



Shaping Tomorrow's
Built Environment Today

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Michael R. Vaughn, P.E.
Manager Research & Technical Services

TO: Richard Hackner, Chair TC 7.5, rich.hackner@gdsassociates.com

FROM: Michael R. Vaughn
Manager of Research and Technical Services

CC: Christopher Wilkins, Research Liaison 7.0, chris.wilkins@crbusa.com
David Yuill, Research Subcommittee Chair TC 7.5, dyuill@unl.edu
Jin Wen, David Yuill, Michael Bobker, Work Statement Author(s), jinwen@drexel.edu;
dyuill@unl.edu; mbobker@ccny.cuny.edu

DATE: October 31, 2017

SUBJECT: Work Statement (1781-WS), "Development of a Methodology to Evaluate Fault Detection and Diagnosis Tools for Air Handling Unit Systems"

During their fall meeting, the Research Activities Subcommittee (RAS) of RAC reviewed the subject Work Statement (WS) and voted 5-0-0 CNV to return with comments.

Below are the main issues and concerns that must be addressed in your next submission of the WS if you choose to resubmit.

1. Revise the scope and task breakdown not clearly laid out.
2. Budget seems to be too high.
3. A lot of risk in work statement now. Better craft work statement to minimize risk.

A WS evaluation sheet is attached as additional information and it provides a breakdown of comments and questions from individual RAC members based on a specific review criteria. This should give you an idea of how your WS is being interpreted and understood by others. Some of these comments indicate areas of the WS where readers require additional or corrected information or rewording for clarification.

Please coordinate changes to this Work Statement with your Research Liaison Christopher Wilkins, chris.wilkins@crbusa.com or RL7@ASHRAE.net prior to resubmitting it again to the Manager of Research and Technical Services for further consideration by RAC.

Also, it is necessary that you provide with your next submission a new TC vote on the revised Work Statement, and a letter describing how each of the above items were addressed in the revision.

If you wish for this work statement to be reconsidered at the next RAC meeting, the revised Work Statement must be sent (electronically) to Michael Vaughn, Manager of Research and Technical Services (morts@ashrae.net) by **December 15, 2017**. The next opportunity for consideration after this deadline is May 15, 2018.

Project ID	1781	
Project Title	Development of a Methodology to Evaluate Fault Detection and Diagnosis Tools for Air Handling Unit Systems	
Sponsoring TC	TC 7.5, Smart Building Systems	
Cost / Duration	\$275,000 / 24 Months	
Submission History	1st WS Submission, RTAR accepted F15	
Classification: Research or Technology Transfer	Basic/Applied Research	
RAC 2017 Fall Meeting Review	RTAR STAGE FOLLOWED	
Check List Criteria	Voted NO	Comments & Suggestions
State-of-the-Art (Background): The WS should include some level of literature review that documents the importance/magnitude of a problem. If not, then the WS should be returned for revision. RTAR Review Criterion		
Advancement to the State-of-the-Art Is there enough justification for the need of the proposed research. Will this research significantly contribute to the advancement of the State-of-the-Art. RTAR Review Criterion		
Relevance and Benefits to ASHRAE: Evaluate whether relevance and benefits are clearly explained in terms of: a. Leading to innovations in the field of HVAC & Refrigeration b. Valuable addition to the missing information which will lead to new design guidelines and valuable modifications to handbooks and standards.		
IF THE THREE CRITERIA ABOVE ARE NOT ALL SATISFIED - MARK "REJECT" BELOW BUT ADDRESS THE FOLLOWING CRITERIA AS APPROPRIATE		
Detailed Bidders List Provided? The contact information in the bidder list should be complete so that each potential bidder can be contacted without difficulty.		#12 - 4 potential bidders.
Proposed Project Description Correct? Are there technical errors and/or technical omissions that the WS has that prevents it from correctly describing the project? If there are, than the WS needs major revision.		#12 - How is fault severity defined? Is there a standard definition of severity levels for AHU? The WS states that a similar development was completed for RTUs. In a way a RTU is more complex than an air handler because it includes the vapor compression system (compressor, condenser, expansion device and evaporator) in addition to air handling equipment (fans, dampers...). The WS states that a MOT is currently being developed for RTUs. An AHU must work in conjunction with a chiller and a hydronic system. Will there be another effort to address FDD in chillers?
Task Breakdown Reasonable? Is the project divided into tasks that make technical and practical sense? Are the results of each task such that the results of the former naturally flow into the latter? If not, then major revisions are needed to the WS that would include: adding tasks, removing tasks, and re-structuring tasks among others.		#12 - Two phases with 7 tasks in the first and 5 in the second are defined. Should call them Phase I and II and under number tasks under each, e.g., Ph-I/Task 1, Task 2, etc.
Adequate Intermediate Deliverables? The project should include the review of intermediate results by the PMS at logical milestone points during the project. Before project work continues, the PMS must approve the intermediate results.		#11 - Intermediate deliverables were not well laid out and confusing. Need to be better identified. #12 - Deliverables for each task are defined. #8 - Waiting 24 months to look at case studies results and evaluate fdd tools seems like a big risk
Proposed Project Doable? Can the project as described in the WS be accomplished? If difficulties exist in the project's WS that prevent a successful conclusion of the project, then the project is not doable. In this situation, major revision of the WS is needed to resolve the issues that cause the difficulty.		#12 - Not sure and unable to judge. #8 - Seems overly ambitious given the list of requirements
Time and Cost Estimate Reasonable? The time duration and total cost of the project should be reasonable so that the project can be as it is described in the WS.		#11 - if the AHU and software are donated! #12 - Duration is OK but at \$275K, this project is expensive. This project is more expensive than the typical ASHRAE research project. #8 - Cost seems high for what we are getting
Proposed Project Biddable? Examining the WS as a whole, is the project described in the WS of sufficient clarity and detail such a potential bidder can actually understand and develop a proposal for the project? This criterion combines the previous three criteria into an overall question concerning the usefulness of the WS. If the WS is considered to not be biddable, then either major revisions are in order or the WS should be rejected.		#12 - Not sure and unable to judge. The WS is detailed and all tasks are and deliverables well defined. #8 - Hard to evaluate proposals based on bids?
Decision Options	Initial Decision	Final Approval Conditions
ACCEPT		#11 - Need to review the breakdown of task I (a to g!) #12 - Unable to judge. Since a MOT is already being developed for RTUs, it may be advisable to leverage the methodologies developed for the RTUs in developing an FDD for AHUs. #8 - rework the deliverables and define in greater detail the data / effective methods to eval fdd tools. #3 - They have addressed all RAC comments. I am still not convinced that a single methodology can be developed for what are essentially custom-designed systems that exist in a great variety of configurations.
COND. ACCEPT		
RETURN	X	
REJECT		

