Process Improvement in Construction Management

A Major Qualifying Project

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by

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Abstract

The objective of this project is to determine the most efficient ways to mitigate problematic disruptions in construction management. The rationale for this project is the devastation of the Covid-19 pandemic on all businesses. When the workforce is depleted, it causes economic distress on individuals and the country as a whole. The state of the art is similar studies done by the US Bureau of Labor Statistics, the American Bar Association, White House reports on supply chains, and business reports done by MIT and WPI. The methods used for this project are research analysis, interview tactics, and hands on experience. The major results from this project are remote working from home, “no damages for delay” insurance policy, increased rate of follow-up calls with subcontractors and manufacturers, and heightened awareness. The conclusions of this project are to not be hesitant to change routine tactics when they cease to provide positive results, adjust the supply and demand of workforce, and strive for strong relationships with subcontractors and manufacturers.

Acknowledgments

I cannot express enough thanks to all my past teachers, specifically my advisors for this project: Professors Walter Towner and Jessica Rosewitz. Thank you for helping me put together this project in the last quarter of school. I am very grateful for all the time and effort you have given to me.

This project could not have been completed without the help of Skanska. Giving me the opportunity to work on an amazing job site during such difficult times. Thank you to Skanska Project Executive, James Craft, for giving me the time to interview him. Without this experience and knowledge this project would not have been possible.

Finally, I want to thank my family and friends for their constant support, I sincerely treasure it. Without these morale boosters and pillars of guidance I would not have been able to accomplish what I have.

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Executive Summary

This project evaluates professional construction management risk mitigation tactics regarding the Covid-19 pandemic. The project seeks to determine the most efficient ways to mitigate unforeseen problematic disruptions using research and interview tactics. Narrowing down my project was not the easiest thing because it had to be a mixture of business and civil engineering. This was the foundation for how I found my advisors for the project, which led me into the realm of construction management.

My rationale for this project is the importance of keeping a strong workforce. A significant number of businesses were harshly affected or even terminated from this disease. This puts a dangerous number of people out of work which causes economic distress individually, but also on a global scale.

My research gave me insight into factors increasing costs and supply chain discrepancy. Increased sanitation increases costs because office and trailers are required to cleaned more often than usual. On site, enforcement of masks and more sanitation stations are implemented. Employee absenteeism extends costs because not only are sick employees staying home but even close contacts are asked to quarantine. Social distance requirements are another reason for

escalation in price. Enforcing social distance protocols means there is a limited amount of people on the job site, and they must remain 6 feet apart, ultimately making work harder and slower. Materials price increase and transportation delays go hand in hand. Because it is harder to transport materials it limits the supply, which increases costs. Another reason why transportation delays increased costs is because a lot of public transportation was shut down or limited, making it harder to fill the workforce needed.

Through my research and interview the conclusions to mitigate unforeseen disruptions are to not be hesitant to change routine tactics when they cease to provide positive results, adjust the supply and demand of workforce, and strive for strong relationships with subcontractors and manufacturers. When the routine game plan is failing to work in the realm of management, it is important to move with haste when changing old ways. A relevant example of this could be using remote working to maximum efficiency during times of social distancing. Social distancing also relates to the importance of adjusting the manpower and workforce for projects. When the manpower is limited to specific regulations it is essential to manage this weakened workforce to be even more productive. My final and most impactful solution to avoiding problematic disruption is to maintain and strive for strong relationships with manufacturers and subcontractors. On a social level this will make work more enjoyable, but the real benefit is strong relationships will look out for each other. This could put the company in a higher position to receive limited materials or workforce.

1. Introduction

1.1 Objective

The objectives of this research project can be summarized as follows:

- To understand how different construction management companies prepared and reacted to the complications of the Covid-19 pandemic.

- Determine the effectiveness of each style of approach to avoid supply chain issues, economic distress, and disruption in workplace routine.

- Develop recommendations for addressing efficient risk mitigation and sustainability practices.

1.2 Rationale

This work is important because the Covid-19 pandemic put 7.9 million people out of work in the United States in May 2021 – US Bureau of Labor Statistics. This graph shows the number of people who were unable to work due to Covid-19 from May 2020 – June 2021.

