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Applying Agile Beyond Information Technology and Software

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Abstract

This research explores where Agile practices used for software development within the information technology domain, can be successfully applied in other domains. Private industry is already applying Agile principles in manufacturing, construction, health, research and development, and finance. These approaches are captured in this research in terms of best practices and lessons learned. This research explores where accepted Agile principles and practices can accommodate organizational agility and program management environments.

This research identifies suggested guidance where Agile can be applied more broadly, especially when adopting the four Agile values.

1. Determine if Agile is a good fit.
2. Determine the scope of the Agile effort.
3. Consult with experts.
4. Tailor Agile values and principles to the situation.
5. Develop an approach.
6. Leverage lessons learned.

Introduction

This paper presents research on whether Agile development can be successfully applied to domains beyond information technology (IT) and software. This research will explore where accepted Agile values, principles, and practices have been applied in other technical domains and offers guidance for organizations to adopt Agile within their organization.

Background

Agile software development is an overarching term that encompasses numerous modern methods for software development that adhere to a common set of values and principles. When

those values and principles are applied, Agile projects, programs, or organizations display shared characteristics such as collaboration; small, self-organizing, and cross-functional teams that include customers and users; adaptive planning; early and continuous delivery; and rapid and flexible response to change.

Agile Values and Principles

When discussing the history of Agile, everyone acknowledges the significance of the 2001 meeting of 17 software developers in Snowbird, UT, that led to publishing the *Manifesto for Agile Software Development* that specified four values, and the *Principles Behind the Agile Manifesto* that defined 12 principles, which are cornerstones for all Agile methods.

Agile Values (Beck et al., 2001a)
1. Individuals and interactions over processes and tools
2. Working software over comprehensive documentation
3. Customer collaboration over contract negotiation
4. Responding to change over following a plan.

Agile Principles (Beck et al., 2001b)
1. Customer satisfaction by early and continuous delivery of valuable software.
2. Welcome changing requirements, even in late development.
3. Deliver working software frequently (weeks rather than months).
4. Close, daily cooperation between businesspeople and developers.
5. Projects are built around motivated individuals, who should be trusted.
6. Face-to-face conversation is the best form of communication (co-location).
7. Working software is the primary measure of progress.
8. Sustainable development, able to maintain a constant pace.
9. Continuous attention to technical excellence and good design.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. Best architectures, requirements, and designs emerge from self-organizing teams.
12. Regularly, the team reflects on how to become more effective, and adjusts accordingly.

Software development methods that are now part of the Agile umbrella pre-date the 2001 publications. Some of these methods include: Rapid Application Development (RAD) from 1991, Unified Process (UP) from 1994, Dynamic Systems Development Method (DSDM) from 1994, Scrum from 1995, Extreme Programming (XP) from 1996, and Feature Driven Development (FDD) from 1997. Today there are many methods of software development that are considered Agile. Some of the most popular methods include adaptive software development, Agile modeling, UP, disciplined agile delivery, DSDM, XP, FDD, Lean software development, Lean startup, Kanban, RAD, Scrum, Scrumban, and Scaled Agile Framework (SAFe; "Agile Software Development," 2019).

Agile methodologies did not derive from software development or IT in the first place. Many trace agile concepts back to 1930s when Walter Shewhart of Bell Labs began applying the Plan-Do-Study-Act (PDSA) cycle for product and process improvement. He taught PDSA to his mentee, Edwards Deming, who later applied it extensively in post-WWII (1950s) Japan to develop the famous Toyota Production System, which became the primary source for today's "lean" thinking. In an ironic twist, after Agile was defined, some purists refused to recognize software development based on lean as Agile until they improved their focus on customer collaboration. Ultimately, Agile methods based on lean such as Lean software development, Kanban, and their hybrids (Scrumban and Lean scrum) gained acceptance (Rigby et al., 2016).

Understanding the scrum process and terminology will be particularly useful, as it is the most widely implemented Agile framework and our research found that it served as the starting point for adaptation in most domains beyond IT and software.

Given the history that Agile does not originate from software and that it produced a wide variety of methodologies in practice today, it naturally leads to the research question—can Agile be, or has it been, adopted to acquisition domains beyond IT to improve speed of delivery and increase user satisfaction just as it has done for software?

