Medic Restraint Systems within the Patient Compartment

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Abstract

Those who work in Emergency Medical Services as medics have a difficult and dangerous job, the causes of which EMS as an industry is only beginning to address. Currently, differing priorities between medics out on the field and the manufacturers and administrations tasked with keeping them safe make attempts at mitigating detriment particularly challenging. Preventing fatalities within the patient compartment is particularly difficult to implement. This thesis lays an understanding of how that dichotomy manifested, and how fatalities in the EMS community are linked to manufacturer's failure to take into account the behaviors of the medics within the patient compartment when developing their solutions.

This thesis takes a transformative approach when addressing how a safety solution would work within existing user workflows , and how to make it more comfortably adopted. It sets out to identify what factors of a medic's job take the most toll, and uses user-centered design methodology to offer a solution that satisfies both users' and administrators' goals. The solution consists of an overhead seat belt rail system attached safety harness that is integrated into the medic uniform. The value of this solution is an increased level of safety in the patient compartment that helps protect medics in the event of a crash, while allowing flexibility of movement so the medic may quickly and effectively treat their patient. Medics are subsequently less likely to be taken out of commission for injury, while also not compromising the level of care provided to the patient.

Emergency Medics Have a Dangerous Job

Increasingly EMS workers are expected to provide an advanced level of treatment and care, in addition to transport, which increases their task load and susceptibility to harm.

3x

more likely to suffer injury and fatalities on the job than other professions in the United States

4-10x

more likely to develop PTSD from their work than the general population

Daily

exposed to an increased risk of blood-borne pathogens, disease, and infection

... in an unstructured environment.

Why is this happening?

Identify

Which element of a medics' job (the tasks they must perform, the equipment they must use, or the environment they must operate in) causes the most detriment to medics wellbeing?

Is the physical or mental element of detriment more significant?

Can this issue be solved through design?

Understand

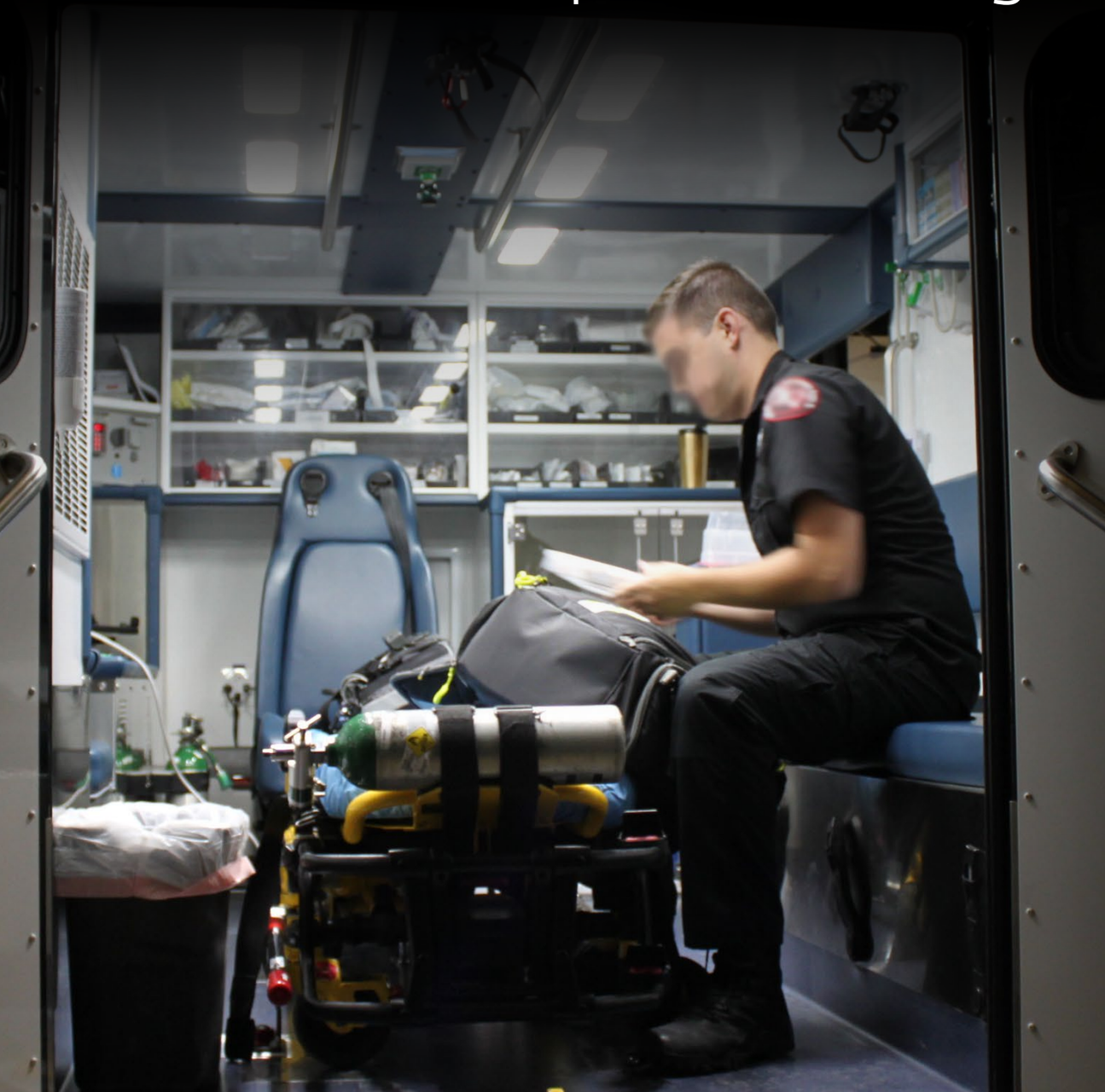
Why do medics not buckle in? What tasks cannot be done while seated and secured, from the medics' point of view?