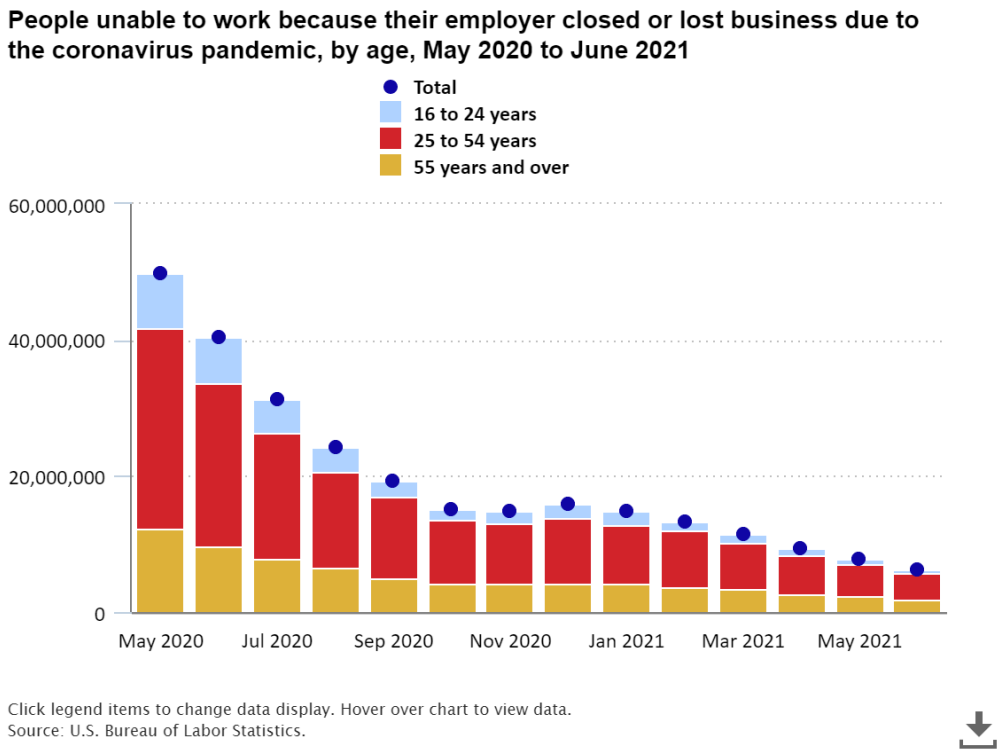


Figure One

US Bureau of Labor Statistics, "6.2 Million Unable to Work Because Employer Closed or Lost Business Due to the Pandemic, June 2021." *U.S. Bureau of Labor Statistics*, U.S. Bureau of Labor Statistics, 8 July 2021, https://www.bls.gov/opub/ted/2021/6-2-million-unable-to-work-because-employer-closed-or-lost-business-due-to-the-pandemic-june-2021.htm.

This graph shows the United States monthly number of people put out of work due to their employer closing or losing business because of the Covid-19 pandemic. The bar graph is color coded to represent different age groups. While the graph may not be relevant to current times, it does a great job depicting how impactful unforeseen disruptions can be.

Keeping the workforce active has a plethora of benefits on small to large scale influence. As an individual steady work is required to support yourself by earning money to pay for essential bills, luxury items, and responsibilities. As a country, keeping an active workforce is indispensable because if the country as a whole does not meet the demand of the workforce, the economy will fail.

In order to sustain a thriving workforce, companies and businesses must have successful risk mitigation and sustainability practices. Disasters, pandemics, and catastrophes of all kinds have occurred historically and happen arbitrarily. Some other examples are natural disasters, workforce strikes, and warfare. Proper management is the only way to circumvent failure in the business.

1.3 State of the Art / Research

The American Bar Association, "Dealing With The Construction Impacts Of COVID-19." *Americanbar.org*, FSLC Committee, 2020, https://www.americanbar.org/groups/tort_trial_insurance_practice/publications/committee-newsletters/construction_impacts_of_covid/.

The American Bar Association wrote an article addressing all general factors that caused an increase in costs due to the Covid-19 pandemic. Some of the major elements they talked about were employee absenteeism, increased sanitation, social distance requirements, material price increases, and material delivery delays.

Employees being increased rate of being absent has expanded for multiple reasons all relating to Covid-19. The illness forces quarantining for up to 2 weeks, which is an

extremely long time. To decrease the spread of the disease states were limiting public transportation, making it harder to travel to work. States had also introduced social distancing which directly reduced the number of workers on site.

Extra costs had to be accounted for because heavily increased sanitation practices were now either required or heavily recommended. Practices such as temperature tracking, increased hand washing stations, and safety practices were all new and absolutely bear a significant cost of time and money.

Material deliveries saw an increased rate of delays and or price increase. This is a result of manufacturing markets struggling with closed ports/transportation, temporary shutdowns, and decreased workforce.

