Proposal number:	2020-07
Proposal title:	**AEC and pandemic:** response and impact
Principal investigator(s)	Martin Fischer
Research staff:	Natasa Mrazovic
Total funds requested:	**$ 44,058**
Broad Category Addressed in this Research	**Pandemic/** quality of business & economy / experience improved for all stakeholders
Project focus area addressed by proposal	**Pandemic Impact Analysis & AEC's Response & Vision for the Future after**
Stakeholders' benefitted by the research	Research is *primarily* expected to benefit each of the following stakeholder groups: **Owners, Designers, Builders**
Expected time horizon to impact the industry	**< 2 years**
Type of research	**Exploitation & Exploration**
Industry Involvement	-
Abstract (up to 150 words)	**Observed Problem:** The COVID-19 pandemic is bringing considerable changes to AEC's business-as-usual. Are we responding adequately? What are short-term and long-term impacts? How will we proceed afterwards? **Primary Research Objective and Solution:** Monitor and analyze AEC stakeholders' response to the pandemic and develop lessons-learned guidelines for a "new normal" afterwards. Identify and analyze the quantified and qualified short- & long-term impacts. **Anticipated Value to CIFE Members and Industry:** A shared platform to exchange the information. Understanding the impact of the crisis on the industry and vision/guidelines to prepare for the future. Help practitioners to more smoothly adjust to the new normal and be better prepared for future crises. **Proposed Research Approach and Methodology: a) Monitor** challenges and solutions from stakeholders/ insiders charged with managing the response; **b) Discover** what stakeholders would do differently; **c) Case studies:** analyze specific projects; planned vs. executed; **d) Analyze the effectiveness** of various responses and **consider** more successful **alternatives; e) Develop a shared platform, and new guidelines** and **list new technologies,** including CIFE research projects, that can be used as more successful alternatives; **Anticipated Research and Theoretical Contributions:** Literature review, Case studies, Guidelines, Technologies vs. challenges.

Observed Problem

We are in the midst of COVID-19 pandemic [1][2]. Since the mid of March 2020 in the US, we have been experiencing fast-pace sometimes hour-to-hour dramatic shifts in all aspects of our lives. The outbreak predictions show that the number of "active" COVID-19 cases will peak on April 20 (± 4 days) and that the US first-wave outbreak will decline in the first week of June [3]. The initial shock and **the uncertainty of the health crisis development globally and locally made long-term impact predictions** at this stage almost impossible. Return to a new "normal" is expected in the Fall of 2021 "once we are all vaccinated" [4]. On April 14 2020, International Monetary Fund (IMF) provided the first prediction of the "Great Lockdown" recession to be the steepest since the Great Depression; gross domestic product will shrink 3% this year in comparison to the January's 3.3% predicted expansion [5][6].

The shelter-in-place and other social distancing measures have helped limit the spread of the illness but have also resulted in a dramatic reduction of economic activity and a collapse in revenues. The scale and speed of the downturn have been staggering.[7][8] The AEC industry has been impacted as all other businesses (Figure 1). "The big question on everyone's mind these days: Will the coronavirus stunt construction's rising market?"[9] Some global estimates show "Medium" impact on AEC (Figure 1), others report 50% reduction[10]. In the US, the preliminarysurveys show contradicting results; AIA survey shows that 2/3 of firms reports slowing or stoppage of projects [11], while Construction Industry Confidence Index (CICI) surprisingly increased 4 points to 56 in the 1st quarter of 2020 from the 4th quarter of 2019 [9] – it seems that concerns about COVID-19 have had a surprisingly small impact on industry executives' view of the construction market in the near term. Research and analysis of the impact in the next 12 – 18 months through metrics such as supply chain, direct cost/productivity, and ripple effect analysis [12] and/or key process indicators (KPI) [13] are required to accurately quantify the impact of the pandemic on AEC.
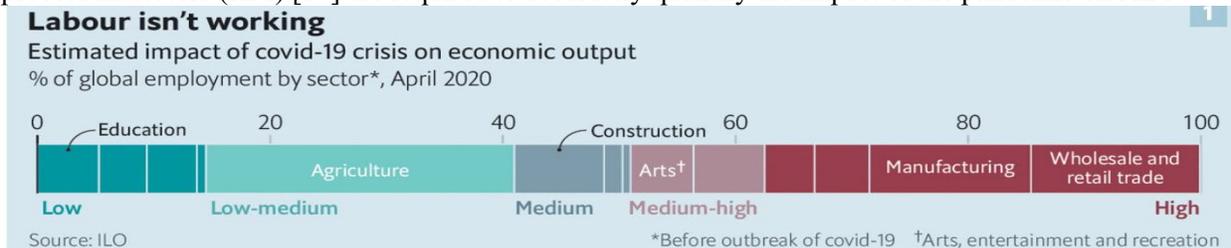
Figure 1: Estimated impact of COVID-19 on economic output; the impact on construction is considered "Medium".
Reproduced from an article in The Economist *The changes covid-19 is forcing on to business*, on April 10 2020.[14]

