MINUTES

EXECUTIVE COMMITTEE MEETING

Monday, February 27, 2023

Approved by the Executive Committee on June 24, 2023.

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PRINCIPAL APPROVED MOTIONS

Executive Committee Meeting

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1 – 2	ExCom recommends that the Board of Directors approve the formation of a new standing committee named Global Technical Interaction Committee reporting to Technology Council and recommend that the Board of Directors implement this by approving the proposed new Rule of the Board (as shown in ATTACHMENT A).
2 - 4	The Executive Committee recommend that the ASHRAE Board of Directors approve the revisions to 2.2 of the Rules of the Board (as shown below): **2. GENERAL RULES** 2.2 The Board of Directors delegates responsibility for the operation of the Scholarship Program, **including the approval of scholarship agreements,** to the Scholarship Trustees, which has sole authority for the final selection and approval of scholarship recipients, the number of scholarships awarded, the frequency of awards, the amount of each award. The scholarship trustees shall report to the Board of Directors through the Executive Committee.

ACTION ITEMS

Executive Committee Meeting

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No. - Pg.	Responsibility	Summary of Action	Status	Goal Date
1 – 6	Scoggins and Maston	Conduct a comparison of Energy Star NextGen Certification and Building EQ. Also investigate how Building EQ can be better marketed to gain more traction around the world.		
2 – 8	Knight, Scoggins, and Staff	Develop a concept document to present to Dr. Jha ahead of the May 11 White House COVID announcement.		

MINUTES
EXECUTIVE COMMITTEE MEETING
Monday, February 27, 2023

MEMBERS PRESENT:
Farooq Mehboob, President
Ginger Scoggins, President-Elect
Dennis Knight, Treasurer
Billy Austin, Vice President
Dunstan Macauley, Vice President
Sarah Maston, Vice President
Ashish Rakheja, Vice President
Jeff Littleton, Secretary

GUESTS PRESENT:
Bill McQuade
Bryan Holcomb
Chandra Sekhar
Corey Metzger
Jim Arnold
Drake Erbe
Eileen Jensen
Heather Schopplein
John Constantinide
Kishor Khankari
Cheng Wee Leong
Mahroo Eftekhari
Richie Mittal
Scott Peach
Steven Bushby
Doug Cochrane
Steve Sill

STAFF PRESENT:
Candace DeVaughn, Manager - Board Services
Chandrias Jolly, Assistant Manager - Board Services
Joyce Abrams, Director - Member Services
Vanita Gupta, Director - Marketing
Mark Owen, Director - Publications & Education
Stephanie Reiniche, Director - Technology
Alice Yates, Director - Government Affairs
Craig Wright, Director of Finance
Daniel Gurley, Manager – Membership & Member Contact Center
Ryan Shanley, Manager – International Standards

CALL TO ORDER

Mr. Mehboob called the meeting to order at 8:00 am.

CODE OF ETHICS

Mr. Mehboob read the code of ethics commitment and advised that the full code of ethics and core values were posted online.

ROLL CALL/INTRODUCTIONS

Roll call was conducted. Members, guests, and staff were in attendance as noted above.

REVIEW OF MEETING AGENDA

Mr. Mehboob reviewed the meeting agenda. 'Request from MP' was added to *New Business* and assigned to Ms. Scoggins.

POSTPONED MOTION (February 8, 2023)

The postponed motion was brought back to the floor:

1. ExCom recommends that the Board of Directors approve the formation of a new standing committee named Global Technical Interaction Committee reporting to Technology Council and recommend that the Board of Directors implement this by approving the proposed new Rule of the Board (as shown in ATTACHMENT A).

Mr. Knight advised that Ms. Reiniche and Mr. Bushby were in attendance to provide additional background on the motion. He reported that the ROB was reviewed, and the attachment includes proposed updates. The MOP and Reference Manual for the proposed committee have also been created and reviewed. If the proposed new standing committee is approved, they will be ready to hit the ground running.

Mr. Bushby reviewed the presentation that was attached to the agenda.

Mr. Knight stated that he did not feel this was a grassroots motion; this work was directed by the BOD, Presidential Members, and ExCom and has been on BOD agendas for the last seven years. He suggested that if approved, the BOD be immediately notified, provided the information attached to this agenda, and notified of the intent to bring this motion forward at the next BOD meeting. He reported that the intent is for the motion to be voted on at two successive BOD meetings and, if approved, that the new standing committee would start its work on July 1st.

Mr. Bushby reviewed motion's fiscal impact. He reported that, to be effective, the new committee would need to interact with other committees. Some members of the committee would have their travel expenses to the Annual and Winter Conferences covered, in whole or part, by other committees or groups.

Mr. Mehboob asked for additional information on the budget process for standing committees.

Mr. Littleton reported that Society assumes that every member of a standing committee will be reimbursed for transportation regardless of whether they serve on multiple standing committees. He reported that historical transportation expenses are also reviewed and considered.

Mr. Wright added that staff liaisons look at who serves on a committee and adjusts the budget accordingly. He reported that if a member serves on multiple committees her/his transportation expenses are split between the multiple committees.

Mr. Mehboob asked if there were an estimate for transportation costs per member.

Mr. Wright reported that for US based travelers, the assumption is $600 but staff is considering raising that based on rising costs. For international travelers, the assumed cost is $800 which may also be increased next Society year as well.

Mr. Knight spoke in favor of the motion. He reported that this outcome is the culmination of charges over multiple years.

Mr. Bushby stated that the goal is coordinating with standards. The Vice Chair of Standards and TAC will be members of the proposed new committee as well. The Vice Chair was selected because they are engaged and will help build continuity between the committees. He reviewed the other voting members.

He reported that the expectation was that ISAS would disappear.

The floor was opened for discussion.

Ms. Maston spoke in favor of the motion. She stated that she did not perceive this motion as a major organizational change and that a 60-day cooling off period was not necessary.

Mr. Littleton responded that per the ROB, the motion is a major organizational change. He advised that the BOD has to present the motion at one meeting and vote on the motion at another. He reported that this process can be done in time for the desired July 1st start date.

Mr. Knight expressed agreement with Mr. Littleton's interpretation of the ROB. He expressed his opinion that the ROB should be rewritten to update the definition of a major organizational change. He stated his opinion that the intent of the ROB initially was that it only applies to committees that report to the BOD.

Mr. Mehboob raised the following points for ExCom's consideration prior to vote:

> *Would approving or defeating the motion send a strong statement regarding Society's global relevance?*
>
> *If it has taken seven years to reach this point, is this the right path?*

He suggested that it not be inferred that the committee would drive Society's relationships with REHVA or AASA. Feel that Society's current structure works well.

Ms. Scoggins stated that standards are being challenged and Society runs the risk of ISO becoming more domestically accepted. This has been an ongoing conversation for many years and the proposed new committee solidifies Society's interactions and playing in the sand box.

MOTION 1 PASSED (Unanimous Voice Vote, CNV).

Mr. Littleton advised that notification regarding this approval would be sent to the BOD very soon.

PROPOSED SCHOLARSHIP ROB CHANGES

Mr. Littleton reported that the proposed ROB changes were very simple and align with Society streamlining efforts and the work to shift operational details away from the BOD. The effect of the change would be that the Scholarship Trustees would have authority to approve new scholarships. He advised that there would continue to be a strong connection and partnership between the Scholarship Trustees and the Foundation Trustees.

Ms. Scoggins moved that

2. The Executive Committee recommend that the ASHRAE Board of Directors approve the revisions to 2.2 of the Rules of the Board (as shown below):

2. GENERAL RULES

2.2 The Board of Directors delegates responsibility for the operation of the Scholarship Program, **including the approval of scholarship agreements,** to the Scholarship Trustees, which has sole authority for the final selection and approval of scholarship recipients, the number of scholarships awarded, the frequency of awards, the amount of each award. The scholarship trustees shall report to the Board of Directors through the Executive Committee.

There was no discussion of the motion.

MOTION 2 PASSED (Unanimous Voice Vote, CNV).

POSSIBILITY OF MEMBERS PROVIDING ASSISTANCE TO TURKISH CHAPTER

Ms. Scoggins reported that she reached out to leadership of the Turkish Chapter to let them know that ExCom and Society was thinking about them, considering the recent natural disaster. Suggestions for how Society could assist Turkish Chapter members were sent to Ms. Scoggins.

She stated that she wasn't sure if Society had a vehicle to assist members that may have been impacted by the earthquakes in Turkey.

Ms. Maston stated that she would like to do something, and that local direction would be helpful.

Mr. Rakheja stated that he was in favor of Society providing assistance. He suggested that financial support would be the best route as anything else would be difficult. He suggested that a fund could be set up where members could donate, and the funds could be transferred to the Chapter and members.

Mr. Gurley reported that an email had been sent to all members in Syria and Turkey letting them know that if they needed assistance they should reach out to Society. Dues will be waived for impacted members and ASHRAE products that may have been lost will be replaced at no cost.

He advised that Society has not done a monetary fund in the past. He cautioned this course of action since it is uncharted territory.

Mr. Macauley asked if Society could start a fund to provide assistance to members impacted by natural disasters. He suggested that the Development Committee be engaged to look into possibilities and provide ExCom with recommendations. He stated that he was sure that other members would like to assist in any way possible.

Mr. Littleton stated that it can be challenging to provide basic monetary support for natural disasters. He expressed that it was appropriate to waive dues and provide replacement products as those are steps that Society always takes. He suggested that providing financial support to areas impacted by natural disasters is somewhat outside of Society's scope and purpose.

He advised that CIBSE has a benevolent fund. CIBSE members contribute to the fund and a committee of members distribute those funds to members in dire circumstances.

Mr. Macauley expressed agreement with Mr. Littleton. He suggested that Society establish a sponsored fund with an international relief organization.

Mr. Knight suggested that a package could be compiled on building readiness and reoccupying buildings; and that resource could be made available to emergency preparedness jurisdictions around the world. He stated that this could be another way to promote ASHRAE as a resource.

Ms. Scoggins stated that several good ideas were suggested, but that much of the discussion was focused on long range planning. There is currently an immediate need. She asked if there would be an issue with setting up a GoFundMe for members impacted.

Mr. Littleton stated that he was not sure if Society should reach out to members and ask them to contribute to a GoFundMe. He suggested that if Society is soliciting funds, Society should control those funds as it would be Society's obligation to ensure that funds were used appropriately. He suggested that the Development Committee could be engaged.

Mr. Mehboob stated that the Turkish disaster is certainly terrible, and everyone's hearts go out to those impacted. He stated that there have been multiple chapters impacted by disasters. He suggested that to act in this one instance would obligate Society to respond to all future requests.

He stated that the CIBSE fund was individual specific and not event or country specific.

He expressed his opinion that Society is not in the business of responding to natural disasters in this way.

Ms. Scoggins stated that she would respond to the Chapter leadership and ask if there were anything she could do personally, but she would not commit Society to anything.

It was asked if this item should be forwarded to the Development Committee.