Agile Environments

Numerous references discuss the modern business atmosphere that has evolved over the past several decades and led to conditions where Agile is optimized to excel. The International Council on Systems Engineering (INCOSE) describes an Uncertain, Unpredictable, Risky, Variable, Evolutionary (UURVE) environment that drives the need for an Agile approach (Dove & Schindel, 2016). This is nearly identical to the concept of a Volatile, Uncertain, Complex, and Ambiguous (VUCA) environment, a term popularized by the U.S. Army in the 1990s that also supports the need for Agile (Kirkpatrick et al., 2019). *The Scrum Fieldbook* makes the case that things change so rapidly, the old ways of working are breaking down and that complexity is not the exception but has become the norm (Sutherland, 2019). Henrik Kniberg, in "Agile Everywhere!" his keynote to Agile Tour Montreal, provides a simple graphic on when Agile is most needed that summarizes these concepts by comparing the spectrums of understanding on what to deliver and how to deliver it (Kniberg, 2016). There is a great deal information about when and where Agile is applicable—as in a "good fit."

The *Harvard Business Review* article "Embracing Agile" (Rigby et al., 2016) provides a thorough summary of the right conditions for Agile, outlining favorable and unfavorable conditions, as shown below.

Table 1. When Is Agile Right?

Conditions	Favorable	Unfavorable
Market Environment	Customer preferences and solution options change frequently.	Market conditions are stable and predictable.
Customer Involvement	Close collaboration and rapid feedback are feasible. Customers know better what they want as the process progresses.	Requirements are clear at the outset and will remain stable. Customers are unavailable for constant collaboration.
Innovation Type	Problems are complex, solutions are unknown, scope is not clearly defined. Product specifications may change. Creative breakthroughs, time to market is important. Cross-functional collaboration is vital.	Similar work has been done before, and innovators believe the solutions are clear. Detailed specifications and work plans can be forecast with confidence and should be adhered to. Problems can be solved sequentially in functional silos.
Modularity of Work	Incremental developments have value, and customers can use them. Work can be broken into parts and conducted in rapid, iterative cycles. Late changes are manageable.	Customers cannot start testing parts of the product until everything is complete. Late changes are expensive or impossible.
Interim Mistakes	Interim mistakes provide valuable learning.	Interim mistakes may be catastrophic.

The Government Accountability Office (GAO) Report 12-681, *Software Development: Effective Practices and Federal Challenges in Applying Agile Methods* (GAO, 2012) identified 32 practices and approaches as effective for applying Agile software development methods to IT projects. Ten of the practices were found to be common across all five agencies reviewed:

- Start with Agile guidance and an Agile adoption strategy.
- Enhance migration to Agile concepts using Agile terms, such as user stories (used to convey requirements), and Agile examples, demonstrating how to write a user story.
- Continuously improve Agile adoption at both the project level and the organization level.
- Seek to identify and address impediments at the organization and project levels.

- Obtain stakeholder/customer feedback frequently.
- Empower small, cross-functional teams.
- Include requirements related to security and progress monitoring in your queue of unfinished work (the backlog).
- Gain trust by demonstrating value at the end of each iteration.
- Track progress using tools and metrics.
- Track progress daily and visibly.

These two references from HBR and GAO point to the need for conditions to be right for Agile principles to be adopted and integrated into the business atmosphere to be successful.

Agile Applied to Management and Organizations

Agile Management

The report "Unleashing the Power of Small, Independent Teams" from the *McKinsey Quarterly*, July 2018, proposes that the key to Agile management is found in the enactment of small independent multi-functional teams that are given a specific task/goal/product that matters greatly to the customer, empowered to self-organize and make decisions, and provided with the tools to move fast. Further, the teams must be supported by organizational management that takes on roles and responsibilities quite different from the traditional model. Management must learn to direct teams to the best opportunities, define outcomes and let teams chart their own course, staff teams with the best personnel, oversee with a light touch, focus on removing roadblocks and providing support, ensure proper governance, provide teams a clear view of the customer, allocate resources up front and hold teams accountable, and commit to retraining/coaching managers for their redefined roles (Bossert et al., 2018).

Organizational Agility

Organizational Agility is a term used to refer to the idea of Agile management. The MITRE Corporation, Enterprise Strategy and Transformation Technical Center, developed a model for Organizational Agility (Kirkpatrick et al., 2019a). The model defines Organizational Agility as, "the capacity to adapt quickly and effectively in response to or in expectation of changes in the organization's environment" (Kirkpatrick et al, 2019a, p. 4). This work found that attributes of traditional organizations include: a hierarchical structure, leaders that sense/scan the environment every 2 or 3 years, decisions are made by those at the top, a less educated workforce is required, less customer input, and strategy is set at the top while power trickles down. These traditional characteristics no longer work well in the VUCA environment most businesses faced in the late 20th century. The Organizational Agility model found that three routines best characterize Agile organizations in the VUCA environment: sensing, interpreting, and responding. The Organizational Agility Model applies the sensing, interpreting, and responding routines across seven organizational dimensions, and compares the varying approaches between traditional and Agile organizations (Kirkpatrick et al., 2019b).

