

AC 2007-756: MOBIUS MICROSYSTEMS: A CASE STUDY IN THE COMMERCIALIZATION OF GRADUATE RESEARCH IN ELECTRICAL ENGINEERING

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Mobius Microsystems: A Case Study in the Commercialization of Graduate Research in Electrical Engineering

Abstract

Mobius Microsystems is a fabless and intellectual property (IP) semiconductor company founded by a graduate student (McCorquodale) and his faculty advisor (Brown) and based upon the dissertation research conducted by the student. The company is presented by the founding researchers as a case study in the commercialization of graduate research in electrical engineering. While a previous paper by the authors [1] has discussed the internal resources required at the research institution to facilitate commercialization, this paper focuses on the specific experiences associated with “spinning out” the venture including establishing the venture, financing it, bringing the developed technology to market by securing customers, and securing follow-on financing. It will be shown that two of the most critical components for success include the ability to recruit experienced entrepreneurs with relevant domain expertise and accessibility to capital. Most ventures originating from a research institution require some form of seed stage financing, followed by an institutional financing round. Without the former it is difficult to secure the latter, while with only the former it is difficult to establish infrastructure, recruit employees, and built perceived credibility in order to secure customers. Such dynamics put specific regions of the country at a significant advantage in attracting new technology-based ventures, as they are able to provide adequate access to both capital and talent. Despite regional challenges, *Mobius Microsystems* succeeded in securing seed stage capital along with its first few customers prior to closing an institutional equity round of financing. Many challenges including under-capitalization of the company at its outset, difficulty recruiting, understaffing for initial customer engagements, and difficulty fundraising were overcome before this success was realized. Through experience, this paper describes the “facts on the ground” associated with commercialization of university research in engineering. It closes with recommendations for educators in terms of curriculum development and for political leaders in terms of economic legislation.

I. Introduction

The commercialization of university research and its relationship to the Bayh-Dole Act of 1980 has received substantial attention recently. Proponents, including many legislators, have identified its importance to economic development [2]. Critics have argued that it may corrupt the mission of university research and shift it away from the pursuit and dissemination of basic knowledge and towards research endeavors that have applied and industrial purposes. There also exist legitimate concerns associated with exclusive licensing of patented technologies to businesses and the ability of those businesses to delay the publication of research findings or inhibit the pursuit of research enabled by the licensed technology [2]. The authors contend that the latter concerns are serious though they can be addressed through proper licensing guidelines or new legislation. Despite these concerns, the authors also contend that the commercialization of engineering research is vital to economic development, both at the local and national level, and that it can exist harmoniously with the mission and goals of a research university. Moreover, the commercialization of research through a new technology venture presents one of the best opportunities for economic development and growth. New technology ventures are typically led by the original researcher or group of researchers. However much recent academic development in technology entrepreneurship has not focussed on the relatively linear and analytical protocol associated with the commercialization of such research. Rather, most recent efforts, such as those in [3]–[7], have presented relatively ad hoc approaches to introducing entrepreneurial concepts to engineers. Though these efforts address the fact that new technology ventures are most likely to be led by scientists and engineers and that these students require proper training, these academic programs do not address the development of research-oriented ventures. Consequently, the authors argue from experience that the academic curricula in research-oriented technology entrepreneurship is immature, insufficient, and lacks focus on the dissemination of proper and relevant knowledge for commercializing research advances. Moreover, the authors argue that the development of such a curriculum should be the primary focus of education in technology entrepreneurship and it should be geared exclusively toward students pursuing graduate-level research in science and engineering.

These arguments are presented within the context of a case study of *Mobius Microsystems* (*Mobius*)—a company founded by the authors. *Mobius* is a semiconductor company specializing in all-silicon clock, or timing, components and intellectual property (IP) macros. The company's flagship technology is based on research originally conducted by the authors at the University of Michigan from which *Mobius* retains a world-wide exclusive license. The case is presented as an illustration of the typical protocol for the commercialization of university research while demonstrating gaps that exist in both the academic curriculum and in the extracurricular resources which are mandatory for the “spin out” of new technology ventures. The case is presented as a history of the company and is followed by an analysis. The paper concludes with both academic and legislative recommendations based on the analysis.

