

**COREFORM USER INTERACTION DEVELOPMENT  
PROJECT ID: CEEN\_CPST\_015**

**by**

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**A Capstone Project Final Report**

**Submitted to**

**Greg Vernon and Michael Scott  
Coreform, LLC**

**Department of Civil and Construction Engineering  
Brigham Young University**

**April 11, 2022**

**Executive Summary**

**PROJECT TITLE:** COREFORM USER INTERACTION DEVELOPMENT  
**PROJECT ID:** CEEEn\_CPST\_015  
**PROJECT SPONSOR:** Coreform, LLC  
**TEAM NAME:** BFPS Engineering

Create a digital model that can test different syringe types without having to create a physical version. This model will enable the company to test different geometries before needing to create a physical model. Additionally, provide a list of user interactions to Coreform outlining specific improvements for their FEA analysis tool, Cubit.

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## **Introduction**

Coreform LLC has developed a finite element analysis tool called Cubit to facilitate meshing of complex models. One of their clients is interested in using their service to model a syringe leakage problem to replace current empirical testing methods. Our task was to familiarize ourselves with various finite element analysis programs and methods, create a problem statement, develop breakout models, and provide feedback to Coreform with respect to the user experience involved in using Cubit. The objective of these tasks was to give insight to Coreform that would allow them to provide their client with an effective, user-friendly product.

## Schedule

Monday Jan 10 - Received official assignments for Coreform from Dr. Scott.

Wednesday Jan 19 - Meet with Greg Vernon who would be assisting in the capstone project. Talked about expectations, general layout, schedules, and meeting with BD representative

Friday Jan 28 - Met with Jaiyu, representative with BD. Discussed their desires and what they expect Coreform to deliver to them.

Monday Jan 31 - Began regular in-person meetings with Greg that lasted throughout the semester as well as virtual Wednesday and Friday meetings

Friday Feb 4 - Submitted PIRT spreadsheet and write up

Monday Feb 7 - Received Medical syringes from BD thanks to the BYU nursing program

Monday Feb 7 - Began making simple models of the syringe using Abaqus

Wednesday Feb 16 - Met with BYU nursing program to see how they administered and used syringes in patients. Asked questions to receive their thoughts.

Monday Mar 7 - Began making models in Coreform Cubit software

Monday Mar 21 - Received completed renderings from Greg

Monday Mar 22 - Completed Capstone poster

Monday Apr 4 - Final presentation and dinner with Greg

## **Assumptions & Limitations**

Throughout this project, we made simple models of complex real-life problems to focus on the usability of Coreform Cubit software. Due to our inexperience with 3D modeling in CAD and Abaqus software, we were more limited in our abilities to make complex models. However, due to that, it allowed us to learn the software and provide sufficient feedback for improvements for the Coreform Cubit software. Due to the lack of complexity of our models, we were not able to fully represent the syringes, but were able to get a general idea of their behavior.

## Design, Analysis & Results

Our team developed thirteen user interactions for Coreform's review. They are as follows:

- Constraint-based sketching environment
- Hotkey functionality
- Function summaries
- Syntax and spelling suggestions in code
- Dimensions on model space grid
- Ribbon interface
- Object extrusions
- Hover over previews
- Materials palette
- Pop-up dialogue guidance
- Run job button
- Assigning loads
- Automatic journal

These user interactions will be reviewed by Coreform and will be used as suggestions to improve the user experience in Cubit. While some of these interactions may not be directly implemented as we gave them, we are confident that the insight gained by reviewing these items will improve the functionality of Cubit and reduce time spent preparing models in Coreform Cubit.

