How to proactively incorporate human factors into your product designs

With Creo® Elements/Pro® Manikin Extension, engineers can quickly, easily and cost-effectively test designs for human factors—at an early stage in the design process, when it is simpler and less expensive to make changes that improve usability. These best practices will help users get started.

In today’s discerning marketplace, health, safety, comfort and productivity are seemingly unrelated but critical goals for new product designs. Whether developing safe toys for children, easy-to-maintain machinery, furniture to promote correct posture, or highly productive interfaces, ergonomic factors play a critical role in every successful new product. Today’s leading manufacturers know the importance of integrating ergonomic effectiveness practices throughout the design process, rather than at the very last phase of design, or at the prototype stage.

Human Factors specialists typically perform this analysis using complex, expensive, and stand-alone software. This disjointed process can lead to product development delays, multiple design iterations, and expensive rework before designers can achieve a good product design that optimally accommodates the target audience for their product. Enter Creo Elements/Pro Manikin Extension.

Creo Elements/Pro Manikin Extension is a comprehensive, 3D digital human modeling solution that is seamlessly integrated into Creo Elements/Pro, the industry-standard 3D CAD (computer-aided design) software. Creo Elements/Pro Manikin Extension allows engineers and designers to proactively incorporate human factors into their designs. Instead of waiting until the end of the design phase, ergonomics can now be evaluated much earlier in the design process, when it is simpler and cheaper to make corrections. As early as the conception phase, designers can ensure that products meet customer requirements, are comfortable and safe to use by the targeted population, and possess a competitive advantage. Creo Elements/Pro Manikin Extension provides a user-friendly interface, along with features that non-specialists can use without training.

This article describes Creo Elements/Pro Manikin Extension’s capabilities, and furnishes some best practices to help designers achieve the maximum benefits from incorporating human factors into their designs.
How does Creo Elements/Pro Manikin Extension work?

Creo Elements/Pro Manikin Extension enables engineers/designers to integrate a 3D digital model of a human being, called a manikin, inside their CAD environment, and make the manikin interact with the 3D product model. The manikin provides an accurate representation of human physical characteristics, such as size, shape, vision, movement, strength and comfort. By placing a manikin in their design, engineers/designers can visualize and optimize how a human uses the product.

For example, engineers/designers can see what the manikin can see and reach, as well as determine clearance when the manikin is sitting, standing, kneeling, using a joystick, pressing a button on a dashboard, and so on. Creo Elements/Pro’s comprehensive Manikin library allows engineers and designers to test their designs using manikins of different genders, shapes—and even nationalities.

On top of the core Creo Elements/Pro Manikin Extension functionalities, engineers/designers can add the Creo Elements/Pro Manikin Analysis Extension for additional analysis. This add-on module adds a set of analysis algorithms that enable more advanced assessments of human-product-workplace interactions, such as manual handling, workplace layout, and repetitive movements. With this advanced tool, engineers/designers can easily perform more comprehensive investigations into lifting, carrying, handling, and pushing, so designers can answer challenging questions such as: “What is the recommended weight someone should lift in a particular posture?”

Engineers/designers, as well as Human Factors experts, can also validate their designs against a number of quantitative Human Factors and workplace standards and guidelines, including lifting and lowering (NIOSH 91, Snook), pulling and pushing (Snook), carrying (Snook) and posture (RULA).

Unlike third-party systems that require designers to constantly export product design data from their CAD system and import it into a separate human modeling system, Creo Elements/Pro Manikin Extension is completely integrated into the Creo Elements/Pro solution. The manikin has been built entirely inside Creo Elements/Pro and is considered a pure Creo Elements/Pro assembly. Engineers/designers can therefore leverage all existing Creo Elements/Pro tools and the familiar user interface, significantly improving the efficiency of Human Factors analysis.
What is Creo Elements/Pro Manikin Extension used for?

Engineers and designers can use Creo Elements/Pro Manikin Extension to improve Human Factors in the design of any type of product that humans interact with—no matter how simple or complex—from the cockpit of an aircraft, to the passenger section of a helicopter, to a workstation, a simple picnic table, and much more.

When used in cockpit design, for example, Creo Elements/Pro Manikin Extension can help engineers/designers discern which controls the pilot can see, whether something is obstructing the view, which controls pilots of different sizes can reach, and how easy the controls are to manipulate to their full motion. When working on a tractor design, engineers might use Creo Elements/Pro Manikin Extension to determine how easy it is for the driver to reach the pedals or to turn the steering wheel.

Engineers and designers can also perform similar evaluations to ensure that their designs are easy to maintain. For example, they can validate that the driver of a vehicle can reach, detach and easily replace defective components, without having to dismantle the entire vehicle. They can also verify that all target users can easily see damaged parts, as well as access them and apply sufficient force to remove the defective component. The manikin can also validate different scenarios, such as an operator working with bare hands or using different hand tools.

A new role for human factors experts

Historically, standard ergonomic/human factors testing tools have been designed primarily for specialists. With Creo Elements/Pro Manikin Extension, however, product designers can assume more of this ergonomic testing themselves.

In large organizations that employ the Creo Elements/Pro Manikin Extension, ergonomic experts can play a more strategic role in the design process. Ergonomic experts can establish ergonomic testing guidelines while giving product engineers and designers the day-to-day responsibility of applying these guidelines to their designs. As a result, ergonomic experts have more time to perform more critical or advanced analysis, and investigate specific cases where designers have raised a potential issue.
Best practices for using Creo Elements/Pro Manikin Extension software

The following four best practices will help organizations make the most of Creo Elements/Pro Manikin and Manikin Analysis Extension software in testing the ergonomic aspects of their designs:

Build a task once, then test that task using multiple manikins

When using Creo Elements/Pro Manikin Extension, users should start with a script that details who will use the product and how they will use it. The script should include a set of activities that take into account customer specifications.