II. The Development of *Mobius Microsystems*

A. University Incubation and Seed Financing

The authors and founders of *Mobius* collaborated for several years at the University of Michigan in the capacity of faculty advisor (Brown) and graduate student researcher (McCorquodale) while

pursuing research in electrical engineering. Brown had been involved in the successful launch of 2 research-based start-up companies during his tenure at Michigan. In 2000, the two began exploring the use of all-silicon self-referenced radio frequency integrated circuits for clock signal generation in microprocessors and similar applications. Throughout McCorquodale's dissertation work, Brown encouraged him to explore his entrepreneurial interests beginning with the suggestion of developing an abstract for a state-wide business plan competition in the Michigan Great Lakes Entrepreneurs Quest. The developed and submitted abstract won an award. Encouraged by the results, McCorquodale set out to compliment his dissertation research with an academic curriculum in technology entrepreneurship. Unfortunately, the University of Michigan College of Engineering did not offer a single graduate-level course in technology entrepreneurship (though one has been added in 2007). Thus, he petitioned the College seeking approval to enroll in the business plan development course offered as part of the MBA sequence in the University of Michigan Ross School of Business. There, and as part of the standard format for the course, he presented his technology and business concept and successfully recruited a team of MBA students with whom he developed a complete business plan that went on to take runner-up at the University of Michigan's Pryor Hale business plan competition. More importantly, though, he acquired a better understanding of the process of new venture development.

Over the course of the next several years, the authors pursued research and sought to patent the concepts and technologies that they developed. McCorquodale audited a patent fundamentals class for engineers, which was offered within the Department of Electrical Engineering, and acquired an understanding of the development of intellectual property. Subsequently, the authors filed disclosures with the University of Michigan's Office of Technology Transfer after which the project was assigned to a business development specialist. With her support, and in collaboration with a patent attorney retained by the university, full-utility applications were developed and filed with the United States Patent and Trademark Office.

With the intellectual property protected, the authors began to publish their work while also seeking to form a management team for the new venture. McCorquodale returned to the Ross School of Business and solicited the support of the Zell-Lurie Institute for Entrepreneurial Studies. A team including two MBA students (Wilkins and Rushing) and one local veteran entrepreneur from the software field (Vincke) was assembled. That team developed a practical, as opposed to academic, business plan for the purposes of seeking seed venture financing. The team focussed on a product development strategy for the enabling technology developed by the authors. Additionally, and leveraging their student standing rather creatively, the team entered and won first place at 7 different intercollegiate business plan competitions thus garnering over \$160k in cash awards [8]. The team was also awarded \$20k through the "Dare to Dream" grant program sponsored by the Zell-Lurie Institute for Entrepreneurial Studies. With this modicum of capital, *Mobius* established its first office in Ann Arbor, MI during the summer of 2003 with the management team including the McCorquodale, Wilkins, and Vincke. Additionally, the team partnered with a Silicon Valley legal firm that was supporting new venture creation out of Midwest research institutions. The arrangement allowed for deferred fees associated with incorporation and other legal work for a modest and dilutable equity position in the company.

The team focussed diligently on executing the business plan while exploring avenues for raising capital. It was estimated that with \$1M *Mobius* could validate its new technology using a semi-

conductor IP business model in which *Mobius* would use its enabling technology to design the clock module of semiconductor components for its customers. By late 2003 the authors developed functional prototypes of their work. Consequently, *Mobius* was able to raise approximately \$300k from a local venture fund and by early 2004, *Mobius* raised another \$700k from over a dozen accredited angel investors in the states of Michigan, Ohio, and Illinois. Despite success, these fundraising efforts were non-trivial and consumed the better part of McCorquodale's time. Moreover, such financing would never have been secured had McCorquodale and his colleagues not work so diligently to establish relationships in the regional investment community. Perhaps most important was initial financing from the local venture fund, *Waypoint Ventures*, which served as an impetus for angel investor participation.