A company's survival and business continuation during and after the pandemic depends on its emerging and/or continuing response to a new normal defined by federal, state and local guidelines with regard to the rules of physical distancing and work from home (WFH), and essential services considerations [15][16][17][18][19]. Since the mid of March, the rules were rapidly changing and now in April they vary significantly among different states and regions [20][21][22]. Nevertheless the priorities of all businesses are identical for all stakeholders: safety and personal well-being of the workforce while continuing to provide service to the clients [18][23][24][25].

For the past four weeks we saw some companies struggling, using improvise/adapt/overcome marine survival method, some playing defense/offense on a day-to-day basis, while others are following their business continuity plans in time of disasters, and some are already thriving, especially those related to IT and healthcare services. Encouraging optimistic view of many stakeholders "to take this opportunity to improve ourselves and the way we do business" is promising [18][23][24][26][27]. This research will monitor, analyze and systemize the challenges and response / efforts to the outbreak for all AEC stakeholders (from architectural offices to construction sites and building operations). We will analyze if a business was prepared for such a pandemic, how it reacted throughout the pandemic, and what are the consequences afterwards (recovery and/or adaptation & improvement). We will look for an intuition and vision for what needs to be done better and what we at CIFE can do better.

Theoretical and Practical Points of Departure

Based on 104 references that appeared in the last 4 weeks (including 28 webinars we have watched on this topic from 16 organizations (such as AIA[28], NECA[29], Realcomm[30], OSHA[31]) and the 76 documents (journal articles, blogs, interviews, communication letters and briefs) found in communications/ websites of 42 organizations); it is clear that thinking about the impact of COVID-19 on the AEC industry has rapidly become the most important issue. Given our observation of countless project-specific problems and the response of the industry, we grouped the issues into 9 overlapping topics: (advance) planning, open communication and collaboration, procedures of shifting workflows, health and safety of employees, management of employees in crisis, adoption of new technologies, healthcare facilities, silver lining, and future predictions.

Although 1/3 of webinars and documents are focused on specific topics (such as NECA's webinar "Cashflow amid COVID-19"[12] or new healthcare facility concepts such as temporary ICU pop-up unit called Jupe [32]), the majority (2/3) of the references addresses procedures of shifting workflows in pandemic and health and safety of employees, because the industry is focused on current projects; continuing business while keeping the workforce safe. It is interesting to note that 40% of references highlights the impact of adoption of online communication and collaboration technologies, and all agree that the future lies in high-tech (automation, robotics, virtual workflows, new hands-free sensor technologies especially in healthcare). Advance planning and management of employees in crisis were mentioned in 10% of references only leaving some questions open such as how many businesses were ready for the pandemic (i.e., had a business continuity plan (BCP) before the crisis) and how the managers are keeping the workforce engaged in a new environment after the initial shock and the transition period. With certainty we can say that after this crisis, every AEC business will have a BCP. All 104 references are publicly available and free showing that the industry understands the importance of working together to survive the crisis. The expression "We are all in this together" came up in almost all webinars/ interviews. All participants openly communicate challenges, methods, success stories, and opportunities, mostly filled with optimism and empathy showing the understanding of "silver lining" in the crisis. Future predictions came up in approx. 15% of the documents, mostly specialized articles, showing that in the first phase of the pandemic everybody was busy with the transition/ survival. A rough educated guess of the estimated intensity and the temporal aspect of the specific 9 topics is shown in Figure 2. All aspects are absolutely dependable on the health crisis developments, i.e., drugs and vaccine discovery.
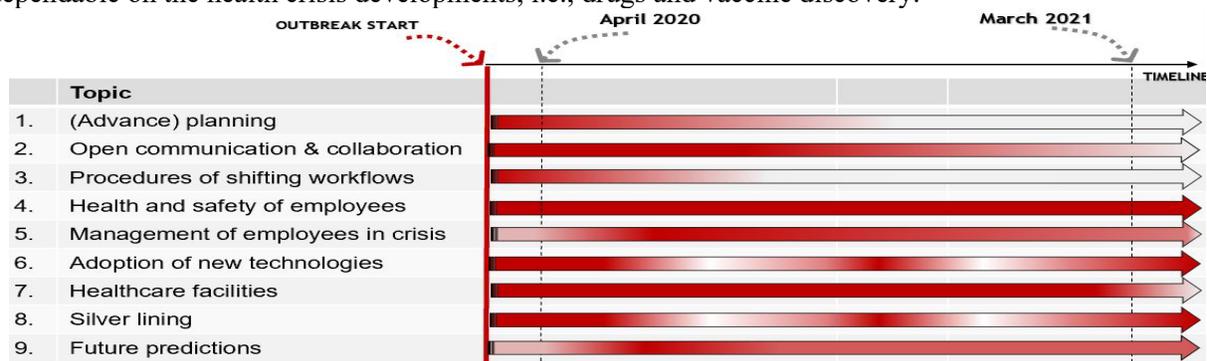

