FINDING THE RIGHT BALANCE

APPLYING A BIMODAL APPROACH TO CONNECTED PRODUCT DEVELOPMENT

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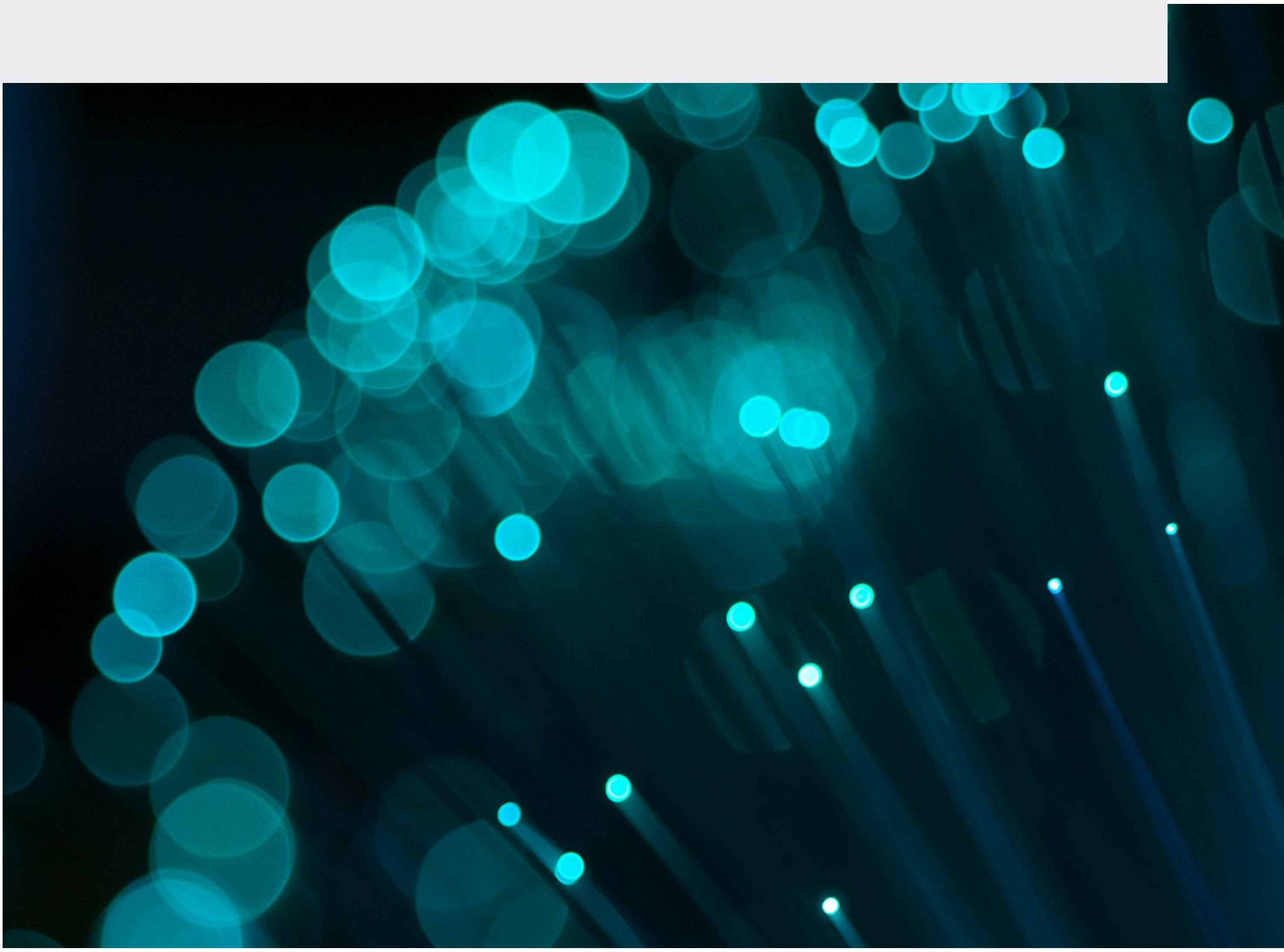
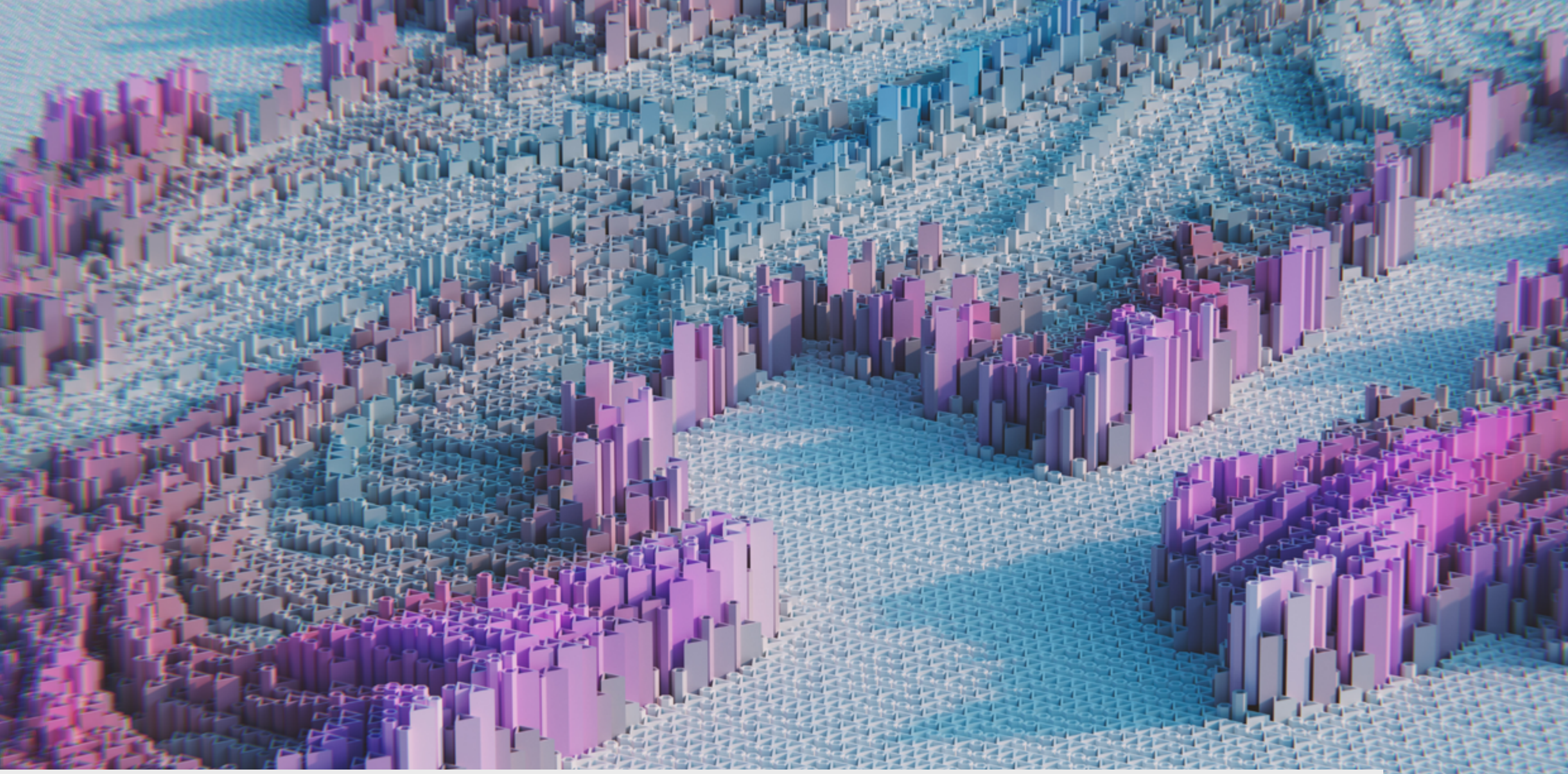