Table 2. Organizational Agility Model

Organizational Dimensions	Traditional Organizations	Agile Organizations	
		Stability	**Flexibility**
Organizational structure	Hierarchical structure based on function	Flat organizational structure with permanent teams	Temporary teams form, re-form, and dissolve when needed
Knowledge sharing and experimentation	The environment is scanned annually by leaders	Routine processes are in place to scan the environment, widely share and store information	Employees reflect on information to make sense of it and determine the impact to the mission
Decision making	Leaders make decisions and solve problems	Decisions are communicated upward to leaders, who provide resources and oversight	Decisions are made at the lowest level where expertise resides
Leader actions	Leaders restrict information sharing and inhibit learning	Leaders are informed about decisions made at lower levels	Leaders encourage employees to share what they learn
Process management	Processes are either overly rigid or ill-defined	Some processes are well-defined and continually improved	Some processes are flexible; experiments are conducted to facilitate learning and innovation
Roles	Roles are ill-defined or not flexible	Some roles are stable and clearly defined	Some roles are intentionally flexible to quickly meet changing conditions and customer needs
Norms and expectations	Norms are to retain information, not collaborate, and view learning as a cost	Leaders create climate of psychological safety. Employees are expected to view "mistakes" as learning, share information, and collaborate. Learning and training are viewed as an investment; employees are trained proactively in anticipation of future skill needs.	
Overall	Respond to change slowly, ineffectively	Anticipate as well as respond to changing environmental conditions to carry out their missions quickly and effectively	

There are two important strengths in this model. First, it acknowledges that some aspects of most organizations are best suited for a stable approach that is closer to traditional than Agile. The model allows for those areas to be tailored for each organization on a case-by-case basis. By not requiring an "all or nothing" commitment to Agile, the framework mitigates some of the key barriers for those contemplating the use of Agile (e.g., inertia, risk of breaking already efficient processes, and time to train and develop necessary skills). Secondly, in an Agile organization, personnel in authority support these routines by providing access to resources and by removing obstacles, but most important, leaders at all levels must provide psychological safety.

Psychological safety is like trust, and both terms are used in describing attributes of Agile. When psychological safety is not present, team members are more reluctant to take risks, ask questions, or offer new ideas for fear of embarrassment or reprisals (Kirkpatrick et al., 2019b). The concept of psychological safety leading to the absence of fear is further supported and elaborated on in *The Scrum Fieldbook*. Sutherland feels so strongly about the need for psychological safety (and trust) that he addresses the importance in three of his five scrum values: openness, respect, and courage. He also emphasizes its importance in empowering personnel to highlight problems. Sutherland supports a principle of the Toyota Production System that not having any problems is the worst problem because they always exist and not

knowing what they are makes it impossible to fix them (Sutherland, 2019, pp. 110–112 and 131–136).

Agile Applied to Other Domains

Manufacturing

Aircraft—Saab Fighter Jets

Saab made the commitment to build the Gripen E fighter jet using Agile practices that are "implemented at every level and in every discipline: software, hardware and fuselage design. The Saab Agile framework contains practices from Lean, Scrum, Kanban, XP and others" (Furuhjelm et al., 2015). This is one of few examples of applying Agile to the design and manufacturing domain writ large and not just in the software development component of a production item. The following describes a summary of the characteristics of the Saab Agile framework as derived from two sources: Team Autonomy, Common Iterative Project Master Plan, Continuous Improvement, Clarity, Commitment, Transparency, Continuous Delivery, Prioritization, Living Strategic Plan (Furuhjelm et al., 2016; Sutherland & Justice, 2020).

Saab's Agile framework includes several catalysts (additional characteristics) atypical to scrum but critical toward implementing Agile in the aircraft manufacturing domain: Modular Architecture, Modeling and Simulation, and Co-located Pilots.

Result: The use of Agile on all aspects of the Gripen E program resulted in a fighter jet with 50 times lower development costs compared with the F-35, 10 times lower unit costs compared with the F-35, and the lowest cost per flight hour of any modern fighter jet (Kniberg, 2016).

