

Building Confidence in Human-centred Rail Design

Using flexible digital mannequins to reduce uncertainty, test real user needs and manage design risk in complex projects



Figure 1: DCA has developed the EVERYBODY digital mannequin system – customisable 3D models designed to represent a wider range of real human body types and more realistic movement.

Good ergonomic design is often invisible when done well, but it is fundamental to safe, comfortable, and efficient use of a product or service. In the rail industry, detailed standards precisely define important dimensions and features in passenger areas and the cab, but there is far less prescriptive guidance available for areas accessed by the crew. When designing catering facilities, crew control points and maintenance areas, designers and human factors specialists need to develop their own design specifications from first principles.

Where there is no prescribed dimensional requirement to work to, the question becomes whether a real person can complete the task safely and confidently: connecting a large high-voltage shore supply cable while reaching into a maintenance area; operating a pneumatic isolation valve under an access

skirt; or manoeuvring an atlas cart into a confined galley.

Physical mock-ups and testing with real users are invaluable and remain an important part of the process.

There is also huge value in explicitly considering the human 'fit' earlier in the design process, but to do this, human interactions often need to be represented digitally. This can be complex, as people not only vary in shape and size, but also move in nuanced ways that many traditional design tools cannot fully represent.

To address this, DCA has developed a system of digital mannequins known as EVERYBODY. These customisable 3D models are designed to represent a wider range of real human body types and more realistic movement, allowing ergonomic considerations to be brought more directly and earlier into the design process.

When the detail starts to matter

Ergonomic assessment is most valuable when the answer is not obvious. If a task is clearly achievable, or clearly not, in-depth analysis is not usually necessary. Ergonomic models tend to be used for the cases which are closer to the boundary, where small differences in posture, body position, or available clearance can affect whether a task can be completed safely. Many existing models are by necessity based on simplified biomechanics and standardised body dimensions. These form a valuable foundation and support compliance with regulations and technical specifications, but they often lead to conservative assumptions in borderline cases.

This is where a more precise representation of human movement can help narrow the uncertainty. A person may be able to reach further by twisting through the trunk or raising the shoulder, but this is difficult to account for accurately using simplified reach envelopes. In a tightly constrained equipment bay or underframe access area, for example, the position of a large high-voltage shore supply connection may already be shaped by surrounding equipment (such as the couplers), reliability requirements (such as prevention of dust ingress), structural interfaces and cable routing. Where there is limited scope to reposition the connector without compromising other requirements, a more detailed digital assessment can help show whether the task can be completed safely and assess whether the ergonomic risk has been reduced as far as reasonably practicable.

The EVERYBODY mannequins support this more nuanced approach by allowing designers to explore more realistic postures and movements within the CAD environment. They can show how a user might position themselves, including subtleties of trunk and shoulder movements, to handle a stiff cable in the available space. This gives teams a more detailed basis for judging whether a design is workable, especially where the task is close to the limit of what is practical.

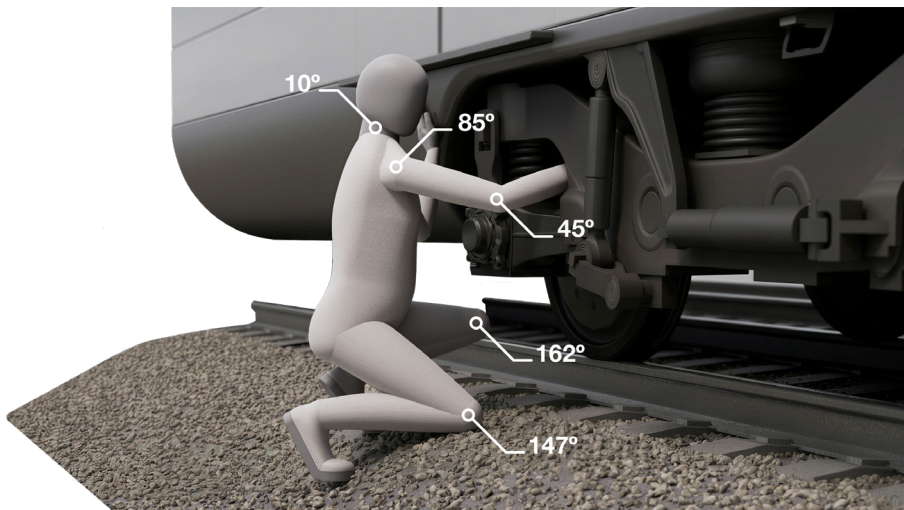


Figure 2: A male digital mannequin with 95th percentile stature (i.e. height) and 50th percentile build (i.e. torso depth; hip breadth), from 2020 British data, inspecting a bogie.