B. University Spin-Out and Seed Stage Execution

McCorquodale defended his dissertation research in early 2004, departed from the University, and became CEO of *Mobius* while Brown maintained his faculty position at the University, though he held a seat on the Board of Directors at *Mobius*. With just over \$1M in capital, the team sought to validate the technology through commercial design wins. The seed stage team struggled with productization efforts and technical marketing and sales, though published research provided fodder for potential customers. The greatest challenge was that apart from McCorquodale, the seed stage management team had little or no technical or market domain expertise. Nevertheless, the team acquired two design wins within two months on the market. Consequently, the team scrambled to recruit integrated circuit design engineers for these projects which was a substantial challenge given the geographic location of the company and the lack of talent with such experience. Eventually, 5 engineers were hired over 6 months and 4 of them were recruits from within the founders' network. With an engineering team in place, the design effort for each customer project began. As is typically the case for a new technology venture, cash and resources were limited, the hours were long, and the development of the technology for the customer was wrought with challenges.

By late 2004, *Mobius* had outgrown its original offices and sought the development of new office space. The team explored local financial incentives awarded for maintaining an office in the State of Michigan. It was determined that the Hi-Tech Michigan Economic Growth Authority (MEGA) program was a good fit for *Mobius*. The program provided a 10 year state income tax rebate to technology companies headquartered in the state. *Mobius* was awarded the tax incentive for establishing a new office in downtown Detroit and is the only start-up company in Michigan to have been awarded the MEGA.

In early 2005, the management team at *Mobius* began to seek its next round of fundraising from both initial investors and venture capital firms. The team also explored both state and federal government grant programs, but such programs were determined to be inappropriate funding sources for the company because of the long review cycles, the limited capital, and the fact that most solicitations called for the development of new technologies while *Mobius* was seeking financing to continue commercialization of its existing technology. Over the course of the next 6 months, the *Mobius* management team spoke with nearly every single venture capital firm in the Midwest region including the states of Michigan, Ohio, Illinois, Indiana, and Wisconsin. The efforts were to no avail. The primary objections associated with investment in *Mobius* included the round size (too large), the stage of the company (too early), and the field (semiconductor components).

By June of 2005, the team determined that it would be impossible to raise the capital needed either locally or regionally. Consequently, McCorquodale moved to the State of California to focus on raising venture capital in Silicon Valley. Additionally, he recommended to the board that he step aside from the role of CEO to CTO and an industry veteran in the semiconductor field (Sikes) moved into the CEO role. Together, Sikes and McCorquodale focussed on securing venture financing from California venture firms. Within a few months, and leveraging the success of the seed stage work, the two raised an equity round of over \$10M. As a condition of the fundraising, the headquarters of the company were moved to California but a design center was maintained in Detroit. Additionally, the seed stage management team, less McCorquodale, was terminated due to a lack of domain expertise. Similarly, the board was reorganized. A new management team with the relevant experience was hired in CA. Currently *Mobius* is developing its component (as opposed to IP) product business. At the time of this writing, an engineering lot of components (tens of thousands) has been designed and fabricated successfully. These components are currently being characterized, after which customer sampling will initiate.

III. Analysis

The presented case is clearly representative of the typical protocol for commercialization of university research in engineering. It illustrates the academic background required for successful commercialization including the topics of intellectual property development, business plan development, new product development based on enabling technologies, financing, and management. As described, some courses and resources relevant to these topics are available at the University of Michigan, a topic which was further explored by the authors in [1]. However, a holistic approach and linear academic sequence to research-based entrepreneurship is nonexistent at the University of Michigan.

Team development was clearly a critical component to the successful development of *Mobius*, though the case brings into question the role of business school students in the development of new technology ventures. As mentioned previously, new technology ventures are typically led by the founding researchers, as opposed to business school students. Nevertheless, entrepreneurship courses are typically housed within the business school of a university, as is the case at the University of Michigan. However, the authors argue that the skills developed in MBA programs have marginal utility in a new technology venture. Rather, the start-up team for a new technology venture requires deep technical domain expertise in both the new technology and the market space into which it is intended to be developed. Such skills are much more likely to be developed and refined within a program in the college, or school, of engineering than in the school of business. Moreover, it is unlikely that any student or faculty researcher will possess sufficient market domain expertise. Thus individuals with such knowledge are likely to be sourced from the relevant industry as is inevitably the case once professional venture financing is secured. Herein lies one of the primary challenges with the seed stage of a new venture. It can be difficult to source talent with relevant domain expertise despite the fact that the technology is originated from a tier-1 institution in the field. Indeed, *Mobius* faced this challenge as it is difficult to source potential management team members with experience in the semiconductor industry in Southeast Michigan. However, the authors were successful at recruiting engineers who were even working in different regions of the country as well as abroad. Previous professional experiences with the

founders, familiarity with the technology through research, proximity to family, lower cost of living, and similar personal circumstances were often cited by recruits as reasons for joining *Mobius*.