THE MULTIPLE COMPLEXITIES OF CONNECTED PRODUCT DEVELOPMENT

The definition of "product" is rapidly changing - and revolutionizing the way people think about product development. Over the next three years, 90% of consumer product companies expect to see revenue from intelligent services.[1] The rise in connected products and their services means products are moving away from having a single, transactional sales event with one-time customer interaction; they now offer rich customer experiences with ongoing customer relationships.

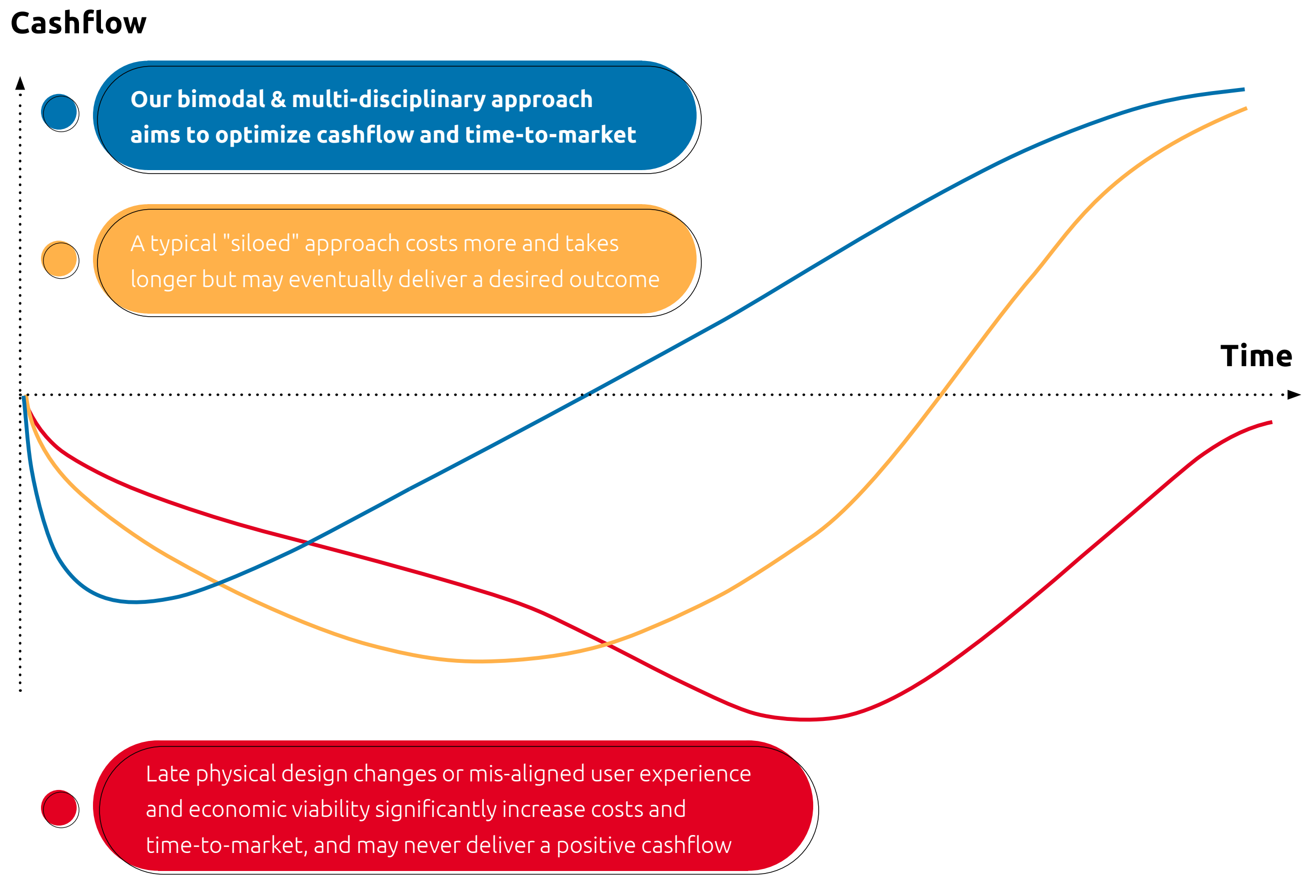
Creating new connected products combines the necessities of developing traditional physical products - such as supply chain lead time, regulatory requirements, and manufacturing capital investments - with the complexity of operating digital ecosystems such as enterprise transformation, cybersecurity, and customer data management.