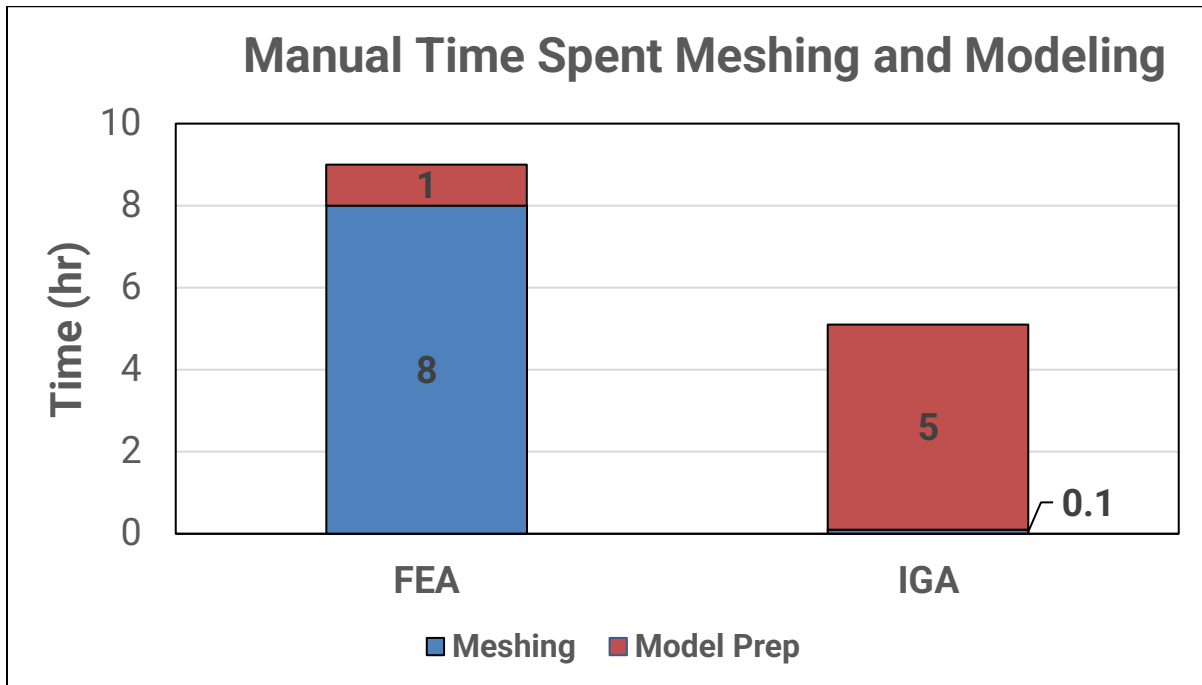
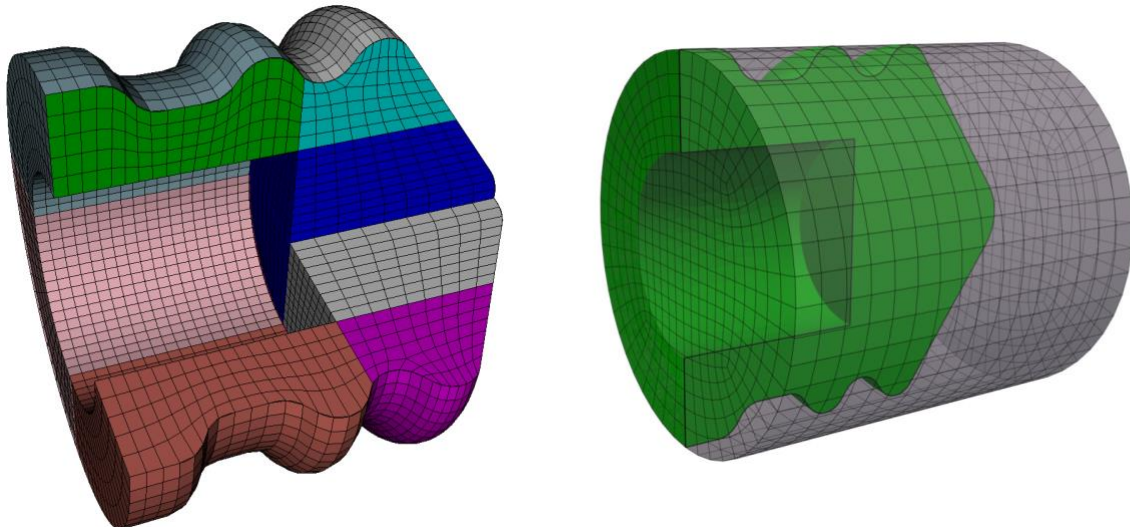


Figure 1 – Time spent preparing a model in FEA and IGA

The above figure shows how much time is spent meshing and preparing the model in both traditional FEA methods and Coreform IGA methods. Cubit cuts down the most time-consuming part of creating a model by reducing the time needed to mesh from eight hours to 0.1 hours. In current state, Cubit’s user interface slows model prep from one hour to five. BFPS Engineering’s submitted user interactions are an attempt to reduce the model prep time to make it comparable to that of FEA modelling.