Supply Chain Disruptions, Helper, Susan, and Evan Soltas. "Why the Pandemic Has Disrupted Supply Chains." *The White House*, The United States Government, 30 Nov. 2021, https://www.whitehouse.gov/cea/written-materials/2021/06/17/why-the-pandemic-has-disrupted-supply-chains/.

Covid has impacted the supply chains of all industries, but some more than others. This source shows how hard the construction industry was affected in relation to other industries. The graph lists the different supply chains by sector, which then has a correlating bar to show the percentage of delays in June, 2021.

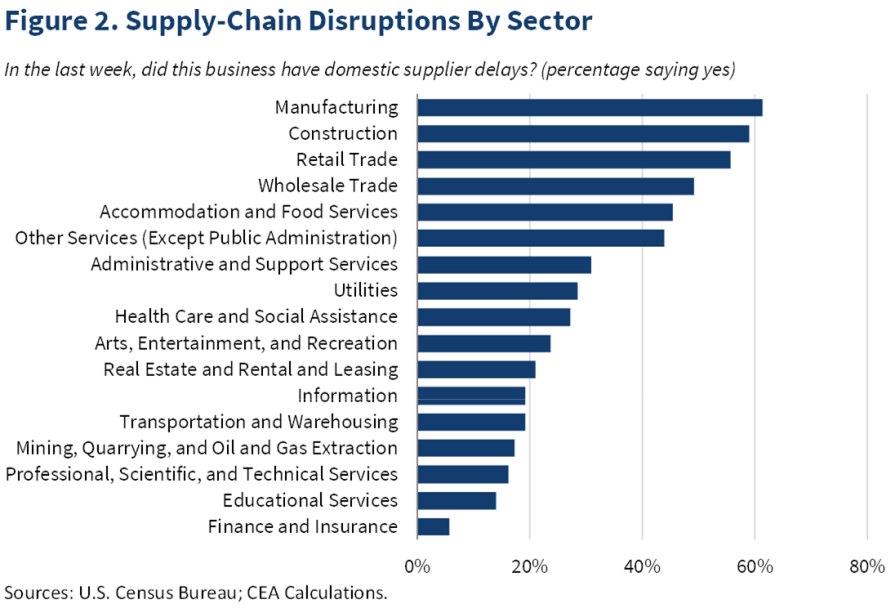


Figure Two

As you can see, as of June 17th, 2021, all sectors of supply chains were negatively affected by Covid-19. Manufacturing and construction go hand in hand as they work closely together to accomplish their goals. Everyone was negatively impacted by Covid-19, but when it comes to supply chain disruptions, the construction industry has experienced the most hardship.

Business Insurance, Lerner, Mathew. "Project Delays Add to Construction Insurance Costs." *Business Insurance*, 1 Nov. 2021, https://www.businessinsurance.com/article/00010101/NEWS06/912345471/Project-delays-add-to-construction-insurance-costs.

Delays have always been a part of construction, sometimes there is just no way to avoid them. With Covid-19 drastically affecting the industry it increased the rate of

delays. These delays force insurance policies to change or be extended to adhere to the delay, ultimately increasing the expected cost of the job. “Many of these projects were placed before the market had changed, so now underwriters are looking at those rates changed with the new exposures, and it’s causing challenges for the industry,”(Gloriod).

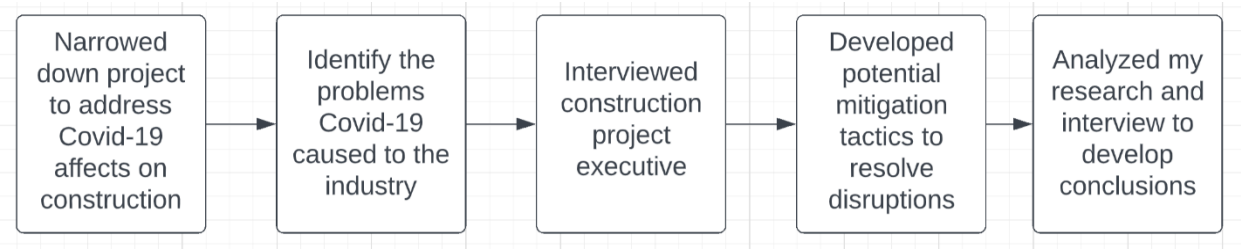
Strategies to Avoid Business Disruption, Gans, Joshua S. “Keep Calm and Manage Disruption.” *MIT Sloan Management Review*, 22 Feb. 2016, https://sloanreview.mit.edu/article/keep-calm-and-manage-disruption/.