ACCEPT Vote - Work statement(WS) ready to bid as-is

CONDITIONAL ACCEPT Vote - Minor Revision Required - RL can approve WS for bid without going back to RAC once TC satisfies RAC's approval condition(s) to his/her satisfaction

RETURN Vote - WS requires major revision before it can bid

REJECT Vote - Topic is no longer considered acceptable for the ASHRAE Research Program due to duplication of work by another project or because the work statement has a fatal flaw(s) that makes it unbiddable

WORK STATEMENT COVER SHEET

(Please Check to Insure the Following Information is in the Work Statement)

- A. Title
 - B. Executive Summary
 - C. Applicability to ASHRAE Research Strategic Plan
 - D. Application of the Results
 - E. State-of-the-Art (background)
 - F. Advancement to State-of-the-Art
 - G. Justification and Value to ASHRAE
 - H. Objective
 - I. Scope
 - J. Deliverables/Where Results will be Published
 - K. Level of Effort
- | | |
|---|--------------------------|
| Project Duration in Months | <input type="checkbox"/> |
| Professional-Months: Principal Investigator | <input type="checkbox"/> |
| Professional-Months: Total | <input type="checkbox"/> |
| Estimated \$ Value | <input type="checkbox"/> |
- L. Proposal Evaluation Criteria & Weighting Factors
 - M. References
 - N. Other Information to Bidders (Optional)

Date:

Title:

WS#
(To be assigned by MORTS - Same as RTAR #)

Results of this Project will affect the following Handbook Chapters, Special Publications, etc.:

Responsible TC/TG:

Date of Vote:

For					
Against	*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Abstaining	*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Absent or not returning Ballot	*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Total Voting Members		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

This W/S has been coordinated with TC/TG/SSPC (give vote and date):

Has RTAR been submitted?
Strategic Plan
Theme/Goals

Work Statement Authors: **

Proposal Evaluation Subcommittee:
Chair:
Members:

Project Monitoring Subcommittee:
(If different from Proposal Evaluation Subcommittee)

Recommended Bidders (name, address, e-mail, tel. number): **

Potential Co-funders (organization, contact person information):

(Three qualified bidders must be recommended, not including WS authors.)

- Is an extended bidding period needed?
- Has an electronic copy been furnished to the MORTS?
- Will this project result in a special publication?
- Has the Research Liaison reviewed work statement?

