Using Virtual Operator-in-the-Loop Analysis to Avoid Market Rejection at the Earliest Stages of Cab Design

Problem

Currently, design processes are front-loaded with traditional engineering efforts that include Finite Element Analysis (FEA), Computational Fluid Mechanics (CFM), Multi-Body Dynamics (MBD), and others. These technologies are most valuable at the earliest stages of design. They can significantly reduce the need for physical prototypes, which would otherwise be needed in trial-and-error approaches to ensure requirements for structural integrity, aerodynamics, thermodynamics, and the behavior of mechanical systems under the influence of internal and external forces.

However, none of these technologies consider the operator of the product. In fact, current design processes largely developed during WWII are not able to consider the human-in-the-loop until after a design exists. By this time in any product's design cycle, change is no longer a realistic option. This leads to a "design by committee" approach with an inherent fear to change what has been done in the past—an approach that guarantees any existing human-centric issues will be baked into every new design going forward.

Not only are the operators—who use the products and therefore ultimately determine whether the products will succeed in the market—effectively treated as the least important design criteria, trial-and-error approaches to product development can cost manufacturers hundreds of thousands of dollars in reworking designs and prototypes. In addition, poor equipment design can result in injury to operators, costing U.S. companies up to $170 billion per year. [SOURCE: OSHA] Poor cab design can increase operators' exposure to the risk of injury.

No manufacturer wants a cab design to be difficult to use or potentially hazardous for the operator. No one wants users of their product to complain about poor design or reject their brand. However, outdated manufacturing processes and a lack of access to software that has the capability of analyzing, evaluating and predicting human-in-the-loop (HITL) systems have prevented equipment manufacturers from avoiding exposure to liability and redesigns that cut into profits.

Instead, what if:

- We could get the cab design right before we create prototypes?
- We could predict human behavior and physical performance in the early design phase?
- We could avoid compromises on cab design due to HITL issues being discovered far too late in the process to make changes?

Through software developed to simulate and predict human performance for the U.S. Department of Defense, we can achieve all of the objectives above, and more. The move toward a human-centric virtual cab design process will benefit equipment manufacturers.

Solution

Through an extensive digital human modeling environment that has been used to accurately predict many aspects of human performance, Santos technologies can be used to improve and optimize cab designs. Unlike other human modeling software, this virtual human simulation technology **predicts** human behavior and performance. Because it is proactive, it can provide operator-centric evaluations that can inform and support human-centric design decisions at the earliest stages of product development where change is both more effective and less costly.

When designing a cab for human-operated equipment, the manufacturer can evaluate the cab controls as a system of systems while considering human strength, fatigue, flexibility, balance, vision, external forces and environmental conditions. This provides manufacturers with a powerful, feature-rich and flexible environment for human-centric evaluations of products early in the design stage, which leads to better designs that can be brought to market sooner.