Enabled by IT and AI advances over the last couple of decades, physical device development is following a path similar to digital product development: moving from waterfall to Agile development methodologies. Continuity of computer simulations and validations deliver further convergence where a connected product's design, production process, and operations can be virtualized; an ultimate example would be flying an aircraft before building it.

Ideally, the development of connected products would be entirely Agile. However, at the current time, intermediary bimodal stages - with a combination of agile and waterfall activities - are typically the best path forward.

[1] *Capgemini Research Institute, Intelligent products and services survey, April–May 2022, N=1,000 respondents from unique organizations that have or are currently building visions and strategies for a move to intelligent products and services.*

Adopting an iterative, bimodal approach that orchestrates Agile and some waterfall steps improves the potential for cashflow, reduces time-to-market, and enhances customer experience. This approach includes leveraging a shift-left paradigm, multidisciplinary design, and model-based system engineering.



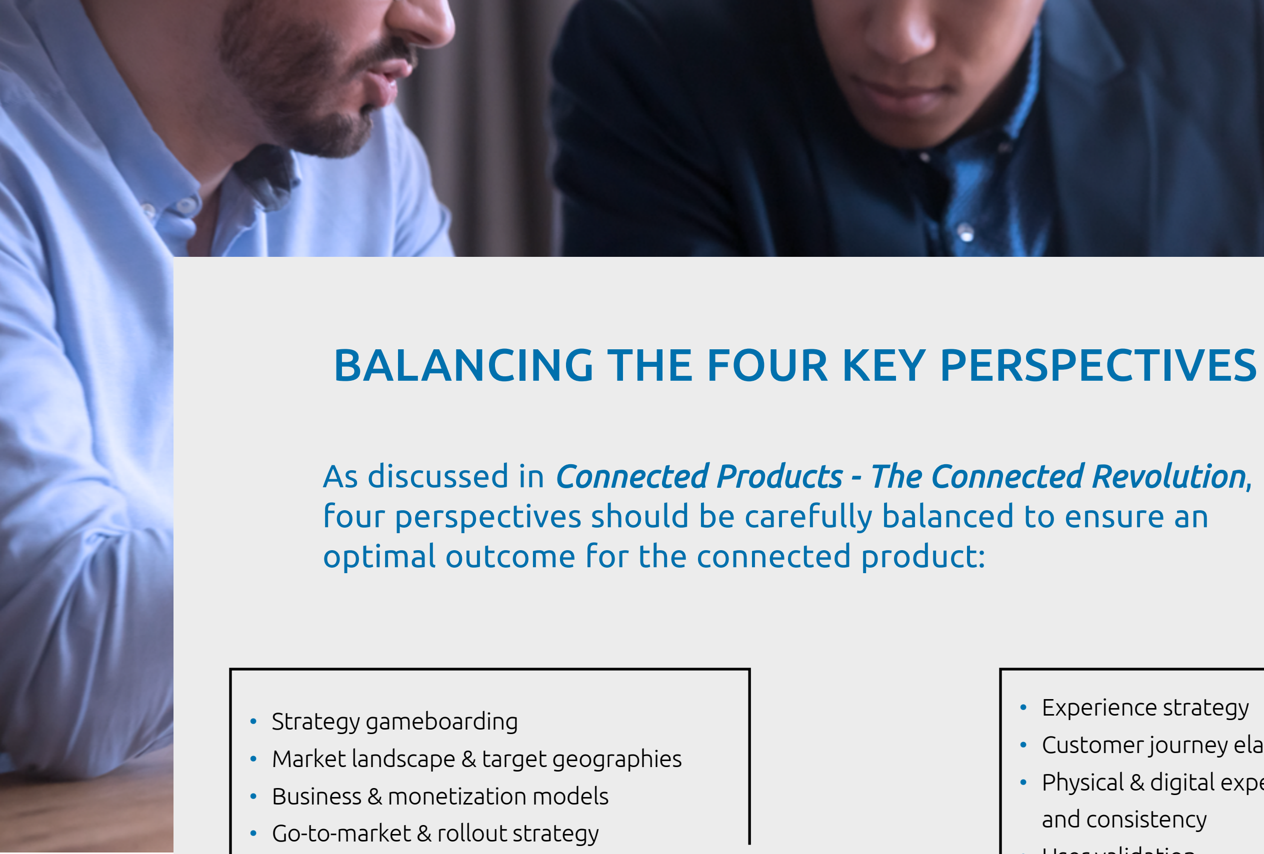
Shift-left is the practice of moving validation activities to earlier stages of the development lifecycle.

A typically siloed approach starts with a single perspective, whether user experience, technical proof-of-concept, or business case, and then moves sequentially to another perspective. This leads to much rework as findings in a down-stream perspective often conflict with decisions of an up-stream perspective.

