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How Developing Electrical Technologies Can Meet Human Needs with Christian Compassion

Harold Underwood

Having students work on service-oriented projects that meet basic human needs has become a popular strategy in engineering education; such active learning motivates students and prepares them for professional practice. While conventional engineering service project teams often implement a solution that meets human needs on the spot, exploratory technology development service projects, such as I address here, take time to reach proof of concept maturity, before wider application may occur. Whether implementing or developing, a Christian Engineer following Jesus finds solid ground by establishing links between objectives of a service-oriented project and the counsel of Scripture. Hebrews (13:3) calls Christian to identify with prisoners, and those who are mistreated; Romans (8:19-21) suggests that the creation waits with anticipation for children of God to be revealed, and to be free from its bondage; James (2:14-17) explains that good works reveal the faith of a compassionate heart. While interpretations may vary, I argue these passages support the value of Christian compassion as expressed in engineering projects focused on needs of people restricted in some way (e.g., physically or socially), that they may gain more independence. Such scriptural support provides a foundation, but the Christian gospel presents God as an active agent in Jesus Christ, caring and participating with his image bearers in creative works of service, to fine tune both workers and the work, just as he did in the creation itself. Thus, the gospel compels a Christian to prayerfully seek the Lord, search the scriptures and consult with others beyond mere project justification to ongoing guidance, so those served as well as the servants are mutually blessed. Specifically, I suggest that despite inherent risks and limitations, developing electrical technologies conveys Christian compassion to the needs of certain people otherwise overlooked. Two examples of ongoing projects hosted by the Collaboratory for Strategic Partnerships and Applied Research at Messiah College will illustrate: 1) flight tracking and messaging systems (FTMS) to follow small planes in remote locations, as a safety risk management service to the pilot and family; and 2) an assistive communication system known as wireless enabled remote co-presence (WERCware) intended for those with cognitive and behavioral disabilities to foster sustained employment and more independent living. After identifying scriptural and social support for these projects, this paper will describe our strategy for ongoing guidance, and comment on the challenges of maintaining responsible balance in our most recent work. Transferable principles will be suggested for the reader who wishes to extrapolate from our experience to another institution.

1. Introduction

The benefits of experiential learning such as service-oriented projects in engineering education have become well known, inside the Christian community and without, as indicated in the literature including a companion paper by this author. While experiential learning can include a variety of activities, I focus here on service-oriented engineering projects, that address basic

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human needs otherwise overlooked by the commercial world, and serve those that cannot or do not initially provide monetary compensation for benefits received. On the other hand, I also intend the descriptor service-oriented in a broad sense to include a wide range of engineering project activities from A) the conventional service project involving a site-team\textsuperscript{iv} implementation trip, to B) an exploratory\textsuperscript{v} technology development project requiring applied research to meet objectives; in each case, the project should be guided by a client familiar with the target community being served. Category A examples might include construction or installation of 1) a clean water facility to improve health, 2) a solar photovoltaic panel for electrification to raise standards of education, or 3) foot-bridge over wetland to promote access to resources, targeted to the poor in a developing country. Such implementation projects represent a few of those deployed over the years by the Collaboratory for Strategic Partnerships and Applied Research (Collaboratory) at Messiah College. I describe two category B examples in section 4 of this paper: Wireless Enabled Remote Co-presence (WERCware) and Flight Tracking and Messaging Systems (FTMS). For quality and integrity, even category A examples require preliminary (exploratory) site-survey, design, testing, redesign and follow-up phases of engineering activity to ensure the work meets the need effectively, and in a sustained way. So, longer-term category B projects where applied research and testing is required to develop a “proof of concept” prototype must not be automatically dismissed; exploratory technology development should be eligible for service-oriented status, even if the application is not so immediate. To keep them on track, one further criterion for both project categories serves as a safeguard: a knowledgeable client together with the project manager (e.g., faculty member) through frequent meetings with students to guide the work, critiquing progress on the objectives, and arranging field studies when real consumers can test the prototype to provide feedback for future improvements.

