Crash Test Dummy User Configuration

STS Research Paper
Presented to the Faculty of the
School of Engineering and Applied Science
University of Virginia

By

Marissa Marine

April 13, 2022

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: ____*Marissa Marine*____________________________________

Approved: ____ Date ________________________
Benjamin J. Laugelli, Assistant Professor, Department of Engineering and Society

Introduction

Crash test dummies are used to evaluate the safety of vehicles and study the effects of automotive accidents on the human body. The first crash test dummy was developed in 1949, and the technology has evolved significantly since then. The current industry standard dummy is the Hybrid III, which represents a 50th percentile adult male. The failure of crash test dummies to represent women and the resulting consequences have been analyzed by many scholars. However, these analyses are limited because they fail to explain how and why the current crash test dummy designs came about. By only looking at the consequences of the design, a thorough understanding of why the crash test dummy was designed the way it is is lost. Analyzing the designers' perception of their users allows for a better understanding of why crash test dummies fail to represent women.

Using the framework of user configuration, I argue that the designers of the crash test dummy embedded their assumption that all users can be approximated as an average male into the design. Their assumptions are evident in the dummy's early development, as well as the physical features of the dummy. User configuration will allow me to investigate how the design of the crash test dummy came about, and how the designers' implicit assumptions impacted the design. To support my argument, I will analyze the physical features of crash test dummies through images, data, and engineering drawings. I will also examine performance testing requirements present in the crash test dummy user manual.

Literature Review

Many scholars have analyzed the design of crash test dummies, and how they fail to accurately represent women. These analyses typically focus on the consequences of this failure, such as the increased risk of injuries and death for women in car accidents (Bose et al., 2011). These consequences are important to study, but so is how and why these crash test dummy designs came about. This can be accomplished by employing user configuration to investigate the assumptions about the users that were embedded into the design of the crash test dummy.

In her book *Invisible Women: Exposing Data Bias in a World Designed for Men*, Caroline Criado Perez discusses the gender data gap, which she defines as the large discrepancy in the amount of data available on women compared to men. She explains that the lack of data about women is generally not malicious, but rather a product of a way of thinking that holds male as the default norm (Criado-Perez, 2020). Perez provides numerous examples of what this default male view has impacted, including language, smartphone emojis, media, and interpretations of historical artifacts. She also explains how the lack of data on women led to car safety systems that don't account for women's measurements, since they were created based on average male data and crash test dummies. Perez attributes the design of the crash test dummy solely to the gender data gap and way of thinking of male as the default norm. However, she doesn't consider how the designers of the crash test dummy embedded their own ideas and assumptions about the user into the design.

Linder and Svedburg discuss how traffic safety regulations reveal that the average adult male is used to represent the whole adult population and that the average sized female has been excluded from these regulations. This paper investigated the crash test dummies that are used for five different regulatory safety tests. For all five tests which assess safety belt performance, frontal collision protection, and lateral collision protection, the only crash test dummies used in the driver's seat were 50^{th} percentile adult males (Linder & Svedberg, 2019). These tests exclusively use the 50^{th} percentile adult male to represent the whole adult population. This paper claims that the lack of legal provisions requiring the use of female crash test dummies means there is no incentive to develop and use a female crash test dummy. Linder and Svedurg analyze this problem with more of a legal perspective, and fail to consider how the assumptions of the designers were embedded into the design of the crash test dummy as an average male.

The work of Perez confirms that crash test dummies do not account for women's measurements, and that male is often viewed as the default norm. Linder and Svedburg confirm that car regulatory safety tests almost exclusively use a 50^{th} percentile adult male dummy. They also show how this increases safety risks for women in car accidents, such as women having double the risk of sustaining whiplash injuries and a 71% higher risk of a belt-restrained female driver sustaining a serious injury compared to a belt-restrained male driver (Linder & Svedberg, 2019). While these are important aspects of the problem surrounding crash test dummies, I will use the framework of user configuration to analyze how the designers' assumption that all users can be approximated as an average male was embedded into the design of the crash test dummy. This analysis will advance understanding of the impact of the designers' implicit assumptions on the resulting technology.

Conceptual Framework

My analysis of the crash test dummy draws on the Science, Technology, and Society (STS) framework of user configuration which allows me to investigate how the designers' own assumptions about the users were embedded into the design. User configuration was developed by sociologist Steve Woolgar. It centers around the concept that engineers and designers configure user identity by embedding certain ideas and assumptions they have about users into the technologies they design (Woolgar, 1991). This can happen either consciously or subconsciously, and these ideas and assumptions can be either implicit or explicit. In many cases the designers are not aware of how their own assumptions and implicit biases influence the technologies they create.