Yes	No	How Long (weeks)
<input type="checkbox"/>	<input type="checkbox"/>	<input style="width: 100%;" type="text"/>
<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	

* Reasons for negative vote(s) and abstentions

** Denotes WS author is affiliated with this recommended bidder
Use additional sheet if needed.

WORK STATEMENT#

Title:

Sponsoring TC/TG/MTG/SSPC:

Co-Sponsoring TC/TG/MTG/SSPCs (List only TC/TG/MTG/SSPCs that have voted formal support)

Executive Summary:

Applicability to the ASHRAE Research Strategic Plan:

[Empty box for applicability to the ASHRAE Research Strategic Plan]

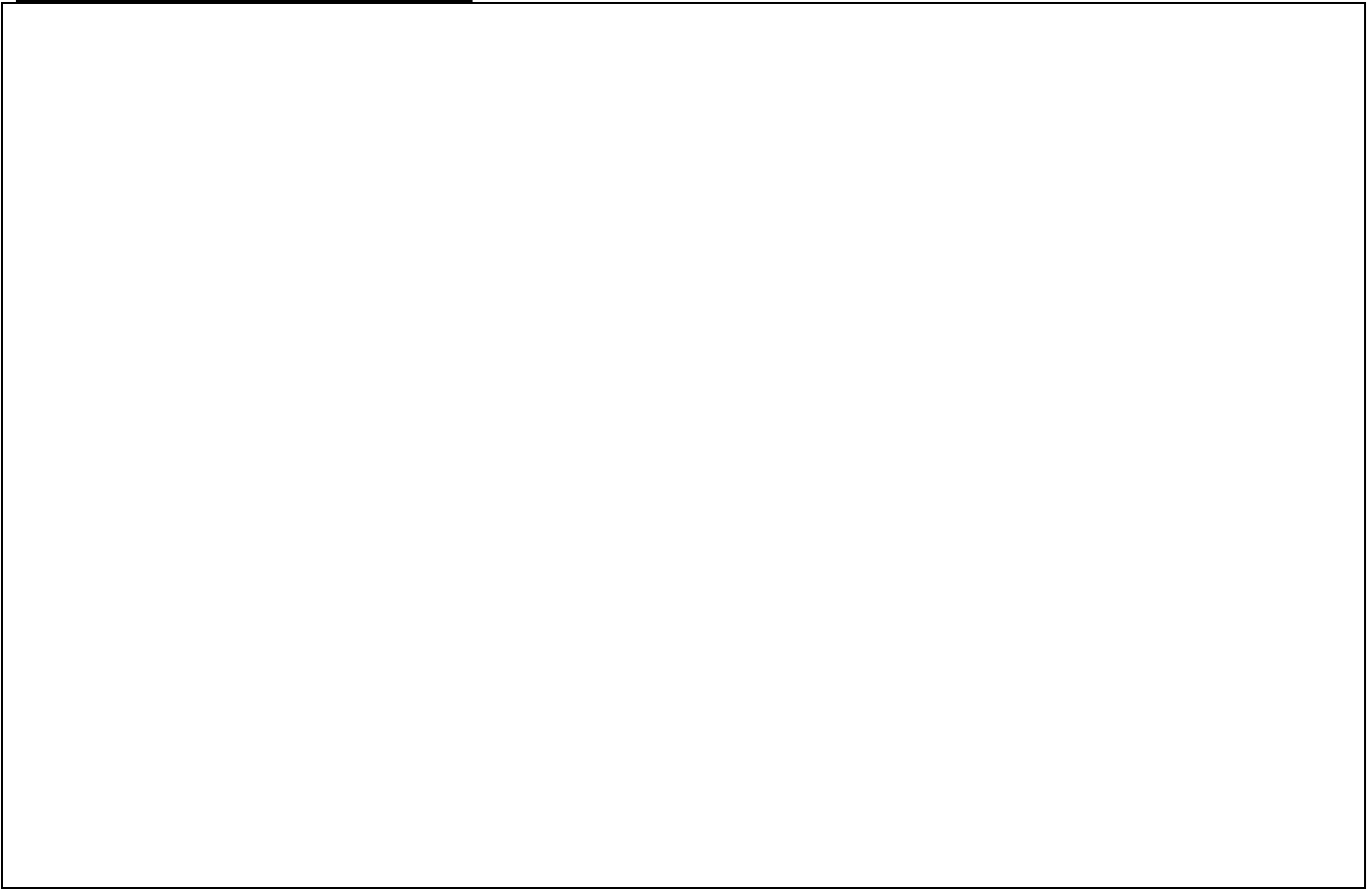
Application of Results:

[Empty box for application of results]