2. Scriptural directives

In his sermon on the mount, Jesus compares those who hear his words and put them into action to a wise person who builds a house on the rock. Building on a solid foundation, to a Christian engineer, has meaning on multiple levels: the direct physical application, rational worldview implications and spiritual consequences. Coming at the end of his sermon, Jesus surely meant at least that if we as his followers act like salt and light on the earth, give to the needy, and treat others as we wish to be treated (to recap just a few main points), we live more worthwhile God-pleasing lives in general. But further extending Jesus’ words to the engineering context provides impetus for projects that focus outward, fitting for salt and light, directing attention towards the needy, and treating those served as we would wish if we were in their place. While these ideas offer solid ground for service-oriented projects, heeding Jesus admonition to avoid pitfalls in the foundation also requires examining the scriptures broadly. Any divine counsel found applicable to engineering project initiatives helps set worthier objectives and direct healthier work.

In Romans, the Apostle Paul offers more basic principles to guide the Christian life in thought and in practice. Following up on the Christian believer’s continued struggle with sin, Romans 8 reveals the glorious truth of no condemnation in Christ. We learn that with the freedom of spiritually enlightened minds, believers may live as children of God. Sharing in his suffering, we are told, enables us to share in his glory. In the suffering versus glory context, Paul says
I consider that our present sufferings are not worth comparing with the glory that will be revealed in us. For the creation waits in eager expectation for the children of God to be revealed. For the creation was subjected to frustration, not by its own choice, but by the will of the one who subjected it, in hope that the creation itself will be liberated from its bondage to decay and brought into the freedom and glory of the children of God. (Romans 8:19-21, NIV)

Which prophecy refers to future event(s) (e.g. “will be revealed”), and which has already occurred has been a matter of ongoing debate among Bible scholars and commentators. Advocates of “realized eschatology” claim the end has already come, while proponents of “future eschatology” say the end lies ahead. Could the truth lie in between? Though “we now see in a mirror dimly” (1 Cor. 13:12, ESV), while the “kingdom of God has come near” (Luke 10:9, NIV), glimmers of God’s glory that now seem evident may “foreshadow” the fullness of His glory yet to appear in the final redemption. The creation “waits” as Romans 8 describes, even anticipates the appearance of God’s children. This revelatory appearance of His offspring may not necessarily be so obvious; as Tim Keller explains, it is likely to be accompanied by the glory of God’s holiness, incomplete until later. VI Yet all Christians saved by God’s grace have Jesus’ mandate to make their presence known as the Lord’s elect children, in the form of “salt and light.” Next, the Romans 8 passage indicates that the Lord of creation cast his work into a temporary state of “frustration” (just as he expelled Adam and Eve from Eden), planning all along to free it again by “glory of the children of God.” While final perfection of this redeemed state must be future eschatology, as the Lord does not yet reign supreme on this earth, will not the grace and Spirit of God alive in Christian believers today reveal a few faint glimmers of light, when Jesus’ followers including engineers make progress toward his desired end? Here, brokenness of creation goes beyond consequences of the Fall, offering children of God a present redemptive opportunity, as agents of God’s glory. Thus, a partial display of God’s glorious grace may occur by good works, creatively applied via gifts of his image bearers, even today.

Many forms of brokenness in this world can be identified, such as the destitution of poverty, injustice that results in the suffering of innocent who have committed no crime, and the struggle of those with disabilities in situations that require certain social or physical skills. The author of Hebrews, just after addressing the kingdom that cannot be shaken, identifies a few practical acts and attitudes toward others, including the broken, that represent sacrifices pleasing to God. Remembering prisoners “as if you were together with them in prison, and those who are mistreated as if you yourselves were suffering” (Hebrews 13:3, NIV) make this list. Christian prison ministry certainly has a valuable place for offering hope of forgiveness, redemption and reformation to those incarcerated for crimes committed, and encouragement for those wrongly punished (mistreated). I suggest here, though, that the “prison” many people face may involve less obvious “bars” of involuntary restriction: disadvantage, lack of freedom due to poverty, criminality of others, and disabilities over which the bearers have little control. For those who experience this sort of captivation and mistreatment, the injunction of Hebrews must also apply. People in these situations live not just in developing countries, but throughout the world, even perhaps in our own communities or families. Some engineering projects should certainly be devoted to ameliorating difficulties for them. I describe two examples of this sort in section 4.
Finally, here, on scriptural directives, consider James, a stalwart advocate of demonstrating Christian faith by one’s good deeds. In chapter 2, we have his inspired words