Mr. Mehboob responded that the discussion was a philosophical one, and the BOD would need to provide direction for the Society to be in the business of responding to natural disasters in this way. Until that time, no further action should be taken.

PROPOSED ENERGY STAR NextGen CERTIFICATION FOR COMMERCIAL BUILDINGS AND POSSIBLE IMPACTS ON BUILDING EQ

Ms. Scoggins reported that the Energy Star program seemed to have morphed into a very similar program to Building EQ. Presidential Member Don Colliver brought this to her attention and asked that ExCom discuss it.

Mr. Knight stated that he was aware of the program. He has experience with school districts who wanted to use the Energy Star certification. He suggested that the item be referred to Building EQ for consideration and recommendation.

Mr. Cochrane stated that Mr. Colliver contacted him as well and the item had already been passed on to Building EQ. It will be included on an upcoming agenda.

Mr. Rakheja reported that he received comments from Ms. Reiniche and Building EQ that can be shared with the group.

Mr. Knight suggested a collaborative approach with DOE and EPA. There are over ½ million buildings in this program. If there were a collaboration, the data would be extremely useful to members in their day-to-day work.

Ms. Scoggins suggested that Building EQ be asked to provide an analysis between the two programs.

Mr. Mehboob expressed agreement with Ms. Scoggins. Should also consider how Building EQ can be marketed as an ASHRAE brand across the world.

Ms. Scoggins and Ms. Maston will conduct a comparison of Energy Star NextGen Certification and Building EQ. Will also investigate how Building EQ can be better marketed to gain more traction around the world. **AI - 1**

WASHINGTON MEETING UPDATES

Ms. Scoggins provided an update on the proposed pathogen mitigation standard. There have been ongoing conference calls with Ms. Scoggins, Ms. Yates, Mr. Bahnfleth, and Mr. Littleton on this item.

Ms. Scoggins participated in a call with White House representatives. The discussion focused on the COVID Response Team's path forward on pathogen mitigation. Reiterated that they are interested in knowing when the standard will be complete. Would like a full commitment from Society and details on the standard. Prefer a forward-facing product for building owners and operators. Federal COVID emergency measures will end May 11, 2023, and the team wants to announce the new standard at that time.

Mr. Littleton stated that the standard will not be complete by May 11. Correspondence was sent to the White House in April advising that the standard would be completed in six months. He suggested that Society consider ways to leverage White House communications as a loudspeaker to promote an ASHRAE Standard as part of the US solution to COVID. He asked if portions of the document could be released for the May 11 deadline?

Mr. Knight stated that Society has an entire body of knowledge created by the ETF. Can't the existing information be organized and packaged to respond to the May 11 deadline?

Ms. Scoggins stated that the forward-facing content would take some time.

Ms. Yates clarified that the White House did not request anything from Society. Society has been offered an opportunity to prepare content that the White House could use as part of its COVID response.

She reported that the White House would be making a host of announcements regarding COVID. There will be a gradual build up of announcements to May 11 as well as additional announcements after.

Mr. Macauley stated that there was an opportunity from a brand recognition aspect to have an ASHRAE document utilized by the White House. He suggested that Society take advantage of the opportunity. He suggested that a committee be appointed to determine what resources and steps are necessary to meet the May 11 deadline.

Mr. Littleton was asked to offer his thoughts. The challenge is ensuring that guidance provided on May 11 does not conflict with the subsequent release of the new standard. Society can certainly consider hiring a contract writer to shape the ETF guidance into public-facing material.

Mr. Mehboob asked if it were possible to hire a contractor and meet the deadline?

Ms. Scoggins stated that Mr. Bahnfleth was aware of the challenges. She advised that ExCom should allow the group to meet and report back what they need and what they can/can't do. She reported that the only organizations involved in the meetings were ASHRAE and an IAQ association. Dr. Jha has specifically mentioned ASHRAE in a teleconference and the work being done on this standard.

Mr. Sekhar expressed agreement with Mr. Knight. He stated that the work of the ETF can be Society's starting point. He expressed his opinion that some sort of document or overview could be completed by May 11.

Mr. Macauley stated that when the standard was approved, hiring someone to help with the editing process was also approved but that has not been done. May is not that far away. Society must move faster than it normally does.

Mr. Littleton reported that Mr. Bahnfleth has been advised that Society is ready to provide whatever resources are needed. He stated that Mr. Bahnfleth understands the time crunch and demands. He suggested that a concept document be developed and then shared with our colleagues at the White House, to inform them of what Society proposes generating for the May 11 declaration.

Mr. Mehboob reported on the consensus of the group. There is a desire to take advantage of the May 11 White House announcement.

He suggested that the conceptual document be presented to ensure that the White House agrees with that direction. If they do, Mr. Bahnfleth and his team can be instructed to move full steam ahead. Recommend developing the skeleton of the standard as quickly as possible. To Mr. Macauley's point, there may need to be a small group tasked with developing the outline.

Ms. Yates stated that it would be worthwhile to have a discussion with the White House. She expressed her opinion that it was highly probable that the response will be positive.

She stated that the preference would likely be for the standard to be finalized. Don't think the White House wants to talk conceptually; want to be able to give concrete guidance on how people can safely

return to buildings. To Mr. Knight's point, that guidance is available from the ETF. She suggested that one likely favorable option would be to repackage ETF guidance and ensure that it is in alignment with 241P.

Mr. Knight, Ms. Scoggins, and staff will develop a concept document to present to Dr. Jha ahead of the May 11 White House COVID announcement. **AI - 2**

AI STRATEGIES AND IMPLICATIONS

Mr. Knight reported that there have been multiple discussions around generative AI bots. Mr. Mehboob tasked the group with investigating next steps for Society. The full report is included in ATTACHMENT B.

Last Friday, subject matter experts and staff met. This would not be a short-term undertaking. The consensus was that this subject is worthy of a Presidential Ad Hoc.

Society already subscribes to Microsoft and has access to Microsoft Virtual Assistant; can begin testing the waters using this platform.

Mr. Mehboob stated that the group produced great work in just two weeks. He expressed that he would like ExCom to have consensus on the matter and asked that comments be made at this meeting or sent to Mr. Knight.

Ms. Maston expressed agreement that the initiative should move forward. She strongly recommended that an ad hoc be formed instead of creating a MTG within TAC.

Over the past six months, TAC has been working diligently to update their MOP and Reference Manual. The MTG MOP has been updated to meet recently. Additional details on these updates are included in ATTACHMENT C.

Ms. Scoggins stated that she was not opposed to creating an ad hoc but she expressed that there are cognizant bodies in Society that could address this.

Mr. Knight suggested that ExCom should not become bogged down in the technical aspect, as it is bigger than just a technical issue. He stated that he was not against an MTG, but the immediate impact of AI will be on the business operations side of Society. Suggested that staff, a MTG, or an ad hoc could address the impact to business operations.

Mr. Mehboob stated that such a large issue should be approached holistically and not put into a silo.

Mr. Macauley expressed his opinion that representation was needed from all councils and staff. The cognizant body was not as critical as proper representation.

Mr. Littleton stated that he was not sure if Society had the necessary expertise within the existing committee membership. Society has members that can contribute but an AI expert is needed that can help clarify all the ways AI can be employed. At some point, external expertise will need to be tapped.

Ms. Maston stated that, oftentimes, if an issue is deemed important, the technical committees are an afterthought. If leadership keeps sending this message, the TCs will hear it loud and clear.

Mr. Mehboob stated there does seem to be a consensus that Society should move on this subject. There will be additional investigation as to the best mechanisms to move forward.

He thanked ExCom for the discussion and Mr. Knight and his team for the report. He urged all members to read the full report.

EXECUTIVE SESSION

Executive session was called at 10:29 am.

Open session reconvened at 10:53 am.

NEW BUSINESS

REQUEST FROM MP

Ms. Scoggins reported that the YEA Committee was tasked with developing a plan to address decarbonization. To assist in this work, the committee has requested a consultant.

Mr. Mehboob advised that a YEA Committee consultant was approved.

ADJOURNMENT

The meeting adjourned at 11:03 am.

Jeff H. Littleton, Secretary

ATTACHMENTS:

A. Proposed New Rule of the BOD – ISI Task Force
B. Report on Potential Applications for Generative AI and Machine Learning Within ASHRAE
C. MTG MOP Update Details

Report to the Board of Directors Executive Committee

From International Standards Interaction Task Force

January 24, 2023

Task Force Membership

Steven Bushby (Co-Chair)	Ashish Rakheja
Drake Erbe (Co-Chair)	Hesham Safwat
James Bennet	Kelly Seeger
Oswaldo Bueno	Chandra Sekhar
Jaap Hogeling	Oludare Soluade
Jonathan Humble	Henry Yeo
Dennis Knight	Stephanie Reiniche (ASHRAE Staff)
Farhan Mehboob	Ryan Shanley (ASHRAE Staff)
George Pantelidis	

RECOMMENDED ACTION

The Task Force unanimously recommends that the Board ExCom approve the formation of a new standing committee named Global Technical Interaction Committee reporting to Technology Council and recommend that the Board of Directors implement this by approving the following proposed new Rule of the Board:

2.XXX GLOBAL TECHNICAL INTERACTION COMMITTEE

2.xxx SCOPE AND PURPOSE

2.xxx.1 The Global Technical Interaction Committee shall be responsible for harnessing the technical resources of ASHRAE to impact international standards and maximize the global influence of ASHRAE standards, guidelines, and other technical work products on the practice of HVAC&R and the built environment.

This includes developing, implementing, and managing processes that enable information flow and coordination between chapters, technical committees, standard project committees, and international technical advisory groups.

2.xxx.2 The committee shall inform the ASHRAE leadership and membership of the potential impacts of the activities and make recommendations on new activities and policies in response.

2.xxx.02 MEMBERSHIP

2.xxx.02.1 Maximum of thirteen (13) voting members, including a chair and a vice chair.

2.xxx.01.1.1. Vice Chair of Standards Committee

2.xxx.01.1.2. Vice Chair of Technical Activities Committee

2.xxx.01.1.3. Representatives of ASHRAE U.S. Technical Advisory Groups for ISO committees that are administered by ASHRAE (currently there are four).

2.xxx.01.1.4. A minimum of three and maximum of six members at large representing the global community targeting areas outside North America in consultation with the Regional Chairs.

2.xxx.01.1.5. Non-voting members include a Board ex-officio member, a coordinating officer, a Government Affairs Committee liaison, and an ASHRAE Associate Society Alliance liaison.

2.xxx.02.2 Qualifications

2.xxx.01.2.1 The chair and vice chair shall hold the grade of Member or higher in the Society.

2.xxx.01.2.2. The majority of the voting members of the committee must be ASHRAE members of Associate Grade or higher.

2.xxx.01.2.3 At-large members should have experience in international standards, or their local country codes and standards.

