

INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1810-TRP, "Development of Reference Building Information Model (BIM) Test Cases for Improving Usage of Software Interoperability Schemas"

Attached is a Request-for-Proposal (RFP) for a project dealing with a subject in which you, or your institution have expressed interest. Should you decide not to submit a proposal, please circulate it to any colleague who might have interest in this subject.

Sponsoring Committee: TC 1.5 Computer Applications

Budget Range: \$135,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1, 2019** or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, December 17, 2018. NO EXCEPTIONS, NO EXTENSIONS. Electronic copies must be sent to rpbids@ashrae.org. Electronic signatures must be scanned and added to the file before submitting. The submission title line should read: 1810-TRP, "Development of Reference Building Information Model (BIM) Test Cases for Improving Usage of Software Interoperability Schemas, and "*Bidding Institutions Name*" (electronic pdf format, ASHRAE's server will accept up to 10MB)

If you have questions concerning the Project, we suggest you contact one of the individuals listed below:

For Technical Matters

Technical Contact
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For Administrative or Procedural Matters:

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Contractors intending to submit a proposal should so notify, by mail or e-mail, the Manager of Research and Technical Services, (MORTS) by December 3, 2018 in order that any late or additional information on the RFP may be furnished to them prior to the bid due date.

All proposals must be submitted electronically. Electronic submissions require a PDF file containing the complete proposal preceded by signed copies of the two forms listed below in the order listed below. **ALL electronic proposals are to be sent to rpbids@ashrae.org.**

All other correspondence must be sent to ddaniel@ashrae.org and mvaughn@ashrae.org. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EST, December 17, 2018. NO EXCEPTIONS, NO EXTENSIONS.**

The following forms (Application for Grant of Funds and the Additional Information form have been combined) must accompany the proposal:

- (1) ASHRAE Application for Grant of Funds (electronic signature required) and
- (2) Additional Information for Contractors (electronic signature required) ASHRAE Application for Grant of Funds (signed) and

ASHRAE reserves the right to reject any or all bids.

State of the Art (Background)

The non-profit gbXML.org (a non-profit) houses the free Green Building XML (gbXML) schema that is an openly published structured data framework (known as an 'open schema') that helps facilitate the transfer of building properties stored in 3D Building Information Models (BIM) such as Autodesk, Bentley Systems, and Graphisoft to engineering analysis tools such as OpenStudio and eQuest. Use of gbXML dramatically streamlines the transfer of building information to and from BIM and engineering analysis tools, eliminating the need for time consuming plan take-offs and re-entry of the same data more than once. Building analysis software tools that integrate with gbXML perform yearly building energy analysis, peak HVAC load calculations, lighting analysis, airflow analysis, computational fluid dynamics, and much more (see <http://www.gbxml.org>). gbXML is modestly funded from a variety of sources including the U.S. Department of Energy (on a project-basis), Autodesk, Bentley Systems, and other organizations.

The current state-of-the-art is fair at best. While gbXML has been around for 18 years and is integrated into all major BIM and building performance software tools, end-users still complain of faulty interoperability. For example, geometric information from one BIM authoring tool is not properly represented in a popular HVAC load calculation software tool. While users can always manually edit and tweak data in an XML file (fortunately, it is clear text), the ideal interoperable work-flow should not include any type of human intervention. In fact, the ideal work-flow includes “saving as gbXML” from the BIM authoring tool, and then importing into the building analysis tool without any errors, complications, nor human intervention.

Geometry benchmark tests (or gbXML test cases) help to ensure that, as building geometry produced by building designers becomes more complex, the geometry produced for energy and heating and cooling loads analysis maintains the integrity of information that is required for a proper analysis. gbXML.org maintains a small battery of benchmark tests for vendors and other interested parties to ensure compliance with gbXML.org's standards for geometry accuracy and completeness. These tests are prescriptive and serve as marks of excellence that identify the ability of a technology to translate geometry properly from its native format to gbXML.

BIM authoring and energy analysis tools, such as National Renewable Energy Lab's (NREL) open source tool, OpenStudio, rely on high quality interoperability with third party software through gbXML. NREL recently funded development of a validation procedure for tools which author gbXML. In this validation procedure, a series of 9 known test models were developed using the software tool and then exported to gbXML. These exported models were then compared to known truth standards. If the software passed all of the validation tests then it could be certified as producing correct gbXML. Currently, the basic validation procedure is established and an initial validation website is available. However, only one tool (OpenStudio) has passed the validation procedure. Increased adoption of the gbXML validation procedure by software vendors will improve the quality of gbXML produced by these tools and will increase user's ability to transfer data between BIM tools and analysis tools such as OpenStudio for energy analysis. Only 9 test cases have been developed so far (based upon ASHRAE RP-1468), and they focus solely on building geometry. There are many additional geometric test cases that could be developed.