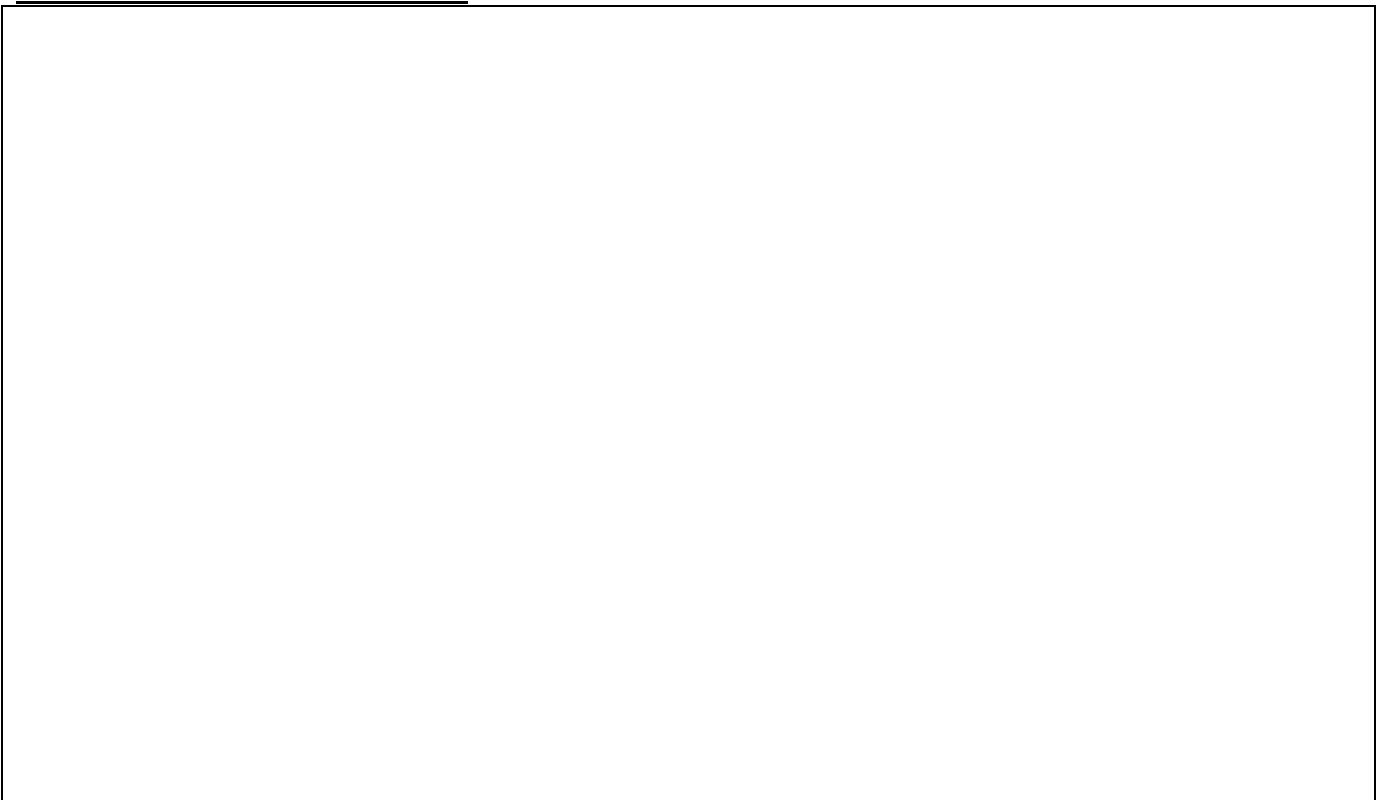
State-of-the-Art (Background):

[Empty box for state-of-the-art (background)]

Advancement to the State-of-the-Art:

A large, empty rectangular box with a thin black border, intended for the user to provide details on the advancement to the state-of-the-art.