Motor Vehicles—WIKISPEED and Tesla

The **WIKISPEED SGT01** car was an entrant in the Progressive Insurance Automotive X Prize contest. The contest goal was to produce a full-sized, road-legal car, getting 100+ mi/gal (2.25L/100 km). WIKISPEED used an Agile design approach that demanded that modules were loosely coupled and could be tested apart from the whole. The WIKISPEED car developed major sub-assemblies, such as suspension, motor, and body, that can be replaced in the time it takes to change a flat tire. The modularity supported many of the design and process principles. It allowed for rapid iterations and experimentations during development and testing. The loosely coupled components, with simple and well-defined interfaces, minimized system interdependencies that enabled more rapid and reliable software and hardware development. While most of WIKISPEED's Agile implementation adapted standard principles, one atypical aspect is that WIKISPEED was able to complete the work using a distributed team (Socha et al., 2020).

WIKISPEED Result: WIKISPEED successfully built one prototype to prove concepts using Agile principles. The Agile methods resulted in a product cycle times measured in weeks, not years (as compared to traditional motor vehicles). The company is working on other prototypes for a mail delivery vehicle, next generation taxicab, ultra-light racing vehicle, and five-seat sedan for ARPA-E's (Advanced Research Projects Agency-Energy) LiteCar Challenge.

Tesla's Agile approach is disrupting the automobile industry by shifting the core of its products from mechanics to software, and the company is using that advantage to skip beta testing on its latest vehicle, Model 3, and going straight into production. Antonio Patti, a digital strategist at the Transport Company of Milan, wrote in a 2017 blog post:

> "Skipping the beta testing for a traditional car-maker is a sort of suicide, but if you are Tesla it is the first application of its agile car development framework approach.

Tesla's cars are different from the other cars. Its engines, chassis, interiors and all the other components are way simpler [than] other cars so, once tested and standardized, they don't need to be tested again for all the models." (Patti, 2017)

The data collected from the same hardware used previously on the Model S and Model X is sufficient to justify going directly to production and skip beta testing.

Tesla no longer views the Model 3 as a new concept car that requires beta testing but instead as the next company model, an iteration of the product where the important hardware parts have already been tested and the easily replaceable components and less critical functions are still in development (Patti, 2017).

Tesla Result: Tesla shifted its products from mechanics to software to skip beta testing and go straight into production. This approach allows enacting product updates and mechanical improvements through updated software directly to the customer, avoiding extensive recalls and utilizing large amounts of data drawn from customers to continually improve products.

Automotive Parts, Power Tools, and Agriculture Sensors—Bosch

The example of Bosch's transition to an Agile company is included in this research not because it contains any unique methods but due to the sheer size and diversity of the company. Bosch is an enormous company with 390,000 employees located across 60 countries that has been in existence since 1886 and is well known as an innovator. In May 2017, when commenting on why Bosch was turning to Agile across all parts of its business, CEO Volkmar Denner said, "For Bosch [A]gility is crucial, it allows us to adjust to the increasing speed of change around us. Agility allows us to remain in a position as an innovation leader" (Howard, 2017). Denner realized that the world environment had radically changed and his company needed to react faster, provide more customized solutions, and be more connected (everything is part of the Internet of Things). He is clearly underscoring the UURVE and VUCA environments introduced earlier as driving factors for why every program/project or organization should be considering Agile. Bosch homed in on the approach of implementing Agile as a leadership-driven transformation.

Result: Bosch cut its automotive parts development time in half; for home and garden power tools their innovation increased and employee engagement improved; and for agricultural sensors, 10 new innovations were developed in 1 month when it traditionally took 6 to 8 months for each innovation (Howard, 2017). Perhaps, more important, Bosch provided some valuable lessons learned through its two false starts and demonstrated that with persistence and commitment, Agile could be applied even in the largest, most widely dispersed companies.

Shipbuilding and Submarines—GDEB and HII/NNS

General Dynamics Electric Boat (GDEB) and Huntington Ingalls Industries' Newport News Shipbuilding (HII/NNS) both have achieved success in manufacturing surface ships and submarines by applying Agile principles. A *Naval Engineers Journal* article and several GAO reports provide excellent detail on recent efforts to adapt Agile principles into shipbuilding and submarine manufacturing processes. For completeness, the following list of comprehensive reports providing extensive industry reviews is provided:

- "Benefits and Challenges of Implementing Agile Development in Modular Shipbuilding," *Naval Engineers Journal*, June 2019 (Castell et al., 2019)
- "Research on Systematization and Advancement of Shipbuilding Production Management for Flexible and Agile Response for High Value Offshore Platform," *Journal of Naval Architecture and Oceanographic Engineering*, September 2011 (Song et al., 2011)

- "Can a Shipyard Work Towards Lean Shipbuilding or Agile Manufacturing?" *Sustainable Maritime Transportation and Exploitation of Sea Resources* (Alves de Moura & Botter, 2012)

Result: Numerous reports cite excellent details on recent efforts in shipbuilding and submarine manufacturing to adapt Agile principles in their processes.

