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Twenty-Five Years of Christian Engineering: A Literature Survey

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Abstract

This paper surveys the complete set of over one hundred published papers that have appeared in the previous proceedings of this Christian engineering conference, identifying the themes, questions, and issues that have been explored thus far. Major themes include Biblical principles and virtues, design norms, the great Biblical directives, vocation/calling, and attributes of God. Next, a taxonomy is proposed to organize the concepts into an overall structure. Finally, the paper identifies open questions and topics that deserve further discussion.

1 Introduction

The only established, regularly held conference to connect Christian faith with engineering and technology has been the Christian Engineering Conference (previously named the Christian Engineering Education Conference until 2013). With nine conferences and over one hundred published papers, this conference features a wide diversity of thinking and philosophy on the integration of Christianity with the discipline of engineering. After twenty-five years of intellectual travel, it is time to look at the roadmap to see where we have been and see where we might go next.

Before presenting the survey, the rest of this introduction summarizes the history of the conference and then explains the process of coding used to conduct the literature survey. Section 2 highlights major themes that appear in the literature, including key definitions, and areas of disagreement. Section 3 presents a proposed taxonomy of the cumulative thinking represented by the conference proceedings, along with a mind map visual representation. Section 4 suggests areas where more work should be done, and Section 5 offers some concluding remarks.

1.1 A Brief History of the Conference

In 1992, three professors from Calvin College in Grand Rapids, Michigan organized the first national conference for Christian engineering educators, hosting it on Calvin's campus. Retired Professor James Bosscher had suggested the idea of the conference at a meeting of Calvin's engineering faculty and two other faculty agreed to join him to develop the event: Rich Van Andel and Steve VanderLeest. In order to draw Christian faculty from other institutions, the conference was scheduled in the days following the American Society for Engineering Education (ASEE) national conference, held in Toledo that year. Calvin arranged for vans to transport conference attendees from Toledo to Grand Rapids. Over 40 people attended the Christian Engineering Education Conference (CEEC) that first year.

Although there was great enthusiasm to hold another conference, the next one wasn't organized until the summer of 1995 when VanderLeest returned to Calvin after finishing his Ph.D. work. Bosscher and VanderLeest then worked with colleagues at Messiah College in Grantham, Pennsylvania to host the second CEEC on their campus in 1996. Although VanderLeest organized a dinner meeting in Milwaukee in 1997 during the ASEE conference to generate further interest, and Don Peter and his colleagues hosted another dinner with evening discussion at Seattle Pacific University in 1998, it was not until 1999 that another full conference was held, this time at the Jungle Aviation and Radio Service (JAARS) facility of Wycliffe Bible

Translators in Waxhaw, North Carolina. Faculty from Calvin College as well as Dordt College helped organize the conference this time, including a published proceedings for the first time.

Three years later, the conference went international, meeting in Montreal, Quebec, Canada in 2002 with leadership from Calvin as well as Baylor University. At this point the conference settled into a rhythm, held every two years (always following in the days after ASEE), with a more informal dinner meeting in the alternate years.

This year's twelfth conference marks the twenty-fifth anniversary of the event. It also marks the year that a loose-knit community of Christian engineers formally established and incorporated the Christian Engineering Society that now provides a more official home for the conference[1]. The body of work represented in the nine preceding proceedings is now substantial enough that this also seems an appropriate time to look back and take stock of what has been said thus far.

1.2 Coding Process

An engineering survey of a plot of land documents the circumference and major points of the landscape. Hopefully this paper provides something similar, documenting the overall scope of the intellectual work represented in the proceedings of the Christian Engineering Conference.

The prospect of analyzing all the published papers of the conference is somewhat daunting, spanning twenty meetings, eleven conferences from 1992 to 2015, nine proceedings (from all but the first two conferences), 111 papers, and 114 unique authors. Most authors (75%) only appear once, though 25% returning authors can also be taken as a sign of health and continuity. The papers total to 1,182 pages and over half a million words. The average conference paper is 10 pages long and lists 18 references. Papers ranged in length between 4 and 25 pages. Some papers provided no end notes; the most in one paper was 54. Figure 1 illustrates the size of each proceedings by number of papers and number of pages.

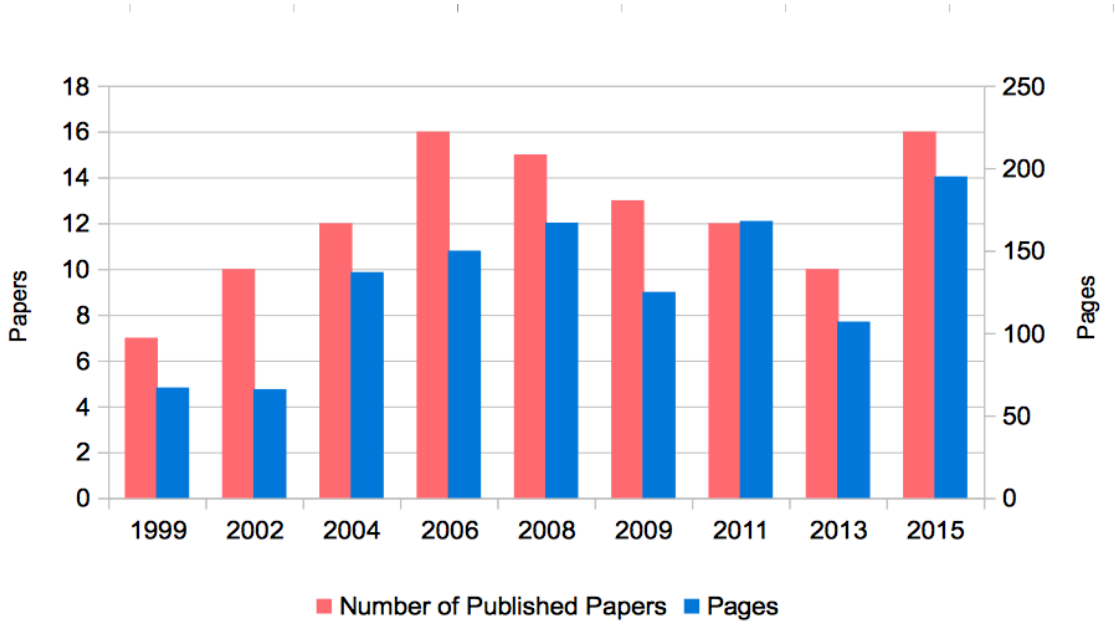

Figure 1: Number of Papers and Pages Per Proceedings

As part of my preliminary analysis to identify and code the main concepts introduced in the proceedings, I first collated the individual words across all papers. After eliminating common "stop" words (such as "a", "or", "the") and combining various forms of the same word (such as design, designs, designed, designing), the most frequently used ten words used in the proceedings appear in the table below.