Though a proper curriculum in technology entrepreneurship is likely to stimulate interest in the topic, these endeavors will never come to fruition without the availability of capital to finance new technology ventures. The case of *Mobius* clearly illustrates regional challenges associated with the “spin-out” of a new technology venture. Clearly, non-equity financing is an unlikely source of funding for a new technology venture as capital requirements are high and little if any collateral exists within the company, the latter of which would be required for bank financing. Moreover, federal grant programs, such as SBIR and STTR, are not attractive because such grants are for new research, have long review cycles, and provide insufficient capital. Consequently, the authors contend that equity financing is the most likely funding source for a new technology venture based on university research. Unfortunately, equity financing, in the form of venture or angel capital, can be extremely difficult to secure due to limited availability in certain regions of the country such as Michigan. Outside of the States of California, Massachusetts, and Texas, venture financing is scarce in the United States. Thus, if an academic curriculum is intended to stimulate technology entrepreneurship, poor quantitative results will be achieved without access to capital. As was the case with *Mobius*, these facts forced the founders to leave the region to seek the required capital. However, seeking capital outside of the region in which the company is founded inevitably implies that the company headquarters will be relocated. Contrary to popular belief, this is perfectly reasonable as professional investors in early stage companies take governance positions within the company and expect regular meetings to protect their investment. However, the authors argue that an organizational structure with two offices can be successful, as has been the case for *Mobius*. Specifically, the primary design center remains in Michigan and close to the University while the governance, management, and marketing and sales teams are in California. In fact, this model has proven successful for other ventures spun-out from the University of Michigan including *Sensicore*, *Discera*, and *Arbor Networks*.

Lastly, though *Mobius* was successful at securing a state tax abatement through the MEGA program, it is difficult to argue that such programs stimulate or even facilitate entrepreneurship as *Mobius* is the only emerging technology venture to date to have received the MEGA award in the State of Michigan. Interestingly, this program, among others, is often promoted as stimulating economic development through new ventures. However, the arguments in [9] discuss the shortcomings of such efforts to service new and small businesses.

IV. Recommendations

The presented case and analysis, in conjunction with the discussion presented in [1], demonstrates that the commercialization of university research is highly analytical and requires certain basic knowledge along with the development of relevant skills, all of which can be acquired through an academic program. Moreover, it addresses critical extracurricular components, such as access to executive talent and capital, both of which are mandatory to achieve quantitative results including the number of new ventures created. Consequently, the authors propose the following:

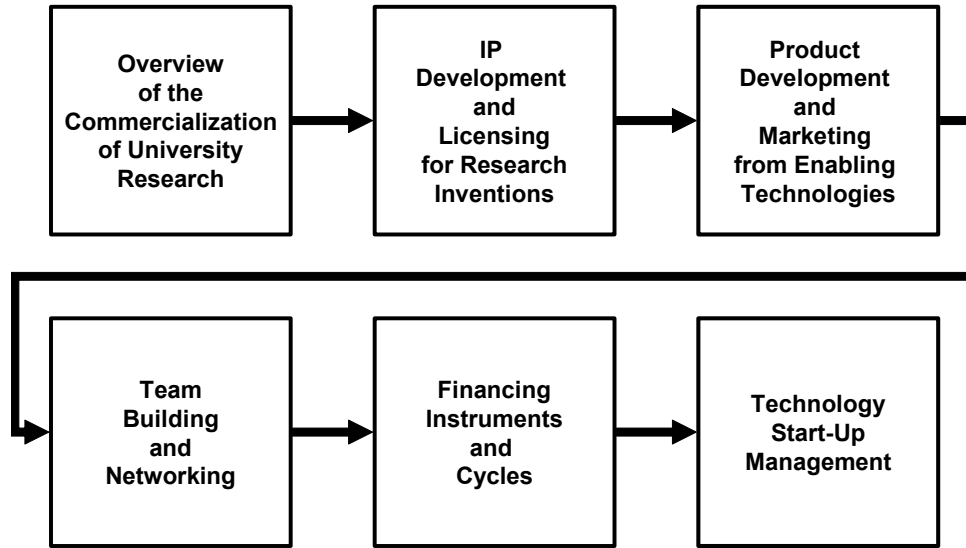


Figure 1. Recommended graduate curriculum in commercialization of engineering research.