2.xxx.02.3 Term of Service

The term of service shall be one year for the Vice Chair of Standards and the Technical Activities Committee and for other voting members four (4) years, subject to ROB 3.300 *Election and Appointment Procedures.*

2.xxx.03 OPERATION

2.xxx.03.1 The committee will think and act globally, planning and implementing activities promoting the ASHRAE standards within ISO, CEN and other international standards developing organizations.

2.xxx.03.2 The committee will promote international standards and technical products, create materials to highlight their development and engage members outside North America.

2.xxx.03.3 The committee will identify areas where ASHRAE should provide administrative support for ISO technical committees, sub committees, or working groups and support member participation in other standards activities outside the United States.

2.xxx.03.4 The committee will identify areas where ASHRAE should seek member engagement in the development of standards and technical products in other standards developing organizations outside the United States.

2.xxx.03.5 The committee will coordinate with the Government Affairs Committee, enabling them to inform policy makers about the relevance of existing and developing international standards.

2.xxx.03.6 The committee may wish to bring members of other societies and groups with needed expertise to meet with this committee. Transportation costs to bring members of other societies/groups with needed expertise to meet with this committee may be paid if approved by the chair of Technology Council.

2.xxxx.04 STRATEGIC PLAN

2.xxx.04.1 The committee shall develop procedures for recommending updates to the strategic plan as needed.

2.xxx.04.2 At a minimum the committee shall submit a report to Technology Council prior to the Annual Meeting that includes the status of each activity which supports the fulfillment of the committee's assignments under the strategic plan.

2.xxx.04.3 Prior to each Annual Meeting, the committee shall report to Technology Council all recommendations for changes to the strategic plan provided by the committee's constituents.

BACKGROUND: At the start of this Society year, this Task Force was charged with refining a proposed structure and scope of a committee that reports to Technology Council, as proposed during the prior Society year and postponed pending restructuring of the Society. The Task Force was further charged to include examples of assignments that can move into this committee, such as action recommended by task forces or other ASHRAE bodies that focus on global relevance. The Task Force was told to submit the proposal to the Board ExCom by the January 2023 meeting.

The proposed Rules of the Board have been shared with the Society Rules Committee for feedback. The Task Force accepted the editorial comments received. One comment was made that part of the purpose/scope could be moved to the Manual of Procedures, but the Task Force did leave those in because it felt the list in the scope was important to leave in the Rules of the Board.

To address the remaining charge that covers responsibilities related to review of global facing MOUs, identifying emerging issues so ASHRAE is proactive rather than reactive and on what happens to the responsibilities of ILS/ISAS the task force has crafted a draft Manual of Procedures (See Attachment A.) and a draft Reference Manual (See Attachment B.). The responsibilities that consider whether an ISO standard shall be adopted by ASHRAE as an American National Standard will remain in Standards Committee as that is part of the ANSI Process. (Note: At this time there are only 2 ISO standards that were adopted as American National Standards). The responsibilities of the Intersociety Liaison Subcommittee have really been done as part of the duties of the Board of Directors ExCom and/or the Society President.

The formation of this standing committee also addresses the following goals and initiatives from the Society Strategic Plan:

Goal 1 - Position ASHRAE as an Essential Knowledge Resource for Sustainable, High Performance Built Environment.
1.b. Expand capabilities globally to create, aggregate and disseminate essential information and knowledge focusing on emerging market trends and transformative approaches.

Goal 2 – Maximize Member Value and Engagement
2.b. Expand the impact of collaboration and partnerships with industry organizations, universities, and government agencies

Goal 3 – Optimize ASHRAE's Organizational Structure to Maximize Performance
3.b. Optimize ASHRAE's organizational systems and structures to increase capacity, efficiency, and effectiveness.

FINANCIAL IMPACT: If approved the staff that supported ILS/ISAS would have the responsibility of supporting this new Standing Committee. This would not increase the staff burden or take away from existing programs. The current staffing budget would move from the ILS/ISAS program code under Standards Committee to this new Standing Committee. The committee would have two face-to-face meetings (Society meeting) and much of the membership is in the group that would have transportation reimbursed if requested. All other meetings of the committee would be virtual. The current budget for travel, excluding staff for international standards travel is listed at $6,900 for this fiscal year. In the fiscal year 19-20 Standards Committee was provided a budget of $29,000 to allow for participation in global standards activities (ISO/CEN or others) and that budget, if the request is approved, should be moved to the standing new committee and set at the $29,000 level. The travel budgets for the interim society years for travel for participation in global standards activities was decreased because all meetings were virtual. Meetings are now being held in person which is why there is a need for an increase in the budget. There is potential for income to the Society when ASHRAE's global presence is increased with the potential for membership growth, increase in sales of products or sales for newly developed products, and brand recognition.

ASHRAE Shaping Tomorrow's Built Environment Today

Short Report On
Potential Applications for Generative AI (Artificial Intelligence) and Machine Learning Within ASHRAE

Date: February 25, 2023
Report to: ASHRAE ExCom
From: M. Dennis Knight, Society Treasurer

Motions: None currently

Recommendations

Based on the information contained in the background information, appendices, and attachments to this report, I suggest that President Mehboob and ExCom consider the appointment of a Presidential Ad Hoc to do a deep dive into this subject to formulate a roadmap with further recommendations for the adoption, integration and implementation of AI. This is not a short term undertaking and could require significant input and time from staff and volunteers and substantial financial commitments moving forward. The expected outcome from this ad hoc should address the following, as a minimum:

1. Determine what potential tools are available in the marketplace and what tools we may already have available to us such as Microsoft Virtual Assistant and Microsoft PowerBI through existing subscriptions.
2. Develop a prioritized list of use cases for this technology to cover, as a minimum (some of these use cases and their investigation could, in themselves, be potential research projects and revenue streams for ASHRAE and may require outside consultants, associated partners and outside organization input and the generation of RFQs and RFPs):
    a. ASHRAE Web site navigator/search Advisor
    b. Membership self-service Advisor
    c. ASHRAE Standards Advisor
    d. ASHRAE Data Store
    e. ASHRAE Research Advisor
    f. Algorithms and Learning models for HVAC time series data
    g. ASHRAE 90.1 or other standards Specific Advisor with official interpretations and navigation features
    h. New research on AI Applications in ASHRAE

i. Owner and project-specific computable requirements and criteria (see attached research paper Van Woods co-authored, there is a very short section specifically on 4.2 Building Commissioning)
j. Computable “smart” ASHRAE technical guidelines, standards, codes, etc.
k. Generative design, semi-automated and isolated automated generation and optimization
l. Design analysis, calculation, and quantification
m. Design validation
n. Improved search, interpretations, and conclusions from ASHRAE guidelines, standards, codes, etc
o. Usage patterns of existing facilities
p. Data patterns in existing contract documents (see presentation “Identifying Data Patterns In Professional Practice”)
q. NLP of government guide specifications to find areas of incompatibility, inconsistency, duplication, or opportunities or inconsistency with ASHRAE requirements, or areas

3. Key stakeholders include, and should not be limited to:
    a. Membership (through surveys and roundtable discussions)
    b. Staff Directors
    c. Members Council
    d. PubEd Council
    e. Technology Council
    f. TAC
    g. Finance Committee
    h. RAC/Research
    i. Public/Society at large
    j. Technical Committees (potentially numerous – to be identified by the ad hoc)
    k. Standards
    l. AASA, CIBSE
    m. Federal Agencies
    n. Others?
4. Develop estimated fiscal impact statements with time lines for potential implementation that refer to the ASHRAE fiscal year structure (i.e. 2023-24, 2024-25, etc.)
5. Develop draft business and member benefit cases for both the application of the technology in general within ASHRAE and more specifically for any specific use cases that the ad hoc recommends for immediate implementation.

6. I recommend member Krishnan Gowri be considered to chair this ad hoc.

Background Information:

This report is the result of a request made to me by President Mehboob during the ASHRAE Board of Directors meeting at the Society Winter Meeting on Wednesday afternoon February 9, 2023. The background is broken down into three segments:

1. Minutes of a meeting I held on February 17, 2023, with several subject matter experts, board members and staff are included as Appendix A to this report.
2. Comments received from stakeholders subsequent to the to February 17th meeting are included as Appendix B to this report.
3. A PDF of a paper coauthored by Van Woods with the USACE and two colleagues from Carnegie Melon University on Computer Aided Requirements Management is included as Appendix C to this report.

End of Report

Appendix A

A Zoom meeting was held with a small group of ASHRAE volunteers and ASHRAE staff on Friday February 17, 2023 to discuss the topic identified in the title of this report. The following are the minutes of that meeting:

Invitees: (blue text names attended the meeting)
Chris Gray
Dru Crawley
Dunstan Macauley
Susanna Hanson
Luke Leung
Farooq Mehboob
Ginger Scoggins
Jeff Littleton
Krishnan Gowri
Ian Keough
Van Woods - US Army Corps of Engineers - (Note - I had about a 45-minute telephone call with Van after the meeting - those notes will be summarized in a separate document)
Dennis Knight

Additional Attendees:
Joyce Abrams - ASHRAE Staff
Scott Munns - Trane Technologies
Craig Wright - ASHRAE Staff
Stephanie Reiniche - ASHRAE Staff

Introduction:
During a strategic discussion at the ASHRAE Board of Directors meeting at the Society Winter meeting on Wednesday afternoon February 9, 2023 I was asked by President Mehboob to assemble a small group of board members and subject matter experts from within ASHRAE and outside to hold a high level discussion about the Potential Applications for Generative AI (Artificial Intelligence) and Machine Learning Within ASHRAE and to provide ExCom with a short report within two weeks of possible recommendations and next steps. This meeting is the first step in fulfilling that request.

Prior to the meeting the group of invitees exchanged emails and performed a few thought experiments with a free online generative AI conversational chat tool known as ChatGPT to get a feel for what the technology can potentially do. Some of that content has been shared with the group. The ChatGPT tool's foundational model and its associated "data lake" training ended in 2021 and uses mostly publicly available data scraped from the internet to generate its "human like" replies to online users' questions and queries. At this point the answers, at least with respect to ASHRAE, while interesting and impressive, seem a bit shallow and formulaic. That is most likely because the tool was not trained using any specific historical or detailed technical data that has been generated in ASHRAE's 129-year history.

In addition to using the free online tool for experimentation, my first email to the group suggested that everyone read a recent article published by McKinsey's QuantumBlack AI department published on December 20, 2022 titled "Generative AI is Here: How tools like ChatGPT could change your business." The conclusion of the article suggests the following:

"In companies considering generative AI, executives will want to quickly identify the parts of their business where the technology could have the most immediate impact and implement a mechanism to monitor it, given that it is expected to evolve quickly. A no-regrets move is to assemble a cross-functional team, including data science practitioners, legal experts, and functional business leaders, to think through basic questions, such as these:

- Where might this technology aid or disrupt our industry and/or our business's value chain? *(Ian Keough comment during the meeting: Everywhere and everything - it might not be obvious where that might happen right now …)*
- What are our policies and posture? For example, are we watchfully waiting to see how the technology evolves, investing in pilots, or looking to build a new business? Should the posture vary across areas of the business?
- Given the limitations of the models, what are our criteria for selecting use cases to target?
- How do we pursue building an effective ecosystem of partners, communities, and platforms?
- What legal and community standards should these models adhere to so we can maintain trust with our stakeholders?