Table 1: Most Frequent Distinct Words in Proceedings

Frequency	Word	% of all words (not counting stop words)
4824	engineering	1.69%
3051	student(s)	1.07%
2986	Christian(s, ity, ly)	1.04%
2482	God	0.87%
2199	design(s, ed, ing)	0.77%
2092	technolog(y, ical, ies)	0.73%
1822	universit(y, ies)/college(s)	0.64%
1802	work(s, ing, ed)	0.63%
1474	engineer(s)	0.52%
1419	develop(s, ing, ment, ed)	0.50%

The most frequently noted book of the Bible within the collected proceedings is Genesis (179). The most frequently cited authors are Borgmann (102) and Monsma (83). Just for fun, the most frequently mentioned body part is the hand, the most frequent food named is coconut, the most common celestial body cited is the sun, most common element mentioned is oxygen, most noted country is Uganda, and the most common metals mentioned are iron and then gold.

Although simply counting words provides some insights into the collective mind of the conference authors, a more useful, but more challenging analysis is to identify major themes and concepts. My process was to skim every paper at least once, documenting the major themes. My process of coding (categorization and labeling) had a narrow focus tied to the distinct central purpose of the conference: I included only concepts with explicit connection between faith and engineering/technology. Thus, concepts primarily discussed from a technical, engineering, or scientific perspective without reference to Christian faith or Biblical principles are not included. Not that such discussions are unimportant – they often serve as useful and interesting context in papers within the proceedings. Nevertheless, I left these out of my analysis. Likewise, concepts primarily discussed from a Christian faith or Biblical perspective without a connection to engineering or technology are not included. These discussions also serve as useful and interesting context in papers within the proceedings, but again, I left these out of my analysis. Occasionally the connection would be stated, but if no further scrutiny or discussion was provided, I left these out of my analysis. Even with this tight filter, I identified 75 distinct concepts, with every paper receiving at least one coding label, and some receiving dozens, averaging 7 to 8 code labels per paper. Examples of concepts I coded included vocation, stewardship, grace, serving the marginalized (poor, disabled, etc.), sacred vs. secular, and many

others. Some of these labels by themselves do not necessarily show the connection between faith and engineering, but I noted these concepts in papers where the connection was established.

Beyond this filter, I attempted to remain objective, but of course it is challenging for anyone to recognize points of view different than one's own and surely my own biases slipped into the coding process. Ideally, I would read all papers closely and read them twice: first to find all concepts, then again, in case I hadn't recognized a concept in the early papers. Sadly, the project was already ambitious, so I only re-read papers to establish examples of the major themes listed later. Even with collapsing some similar concepts into a single code, the 75 concepts I found are far too many to treat each one individually in this one survey paper. As a way to summarize while hopefully retaining some useful insights, I selected a few major themes, which I present in section 2, and then I attempted to create an overall taxonomy, presented in section 3. Perhaps just as important, in section 4 I identified some themes or important questions that seem underrepresented in the proceedings thus far.

2 Major Themes

This section describes some of the significant themes of the proceedings, focusing not only on areas of common agreement that serve as a foundation, but also on areas of debate or open questions that merit further exploration. The six selected themes are: definition of technology, definition of engineering, Biblical principles and virtues, great commandments, calling, and attributes of God.

2.1 Definition of Technology

Technology is a slippery thing to define and indeed, by some definitions it is not a thing, but rather an activity. Technology is a gift from God[2], a tool, a means to an end, a boon, a curse. It should be holistic, appropriate, sufficient, responsible. It might be high, modern, or cutting-edge. Humans deploy it, deplore it, develop it, transfer it, and design it.

The nuance between technology as thing and technology as activity is not always obvious in casual usage within the literature, hence some further discussion may be helpful. Most of the authors discuss technology with usage that implies it is a thing. In other cases, the usage is ambiguous. Some authors define technology to extend, amplify, reduce, or even amputate human ability[3]. In this thinking, technology is the result of an activity: "Technology is the product of the engineering design process."[4] An analogy to this usage of the term technology is how we use the term "composing" to refer to an activity and use the word "music" to refer to the result of that activity, where engineering equates to composing and technology equates to music.

Some authors clearly lean on the definition from the ground-breaking book *Responsible Technology* that defines technology as a cultural activity[5], and subsequently names the results from this activity as "technological artifacts". When conceived as an activity, the phrase "doing technology" implies engineering (and perhaps more). Thus, technology and engineering become nearly synonymous: "Technology is … a cultural activity – a creative process of designing the things …. Technology is often misperceived as including only objects and machinery …. A definition of technology, and therefore engineering, that reflects the 'people-centeredness' of it, and the opportunities it presents for serving God by providing for the needs of our fellow creatures, will be more attractive for all potential Christian engineers."[6] Although some authors in this camp maintain a strict separation of technology (as activity) and artifact (as the thing that

results), more often technology becomes a shorthand term for either the activity, or the result, or both. This usage is analogous to how we often use the term "science" to refer to both the activity and the result of the activity. Just as doing science results in science, doing technology results in technology. As a further nuance, Ermer defines the activity of technology to include the entire lifecycle of technological artifacts and interconnections, hinting at a relational aspect of technology: "This includes all the interactions between individuals and cultural organizations in which technological systems are embedded and the created environment from which we extract materials."[7] For reference, a few authors mention Philosopher Carl Mitcham, who expands the definition even further, naming four modes of technology: object, knowledge, activity, and volition (will).[8] Though recognizing the value of the broader definitions, the remainder of this paper follows the more common usage of "engineering" to refer to the activity that results in the thing called "technology".