Construction

Uranium Enrichment Plant—Centrus Energy Corp

Construction projects are generally considered poor candidates for Agile because they are thought to require sequential phases (i.e., initiation/planning, design, construction, testing, turnover, and closeout) and any changes in the plan get progressively more expensive later in the life cycle. Centrus Energy Corp. elected to apply Agile concepts to a construction project to build the next generation U.S. uranium enrichment technology. The project required building, installing, operating, and testing a large cascade of machines and centrifuges. Centrus chose to use Agile because there was a mandated aggressive schedule and funding was being provided in tranches, both of which rendered the traditional construction approach unworkable. To implement Agile, Centrus effected numerous changes not part of conventional construction.

Result: Centrus met an aggressive schedule, was under budget, had no safety issues or deficiencies from any oversight and regulatory agencies, and had a significantly higher than average productivity for a nuclear project or even for a less complex construction project (Straçusser, 2015).

Prefabrication—PCL Constructor

PCL Constructor, Canada's largest general contractor company, in 2012, formed PCL Agile to implement Agile principles including prefabrication as a form of incremental development. PCL Agile now regularly provides offsite modular construction in large warehouses to assemble smaller components and larger built-up assemblies, to overcome site logistical challenges where lay-down (working real estate) areas are scarce (Caulfield, 2018). Many vertical construction projects are located within dense downtown areas that lack ample space necessary for construction staging and equipment maneuvering. More architects are using prefabricated solutions to ensure projects are completed on time while mitigating unforeseen change conditions. For PCL Agile, this approach led to better site access in the field, improved quality control within a climate-controlled environment, reduced congestion and trade stacking at the site, increased worker safety, decreased waste due to reusable parts, and reduced transportation costs, which strengthened contractor and customer relationships.

Result: PCL Agile now regularly provides offsite modular construction in large warehouses to assemble smaller components and larger built-up assemblies, to overcome site logistical challenges where lay-down (working real estate) areas are scarce.

Construction Project Management—Construction Blog

In a NTaskmanager.com blog post, Fred Wilson notes that despite not seeming to be a good fit for construction, Agile is proving its effectiveness and efficiency in this industry. Wilson sees Agile principles already being incorporated and feels the existing roles in construction can easily map to Agile roles—for example, the superintendent acting as a scrum master coordinating work and ensuring task completion, the project manager acting as the product owner prioritizing tasks and interfacing with the customer, and workers completing the physical tasks acting as the development team. Project management software is now commonly used in construction, allowing real-time collaboration (between architects, engineers, subcontractors, owners/clients), monitoring progress, facilitating quicker decisions, and saving costs in materials and overtime (Wilson, 2018).

Rachel Burger observed that Agile construction is best suited for the pre-design and design phases where customer involvement can be increased and the complex project can be broken into easier-to-manage subprojects, enables collaboration, sharing of information, re-prioritization of tasks due to unforeseen circumstances, coordination for major installs between all trades affected, and feedback for continuous improvement on productivity and profitability (Burger, 2019).

Result: Agile construction also applies to project management where the roles and responsibilities must be redefined. It has already made its way into project management software tools, allowing for real-time collaboration, and affords the potential to improve speed, reduce costs, and increase customer satisfaction.

Health

Big Data—3M HIS

Daniel Keys Moran is a computer scientist, novelist, and big data expert who popularized the saying, "You can have data without information, but you can't have information without data" (Sutherland, 2019). 3M Health Information System (HIS) is a research and development (R&D) program that is trying to address the big data problem of how to turn huge amounts of data into actionable information for hospitals, insurance companies, and health plans. 3M HIS integrates inputs such as doctors' notes, lab reports, and demographic data to support proactive versus reactive actions. In May 2015, 3M was faced with the daunting task of updating its system from International Statistical Classification of Diseases and Related Health Problems Version 9 (ICD-9) with ~14,000 codes to ICD-10 with ~141,000 codes within 6 months (by October 2015) and the efforts were not going well. 3M HIS had ~5,000 customers that used its system daily to determine the correct codes and properly reimburse hospitals and clinics from insurance companies, so the program decided to adopt Agile and hire Scrum Inc. to consult. 3M met the deadline and continued to improve its adoption of Agile over the years.