What good is it, my brothers and sisters, if someone claims to have faith but has no deeds? Can such faith save them? Suppose a brother or a sister is without clothes and daily food. If one of you says to them, “Go in peace; keep warm and well fed,” but does nothing about their physical needs, what good is it? In the same way, faith by itself is, if it is not accompanied by action, is dead. (James 2:14-17, NIV)

Restated in a positive sense, James says that actively meeting basic needs of someone close (i.e., doing good works), offers evidence of a faith that is alive. While interpretations may vary, the Bible also teaches that saving faith (i.e., salvation) must be worked out “with fear and trembling, for it is God who works in you, both to will and work for his good pleasure” (Phil. 2:12,13 ESV). The sanctifying power of God’s grace puts good works required by James in better perspective. To the point of this paper, while feelings of compassion alone towards the needs of others do not necessarily help anyone, Christian compassion accompanied by a real deliverable can effectively meet a felt need. Thus, a real deliverable should certainly be the goal of what is produced by service-oriented engineering projects, whether it be the short-term implementation result, or the one ultimately achieved by the long-term technology development approach.

3. Project guidance

Credible authorities now view the origin of the universe, and its subsequent development, as a supremely powerful yet carefully planned, sustained and guided process. In Case for a Creator, the journalist turned author and pastor Lee Strobel presents arguments for Intelligent Design and fine tuning supported by several prominent scientists and philosophers who enumerate such precisely balanced conditions. Besides serving as convincing clues about God’s character imbedded in his creation, what if such fine tuning also suggests how the Lord involves himself in our personal and workplace endeavors, sovereignly guiding us (e.g., through finely tuned circumstances, personal relationships, etc.) to produce more godly character as we grow in maturity? By extension to engineering project management, we need a Christian model for guidance that provides checks and balances on the project work, and the teams that pursue it. Teams should make satisfactory progress toward service-oriented project objectives, and ensure that expressed needs of those served are ultimately and adequately being met. Timely feedback by a knowledgeable client, and technical consultants, during periods of development can help project teams make necessary corrections and/or reinforce good work being accomplished.

A previous publication details the agile project management strategy we follow, in the Collaboratory at Messiah College, to help guide our students in service-oriented engineering project work, as they prayerfully proceed. Weekly discipleship meetings offer all project team members voluntary opportunities for worship, inspiration, reflection and practical application of spiritual matters. As for time management, our student project teams commit to 6 to 9-week blocks of time—called Minimum Viable Progress (MVP) periods—during which they address the next critical objectives necessary to move the work forward. At the beginning of each MVP, student teams formulate and submit their objectives for review to the project manager, a faculty member or professional engineer. The project manager either approves these new objectives, or
recommends revisions. Upon approval, student teams proceed to brainstorm individual tasks, and time-estimate them by a bidding process, during the MVP planning stage. These estimated project task hours together with hours per week committed by each project team member determine the predicted length of an MVP period. If the predicted MVP period does not fit the specified 6 to 9-week time frame, the team must adjust it by putting some tasks in the “ice box”, or adding additional tasks. MVP periods deliberately framed in this way, apart from the typical 12 to 15-week semester, free project teams from artificial boundaries of the academic calendar (i.e., to help students realize that real-world projects do not necessarily begin or end in synch with an academic semester). In coordination with the Collaboratory, each MVP ends with a review, much like a design review. Those who attend the design review include 1) the student project team providing an informal Q&A presentation, 2) a student administrator moderating the time and discussion, and 3) a panel that includes project managers, voluntary technical consultants, and the client, if available. The panel makes comments, asks questions and ultimately assesses the team. During the MVP, the client typically communicates regularly with the project team (e.g., via email, Skype or face-to-face meetings); the panel assesses quality of the evident client communication as one of several rubric items.