Building Information Modeling (BIM) is currently attracting substantially increasing attention, with well-attended technical sessions at ASHRAE meetings illustrating the promise of BIM and advocating the benefits of employing BIM-enabled work processes in professional practice. However, many ASHRAE members are still unsure of how to adopt BIM processes into their daily practice to achieve the claimed benefits. There are a number of hurdles to BIM that are being addressed in other research projects or proposals. The hurdle being addressed in this research project relates to the struggles of disparate building software tools communicating with one another.

Several efforts are underway within ASHRAE to address the issue of standard data representation (information exchange standards). SPC-205 *Standard Representation of Performance Simulation Data for HVAC&R and Other Facility Equipment* is developing data representation standards for equipment performance for use in energy simulation tools. The recently completed ASHRAE-supported research project 1609-RP *Defining the Capabilities, Needs and Current Limitations of Building Information Modeling (BIM) in Operations and Maintenance for HVAC&R* developed information exchange standards for representing asset management information, and a procedure for capturing this information during design and construction/installation for use during operations and maintenance (O&M), based on existing ASHRAE standards, guidelines, and technical publications. ASHRAE WS-1801, *Populating and Utilizing ASHRAE Online BIM Data Content*, has been accepted and will soon begin as a

research project. In addition, the new ASHRAE SPC-224P is commencing at the ASHRAE Chicago 2018 meeting which will focus on developing a new BIM standard: “Minimum Requirements for the Application of Building Information Modeling (BIM) for the Planning, Design, Construction and Operation of Buildings.”

Justification and Value to ASHRAE

ASHRAE members and the Society as a whole have expressed increasing interest in adopting Building Information Modeling (BIM) to improve professional work processes and the overall performance of the built environment. Several ASHRAE technical activities (e.g., SGPC-20, MTG-BIM), research projects (e.g., 1354-RP, 1468-RP, 1609-RP), and a standards committee (SPC-205, SPC-224P) have been working to develop relevant and useable information exchange standards, which define standard data representations for key information required to perform HVAC&R work processes.

This research project will promote the usage of BIM-enabled work processes as it will make it easier for practitioners to take advantage of software tools such as building energy analysis software that communicate with BIM-authoring tools.

In addition to facilitating the adoption of BIM by ASHRAE members, the test cases, sample gbXML files, and BIM authoring files that are hosted on data.ashrae.org will raise the visibility and perceived value of BIM-enabled interoperability within ASHRAE and promote its continuing development within other technical activities of the Society.

The new ASHRAE Building EQ web portal (<https://buildingeq.ashrae.org>) imports building information from a gbXML file. Software vendors who produce valid gbXML based upon the test cases created in the research project would subsequently be able to produce a gbXML file format that could be imported into the Building EQ portal.

This would aid in adoption of the portal since building data would not have to be manually entered. Also, the availability of BIM data based on existing ASHRAE publications such as standards, guidelines, and technical publications would increase reference to, and adoption of, these ASHRAE publications.

Objectives

The overall objectives of this research project are: 1) to develop 20+ gbXML test case documents that software vendors can follow to develop their own gbXML files that will then be uploaded to a web-based validator that will provide feedback on the validity of the files.; 2) Develop 20+ corresponding gbXML files, 1 for each test case, that provide templates for software vendors to base their outputs upon; 3) Further develop an existing web-based validator software tool that will validate the 20+ test cases; 4) Upload all deliverables including software vendor output files to data.ashrae.org. This is all in the name of improving the interoperability experience between BIM authoring tools and building analysis software tools.

Scope:

The following tasks describe in more detail the expected approach to achieve the desired project objectives.

Task 1: Identify 30+ candidate gbXML test cases

Interview energy modeling practitioners, BIM and building analysis software designers and other related professionals so as to best determine which current BIM to BEM work-flows are not ideal. Based upon this feedback, the contractor will be able to determine potential test cases that best address the needs of practitioners. Using the ASHRAE 1468-RP use case documentation, 30 or more candidate test cases related to building geometry, HVAC systems (hydronic and air), energy use schedules, occupancy and plug load schedules will be drafted. The test cases in the research project will not focus on any type of BIM automation such as auto-zoning. That would be far beyond the scope of this project.

This task will also involve determining how many test cases are appropriate for the requested funding. The “20+” final test cases mentioned throughout this work statement may indeed be way too many for the budget. On the other hand, it may be possible to complete all 30+ candidate test cases for the funding amount. This task will determine the optimum number.

Interim Deliverables: A list of the 30+ candidate test cases will be provided along with descriptions
PMS Review Points: Review each of the 30+ candidate test cases.

Task 2: Identify related test case documentation work

Identify other relevant test case documentation work for other related schemas such as ASHRAE Standards/Guidelines/Publications, COBie Guide, buildingSmart's IFCs, NREL's BuildingSync, and more. This will help to justify the selection of the 20+ test cases to be selected in the next task.