Result: 3M recognized that it needed to change to meet an aggressive schedule and that it did not possess the necessary expertise to make the needed change. 3M used an expert consultant to help prioritized the work, instituted stabilized teams, worked off the backlog, reduced interruptions, and changed the scrum process to improve velocity, and successfully meeting deadlines.

Mental Health—Monash Health

Monash Health is the largest public health service provider in Melbourne Australia. Dr. Melissa Casey, Director of Psychology at Monash Health, led the change to Agile after realizing their system was broken from observing her teams struggle to meet key performance indicators for emergency care and measuring a significant increase in patients presenting in crisis to emergency rooms. In 2013, after several weeks of design, clinician workshops, and collaborating with Agile consultants the first prototype Agile Psychological Medicine Clinic (APMC) opened. The methods APMC found most useful were adopting an Agile ethos, using Agile consultants, developing flexible treatment programs, and instituting rapid delivery of care (Faucher, 2019).

Result: APMC was so successful that Dr. Casey and her team won a State-level award for delivering innovative mental health care the first year after opening. In addition, four more clinics modeled on the prototype opened near other hospitals. Over a 12-month period patient data showed a 23%–46% improvement on several standardized measures following treatment, a significant decrease in the number of clinicians and case managers involved in each case (handoffs), and an increase in clinician job satisfaction.

Research and Development

Laboratories/Academic Research—Broad Institute of MIT/Harvard

The Broad Institute of Massachusetts Institute of Technology (MIT) and Harvard is one of the world's leading genomic research centers, with over 1,300 employees across 30 academic laboratories, each with a different research focus but all working to enhance health and human medicine. Within each laboratory are numerous teams that share a common research theme but conduct individualized experiments. At Broad, Kendra West co-founded AgileAcademia a group of more than 80 members across 22 teams that look to improve team function through Agile practices.

West and her AgileAcademia group identified several methods that helped their teams embrace Agile. The methods they highlighted were introducing Agile in a comprehensible manner because academics have a hard time getting started and try to understand the whole process and avoiding using intimidating Agile terminology (e.g., project reflecting instead of retrospective and check-in vs standup). With some effort, the same intentions behind Agile were applied for great success in the R&D environment (West, 2018).

Result: Broad Institute identified typical challenges R&D laboratories adopting Agile would face. They found methods to address roadblocks and successfully incorporated Agile values.

Innovation—3M HIS

Another R&D example echoes many of the same tips recommended by the Broad Institute. This example comes from the 3M HIS work previously described under the health domain. 3M HIS is made up of dozens of Agile teams and some of those teams also work in the R&D environment where they must design, create, prototype, and refine new and innovative approaches. These teams are faced with the dilemma of how to best adapt Agile to research projects. They discovered implementation was not insurmountable, given that the research process is already naturally iterative with many false starts and incomplete finishes.

The 3M HIS R&D teams decided to customize the SCrum fOr REsearch (SCORE) method proposed by Hicks and Foster (2010). The techniques that worked for them included reducing the daily scrum to two meetings per week and eventually to one per week and making all other meetings "on demand" between team members and scrum master to troubleshoot or review results (Butterfield & LaBrec, 2019; LaBrec & Butterfield, 2016).

Result: The 3M HIS R&D teams adopted a more efficient use of time for faculty, improved both morale and productivity for student researchers due to the transparency and accountability, and generated a group identity for a research community for shared knowledge to the benefit of all.

Product Research—HPE

Ruly Weisbach was the R&D director at Hewlett-Packard Enterprises (HPE) in 2015 and led six R&D groups through the transition to Agile. His experience in the R&D environment was that early on the teams used the terminology, held the meetings, and followed processes but were still not Agile. In the R&D domain, his teams tended to start on too many features at once, so the work in progress (WIP) was always overloaded, making it impossible for a product owner to get feedback and react to it, and the list of features would take years to deliver.

For HPE R&D, Weisbach tackled this by (a) reviewing the backlog with the team and ruthlessly removing items that didn't fit the definition for a minimum viable product (MVP), which they defined as the top 5 themes and 50 features; (b) structuring the organization by features not domains (functional expertise); (c) tracking features in addition to user stories so that teams

were consistently delivering new functionality to the customer; and (d) planning short term for MVP, not long term on features that were not the priority, which kept the backlog manageable and prevented feature creep (Weisbach, n.d.).