While only a few papers offer definitions of technology, many more suggest faith-based guidelines for technological development and often offer an example application to a particular technology. Table 2 lists the technologies appearing in the proceedings most often. Some of these items not everyone would consider technology, but nevertheless, the list provides some interesting insights into the collective mind of the authors. The origins of the conference in the education community are certainly evident (textbook, curriculum, campus), though these are rarely examined critically as technological objects themselves.

Table 2: Most Common Technologies Named in Proceedings

Frequency	Word
430	(hand, text) book
331	curriculum
284	computer
147	building
144	campus
141	machine(s)
104	pump
100	(the) web (page, site, search)
89	bridge
84	oil
72	fuel
72	equipment
64	furnace
56	digital
55	software
55	money
53	radio

2.2 Definition of Engineering

The conference papers are more uniform in their usage of the term engineering, with some variation in discussions that contrast the discipline or activity of engineering with other disciplines or activities, such as science or business. Engineering is a technical discipline, a body of knowledge, a helping profession, an activity. It is a gift from God, a calling, and a creational task of unfolding creation. In the face of sin, it intertwines "labor and redemption"[9]. Engineering can be an adjective that defines tools, analysis, students, professionals, ethics, societies, courses, design, and books. It can be practiced, taught, and reversed. It is an activity that includes planning, problem-solving, creativity, and design. It is done for a practical purpose to produce a technical solution that helps individuals or groups to solve a problem. It uses math, science, economics, psychology, and other disciplines to refine the choice of problem, identify constraints, create alternative solutions, and objectively select the optimum solution in the face of trade-offs. Engineering is "the discipline that designs and develops technology."[10] It is "a creative endeavor, a fusion of science and technique."[11]

Some authors argue against considering engineering to be merely applied science or a subset of it,[12] while others start with application of science, but expand to human experience and note the problem-solving aspects, defining engineering as "the application of science and human experience to solve problems faced by people. This is often done in poorly understood or uncertain situations, using the available resources."[13]

Definitions are important so that we understand each other, but definitions can contain biases that intentionally or unintentionally exclude, as Jewett VanAntwerp and Ermer point out regarding potential gender bias[14] in definitions of engineering.

2.3 Virtues, Vices, and Norms, Oh My!

A number of spiritual attributes or virtues appear in the proceedings (Table 3), in far higher numbers than vices (Table 4). The most common use of the virtues or vices is in reference to personal or professional behavior. The papers less often apply them to technology design.

Table 3: Frequency of Virtues in Proceedings

Frequency	Word
746	faith
303	lov(e,es,ed,ing)
281	justice
184	care/mercy
178	wisdom
113	hope
95	hum(ble, ility)
62	honest(y)
35	diligence

Table 4: Frequency of Vices in Proceedings

Frequency	Word
32	pride(ful), egoism
23	greed(y)
9	lust(s)
9	sloth, laz(y, iness, ier)
6	glutton(y, ous)
6	wrath, rage
5	envy

Discussions on faith and love in the conference tend to be quite diffuse, often used as umbrella virtues. The next most frequently identified virtue in the proceedings, justice, finds application to behavior in a paper by Ermer[6], where she explores questions of fairness in how gender influences behavior, acceptance, and respect in engineering; and in a paper by Sykes and VanAntwerp[15], exploring justice as an aspect of character. An example application of justice to the design of technology (rather than to personal behavior) can be found in a paper by VanderLeest[16]. As an example of examining a vice, Schwindt[17] provides an interesting analysis of the damage of the sin of pride (and compares to the virtue of humility).

While the virtues discussed above are mostly applied to behavior and not directly to technology design, by contrast, the design norms from the influential 1984 book *Responsible Technology*[18] are quite commonly applied to technology in many of the papers. Ermer[19] provides a brief overview of the norms and demonstrates using them in an enhanced decision matrix. Adams applies the norms to Information Services[20]. VanAntwerp[21] and VanderLeest[22] both identify tensions within the norms and suggest possible expansions.

2.4 The Great Commandments

Christians from many different traditions commonly recognize the key Biblical directives, which engineers might call requirements. In this section, we look at the two greatest commandments that Christ gives us in Matthew 22:37-39 to love God and love neighbor, along with two other significant Biblical directives, the Great Commission and the Cultural Mandate.

The greatest commandment, to love our God, is a multifaceted endeavor, even when limiting our focus to connections with engineering and technology. The 2015 conference provided several examples of one aspect of loving God: glorifying Him. Anson[23] notes that we should glorify God because of the engineering skills he has given us and then called us to use. Rueben suggests the technology of "robots … as beautiful art that pleases and glorifies God (e.g., kinetic sculpture, theater)…."[24] In describing the principles underlying the civil engineering program at Dordt College, Sikkema and Vander Werff[25] note the "unfolding potential of technology and how it manifests God's glory." Another aspect of loving God is worshipping him. Some of the literature examines misdirected worship – worship of anything other than God – such as directing our adoration towards idols of nature[26], work, technology[27], or science, for example. One can also find plentiful examples of properly directed worship connected to technology. One paper[28] mentions technological aids to worship, such as projected music slides, microphones, or lights.