To develop these user interactions, we modelled BD’s syringe in both Abaqus and Coreform Cubit. Below are images of the Abaqus and Coreform models. While Abaqus is a powerful software, meshing takes a lot of user time to mold the mesh around the exact geometry. Cubit’s IGA method significantly cuts down on this time by creating a bounding box that closely approximates the properties of the exact shape.



*Figure 2 – Meshed stopper with traditional FEA (left). Flex IGA stopper model using Coreform Cubit (right).*

Not only will the submitted user interactions help Coreform improve Cubit, but we are confident it will help them to solve the biomedical syringe problem of BD. This capstone project improves Coreform’s ability to meet their clients’ needs and exceed their expectations.

## Related Issues

While this project has significant impact for Coreform's ability to meet their clients' needs, it also generates a few externalities. This capstone project majorly affects public health, welfare, global factors, environmental factors, and economic factors. Safety, cultural factors, and social factors are negligibly affected if at all.

Improving Coreform's Cubit software allows companies like BD to improve on their product development, which products are designed to improve public health and welfare. Making BD's processes more efficient allows for more rapid development of products that can save lives. Other clients of Coreform's will undoubtedly be able to utilize such improvements in a similar way.

We anticipate that Coreform's Cubit will become a global competitor with other modelling softwares such as Abaqus. Developing this product on the world scene will expedite the improvements made to such products around the globe as it will spur competition between developers of these softwares. If it can replace Abaqus as the leading modelling software, that will be because it provides the more and better benefits over Abaqus. All these possible results will change the world scene concerning modelling.

The environment will be benefitted by the improvement of Coreform's Cubit. BD expects to use Cubit to make their design process of new syringes more streamlined. This will involve making far fewer physical prototypes, significantly reducing the negative environmental impact of making many syringes that won't directly benefit end

users. Other clients will likewise be able to perform far more testing of new prototypes in Cubit, avoiding the fabrication of many prototypes across multiple industries.

Economically, Coreform's clients will be benefitted by Cubit. Currently, the cost of a Cubit license is a fraction of the cost of an Abaqus license. Reducing the use of Abaqus in favor of Cubit will save these companies money just by virtue of the cost of software. Additionally, companies that adopt Cubit will be able to reduce the operation of physical testing facilities, fabricate fewer prototypes, complete projects more quickly, and work fewer manhours for the same result, ultimately reducing the cost of operation by a large margin.

## **Lessons Learned**

The first challenge that we initially encountered was the lack of communication that we had between ourselves and the client/sponsor. While most capstone groups began working on their projects in the fall, we had to wait until January to get going on anything. Due to that, we had a lot more limited time to learn the software programs to model the syringes accurately and effectively. We learned that it is best to start something early so that way you have more time to get things accomplished and depending on the project, we can give it the correct allotted amount of time needed.

In addition, we also learned the importance of having a broad ability to learn and to grow in different strengths. Our team did not have previous experience with finite element analysis prior to this project. We had to learn quickly to try to gain the most knowledge we could so that we could accomplish the task that was at hand.

Lastly, we also learned that it is important to be on the same page as your client/employer. Initially at the beginning of the project, we were not on the same page with our sponsor with the things that were desired and that were to be delivered. This made us initially think that we had to do more than we initially expected. In this case it was okay but if had we thought we had to do less than the sponsor expected, that would have resulted in problems. It is crucial to any project to be on the same page as those you work with.

## **Conclusions**

The results from this project suggest that modeling in Cubit is the greatest challenge for Coreform and that the implementation of the suggested user interactions regarding modeling would be the most beneficial. As our team struggled to manipulate the syringe problem in Cubit we determined that creating more user-friendly buttons and palettes would improve the effectiveness of the program and enhance its appeal as a product to Coreform's clients. Our experience using Abaqus, SolidWorks, and AutoCAD showed us that ease of modeling is extremely important in solving clients' problems.

## **Recommendations**

BFPS Engineering recommends that Coreform review submitted user interactions and implement those determined to make a significant improvement to user experience. Other user interactions should still be considered for implementation based on how beneficial they would be to users and the amount of work needed to implement them.

More user interactions may be developed by another research group before or after implementation of suggested user interactions. Additionally, when the suggested interactions are implemented, we suggest that Coreform thoroughly test the improvements and survey clients on how much time these improvements save them when modelling and meshing their models.

