, but definitely prior to April 2022, in anticipation of the upcoming delivery of the new Frontier system. During or after the successful completion of the tasks in this SOW, additional tasks may be developed that may include but not limited to interoperability with other OpenMP runtimes for device code, Fortran co-arrays, etc., specific maintenance support not currently described and, and further enhancements as the relevant language standards are updated.

1.2. Work Description

Section C - Specifications/Statement of Work, continued

The following tasks are listed in expected order of performance, except for Task 10, which will be active through the life of the subcontract. If priorities change, the order in which these tasks are executed may change.

1. The OpenACC implementation in GCC will be updated to the current version of the standard (2.7), supporting NVIDIA GPU targets.
2. The OpenACC implementation will be extended to support the treatment of a multicore CPU as an offloadable device.
3. The OpenACC implementation will be extended to support managed memory, pinned memory, and unified memory on NVIDIA CUDA devices via the addition of compiler options and appropriate use of the CUDA APIs.
4. The current implementation of the OpenACC kernel pragma does not provide good performance. This implementation needs to be improved, with the goal of providing performance similar to that obtained with comparable "parallel regions".
5. The OpenMP implementation in GCC will be updated to support version 4.5 of the standard, with an emphasis on the target offload capabilities, supporting NVIDIA GPU targets.
6. The Fortran implementation in GCC will be updated to support TS 29113: Further Interoperability of Fortran with C, which is part of the Fortran 2018 standard.
7. The OpenMP implementation will be extended to support the current version of the standard (5.0) for NVIDIA devices. Note that the staging of OpenMP development (version 4.5 support, then version 5.0) is intended to facilitate providing the majority of desired capabilities (defined in 4.5) sooner. It is acceptable to merge Task 5 and Task 7 as long as it will not significantly delay delivery.
8. The OpenACC and OpenMP implementations will be extended to support AMD GPU targets.
9. The OpenMP implementation will be extended to support version 5.1 of the standard after it is published (expected in November 2020) for both NVIDIA and AMD targets.
10. General support and maintenance will be provided for GCC (bug fixes, performance improvements, etc.) at the direction of the TPO. At a minimum, support and maintenance will be provided 8 hours per day, 5 days per week excluding holidays. These activities are expected to be primarily in the newly implemented capabilities but may be in any portion of the GCC suite. For example, a bug in a Fortran feature not part of this SOW may adversely impact OLCF users, making it a requirement that it be addressed promptly under this Task.

2. APPLICABLE CODES, PROCEDURES, AND REFERENCES

Information about the Oak Ridge Leadership Computing Facility (OLCF) and the Titan, Summit, and Frontier systems can be found at <https://www.olcf.ornl.gov/>

Section C - Specifications/Statement of Work, continued

Information about the GNU Compiler Collection (GCC) can be found at <https://gcc.gnu.org/>

Information and the current specification for OpenACC can be found at <https://www.openacc.org/>

Information and specifications for OpenMP can be found at <https://www.openmp.org/>

References to "Fortran 2018" means the ISO standard Fortran 2018 (ISO/IEC 1539-1:2018) / November 28, 2018.

The SPEC ACCEL benchmarks (version 1.2 and later) will be used to help evaluate the performance and correctness of the OpenACC and OpenMP implementations:
<https://www.spec.org/hpg/index.html#accel>.

The SPEC HPC2020 benchmarks (to be released in November 2019) will be used to help evaluate the performance and correctness of the OpenACC and OpenMP implementations:
<https://www.spec.org/hpg/search/>.

The SOLLVE V&V Suite (under development) will be used to help evaluate the correctness of the OpenMP implementation: https://bitbucket.org/crpl_cisc/sollve_vv.

The OpenACC V&V Suite (under development) will be used to help evaluate the correctness of the OpenACC implementation: <https://github.com/OpenACCUserGroup/OpenACCV-V>

3. TECHNICAL AND FUNCTIONAL REQUIREMENTS

The SOLLVE V&V toolkit and benchmarks from the SPEC High-Performance Group will be used to help assess the capabilities developed under this subcontract. However, these and other codes of interest to OLCF (including user codes) are generally under continual development, and there is no single code base that represents a definitive test of the capabilities in this SOW.

Performance of the generated executables will be comparable to that obtained with other compilers on the same hardware. Where appropriate, LLVM will be the primary target. Where LLVM does not offer the capabilities to be evaluated, other suitable compilers will be identified by mutual agreement.