A. Academic

Recent reports, such as [3]–[7], have discussed the introduction of technology entrepreneurship to undergraduate students in engineering. Though the authors support those and similar endeavors, such efforts are mostly decoupled from the commercialization of engineering research. Instead, the authors recommend the development of a curriculum exclusively focussed on the development of new technology ventures from research. Such a curriculum, as illustrated in Figure 1, would likely be realized as a sequence including an overview of commercialization of engineering research, intellectual property development and licensing, product development and marketing from enabling technologies, business opportunity analysis and development, team building, financing instruments, and management of new technology ventures. In [1], the authors have proposed such a curriculum through the concatenation of disparate academic courses already in existence at the University of Michigan. However, the authors argue that the program should be continuous and easily accessible to graduate students in science and engineering. Furthermore, it should be analytical and rigorous as opposed to anecdotal or subjective. Moreover, the authors recommend that such a curriculum be developed and managed by the college, or school, of engineering as opposed to the business school. This latter endeavor is not unprecedented and has been pursued at the University of Texas-Austin [10] and the University of North Dakota [11].

The authors also recommend that such a curriculum would be interactive with those relevant to starting a new technology venture including IP attorneys, industry experts, and investors. Team building should be a focussed consequence of these interactions. The authors discourage the development of seed stage start-up teams in collaboration with the business school unless the students from the business school possess the specifically relevant domain knowledge needed to develop the new venture. However, it should be noted that students from the business school can and certainly do play an important academic role with aspiring technology entrepreneurs. Specifically, through academic course work, the interactions between business students and science and engineering students is likely to provide an impetus for the development of a preliminary business plan, just as was the case for *Mobius*.

B. Local and Legislative

A region like Southeast Michigan does not contain a management talent pool with significant experience launching new ventures, let alone new technology ventures. Consequently, it is not uncommon for new ventures in Michigan to relocate to a region with such talent, such as Northern California or Massachusetts. However, this need not be the case. The authors recognize a “chicken and egg” dilemma with the current situation in which new ventures struggle to launch without relevant management talent and yet such talent does not exist because there does not exist a critical mass of new ventures. The simplest concern held by an executive recruited to a new venture is to consider what other opportunities exist if he or she were to move and the venture fails. Extend this concern even further to consider that such a recruit is likely experienced in his or her career and would likely be moving a family or at least be uprooting some significant personal infrastructure. To the recruit, who is likely to have little if any connection to the region in which the new venture exists, this seems like a high-risk proposition particularly considering that the venture may fail. Consequently, the authors argue that financial assistance is likely the only instrument that can be employed to close this gap in commercialization efforts in regions like the Midwest. For example, new technology ventures could be awarded travel grants or subsidies for executives to commute for some period of time in order to facilitate development of the new venture. Another possibility is that recruited executives could be awarded a “parachute” grant in order to move back if the venture fails and he or she cannot find another related opportunity in the region. Such financial instruments could dramatically de-risk the opportunity for potential executives to explore new ventures in different regions of the country. The authors do not intend to provide a definitive list of solutions to this issue of executive recruiting, rather these ideas are intended to illustrate the nature of the challenge and the simplicity with which it can be addressed.

It is well known that Northern California is the epicenter of the venture capital industry and hub of countless new technology ventures. In the first 3 quarters of 2006, \$19.2B in venture capital was invested in the United States and over \$6.7B of that was in Silicon Valley alone [12]. Other regions of the country are at a relative disadvantage to varying degrees. By comparison, only \$72M of venture capital was invested in the state of Michigan over the same time frame [12], thus constituting a difference by two orders of magnitude. These statistics, illustrated in Figure 2, are