## Appendix A

### Tristan Parker

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#### EDUCATION

**Bachelor of Civil Engineering Degree** **Aug. 2019 – Apr. 2022**  
**Business Minor** Provo, UT

*Brigham Young University*  
GPA 3.92

- Received Joseph Layne Black scholarship for Fall 2021 – Winter 2022 school year
- Sustainable Infrastructure: Mastered understanding of sustainability across the triple bottom line and gave multiple presentations
- Global Leadership: Lead in multiple positions such as scheduler, location specialist, discussion leader, and assignment leader

#### WORK EXPERIENCE

**Production Engineer** **May 2021 – Present**  
*Acute Engineering* Orem, UT

- Analyze light-frame construction structures provided by clients
- Resolve inquiries from builders and city inspectors
- Help train other production engineers
- Completed over 135 projects and letters within first four months of employment

**Teaching Assistant** **Sept. 2020 – Apr. 2021**  
*Brigham Young University* Provo, UT

- Wrote some of the curriculum
- Lead students to understand the curriculum in small group settings

**Production Operator** **Mar. 2017 – Apr. 2020**  
*US Synthetic, a ChampionX Company* Orem, UT

- Operated and maintained a variety of machines to produce synthetic diamond cutters and bearings for oil drills and other equipment
- Worked with a small team to produce up to 450 diamond cutters per 8-hour shift
- Served as temporary supervisor once per week for three months

**Loan Processor/Document Preparation Specialist** **Mar. 2016 – Dec. 2016**  
*Flagship Financial Group, LLC* Lehi, UT

- Gathered and analyzed professional documents relevant to VA home loans
- Compiled and submitted an average of 30 mortgage files each month
- Trained two other employees

#### SKILLS AND AWARDS

- Trained and experienced in commercial use of AutoCAD
- Trained to LEAN Manufacturing Principles
- Proficient with Python and VBA programming
- Eagle Scout, On My Honor, and Den Chief Service Awards (Boy Scouts of America)

## N. Tyler Sprague

ntylersprague@gmail.com | Phone: (505)-515-6206 | Springville, UT

### Civil Engineer

Dedicated, self-motivated leader who is passionate about structures and specializes in design. Learns quickly and readily pursues knowledge. Approaches problems independently and seeks feedback on solutions. Skilled in finding appropriate and accurate information when problem solving. Collaborates well and has years of leadership experience. Adept in CAD technology and software, as well as in GIS and Excel.

#### Skills

Detail-oriented, experienced leader in different cultures and languages (Portuguese and Spanish), AutoCAD, Revit, ArcGIS, Excel and Word, over 15 years musical training.

#### Education

**BS, Civil Engineering** April 2023  
*Brigham Young University* Provo, UT

- GPA 2.89
- Structural Engineering Emphasis
- Family Life Minor
- Relevant coursework: Statics, Mechanics of Materials, Structural Analysis

#### Professional Experience

**Production Engineer, Acute Engineering, Orem, UT** Nov 2019-Present

- Analyze and engineer light-frame structures to meet appropriate building codes
- Design code-compliant connections
- Develop spreadsheets using Excel
- Mentor 4 engineers
- Thoroughly review projects from other engineers

**Security Guard, BYU Library, Provo UT** Jan 2019-Nov 2019

- Ensured the safety of over 10,000 patrons/day and the security of over 10 million valuable materials
- Enforced BYU Police security standards and policies
- Attended and applied official police trainings on topics including pepper spray, self-defense, and first aid

**Sales Rep/Pest Control Technician, Greenix Pest Control, Cleveland, OH** May 2019-August 2019

- Engaged in sales processes with thousands of customers and potential customers
- Collaborated with team members daily and implemented training techniques
- Tailored services to meet customer needs
- Serviced approximately 60 homes per week
- Eradicated pests from customers' homes, respecting personal preferences, safety and the environment
- Organized work schedules, company equipment and collaborated with salesmen to maximize jobs

**Caretaker, Beehive Homes, Albuquerque, NM** May 2016-August 2016

- Provided all basic needs for 18 elderly clients, including nutrition and medication

**Nathan C. Bell**

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(385) 270-2505 | nathanbell2016@gmail.com | www.linkedin.com/in/nathan-c-bell

**EDUCATION**

**Brigham Young University (Provo, UT)** Anticipated Graduation: December 2022 • Major: Civil Engineering

- GPA: 3.58
- Recipient of multiple scholarships from the Ira A. Fulton College of Engineering • Completed courses: Statics, mechanics of materials, dynamics, structural analysis, fluid mechanics, elementary principles of soil, fluid flow mechanics, reinforced concrete design • Learned in AutoCAD, Revit, and ArcGIS engineering software