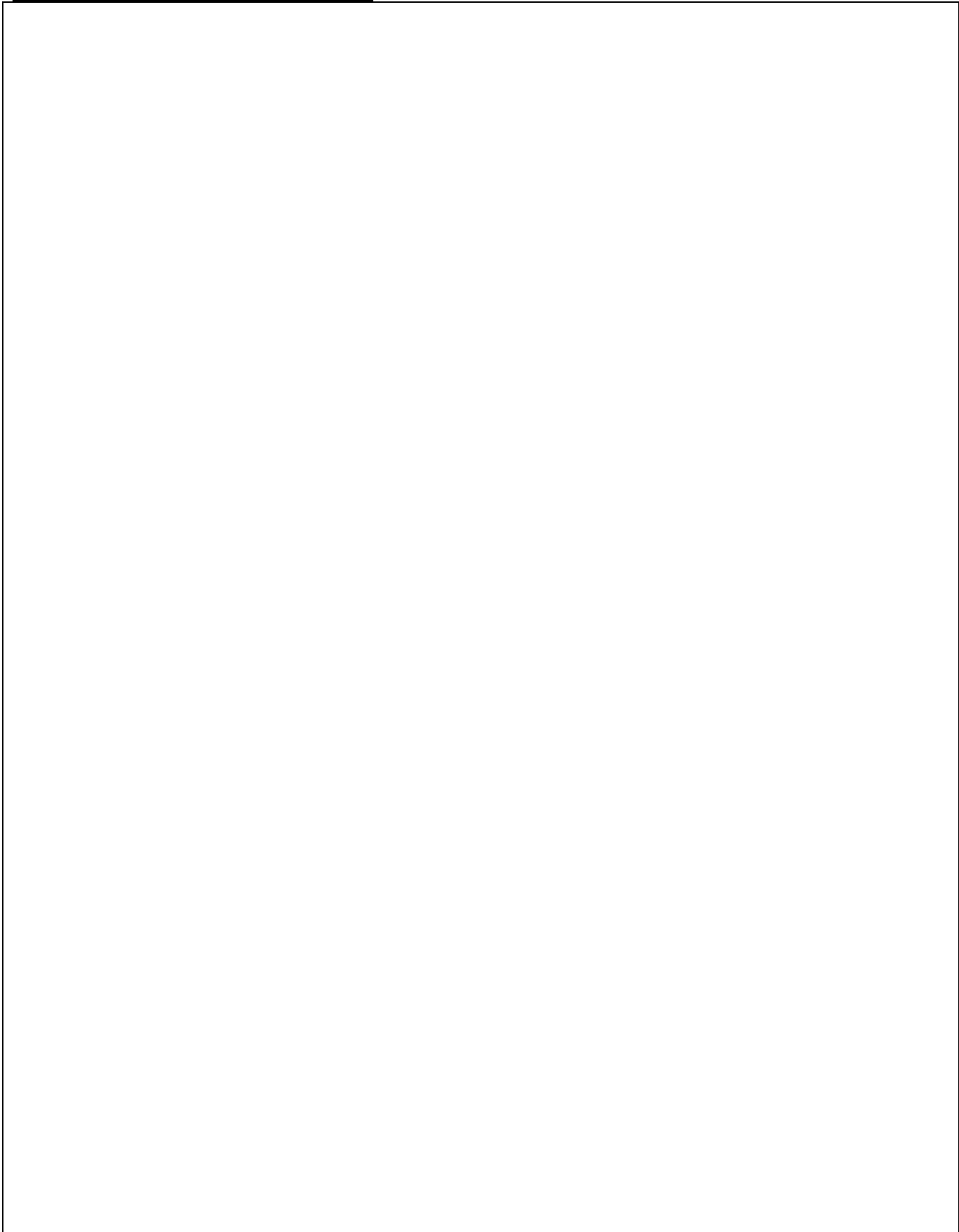
Justification and Value to ASHRAE:

A large, empty rectangular box with a thin black border, intended for the user to provide justification and value to ASHRAE.

