AGILE @ HARDWARE MANUFACTURING

Smash your time-to-market, boost innovative potential and change the game in your industry with these innovative methods and practices.

A GLADWELL ACADEMY & BLINKLANE CONSULTING WHITE PAPER
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### WHY BRING AGILE IDEAS TO HARDWARE DEVELOPMENT?

The advantages of working Agile have been a revolution for the world of software development - and following that, for much of the business world in general. From services firms to municipal governments, the promise of Agile ideas is irresistibly convincing.

- The ability to ‘turn on a dime, for a dime’.
- The ability to drastically reduce time-to-market.
- The increased sense of empowerment that pervades all layers of the organization, so even the humblest coder feels like they might improve the entire company - given a valuable enough insight.
- The ability to improve client collaboration during development, by effectively responding to new insights and changing requirements.
- The earnest commitment to customer value, rather than to internal goals and priorities.
- The substantial elimination of waste from the equation.

### THE DIFFERENCE DISAPPEARS

The proliferation of Agile ways of working beyond software developers goes hand in hand with the increased popularity of software development itself, though. More and more organizations are building in-house software development departments to support the increased digitalization of their services. It’s online banking portals developed by in-house developers at banks, or civil services databases engineered at municipal governments. It’s still software, in other words.

This also holds true for many hardware developers: firms that never included software in their products, are finding themselves in need of a programmer or two (or thirty). Think of cars running millions of lines of code to run, teddy bears that play mp3s, intelligent lighting solutions, medical devices with AI applications, et cetera et cetera. The lines between software and hardware is blurring. Software is eating that world as well.
HUGE POTENTIAL GAINS

The potential for hardware manufacturers to benefit from Agile principles and methods can be called enormous. Inestimable, even. Likely to change the course of industrial history.

These years, so many new technologies are emerging: uprooting existing industries, creating new ones. Hydrogen and photovoltaic energy, nanotechnologies, biological and genetic engineering, graphene-based applications, advances in semiconductors, robotics and artificial intelligence, virtual and augmented realities. The list of innovations and potential applications goes on and on.

In markets buffeted by these disruptive new technologies, time-to-market is key. To the victor go the spoils, and in mass-manufacturing, the spoils are enormous. Since a reduced time-to-market and increased innovative power are the prime benefits that Agile ways of working have to offer, there is quite literally a world to be won.

WHY NOT?

But it isn’t just the spoils that are enormous. The obstacles are too.

To implement revolutionary complex technologies in a commercially viable manner, ie. fit for mass-production, often takes months if not years – along with millions of Euros, easily. This is a fundamental difference between hardware and software development: that you can’t change your product just by editing a couple hundred lines of code.

Changing the routing for a semiconductor, the thickness of a car door or the placement of a hinge in an appliance can mean months of work. Moreover, the main cost driver in a hardware environment is machinery, whereas in a software environment people are what mainly drives cost. In an environment that depends on raw materials or semi-finished products, changes create waste.

It has long been understood that a transparent, modular system is intrinsically more open to adaptation and experiment than an integral, opaque design. Software has been developed with a modular approach since its early beginnings; hardware development has conventionally seen more of an integrated approach, fitted with strict quality stage gates to keep transaction costs manageable, at the price of over-design, suppressed variability and a slow market response time.

For decades, these have been the main reasons that Agile methods and principles were seen to have little to no place in hardware design and manufacturing. Until today.
AGILE METHODOLOGY FOR THE HARDWARE ENVIRONMENT

In recent years, a number of bright, pioneering minds have adapted Agile methods to better suit the hardware environment. At BlinkLane Consulting, our consultants have gathered ample experience in applying several Agile methods to hardware environments for a wide range of clients - more of which can be learned about in the ‘Cases’ chapter.

“NOT INVENTED HERE!”
It is important to realize however that the motivational resistance against these methods – a resistance that is regularly seen during the initial phase of a transformation, in organizations of any type – is even more passionately felt in organizations with a hardware focus. Dismissive statements abound - mostly in the vein of ‘not invented here’, ‘old wine in new bottles’ and ‘that’ll never work here, because…’.