Decisions as to acceptance of the deliverables are ultimately the sole responsibility of the Company's Technical Project Officer (TPO).

4. RESPONSIBILITIES

Company will work with Seller to facilitate the establishment of any required non-disclosure agreements required to support forthcoming NVIDIA and AMD devices (GPUs, CPUs, etc.).

Section C - Specifications/Statement of Work, continued

Company will work with Seller to obtain any additional computer hardware that may be required by Seller to support development and testing under this SOW. Seller shall obtain hardware from appropriate vendors by way of loan or purchase. Company's preference is that Seller pursue loaned hardware. Where a loan is not feasible, Company's TPO will approve the Seller's purchase in writing before the purchase occurs. Company may also pursue such a loan or agree to purchase the hardware directly from the vendor. Computer hardware purchased under this subcontract will be property of the Company and shall be returned to the Company upon completion of the subcontract.

Seller and Company staff will hold regular teleconferences to discuss the status of the project. The Company holds at least two (2) programmatic meetings yearly. At least one member of the Seller's senior staff that can discuss the work shall plan on supporting Company's yearly programmatic meetings. Travel will be required.

Company will work with Seller to identify and obtain codes suitable for evaluating the performance and correctness of work under this subcontract. This will include test suites, benchmarks, and user codes. Access to some codes (particularly SPEC HPG benchmarks) may require the purchase of a license or organizational membership.

5. DELIVERABLES/SUBMITTALS

Deliverables will be in the form of changes and additions to the GCC compiler suite, including appropriate documentation, made available under the GNU General Public License open source license used by GCC. Deliverables are to be timely upstreamed to the maximum extent possible. Until deliverables are accepted upstream, and for any changes that are refused upstream, Seller will maintain a public repository and/or download site which makes available the complete version of the GCC suite including all contributions under this SOW integrated with the most recent release version of GCC in order to make the results of the work available to the OLCF and other interested parties.

We are interested in obtaining the capabilities in the SOW quickly. The delivery schedule is as follows:

Task No.	Brief Task Description	Delivery Target (from Award Date)
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- | | | |
|---|--------------------------------------|------------|
| 1 | OpenACC 2.7 for NVIDIA | +6 months |
| 2 | OpenACC multicore offload | +6 months |
| 3 | OpenACC memory management for NVIDIA | +6 months |
| 4 | OpenACC kernel improvements | +6 months |
| 5 | OpenMP 4.5 for NVIDIA | +6 months |
| 6 | Fortran TS 29113 support | +12 months |



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Section C - Specifications/Statement of Work, continued

- 7 OpenMP 5.0 for NVIDIA +18 months
- 8 OpenACC and OpenMP add AMD support +24 months
- 9 OpenMP 5.1 for AMD and then NVIDIA +12 months after release of standard in November 2020
- 10 General maintenance and support Continuous



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Section F - Performance Period and Payment Information

F.1. Performance Period.

a. The period of performance under the Agreement shall begin on 11/04/2019 and end on _____.

b. Seller agrees to accept task orders issued during the performance period. Seller shall complete work on task orders issued before the performance end date even though the task order performance period extends beyond that date. The rights and obligations of the parties respecting those orders shall be governed by this BOA to the same extent as if completed during its term.

F.2. Payment Terms. The terms of payment shall be Net 30.

F.3. Electronic Funds Transfer (EFT). Electronic Funds Transfer (EFT) expedites payments to subcontractors and is our preferred method of payment. A remittance notification (email or fax) is automatically generated to you at the time of payment. To sign up for EFT, revise your banking information, or contact us to verify your current payment information, visit <https://web.ornl.gov/adm/contracts/eft.shtml>.

F.4. Vendor Account Status System. For detailed payment information or inquiries concerning invoices and payments, visit the UT-Battelle, LLC Accounts Payable Vendor Account Status System(VASS) at <https://web.ornl.gov/adm/ap/> or telephone (865)241-4151.

F.5. Offeror's Fiscal Year End Month. Enter the ending month of your fiscal year: _____

F.1 The following clauses will apply to Task Orders issued under this Basic Ordering Agreement. Each Task Order will aspecify the terms that will apply.

Invoicing (Fixed Price)

The Seller shall submit a proper invoice for payment in accordance with the negotiated terms to the address shown in the block titled "Send Invoices To" on the first page of this document. Each invoice shall reflect milestones or services complete and billable under the Agreement. All payments will be made in U.S. Dollars.