Meanwhile, it's essential to encourage thoughtful innovation across the organization, standing up guardrails along with sandboxed environments for experimentation, many of which are readily available via the cloud, with more likely on the horizon."

Also, during our meeting with the CIBSE delegation from the UK at the Atlanta meeting we were informed that CIBSE is already exploring this technology and has hired a consultant and has begun populating at "data lake" with some of CIBSE's technical documents and intellectual property. CIBSE offered to share their experience with ASHRAE, and lessons learned in the coming months as they move toward being an early adopter of the technology.

The following is a brief synopsis of the group's discussions today:

We held a brief round of introductions and went over the introductory material above. Then we opened the floor for comments from the subject matter experts who agreed to join us on the call today.

Krishnan Gowri (KG): A session was held at the winter meeting and sponsored by Technical Committee (TC) 1.5 on chat bots and how our members and their businesses might benefit from them. He suggested that we consider using Microsoft Virtual Assistant as the front end to access material like our dictionary of HVAC&R terminology.

- Others are beginning to consider using a conversational AI or machine learning tool for system diagnostics using existing knowledge and trends to predict equipment failures and generate new content.
- We could have a conversational chat bot overlaid over the ASHRAE web page to organize information requested by members.
- TC 7.5 has several things going on with the Kaggle competition.

(Kaggle is a data science hub. It provides access to over 50,000 public datasets and 400,000 data notebooks. Krishnan and ASHRAE have been participating in competitions and exercises designed to explore and introduce professionals to the application of data science and big data analysis analytics for HVAC&R for several years. Here is a link to the Kaggle website.)

Note - The Microsoft Virtual Assistant platform may already be available to ASHRAE for creating internal conversational bots. The tool is available to Microsoft Teams subscribers. Here is a link to the Microsoft Virtual Assistant webpage for additional information. This site has a lot of information, demonstrations and guided tours of the

product and its capabilities. It integrates with Microsoft's other Power products. I know we are already using PowerBI for some of our financial analytics.

Dru Crawley (DC): Suggests we try to define why we want to consider using the technology and what we would like to use AI for. Bentley is using deep learning to analyze 3-dimensional data and information in BIM models.

Ian Keough (IK): Ian provided a link to a short video about the potential that we could watch during his introductory remarks:
https://twitter.com/HyparAEC/status/1626185397561700352
Looking at AI and how it's being used in other industries. The best applications are using natural language (NL) interfaces. Taking NL interfaces and mapping to create generative … (I did not get this part jotted down??)
These interfaces are lowering the boundaries for entry for many companies.
Computational design, project based.
Companies have been trying to use BIM and read data from BIM to create models that could replace designers or at least the early phases of design for a while. The problem is these systems were not designed to generate machine readable data and use it in an AI application. Most companies are spending most of their time cleaning up their old data. They have years of unstructured BIM content created by multiple users with no standards. It's a challenge. How do we start to create a framework to generate data/content that can be used by machines - in a standardized format - for these AI and Machine Learning (ML) tools to access and use?

*Note - I am not sure if anyone noticed, but Ian was using a notetaking AI called **chorus ai** which is a conversation intelligence AI application owned by ZoomInfo primarily used by sales teams to gather intelligence from sales force interactions with clients and potential clients to improve business sales and forecasts. I am assuming the application could be used for much more and maybe a lightweight technology ASHRAE could explore to help manage some portions of our member services. The application logged into our meeting as Hypar Notetaker. Here is a link to the company's website: https://www.chorus.ai/*

Scott Munn (SM): agrees with Ian. Large bodies of text created over decades and being able to have an AI internalize that is a powerful potential. They are seeing big potential with control applications. This is a different use case though. Predictive

analytics, fault detection, then move to cognitive analytics - where the AI actually begins to make autonomous decisions.

Susanna Hanson (SH): for example - standards. What can AI write for us?

Jeff Littleton (JL): We have a large 4-volume handbook (HB) series. Updates are issued every year. What does it take to implement a NL interface if the HBs are not partitioned in a way to be machine readable? They contain a lot of complex content and formulas.

IK: He used a startup called Upcodes as an example. They began “ingesting” the I-codes and thought that within 1-year they would have a complete solution for code queries and NL guidance for engineers, architects, etc. They are now 5 years into the process and their biggest challenge is all the jurisdictional modifications to the codes across the US. They are numerous and some are very subtle. They are just now able to strip out formulas and put them to use. For example: input the slope of a roof and the snow load region and the system extracts information from tables and formulas in the IBC and the bot calculates project specific structural design criteria from them.
In addition, for NL chat bots like ChatGPT there are lots of opportunities to train the bot with content from ASHRAE and have the bot generate content written in the style of ASHRAE.

Jeff Littleton (JL): How do we control how chat bots from outside ASHRAE tap into our data and how do we control access?

IK: Not an expert at that but the data must be accessible and indexable if a public bot is going to be able to get to the data and use it.
Some companies are creating custom solutions and training them.

DC: Maybe we don't think about our entire handbooks - possibly prioritize a few key chapters and see what can be done.

KG: All handbooks (HBs) are in word format. Use an AI chat bot to generate responses to queries at first and keep the formulas as static images for the time being. This would help engineers and users by not having to go to the back of the book, find keywords and going back and forth between volumes to put together a design process. Some learning and rule sets would have to be created. This could be built on Microsoft Virtual Assistant.

JL: There is clearly a marketing element to this. If someone uses another NL tool - how will they find our information.

SH: How does an AI know when it is wrong.

Dennis Knight (DK): Gave an example of my session with ChatGPT - I asked what the last 6 ASHRAE presidential themes were. It got two right. I provided feedback to the bot that the other 4 were wrong and provided the correct answers to help it learn. This is part of the initial training of the tool(s). A team of experts must take the time once a tool is trained to try and break it. Ask lots of various questions, correct wrong answers, and ensure the tool is providing useful answers similar to the answers the experts would have given had they been asked the same questions.
I asked how do we go from data puddles to data pools to data lakes and make them useful?

(Note - a data lake is a term being used in the industry to represent an organization's historical data that is accessible to the tools using generative AI technology to perform the functions the organization intends the tool to be used for.)

IK: Data Lake strategies are highly variable right now. Some are just taking data out of their existing systems and dumping it into a central location where it may be used at some point. Other companies are being much more strategic. They are looking at their data resources, thinking about the applications and use cases and structuring their data to optimize its use for those applications.

Luke Leung (LL): He is kind of in the Santa Clause and Easter Bunny phase. There is a lot of talk out there, but he is not currently actively doing anything with the technology at his work.

JL: I try to organize the uses into buckets - how can AI be deployed in our community?

1. How ???(I missed the first bucket)
2. How to improve the business of ASHRAE - operational, identify trends, identify gaps that need to be filled and how valuable it could be.
3. Improve the useability of our technical guidance?
4. How to improve the member experience?
5. How will the industry use AI and is ASHRAE in a position to write standards to define a system and generate a useable model?

I am convinced this will affect everything we do - will generate some winners and some losers. ASHRAE wants to be on the winning side of this transition.

LL: He is with Jeff. He is working with an NREL startup as an advisor. What are a couple of things we can do. Gave an analogy to music. Some machines read musical notes and create beautiful music - others junk.
How do we train a chat bot with our IP to get beautiful solutions and be able to know when something is wrong with the answers being provided?
Wouldn't it be a nice solution to be able to use the tool to speak to a user like a city administrator or mayor and provide ASHRAE content tailored to the administrator's needs?

IK: The systems are automated through Application Programming Interfaces (APIs). An API is a standardized contract between different software systems on how they will interact with each other and what data is available for use through the API between them.

SH: Question of how an AI can be used to control a building. TCs - how to define a control system. How do we write standards that can define the controllability of a building at a higher level - example - what is being worked on by TCs that is going on in Standards 232 and 223P -

Scott Munn (SM): Tagging. Those things can be reasonably standardized.

JL: Our business model is to bring together the best subject matter experts in the world, aggregate their knowledge, curate it, publish it, make it available for a fee or as a member benefit? How can this be monetized?

IK: This is Hypar's whole business model. They bring experts together and make their content broadly available. We monetize it through software that would like to use the data through APIs that make calls for the data. For example, through a member benefit or subscription maybe a member would get access to all the tools licensed through ASHRAE APIs to have access to ASHRAE's data.

DK: I gave Ian the example of how we created a dedicated server at ASHRAE HQ years ago called data.ashrae.org with the intent during the early adoption phase of BIM that it would be a data repository for ASHRAE member vetted BIM content that software would access through APIs for a fee. This has never materialized.

KG: For every API call there is a percentage fee. Amazon Web Services is one example of a service that tracks and monetizes usage through APIs. Microsoft and Google have similar solutions.
We need to identify the new AI technologies and applications of each to ASHRAE from stakeholders perspective, or identify each stakeholder needs and determine if AI technologies can be developed.
An Initial List could consist of:
AI Technologies:

Rue-based Chatbots
Conversational AI Chatbots
Machine Learning Models (Deep learning, supervised/unsupervised learning models, neural networks, reinforcement learning models)

ASHRAE Stake holders

Member services
Public/Society at large
Technical Committees
Standards
Research
Publication Staff

Use Cases/Activities:

1. ASHRAE Web site navigator/search Advisor
2. Membership self-service Advisor
3. ASHRAE Standards Advisor
4. ASHRAE Data Store
5. ASHRAE Research Advisor
6. Algorithms and Learning models for HVAC time series data
7. ASHRAE 90.1 or other standards Specific Advisor with official interpretations and navigation features
8. New research on AI Applications in ASHRAE

All advisors above are meant to conversational AI chatbots that are trained with existing information, FAQ and rule bases that will also learn from user interactions to interpret and intelligently respond connecting all aspects of identifying ASHRAE materials/resources, providing links for publicly available and priced publications or standards.

Someone posted a link to the following article in the chat box for the meeting:
https://www.washingtonpost.com/technology/2023/02/16/microsoft-bing-ai-chatbot-sydney/?utm_campaign=wp_post_most&utm_medium=email&utm_source=newsletter&wpisrc=nl_most&carta-url=https%3A%2F%2Fs2.washingtonpost.com%2Fcar-ln-tr%2F3927117%2F63efb5ff1b79c61f879897d1%2F596a6904ae7e8a0ef33e3130%2F45%2F72%2F63efb5ff1b79c61f879897d1&wp_cu=695e7c6f7e74c194549134cecc8024ff%7CC0DF36E2B3D57260E0430100007FA511

End of February 17, 2023, meeting

Appendix B

Comments received since the February 17, 2023 Zoom meeting :

LL: Consider organizing or convening a workshop with partners like the AIA, NIBS, CIBSE, Google AI, Open AI, Azure, Dr. Dario Gil (IBM), Dr Fei-Fei Li (Stanford) government agencies, etc. with the expected outcome to be what are the use cases and what standards can we write allow this technology and our organizations and members do their work better by applying the tools. Data delivery standardization could be a very focused desired outcome. We could run it through NIBS potentially given their links to the federal agencies or we could run it similar to our Global HVAC&R Summit.