Another mentions construction of a house of worship[29]. Career choice, rightly done, can be "viewed as an act of worship."[30] Ben Kelley explores multiple aspects of worshipping God through technology in his helpful paper "The Use of Technology in the Global Church."[31]

The second greatest commandment, loving our neighbor, is also multifaceted. Within the proceedings, the most common connection of this command to engineering and technology is via serving the marginalized of our society, including the poor, the hungry, the disadvantaged, and the disabled. This charge is so significant and direct that over a third of all papers in the conference make this connection. The thread of providing service to the destitute runs throughout the proceedings, from the very first published paper[32] that makes the case for serving our marginalized neighbor as a matter of justice, to Bradley's zealous analysis of coconuts to serve the poor[33], to one of the most recent papers[34] making the case for engineers to serve our neighbors who lack clean drinking water. Within this frequently discussed theme, one particular form is most common: humanitarian projects for the poor and oppressed in international locations. One example is a study[35] of the spiritual impact of humanitarian projects from four different engineering academic programs. Using our engineering skills as an act of service to those that likely cannot repay our kindness is surely a way we can be the hands and feet of Christ in the world and fulfill our particular calling to design technology. However, some authors have noted that this calling holds true even when we design technology for those that are not impoverished. That is, engineering is a helping profession and we ought to love our neighbor through the instrument of our technology. Shaw puts it this way: "Love for my neighbor involves doing all within my power for his good. This includes the development and refining of life-improving and life-saving devices and technologies."[36]

The conference literature suggests obedience to the Great Commission (Matthew 28:18-20) in at least two distinct ways. First, engineers can develop technology that aids in bringing the gospel message to the ends of the earth, such as designing navigation aids for aviation-based missions to remote regions[37]. Second, engineers can bear witness to the gospel to those around them in their professional capacity as they work. That is, engineers have access to distinct segments of our society and can gain a hearing within cultural segments where other Christians might not. For example, Helweg discusses Christians in academic administration in public institutions, suggesting a two-fold benefit: "First, a Christian in a highly visible place has the opportunity to show the world a standard of excellence that brings glory to God. Second, the higher one ascends in administrative positions, the wider the area of influence in communicating the Gospel."[38]

Christians are generally familiar with the three New Testament great commands discussed thus far. We hear them preached from the pulpit on Sundays; we read about them in devotional books; much of our hymnology is built around these ideas. However, Jesus said he did not "come to get rid of what is written in the Law or in the Prophets. I have not come to do this. Instead, I have come to fulfill what is written." (NIRV, Matthew 5:17) Thus we might also expect some guidance from the Old Testament regarding engineering and technology. Consider Micah 6:8, the well-loved summary of what God requires of us, directing us towards mercy, justice, and humility. The proceedings contain multiple instances of applying these virtues in engineering, with examples provided in the previous section. Another directive from the Old Testament that is less familiar to many Christians, but well established in these proceedings is the so-called cultural mandate that God gives all humans in Genesis 1:28: "Be fruitful and increase in number;

fill the earth and subdue it. Rule over the fish in the sea and the birds in the sky and over every living creature that moves on the ground." This passage is also sometimes called the dominion or stewardship mandate. Reading the mandate literally, the human race has obeyed the command, perhaps too well – in the view of some, we have overpopulated the earth and overplayed our dominion, to the point that some of God's creatures have been driven to extinction. However, in the literature of this conference, many authors read the mandate quite broadly and figuratively. They interpret the mandate to also include a command to steward the earth, to not only preserve and care for God's creation, but also to cultivate and develop it. Thus, stewardship appropriately appears in the literature as one of the design norms.[39] One example of a technology directed towards stewardship appears in Timmer's description of a biomass cook stove[40]. Developing God's creation becomes a rich and ambitious assignment beyond physical cultivation: to create culture and society in all its diversity, composing music, developing government, establishing schools, writing stories, and importantly for this conference, designing technology. This task is sometimes described as unfolding creation[41], one that is assigned to all humans as stewards. For engineers, the task is rather directly connected to our skills at using creation's resources as the raw material of our technological products.[42] We see the Biblical narrative that starts in the garden of Eden and ends in the City of God as an affirmation of cultural development, and even more specifically, of technological development[43,44].

2.5 Calling

Of all the 75 concepts that I coded across the proceedings, the one that appeared the most frequently was the idea of calling, or vocation. More than simply a job or trade, broader than a career or profession, calling is the sense of God's will for one's life, the inner urge that connects one's particular gifts with a deep sense of purpose. The frequent appearance of this topic is not surprising. Christians with a strong desire to honor their faith in all aspects of their lives are faced with an apparent paradox when their talents and gifts do not line up with society's narrow definition of a religiously devoted career, which is limited to pastor/priest, foreign missionary (preferably in a destitute location requiring great sacrifice through physical hardship), or along the same lines of hardship, perhaps a Sunday School teacher for middle schoolers. However, a richer and Biblically-based understanding of calling encompasses much more. God's calling extends to our roles as spouses, mentors, neighbors, parents, and citizens. It extends to our work, where work is understood as a creational good, part of our innate purpose.

The proceedings thus make the case that engineering is a legitimate calling from God. Tuinstra[45] provides an in-depth justification, demonstrating why there is no distinction between sacred and secular callings and then pointing to specific examples of the unique calling of engineers. Others point to Colossians as the basis for legitimacy and encouragement[46] "Work at everything you do with all your heart. Work as if you were working for the Lord, not for human masters." (Colossians 3:23, NIRV).

2.6 Attributes of God

The proceedings are replete with explorations of the characteristics of God and application to the practice of engineering. Examples of God's sovereignty include a paper on miracles and heat transfer[47], as well as a paper that points to sovereignty as the foundation of faith guiding technology development[48]. Other authors look at God's will and purpose, such as one paper[49] pointing to common grace providing insights even from unbelievers in order to help Christians understand God's will, and another paper that exhorts us with the words "only by obedience to his will that the creation can fulfill its purpose in the service of God,"[50] then links this obedience

to the cultural mandate (discussed earlier section in this paper). This is only the beginning, with many more papers covering God's wisdom, truth, love, grace, mercy, omniscience, and justice, to name a few.

An important subset of the papers that examine attributes of God choose to focus on a particular person of the trinity. While God the Father almost always appears within discussions in connection with the full trinity, the other two persons of the Godhead have been examined distinctly in search of insights for bridging faith with engineering and technology. For example, VanAntwerp's paper[51] is an excellent study of God in the person of the Holy Spirit. Other authors mining the depths of the distinctive attributes of God the Son have looked at the threefold office of Christ as prophet, priest, and king[52].