An important concept of user configuration is that technology functions as a “script” that defines the actions, corresponding actors, and settings in which the actions take place (Woolgar, 1991). This technological script determines what users can and cannot do. As a result of user configuration and this technological script, user interactions with technology are constrained by the design. The design choices that engineers make determine who can use the technology and how the technology can be used. User configuration states that engineering design results in a configured user, which is a user as imagined by the designer and embedded into the technology’s design (Oudshoorn & Pinch, 2003). This configured user may or may not align with the actual user of the technology. When the configured user fails to align with the actual user, this can lead to the technology being ineffective, or simply not being used. This can also potentially harm the actual users, if their characteristics and intentions are not accounted for in the design.

In the analysis that follows, I will use user configuration to illustrate how the designers of the crash test dummy embedded their own assumption that all adults can be approximated as an average male into the design. I will analyze the early development of the crash test dummy and the physical features of the most commonly used crash test dummies to highlight the design features resulting from this embedded assumption.

Analysis

The designers of the crash test dummy embedded their assumption that all users could be approximated as an average male into the design of the technology. This is evident through both the early development of the crash test dummy and the physical features of the current industry standard dummy, the Hybrid III. The framework of user configuration will help to identify the aspects of these elements influenced by the designers' assumptions about the users. The designers of the crash test dummy inaccurately configured their user, which had many ramifications for women.

Early Development

The embedded assumptions the crash test dummy designers made about their users were evident in the earliest stages of development of the first crash test dummy. The first crash test dummy was the Sierra Sam created in 1949 by Samuel Alderson at Alderson Research Labs and Sierra Engineering Company (Bellis, 2019). The Sierra Sam was created under a contract with the United States Air Force to be used to evaluate aircraft ejection seats. This was a 95th percentile adult male dummy, which is shown in figure 1. When looking at the structure of the Sierra Sam it is important to note the relative simplicity of the design. It was made out of rubber and steel, and meant to be a basic representation of a human to test ejection seats. It is also important to notice that there is no evidence of any consideration for women in this design based on the hip structure and body shape. Alderson assumed that all users of aircraft ejection seats could be represented by this dummy, and embedded his assumption into the design.

Figure 1: The Sierra Sam crash test dummy

As I have argued, the designers of the crash test dummy embedded their assumption that all users could be approximated as males into the design of the earliest crash test dummy. Some might think that this was not an embedded assumption, but rather a conscious design choice made to reflect the overwhelmingly male population of the air force at the time. However, this view fails to consider that the crash test dummies did not change when translated to civilian use for car safety, or when women were allowed to become air force pilots in 1976. Even when the user base of crash test dummies was expanded to include women, the crash test dummies stayed the same. This illustrates that the designers had embedded the assumption that the existing dummies were representative of the whole adult population into the design.

Additionally, the first female crash test dummy was simply a scaled down version of the 50th percentile adult male dummy. This further indicates that the designers assumed everyone could be represented as a male, and embedded the assumption that women are just small men into this design. Still to this day, the only female dummy commonly used is the Hybrid III 5th female, which represents a 5th percentile adult female, but is still just a scaled down version of the male design. This dummy is an extremely poor representation of women, as it is about the size and weight of the average 12-year-old girl today, at about five feet tall and 108 pounds (*Hybrid III 5th Female*, n.d.). It also completely ignores differences in female geometry, muscle and ligament strength, spinal alignment, responses to trauma, and mass distribution. All of these factors greatly impact injuries resulting from a car accident (*Inclusive Crash Test Dummies: Analyzing Reference Models | Gendered Innovations*, n.d.). This 5th percentile female dummy is shown in figure 2, and at first glance it might appear to be configured as a female, but all of its anthropometrics are just scaled down from the male dummy. It is important to note the visual appearance of breasts on this dummy, however, they do not serve any functional purpose for testing possible injuries to women. This “female” dummy is also mainly only used in the passenger seat during crash tests, and rarely ever in the driver’s seat.

Figure 2: The Hybrid III 5th percentile female dummy

This further illustrates how the assumption that all drivers can be represented by the average male was embedded into the designs of crash test dummies.

Hybrid III Features

The Hybrid III crash test dummy is the most commonly used crash test dummy in the world for frontal crash testing and evaluation of safety restraints, and its physical features are telling of the assumptions the designers of crash test dummies made about its users. The Hybrid III represents the 50th percentile adult male. It was originally developed by General Motors, but is now developed by Humanetics and the National Highway Traffic Safety Administration (NHTSA). It is a regulated test device in both the United States and Europe and is the industry standard crash test dummy for most safety tests (*Hybrid III 50th Male*, n.d.).