DC: A couple of interesting articles on AI this week... first one is good at talking about the types of AI and how each type is useful:

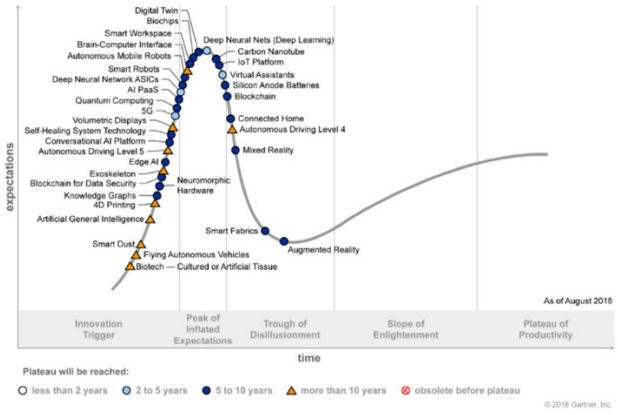
How to try the new AI tech everyone is talking about
https://www.washingtonpost.com/technology/2023/02/10/ai-guide/

AI, drones, & country-sized digital twins: mirroring the real world in code
https://johnkoetsier.com/ai-drones-country-sized-digital-twins-mirroring-the-real-world-in-code/

AI in the Workplace Is Already Here. The First Battleground? Call Centers.
https://www.wsj.com/articles/ai-chatgpt-chatbot-workplace-call-centers-5cd2142a

If you can't to the articles, let me know and I'll grab a PDF.

I've been watching this area for many years -- the hype around AI is more than I've ever seen, hitting the peak of inflated expectations... like this hype curve from Gartner a few years ago.



Van Woods (VW), USACE:
Dennis, thank you for the notes, and I regret not being able to make the meeting this time but look forward to further conversation in this area. I am in the camp that believes that AI/ML will bring about very significant transformation and that the latest developments are impressive but just the beginning…I am also reminded of the always present hype cycle and the innovation adoption curve and the importance of finding real business value beyond the novelty.

Use cases:

1. Owner and project-specific computable requirements and criteria (see attached research paper I co-authored, there is a very short section specifically on 4.2 Building Commissioning)
2. Computable "smart" ASHRAE technical guidelines, standards, codes, etc.
3. Generative design, semi-automated and isolated automated generation and optimization
4. Design analysis, calculation, and quantification
5. Design validation **
6. Improved search, interpretations, and conclusions from ASHRAE guidelines, standards, codes, etc
7. Usage patterns of existing facilities
8. Data patterns in existing contract documents (see presentation "Identifying Data Patterns In Professional Practice")
9. NLP of government guide specifications to find areas of incompatibility, inconsistency, duplication, or opportunities or inconsistency with ASHRAE requirements, or areas

I am very glad Ian mentioned the Upcodes example, because I am extremely interested in "smart" standards, guidelines, codes, etc. My examples 1, 2& 5 above are probably the highest value use cases I can see for us as owner's representatives because so much time is spent defining requirements and then validating them. It would be quite transformative if AI/ML could provide even an 80% solution of determining whether a design met project specific ASHRAE requirements, without the current "100,000 clashes" equivalent overload. A key pillar to higher-level reasoning is being able to express the requirements in a computable method, but maybe AI/ML can help bridge the gap from the current textual and tabular requirements to enable greater analysis of designs.

Lastly, I'm keen to pursue "data commissioning" as a concept because procurement of high-quality data about assets has been extremely challenging, and AI/ML stands to gain from more and higher-quality data (see presentation in #8 above).

The third bullet below about a panel with NIBS is something in my current role on the NIBS BIM Council Board of Direction would be very interested in discussing further opportunities in this area.

Appendix C

A PDF of an article related to BIM authored by Van and two coauthors from Carnigie Melon University on Computer Aided Requirements Management is attached.

EMERGING CAD PROCESSES: AN ANALYSIS AND REVIEW OF COMPUTER AIDED REQUIREMENT MANAGEMENT

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Abstract. Many large institutional organizations and corporations actively manage their facilities and future design needs. Facility related criteria express prescriptive and descriptive requirements that are relevant to their mission-specific, institutional objectives. Creation, maintenance, distribution, and the effective use of this information are currently typically managed in an *ad hoc* manner without domain-specific computational support. In this paper, we review current approaches of managing facility requirements that provide computational support. We provide suggestions for the future role of requirement management in design and planning.

1. Introduction

Information management has been a primary focus of building design computing for over three decades. One of the key information management tasks, especially during the problem formulation phase of design, is managing the poorly or partially presented design requirements, and extracting useful design information from them. Problem formulation involves utilizing different types of information that express a desired state or a proposed solution at different stages of the design process. Requirements represent these different types of information and they can come in the form of needs and wants of the clients and users, constraints and standards of the selected technologies, information about functional and operational aspects of the desired design solution, implications of the design decisions, existing conditions, or quality determinants. The desire to achieve

results within a predictable level of quality, cost, and schedule motivates organizations to spend considerable resources in the process of managing requirements. As a result, interest in computer support for requirement management tasks has been increasing.

The basic process of managing requirements refers to 1) the elicitation and expression of desired characteristics, 2) the usage, maintenance, and distribution of this information, and 3) the measurement and tracking of the degree of design compliance and other performance analyses. Requirement specification starts early in the design process and provides the context and design rationale for most subsequent design decisions. However, current approaches do not address the bottlenecks observed in inefficient use of the requirement information, unsupported change management, consistency checking and design compliance verification processes in building design. As a consequence, the use of early design information is left to be a time consuming, error prone, ad-hoc, and manual process. Our interest is in exploring how to electronically manage requirements in order to increase quality by addressing these bottlenecks, while facilitating better information management throughout the overall building life cycle.

The use of building product data models and computer supported design processes are no longer imaginary scenarios, but are necessary for design productivity and performance. Moreover, increasing computer literacy in general purpose applications, as well as in assistant tools that address performance analysis, collaborative design, and information management are promising developments for design life cycle information management. Initiatives like Leadership in Energy and Environmental Design (LEED) Green Building Rating System are also increasing the awareness of the professionals in managing the information that is created during the design delivery process. However, the concept of providing computational support for requirement management is still rather new in the building industry and has not reached a level of maturity where utilization of early design information has become more accurate, robust and persistent throughout the design life cycle.

This paper will describe computer aided requirement management (CARM) by focusing on selected studies and tools from government, industry and academic research. Section 2 will summarize the motivations behind various stakeholders' interest in digital requirement information management. Section 3 will present an array of exemplary tools and approaches addressing building data modeling, collaborative information sharing, usability, and design and life cycle integration aspects of requirement management problems. Following this discussion, Section 4 will discuss building product data and process modeling for CARM. Section 5 will provide examples of applications of requirement management in other design-related domains, specifically from software engineering. And finally,

Sections 6 and 7 will give a summary of our observations and our concluding thoughts for a roadmap, respectively.

2. Needs and Wants

Reasoning with requirements is inherently a user-mediated process. An interesting aspect with most designs is that any specification of requirements in an open domain is partial at best, given the presence of requirements that are implicit (not yet expressed) and tacit (difficult or impossible to model) (Hutchins 1995, Polanyi 1962). This is commonly referred to as the emergent nature of design, which leads to the inherent difficulty (or some would say impossibility) of automatically generating design solutions from requirement specifications, no matter how detailed they may be. This holds true even when dealing with routine cases, such as computing requirements for recurring building types (Erhan 2003).

Currently, many requirement specifications are already stored as digital artifacts, albeit in loosely structured formats. These include items such as facility design guides and conceptual design analysis reports in textual formats in word processing documents. The use of digital spreadsheets for architectural programming spatial analysis is also common. However, these only provide digital storage media and are not accompanied by any advanced computational support specific to the process commonly referred to as briefing or architectural programming.

While the basic premise is to formalize what is expected and what is delivered, there are opportunities to meet more advanced user needs in requirement management. The user in this case includes facility owners and designers, as well as the many other architecture, engineering and construction (AEC) industry professionals participating in the design and delivery of buildings. During the requirement elicitation processes, issues such as collaborative data management for group elicitation and support for broader data gathering methods, such as surveys, are of relevance. The common participation of numerous stakeholders makes distribution of requirement information, change notification, and version control processes critical. Issues surrounding data maintenance and updating are also inevitable, given that requirement information for buildings are rarely static over time. In addition to the requirement elicitation and information distribution issues, the actual usage of the created information for decision-making brings to the fore unique needs for CARM. Decision-making processes utilize requirement information relevant to both designers and managers such as requirement dependencies, preliminary cost and schedule, and other possibly analyzable trends, such as coverage rate and creativity.

Given the collaborative nature of the requirement management process, requirement tracking in terms of compliance validation, responsible agent

identification for a particular requirement item, priority, approval, and completion status all become crucial pieces of information to control. Other desirable functionalities include providing efficiencies through adaptable reuse, possibly in the form of solution templates and reusability strategies or patterns. And finally, an item that is commonly overlooked is how such approaches fit into current and legacy information documentation. Computational support for reverse engineering and data mapping to loosely structured documents are exemplary functionalities in this area.

Currently, treatment of requirement management via computer aided design tool support is dispersed. While there are tools that cover the common information management aspects of CARM, such as navigation, accessibility, exchange and maintenance of data, these do not impact the use of requirement information as a design aid. In section 3 we will present example studies from industry, academic and government research platforms to demonstrate the focus areas in CARM.

3. Approaches to CARM

Research, both in academia and in government agencies, has been addressing the CARM problem for more than a decade now. Recently, these developments have resulted in a significant increase in the number of prototype tools that address requirement management both in research and in commercial initiatives. Exploration of appropriate computational techniques to aid designers in CARM, generally speaking, calls for an emphasis on information processing and design integration. More specifically, the literature on design requirement management in architecture reveals multiple tracks: architectural programming, performance modeling, design integration, and requirement management in other design disciplines whose problems are similar to architectural problems in complexity and structure, such as software engineering. These suggest a variety of approaches for managing requirement information in AEC.

Requirement discovery and representation problems based on designers' need to translate customer and product needs into technical constructs are generally referred to as requirement elicitation. Techniques used in this area, such as QFD for client requirement processing (Kamara et al. 2000), value added functional analysis (Elbibany et al. 1997), and axiomatic design (Suh 2001), are commendable approaches to structuring the process, but their manual approach and lack of overall integration with building models make them expensive and time consuming to use. Moreover, such techniques address requirement management problem during early phases of design which creates potential bottlenecks in the use, maintenance, distribution, design compliance verification, and tracking of the requirement information

in subsequent design phases. In this paper, we review examples which address one or more of the following: managing design life cycle through requirement information, integrating requirements to building product data modeling, and extracting potential generalized approaches for requirement management support.