Result: The HPE solution for Agile R&D was to force all teams to focus on prioritizing the backlog and delivering the most important feature first, which is identical to the swarm attribute discussed in *The Scrum Fieldbook* about the 3M HIS work.

Finance—ING

ING started a pilot Agile transformation in 2010 that was limited to three IT teams. Those teams showed enough success to convince the company to adopt it across the entire software development department in 2011. By 2014, executives recognized the success in software and IT but noted it had not translated to business gains (Siroky, 2020). That realization was the motivation for ING's full implementation of Agile. Starting in 2014, ING spent 8 to 9 months examining what worked at companies such as Zappos, Google, and Spotify and planning how to adapt those concepts for ING. The full transition started in June 2015 when ING started focusing on the customer journey (i.e., an individual may go to a branch for financial advice but wants to go online to make the investment) or ING risked becoming irrelevant.

A McKinsey & Company article (Schlatman & Jacobs, 2017) based on interviews with the chief information officer (CIO) and chief operating officer (COO) provides the best insights into their reasons to move to Agile, the ideas they adapted from other companies, how they implemented them, and the challenges and risks they faced. Some of the main points of the article are summarized below, but the full source is highly recommended for anyone contemplating an organizational shift to Agile.

ING adapted a squad/tribe/chapter construct from Spotify. To apply Agile at scale across the company, ING organized its ~2,500 employees into 350 squads no larger than 9 people, all co-located, formed to work toward a specific client-related objective with end-to-end responsibility, and ready to dissolve once its mission was complete. The squad/tribe/chapter approach is how ING adapted Agile for its own use, but even more important are some of the adaptations and observations the company made in applying Agile company-wide beyond IT and software (Perkin, 2017; Schlatman & Jacobs, 2017).

Result: ING has been quicker to market, has increased employee engagement, releases software every 2 to 3 weeks versus 5 to 6 times per year previously, and has increased customer satisfaction and employee engagement scores.

Lessons Learned from Adopting Agile

Table 3 presents a synopsis of the successful results of the domain research on companies that adopted Agile into their processes and methods from the Agile Applied to Other Domains section of this paper. Most companies improved quality, decreased production time, and/or reduced costs. They also improved collaboration across the organization, breaking down barriers to communication, which resulted in increased employee satisfaction. They generally improved their viability and relevance within the market under changing market or technology conditions, enabling company longevity.

Table 3. Agile Application Lessons Learned

Company	Agile Results
Saab	The use of Agile on the Gripen E program resulted in a fighter jet with 50 times lower development costs compared with the F-35, 10 times lower unit costs compared with the F-35, and the lowest cost per flight hour of any modern fighter jet.
WIKI SPEED	Successfully built one prototype to prove concepts using Agile principles. The company is now working on other prototypes: mail delivery vehicle, next generation taxicab, ultra-light racing vehicle, and five-seat sedan for ARPA-E's LiteCar Challenge.
Tesla	Shifted products from mechanics to software to skip beta testing and go straight into production. Enacting product updates and mechanical improvements through delivery of updated software directly to the customer, avoiding extensive recalls to continually improve products.
Bosch	Cut development time in half; divided into cross-functional teams leading to increase innovation and improve employee engagement; developed 10 new innovations in 1 month when it traditionally took 6 to 8 months for each innovation.
Shipbuilders	Numerous reports cite excellent quality improvements in shipbuilding and submarine manufacturing by adapting Agile principles.
Centrus	Met an aggressive schedule, under budget, with no safety issues or deficiencies from oversight and regulatory agencies. They had a significantly higher than average productivity for a nuclear construction project or a typical less complex construction project.
PCL	PCL Agile now regularly provides offsite modular construction in large warehouses to assemble smaller components and larger built-up assemblies, to overcome site logistical issues.
Construction Projects	Agile has already made its way into the construction domain through software tools and real-time collaboration to improve speed, reduce costs, and increase customer satisfaction.
3M HIS	3M prioritized its work, instituted stabilized teams, reduced backlog, reduced interruption, and changed its scrum process to improve velocity.
Monash Health	So successful four more clinics modeled on the prototype opened near other hospitals. Over a 12-month period patient data showed a 23%–46% improvement on several standardized measures following treatment, a significant decrease in the number of clinicians and case managers involved in each case (handoffs), and an increase in clinician job satisfaction.
Broad Institute of MIT/Harvard	Incorporated tailored Agile values into its laboratory environment; utilized flexible sprints and adopted the right tools and techniques to fit each research lab space.
3M HIS R&D	3M HIS R&D teams adopted a more efficient use of time for faculty, improved both morale and productivity for student researchers with transparency and accountability, and generated a group identity for a research community and shared knowledge to the benefit of all.
HPE	The HPE solution for Agile R&D allowed all teams to prioritize the backlog and delivering the most important feature first. This approach used the swarm attribute referenced in *The Scrum Fieldbook*.
ING	Quicker to market, increased employee engagement, and released software every 2 to 3 weeks versus 5 to 6 times per year. Customer satisfaction and employee engagement scores are all up.

