
# CASE STUDY

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## The Challenge

In the fast-paced world of engineering, taking a concept from an early idea to full-scale production is a notoriously resource-heavy journey. Traditionally, much of this friction is centered around prototyping. Design projects often require tens or hundreds of physical models, which places immense pressure on resources, decreases efficiency, and generates significant waste. For complex products, final-stage prototypes can easily cost upwards of £100,000.

But the challenges extend far beyond just modelling the product itself. Planning factory layouts, testing user ergonomics, and reviewing complex spatial assemblies are equally fraught with communication breakdowns. Because standard digital tools (like flat CAD screens) lack physical scale, and physical mock-ups lack dynamic analytics, stakeholders often struggle to fully conceptualise a design or space. This disconnect obscures the impact of changes, leading to inefficient decisions and costly refinement loops.

Crucially, up to 80% of a product's production cost – ranging across design, testing, and fabrication - is locked in during these early design and planning phases. The manufacturing sector desperately needs smarter, streamlined toolchains that bridge the gap between digital simulation and physical reality across the entire workflow. To make efficient decisions, engineers need tools that support intuitive spatial understanding, whether they are designing a handheld product or laying out a multi-million-pound factory floor.

**Innovation**
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# Innovation

To solve the prototyping bottleneck, we didn't just build a single application; we developed a comprehensive, versatile portfolio of over nine distinct Extended Reality (XR) systems. Moving far beyond the capabilities of standard commercial software, our innovation lies in the sheer breadth of the toolset, proving that XR can seamlessly support almost every stage of the technical engineering lifecycle.
Rather than focusing on one niche, we created an end-to-end ecosystem that bridges the physical and digital worlds across a wide variety of tasks:
**Ideation & Geometric Design:** Tools that allow engineers to model spatially in 3D directly within their physical environment, complete with real-time CAD streaming.
**Design Review & Collaboration**: Immersive environments where teams can interrogate complex assemblies using 3D sectioning, spatial sketching, and audio annotations tied directly to physical geometries.
Spatial & Factory Planning: Environment capture tools that instantly digitise a room, allowing teams to rearrange heavy machinery and run real-time production flow simulations and safety checks.
**Human-Centric Testing**: Interface design and user-capture systems that track a technician's hand movements without external sensors, capturing precisely how they interact with hybrid physical-digital prototypes.
**Interactive Analysis:** Workspaces where users physically manipulate components and instantly see real-time kinematic, dynamic, or fluid simulation feedback.
By building this expansive suite of tools, we transformed XR from a standalone visual gimmick into a holistic, deeply integrated engineering toolchain. We successfully embedded advanced lifecycle analytics directly into intuitive prototyping activities, allowing designers of all expertise levels to physically feel, digitally test, and instantly iterate upon their ideas in real time.

# Result

To rigorously test this expansive XR ecosystem, we took it out of the lab and into the hands of industry professionals. We hosted an intensive workshop in Bristol, where 16 technical personnel from across the engineering sector spent over an hour interacting with the full suite of tools. They evaluated the systems against their current workflows to see where this technology could replace or enhance their traditional methods.
The results were overwhelmingly positive: the value of XR extends far across the entire design and production spectrum. Industry practitioners confirmed that the systems provided significant value that far exceeded any perceived adoption costs, offering capabilities simply unavailable in their current toolsets.
Importantly, users responded to the breadth of the portfolio. User-tracking and mixed-reality prototyping systems were highlighted as seamlessly aligning with physical engineering processes, while the spatial visualisation and design review tools were praised for drastically improving cross-team communication and accelerating decision-making.
Because the tools are built around human-centric workflows, they proved highly intuitive. Participants noted low mental and physical fatigue, and high cross-discipline accessibility. Our research definitively proved that a comprehensive XR ecosystem is not a futuristic novelty—it is a highly practical, usable upgrade that reduces design risk, increases efficiency, and is ready to be integrated into the daily tasks of modern engineers.

# Impact

The "so what" of this project is a fundamental shift in how the engineering and manufacturing sectors can operate. By adopting this broad suite of XR technologies, companies stand to radically optimise their entire development lifecycle. This goes far beyond saving £100,000+ and reducing material waste on physical prototypes; it means optimising factory floors before a single heavy machine is moved, and capturing human processes in real-time to eliminate manufacturing errors.
Because 80% of a product's lifecycle impact is decided early on, empowering teams to make faster, more informed spatial decisions will result in significantly more sustainable products and highly efficient production lines. The capabilities demonstrated in this project are not currently available in commercial software, giving early adopters a unique, cutting-edge advantage.
The commercial potential has already generated significant momentum. This work has sparked peer-reviewed publications at international design conferences and is directly informing over £3 million in ongoing grant applications. Furthermore, it has catalysed real-world industrial partnerships. We are actively fostering connections with major industry players, and are planning a Knowledge Transfer Partnership (KTP) to implement these XR tools directly into a commercial enterprise.
Ultimately, this research accelerates the R&D cycle. By placing the human back at the centre of the design and planning process—armed with real-time analytics and interactive mixed reality—we are paving the way for a faster, greener, and more collaborative future for global manufacturing.

# AMRC (Part of HVM Catapult)

"This project was an excellent opportunity to collaborate with Chris and his team on an exciting and industry relevant challenge. This research has identified opportunities to improve the way that design and innovation is approached by industry, and to improve accessibility to these novel workflows. These technologies need close collaboration between academia, developers, researchers, and industry if they are to reach their maximum potential. This project has been a catalyst for fostering this collaboration between the AMRC and Bristol Design Futures Lab, and we look forward to what future collaborations between our teams can achieve." - **Sam Hyde, Technical Fellow at AMRC.**

# Ketan Pancholi

"This project has created a credible route towards lighter, safer and longer-lasting cryogenic hydrogen components for transport decarbonisation. Working with NCC UK has been instrumental in providing access to facilities, industrial networks and translational expertise that have helped move the research beyond the laboratory and towards commercial relevance. The collaboration has strengthened the pathway from academic materials innovation to practical hydrogen applications."

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