3.1 GOVERNMENT INITIATIVES

The United States government is arguably the largest owner of facilities worldwide, as well as the owner of the largest amount of documented requirements and criteria. The amount of requirements are due to 1) the shear magnitude of quantity of facilities that are necessary, 2) the vendor neutral nature in which the government operates which requires performance specification rather than specific manufacturer and product preferences, 3) the strict performance requirements necessary to uphold the unique security and technical functions, 4) the presence of commonly recurring facility types which leads to an accumulation of corporate knowledge over time, and 5) the need to collaborate between highly dispersed groups as well as between public and private organizations.

Government agencies have been placing a special emphasis on the importance of managing requirements for the design life cycle, with a focus on the quality of the building end product. The Whole Building Design Guide (WBDG) is an example to these efforts (WBDG 2003). WBDG is a collaborative effort among federal agencies, private sector companies, non-profit organizations, and educational institutions lead by the National Institute of Building Science (NIBS). The goal of the 'Whole Building' design approach is to create successful high-performance buildings by focusing on a holistic process. To achieve this goal, an integrated design approach to the project during the planning and programming phases is promoted. The premise of WBDG is that buildings must be competently planned, functionally adequate, appropriate in form, cost-effective, constructible, adaptable, durable, and contextual. Its aim is to emphasize the interdependence among building systems and provide resources for professionals that share these goals, many times organized by facility type.

Another significant effort that government agencies have pursued is to move towards an electronic publishing format for the requirements they use for their facilities. The Army Criteria Tracking System (ACTS 2003), RPLANS (RPLANS 2003), and the Army Corps of Engineers Engineering Regulations repository websites (EngRegs 2003) are a few of these online resource examples. The mission of these resources is to provide policy guidance and program management on all matters relating to the overall management of Army installations worldwide. The software applications used and created are directed towards easing collaborative information

creation, sharing and maintenance. They also try to alleviate bottlenecks caused by manual techniques, which are both prone to errors and do not support change management well.

These government initiatives have been also pursuing software support to maintain the information generated and its integrity. SpecIntact (Specifications-Kept-Intact) is an automated system for preparing standardized facility construction specifications (UFGS 2003). It is developed for worldwide use by NASA, the U.S. Naval Facilities Engineering Command (NAVFAC), and the U.S. Army Corps of Engineers (USACE). The functionalities of the software mainly focus on creating an automated collaborative environment where project stakeholders can develop, share, and reuse building information. The software is intended to manage the Unified Facilities Guide Specifications (UFGS) under Construction Criteria Base (CCB). CCB is an extensive electronic library of construction guide specifications, manuals, standards and many other essential criteria documents by the National Institute of Building Sciences (NIBS). The tool can be viewed as an advanced, but specialized text editor, allowing editing and organizing requirements using standard generalized markup language (SGML), an international standard that allows defining and tagging of information within documents. The tool is used in assisting information exchange management.

3.2. COMMERCIAL TOOLS

There are only a few commercial examples illustrating any type of integrated design environment that supports requirement elicitation while also providing features for the design process, allowing a designer to review and compare the current state of a design proposal to the specified user requirements. Trelligence is an exception as it is a good example of tracking functionality dealing with requirement elicitation, definition and design (Figure 1). It provides visual feedback, context specific indication of relevant performance objectives, and graphical aids for space layout (Trelligence 2003).

Commercial tools integrated with database support are also available. For example, SpecLink and Perspective by Building Systems Design, Inc. offer comprehensive search mechanisms and change management for keeping track of requirement information. User interfaces developed specifically for managing requirements increase the usability of these applications in CARM (BSD 2003). And finally, there are also tools that integrate requirement management with a building product data model back-end. Solibri Model Checker by Solibri Inc. is a typical example. The application acts as the equivalent in concept to a spell checker program for building models based on Industry Foundation Classes (IFC) by allowing automated

checking of design errors that can be specified by the end user (Solibri 2003).

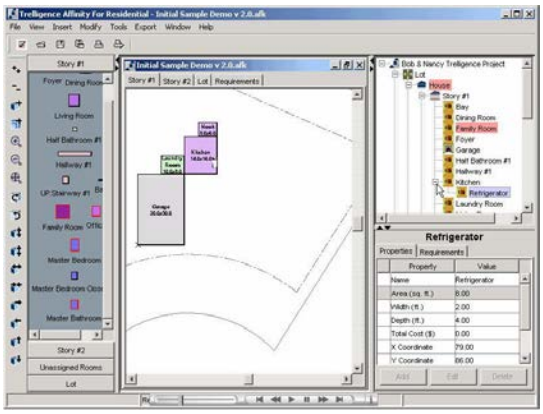

Figure 1: *Screen shot from Trelligence showing the integrated design and requirement information medium.*

3.3 RESEARCH-BASED INITIATIVES

There are multiple research-based initiatives that are of relevance. We will review systems that we consider seminal in this area. They allow the possible use of requirement data in design life cycle, and also provide strategies to manipulate this data. They offer possibilities to extend information management into design beyond requirement documents management. We have selected SEED-Pro, Rabbit, Facility Composer, Design Intent Tool and Metracker systems. SEED-Pro (Akin et al. 1995) and Rabbit (Erhan 2003) have been developed at the School of Architecture at Carnegie Mellon University as a result of the Software Environment for Early Phases of Building Design (SEED) research (Flemming et al. 1995). The Facility Composer suite of tools has been developed by the Construction Engineering Research Laboratory (CERL 2003); the Design Intent Tool (DIT) by Lawrence Berkeley Labs (DIT 2003); and Metracker by The Public Interest Energy Research (PIER) (Metracker 2003). In this section, we will briefly present these systems focusing on their features that we believe are influential in providing a vocabulary for more advanced support for CARM.

3.3.1. SEED-Pro

SEED is a computer supported design environment featuring an open-ended modular architecture, where each module focuses on a design activity that takes place in the early design stages. SEED provides support for a range of

tasks starting with architectural programming and spanning to 3D configuration management, for the entire design life cycle process. Each module consists of five main components: input, specification, generation, evaluation and output. These are supported by a database to store and retrieve information, as well as a user interface to facilitate the interaction with designer.

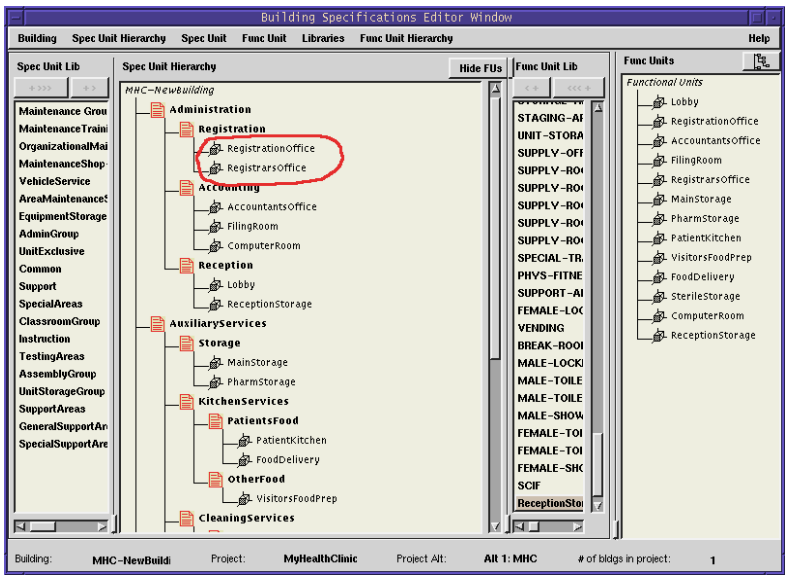

Figure 2: *Main requirement modeling window of SEED-Pro*

To support design generation, a well-defined set of explicit requirements is needed. SEED-Pro, the building requirement specification module of SEED, has been designed with the intention to assist the modeling and generation of design requirements in a form that is usable by other modules of SEED (Akin et al. 1995). It fulfills the following objectives:

- Storing and handling multiple aspects of requirement information including site characteristics, codes, client preferences, and design performance criteria.
- Using criteria established during the requirement specification phase as a basis for design generation.
- Integrating building requirement specification and architectural design as a seamless process.
- Making requirement specification decisions and improving the computability of requirement specification information by allowing non-numerical types of reasoning in the database.

- Providing a flexible interaction that does not tie the user to a specific requirement specification model.
- Using past requirement specifications in future projects.

The main interaction window in SEED-Pro supports the development of a hierarchical decomposition of the requirement for design (left two columns in Figure 2). In this hierarchy, all components of the buildings functional, programmatic, budgetary, site-related and organizational aspects can be modeled. Each of these components is further specified through a predefined attribute-value model. Furthermore, SEED-Pro allows the user to create functional constraint hierarchies (right two columns in Figure 2), which correspond to these requirement specifications. In this way the designer can specify the precise area, adjacency, and other performance constraints to be met by succeeding modules of SEED, whether these are for space planning (SEED-Layout, Flemming and Chien 1995), system configuration (SEED-Config, Woodbury and Chang 1995) or standards conformance (Garrett et al. 1995).

Through the sharing of domain object classes, SEED-Pro provides seamless interaction with all of the other modules of SEED and shared data across these modules. SEED-Pro maintains a robust record of design requirements, criteria, and constraints to be used persistently during design. Seed-Pro, in its second version called SP-II, handles all of these functionalities in addition to providing flexibility to dynamically specify the parameters of the modeling environment, including, variables, data types, relations and dependencies between variables. This overcomes the inflexibility caused by the pre-defined attribute-value sets present in the earlier version of SEED-Pro.

3.3.2 Rabbit

The Rabbit environment (Erhan 2003) primarily focuses on eliciting requirements for recurring building types interactively (Figure 3). Erhan's study aims to help designers, facility owners, and planners interactively define (enter program components with constructs as design program parameters), generate, and modify program requirement information by providing a visual navigation system to the user. Similar to Seed-Pro (Akin et al. 1995) and SP-II (Donia 1998), this study focuses on the computer's ability to generate architectural programs that can be accepted as input by other applications, like generative design and decision support tools. Of particular interest with this approach are the underlying graph transformation concepts, the flexibility in ability to express the design requirement assumptions, and the visual display tools that illustrate

dependencies, as well as the ability to provide immediate feedback on allowable interactive transformations of data.