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Section G - General Provisions

NOTE: Standard government forms (SF) mentioned herein are available at <http://www.gsa.gov/forms>. Other forms, clauses, articles, and documents are available at our web site, <https://web.ornl.gov/adm/contracts/documents.shtml>.

NOTICE:

This contractor and subcontractor shall abide by the requirements of 41 CFR 60-1.4(a) [41 CFR 60-1.4(b) for Construction], 60-300.5(a) and 60-741.5(a). These regulations prohibit discrimination against qualified individuals based on their status as protected veterans or individuals with disabilities, and prohibit discrimination against all individuals based on their race, color, religion, sex, sexual orientation, gender identity, or national origin. Moreover, these regulations require that covered prime contractors and subcontractors take affirmative action to employ and advance in employment individuals without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, protected veteran status or disability.

To the extent applicable, the employee notice requirements set forth in 29 CFR Part 471, Appendix A to Subpart A, are hereby incorporated by reference into this agreement.

The Representations and Certifications submitted by the Seller as part of its offer will be incorporated by reference into this Basic Ordering Agreement and any task order issued hereunder.

All articles and documents incorporated by reference, including those made a part of General Provisions, apply as if they were set forth in their entirety.

Order of Precedence. Any inconsistency between the Basic Ordering Agreement and any task order shall be resolved by giving precedence to the task order.

The following General Terms and Conditions will apply to task orders issued under this Basic Ordering Agreement. Each task order will specify which terms will apply.

The following General Terms and Conditions will apply to any resulting Task Order. Each task order will specify which terms will apply.

General Terms and Conditions - Commercial Items (CI September 27, 2018)

Section H - Special Provisions

NOTE: Standard government forms (SF) mentioned herein are available at <http://www.gsa.gov/forms>. Other forms, clauses, articles, and documents are available at our web site, <https://web.ornl.gov/adm/contracts/documents.shtml>.

All articles and documents incorporated by reference, including those made a part of Special Provisions, apply as if they were set forth in their entirety.

H.1 BOA Clauses Incorporated by Reference.

These clauses will be incorporated, as appropriate, in Task Orders issued under this BOA:

Exhibit 1B, Patent Rights-Acquisition By The Government
(Feb 2009)

Exhibit 1C, Patent Rights -- Retention By The Seller (Short Form) (Mar 2001)

Exhibit 4, Authorization and Consent (Dec 2005)

Exhibit 5, Patent Indemnity (4/84)

Exhibit 9, Technical Data (Jun 2011)

Milestone Payment Clause (May 2010)

H.2 BOA Program Manager

The Program Manager for this BOA is _____ (TBD). The responsibilities of the Program Manager include ensuring task orders are within the scope of the BOA's general SOW and monitoring use of the BOA so that the cumulative sum of all task orders stays within the ceiling limits of the BOA.

H.3 Key Personnel - BOA

(a) The following personnel are considered to be essential to the work being performed in this BOA:

[List]

(b) The Seller must notify the Company before diverting any listed person(s) to another program, providing justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on the program. No diversion shall be made without the consent of the Company; provided, that the Company may ratify a diversion in writing and the ratification shall constitute consent. The list of key personnel may be revised by mutual agreement during the period of this Agreement.

H.4 Key Personnel - Task Orders

Personnel considered to be essential to the performance of a task order may be named as Key Personnel in that task order. This preceding clause shall apply to those Key Personnel during performance of the task order.

H.5 Technical Direction

The clause, "Technical Direction (Jan 2006)", is incorporated by reference. Any resulting



Section H - Special Provisions

task order may also have a TPO who will be identified in the task order. If so identified, this clause will apply to the performance of the task order.

In addition to the provisions of the clause referenced herein, the task order TPO shall be responsible for providing a Statement of Work specific to the task order, approving task order proposals, committing funding, reviewing deliverables, and approving payment for work accomplished by Seller.



Section J - Representations and Instructions

J.1. Representations and Certifications. If response exceeds \$10,000, you must return a completed Representations and Certifications form (available at <https://web.ornl.gov/adm/contracts/documents.shtml>).

J.2. General Solicitation Instructions. Responses are subject to the provisions of the General Solicitation Instructions form (available at <https://web.ornl.gov/adm/contracts/documents.shtml>).

J.3. Sales Tax. DO NOT INCLUDE SALES OR USE TAX IN QUOTED PRICES. See Blanket Certificate of Resale at <https://web.ornl.gov/adm/contracts/documents.shtml>.