At the end of the MVP review, the student project team leaves the room while the panel discusses, deliberates and evaluates a range of rubric items as prompted by the student administrator. Rubric items assessed include the following:

- attributes of the presentation and receptivity to comments and questions by the panel
- professional quality of documented work pre-submitted by the team
- progress against stated objectives for that MVP period
- alignment with key project indicators overall (as stated in the Project Charter required of each project team initially and updated annually, which speaks to its mission fit within that of the Collaboratory)
- team composition (whether the right kind of engineering specializations and/or other major disciplines seem to be represented on the team including advisors and consultants)

After reentry by the student project team, panel representatives briefly report highlights of the MVP review assessment, offering both positive feedback and constructive criticism, followed by more detailed written comments. Notably, the MVP review serves as a key guidance tool, affirming good work, and identifying any deficiencies with recommendations for improvement. The review also helps the project team identify new objectives, technical and otherwise, for the next MVP period, toward producing for the client and end users being served a deliverable of the highest possible quality, which they deserve.

4. Service-oriented Exploratory Engineering Technology Development Projects

This section presents two service-oriented exploratory technology development projects, currently ongoing at Messiah College, that satisfy mission fit of the Collaboratory. They also require applied research to meet objectives as in the category B distinction above, and follow the project guidance policies as described in the previous section. The following subsections present
further motivation and objectives for these projects by including some additional rationale and context from which they originated.

4.a. Redesign of an Automatic Flight Following System

One of the most dedicated and well-trained yet vulnerable servants among those who give their talents for relief, development and missionary organizations, a pilot will fly small planes into remote locations delivering supplies and personnel to their destinations. Often, the pilot leaves his or her family behind to hope and pray for a safe journey and timely return. A pilot and passengers face potential risks including technical problems with the plane, unexpected severe weather, and criminal intent of a bandit or drug runner at intermediate stops. These risks can and have resulted in scenarios such as the landing of a plane in a place outside of its flight plan, or worse, a high-jacking, a kidnapping or even a crash. The result may range anywhere from mere inconvenience to serious emotional and physical trauma—temporary or long term—or even untimely death. In the most serious of these scenarios, authorities can only decide whether to launch a costly search and rescue operation, for recovering the pilot and/or passengers, by locating the plane when the event (e.g., deviation from the flight plan) occurred. Without a precise enough GPS coordinate location, search and rescue may not be justifiable. Thus, in the worst case, the pilot, any passengers, and family members left behind could remain separated and without hope of reunion in this life. Is this a kind of human tragedy that Jesus would leave unaddressed? No, Jesus compares himself to a shepherd who goes from the ninety-nine sheep in the protected fold to recover one lost. Likewise, missionary aviation has done whatever possible to rescue a lost pilot, whenever that might become necessary.

The conventional missionary aviation problem of tracking small planes outside of radar control has been historically solved by the pilot periodically reporting flight status by two-way radio to a family member acting as a ‘flight shepherd’, monitoring progress on the ground. A notable innovation to this convention was designed and developed in the field by JAARS missionary aviators in the 1990s. With the Automatic Flight Following System (AFFS), JAARS introduced the concept of shepherding a flight using an electronic ‘protected fold’. In 2005, after experiencing a short-term trip with PACTEC in Afghanistan, and talking with one of the pilots hoping to benefit from more of the latest flight tracking technology, this author was introduced to one of our main stakeholders, Cary Cupka, an avionics and safety philosophy consultant; this long-term relationship ultimately resulted in our taking on the upgrade of AFFS with one of the original developers, Carman Frith, as a Collaboratory engineering project. While our organizational client and objective focus has shifted over time, a project team at our institution has been working to upgrade and improve flight monitoring and communications technology ever since. In recent years, aging AFFS technology, limitations of its High Frequency (HF) radio band mode, and emerging communications alternatives, have led most JAARS flight programs to outsource flight tracking. Yet, our consultant, Cary Cupka and others believe the legacy AFFS scheme with its field-tested value is a strategically positioned platform for radically improving the electronic ‘protected fold’ by voluntarily integrating new concepts developed by civil aviation after the disappearance of Malaysian Airlines flight MH370 in 2014. Our goal is to redesign AFFS with the latest electronic component upgrades, and introduce interoperable
communication (including satellite) modes, so that the well-tested user interface of its aircraft control unit (ACU), with a form factor known to fit safely in the typical aircraft cockpit, can meet modern safety needs of small aircraft, and offer more.