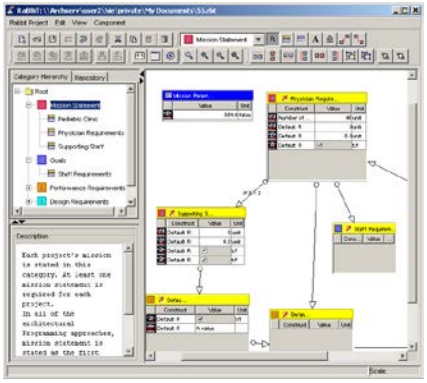

Figure 3*: Rabbit's programming environment*

3.3.3. Facility Composer

The Facility Composer suite is a set of tools developed by the Army Corps of Engineer's Construction Engineering Research Laboratory (CERL) that supports the notion of criteria-based facility modeling (CERL 2003). The suite consists of three primary tools: Requirements Composer, Planning Composer, and Layout Composer. These correspond to capabilities to: assist the creation and modification of reusable, building-type specific, default criteria stored in criteria libraries; support for architectural programming and other project-specific criteria value specification during interactive design charrettes or at the designer's desktop; and support for the creative and analytical aspects of architectural conceptual design in a 3D environment, respectively.

Features of Facility Composer include an interface that supports high-level domain specific actions in an interactive graphical environment (such as a project tree that is tied to the project's graphical representation as seen in Figure 4), the notion of a project hierarchy and the ability to specify criteria at different levels of detail (with inheritance and specialization) organized by user-definable design disciplines, support for the generation of alternatives, and multiple geometric representations for any given solution ("Above/Current/Below" which corresponds to architectural plan delineation conventions, "Bubble Diagram", and "Color by Function").

It is envisioned that after having built numerous buildings of a particular type, say barracks (or an apartment complex as a similar example in the private sector), over time much of the relevant criteria will have emerged and have been expressed. These types of collections of criteria can be stored in a 'criteria library' of sorts, which would allow for rapid reuse by reducing

the amount of up front repeated data entry. Use of criteria libraries are also expected to result in improved customer requirement elicitation, less errors and omissions resulting in fewer problems due to inconsistent expectations, and better preliminary budget estimation in cost, capability, and time.

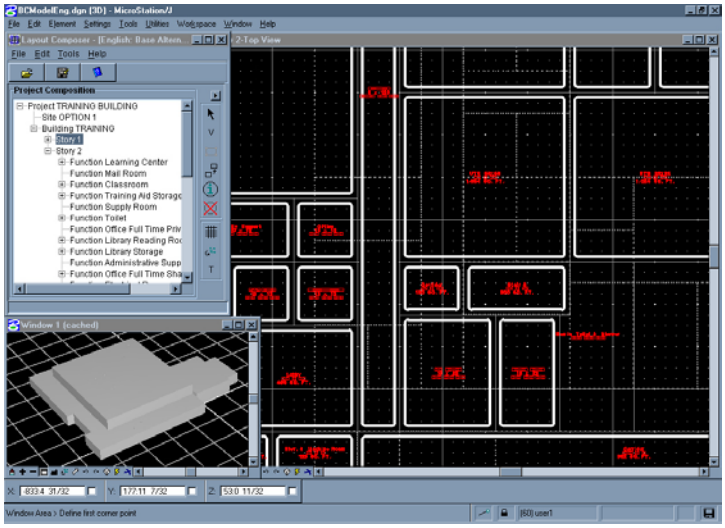

Figure 4: *Integrated environment of layout composer with requirements compose as implemented in Microstation/J*

The application allows architectural programming processes to support top-down, bottom-up, or middle-out approaches within project hierarchies that consist of *Project, Site, Building, Storey, Function* (space types), and *Space* instances. For example, in the project composition hierarchy, one could program the requirements for 1000 sf. of offices in a *Building*, for which during design, *Storey* A ends up with 400 sf. and *Storey* B ends up with 700 sf. Note the allowance for discrepancy from the initial programmed amount. The user can visually discern that they have committed too much area for which they could reduce the higher-level goal or the lower level assignment. The reverse (starting with specification at the lower level and working up), and hybrid approaches are possible as well.

The Layout Composer application integrates the required functionalities of CARM in a CAD environment. Once the architectural programming has been conducted, the design architect can take the expression of desired functions and their area allowances and adjacencies, as well as other project criteria, to begin establishing one or more preliminary spatial configurations graphically within the CAD environment. The application provides domain-specific functionality such as the ability to create stories and placing spaces on them, while leaving CAD-specific functionality such as snapping and

other geometric editing capabilities, as well as 3D volume rendering with transparency and animation to the CAD environment.

One of the goals is to make the user interaction dramatically easier than current modeling approaches by providing specific tools and components (for example the hierarchical project tree and criteria table), as well as by having the system automatically keep track of the evolving design in order to illustrate variances with the desired criteria. The system is designed such that operations and properties at higher levels in the hierarchy automatically propagate to lower levels, and lower levels can also provide specialized values. This enables features like being able to delete or move all of the spaces on a storey by changing the story instance, or by changing a floor-to-floor height between stories, which automatically adjusts the height of the spaces on each of the stories, including a space that might span across multiple stories. This is in contrast to current commercial application approaches that require file-based approaches or are not capable of these features.

Another feature of the suite is a concept called wizards. These allow an organization to define chunks of design logic in a computable format along with their associated criteria. A wizard allows new design processes and calculations to be included without requiring a recompiling of the main application. In addition to application extensibility, it also enables more effective information management and reuse by decoupling design logic from the main application, and by providing greater cohesion between the design logic and the criteria it uses. Take, for example, a Parking Lot wizard. Chances are the user could use such a wizard to aid in the creation of suitable parking lots for any number of building types. There may be certain building types that would have to have a specialized version of the wizard that might, for example, account for more security.

Development of the system was heavily influenced by prior collaboration with the SEED project and from prior work at CERL on the Modular Design System (MDS 2004). In particular, there was the observation of the benefits of clearly delineating between user need specification, functional requirement description (spatial types and their associated criteria), spatial layout exploration, and spatial configuration representations (Flemming et al. 1995). This approach was shown to be robust as it recognized the intrinsic nature of many designs in open or “wicked” problem domains (Rittel 1973) in allowing for each upstream solution to serve as a specification of a desired state for which one or more downstream solutions could be developed. Other desirable characteristics were the aspects of extensibility, and also the importance of providing separate and specific interfaces for different phases in the process within an integrated environment. SEED was one of the first implementations in which these primary tenets were observed in an integrated environment. This was a

departure from prior work at CERL where requirements were implicitly encapsulated in graphical representations of pre-designed geometric configurations.

3.3.4.Design Intent Tool

Design Intent Tool (DIT) helps building owners, architects, and engineers develop a "design intent document" (DIT 2003). This document is aimed to facilitate record keeping and ensure that the owner's and designer's up front vision and goals are achieved and periodically verified through performance measurement. The focus of the "document" as it is scoped in DIT is on energy-efficiency, while intended for any aspect of design. The documents evolve as the project moves through the milestones of programming, design, and construction, into building occupancy and potential future renovation and retrofits. Design intent documentation is crucial to the post-construction commissioning process (verifying the proper installation, operation, and performance of energy-efficiency features), and is the essence of communication and contractual obligation between the building owner, architects, engineers, builders, and commissioning agents. This intent also keeps track of the requirement information as it goes through various stages of design. The document provides a reference medium for design life cycle management and collaboration.

3.3.5 Metracker

Metracker is a prototype computer tool designed to demonstrate the specification, tracking, and visualization of building performance objectives and their associated metrics across the complete life cycle of a building (Metracker 2003). The underlying concept is that, in order to better assure the intended performance of a building, it is necessary to establish a baseline for expected performance and periodically compare actual performance to this baseline. This process requires a standardized, yet flexible, format for archiving performance data, and sharing these data between various software tools and their users throughout the building life cycle. Ideally, these performance data are archived with, and related to, other information about the building. To these ends, Metracker is based on the IFC data standard.

4. Building product data modeling

Generation of requirements such that other applications can extract design information from the modeled information has been a natural outcome of the studies on shared information models and building product data modeling. One of the core research questions in studies involving AEC and information technology related tasks is semantic data modeling stemming

from the lack of effective data exchange mechanisms (Bjork 1991, Eastman 1999, Galle 1995, Ekholms & Fridqvist 1999, and others). The core IFC model focuses on the building as a product. While this approach encapsulates some of requirement information, it is not complete. Recently, a number of studies aiming to augment the IFC model with requirement information have been increasing. In this section we will present sample CARM approaches in building product data modeling.

4.1. REQUIREMENT DATA MODELING

There are several ongoing projects that aim to study building product data models and their capabilities in supporting early design. The aim of such studies is the capturing of requirements and information from multiple stakeholders. The International Alliance for Interoperability (IAI) Early Design Project hosted by CERL and the Architectural Ecology organization (IAI 2003), and the Product model extension for requirement management interfaces (Premiss) project at Stanford University (Kviniemi and Fisher 2003) are examples of such efforts.

The IAI Early Design project at CERL aims to provide IFC based modeling of data to support early design processes. The intent of the project is to make early design information available in an interoperable product data model form, so that the information can be used at other stages of the design life cycle. In this project, performance based requirement specification is the priority for early design information modeling. Specifically, the project aims to identify and define the information objects that are used by owners; encourage users to define what is required during the early design phase; develop IFC support for refining the building concept, spatial functions, and spatial programming; and design criteria specification and early geometric representations, for example, for blocking and stacking and bubble diagramming.

The Premiss project suggests extending and/or refining the current IFC model with requirement specific data classes. This effort points out the inadequacies of building data models in including requirement data within the design life cycles (Kiviniemi and Fisher 2003). Kiviniemi and Fisher identify: the difficulty of keeping track of requirements during projects, especially in cases where projects are long and people change; difficulty of tracking the implications of changes in requirements and how design components relate to requirements; lack of tools to manage requirements and the need to manage requirements on class and instance levels.

4.2. BUILDING COMMISSIONING

The building commissioning (BC) project at Carnegie Mellon investigates how building commissioning of HVAC systems are conducted and

represented in the building product model (Akin et al. 2003). The effort identifies process activities such as the generation of the design intent document during the programming phase, while comparing the ASHRAE guidelines and actual practices. This includes requirement data such as construction cost estimates, testing, adjusting and balancing requirements, preparation of design concepts based on design intent, construction documents based on design concepts, and verification processes based on the documents produced during these phases. The processes described in this study rely on the flow of decisions, procedures and output documents of the commissioning process. BC undertakes validation and verification of design intent. Moreover, by emphasizing the importance of approaches such as Continuous Commissioning© (an ongoing process for commissioning) and suggesting a persistent commissioning model that combines the process with the building life cycle, the project places requirement information in front-and-center of the building life cycle processes (Akin et al. 2004).

5. Requirement computation in other design disciplines

Design disciplines whose problem domains are similar to architectural problems in complexity and structure, such as software engineering, mechanical engineering, and civil engineering have similarities in requirement computation with architectural design. We will focus on software requirement engineering in this section.