Having touched on a few important boundary stones pathway of the proceedings, we can now turn our attention to a suggested roadmap for the entire acreage.

3 A Taxonomy of Christian Engineering

One way to organize a large body of work is by classifying the constituent elements in the form of a taxonomy. What good is a taxonomy? It can be a tool to help us communicate more effectively by providing some common structure to a conversation. It can help organize our collective thoughts so that we notice where colleagues are working on similar or complementary topics that would benefit from cross-fertilization. It can also help us identify gaps in our thinking, where we should consider cultivating further thought and research.

My proposed taxonomy emerged out of the activity of coding the concepts with the proceedings. The exercise of coding, i.e., choosing which words and concepts to identify within a given paper, is always biased to some degree due to the worldview, opinions, and perspective of the coder. Even with stated guidelines and rules, the personality of the coder seeps in to sway the selections, though using multiple people to code the same documents can help balance the biases. The exercise of categorizing the coded concepts and arranging them into an overarching and organizing outline is likewise biased. With humility, I must allow that there are surely other ways to till the soil of concepts found in the proceedings into a systematic landscape. I myself considered several approaches, but offer only the following scheme as just one way to relate and contrast the diverse work of the conference. Further humility is required since these proceedings are not the only source of published work on the subject of bridging Christian faith with engineering and technology.

The focus of the coding influenced the broadest distinguishing factor of the taxonomy. Since the coding was limited to those concepts that bridged Christian faith with engineering and technology, I then used the direction of traversing this bridge as the fundamental way to organize the concepts: either faith influencing engineering or engineering influencing faith. One might instead consider choosing the divide between engineering and technology, or between engineering and science, or between various Christian traditions, or between various engineering disciplines. However, I suggest that none of these possibilities is as central to the conference as the bridge between our faith and our profession. Although this division may be central, it is not balanced. The vast bulk of our research focuses on one direction along the bridge: Christian faith influence on engineering and technology. The other direction – engineering/technology

influence on faith – has received less attention in the proceedings, and that seems appropriate. Yet making the distinction in this way also seems helpful, and in fact, a third category at the top level must then be recognized – the topic of appropriate terminology and ordering of this relationship.

This choice of organization frames the discussion in a certain way, and this author hopes that the framing itself gets attention from future authors. I propose that while the conference can benefit from work outside of this framing (such as work purely focused on engineering, or education, or theology, or science), we collectively benefit when most of the work lies within the suggested framework. This is more a matter of practicality than philosophy or theology. There are other, well-established conference, journals, and societies that provide a fertile and welcome home for the topics I suggest are peripheral to, but not excluded from, this conference. In the interests of building momentum, effective use of time, and effective communication of ideas, it seems prudent that this conference continue to focus on the unique combination that no other conference provides in such depth.

Having staked the claim for this overall framing, there are at least two problems with this choice that I could not easily resolve and thus leave as open questions for the reader. First, while some readers will interpret the words engineering and technology as nearly synonymous, others do not. I resorted in the taxonomy to listing "engineering/technology", but this does not seem entirely satisfactory. A second, related problem is that while most authors and conference attendees would label themselves as engineers, technology is not the sole domain of engineers. Stop a person on the street and ask "who creates technology?" and the most likely answer is scientist, not engineer. Consider the mathematician, computer scientist, communications studies researcher, business owner, inventor, entrepreneur, artist, and others who might rightly consider themselves contributors to technology (if not directly, at least as stakeholders). Where should they go to discuss faith and technology, if not this conference? Does the use of engineering in the title of the conference deter them, and if so, is that OK? There are other conferences for non-engineering disciplines that at least occasionally touch on technology, and then connect discipline plus technology to faith, e.g., the American Scientific Affiliation and the Association of Christians in the Mathematical Sciences. Each level deeper into the outline was filled with additional difficult choices, but in the interest of brevity, I present my proposed taxonomy with no further background discussion.

I. Christian Faith influence on engineering/technology
   A. Legitimacy of this line of inquiry
      1. Legitimacy of faith to influence engineering
         a. God's sovereignty (Christ's Lordship)
            i. A Christian worldview ought to influence all of life, including one's profession (such as engineering).
            ii. All creation falls under God's rule, including engineering/technology.
            iii. God is the audience of our work, including engineering.
         b. God's providence
            i. Provides His people with particular talents and gifts appropriate to their calling, including technical gifts for engineers.

c. God's glory
    i. All work should be done as for the Lord. Good work is an act of worship, to the glory of God, including engineering

2. Legitimacy of engineering to be influenced by faith
    a. No sacred/secular divide
        i. All work (including engineering) is sacred and should be influenced by faith.
        ii. Engineering is a vocation and calling from God.
    b. Technology value-laden
        i. Technology is biased, value-laden, non-neutral (though some slight debate on this point, at least for technology as object), thus Biblical principles ought to guide its development.
        ii. Technology in creation-fall-redemption narrative
            (A) Christians should find the creational good and fight the taint of sin on technology.
            (B) Christian engineers should act as agents of redemption through the technology they design.
        iii. Technology is an act of will (volition) and Christians should align this willful act with God's will.
    c. Engineering is part of human nature
        i. Work (including engineering) is part of human nature and should be influenced by faith.
        ii. *Imago dei* (humans bear the image of God) aspects related to engineering
            (A) Humans are distinctly tool makers among God's creatures, reflecting God's image via creativity, volition (free will).
            (B) We are co-creators when unfolding creation (cultural mandate), including technological cultural development.
        iii. Examples of creative activity and craftsmanship (e.g., Bezalel, Uzziah) show Biblical recognition of these skills (related to engineering), particularly for certain humans.
    d. Engineers adept at certain Christian duties
        i. Loving God
            (A) Along with scientists, engineers can particularly appreciate creation's unity and diversity and appreciate God's creation of unchanging, stable physical laws.
            (B) Stewardship of natural resources
                1. Preservation (including creation care, sustainability, environmental stewardship) are tasks engineers are skilled to pursue, though technology can also cause problems in this regard.
                2. Cultivation (including unfolding of creation, cultural development) are tasks engineers are distinctly skilled to pursue. Furthermore, engineers are distinctly prepared to appreciate technology as a gift of God.
        ii. Loving neighbor
            (A) Technology, by its very nature is practical and instrumental, can aid in loving others by solving their problems, improving their standard of living, helping them to flourish, providing safety, etc.