Figure 2: Estimated intensity and the temporal aspect of the specific 9 topics – absolutely dependable on the health crisis developments (drug & vaccine discovery).

The 9 topics are summarized in the following sections with a few relevant references (References chapter).

1) (Advance) planning

Many organizations have crisis response teams, business continuity plans (BCP) and recovery protocols for natural disasters or acts of war (including cyberwar). BCPs also include specific parameters for pandemics. "Plan ahead, be proactive – not reactive."[33] After the initial shock, all industry's institutions, stakeholders and trades established best practices for early response; health and safety, maintain open communication and remain agile [18][23][25][34]. Before the outbreak in the US, only global companies with projects and offices in Asia and Europe could see the effects and measures taken in different countries and prepare/ adjust their BCP in the US [23][25]. Others developed BCPs in the last month or are in the process of

developing [35][18]. A poll during a Realcomm's webinar on April 9 showed that 75% of attendees had a BCP in place, 18% did not and 7% were not sure [23]. Some speakers highlighted importance of testing BCPs to "see if they actually work"; detect backlogs and errors [36][23].

2) Open communication and collaboration

This includes swift internal communications among employees and with clients, keeping pace with mass media and constant monitoring/ changing rules and logistics according to government compliance guidelines, informing about the difference between local, state and governmental guidelines, managing extra (cyber) security awareness, providing regular (daily) updates and news on their websites [25][23][18][37]. During a pandemic open transparent real-time collaboration is crucial for survival. Multidisciplinary collaborative frameworks enhance collaboration; such as Smart City-Public Health Emergency collaboration framework [38] with a structured approach to broadly consider and maximize collaboration opportunities between the smart city innovation community and municipalities for the COVID-19 outbreak (CDC Public Health Emergency and Response Capabilities standards).

3) Procedures of shifting workflows (Plan execution)

In the first week of April in the US, 60% businesses worked remotely [23]. AEC community reports successful transition of office workers to WFH environment [37][25][39]. The time required for transition to WFH differs from business to business, all from 24 hours to 3 weeks. It depends on the type of business and standard daily pre-pandemic procedures, the number of employees, if the transition was gradual or sudden (given the geographical location and the applicable pandemic-related guidelines), IT supporting systems (hardware, software and staff), personal tech-savviness (to learn and adapt quickly new online collaborative and communication tools -some businesses report "reverse mentoring"; younger employees teach older how to use technology[23]). Some businesses report slowdown due to online communication and overcommunication but others report no change in productivity after the initial settlement; "…we even won new projects"; all speakers will continue with interviews/hiring because there is a workload but some projects are temporarily shut down[37][40][41]. Some consider this digital online transformation as an opportunity for improvement: "…we were planning to go online in 12-18 months, now we did it in two weeks and we are never going back!" [37][42]