WHY DO THEY SAY THAT?
These statements themselves are most often unsubstantiated and ultimately not true, but the sentiments behind them ought to be taken seriously. Hardware-focused industry is one of the oldest sectors of our economy, arguably dating back to when prehistoric carpenters built the first chairs from tree trunks.

Then, just three decades ago, much of what makes manufacturing started being off-shored to low-wage countries, leading to those who remained feeling tainted by the ‘low-wage stigma’, even in specialist high-tech or niche manufacturing.

Meanwhile, adding insult to injury, the two upstart industries of services and software have taken center stage in our local economies, drawing the spotlight away from manufacturing.

YES, INVENTED HERE…!
To summarize, some bad blood can be said to remain between the software camp and the hardware camp. How convenient then, that a powerful key to resolving the grudge lies in the early history of Agile methodology itself…

One need only look back on the roots of Agility. Look towards the industry-disrupting process innovations that propelled companies such as Toyota and Sony to market leadership in the eighties and nineties: concepts such as Just-in-Time Delivery, Zero Inventory Planning, and the Kanban method (from which the fantastic Kanban board was born); look towards W. Edwards Deming’s Toyota Production System, look at Kaizen (another Japan-born practice which translates as ‘Continuous Improvement’; where have we heard that term before?)... the roots of Agility lie in manufacturing, long before its seed sprouted in software development.

Armed with a little knowledge of history, a lot of the mistrust felt by hardware professionals against the so-called ‘foreign’ ideas of Agility can be defused, leading the way to tentative enthusiasm and increased openness to change.
PRODUCT-CENTERED AND PROCESS-CENTERED APPROACHES

Several approaches are leading the movement towards Agile hardware development: we’ll be diving deeper into each one during the Agile for Hardware training (see page 16).

There are roughly two avenues that lead to increased Agility in hardware manufacturing. One focuses on design, engineering and assembly matters, which we’ll call ‘product-centered’; while the other is mainly an adaptation of methods that focus on how people work together, which we’ll call ‘process-centered’.

PRODUCT-CENTERED APPROACHES

- Modular Architecture
- Adaptive Planning
- Set-Based Design
- Model-Based Systems Engineering
- Continuous Testing, Validation & Integration
- Hardware MVP
- xXtreme Manufacturing
- Lean management
- Scrum
- Large Scale Scrum
- Scaled Agile Framework

PRODUCT-CENTERED AND PROCESS-CENTERED APPROACHES

Adaptive Planning
Also known as Rolling Forecasting, this is an extremely useful approach to the rigidity of conventional annual budgets. The concept fully embraces the fact that the circumstances that governed your initial budget may have changed completely six months later. To accommodate, a rolling forecast works with Year to Date (YTD), and a fixed rolling future period (usually 4 to 6 quarters ahead).

Set-Based Design (SBD) and Engineering
Set-based design (SBD) starts with the wise assumption that certain aspects of the target market and audience behavior are unknowable. Designers anticipate such uncertainty by preparing several versions of their concepts, each designed as a fitting response to different market conditions. They thus avoid committing their concepts to specific conditions – a certain kind of technology, for example – until it has become sufficiently clear what conditions prevail.

Hydrogen and lithium are both currently making waves as a source of electricity for the automobile industry, for example. From an SBD perspective, manufacturers would prepare design versions for both technologies, while waiting for market conditions to become clearer.

Model Based System Engineering (MBSE)
Development for any reasonably complex product involves documentation to keep track of requirements, options and decisions. MBSE was developed in response to the tendency for conventional documentation to grow impossibly large and unmanageable. It involves building a parallel model of the intended result – a model that contains all the related requirements, specifications and process documentation within.

Continuous Testing, Verification & Validation
Testing, verification and validation are all processes intended to check if a product, service, or system meets a set of requirements or specifications regarding performance, qualities and properties. The fact that these processes can today be automated, simulated and repeated in rapid succession greatly reduces the lag they impose on the overall development process.
Hardware MVP
One of the game-changing process innovations from the Agility toolbox is Eric Ries’ Minimum Viable Product or MVP. The first product concept to minimally satisfy a perceived demand and so the intended customer base might assess the new product’s potential. In software development, such a thing is relatively easy to come by: do away with the glitzy UI and smoothed UX and all you need do is just write the first workable version.