(B) Christians can serve the marginalized, including the poor, hungry, oppressed, physically challenged, and the stranger (cross-cultural, humanitarian projects). Compared to other Christians who also have a calling to serve the poor and otherwise marginalized, engineers are distinctly qualified to offer practical help, perform needs assessment, and design appropriate technology as part of the solution to their problems.

(C) Engineers act as redemptive agents

1. Engineers are distinctly qualified to design technology to ameliorate the effects of sin, to restore justice, and to bring shalom through their technological products.
2. Technology itself is tainted by sin, but engineers can act to redeem it.

(D) Engineers have prophetic witness opportunities related to technology, helping society understand the implications of technology.

iii. Gospel witness (Great Commission)

(A) Engineers have access to certain parts of society by virtue of their profession and can thus have prophetic witness/influence, e.g., corporations, professional societies, standards committees, etc.

(B) Engineers have skills to provide help (solving practical problems) and serve where others cannot, and thus gain access to that audience for the gospel.

(C) Engineers can have fellowship and share unique perspectives on faith with other engineers (to encourage believers and witness to non-believers).

iv. Serving the church: Engineers are part of the body of Christ and can use their God-given talents to aid the church in appropriate use of technology (in worship, in mission, in service, etc.).

B. How Christian faith influences engineering/technology

1. Faith influences personal behavior
   a. The virtues (love, mercy, etc.) and spiritual disciplines (prayer, Sabbath, fellowship, etc.) guide our behavior, sometimes in distinctive ways for engineers.
      i. Faith guides the personal moral choices of Christian engineers, i.e., professional ethics.
   b. A worldview that recognizes the sovereignty and authority of God …
      i. … influences the engineer's choice of career direction and project selection
      ii. … bolsters resistance to worldly influences prevalent in engineering, including post-modernism, secularism, technicism, materialism, dualism, naturalism, instrumentalism, abstractionism, compartmentalism, etc.
2. Faith influences professional activity
   a. Engineering design influenced by faith
      i. Faith principles influence design of technology
         (A) Principles that align design choices with God's direction
            1. Biblical virtues and fruits of the spirit, such as justice, love, wisdom, honesty, self-control, etc.
            2. Spiritual practices and discipline, such as prayer, fellowship, etc.
            3. Threefold office
               a. Prophet giving witness regarding technology
               b. Priest providing mediation and service with technology

c. King claiming dominion over technology
4. Design norms from *Responsible Technology*, derived from Christian philosopher Dooyeweerd's aspects of reality, based on God's will as expressed in command to love God and neighbor[53]
a. Cultural appropriateness: (dis)continuity, differentiation/integration, (de)centralization, (plur/un)iformity, large/small scale
b. Open communication: including lingual and social, also called transparency[54]
c. Stewardship
d. Delightful Harmony: form fits function, also called integrity[54]
e. Justice
f. Caring
g. Trust: pistic (faith) aspects

(B) Biblical narratives that mention technology
(C) Restraints and limitations that faith points out
1. Sin/fall/curse calls for redemptive/transformative agency
2. Recognize impact of specific sins
a. Sin of pride in technology
b. Sin of substituting technology for divine grace
c. Sin of idolizing/worshipping technology
3. Finiteness (because we are created, not creator) requires humility
a. Learn from failures
b. Use cautionary principle, lest we take undue risks because we cannot completely predict consequences
c. Beware designs that we cannot fully understand consequences and thus negligently harm our neighbor or creation, e.g., Borgmann's warning about device paradigm (separation of technical means from technical ends), or designs that are too complex
4. Culpability for technological harms due to both our fallen and finite nature

ii. Engineering design practices and tools influenced by faith
(A) Design decisions and trade-offs influenced by Biblical principles
(B) Design processes broadened by respect of persons and creation, e.g., holistic design, sufficient design, appropriate technology
(C) Choice of problem directed by God's will
(D) Creativity inspired by Holy Spirit
(E) Teamwork enhanced by fellowship, love of neighbor, collaboration with fellow image-bearers

b. Education of engineers influenced by faith
i. Curriculum, pedagogy, liberal arts, service learning, interpretation of standards such as ABET Engineering Criteria 2000
ii. Mentoring, advising, discipling, especially regarding calling

c. Profession of engineering influenced by faith
i. Ethics codes and standards influenced by faith

ii. Faith encourages fairness in organization, seeking justice for all, recognizing diversity (race, gender, economic status, etc.)
iii. Faith influences choice of issues that organizations choose to address

II. Engineering/technology influence on Christian faith
  A. Engineering helps us understand Christian faith
    1. Scientific or engineering principles as analogies to help clarify faith principles
      a. God as the ultimate engineer
    2. Scientific or engineering principles (design evidence, finely tuned universe, beauty) pointing to God's handiwork
      a. Appreciation of the Creator
      b. Enrichment of faith
      c. Apologetics based on evidence in the Creation
      d. Inspires innovative design
    3. Application of engineering principles to understand and be inspired by miracles
  B. Common grace allows Christian engineers, with discernment, to accept cheerfully the good help and good ideas of unbelievers.
    1. Christians may choose to honor societal standards such as a professional society code of ethics or ABET EC 2000

III. Proper name and ordering of the relationship between Christian faith and engineering/technology
  A. Terminology: integration, bridge, foundation, synthesis, etc.
    1. Niebuhr's categorizations of Christ and Culture (against, subsumed, above, in tension, transforms)
  B. Primacy[55]: if faith has primacy over profession, then which label is best? "Christian engineer", "engineering Christian", "Christian who happens to be an engineer too", "engineer who is also a Christian", etc.