In extreme cases, these conflicts can require late physical design changes - after agency certification and manufacturing tooling have been paid for- and therefore significantly increasing the capital investments required.

Symptoms of siloed or late changes include:

- low market adoption as users don't perceive a value,
- multiple IoT platforms for the connected products of a single organization,
- organizations stuck in proof-of concept or limited pilot stages,
- devices sold at a high premium without recurring revenue as the organization has not transformed to support subscription revenues.

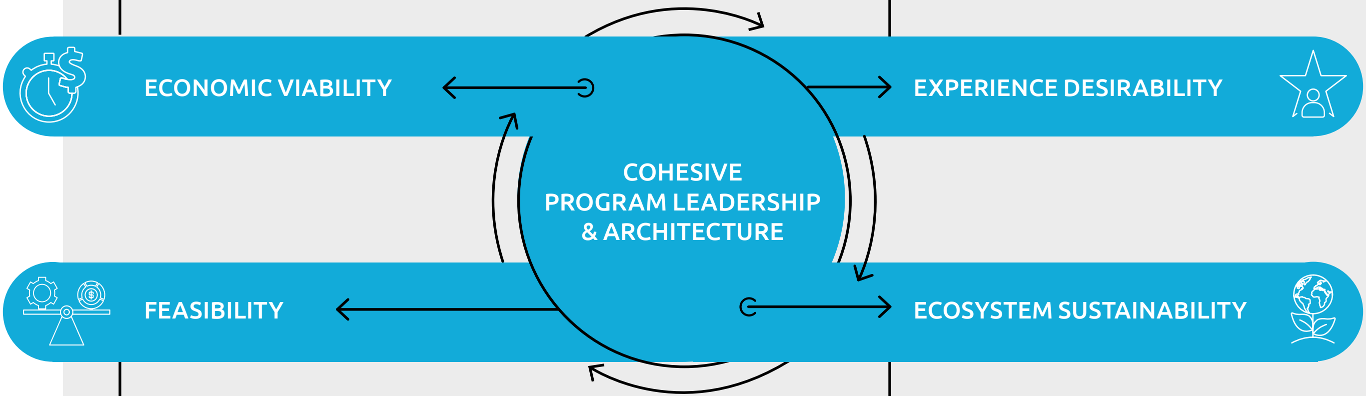


BALANCING THE FOUR KEY PERSPECTIVES

As discussed in ***Connected Products - The Connected Revolution***, four perspectives should be carefully balanced to ensure an optimal outcome for the connected product:

- Strategy gameboarding
- Market landscape & target geographies
- Business & monetization models
- Go-to-market & rollout strategy
- Enterprise transformation

- Experience strategy
- Customer journey elaboration
- Physical & digital experience quality and consistency
- User validation



- Art of the possible and differentiating features
- Science-led & model-based innovation
- Iterative prototyping & shift-left validation
- Balanced design: regulatory, quality, sourcing, cost, etc.

- Netzero ecosystem strategy
- Design for circularity
- Green manufacturing & operations

Accordingly, the connected product development program should plan to address each of these perspectives multiple times at decreasing levels of abstraction. This is often referred to as conceptual, then logical, and finally physical levels of abstraction, where the progressive refinements provide increasing levels of fidelity and details.

This iterative refinement relies upon a cohesive architecture and program management structure to appropriately balance the four perspectives.