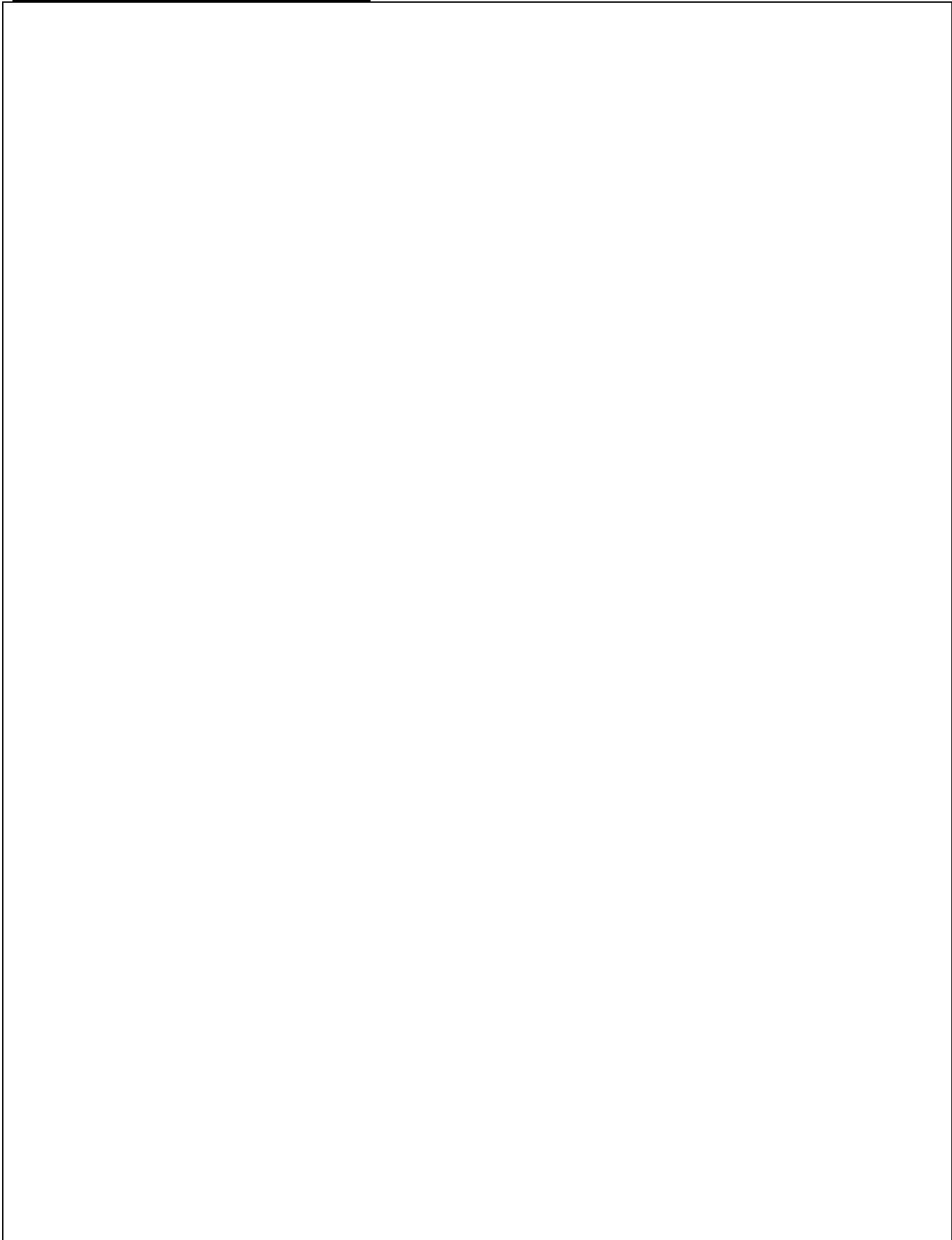
Objectives:

Scope/Technical Approach:

Scope/Technical Approach (Continued 2):



Scope/Technical Approach (Continued 3):



Deliverables/Where Results Will Be Published:

Deliverables/Where Results Will Be Published (Continued):

--

Level of Effort:

--

Proposal Evaluation Criteria:

No.	Proposal Review Criterion	Weighting Factor

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month

Authors:

--

References:

[Empty reference box]

Other Information for Bidders (Optional):

Feedback to RAC and Suggested Improvements to Work Statement Process

Now that you have completed the work statement process, RAC is interested in getting your feedback and suggestions here on how we can improve the process.

Responses to RAC's Comments on 1781-RTAR- "Methods to Evaluate AFDD Strategies for Air Handling Unit Systems"

Jin Wen, David Yuill, and Mike Bobker

TC 7.5 and TC 7.6

August 14th, 2017

During the preparation for 1781-WS, we have thoroughly considered and incorporated all comments provided by the RAC in November 2015. Here is a summary of the comments and our responses:

- 1) *Consideration should be given to breaking this effort into two stages: Stage I should address only a literature review. Based upon the findings of the Stage I project, which should include previous ASHRAE RPs involving field testing of automatic fault detection and diagnosis (AFDD), e.g., RP-1020, a single approach or multiple approaches for testing should be developed for Stage II.*
 - a. Response: We have broken the project into two stages as suggested.
- 2) *The key research question is how well can the variety of Air Handling Unit (AHU) configurations be addressed in a standard method-of-test?*
 - a. Response: This has been a focus of the WS and will be a focus of the proposed project. Task I.c is therefore designed to consider the variety of AHU configurations. The deliverable from this Task will include a summary of the common AHU configurations and the configurations that will be tested in this project. Another task, Task I.d, further identifies the diverse potential faults for different AHU configurations. The key research question here is how can AFDD for AHU be evaluated, considering the challenge of various configurations.
- 3) *Retitle project from "Methods" to "Method" if only a single method is expected from this project.*
 - a. Response: We have changed the title to be "Development of a Methodology to Evaluate Fault Detection and Diagnosis Tools for Air Handling Unit Systems" to better reflect the scope.
- 4) *The use of "Big Data Analytics" for AFDD should be explored further to help validate the project results.*
 - a. Response: The goal of this project is to build up a basis for a future MOT that can be used to evaluate various AFDD tools, including those based on big data analytics. This project, however, does not yield any new AFDD method. The tasks have been designed to be able to incorporate AFDD tools that are based on different principles.