For physical products, it takes a relatively huge investment to arrive at that first version. Even the MVP of a car should arguably be... a car, at least. Such barriers have been made largely insignificant with the recent arrival of new prototyping and simulation techniques, however. With the help of 3D printers, augmented and virtual reality and others (Such as programmable hardware (FPGA), customer hardware (ASIC), singleboard computers), an adventurous hardware innovator could assess the potential of a new car just as easily as a software developer can.

eXtreme Manufacturing
Any disruptive approach needs a shining example for the industry to follow. Founder of eXtreme Manufacturing Joe Justice created just that when he piloted the development of the world’s first highway-legal car with a fuel economy of 100 mpg (miles per gallon). He achieved this remarkable feat by combining many of the approaches mentioned above, complemented by several of the approaches mentioned below – and some others not mentioned here:

1. Optimize for change
2. Modular Architecture
3. Test-Driven Development
4. Contract-First Design
5. Iterative Design
6. Agile Hardware Design Patterns
7. Continuous Integration
8. Continuous Deployment
9. Scaling Patterns
10. Partner Patterns

PROCESS-CENTERED APPROACHES
The ‘process-centered’ Agile ways of working that we’ve helped a wide variety of hardware-oriented clients with are increasingly well-known. We’re talking about Scrum, Lean management and other methods, as well as SAFe, Nexus, Large Scale Scrum (LeSS) and other scaling frameworks.

However, there is once again a substantial difference between the services and software industries and the more hardware-oriented production floors – and one such difference is the tone and style for change management. Those who made their careers in software development and services environments have usually been trained to appreciate certain soft-skill-centered team-building and brainstorming concepts (such as gamification, role playing or team-building and brainstorming exercises). Professionals in hardware manufacturing generally take more down-to-earth and no-nonsense attitude to their work.
CASE STUDIES

1. Semiconductors
2. Lighting Solutions
3. Coffee automation machines
4. Haematology testing
5. Lithography

1. CASE: SEMICONDUCTORS
One of the world’s largest semiconductor makers pioneered with the Scrum method in a crucial domain: that of chip design and testing. Preparations for the 5G chip were getting underway in 2016 when the company decided to try and overcome time sinks, mitigate market uncertainty and combat integration risk using Scrum’s iterative approach to development.

A major time sink in semiconductor design is the supply chain: the world’s major lithography manufacturers have notoriously long ordering times. Integration risk is also well-known in hardware manufacturing: a single component may work well in isolation, but can suddenly cause problems when integrated with other components in a device. Finally, to produce a first working sample of a semiconductor chip wafer costs hundreds of thousands of dollars.

Tape-out
Such factors put enormous pressure on the design freeze moment known as tape-out: when all design decisions sublimate into a first chip wafer to be used in further testing. Tape-out habitually cost this company several months to arrive at completely: having one scheduled meant running into prohibitive quality gates and dependencies that caused them to repeatedly push back the schedule. Bad for morale of course, and perhaps worse, bad for time-to-market.

Months to weeks
Tracking these dependencies, working iteratively, and applying a continuous integration approach, together we were able to reduce the tape-out window from several months to two weeks. Put in terms of Scrum, a tape-out is now no longer more than a single sprint away from execution. A tremendous achievement considering this magnitude of product complexity…!

2. CASE: LIGHTING SOLUTIONS
Recently we worked with a worldwide manufacturer of lighting solutions to bring continuous integration to their manufacturing process.

Their products contain a mix of hardware, software and firmware and these three domains have their own requirements in almost every aspect, not least of which are testing and design.

The solution we arrived at together allows all the involved teams access to a continuous integration platform where hardware, software and firmware can be continuously integrated, tested and validated.

3. CASE: COFFEE AUTOMATION
A global corporation in coffee-based products invited us to co-develop a product innovation for their automatic espresso machine line.

What might we improve here using Agile principles and methods? An obvious candidate is prototyping, but this proved difficult. To provide suppliers with a working prototype still means injection molding, which is prohibitively expensive. And Lean MVP techniques such as 3d-printing can only take a mock-up so far. So, where software designers can endlessly tinker with their product, developing hardware involves ‘freezing’ design to allow for it to be taken into production.