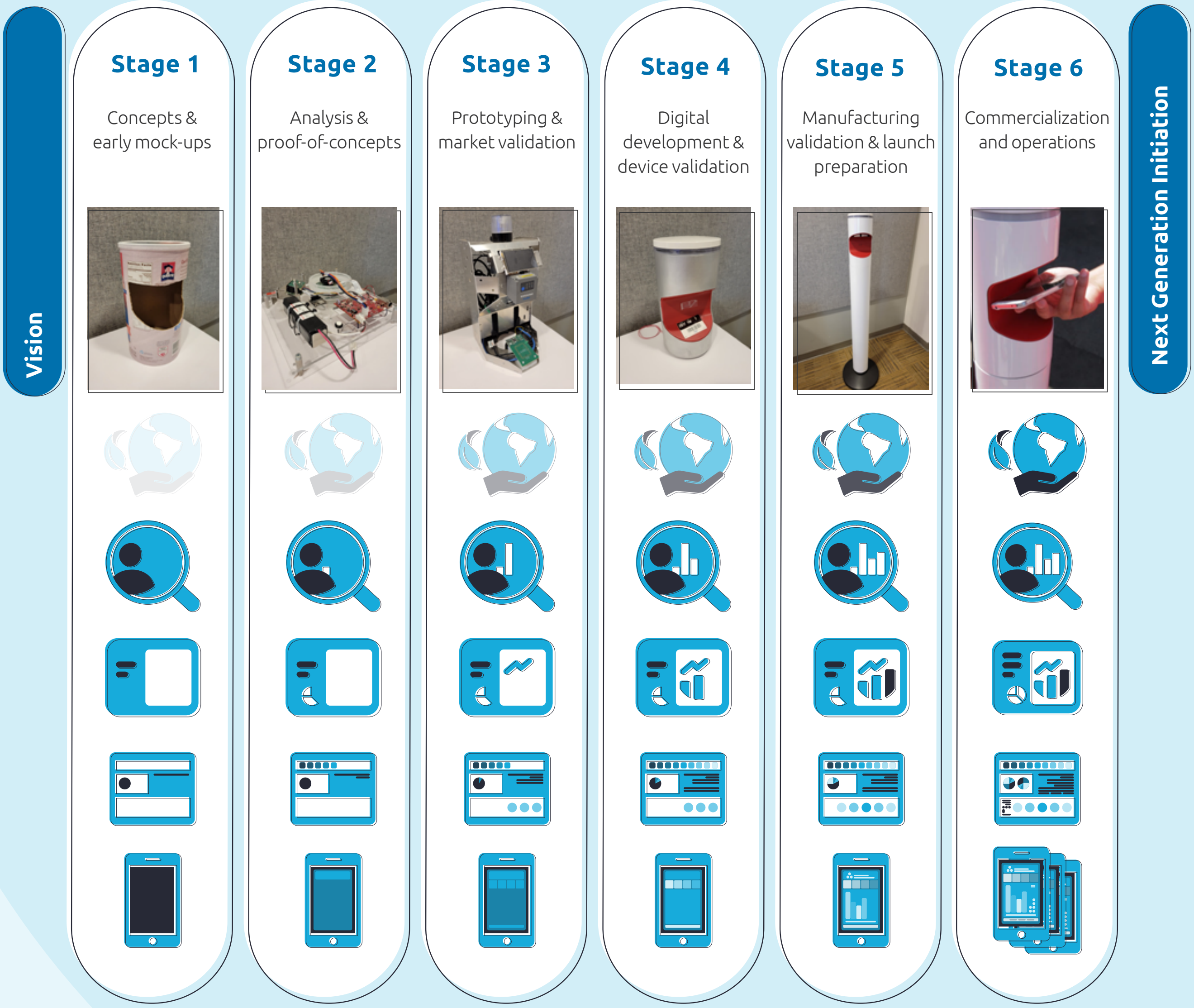
THE CONNECTED PRODUCT JOURNEY

The development of a connected product can be broken down into 6 broad stages.

A HIGH LEVEL CONNECTED PRODUCT JOURNEY EXAMPLE

Key:

- Sustainability (with progressive refinement)
- Business model / investment case (with progressive refinement)
- User research and market landscape (with progressive refinement)
- Digital backend / analytics (with progressive refinement)
- Mobile app (with progressive refinement)
- Physical device (with progressive refinement)



Stage 1 is the initial discovery phase which aims to identify the key concepts, drivers, and constraints influencing the program.

This stage generally includes initial discussions around monetization models, vision for the user experience, and feasibility risks assessment.

Stage 2 is framed to address the main risks through a variety of methods and with a multidisciplinary, iterative, and Agile mindset.

This includes user research, experience desirability and delighters, business model analysis, and feasibility studies such as production processes, proving the main concepts, and sustainability research. Some high-level solution components are identified for the main risks, such as technology families, design patterns, target geographies, supply chain constraints, etc.
This is also where the shift-left paradigm should start in earnest, aiming to model and simulate the riskiest aspects of the endeavor.

The form and function of the connected product and ecosystem can be expected to evolve significantly as the analyses iteratively progress.

Stage 3 is where one or more prototypes are created to provide an initial representation of the product's physical and digital dimensions.
The main purpose of this phase is to refine all aspects of the connected product experience with later prototypes designed to be mostly representative and functional.

By the end of Stage 3, the core **specifications** for the Minimum Viable Product (MVP) or Minimum Lovable Product (MLP) are delivered.

This may be a lengthy stage if prototype feedback is sought from customers or if a regulatory sign-off is required; accordingly, the form and function of the connected product and ecosystem may continue to drastically evolve throughout this stage until the MVP or MLP specifications are finalized.

Additionally, there may be multiple iteration between stages 2 and 3, for example if the prototype feedback requires new proofs-of-concept or profound design changes.

At this stage, simulation models should be as integrated as possible to extend and accelerate validation, and to cover the relevant areas, such as evidence of regulation compliance, production processes, and multidisciplinary design.

Stage 4 typically covers three important workstreams:

- developing the digital components,
- establishing the ecosystem, and
- maturing the physical device.

The prototype's digital components of the previous stage are typically not production grade, so the main digital components start to be developed in this stage in an Agile manner. Similarly, enterprise transformation, ecosystem process change management and partnership agreements are initiated. Additionally, the physical device needs to mature through the Engineering Validation Test and Design Validation Test activities.

Agency certifications are typically obtained at this stage, so the design validation samples must be representative of the final design, typically covering both physical and digital components. Regular feedback from target users and internal stakeholders on all aspects of the ecosystem should continue to be sought as per standard Agile practices, though many physical characteristics are set.

This stage can become significantly more Agile through advanced simulation techniques such as intelligent & adaptive testing to speed a validation cycle and forecasting how much validation can be simulated versus requiring a physical build.

Stage 5 is about preparing for launch: the development of the main digital components gets completed, the physical device matures through production validation tests to verify the mass production yields at mass production speeds, and the market launch preparation activities are carried out following Agile practices where possible. Any additional manufacturing tools required to support early device volumes ramp-up are also validated and qualified.

Agency approvals requiring validation of production processes are usually obtained at this stage. Stage 5 typically requires some extent of physical validation with the corresponding sequenced waterfall steps that carry the accompanying lack of flexibility and risk of expensive corrections. This is why the aim of the shift-left paradigm, multidisciplinary design, and model-based system engineering approach is to minimize the scope and duration of the waterfall steps.

Upon completion of Stage 5, the MVP or MLP is launched.

Stage 6 is where Product Management operations activities begin to support, service, and enhance the ecosystem experience, for example by releasing new digital features, deploying security firmware patches, and adding new partners, product lines, and services to the ecosystem.

MINIMIZING THE RISKS OF CONNECTED PRODUCT DEVELOPMENT WITH A BIMODAL APPROACH

How far towards the goal of Agile and virtualized connected product development a company can move depends on its existing capabilities and desired target market positioning:

- Shifting left the ecosystem design, production processes, and validation activities through virtualization requires time and model-based investment.
- A maturation roadmap should be established, taking into account the current product development capabilities, and defining incremental improvements.