For example, if a designer is testing a car for drivability, the designer might direct the manikin to reach the steering wheel, turn the steering wheel in all directions, reach all the controls on the dashboard, reach the pedals, press the pedals using their full range of motion, and so on. The script should also include tasks that are not typically tested, such as reaching the seat adjustment handle, adjusting the mirror and looking backward, and lifting/tilting the bucket seat. Also included should be common maintenance tasks, such as changing the oil, refilling the windshield wiper fluid, and reaching/tilting the spare tire.

After engineers/designers have built these tasks once, using snapshots and constraints, they can save the script file. Next, they can use the software’s Replace function to enable multiple manikins to go through the same script and validate these tasks, proceeding from the smallest person to the tallest person in the target population. Designers can also use manikins from a foreign country to validate extreme situations. For example, when you design a car for North America, the same car will probably be used in China as well, so you need to have the information of the Chinese population and be able to test. This will increase the designer’s ability to detect problems and ensure that the design accommodates the entire target population.

Combine Creo Elements/Pro applications to fully test the ergonomics of your design

Engineers/designers performing ergonomic testing can improve the power and flexibility of the Creo Elements/Pro Manikin Extension tool by combining it with other capabilities within Creo Elements/Pro. For example, Creo Elements/Pro Manikin Extension allows engineers/designers to place 3D human models into product designs in a series of static posture “snapshots” that might include sitting, standing, kneeling, and so on.

Engineers/designers can augment these capabilities by using Creo Elements/Pro’s animation tool to create animations of the manikin performing a workflow. These animations can be helpful in evaluating how easy it is for a person to perform a series of tasks, such as lifting a box and placing it on a conveyor belt, or removing a defective part from an engine bay.
Designers can even combine animations or their manikin with the Creo Elements/Pro motion envelope to determine the full amount of free space the design will require to allow the manikin to complete the entire motion. For example, if engineers/designers want to test a design for the interior of a car door, they can create an animation where the manikin reaches and activates the handle to raise or lower the window. The volume envelope demonstrates where the manikin’s elbow will go. This helps determine whether any adjustments to the door design are necessary to eliminate clashes between the elbow and the door controls. If a part is being made by a subcontractor, the designer can even generate a part that can be sent to the provider so he or she can make the proper change even without the manikin.

**Take advantage of vision capabilities**

Engineers/designers can use the manikin’s vision capabilities to determine what a person using their design can actually see. For example, by determining what a manikin sees when it looks at a dashboard, engineers can instantly determine whether a person’s view of a key control on the dashboard is being blocked by the steering wheel. Similarly, engineers/designers can determine whether the manikin can see a small part in a confined location in the engine bay. With this information, engineers can quickly correct the problem.

Engineers/designers can also take advantage of Creo Elements/Pro’s mirror reflection capability to determine what a manikin can see while looking into a mirror, such as in the example at right, which shows what an operator of agricultural machinery can see in the mirror. The designer can also determine whether the manikin could use a mirror to see a small remote part in an industrial engine bay.

**Take advantage of accurate data to fix designs**

Manufacturers of complex products, such as aircraft or industrial vehicles, use subcontractors to create many of the parts that comprise an assembled product. The person creating these parts may not be completely aware of the design of complementary parts. For example, a person designing a dashboard may not be fully aware of the geometry and the configuration of the steering wheel. In the past, if there was a Human Factors problem caused by the interaction of the two parts (e.g., the steering wheel might obscure critical controls on the dashboard), the manufacturer might have been quite far along in the product development process before the issue could be identified. At that point, it would be too late or too costly to correct the problem.

Today, Creo Elements/Pro Manikin Extension enables the manufacturing company in our example to give the subcontractor the concrete information they need to make accurate corrections. Creo Elements/Pro Manikin Extension’s vision cones enable engineers to see what the manikin can or cannot see. If the manikin is sitting in an industrial vehicle cockpit, the
designer can use the vision cone to determine which parts of the dashboard would be blocked by the steering wheel. A "clash line" marks any areas of the dashboard that the manikin cannot see.

The manufacturer can then share this exact information with the dashboard designer by sending him/her not only a note or an image of the steering wheel, but also accurate data (i.e., a part) for the clash line that represents the exact location where the display and components must be located on the dashboard design. The Human Factors expert at the manufacturer could then instruct the dashboard designer to avoid placing any important controls in the area obscured by the steering wheel (as illustrated by the clash line). This collaboration optimizes the overall process and minimizes the impact of any design changes.

Conclusion

With Creo Elements/Pro Manikin Extension, a larger audience of Creo Elements/Pro designers can now evaluate the Human Factors of their designs, quickly and effectively, at an early stage in the design process, without having to export their designs and import them into another package. This seamless integration allows designers to improve their overall efficiency by incorporating Human Factors at a very early stage in their designs, so they can find and fix any problems early on, when it is much easier, faster, and less expensive. Also, Creo Elements/Pro Manikin Extension allows multiple members of the design team to more efficiently share information about potential design issues.

About Creo Elements/Pro Manikin Extension

Creo Elements/Pro Manikin Extension and Creo Elements/Pro Manikin Analysis Extension were released in December 2008. In addition to these Human Factors solutions, basic manikin capabilities are also included in all Creo Elements/Pro packages, beginning with Pro/ENGINEER Wildfire® 4.0 M060 and later releases. Currently, available Creo Elements/Pro Manikin Extension populations include Japanese, American, Chinese, Italian, and Dutch, with a Korean population in the works. Custom populations are also available to be developed as a service activity by PTC.”