Apply at scale: The benefits of adopting Agile will not extend throughout a company and business units unless Agile is applied at scale. If Agile can be applied on a small scale to an individual project/program or organizational unit, the benefits will be limited to that scope. If a company decides to adopt Agile at scale, the change needs to be leadership driven, applying the Agile management information presented in this research.

Organizational adoption: Organizations should use Agile principles to transform their company and decide how to apply Agile. They need to outline core principles and transform roles to define outcomes. A company that draws a detailed plan, schedule, and milestones for Agile migration, falls into the trap of waterfall project management while attempting to become Agile.

Teams: Organizations need to release the power of small cross-functional teams with clear purposes, close connections to the end user, and process iteration with short feedback cycles (sprints). Scrum is the most widely used form of Agile, consistently at the top of the State

of Agile™ survey, with ~72% of respondents saying they practice Scrum or a hybrid Scrum (VersionOne, 2019).

Experts: Organizations should consider using an Agile outside consultant, rather than trying to adopt Agile alone. Companies can learn from their expertise and experience.

Common Characteristics of Adopting Agile

The research showed several common characteristics of companies that successfully applied Agile in their domains. These characteristics reflect on the Agile values or principles. When possible, companies adopting Agile should cultivate these common characteristics such as: a) iterative, b) adaptive and flexible, c) collaborative, small teams, d) user/customer focus, e) visual progress, f) short feedback loop, g) continuous improvement, h) trust/psychological safety, i) simplify, j) change in leadership roles, and k) build in quality.

Conclusion

Our research concludes that Agile can be applied successfully across many domains. Several studies and surveys have confirmed that notion. *The Scrum Fieldbook* references surveys. CHAOS Report from Standish Group since 1985 covered many companies and showed that Agile projects are successful/are challenged/fail at 42%/50%/8%, compared with 26%/53%/21% for traditional projects, or a 60% greater success rate and 260% lower failure rate (Sutherland, 2019, p. 40).

The benefits of adopting Agile development practices are clear. Between 2016 and 2019, thousands of Agile practitioners from companies and countries were surveyed, and 50%–85% of those surveyed identified the following benefits (in approximate descending priority): a) user/stakeholder engagement, b) allows for change, c) transparency/visibility, d) faster time to market, e) increased team productivity, f) project predictability (deliveries, cost, and schedule), g) improved team morale, h) business and IT alignment, i) improved quality, and j) reduced risk (fail early; VersionOne, 2015, 2019).

The research concludes that an organization or program can adopt Agile in a domain beyond IT and software. There are no definitive answers for the optimum approach. The following general guidance for implementing Agile is provided:

- **Determine if Agile is a good fit**: There is no point starting down the path to Agile if an organization cannot meet or otherwise substitute for core values and principles such as access to users and the ability to iteratively deliver a useable product (see the Background section).
- **Determine the scope of the Agile effort**: Agile can be applied to all or portions of an organization or program. If applying at scale, Agile management is a necessary component (see the Agile Applied to Management and Organizations section).
- **Consult with experts**: Organizations are unlikely to have Agile experts on hand ready to assist with this journey. Organizations should make sure they have access to experts (*The Scrum Fieldbook* and Agile experts to consult with such as those identified in the Agile Applied to Other Domains section).
- **Tailor Agile values and principles to the situation**: This sounds simple but is where organizations or programs need to put the most thought (see the Background section).
- **Develop an approach**: Remember not to fall into the trap of developing a detailed plan and milestones; instead, use Agile to iterate and refine the approach (see the Agile Applied to Other Domains section).

- **Leverage lessons learned**: Use research, the references provided, and other organizations that already transitioned to Agile (see the Lessons Learned from Adopting Agile section).

Federal agencies face different challenges than private industry when adopting agile. Many constraints, such as budget authorizations, program approvals, leadership change, and different agendas can impact full adoption of Agile, and certainly influence scale. Some of these challenges as well as best practices are included in the GAO Report 12-681. We suggest that Federal Agencies review these items as they adopt Agile practices within their organizations.

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