Strategies of keeping the construction administration going and to conduct offsite building analyses had to be adjusted as well. Some offices are conducting "virtual" inspections to avoid construction site visits; "… in a FaceTime or Zoom online meeting, foreman is showing us the real-time situation on site, or we organize that he takes a video or photos after." Strategies differ project by project, and depend on the essential services consideration; "Our project in New York stopped, but a project in Nebraska is going full speed forward." [37]

Construction sites are adjusting to local, state and federal guidelines, and implementing new health & safety rules. Some sites were closed, some remain operational with implemented new procedures, and some projects were sped up. The project managers are facing challenges: ad hoc planning, mitigations and advance planning with regard safety, staffing, schedule, environmental, quality of assets and the site, supply chain, and financial diligence [43][37][44][18][27][12].

Some of the questions the project managers are facing: how to organize construction site with large workforce? Working in three shifts is expensive but health & safety is paramount; diminish backlogs; how to open up various modes of service delivery to reduce unnecessary travel and contact; supply chain stabilization (flow of parts and materials across borders is restricted or delayed); risk management (What happens if 10% of the service workforce is impacted by the virus? What is 50%? Which customer situations would be prioritized? Etc.)

4) Health and safety of employees

For ongoing construction projects across the globe, the contractors already developed or are quickly ramping up with detailed COVID-19 guidelines and protocols [43][37][44][18][27]. In parallel, companies have task forces to develop protocols for re-starting and operating projects in the post-pandemic "new normal"[43]. New Guidelines & Protocols for COVID-19 Project Operations should include following topics: 1) Health & safety of all workers / team members is No. 1 priority; 2) Published/Posted actions implemented on all projects to reduce the spread of the virus. Informational posters in English and Spanish; 3) Jobsite Physical

Distancing Measures; 4) Measures to Reduce face to face encounters; 5) Stay at Home when first feeling sick guidance/communications; 6) Personal Health, Hygiene, and Etiquette Communications; 7) Temperature Scanning Measures; 8) Surface Cleaning & Disinfecting Protocols; 9) Visual Management & SignageMeasures; 10)Special PTP & JHA agenda items; & 11)Temporary Project Shutdown Protocols [45]. Mental health and well-being in crisis are equally important as physical health. Organizations should empathize employee engagement, encourage and provide resources for personal professional development and "keeping healthy" activities [29][37]. "Never lose sight of the human element. Managing anxiety and emotion is key to a successful recovery. As companies resolve new challenges, a sense of control is regained that engenders new strengths and capabilities."

5) Management of employees in crisis

Effective management of employees is critical in times of crisis and it includes balance of empathy and productivity, putting people first and transparency. "We must remain calm, offer transparency and always tell the truth."[25][30][37] Specific guidelines for talent management and employee engagement [25] include 1) Talent planning is imperative, so develop contingency plans for diverse skillsets and asset types. Adapt training programs for redundancy, and hedge workforces for anything done in-person; 2) Positively challenge employees to deliver on deadline and don't push timelines. Focus on keeping people employed, helping the economy and advancing projects. 3) Be ready for a continually changing environment. 4) Remain vigilant with cybersecurity; a distributed workforce creates increased cybersecurity concerns, and controls must be addressed.

In addition to employee productivity and morale, WFH is a considerable change in business operations that should be addressed in BCP.

6) Adoption of new technologies

The first most obvious positive outcome of the pandemic is fast adoption of tools for communication and collaboration and development and adoption of new technologies. In a WFH setting productivity is measured not only by standard metric of staff utilization vs. project profits, but also from a software perspective, a new metric is adoption of cloud-based applications. Specifically, these are software platforms for collaboration and teamwork (such as Autodesk BIM 360 [43], Miro [47], Zoom [48], Antlr [49], Blue Beams Revu [50] and Studio Prime [51], Google Cloud Suite [52], Hangouts [53], Dune [54], Slack [55]); and tools for remote healthcare services such as Teladoc [56]. [37][23] Given the health and safety guidelines, the potential for development and fast application of new technologies such as automation and robotics on construction site is tremendous. CIFE's ongoing research projects have the potential to be fast developed and applied on real-life projects.