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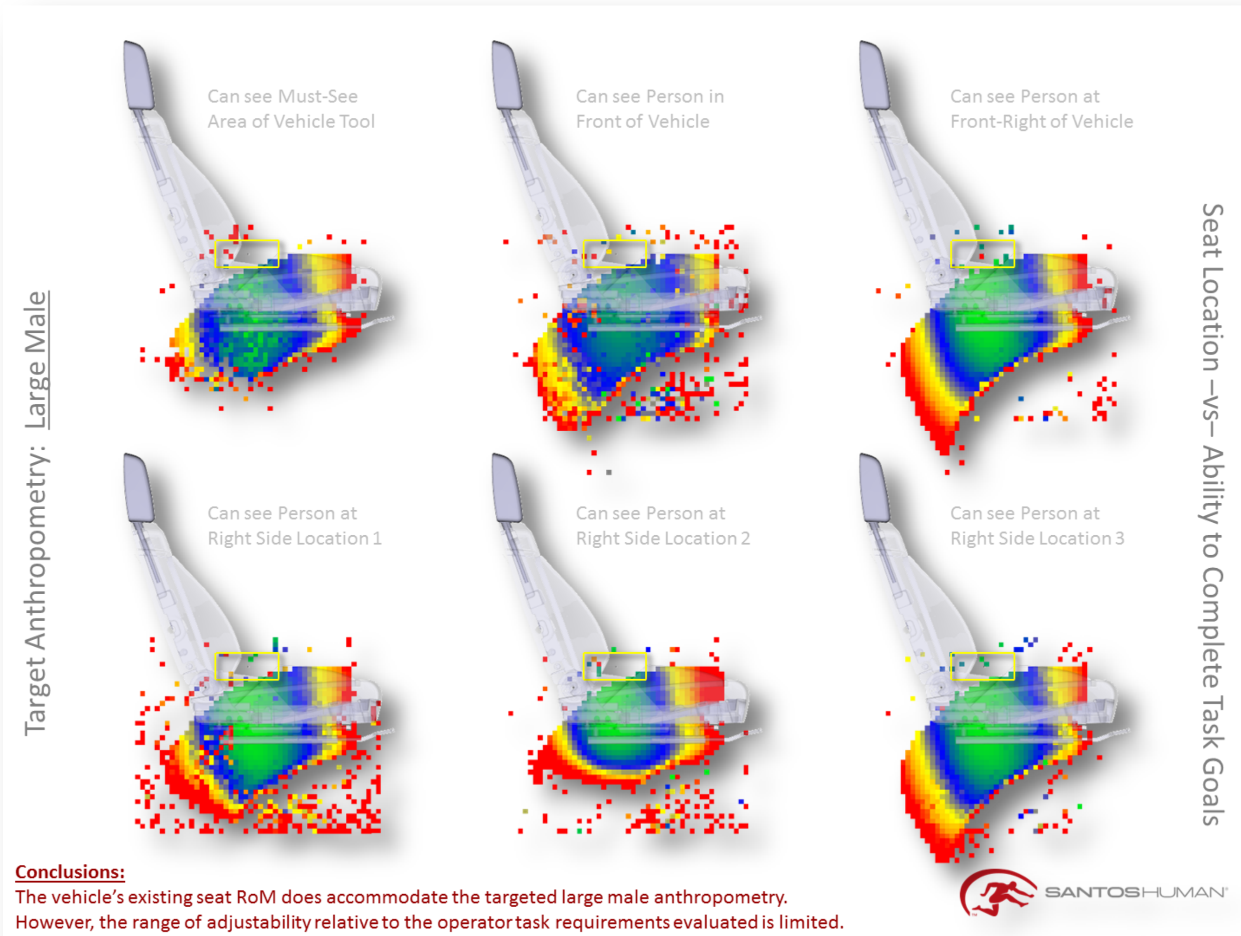
Examples

Following are two examples of trade-off analysis generated within Santos Pro® showing variations in operator task performance relative to seat location for a large male operator and a small female operator, which includes their associated ability to see critical areas on and around the vehicle.



Human Performance Trade-Off Analysis: Large Male Operator

This image shows human performance trade-off analysis results for 6 variations of a common operator task for a large male operator. The yellow rectangle indicates the extent of the range of motion of the seat relative to a seat reference point, which is currently located within the center of the yellow rectangle in all cases. As the seat moves from its lowest, most forward position; to its highest, most forward position; to its highest, most rearward position; to its lowest, most rearward position; and back to its lowest, most forward position, the seat reference point would trace out the yellow rectangle shown.