5 centimeters of design freedom
When the question arose whether the new model should include a chocolate milk module, we drew on an Agile principle: to assume variability and preserve options. Rather than deciding on a yes or no for the module based on input from Customer Care, we asked ourselves: what is the impact of this design decision? As it turned out, the only consequence was 5cm additional width. Assuming variability and preserving options, the manufacturer now builds this new model with 5cm added space for the optional chocolate module.
CASE STUDIES

4. CASE: HAEMATOLOGY TESTING DEVICES
Hardware development in the realm of medical devices is subject to a complex system of regulations and legislation. These devices must comply with a multitude of validation standards before approval, which had brought a perfectionist culture and a drawn-out time-to-market in this client.

Developing medical devices and integrating them into a larger ecosystem of monitoring and reporting is a delicate job that tends to generate a cautious perfectionism: “Let’s think through exactly how we want to develop this before we start.” The result was that potential innovations were only delivered well past their deadline and potentially their first-mover window.

As impatient buyers became increasingly vocal, the overly cautious behavior had to change. We assisted the company in the development of a cyclical method that involved both Computer System Validation (CSV) and Validation and Verification for Medical Devices (V&V) in a 3-week iterative approach. These iterations already allowed for an unprecedentedly frequent integration of finished functionality, modules and parts, and a tighter learning cycle as well.

This in turn allowed us to adjust planning adaptively: from a rigid focus on far-off results that ignored the natural uncertainties of every day, to a focus on those tasks at hand that reduced risk most effectively, allowed for the earliest integration testing of products from suppliers, and delivered the most value in the short term.

The frequent CSV and V&V also allowed for elaborate traceability of specifications, elimination of ‘cut corners’ due to early detection in software and hardware, and thus a comprehensively auditable source that demonstrated the projects’ adherence to the highest quality standards.

5. CASE: LITHOGRAPHY
We were asked to assist a global leader in lithography machines – the machines that make semiconductors. Our mission involved the introduction of Agile methods at a department that was allegedly ‘so complex, that if we can succeed there, we can succeed anywhere in this company’. And... we’re succeeding.

Unprecedented results
After nine months of working with their people, we’ve built several multi-disciplinary teams that combine engineers, operators, designers and product owners. People that orbital-weld gas pipes and people that draw them in. We’ve created mechanisms that bring unprecedented transparency, an unprecedented sense of ownership and responsibility for end results. Teams that work in sprints rather than projects.

Countering cultural resistance
Part of our progress came thanks to the above-mentioned sense of history, which we used to counter the cultural resistance. Another part came from making the disadvantages and losses visible, and therefore undeniable. Showing the teams: This is how long it takes to replace a screw, that is what we encounter when we want to change a sensor. These things are hindering your performance. This must change.

Intrinsic responsibility
The new teams display an intrinsic responsibility for progress that transcends their silo. Recently a team meeting was going to be canceled because the facility couldn’t find a room available. Under the old situation, people would have shrugged and moved on – ‘not my silo, not my problem’. Now the team pulled together and convened anyway, because everyone recognized how the result depended on collaboration.
THE COURSE ‘AGILE FOR HARDWARE’

To advance the advent of these impactful methods and approaches into the world of physical product manufacturing, sister companies BlinkLane Consulting and training institute Gladwell Academy have joined forces to produce the ‘Agile for Hardware’ training course, along with the degree of “Certified Hardware Agilist”.

WOULD YOU LIKE TO:
• Apply the Agile Way of Working to areas beyond software?
• Reduce your time to market?
• Ignite product development, improve productivity and innovation?

WHAT’S IN IT FOR YOU?
Learn how to use the newest Lean/Agile methodologies to drastically reduce your time-to-market, acquire flexibility and respond to changes in requirements and markets with ease. By scaling Agile you will boost teamwork and close collaboration among technical and business people, in the end increasing employee engagement and satisfaction.

WHO SHOULD JOIN?
Professionals involved in developing hardware products and products that combine both hardware and software design. This training is suited to hardware professionals from all industries.

WHAT'S IN IT FOR YOU?
• Improve the quality of your products
• Ignite innovation
• Be more productive
• Achieve predictability in your projects

Programme Outline

DAY 1
From Lean/Agile fundamentals to design and project management

We kick off by going through principles underlying Lean/Agile methodologies, such as responding to change, waste reduction and building for quality. This knowledge is deepened by getting familiar with incremental and iterative product development, Kanban and Scrum.