**ENGINEERING EXPERIENCE**

**Structural Engineering Analyst**

*Acute Engineering (Orem, UT): August 2020 – Present*

- Engineer hundreds of residential homes across the states of Arizona, Idaho, Nevada, Oregon, Utah, and Washington to ensure structural integrity and strength of design
- Develop spreadsheets for structural calculations and analysis to achieve quick turnaround time •

Collaborate in teams with professional engineers to accomplish projects in dedicated time **Field**

**Technician**

*EarthTec Engineering (Lindon, UT): April 2020 – August 2020*

- Determined several inquiries about material placement and procedures
- Traveled daily throughout Utah and Salt Lake Counties to multiple construction job sites •

Tested lab specimens to find concrete compressive strength and soil proctors S

**RELEVANT EXPERIENCE**

**Cattle Herder**

*Peterson Ranch (Salem, UT): Mar 2019 – Present*

- Maintain and care for herd of over 40 cows to promote growth and

**Referee**

*BYU Intramurals (Provo, UT): Jan 2019 – April 2020*

- Managed conflicts and harsh criticism in a team setting to allow fair play and sportsmanship

**Route Manager**

*Hawx Pest Control (St. Louis, MO): May 2019 – Aug 2019*

- Directed specific routes and sales representatives to help build company revenue •

Presented several products and services to thousands of clients in their homes

**Full-Time Regional Supervisor and Volunteer**

*The Church of Jesus Christ of Latter-Day Saints (Guam): Aug 2016 – Aug 2018*

- Oversaw dozens of volunteers on small pacific islands in the Micronesia island group while learning their native language and giving daily service
- Supervised and conducted monthly conferences and meetings to train other volunteers

**SKILLS & ACCOMPLISHMENTS**

- Respectable understanding of building materials and processes
- Certified in ACI grade I concrete testing and nuclear gauge safety and use
- Proficient in Microsoft Office programs and basic programming languages • Excellent interpersonal communication skills in person, in writing, and via technology

**Sarah Fox**

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**EDUCATION**

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**Brigham Young University** Dec 2022  
Bachelor of Science/Arts: Civil Engineering Provo, UT

- GPA 3.09
- Member of American Society of Civil Engineering
- Member of BYU Concrete Canoe Club and BYU Wind Energy Club

**EXPERIENCE**

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**Acute Engineering** Jan 2021-Present  
*Structural Analysis Intern* Orem, UT

- Complete analysis on structures using Microsoft Excel, Autocad, and Blubeam often working in teams of 5
- Assist in creating an Excel spreadsheet to make calculations according to current building codes
- Create structural details for construction team to accurately implement proper engineering design
- Improve efficiency to return projects to clients in quick turnaround times, often within 1-2 days
- Refine knowledge of building code to better my understanding of engineering projects

**BYU Civil Engineering Department** Aug 2020-Dec 2020  
*Teaching Assistant – Global Leadership Class* Provo, UT

- Exhibited and taught leadership skills to students
- Adapted previous lectures be more effective in a digital learning environment
- Graded and left feedback for 98 students on 34 different assignments to help them improve leadership
- Curated new teaching techniques while collaborating with 2 other TA's

**City of Rexburg** Jun 2016-Aug 2017  
*Building Technician Intern* Rexburg, ID

- Obtained and processed information given by builders to obtain building permits
- Located 100's of building projects using GIS applications to make it easier to search data
- Digitized information efficiently to make data easier to find

**SKILLS/ ABILITIES**

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▪ ArcMap, ArcGISPro	▪ Fluent in Portuguese
▪ AutoCAD	▪ Revit
▪ Blubeam	▪ Simpson Connector Selector
▪ Excel including VBA	▪ Simpson Anchor Designer

**RELEVANT COURSEWORK**

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**Material Science**

- Tested various materials in tension and compression, creating graphs of findings

**Soil Mechanics**

- Authored professional lab reports to convey information learned from experiment findings in an organized fashion

**Transportation Engineering**

- Generated a presentation on the effects of COVID on transportation services

**VOLUNTEER EXPERIENCE**

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**Church of Jesus Christ of Latter Day Saints** Mar 2018-Aug 2019  
*Volunteer Representative* Sao Paulo, Brazil

- Personally provided leadership and training to 4 other volunteer representatives
- Taught weekly English classes to 20 native Portuguese speakers
- Built relationships with local citizens by communication 10-12 hours per day in Portuguese
- Performed statistical analysis of key indicators to increase productivity of representatives' work effort

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