Figure 3 (*Hybrid III 50th Male*, n.d.) shows an image of the Hybrid III dummy, and figure 4 (*Parts List and Drawings Subpart E: Hybrid III 50th Percentile Male*, 1997) is an engineering drawing of the Hybrid III from the NHTSA. At first glance, it is easy to identify that this represents a male based on the overall body shape and stature, and lack of breasts. This is an important aspect of the dummy to notice, as it shows that the designers of the dummy assumed that an average male shape would be sufficient to evaluate the safety of all vehicle users. However, breasts can interfere with the placement of the seat belt on women, as well as sustain serious injuries. This is an example of a consequence to users, specifically women, of the designers inaccurately configuring their user (DiPiro et al., 1995).

Figure 3: Hybrid III 50th percentile male dummy

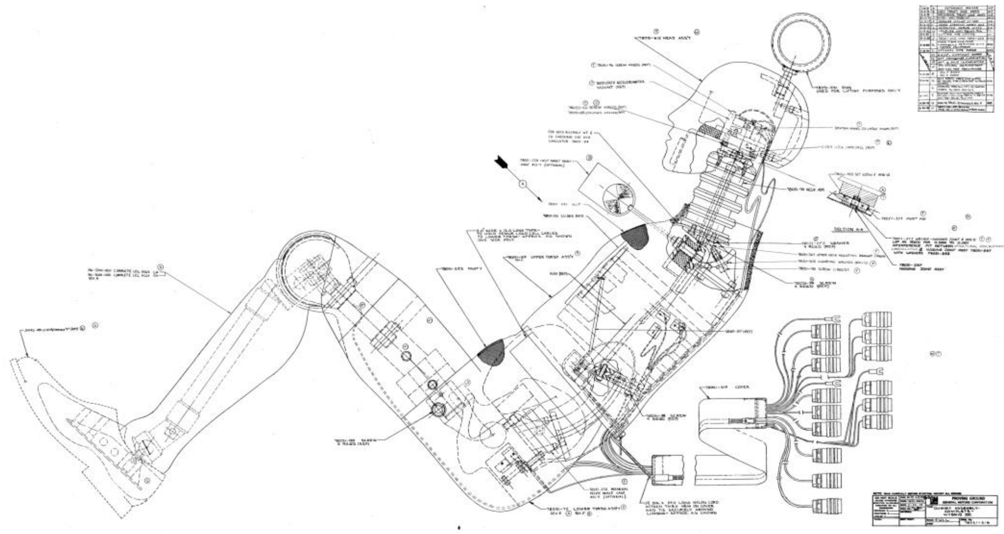

Figure 4: Engineering drawing of the Hybrid III

Looking further into figure 4, it is important to notice the shape and configuration of the lower torso. Figure 5 focuses on this area in more detail. Specifically, in figure 5 the diagram on the left shows the location of the hips within the lower torso. It is important to notice how narrow the hips are, specifically a narrow pubic arch which is a telling indication of a male pelvis.

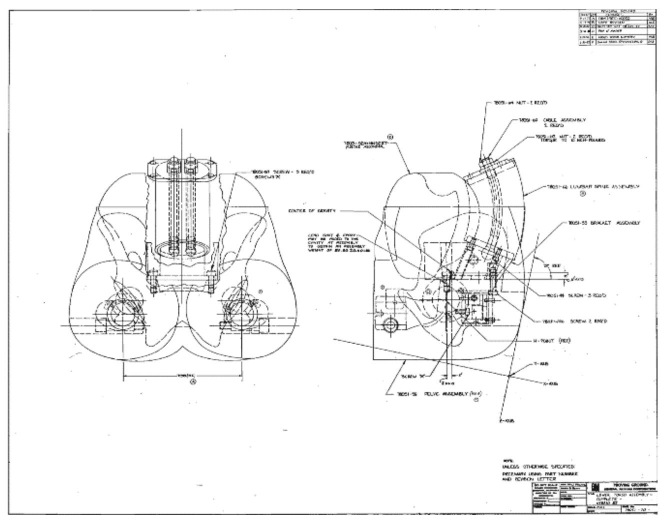

Figure 5: Engineering drawing of the Hybrid III lower torso

Additionally, the area of the dummy analogous to the base of the human sacrum is tall and narrow, further indicating that this solely represents a male pelvis. This supports the idea that the physical features of the dummy illustrate how the assumption that all users can be approximated as an average male was embedded into the design.