Software engineering is a relatively new field of "design." The immediate parallels between software engineering and architecture are less obvious compared to mechanical or civil engineering. While the products of architecture and software engineering differ significantly, the nature of the design process shows quite a number of parallels. In software engineering, architecture serves as a source of countless metaphors in defining the software development process (e.g. Leffingwell and Widrig 2000, Gamma et al. 1995). Architects produce blueprints as software engineers produce system diagrams, architects use design patterns as established good solutions as software engineers use them in the same way. Architects rely heavily on requirement elicitation to define their problems as software engineers do. Like software solutions, architectural solutions are not unique. Most profoundly, both architecture and software engineering are disciplines that deal with ill-defined problems.

In software engineering, requirement engineering is a distinguished sub-discipline, which addresses the problem of managing initial design requirements throughout the product life cycle. Similar to architectural design, as near as in the 1980s, requirement management in software engineering relied on manual techniques. The outcomes of these efforts

were documents that were often hundreds of pages long and difficult to comprehend. Hence, they did not receive much use.

The emergence of tools specifically designed for requirement management occurred in the mid 1990s. These tools provide information management capabilities with built-in databases, document templates and functionalities to extract requirement information from existing documents. While the leading domain of applicability is software and systems engineering, most of the requirement management tools are built upon generic capabilities of the commonly utilized desktop applications like Microsoft Word, Access and Excel.

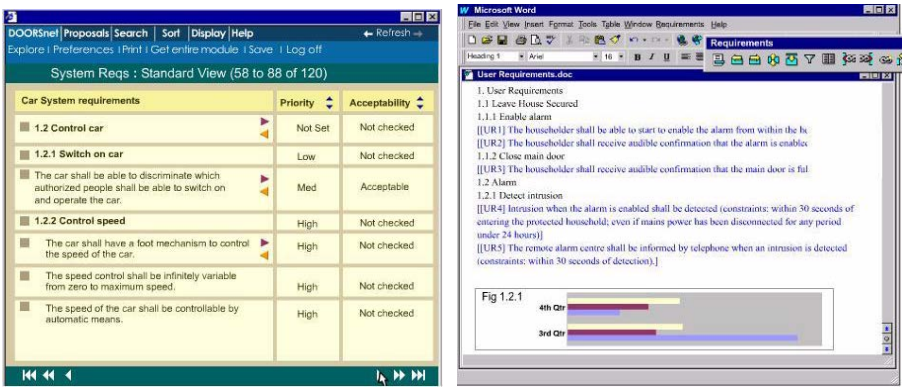

Figure 5: *Example screens from Doors illustrating web based interaction and requirement definition through the Word interface*

Requirement engineering in software design is designated as an information management problem that includes organization, traceability, analysis, and visualization aspects. Most of the existing requirement management tools to support software design provide two-way functionalities to enter requirements into the system; either directly using the application interface or using variety of file formats like those of Microsoft Office applications and HTML. The structure of requirements hence is captured as strings. The tools commonly have versioning capabilities along with database backup that stores requirement information. The database support, however, does not refer to any common data model. It is usually internal to the application, thus posing semantic bridging problems when interoperability is needed.

Requirement traceability is one of the attractive functionalities of software requirement management tools. Traceability can be defined as the ability to relate requirements to each other by parent-child relationships and traced-to and traced-from relationships. In cases of change, by the aid of such defined hierarchies, the application warns the users to suspect the

related requirements and revisit them for editing in accordance with the changes made.

DOORS by Telelogic, Inc. and Rational Requisite Pro by IBM are typical examples to software requirement management tools (Figure 5 and Figure 6). These, and many other quite similar ones in software engineering, provide generic, yet powerful functionalities for document management. History record definition, configuration management, version control, filtering data by project management attributes, and import and export capabilities to other applications like Microsoft Word, reduce the burden on the user significantly. Web based interfaces enhance collaborative project management and provide quicker feedback to the projects. Moreover, it is possible to view data in graphical format that enables the users to utilize analysis and visualization techniques.

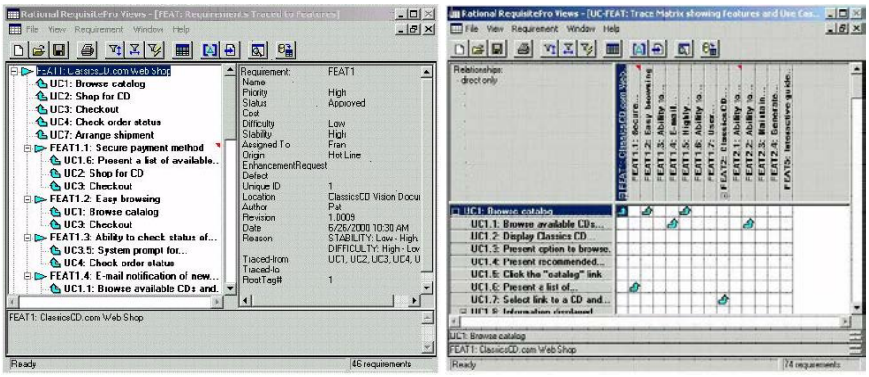

Figure 6: *Traceability matrix and traceability tree editable graphical views in Rational Requisite Pro.*

6. Observations

The tools and approaches reviewed in this paper sample some of the representative features of CARM. The large number of emerging software tools which address information tracking, change management and collaborative environments is a clear indicator that CARM is becoming increasingly more desirable. Generally we observed the following trends in our review of the current approaches:

Dependency on generic tools: The state-of-the-art in CARM relies heavily on the capabilities of generic office applications. Applications that are most often used are those which cull common features from commercial, generic office applications and bridge them with requirement management specific functionalities. Many of the existing tools provide requirement management

specific interfaces on top of database functionalities. Such tools help with easier navigation in the specification space. They help in organizing and categorizing otherwise hard to track specifications. The assistance these tools provide includes ease of access and editing, multiple visualization capabilities (charts, tables, and tree views) and project management capabilities, such as versioning, time stamping, and identity tracking. While these functionalities are already common in database applications, lack of an agreed upon data model use decreases the wider applicability of such tools.

Support for complex functionalities: Requirement traceability and verification are at the top of the list of functionalities that CARM should support. One of the big challenges is to devise techniques that will be effective while keeping cognitive loads of usability under check. The tools we have reviewed do not support: the ability to trace various segments of the information captured, to verify the information along different design phases, to build a viable requirement structure to perform complex analyses like traceability, to have advanced search capabilities, and effectively visualization of the data. While some applications provide support for some of the identified characteristics, they are stand-alone and do not provide a complete feature set.

Design integration: The computational support serves mostly only for document management purposes when the information carried by design requirements is not directly utilized to assist the user with design related decision making. A sound requirement structure with design awareness is most beneficial. Tasks of generation, validation, verification and propagation are desired functionalities since they support change management, communication enhancement, error tracking and requirement information navigation.

Similarly, intent tracking is seldom provided in CARM tools. DIT, reviewed in section 3.3.4, is one of the few tools focusing on this issue in the relatively limited domain of energy efficiency. Tracing the designer's motives requires the tracking of her moves in the requirement space as she explores the design space. Such a feature would illustrate the causal chain back to the initial design intent, which is formed mostly from qualitative requirements. It also would offer a strategy for change management.

Structured requirements in the digital medium can provide ease of communication through digitally shared CAD documents. Moreover, along with traceability functionalities, such features naturally provide the ability to track the decisions both backwards and forwards. When changes occur, notification of the designer, automated propagation of changed values and

automated checking for inconsistencies, provide the requisite assistance for error tracking.

The building product data modeling studies have started to focus on extending data models to include requirement specific information. This will require CAD applications that can manipulate requirement data and populate the product models effectively. As more systematic ways to digitally represent information are developed, navigating such information spaces will become a high priority for designers since this will enable more effective ways of using the existing requirement information. Methods that provide ways of managing greater degrees of complexity should subsequently translate into improved design performance.

Still lacking, however, are approaches that treat requirement information management as part of design exploration beyond geometric attributes of design. Requirements carry other types of information, such as financial, temporal and behavioral aspects of buildings, which cannot always be captured alone with geometries. A focus on CARM necessitates the immediate focus on the maintenance of temporal and behavioral attributes of design from its inception through its usage, and subsequent possible reuse. Moreover, it is essential that these efforts should treat CARM as a medium to facilitate information based design thinking.

7. Conclusion

In this paper, we reviewed the state of the art in computer aided requirement management in design computing. The past decade has witnessed an increasing number of tools and approaches that strive to organize and utilize information that is generated during the early stages of design more efficiently and correctly. While there are numerous studies, the domain is still far from maturity. We believe one of the dominating reasons for this is the fact that research efforts applied in this domain are dispersed. The need for CARM does not yet occupy a central position in research communities, as do those dealing with building product data management.

Several common functionalities, however, emerge through the tools and studies we reviewed in this paper. Information organization, effective navigation, retrieval and change, and collaborative design environment support are crucial for successful CARM software development. History tracking, traceability and change management appear to be the underlying technologies essential to realize these primary goals within a basic computational decision support environment. We believe the maturity and productive use of early design information is more plausible with a design life cycle management approach. We have illustrated the changing perspectives to design, like LEED, Whole Building Design and Continuous Commissioning©, which increase the desirability of application support for

CARM. We believe the next decade of research and application development will bring a shared CARM vocabulary, similar to the one design computing has been enjoying with drafting tools.

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DeVaughn, Candace

From: Sarah Maston <Sarah.Maston@collierseng.com>
Sent: Monday, February 27, 2023 10:09 AM
To: DeVaughn, Candace
Cc: Jolly, Chandrias
Subject: info for AI topic- I would like to talk to this...

Foreword

ASHRAE Multidisciplinary Task Groups (MTGs) is a group that reports to the Technical Activities Committee (TAC) and responsive to:

a) the purposes of ASHRAE as described in the Certificate of Consolidation,
b) compliant to the Society Bylaws,
c) guided by the Rules of the Board, and
d) abiding with the Commercialism Policy, the Code of Ethics, and the Harassment Policy.

Initiated during Lynn Bellenger's service as Society President, the MTGs are structured to respond to specific problems and tasks with a need for expertise from differing disciplines. By nature, these are directed more to unanticipated topics, relatively short-term tasks requiring creativity and problem-solving skills, as well as technical expertise in differing areas.

Purpose

The overall purpose of MTG is the advancement of the Arts and Sciences in response to Society emerging needs, multidisciplinary in nature, and encompassing the expertise of two or more FGs. This could include, but not limited to, Position Documents, press releases, and white papers.

Formation

An MTG is formed when the Society, or an individual member, has determined a need for a specific activity in a field of interest. It encompasses the expertise of two or more FGs, project committees (e.g., SPCs, SSPCs, GPCs), standing committees, or committees and groups outside of ASHRAE.

MTGs, in order to be effective in addressing emerging needs, must be responsive to the defined need, transparent, inclusive and representative of the participating stakeholders, and be accountable in meeting scope and timeline to the Technical Activities Committee (TAC). The MTGs must conduct their task with a clear, unified vision and constructive consensus towards definition of strategies in response to the emerging need(s).

Sarah E. Maston, PE, BCxP, LEED AP

ASHRAE Vice-President, 2022-23
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