As one might guess, any attempt to map such a complex web of ideas into a sequential and segregated taxonomy will fall short of representing the true intellectual landscape. As an alternative view, the following figure provides a mind map of a subset of the ideas that appear in the proceedings, visually demonstrating the complexity of the relationships.

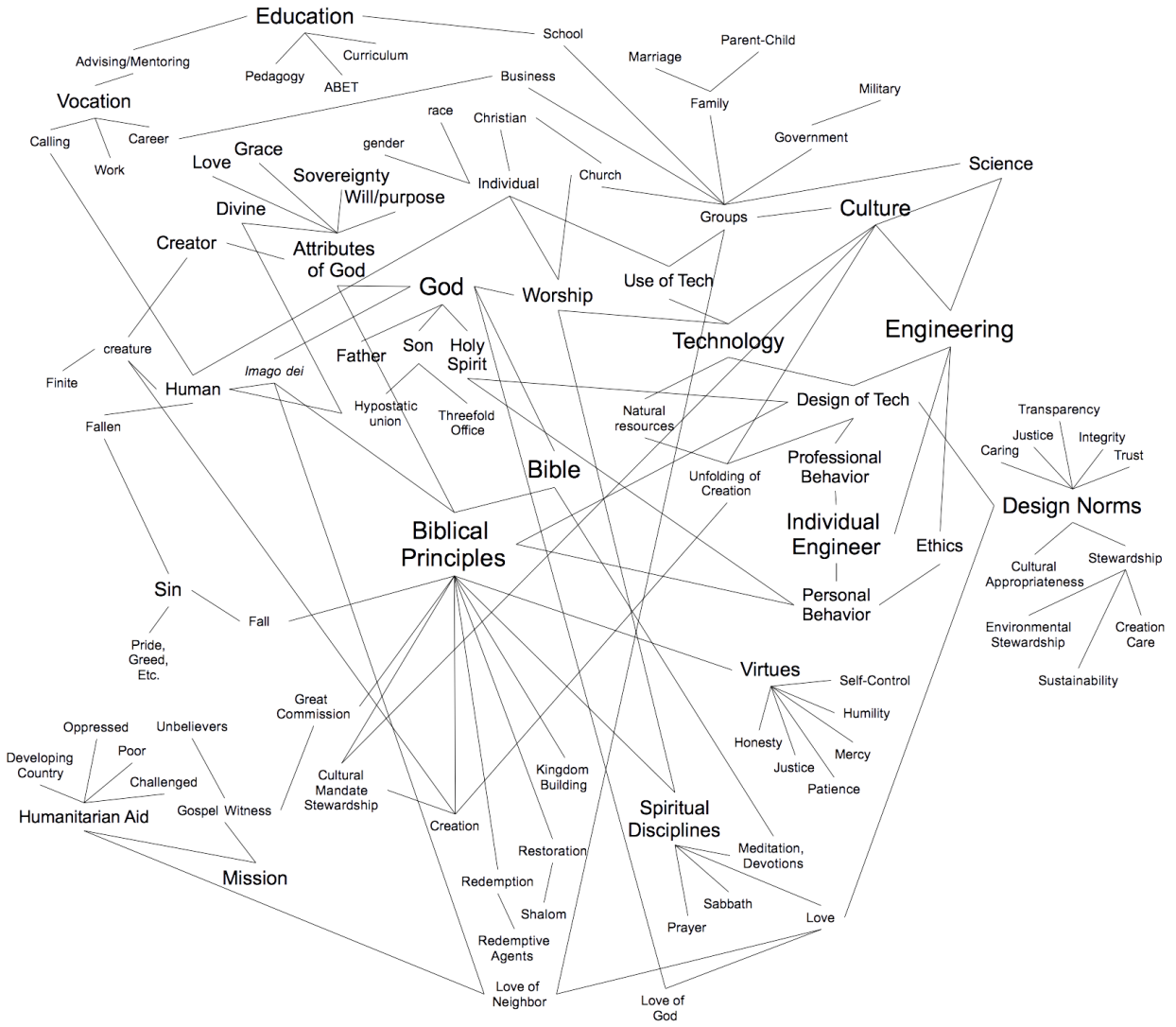

Figure 2: Mind Map of Some Christian Engineering Concepts

One of the purposes of the taxonomy is to help us identify gaps, where more thought is warranted. As a start, the next section mentions nine areas that deserve additional research.

4 There is More Work to Be Done: Missing or Poorly Addressed Concepts

With hundreds of papers over decades of time, we have jointly covered much of our chosen topic to integrate Christian faith with the profession of engineering. However, the topic is so rich and deep that more remains to be done. Although the concepts that have been explored multiple times still merit further study, this section identifies gaps – topics that the existing literature covers poorly or not at all. Before continuing, I note that the discussion presented in this section could easily feel like a critique of the conference in general, or even a critique of specific papers. That is not the intent, but rather this analysis is meant to show gratitude for the work thus far and provide encouragement to extend the work further.

A first area of weakness is that the proceedings rarely attempt to define fully and completely the central terms that form our identity, such as engineering, technology, and design. There are a few

examples, but even these mostly accept definitions from other sources rather than defining them on our own terms. This perhaps implies a common notion that the terms are self-evident. However, as noted earlier in this paper, there appears to be some differences in understanding, which would thus be healthy to examine, contrast, and compare.

As a second area of weakness, consider that the proceedings contain only a few examples of authors tackling current issues or attempting to analyze a novel technology from a faith basis, such as climate change, sustainability, artificial intelligence, genetic engineering, or changes to ABET accreditation criteria. Applying faith principles to concrete, specific cases provides a very useful test of our thinking. Trade-offs and prioritization inherent in design decisions seem easy in the abstract, but become vexing challenges in actual, concrete problems. Thus, more papers should be written that tightly focus on one problem, plumbing its depths and exposing the real struggles we ought to address.