Finally, you will learn how to apply the Lean/Agile approach in non-software contexts. You will learn about design approaches that enhance Agility including eXtreme Manufacturing and Hardware MVP (for example 3D printers, CNC routers, laser cutters Augmented Reality). Finally, you will learn to apply Lean/Agile practices to direct your project processes.

• Lean/Agile Fundamentals
• Designing for Agility
• Agile Project Management

DAY 2
Deepen your knowledge on how to apply Lean/Agile to develop complex products - focusing on partners, compliance and scaling up

The second day of the course is deepening your knowledge on the topics to create synergy, synchronize and align with vendors and suppliers using the Lean/Agile approach. Finally, you will learn how to add complexity and scale up the Agile way of working.

• Working with External Vendors and Suppliers
• Lean/Agile and Compliance
• Scaling Up Agility and Adding Complexity
BlinkLane Consulting issues certification to those aspiring to bring Agile principles to leading manufacturers in a tried and proven manner. Our certification program uses a valid, reliable, and consistent method to assess Agile skills, knowledge, and mentality. A Certified Hardware Agilist is recognized for their ability to support the successful transformation of conventional manufacturers into Agile enterprises.

UPGRADE YOUR CAREER
With so much to gain from a shorter time-to-market, and the Agile way of working having such a strong track record in doing just that, it’s safe to say that Agile methods and principles will have an increasing impact on the world of product development over the decades to come.

Now is a great time to level up your skill set and lead others to excellence by becoming a Certified Hardware Agilist. Possible career directions include Certified Hardware Scrum Master, Certified Hardware Agile Coach.

FIND OUT HERE!
Get all the details at https://www.gladwellacademy.com/training/agile-for-hardware/ or contact Training and Development Advisor Jeffrey Henn at jeffrey.henn@gladwellacademy.com

ABOUT THE AUTHORS

DAVAR AZARMI
Davar Azarmi is a senior consultant at BlinkLane Consulting who brings a lifelong passion for computers, a strong interest in strategic thinking and a knack for entrepreneurship. He has nearly two decades of experience in different aspects of IT and business, including leading multidisciplinary teams, managing large-scale IT projects, creating and managing a software company and overseeing a management consultancy business.

His extensive experience combined with his exceptional educational background has made him an ideal trusted partner for enterprises seeking to transform, adapt, grow and innovate in the new era of digital economy.

Solving complex problems, developing tailor-made solutions, and assisting enterprises to seamlessly implement them while inspiring people along the way are the objectives he lives by.

davar.azarmi@blinklane.com

ALI HAJOU
Ali Hajou is a Senior Consultant at BlinkLane Consulting. Ali has worked in the pharmaceutical, financial, high-tech, and public services industry as a Business Analyst, Product Owner, Agile Transformation Consultant, (SPC) Change Agent, and Agile Coach. In these roles Ali had the privilege to advise, support, train, and collaborate with various development and management teams in sculpting their Agile Way of Working.

Ali is characterized by clients as being patient but persistent, continuously pragmatic, and knowledgeable in engineering a flavor of Agile practices and frameworks (such as SAFe) to ensure a perfect organizational fit. In his role as trainer, Ali has also achieved the level of SPCT (SPC Trainer) Candidate and is endorsed by Scaled Agile Inc. to teach enterprises in the application of the Scaled Agile Framework.

With both practical and academic experience in researching the applicability of Agile practices within highly documentative environments and enterprises with strict corporate governance, he is determined to help anyone that is interested in value-oriented, adaptive, and iterative ways of working.

ali.hajou@blinklane.com
RALPH HOFMAN

Ralph Hofman is one of the founding partners at BlinkLane Consulting. Ralph has 23+ years of experience helping large organizations in the areas of outsourcing, software development and product development. Having spent the last eight years mainly focusing on improving the business agility of large organizations, Ralph uses his expertise to help companies improve their ability to effectively sense and respond to internal and external changes in a swift and cost-effective manner.

Ralph has helped several organizations in the area of non-software product development. He was involved in the introduction of Agile principles and working methods in semiconductors, consumer products and industrial machinery.

ralph.hofman@blinklane.com