When things change in the professional environment it can be fruitful to change tactics with haste. Sticking to old ways can prove failure when circumstances alter from the norm. Sometimes it can be useful to study the competition to find new strategies or methods if the current actions taking place do not suffice. If changing your ways or joining the competition does not work or does not feel appropriate, then taking a step back and waiting for the market to adapt to the changes could be a preferable option.

2. Methods

To determine how to mitigate interference in the construction world caused by Covid-19, I started with literature review of similar projects and research done by others. This gave me background knowledge of what was affected by the disease and to what extent. I performed an interview with Skanska Project Executive, Jim Craft. This gave me insight into how an international construction and development company prepared and reacted to the Covid-19 pandemic. With this information and research, I developed my conclusions on the most efficient ways to handle a significant disruption like Covid-19.

Figure Three: General Approach



My general approach above is the major phases I took to develop and execute my project. Narrowing down my project was not the easiest thing because it had to be a mixture of business and civil engineering. This was the foundation for how I found my advisors for the project, which led me into the realm of construction management.

3. Results

Research Results

Covid-19 Protocols

Covid-19 protocols and regulations were constantly changing as a vaccine was being developed and distributed. This caused significant impact. Remote work from home has been a large change. In times of social distancing, finding a way to do the work that can be done outside of the job site at home can be very helpful to reduce unnecessary capacity. This is difficult to do for trade workers or laborers, but in some areas of management it can be done. Some other protocols are the level of sanitation and prevention methods. This was forcing companies to spend extra resources on cleaning out offices/trailers, increasing cleaning stations on site, and providing/enforcing mask usage for all employees.

Supply Chains

Covid-19 also put nearly 50 million people out of work in May 2020 (peak month of 2022). This has a large influence on economies from a global scale to a personal level. With this scary number of people out of work it puts major delays on construction and manufacturing supply chains. The best way to address this is relationship management and increased follow-up calls for materials and manpower. With the amount of uncertainty Covid-19 provided us with it is important to have good relationships with the people that are counted on to deliver the desired

goods on time. If they cannot accomplish this task, a higher rate of follow-up calls might be able to secure at least some of the product to keep the project moving forward.

Insurance Policies

Using insurance policies is something that people try to avoid, but when it is needed it can be crucial to productivity. “No damages for delay” is an insurance policy that will not extend the project deadline, but it will provide the job with more funds to find a way to still meet that original deadline. This was a very commonly used policy during the peaks of Covid-19 because every job was either delayed or shut down for some period of time.

Break Even Analysis

Construction contracts build in some buffer room for standard delays, but if you can avoid those delays by using these tactics there will be a great return on investment. The profit margin for each job site would be equal to the costs saved minus fixed costs minus variable costs. If implementing these tactics costs a 70k salary per job site and saves 3% of the total project cost, this would be well worth your time.

Savings Investments to Savings Ratio (300M project)

9M					
7.2M					
5.4M					
3.6M					
1.8M					
0	70K	140K	210K	280K	350K

Costs

Figure Four: Return on Investment

This example above is estimated off the Belmont Middle and Highschool job I interned for. It is approximately a 300-million-dollar job. If our investment of 70k per year yields a 3% savings, it will save nearly 1.73 million per year. This is going to vary greatly depending on the size of the job. The larger the job site the more appropriate and effective these tactics of implementing a 70k salary position becomes. The only time this would not be a viable option is if the project costs 2.33 million or less. The reason behind this is because a 2.33-million-dollar job is the break-even number for adding the 70k in yearly cost. 3% of 2.33 million is 70k.

Interview Results

Summary of interview results with Jim Craft, Project Executive for Skanska.

1. Tell me what your occupation is and what you do on a daily basis.
    a. New job bid preparation.
    b. Focus on 2-5 jobs at a time and step in where help is needed.
    c. Help with recruiting/team building for projects.
2. What part of your job has seen the biggest impact?
    a. How to provide leadership to a significant amount of people during weird times.
    b. Trade workers don't care about Covid-19 guidelines.
    c. National protocol that only critical projects can stay operating.