As a third area of weakness, consider that while we have many papers devoted to aid to the marginalized in under-developed countries, there is much more to be said on this topic. In particular, (a) we need more analysis and more examples of cooperation with those being served. In humility, we need to remain teachable and ready to learn from our neighbor. We have paid lip service to the blessings received in the act of service; it is now time to articulate those blessings in full. (b) Many of the projects seem to be geographically distant from the home of the serving engineers. Since most of our authors are from highly developed and richly blessed countries, this makes sense in some ways – our poorest neighbor is likely across the border. However, surely the poor and homeless are also nearby. Why have we spent less time looking at local missions? More explanation of the choice of project (particularly its location) would be helpful so that the glamor and adventure of international travel (even when traveling to impoverished regions) does not tarnish our altruistic motives. (c) We should recognize the tension between two spiritually motivated goals: international travel to aid the poor and stewardship. Does the enlarged carbon footprint and use of energy resources justify the good that comes from such mission trips? Yes, in many cases. However, it would be healthy to examine this question in more detail. This is not an easy equation to balance and will require careful thought. For example, is the benefit of such a trip by a college student transient, or does it extend beyond the immediate time frame of the trip in a sustained improvement that is permanent? Does the benefit extend into the student's own career with further mission work? Is the benefit to a single village or does it extend to other communities with replication of the appropriate technology?

A fourth area of weakness is the coverage in the proceedings of the Great Commission by the particular means of witnessing to others during a mission trip. There are at least two areas worthy of further assessment here. (a) For US-based authors, we do not sufficiently recognize that our neighbors are not necessarily in need of salvation simply because they live in countries that are economically disadvantaged compared to the US. For example, one commonly mentioned destination for humanitarian mission trips in the proceedings, Uganda, has a purportedly higher percentage of Christians (88%) than the US does (71%)[56]. (b) Far more papers have addressed gospel witness through foreign mission trips than have addressed witness of the engineer in the corporate workplace, in professional societies, or in society at large. This bias is understandable, since most of the contributors at the conference are faculty from engineering programs at Christian institutions of higher learning, with far fewer participants

from industry. The proceedings appear to have far more authors experienced with international humanitarian mission trips than authors experienced with work for pay in corporate settings. This is almost the polar opposite of the experience of the vast majority of the Christian engineering population, who participate in mission trips rarely (perhaps once during college, perhaps occasionally later), but who work full time for decades within a for-profit engineering business. The conference cannot help but self-select for this bias. For faculty at Christian engineering schools, their home institution not only funds their attendance at the conference, but also encourages such research and perhaps even requires it. For faculty from institutions that are not faith-based and for engineers working at for-profit businesses, it is unlikely that their home organization would fund attendance at the conference and even more unlikely that it would require or simply accept such research. We should collectively address this challenge, working to diversify participation in the conversation and working to address the topic of gospel witness for all Christian engineers in all aspects of their lives and careers.

A fifth area of weakness is that while the proceedings tend towards application of Biblical principles, virtues, and spiritual discipline to the engineer as an individual, there could be more work on the specific application of these principles to the actual activities of engineering (problem solving, design, ideation, etc.). Furthermore, whether applied to personal behavior or professional activity, there could be more work on the challenge of applying the principles identified already in the proceedings in the context of real-world, for-profit businesses that employ engineers, that are managed by engineers, or that are owned by engineers.

A sixth area of weakness is that there could be more work on prophetic influence on organizations where engineers often have membership, such as professional societies, student clubs, or committees that set standards and codes. Equally important, explicitly faith-based organizations, such as mission agencies, could be the subject of a paper on how engineers can bring a prophetic voice and a technological helping hand.

A seventh area of weakness is that while much has been said on the implications to engineering and technology in regards to the Great Commission, the Great Commandments, and the Cultural Mandate, there is more work to be done here. For example, we should look further at loving our neighbor by serving them with technology. Our focus has mainly been on solving the immediate issues of hunger, need for clean water, mechanical assistance for physically challenged, and so forth. These are important and right. Is there more? What about technology that enhances relationships, addresses injustice beyond the physical, that amplifies our ability to respect, understand, and attend to one another? Furthermore, there are other core directives in scripture that could be fruitfully studied, such as the ten commandments, the fruits of the spirit, and spiritual disciplines such as fasting, to name just a few.

An eighth area of weakness is that while much has already been said on the implications to engineering and technology in regards to certain attributes of God, there is more work to be done. We have made some beginning attempts, such as God's sovereignty or his providence, and should continue that work. There are other characteristics of God that have been examined very little to date, such as analysis of the first person of the trinity, God the Father, or analysis of the so called hypostatic union of Christ, i.e., he is fully human and fully divine.

Finally, a ninth weakness is also an exhortation to my siblings in Christ: let us find joy in our work. Within the proceedings, joy is mentioned as part of the design norm of delightful harmony, occasionally implied by the term enjoyment, discussed briefly by Schwindt[57] and briefly in connection with hope by Sykes and VanAntwerp[58]. There is more work to be done. Let us find joy that is not simply human pleasure, but rather joy that is existential delight in the unity and diversity of creation, joy that is divinely inspired gladness in loving our God and our neighbor with the gifts God has bestowed on us. Many of us feel that joy in our daily work; it is now time to express it more fully in our writing so that others may share in that Godly joy.

5 Conclusions

I am humbled by the breadth and depth of work represented by the proceedings over twenty-five years. My prayer is that God has been glorified and the saints have been edified by all this faithful thinking and writing by our siblings in Christ. Humbling me further, I had hoped to expand this survey to also include more of the literature from outside the conference, but alas, the project was ambitious enough simply with the proceedings of this conference, so only a few other important manuscripts are mentioned.

I ended the previous section with a call to find joy in our work, so I end this paper in an expression of joy in having surveyed the good and faithful writing of all these authors. May our Master look at our work and may we take joy in his response "You have done well, good and faithful servant! You have been faithful with a few things. I will put you in charge of many things. Come and share your master's happiness!" May that kingdom come and may his will be done, to the praise of his glorious grace.

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A survey paper necessarily contains many citations to previous work. In order to make the listings a bit more concise, I have foregone the usual format of listing the full name of the proceedings (except in the first instance) along with the location of the conference (omitted in every case).

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