Thus, the Flight Tracking and Messaging Systems (FTMS) project team, as it is presently known at Messiah College, continues to consult with Cary Cupka and others to redesign AFFS toward a field-upgradable pilot and aircraft-tailored version of the electronic ‘protected fold’ system. Our latest technical progress involves the choice of an industrial grade microcontroller paired with a UDOO ‘maker’ board capable of emulating AFFS 1.0 functionality, with potential for further expansion in the redesigned version. Careful study of the existing AFFS ACU pilot-interface display (circuit) board has enabled the student team to improve its layout, upgrade components, and propose a more compact manufacturable version. To test the overall system during development, serial communication has been established as a hardwired link between the ACU and AFFSWin to simulate sending messages from the ACU to a ground station monitoring the flight. This project presents considerable technical challenge to our student team, typically made up of engineering students with an electrical and/or computer concentration. While significant work remains to reach the “proof of concept” prototype stage, it offers these students excellent pre-professional experience on an exploratory service-oriented project. By this project, the FTMS team has been moving the electronic ‘protected fold’ technology forward toward the worthy goal of reducing the risk pilot families face in flying planes in remote locations to accomplish missions typical of most relief, development and mission organizations.

4.b. Developing a Remote Coaching System for the Cognitively and Behaviorally Challenged

The rise of the internet and electronic media technology has been accompanied in recent years with increased awareness of socially disadvantaged and disenfranchised people. Renowned media theorist, Marshall McLuhan, who foresaw the emerging “global village” once observed, Minority groups can no longer be contained—ignored. Too many people know too much about each other. Our new environment compels commitment and participation. We have become irrevocably involved with, and responsible for, each other.”

Those with needs overlooked by cost-effective marketplace product developments include people with various cognitive and behavioral challenges. Lack of effective helpful intervention for people with these disabilities often means forfeiting gainful employment or independent living opportunities, despite their potential. Such disadvantages represent another less visible form of barrier holding its “captives” who are waiting to be unlocked. At Messiah College, Wireless Enabled Remote Co-presence (WERCware) is another service-oriented Collaboratory project under development for the last nine years to assist those with those with challenges ranging from high functioning Autism to Post Traumatic Stress Disorder (PTSD). WERCware delivers social services to a participant from a remote coach, by means of wireless technology. The history of this project, including key lessons learned, has been previously documented.

WERCware has matured since its inception as a service-oriented student engineering project thanks to grant funding, three field studies, and multiple consultants. The WERCware system presently consists of an Android smartphone platform interfaced with stress-detecting bio-
sensors. Sensor testing, signal analysis via software code, and system integration development represent the latest focus of the student team. Human stress detected by a WERCware bio-sensor will automatically trigger a video conference call between the participant’s smartphone and the remote coach. While a manually initiated call can also do the same, as a backup, the automatic call allows the remote coach to check in, amid stress, and if needed, give social intervention from a participant-specific database, using scripts or other supports. When connected to the remote coach, to safeguard employer or participant confidentiality in defined areas (e.g., restroom), an automatic audiovisual shutoff occurs, by design, as triggered by proximity to Bluetooth beacons.

Like FTMS, WERCware also represents a decidedly service-oriented engineering project, under the guidance of a client representative who is a knowledge expert about the target community. WERCware uniquely involves technology development related to social issues that have never been fully addressed, and includes methods (e.g., human stress detection via bio-sensors and automatic neural networks) that are on the cutting edge. This offers excellent challenging interdisciplinary pre-professional experience for engineering students especially those with electrical or computer concentrations, while developing technology that conveys compassion by better meeting the need of many who are waiting to be freed from socially confining dependence.

5. Achieving Responsible Balance

Beyond effectively meeting the needs of an end user, a good design should carefully balance quality factors, to optimize overall value. As a classic work on Christian values applicable to engineering, Monsma and his group\textsuperscript{xiv} identify normative principles (NPs) involving human choice, to responsibly guide the activities of doing technology. Their seven NPs include appropriateness of culture formation, information or openness of communication, stewardship of economic aspects, a delightful harmony of aesthetic aspects, justice & caring for all of creation, and finally trust, meaning dependability without dishonor to God. While all seven NPs deserve full consideration in a thorough approach, to achieve the delightful harmony (Shalom) advocated by Monsma, this section considers how selected normative principles relate to each of the two projects highlighted in this paper, and the challenge of achieving the right balance.