    d. Hospitals became strenuous between social distancing, noise levels, dust, and higher occupancy rates combined with restrictions on the number of people on site.
    e. Little to no issues or changes with outdoor work.
    f. Struggles with employees staying home.
    g. Using insurance policy “no damages for delay” to cover schedule renegotiation.
3. Did you experience material delays? How did your company address supply chain delays/cancellations?
    a. Millwork deliveries were pushed back 2-3 months. In order to keep things moving you must try to get your hands on any of the millwork to push the envelope.
    b. Resequencing events based on what materials and equipment is readily available.
    c. Not doing things in the right order increases risk and can become a safety hazard.
    d. Last-minute cancellations are the most disruptive.
    e. Steel manufacturing had half the number of workers. Bigger jobs stood higher in the queue to receive the steel needed. Supply went down but the demand remained the same, if not higher.
    f. The Texas freeze ruined custom orders of epoxy counters. Had to get standard colors. This was the same issue with toilet partitions.
4. If you could go back to before the pandemic, but with the knowledge you have now, how would you prepare for it? Or recommend your company to prepare for it?
    a. Prepare for swapping materials.
    b. Try to order things earlier but this is hard to do until the contract is official.
    c. Consider having the owner but things in advance.

    d. With design-build projects it is important to keep relationships strong with manufacturers and materials suppliers.
    e. Prepare employees for an increase in effort due to disruptions and stress of what is going on.
5. Are there any other unique changes you have noticed since the beginning of Covid-19
    a. Culture shifts from a tough guy mentality to a safe or "softer" mentality because it is more acceptable to stay at home when not feeling well.
    b. The aspect of people getting to work from home has created an opportunity for people desiring career changes.

Reflection Results

My MQP experience was very unique compared to others. I started working on a different project and was kicked off because it did not meet degree requirements. This put me in a scramble situation to find an MQP in time. Thankfully, with the help of my advisors we were able to come up with an idea in time. Working alone was not ideal. It was harder to bounce smaller ideas off someone and manage the workload. With that being said it did teach me the awareness required to even set up a project like this.

Another major aspect I learned about was communication. I feel I could have had more productive experience if I was more diligent with my communication with advisors. This communication would have also helped me have a better workflow. I would tend to work in chunks, meaning I would work on the project for 12-14 hour periods and then not work on it for a day. Towards the end I found greater success by working 6-8 hour shifts daily.

My job after school will be directly related to some of the work I did on this project. My job title will be Project Engineer, for Skanska, a construction and development company. This will be awesome because I can put emphasis on the things I learnt throughout this experience. Some specific things like keeping a close relationship with subcontractors and manufacturers is something I will be going the extra mile for.

4. Conclusion

Do not be hesitant to change routine tactics. Sticking with the same business plan or construction model when the environment around you desires a change can only lead to negative outcomes. If the supplies to use the same construction steps and schedule are not available, the only option is to make the most of what is available and rework the approach and stages of the job.

Adjust supply and demand of workforce. Every Project requires different contributions from the trade workers. Finding a way to maximize the balance of the workforce is essential to meet deadlines. Whether it is less people per shift and more shifts or more people per shift and increased overtime, finding the right balance is principal. This could also involve maximizing the use of remote working from home or online video meetings, rather than everyone being present in the office.

Pay attention to all aspects of the industry. Relationships with manufacturers, material suppliers, and subcontractors goes a long way. Having a strong relationship with them will put your job at the top of the hierarchy, helping the project get what it needs when it needs it. Having greater attention to detail and asking more from employees in times of need will help get through these problematic disruptions.

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6. Appendices

Appendix A, Interview Questions Guide

1. What is your occupation?
    a. What do you do on a daily basis?
        i. If the respondent talks about materials, supply chain, purchasing. Etc. Follow up with question 4
        ii. What part of specifically your job has seen the biggest impact from the Covid-19 pandemic?
2. What is the biggest impact on your industry caused by the pandemic?
    a. Other impacts changes?
3. Did your company prepare for the pandemic since it began in March 2020?
    a. What did your company do to prepare you for the pandemic as it is related to your job duties?
4. How did your company address supply chain delays/cancellations and labor shortages?
    a. Did you have to renegotiate insurance policies and construction contracts?
    b. What other job duties did you have to change because of the pandemic?
5. If you could go back to before the pandemic, but with the knowledge you have now, how would you prepare for it? Or recommend your company to prepare for it?
    a. Follow up questions

Appendix B, Full interview

Direct quotation of interview from March 31st

Noah: How would you describe what you do on a basis for work?

James: In my position it on the week. Right now I am in pursuit mode, the daily basis is preparing for a presentation. The week before it was preparing for a bid proposal. I basically continue to provide leadership projects overall. Attending the meetings and consulting with the team that is running the project. When you were there it was Mike Loring and the whole team out there. I am not there on a day to day basis, but usually once a week I will spend a day on the job site to make sure everyone has what they need and to get their work done, check to make sure nothing is going astray, if there is anything that needs extra focus or attention things I can help with.

Noah: How many would you say that you would like oversee or check in with? How many sites?