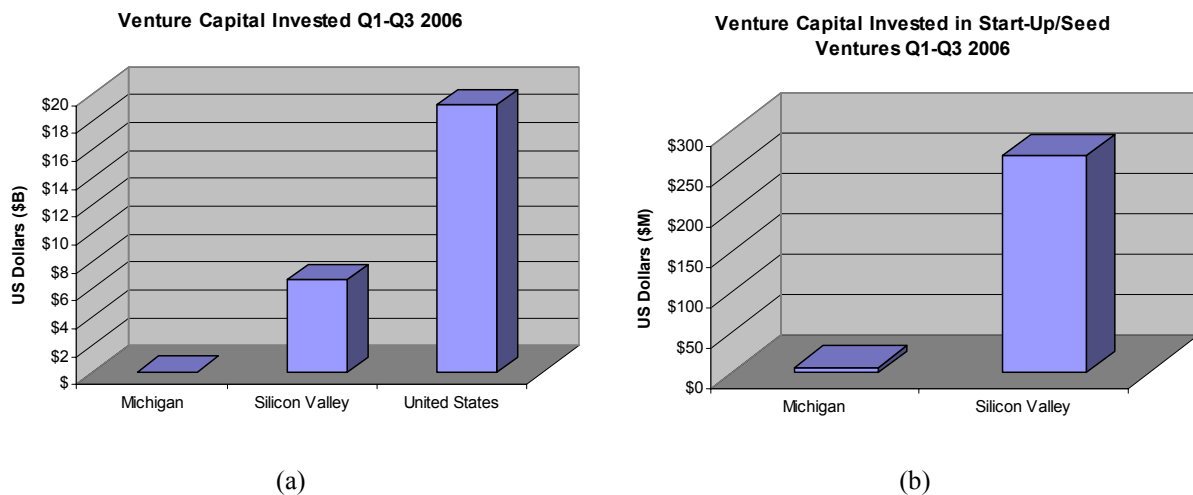


Figure 2. Venture capital invested from Q1-Q3 2006 by (a) region (b) region and start-up/seed stage.

staggering if capital for start-up or seed stage ventures is considered exclusively. In Silicon Valley that figure is \$269M for the first 3 quarters of 2006 while in Michigan it is \$6M as shown in Figure 2. Having recognized this, local legislators and business leaders in Michigan have launched a variety of initiatives across the state to stimulate entrepreneurship and ultimately economic development. Examples in Southeast Michigan include TechTown—an incubator for new technology ventures in Detroit. Similarly, Ann Arbor is home to the recently launched Ann Arbor Spark [13]. Lastly, Oakland County is the seat of Automation Alley—an organization focussed on technology development throughout the region. The fact is that although these organizations provide a forum for general purpose interaction amongst those aspiring to develop new technology ventures, these organizations do little, if anything, to address the lack of capital in the region and the dearth of management talent with domain expertise, which together constitute the most significant challenges associated with the development of new technology ventures in a state like Michigan. Moreover, in a relatively odd twist of the principle of economics, these organizations compete with each other to become the sole technology hub while existing within the same metropolitan region as indicated in [13] where, “Spark organizers hope to accomplish that by becoming a central hub for the whole technology community serving as a resource for existing businesses, connecting them to investors, helping early entrepreneurs get the type of guidance they need and marketing the county as a innovative place to land a business or find a high-skilled worker.”

The authors recommend that state funding for such initiatives be minimized or eliminated altogether. Rather, the authors recommend that legislators reallocate such funds to increase university appropriations for the development of curricula in technology entrepreneurship. Moreover, the authors recommend that legislators seek the development of financial instruments which will inject risk capital into the local venture market. As a simple example, individual accredited investors who invest in high risk venture funds could be granted tax abatements. Such approaches focus efforts where there already exist the most valuable resources—faculty and students who can acquire education in technology entrepreneurship and research across a myriad of disciplines with varying degrees of commercial potential.

V. Conclusions

A case study of the commercialization of graduate research in electrical engineering was presented through the experiences in developing *Mobius Microsystems* out of the University of Michigan. It was shown that the two most significant challenges associated with new technology venture “spin-out” include the ability to recruit executive management talent with relevant domain expertise and the ability to raise capital to finance the business. The case study illustrated creative ways in which *Mobius* overcame these challenges, but the authors argue that new ventures launched at institutions like the University of Michigan need not face the same issues. Consequently, the authors recommended entrepreneurial curriculum development focussed on graduate student research including linear and analytical treatment of all relevant topics for new technology venture development from university research. The authors have also made recommendations to close the gaps in recruiting executive talent and availability of capital in regions like Southeast Michigan. These recommendations are extensible to any region facing similar challenges.

VI. Acknowledgements

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