Interim Deliverables: Draft Reference List

PMS Review Points: Review Reference List for possible revisions prior to subsequent tasks.

Task 3: Select the final 20+ test cases, create 20+ test case documents along with sample Green Building XML (gbXML) files that accompany them

Determine which of the 30+ candidate test cases determined in Task #1 are most relevant and useful. Most likely this list will be condensed to about 20+ final test cases. Next, this task entails creating a document for each test case and a corresponding sample gbXML file. Using the documentation developed in this task, the BIM software vendor should be able to recreate a gbXML file based upon the test case document that resembles the sample gbXML file developed in this task. The expected content in the gbXML test file would include the required envelope or device names, exact dimensions, required ids, and any other pertinent information.

Post the documentation and gbXML files on data.ashrae.org and invite public review both within and outside ASHRAE. Within ASHRAE, begin with the sponsoring committees of this project and expand to committees with interest in BIM interoperability. Outside ASHRAE include contacts within relevant software organizations. This task should start to raise visibility of this effort.

Interim Deliverables: Select the final 20+ test cases, write up documentation for each, and created Green Building XML files that correspond to them; Draft a report and describe the documentation and gbXML files

PMS Review Points: Review the documentation and gbXML files and make sure they correspond to the test case documents.

Task 4: Update the existing web-based validation software

A basic gbXML web validator already exists (<http://gbxml.org/validator/Pages/TestPage.aspx>). However, it is limited to prior test cases that were developed under a previous contract. This task involves updating and developing the web-based validator in the following ways:

1. Adding the new validation logic for the 20+ new test cases
2. Incorporating an open-source geometry viewer that allows the users to visualize a conceptual view of the building or element that is located in the gbXML file.
3. Improving the reporting functionality
4. Allowing users to create accounts and store their projects for future use.
5. Creating a basic model checker that validates information not covered by the test cases (if budget allows)

Interim Deliverables: Source code for the web-based validation; hosted on sample accessible server for testing and demo purposes.

PM Review Points: Make sure web-based validator is successfully testing test case gbXML files, displaying a conceptual view of the gbXML geometry, and performing basic model checking (if budget allows)

Task 5: Create end-user documentation

Create end-user documentation that provides an overview of how to successfully use the test cases. This documentation must be detailed enough to allow experienced industry software users to understand how to create test cases utilizing the software that they develop.

Interim Deliverable: Draft end-use documentation

PMS Review Points: Review draft end-use documentation

Task 6: Create data repository on data.ashrae.org for gbXML test case and gbXML files

This task involves uploading all of the test case documentation, gbXML files, vendor gbXML files, and the validator source code files.

Interim Deliverable: Upload all files to data.ashrae.org

PMS Review Points: Make sure all deliverables are uploaded

Deliverables:

Progress and Financial, Final Task and Summary Reports, Technical Paper(s), and Data shall constitute the deliverables (“Deliverables”) under this Agreement and shall be provided as follows:

a. Progress and Financial Reports

Progress and Financial Reports, in a form approved by the Society, shall be made to the Society through its Manager of Research and Technical Services at quarterly intervals; specifically on or before each January 1, April 1, June 10, and October 1 of the contract period.

Furthermore, the Contractor’s Principal Investigator, subject to the Society’s approval, shall, during the period of performance and after the Final Report has been submitted, report in person to the sponsoring Technical Committee/Task Group (TC/TG) at the annual summer and winter meetings and be available to answer such questions regarding the research as may arise.

b. Final Task Reports and Data Sets

Draft interim reports shall be delivered following the completion of individual tasks as agreed upon between the Contractor and the Project Monitoring Subcommittee (PMS). Each interim report should include a list of any challenges identified that could impact on-time delivery of the research. It is recommended that the drafts be developed and formatted so that they lead to the Task Final Reports listed below. The drafts are intended to increase the transparency between the contractor and project monitoring subcommittee, not to add cost to the project.

Final Task Deliverables

- Written documentation for each of the 20+ test cases (Task 3)
- Sample gbXML files for each of the 20+ test cases (Task 3)
- Source code for the open-source gbXML validator (Task 4)
- End-Use Implementation Guide (Task 5)

c. Final Report

A written final summary report, in a form approved by the Society, shall be prepared by the Institution and submitted to the Society’s Manager of Research and Technical Services by the end of the Agreement term, containing details of all research carried out under this Agreement, including a summary of the individual task deliverables. Unless otherwise specified, the final draft report shall be furnished electronically for review by the Society’s Project Monitoring Subcommittee (PMS)

Tabulated values for all measurements shall be provided as an appendix to the final report (for measurements which are adjusted by correction factors, also tabulate the corrected results and clearly show the method used for correction).