James: Uhm for me its been two because they are two very large projects, but depending on the size it could be a lot more. I would say probably no more than 5 or 6. Depending on the size of them. Two is a good amount when they are over 100 million.

Noah: I guess my main questions would be talking about materials and supply chain, but a good place to start would be like, specifically on your day to day job and responsibilities, what was the biggest impact for you with Covid? I know there is a lot of different angles to look at it, but what would you say the most impactful for you was?

James: Yup, so the first thing was when Covid first hit it was providing the leadership of how to deal with and continue construction through covid, right, so we had to develop plans for the job site of how to work. So construction there is a lot of workers on site and to have them try to work 6 feet apart and then wearing masks. Its difficult already to maintain a safe working environment, making sure everyone has proper PPE and that just adds another level of supervision and enforcement if you will of getting people to actually work and socially distance, and wear the masks, and set up the job site with extra hand washing extra cleaning and wiping down on what they believe the virus could spread on. Basically come up with everything we could do to work as safely as possible and without putting people at risk while working. We want to make sure when people come to work they leave the same way, safely. That includes not spreading disease. That was step one which was pretty intense because you know we're a national company so we have national protocols and have to talk amongst teams to get everyone on board and even get the subs on board so its a lot of conversations, meetings, discussions on how to do it and how to get the subs on board to do it with us. So that was step one, very fast and very intense, to keep the job sites open. Otherwise, everything just shuts down. Which a lot of job sites did. My two job sites remained open because they were considered critical. They were infrastructure high schools and some of the other jobs like some of the hospital jobs like hospital jobs some of them just shut down completely and went to the drawing board to figure out how they were going to operate, shut down for 2-3 months until we had a good plan.

Noah: So they just shut down for like a short period of time and then restarted?

James: Yeah so, they shut down, come up with a plan of how they are going to do their work, so if you're in a hospital and the hospital doesn’t want to spread the disease and we have to get our workforce in and out of the hospital and keep them separated from people and work safely and not spread our breathing or germs into the hospital. So its one thing to keep the dust out and the

dirt and noise but its another to keep all the HVAC very tightly sealed separated and reduce workforce. So some of those jobs decided it was better to work two shifts or three shifts, instead of having 50 people in the work space maybe only have 20 people each shift, you go slower but you only put the right amount in each space. There is many kind of different strategies that came into play of how to work that way. Fortunate for me the two jobs I was on we were still doing steel erection which was outdoors so it wasn't as impactful on the job site right of the bat. So we had the plans down for the way we work by the time we were getting enclosed.

Noah: I guess for materials supply chain or even equipment.

James: So that was the first initial impact right. Then the secondary impact was everyone started getting covid and became nervous and staying home that our workforce shrank. So the next problem I helped overcome was trying to supplement the subcontractors' community's workforce when if they didn't have enough people on the job site. Lets say the mill worker couldn't get enough carpenters so we would reach out to other companies to find workers they could use, and supplement their staff. So that became weekly if not daily folks would say I just cant staff up. So then we would have to manage to whether we could get more people to help them, supplement their workforce and then a lot of overtime work started happening, whatever we could approve to recover the time on the schedule for not having enough workforce.

Noah: And this is causing delays, right? Like extending the project time.

James: It did but it didn't. One job we were able to readily overcome things it was kind of larger. I have to think about this for a bit. Well, we have different rates of success. On keeping the schedule on track. On one job we had some delays and one those delays happened the contracts rights that we have, we have the right to have a delay, but we couldn't get any more money. So, we are trying to figure out how to change the schedule without adding more money.

Resequencing things, for example we had the Brookline job and we had two buildings and one of them pushed out to have the steel erection at the same time and they couldn't get enough labor to do both at the same time. So, one delay pushed into other things creating another delay. Right, so it's a spiral. So, some of those things I'm not going to say they were all covid but for that one Covid basically shut down MA, MBTA, transit 30. So, we were building a building over the railroad, and they needed to have flag people there to coordinate our work, and they basically had covid and said they couldn't support the job anymore.

Noah: Did that job get terminated or was it just a hold off?

James: Nope, it was just a holding pattern until you can figure out what to do.

Noah: Did you have any jobs that got completely terminated?

James: I did not. No, most jobs just had a hold off and then came back. I do not recall any that got terminated for us.

Noah: With the delays did you run into any issues where u had to change contract promises, like when you were delivering the building or increase prices? Did you have to renegotiate anything like that?