Accordingly, it is beneficial to document the current typical connected product development journey, and gradually enhance the multi-disciplinary, shift-left, and virtualization capabilities until the desired time-to-market and cashflow targets are met.

Typical bimodal connected product development lifecycle - Leveraging Waterfall And Agile

Key:

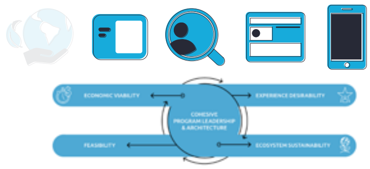
- Sustainability (with progressive refinement)
- Digital backend / analytics (with progressive refinement)
- Business model / investment case (with progressive refinement)
- Mobile app (with progressive refinement)
- User research and market landscape (with progressive refinement)
- Physical device (with progressive refinement)
- Iterative
- Milestone
- Waterfall steps

Vision

Stage 1 – Analysis & proof-of-concepts

- Assess the opportunity and identify impactful, novel, and cohesive concepts to achieve significant ROI.

"Conceptual"

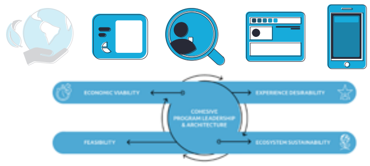


Gate #1 Ready for deep dive

Stage 2 – Concept Analysis, Deep-Dives, proofs-of-concept, Planning

- Analyze concepts to assess customer perception, create an initial investment case, and de-risk feasibility with proof-of-concept(s).

"Logical"



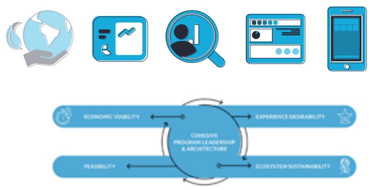
Gate #2 Ready for prototyping

There may be multiple iteration between stages 2 and 3

Stage 3 – Prototype(s), Market Validation, Specs of Minimal Viable / Lovable Product

- Demonstrate a first largely representative and mostly functional form of the connected ecosystem.
- Validate customer perception and specify the MVP / MLP specifications. Shift validation left.

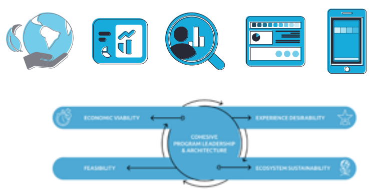
"Physical"



Gate #3 MVP / MLP **Defined** Ready for validation

Stage 4 – Ecosystem & Digital Development, Device Validation & Certification

- Initiate other ecosystem components development: digital experience, partnerships, business process change, etc.
- Refine and validate the selected production-worthy design, platform(s), supply chain, and assembly (EVT & DVT).
- Obtain required certifications.

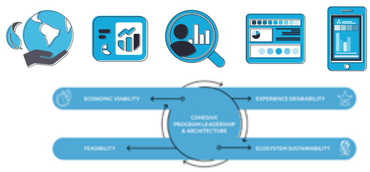


Gate #4 Ready for manufacturing & scaling

Waterfall physical product validation and manufacturing scaling steps take place in stages 4 and 5

Stage 5 – Market Launch Preparation, Ecosystem Completion, Production Line Validation

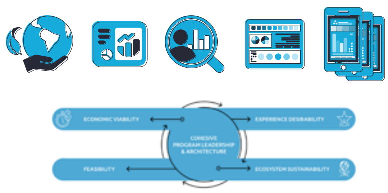
- Establish market launch plan. Complete the digital and ecosystem components development.
- Verify mass production yields at mass production speeds.



MVP / MLP Launch

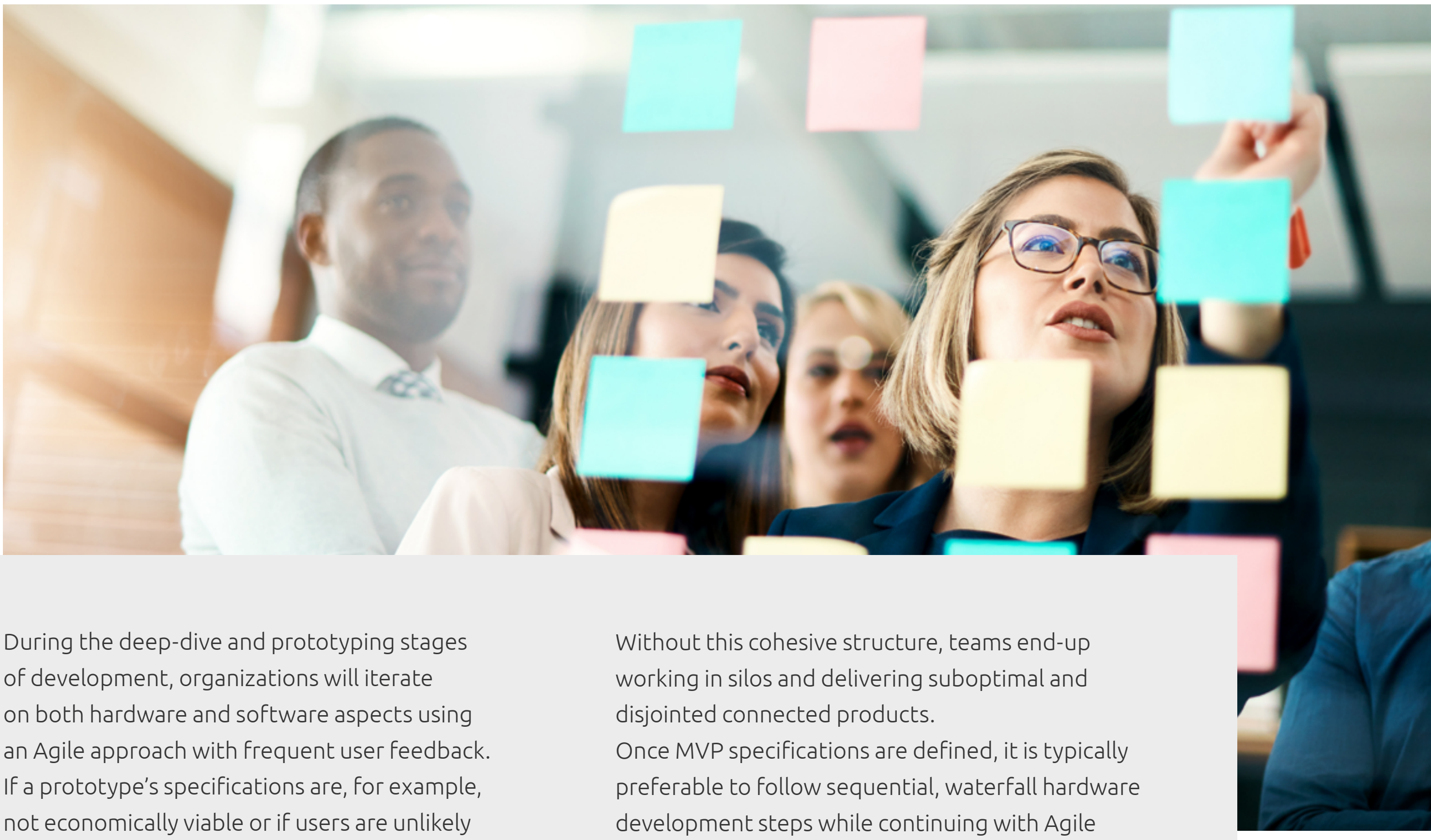
Stage 6 – Commercialization, Operations & Support, Next Generation