Alongside realistic movement, the system can also account for a wider range of body shapes and more recent anthropometric data. This is useful in compact staff areas such as galleys, where small differences in stature or build can affect reach and manoeuvring space. For example, it may help identify which atlas cart bays are easiest to access with heavier or more frequently used carts, whether the swing of a door restricts movement, or whether the position of equipment such as a coffee machine is likely to cause avoidable difficulty in day-to-day use. In these cases, a relatively simple change can make a noticeable difference to comfort, efficiency, and day-to-day usability.

Bringing ergonomics into the design process

One of the more practical advantages of this mannequin-based system is how it fits into existing workflows. The mannequins sit directly within the same CAD environment as the product or vehicle being designed, which means ergonomics can be considered

constantly as the design develops, rather than as a separate step. This is particularly useful in rail projects, where space constraints are often tight and multiple requirements need to be balanced.

Because the models are easy to position and adjust, they can be used repeatedly throughout a project. Designers can compare different options, revisit earlier decisions, and explore alternatives without needing to step outside the design environment.

Supporting clearer decisions

A recurring challenge in rail design projects is that different stakeholders, such as passenger representatives, operating crew, maintenance technicians and manufacturers, all have their own priorities and may, therefore, have different views on which solutions work best.

Tools like the EVERYBODY mannequins help make these discussions more evidence-based and rational. Instead of relying purely on subjective judgement, teams can look at how a design performs for specific tasks and

user groups. This is especially useful where the design is close to a go/no-go decision, or where a simplified assessment would have to be deliberately conservative.

This does not remove disagreement entirely, but it does tend to make conversations more focused. It becomes easier to explain why a particular task is considered achievable, where the remaining risks reside and whether a design change would materially improve the outcome.

A balance of digital and physical methods

DCA continues to use a mix of tools and methods, including Rapid Entire Body Assessments (REBA) and reach assessments (using both 2D and 3D data), ergonomic rigs, virtual reality (VR) models, and fully representative mock-ups, each suited to different stages of a project, and always testing with real users where possible.

The addition of flexible 3D mannequins makes it easier to explore human movement earlier and in more detail. By representing posture, reach, shoulder movement, and trunk twisting more precisely, digital assessments can move closer to the kind of task insight that would traditionally only come from practical assessment with a physical mock-up. They can also be used with different body types and statures, allowing options to be compared for a broader range of users before physical testing begins.

This can make later mock-ups more focused. Rather than using them to explore every possible issue for the first time, project teams can use them to confirm and refine decisions that have already been assessed digitally.

Validating design decisions by representing real movement

Established standards and regulations provide the baseline for safe, accessible, and compliant rail design. They are essential, but they do not cover everything. Where prescriptive guidance does not exist, ergonomics need to be assessed from first principles.

By representing realistic movement and current anthropometric data within the CAD design environment, tools like the EVERYBODY mannequins can give project teams clearer evidence about how real tasks are likely to be carried out. That evidence helps reduce uncertainty, avoid unnecessary redesign, lend focus to practical rig and mock-up assessments, and support better decisions for the people using, operating, and maintaining the various elements of a rail system. 

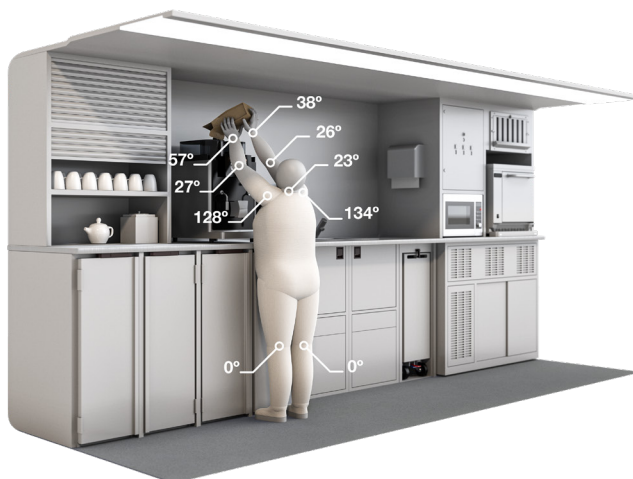


Figure 3: A female digital mannequin with 5th percentile stature (i.e. height) and 95th percentile build (i.e. torso depth; hip breadth), from 2020 British data, refilling a coffee machine in a train galley.

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