James: Schedule yes. We were able to renegotiate. Which we had the right to, based on the contract language it is called no damages for delay, and basically the job was delayed based on the things that happened but no rights to any more money. That's why they put this in the contract, so we get to squeeze, and the owner doesn't get to squeeze.

Noah: I imagine that goes for extending insurance policies for the job too?

James: Everything the extends time costs money. So, all the insurances have to be continued to be paid, yup. All the people on the job site have to continue to be paid. So, also one of the

reasons they do that is so you don't delay the job intentionally because if you could get time and money for delays people would be much more willing to let the job slide. So, it puts pressure on us to find ways to recover the schedule effectively and get it back on track without spending to much money. When there's no money for damages for delay, we can then ask to push the schedule which is where you get more overtime. If were pushing the schedule a month, for instance, and then you say you need to make recovery, if you agree to that you need to make a recovery schedule. If we do overtime these 3 weekends and do 10-hour days for these certain trades, then we can try to recover half that time. You get paid to do the recovery but not for the delay itself. They don't pay you to stay longer, they pay you to go faster. To reduce the impact of the delay. It is a lot of schedule analysis, meetings and discussions with subs. I don't know if you went to any of those schedule meetings where we all get together and get with the sub foreman to find a faster better plan, whether its with overtime or not, to see how fast we go. All of the schedules at first are organization goals and as you get closer to each sequence of events you can always get more detailed and try to find ya know the fastest path of hand offs from one trade to the next, and if you can get all the people in agreement, I need 3 days for this, you need 4 days for that, etc rather than just having a week a week a week.

Noah: So, you would say your definitely on higher alert to save time?

James: We gotta find hours and days. If we have a schedule duration for 10 days for something, can we do it in 8, ya know. Get everyone to buy in to squeeze the schedule down by limiting the float in the schedule.

Noah: I want to ask you a few questions.

James: I got one more large topic. So the materials. That's a weekly event. On the Belmont job we have 23 different sub-contractors who had delays on materials which impacted the job. And

the dealing with that is the same thing. They advise that the delivery date is going here to here and we have to then figure out what can we then do with the schedule, how can we recover that, and also just have multiple phone calls with national folk to see what we can pull in.

Noah: So, they wouldn't deliver it to the job? Would you have to get it from somewhere different?

James: No, so, if millwork was scheduled to be there in May but they can't get it there until June or July. So its 2 or 3 months delay to bring the millwork in. We have to figure out how to make it fast once they get there, but also have discussions to see what they can deliver first. Can you get us one wing over here? Where can we get going. What's the easiest stuff to deliver. Just push the envelope on anything that's in progress and then re sequence our events. Maybe paint the ceilings when we usually do not. We have a normal path of how we install the construction work and, in many cases, we do things out of sequence. Which then creates the opportunity for more damage because you have materials that are normally not there when installing other things so, we have more protection of materials once they are installed, but basically it was fire drill after fire drill when we would get these calls and a lot of time it was the day of the delivery and folks would say, yeah, it's not coming and we don't know when. Now we call all the way up the food chain to the presidents of companies to find out what's going on because they told us last second. A lot of heat in these conversations. You get to the point where you can finally get some information out of them. Not all of it was Covid. I think a lot of it was because about half the factories shut down like the steel for example, the factory had to be at half capacity. Fortunately for us we were able to stay on their production, but they ended up having to work double shifts.

Noah: Did you have to choose which jobs you still wanted the steel to be provided to?

James: They had to, and we were fortunate enough to be in a good spot because of our relationship with the steel company we were able to stay first in the queue, while some other jobs suffered. If they planned to have, well everything in construction is at full capacity so when you cut the factory staff in half because Covid, they were shut down for a couple weeks and then came back at half capacity. It was tons of phone calls of what are we going to do? When are we getting steel? Can you keep producing? And it takes a lot of effort to make sure we were first in line to get the steel. A lot of extra effort and pressure to put on folks to make sure we got our stuff. Basically just supply and demand. The supply went down and the demand stayed the same so it was a lot of projects fighting for material.

Noah: I remember Mike Pisano, I don't know if they ended up sending him on the trip across the country to figure out why the materials promised were not on the way. So, were there any situations where you could not get what you needed for materials and had to either change what materials you were using like for example I know there was a job at WPI that they were renovating a department building and they wanted to include some sort of censored rooms that would only light and heat while occupied and they were not able to get the proper materials so they had to back out of that. So, were there any situations where you could not get a specific type of window or door etc.