- Operate ecosystem, optimize through analytics and voice of the customer.
- Plan for next generation



Time

Next Generation Initiation



During the deep-dive and prototyping stages of development, organizations will iterate on both hardware and software aspects using an Agile approach with frequent user feedback. If a prototype's specifications are, for example, not economically viable or if users are unlikely to buy the product, then organizations may need to pivot and reposition the product to better align with the strategic targets by iterating back to Stage 2 for new proof-of-concepts.

Additionally, advances in manufacturing processes, sustainability drivers, supply chain constraints, network bandwidth, artificial intelligence, and embedded software dependencies are significantly increasing the complexity of connected product development journeys and therefore impose the need for enhanced agility.

These development stages need to leverage the relevant world-class methods and disciplines across the desirability, viability, feasibility, and sustainability perspectives. These methods typically include: business model canvas, customer concept testing, qualitative & quantitative interviews, multi-disciplinary model-based system engineering & simulation, digital twin, digital continuity, and more recently, augmented and virtual reality. **Crucially, to optimize cashflow and time-to-market of a connected product program, all these methods and disciplines need to be orchestrated by a cohesive architecture and program management structure.**

Without this cohesive structure, teams end-up working in silos and delivering suboptimal and disjointed connected products.
Once MVP specifications are defined, it is typically preferable to follow sequential, waterfall hardware development steps while continuing with Agile development for the digital experience and other ecosystem features. The hardware development will naturally need to shift from Agile development to a waterfall model as it goes through the scaling steps of engineering, design, and production validation that may come with expensive tooling, regulatory certifications, and long lead times.

Shifting-left the simulation of production processes, validations, and operation activities further increases overall agility and significantly accelerates the waterfall steps mentioned.

Consequently, organizations that plan on developing many product lines should gradually mature their computer simulations and validation capabilities to meet the desired agility and performance targets.

Changing the physical product design in later stages is both expensive and time-consuming. Mobile apps, backend software, and user presentation can continue evolving in an Agile fashion, but not the layers of the embedded software that are tightly coupled with the physical components on the hardware device.

Companies that don't yet have mature computer simulation and validation capabilities should increase the volumes of validation devices built in progressive steps. This allows for the gradual alignment of the device's design with supply chain constraints, manufacturing costs, regulatory requirements, and with refinements of the connected product specifications.
These steps are as follows:

- engineering validation test builds (EVT)
- design validation test builds (DVT)
- production validation test builds (PVT)

The quantities of devices built typically range from less than a dozen to several hundred at EVT, from 50 to 2,000 at DVT, and from 100 to 20,000 at PVT.

In addition to increased costs, each validation step typically adds several months to the development schedule, and, if repeated, can be extremely costly to the program.

Agency certifications are also often required during the development process. For example, medical devices require FDA certification which can take more than a year to obtain. A new certification is needed every time there is a change in the physical design that could affect the medical function adding one to two years to the development time, not to mention the cost of each medical certification, which can add up to several million dollars.