The weight and dimensions of the Hybrid III are also indicative of the assumptions embedded in the design. The Hybrid III has a weight of 172.3 pounds, height of 69 inches, and a sitting height of 34.8 inches (*Hybrid III 50th Percentile Male | National Highway Traffic Safety Administration (NHTSA)*, 2010). These measurements are all representative of a 50th percentile adult male. For comparison, the measurements of a 5th percentile adult female are a weight of 108 pounds, height of 59.1 inches, and sitting height of 31 inches. Figure 6 shows a table with additional dimensions of the Hybrid III crash test dummy, which are all representative of 50th percentile adult male dimensions. Looking at head circumference as an illustrative example, the Hybrid III has a head circumference of 23.5 inches, compared to 21.6 inches for an average woman (Bushby et al., 1992). Similarly, for all of these measurements, women tend to be smaller than men, and therefore are not well represented by the Hybrid III test dummy. From this data, it is clear how the designers embedded their assumption that all users could be approximated as an average male into the design. The significant differences in anthropometrics between the 50th percentile adult male and adult female illustrate how this could impact the safety of women in vehicles only tested to be safe enough for a 50th percentile male.

External Dimensions for the HYBRID III 50th Percentile Male

Dimension Description	Specifications (in)
Head Circumference	23.5
Head Breadth	6.1
Head Depth	8.0
Erect Sitting Height	34.8
Shoulder to Elbow Length	13.3
Back of Elbow to Wrist Pivot Length	11.7
Buttock to Knee Length	23.3
Knee Pivot Height	19.5

Figure 6: Dimensions of the Hybrid III

Another important feature of a crash test dummy is the location of the center of gravity. This greatly impacts how the dummy will behave in response to various movements and impacts during safety testing. Center of gravity is also something that differs between men and women. Men have a higher center of gravity located approximately in the center of the chest, while women have a much lower center of gravity located approximately at the center of the pelvis (Iida & Yamamuro, 1987). Figure 7 shows a diagram of the Hybrid III with the center of gravity (C.G.) of individual body parts labeled (Foster et al., 1977). The center of gravity of the upper torso is indicative that the center of gravity of the whole dummy closely resembles the center of gravity of an adult male. This is another feature of the Hybrid III that illustrates how the assumption that users can be approximated as an average male was embedded into the design.

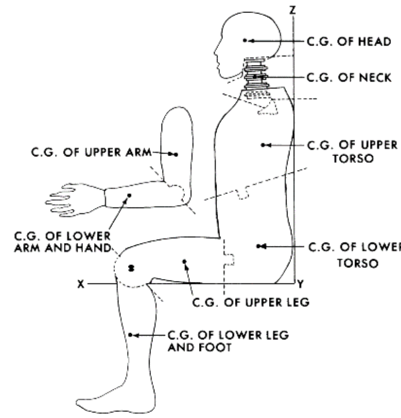

Figure 7: Hybrid III center of gravity locations

Another important feature of the Hybrid III, and any crash test dummy, is the mobility of the joints and their ability to mimic the behavior and injury patterns of human joints. The user manual of the Hybrid III includes specifications for performance testing after the dummy is assembled. For example, tests recommended for each ankle joint are dorsiflexion, plantarflexion, inversion, and eversion tests and for each test the manual includes performance specifications that the Hybrid III should meet. For example, for the plantar flexion test, "At a moment of 4.0 Nm (2.95 ft-lbf), the angle should measure 33° ± 2.0°" (*User Manual: Harmonized Hybrid III 50th Male*, 2017). This corresponds to ankle mobility in an average male, indicating another feature that illustrates the embedded assumption in the design. Women tend to have greater joint mobility and range of motion than men (Rene', 1984), which contributes to a higher risk of injury such as ankle sprains. This means that while the Hybrid III may not indicate an ankle injury, a woman experiencing the same situation could sustain an injury. This is another example of the consequences of when the actual user does not align with the configured user.

Conclusion

By using the framework of user configuration, I have argued that the designers of the crash test dummy embedded their assumption that all users could be approximated as an average male into the design. I demonstrated this through analyzing the early development of the crash test dummy, as well as specific physical features of the industry standard dummy, the Hybrid III. This also illustrated how the designers' perception of the configured user did not align with the actual user, which has the consequence of women being more likely to be injured in car accidents. It is important to understand how the assumptions of designers can be embedded in and impact the final design of a technology. This analysis provides insight into how this affected the design of the crash test dummy, which could also shed light on other similar technologies.

This greater understanding is also extremely important in engineering to ensure that engineers know to be aware of how their ideas, assumptions, and biases about their users can impact the technologies they create. It is important for engineers to use this knowledge to design technologies that accurately configure and represent their population of users. This will help avoid negative consequences resulting from an inaccurately configured user, such as the higher risk of injuries for women in car accidents.

Word Count: 3120

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