James: Yes, there were. Fortunately, we did not have too much of that. But the ones I do recall actually didn't have too much to do with Covid. It had to do with the weather in Texas. That kind of happened subsistent to covid but on top of covid. If you remember when they had the big freeze down there. So that impacted industries of anything to do with oils dyes, and chemicals. So in making the epoxy counter tops which are in a lot of high schools. There was major delays on getting the right resins. They were delays on the powder they use for color. So it took extra time to get the special red dye. Similar with the epoxy counters. We had to swap the toilet

partitions to a standard color rather than the custom because they did not have those dyes. They could barely have enough of the standard stuff never mind the custom ones. We had a lot of our orders in and on the way before the bigger impacts on material delays. It was mainly factories and producers going slower and stuff wouldn't show up when supposed to. So dealing with late materials and working really fast was important. Which is why premium time on Saturdays and Sundays was important, which is also why that summer was crazy!

Noah: Living through the pandemic and having the knowledge you have now, is there a way you could get around some of these issues or is there anything you would change in the company to prepare for it?

James: With the materials, having the ability to be nimble with materials and swap different things is a good plan, but it only helps you so much because its unknown at the time of the order. The process of ordering material is you buy the subcontractor, they submit shop drawings and product data, you approve that, then they start ordering their materials and start the manufacturing process, and a lot of times the manufacturing process does not start until a few weeks or couple months before they want to start the job site because everything is manufactured in a distant time model, so there is not a lot of stock on shelves. It is kind of difficult to manage that. To adjust the workforce.

Noah: Is there a way to adjust the workforce to this? Or is it unavoidable?

James: That's what I'm thinking about.

Noah: The only things I have seen through my research is a couple situations where they were able to order materials early and store them for when needed. Could you see something like this working?

James: That is a potential solution. The issue with that is it depends on the type of project. If it is a public project that is very difficult because you can't release materials until you are under contract. Like façade glass needs to be ordered a year in advance, right. Depending on how fast your schedule is going, you might have to buy that before the contract is done with the owner, based on the timing. So it is a balance of when the design is complete and when the owner releases the contract to proceed. So yes, the larger things like HVAC and larger equipment it is a good idea to get things in advance, approved and released early, but the limitation is there that you can only do, depending on the owner he might have to buy those things direct ahead of time while doing pre construction to get things into queue. Like lock in the steel order for a certain amount of tons of steel. The final design might not be out for a couple of month =s but we are locked in for this amount of steel for this date. So that is a good strategy and there is ways to do each one. So direct purchasing by the owner and or making sure those things get released right off the bat as soon as our contract is in place. And then within the schedule make sure we accommodate for lead times and stay in connection with all the manufacturers. So Skanska has a group that all they do is talk to the manufacturing industry to build relationships to get good pricing and timing, especially on design build type work, we will call them first, and just making sure that we leverage those relationships for service quicker because they know they will get a lot of work from Skanska. We have national relationships with an elevator company, HVAC equipment, electrical equipment, and all sorts of different industries. And by having those contacts you get the latest on what's the lead times are.

Appendix C, Decomposition

FR0: Increase ROI from risk mitigation	DP0: System for increasing ROI from risk mitigation
FR1: Consistent workforce	DP1: System to maintain consistent workforce
FR1.1: Anticipate workforce shortage	DP1.1: System to anticipate workforce shortage
FR1.2: Mitigate workforce shortage	DP1.2: System to Mitigate workforce shortage
FR1.3: Maintain proper workforce	DP1.3: System to maintain proper workforce
FR2: Receive materials/equipment on time	DP2: System to receive materials/equipment on time
FR2.1: Expect materials/equipment delay	DP2.1: System to expect materials/equipment delays
FR2.2: Mitigate materials/equipment delays	DP2.2: System to mitigate materials/equipment delays
FR2.3: Generate JIT schedules for delays	DP2.3: System to generate JIT schedules for delays

FR2.4: Sustain on time expectations	DP2.4: System to sustain on time expectations
FR3: Reduce/maintain required costs	DP3: System to reduce/maintain required costs
FR3.1: Anticipate increasing required costs	DP3.1: System to anticipate increasing required costs
FR3.2: Mitigate increasing required costs	DP3.2: System to mitigate increasing required costs
FR3.3: Create inflation/increased costs plan	DP3.3: System to create inflation/increased costs plan

The ultimate goal of this project is FR0, increase return on investment through risk mitigation, especially during times of disruption. In order to achieve this goal, there are three main objectives listed by priority. FR1, having a consistent workforce/manpower. FR2, receive materials and equipment on time. FR3, reduce and maintain required costs. From there each objective is broken down into smaller steps. This helps break down the project into smaller details to simplify the approach while providing efficiency.