Challenges of a new WFH setting include: communication on multiple channels is key for success when changing work processes and environments; everyone needs instant information access; at-home communication infrastructures can be problematic with overloaded networks causing interruptions in virtual meetings; small incidents ripple into bigger challenges: unreliable WiFi, passwords left in the office and issues with the lack of quality of home-office equipment; cybersecurity and privacy issues. [23][25][37]

7) Silver lining

Countless challenges present numerous opportunities. Increased level of communication ("overcommunication") and collaboration resulted in increased stakeholder engagement and attention to drawings and detail and better communication. The stakeholders highlight with optimism: "The COVID-19 crisis has helped our firm to improve communication on a regular basis and showing us how to improve the business." "The crisis is helping to force digital transformation on us…from now on all employees who can will WFH. Why didn't we accept this way of working before?" Furthermore, personal connections and better relationships are developed. WFH allows us to develop better work-life balance, spend more time with family and work on personal self-actualization and professional development to become agent of change once a new normal arrives. Finally, environmental impact of the pandemic, although temporary, is showing us the ways, we can tackle global warming and sustainability problems.

8) Healthcare facilities

Given the nature of the crisis, healthcare and the related facilities are already in positive transformation. Healthcare is going virtual, and construction of the facilities is considered essential. The construction is

speed tracked: specialized architects work in three shifts to deliver new projects on time [24][37], existing facilities are retrofitted and temporary buildings are built and inspected according to latest regulations [18]. New healthcare facility concepts are developed such as CareCyte [57][58] and Jupe [32].

9) Future predictions

The pandemic will accelerate social and economic changes that would otherwise have taken years to materialize. Given the challenges and success stories mentioned above, obvious future developments are: 1. IT Companies with digital services and e-commerce will make immediate and lasting gains; 2. Remote work will become the default; 3. Many jobs will be automated, and/or remote-capable; 4. Telemedicine will become the new normal accompanied with med-tech innovation; 5. The nationwide student debt crisis will abate as higher education begins to move online; 6. In the first stage goods and people will move less often and less freely across national and regional borders but after multilateral cooperation will flourish [59]. Given the impacts of previous historic pandemics on architecture and urbanism [60][61], we can expect new requirements in buildings, such as hands-free smart lifts, health monitoring sensor technologies, new requirements for office spaces and communications to avoid human contact, less skyscrapers [62]. Overall, we can expect a healthier environmentally friendlier sustainable high-tech future.

Research Methods and Work Plan

We will carry out the research with following methods:

- Continue with monitoring of the developments to learn more about current challenges and solutions from stakeholders/ insiders charged with managing their company's response to COVID-19; methods: literature review, webinars, interviews, news → prepare quarterly reports throughout the pandemic (for the next 12 months till the end of March 2021)
- Discover what stakeholders would do differently based on their experiences dealing with COVID-19; methods: interviews, surveys, literature review → write publications
- Case studies: Analyze specific projects to quantify the impact of the pandemic → reports
- Analyze the effectiveness of various responses to a pandemic and consider alternatives that could be more successful → develop a shared platform including new guidelines and a list of CIFE research projects that can be used as more successful alternatives; develop list of new technologies with specifications (software/hardware) that should be developed as a response to specific challenges.

Expected Results: Findings, Contributions, and Impact on Practice

We expect to develop a shared platform including new guidelines for a future potential crisis response and the vision for AEC post-pandemic "new normal". We will quantify and qualify the impact on specific case studies. Theoretical contributions include the guidelines, literature review, case studies with validated quantified impact. If successfully translated to practice, this research will help practitioners to more smoothly adjust to the new normal and be better prepared for future crises.

Industry Involvement

CIFE members and other industry stakeholders will provide the information about their response to the pandemic: BCPs, challenges, methods, successful stories, specific projects information, and what would they do differently after having the experience of dealing with the pandemic.

Research Milestones and Risks

Given the dynamic changes of the crisis, we will publish quarterly reports of our industry observations throughout the pandemic in the following 12-18 months. Additionally, we will publish the results of the case studies. We will validate the research findings by industry experts (CIFE members) through organized workshops. Major risks include lack of data, uncooperative stakeholders, lack of vision for a new normal and to develop new guidelines for crisis response.

Next Steps

Given the priority of the research topic we expect to obtain funding from industry stakeholders outside CIFE and technology developers.

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