Achieving cultural appropriateness, per Monsma, means balancing sets of opposing factors. One pair of opposites, continuity versus discontinuity, has been an issue during FTMS development. During the early years, before the Integrated Project Curriculum (IPC) at Messiah College, students completing the traditional senior capstone project felt compelled to design projects from scratch. With the pendulum at the discontinuity end of the spectrum, the field-tested value of AFFS did not receive enough attention; students designed an ACU prototype which though innovative, would not fit in the cockpit of the plane, or retain the safety-tested pilot interface. Stakeholders were not so pleased about this development. In more recent years, with the advent of IPC, multiyear projects and Collaboratory oversight, students began to grasp the value of ongoing project work. Such realization convinced FTMS student teams to “buy into” the value of retaining the pilot interface as a project starting point. FTMS design then more realistically focused on internal contents of the ACU and initially replicating the original AFFS functionality, rather than striving for something completely new. The pendulum had reached a midpoint between continuity and discontinuity, where a better balance between innovative design and
field-tested aspects of the ACU met. This balance of culturally appropriate opposites not only better satisfies our stakeholders, it most likely will lead to a higher quality product in the end.

To explore how the NPs relate to WERCware development, consider the balance that must exist between openness of communication, caring and justice. The openness desired in WERCware, an assistive communication technology, should be self-evident: to allow quality audiovisual interaction remotely between a participant and remote coach. If electronic openness were all that was needed, a smart phone at each end might be fine, by itself. However, combining the value of openness with caring and justice, we find that product with unique features is needed. Caring for those with disabilities means giving them as much independence as possible. Thus, we do not want the connection open continuously, only as needed. Hence, the development of biosensors to detect human stress, as an automatic call trigger, in case “heat of the moment” catches the participant unaware. After interaction with the coach, the connection may be closed manually, and remain “off” to promote a healthy “fading” of intervention. We now bring justice into the mix. The participant must use good judgment to determine when to open or close the connection with the coach. As a backup to ensure confidentiality in defined locations (e.g., personally private restrooms or employer secured private document areas) the automatic shut-off feature comes into play. The automatic beacon-triggered shutoff in confidential areas guarantees the connection between parties will be closed to protect the ethical and legal rights of each participant, preventing unnecessary harm from coming to those involved. Thus, openness must be balanced with caring and justice to convey Christian compassion with quality and integrity.

6. Conclusions

As a focus for experiential learning, in this paper I recognize that service-oriented engineering projects intended to meet human needs can fit into two legitimate categories: short term conventional site-team implementation efforts and longer term exploratory technology development efforts requiring applied research. Both kinds of projects can convey Christian compassion, and have value from an educational, engineering and biblical point of view; exploratory projects should not be overlooked. Scriptural directives support a wide range of service-oriented opportunities. These include Jesus’ priorities of being salt and light, attending to the needy and treating them as we would wish to be treated if we were in their place. Other scriptural directives provide further guidance such as the concept of working as redeemers of a broken creation, offering a tangible deliverable to meet the need, and specifically remembering prisoners of various kinds. These directives support both exploratory technology development projects highlighted here. Further rationale and context has been provided for the redesign of AFFS, and developing WERCware, ongoing service-oriented projects in the Collaboratory at Messiah College. The teams working on each of these projects hopes to convey Christian compassion by working with qualified clients to meet unique human needs often overlooked. Striking a responsible balance of normative values in the work represents an ongoing challenge.

Transferable principles from this work include the scriptural directives suggested here in section 2, strategies for engineering project management we have employed for guidance in section 3, and methods of finding service-oriented projects for which I have found networking and travel to be most fruitful. Networking can help match the need or vision to the resources and expertise
faculty and students happen to have at a specific school. Traveling to the neediest places to meet and visit people where they live and work can expose opportunities that others have overlooked.

7. Acknowledgements

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xi AFFSWin means AFFS for Windows, a ground monitoring software application that automatically logs on the screen of a PC, key milestones of a flight from take-off to landing, and records any other critical flight information.