Following approval by the PMS and the TC/TG, in their sole discretion, final copies of the Final Report will be furnished by the Institution as follows:

- An executive summary in a form suitable for wide distribution to the industry and to the public.
- Two electronic copies; one in PDF format and one in Microsoft Word.

d. *Science & Technology for the Built Environment* or ASHRAE Transactions Technical Papers

One or more papers shall be submitted first to the ASHRAE Manager of Research and Technical Services (MORTS) and then to the “ASHRAE Manuscript Central” website-based manuscript review system in a form and containing such information as designated by the Society suitable for publication. Papers specified as deliverables should be submitted as either Research Papers for HVAC&R Research or Technical Paper(s) for ASHRAE Transactions. Research papers contain generalized results of long-term archival value, whereas technical papers are appropriate for applied research of shorter-term value, ASHRAE Conference papers are not acceptable as deliverables from ASHRAE research projects. The paper(s) shall conform to the instructions posted in “Manuscript Central” for an ASHRAE Transactions Technical or HVAC&R Research papers. The paper title shall contain the research project number (1810-RP) at the end of the title in parentheses, e.g., (1810-RP).

All papers or articles prepared in connection with an ASHRAE research project, which are being submitted for inclusion in any ASHRAE publication, shall be submitted through the Manager of Research and Technical Services first and not to the publication's editor or Program Committee.

e. Data

Data is defined in General Condition VI, “DATA”

f. Project Synopsis

A written synopsis totaling approximately 100 words in length and written for a broad technical audience, which documents 1. Main findings of research project, 2. Why findings are significant, and 3. How the findings benefit ASHRAE membership and/or society in general shall be submitted to the Manager of Research and Technical Services by the end of the Agreement term for publication in ASHRAE Insights

The Society may request the Institution submit a technical article suitable for publication in the Society’s ASHRAE JOURNAL. This is considered a voluntary submission and not a Deliverable. Technical articles shall be prepared using dual units; e.g., rational inch-pound with equivalent SI units shown parenthetically. SI usage shall be in accordance with IEEE/ASTM Standard SI-10.

Level of Effort

The project is estimated to take no more than 20 months to complete, with a level of effort of approximately 11 person-months involving 2-3 months of Principal Investigator time and 8-9 months of professional staff time. The estimated total cost is \$135,000.

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	Task 1: Identify 30+ candidate gbXML test cases	2 mo. from start
2	Task 2: Identify related test case documentation work	4 mo. from start
3	Task 3: Based upon results of Tasks 1 and 2, select the final 20+ test cases most relevant to stakeholders. Then, create a document and corresponding Green Building XML (gbXML) file for each test case.	14 mo. from start
4	Task 4: Update the web-based validation software	18 mo. from start
5	Task 5: Develop end-use implementation guide	19 mo. from start
6	Task 6: Create data repository on data.ashrae.org for gbXML test case and gbXML files	20 mo. From start

7	Final Deliverables: Final task reports and data sets, final summary report, technical paper, Project synopsis	20 mo. from start
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Proposal Evaluation Criteria

Proposals submitted to ASHRAE for this project should include the following minimum information:

No.	Proposal Review Criterion	Weighting Factor
1	Contractor's understanding of Work Statement as revealed in proposal. a) Understanding of foundational work done in RP-1468 b) Understanding of intended products of this research project c) Understanding of application of these project products	25%
2	Quality of methodology proposed for conducting research. a) Organization of project b) Management plan	25%
3	Qualifications of personnel for this project. a) Project team 'well rounded' in terms of qualifications and experience in related work, including expertise in formal information exchange documentation and various commercially available software tools used in the buildings industry b) Project manager experience c) Time commitment of Principal Investigator d) Software development experience	25%
4	Probability of contractor's research plan meeting the objectives of the Work Statement a) Detailed and logical work plan with major tasks and key milestones b) All technical and logistic factors considered c) Reasonableness of project schedule	20%
5	Performance of contractor on prior ASHRAE or other projects (no penalty for new contractors)	5%

Proposal Evaluation Criteria

Proposals submitted to ASHRAE for this project should include the following minimum information:

References

1. ASHRAE, 2017. ASHRAE Terminology online searchable glossary of terms for the built environment, <https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology>
2. ASHRAE, 2016. ASHRAE Members Only Research Reports website, <https://www.ashrae.org/standards-research--technology/members-only-research-reports-redirect>
3. ASHRAE, 2013. ASHRAE 1468-RP: Development of a Reference Building Information Model (BIM) for Thermal Model Compliance Testing, https://www.techstreet.com/standards/rp-1468-development-of-a-reference-building-information-model-bim-for-thermal-model-compliance-testing?product_id=1868055
4. Green Building XML (gbXML) website: <http://www.gbxml.org>