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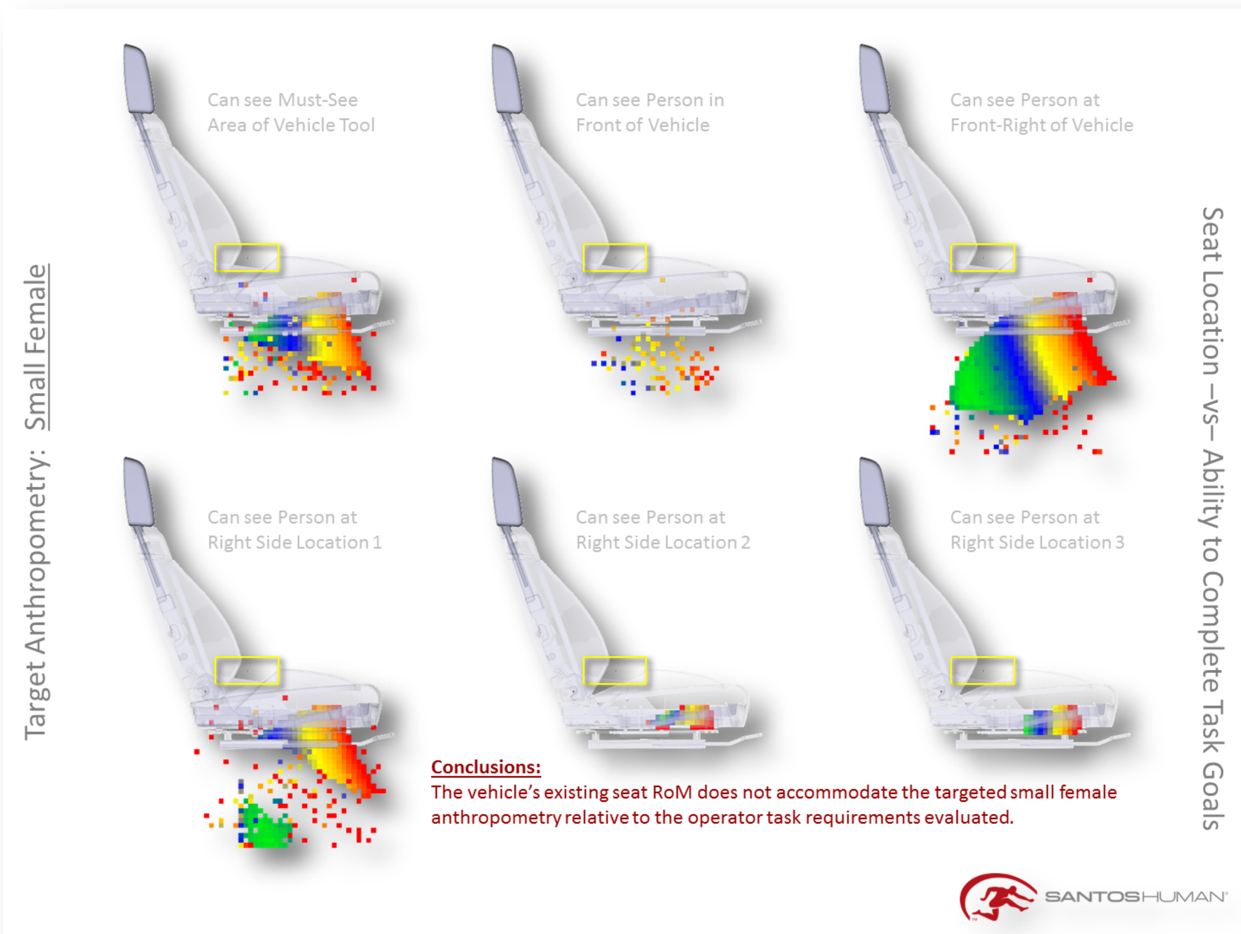
The colored values shown indicate variations in operator performance relative to the location of the seat reference point as the seat's range of motion is ignored in order to identify the entire viable space where the seat can be located and the operator can complete the defined task. Variations in operator performance are indicated through a pseudo-color palette where the seat reference point within the green areas provide relatively better operator performance than areas that are blue; which are relatively better seat locations than areas that are yellow; which are relatively better seat locations than areas that are red. Note that it is impossible for the operator to complete the defined task if the seat is positioned such that the seat reference point is within any non-colored regions. It should also be noted that red does not mean danger and yellow does not mean warning. The pseudo-color palette used was selected to highlight trends in operator performance with as much contrast as possible. While the result of the analysis shows that the seat assembly location and defined range of motion just barely accommodate the large male anthropometric boundary case, it also provides guidance on modification options that could do a better job of accommodating a large male operator.



Human Performance Trade-Off Analysis: Small Female Operator

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This example demonstrates an identical analysis using the same six variations in a common operator task, but for a small female operator. While the analysis shows the cab design does not accommodate small female operators at all, it also provides guidance on modifications that could accommodate a small female operator.

While the task-based operator performance trade-off analysis shown in the series above provides an incredibly valuable guide to much-needed product modifications to an existing cab, the real value of this technology is that these same evaluations can be accomplished at the earliest stages of design so you can get the HITL components right the first time.

Conclusion

Designing Human-in-the-Loop (HITL) systems create challenges for every manufacturer. From golf clubs to space stations, getting the design **right** is the goal. We all know that can take longer than anticipated and can become undermined by toxic design compromises. At SantosHuman Inc. we make a business out of getting it right . . . . the first time. It's not luck. It's the science of predicting physical human behavior and performance.

Our business is bifurcating what can be done with what should be done from an operator-centric point of view. Santos technologies can achieve this at the earliest stages of design, which helps our clients avoid loss of market share and confidence due to:

- Market rejection based on customer dissatisfaction
- Costly and time-consuming product redesigns
- Ongoing budget and deadline overruns
- Increased risk of injury liabilities

There is no reason for human-centric design to be conducted by trial and error any longer.

For More Information

Webinar: http://web2.altairhyperworks.com/2018-santos-use-case-webinar
SantosHuman: https://www.santoshumaninc.com/
SantosHuman YouTube: https://www.youtube.com/watch?time_continue=33&v=KImGWaGynqU