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Michael R. Vaughn, P.E.
Manager Research & Technical Services

mvaughn@ashrae.org

TO: Natascha Milesi Ferretti, Chair TC 7.5, natascha.milesi-ferretti@nist.gov
Jin Wen, Research Subcommittee Chair TC 7.5, jinwen@drexel.edu

CC: Philip Haves, Research Liaison, 7.0, phaves@lbl.gov

FROM: Michael Vaughn, MORTS, mvaughn@ashrae.org

DATE: November 20, 2015

SUBJECT: Research Topic Acceptance Request (1781-RTAR), "Methods to Evaluate AFDD Strategies for Air Handling Unit Systems"

During their fall meeting, the Research Administration Committee (RAC) reviewed the subject Research Topic Acceptance Request (RTAR) and voted to accept it with comments for further development into a work statement (WS) provided that the approval comment(s) below are addressed to the satisfaction of your Research Liaison, Philip Haves, phaves@lbl.gov, or RL7@ashrae.net, in the work statement draft.

1. Consideration should be given to breaking this effort into two stages: Stage I should address only a literature review. Based upon the findings of the Stage I project, which should include previous ASHRAE RPs involving field testing of automatic fault detection and diagnosis (AFDD), e.g., RP-1020, a single approach or multiple approaches for testing should be developed for Stage II.
2. The key research question is how well can the variety of Air Handling Unit (AHU) configurations be addressed in a standard method-of-test?
3. Retitle project from "Methods" to "Method" if only a single method is expected from this project.
4. The use of "Big Data Analytics" for AFDD should be explored further to help validate the project results.

An RTAR evaluation sheet is attached as additional information and it provides a breakdown of comments and questions from individual RAC members based on specific review criteria. This should give you an idea of how your RTAR is being interpreted and understood by others. Some of these comments may indicate areas of the RTAR and subsequent WS where readers require additional information or rewording for clarification.

The first draft of the work statement should be submitted to RAC no later than **August 15, 2017** or it will be dropped from display on the Society's Research Implementation Plan. The next likely submission deadline for a new work statement on this topic is **May 15, 2016** for consideration at RAC's 2016 Annual meeting. The submission deadline after that for work statements is **August 15, 2016** for consideration at the RAC's 2016 fall meeting.

Project ID	1781	
Project Title	Methods to Evaluate AFDD Strategies for Air Handling Unit Systems	
Sponsoring TC	TC 7.5 (Smart Building Systems)	
Cost / Duration	\$200,000 - \$250,000 / 24M	
Submission History	1st Submission	
Classification: Research or Technology Transfer	Technology Transfer	
RAC 2015 Fall Meeting Review		
Essential Criteria	Voted NO	Comments & Suggestions
Background: The RTAR should describe current state of the art with some level of literature review that documents the importance/magnitude of a problem. References should be provided. If not, then note it in your comments.	13	13 - Only two citations are provided, both from the same pair of authors. 9- Does the abbreviation of AFDD mean "Automated Fault Detection and Diagnostic" ? AFDD will not be common words even in HVAC specialists. 2 - Clear but the following question may be addressed: Can any of the existing methods be adapted as standard? This would define better need for this project if not. 11 - The two citations are for a two part, authoritative, comprehensive review article, but other references would be useful, including previous ASHRAE RP's involving field testing of AFDD, e.g. 1020-RP.
Research Need: Based on the background provided is the need for additional research clearly identified? If not, then the RTAR should be rejected.	13	2 - Obvious but there are certain concerns. Can standard method be developed and can it be applied to any AHU or is it unit dependent? 11 - Strong research need, well described.
Relevance and Benefits to ASHRAE: Evaluate whether relevance and benefits are clearly explained in terms of: a. Leading to innovations in the field of HVAC & Refrigeration b. Valuable addition to the missing information which will lead to new design guidelines and valuable modifications to handbooks and standards. Is this research topic appropriate for ASHRAE funding? If not, Reject.	13	10 - I have a different concern about a standard rating method for these (semi-custom) beasts. Does a standard, specifying what must be measured and tested, also serve to inhibit innovation, by discouraging alternative solutions for alternative systems for which some of the metrics might not be important, but others, not yet known, might be?
IF ABOVE THREE CRITERION ARE NOT <u>ALL</u> SATISFIED - MARK "REJECT" BELOW & CONTINUE REVIEW BELOW		
Other Criteria	Voted NO	Comments & Suggestions
Project Objectives: Based on the background and need, evaluate whether the project objectives are: 1. Aligned with the need 2. Specific 3. Clear without ambiguity 4. Achievable If not, then appropriate feedback should be provided.	15, 9	7 - This project should be funded in two stages: Phase I should address only the literature review. Based upon the findings of the Phase I, a better approach for testing should be developed. 9 - The topic of the research is needed and important however the research method is not concrete, in other words, people will not be confident that the research get the good result. It becomes common that many features are analyzed with the method of big data analysis. AFDD will have close relationship with Big Data Analysis. The RTAR can include the relationship with Big Data Analysis. 2 - How the objectives will be met? What will be the reference for a developed method?
Expected Approach and Budget: Is there an adequate description of the approach in order for RAC to be able to evaluate the appropriateness of the budget? If not, then the RTAR should be returned for revision. Anticipated funding level and duration:	15, 6	15 - Expected approach is blank. 2- Approach is missing. The title talks about the methods (in plural) but only one method (singular) will be developed. 6 - Expected approach part is missing. Hard to evaluate the appropriateness of budget. 11 - Approach is summarized in Project Objectives
References: Are the references provided?	9	9 - Big Data Analysis for AFDD should be explored. 6 - Only two references listed. Need more.
Decision Options	Initial Decision?	Final Approval Conditions
ACCEPT AS-IS		7 - This project should be funded in two stages: Phase I should address only literature review. Based on the finding of the Phase I a better approach for testing should be developed. Author has used several acronyms without explanation. 13 - I am familiar with one of the commercial products referenced in the RTAR (Clockworks). The concept of automatic fault detection and diagnosis (AFDD) is intriguing but this RTAR does not define the objective clearly enough. Without this clear definition, it is difficult to anticipate that worthwhile research will result. The range of applications required even for an AHU are very broad and custom. Somehow this proposed research needs to be more focused and more clearly defined before a work statement can be written. 9 - Explain the research method further concretely. The target of the project should be focused in further and the project benefits to ASHRAE should be stated more concretely. For example, how will the handbook be modified with the results of the project. 11 - The key research question is how well can the variety of AHU configurations be addressed in a standard method of test
ACCEPT W/COMMENTS		
REJECT		