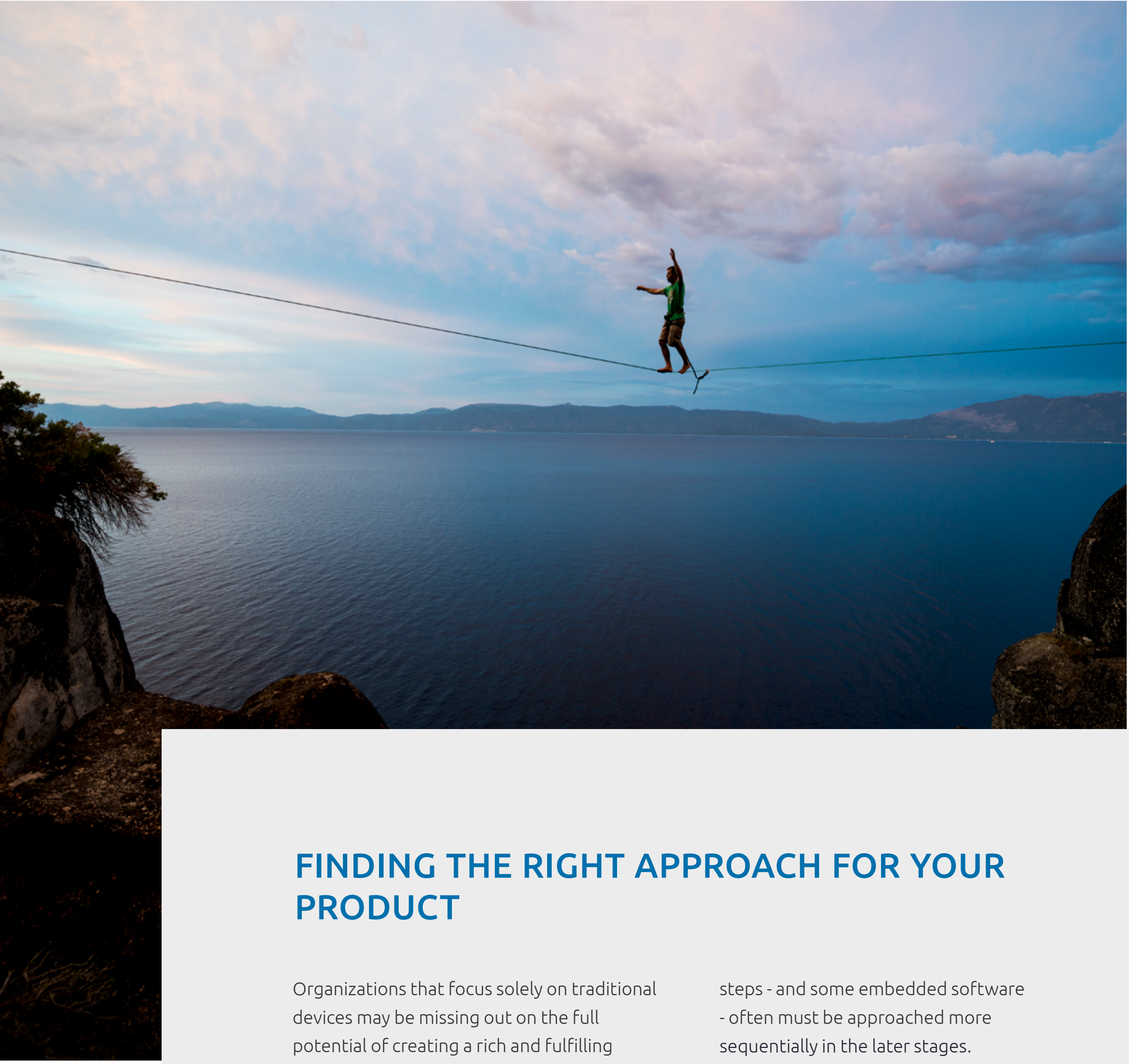
There may be other certifications required such as an electrical or RF certification that need to be re-evaluated every time the corresponding subsystems are changed. Finally, there is a growing requirement for cybersecurity certifications; for example, the EU Cyber Resilience Act is expected to require connected product developers to provide cybersecurity labeling for consumer devices within the near future.

Once development progresses to the product validation and manufacturing support phase, tooling for mass production of the physical device is created, which typically takes multiple months. The investment costs for tooling can quickly be counted in millions of dollars, depending on the product being developed. If there is a notable change altering the physical body of the device or tooling requirement, it will extend the tooling time and bring additional costs potentially in the millions. In a worst-case scenario, entirely new tools may need to be cut. Continuously making changes to the physical device or design incurs extreme costs, delays the time to market, and potentially negates the organization's objectives.

Should problems arise in the product after it has shipped, the result may be costly recalls, or worse yet, fines and injunctive relief.

All these cumulative development risks are best managed through multi-disciplinary simulation models and careful reviews at each progressive step (e.g., the end of EVT) before transitioning to the next development phase (e.g., DVT) where new investments are incurred.

Investing in a shift-left paradigm, with multidisciplinary design and model-based system engineering decreases the probability and impact of these late and cumulative development risks.



FINDING THE RIGHT APPROACH FOR YOUR PRODUCT

Organizations that focus solely on traditional devices may be missing out on the full potential of creating a rich and fulfilling customer experience –and on the potential upsells and adjacent revenues from close customer relationships. Properly positioning the connected product within the relevant user context is essential to unlocking the benefits of ecosystems. This creates greater value, services, and opportunities for new products that can enhance the user experience desirability.

To find the optimal balance between the desirability, viability, feasibility, and sustainability perspectives, a bimodal development approach works best: all the ecosystem components should be developed in an Agile manner in the first stages, but some physical scaling steps - and some embedded software - often must be approached more sequentially in the later stages.

Further agility can be obtained through shifting-left the simulation of production processes, validations, and operation activities - though that requires a gradual maturation of capabilities.

Capgemini is an experienced partner that guides organizations through end-to-end product development. An important part of this journey is establishing how to position the product and understanding the product ecosystem. This is the way to build stronger customer relationships with products that provide real value.

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Capgemini is a global leader in partnering with companies to transform and manage their business by harnessing the power of technology. The Group is guided every day by its purpose of unleashing human energy through technology for an inclusive and sustainable future. It is a responsible and diverse organization of over 360,000 team members in more than 50 countries. With its strong 55-year heritage and deep industry expertise, Capgemini is trusted by its clients to address the entire breadth of their business needs, from strategy and design to operations, fueled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering, and platforms. The Group reported 2022 global revenues of €22 billion.

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