ACCEPT Vote - Topic is ready for development into a work statement (WS).

ACCEPT W/COMMENTS Vote - Minor Revision Required - RL can approve RTAR for development into WS without going back to RAC once TC satisfies RAC's approval condition(s)

REJECT Vote - Topic is not acceptable for the ASHRAE Research Program

Research Topic Acceptance Request Cover Sheet

Date: _____

(Please Check to Insure the Following Information is in the Work Statement)

- A. Title
- B. Applicability to ASHRAE Research Strategic Plan
- C. Application of the Results
- D. State-of-the-Art (background)
- E. Advancement to State-of-the-Art
- F. Justification and Value to ASHRAE
- G. Objective
- H. Estimated Duration
- I. References

Title: _____

RTAR# _____
(To be assigned by MORTS)

Results of this Project will affect the following Handbook Chapters, Special Publications, etc.:

Responsible TC/TG: _____

Date of Vote: _____

For	
Against	*
Abstaining	*
Absent or not returning Ballot	*
Total Voting Members	

Co-sponsoring TC/TG/MTG/SSPCs (give vote and date):

RTAR Lead Author: _____
Expected Work Statement Lead Author: _____

Potential Co-funders (organization, contact person information):

- Research Classification:
- Basic/Applied Research
 - Advanced Concepts
 - Technology Transfer

Yes No

Has an electronic copy been furnished to the MORTS?
Has the Research Liaison reviewed the RTAR?

* Reasons for negative vote(s) and abstentions

DRAFT RTAR Template

Title: _____

Summary

Describe in summary form the proposed research topic, including what is proposed, why this research is important, how it will be conducted, and why ASHRAE should fund it (50 words maximum)

Background

Provide the state of the art with key references (at the end of this document) substantiating it (300 words maximum)

Research Need

Use the state of the art described above as a basis to specify the need for the proposed effort (250 words maximum)

Project Objectives

Based on the identified research need(s), specify the objectives of the solicited effort that will address all or part of these needs (150 words maximum)

Expected Approach

Describe in a manner that may be used for assessment of project viability, cost, and duration, the approach that is expected to achieve the proposed objectives (200 words maximum).

Check all that apply: Lab testing (), Computations (), Surveys (), Field tests (), Analyses and modeling (), Validation efforts (), Other (specify) ()

Relevance and Benefits to ASHRAE

Describe why this effort is of specific interest to ASHRAE, its impact, and how it will benefit ASHRAE and the society. How does it align with ASHRAE Strategic Plans and Initiatives? How does it advance the state of the art in this area in general? Are there other stakeholders that should be approached to obtain relevant information or co-funding? (350 words maximum)

Anticipated Funding Level and Duration

Funding Amount Range: \$ _____

Duration in Months: _____

References

List the key references cited in this RTAR