What is it about these tasks that make following through with proper safety measures so difficult?

Solve

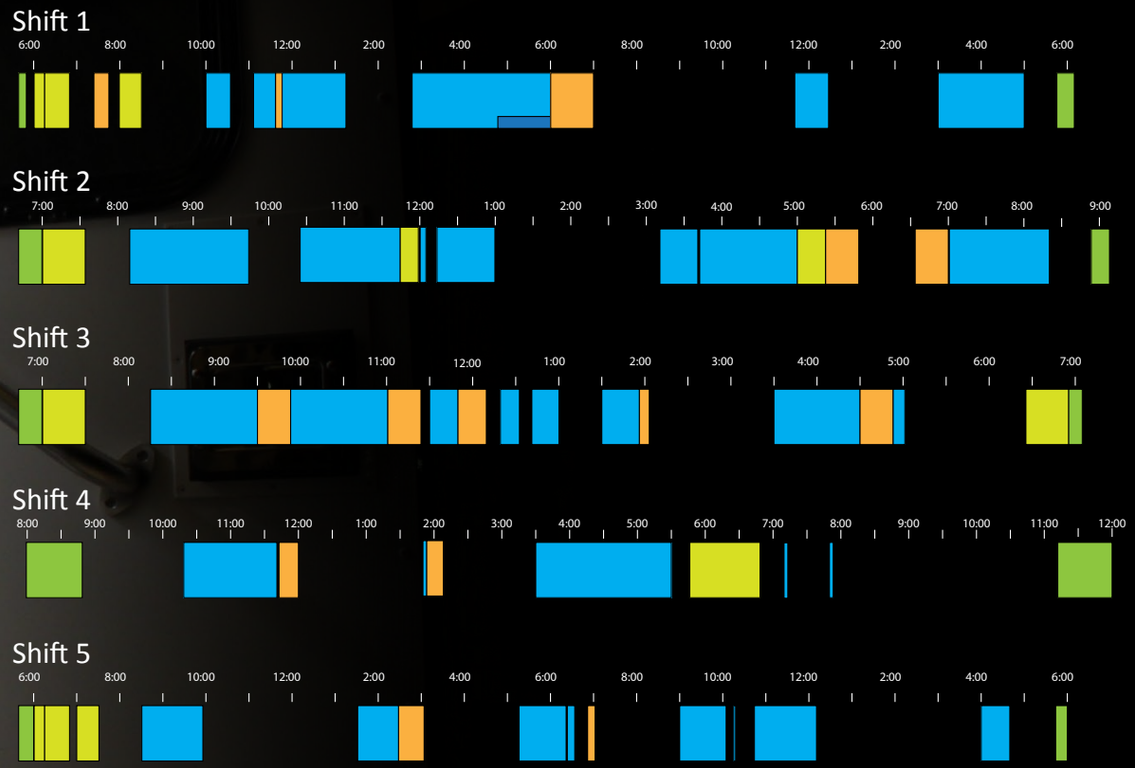
How can design be used to reconcile the importance of medics' safety with their need to freely and effectively treat a patient?

Research Setup: Ride Alongs/Observer Programs



Visual Break-Down of Timelines during Ride Along Shifts

5 shifts; 4 Texas cities; 90 total hours; 28 calls :



- Shift Change
- Maintenance and Re-stock
- Scheduled Breaks
- Active Calls
- Instances of Grid-locked Traffic

Mixed Methods Comparative Case Study

Four different methods of data collection:

Heart rate monitor

NASA Task Load Index

A way of capturing and measuring different causes of stress, such as time demands, physical or mental strain, or perceived competency of a task.

For example, some tasks might be difficult because they must be completed very quickly. Others may seem easy or hard because of the intensity of mental or physical effort required. Yet others feel difficult because they cannot be performed well no matter how much effort is expended.

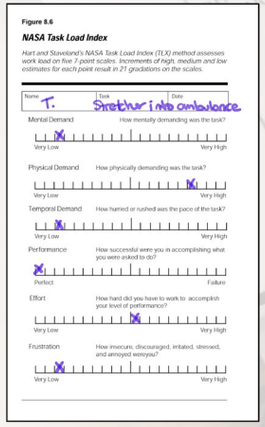


Figure 8.6

NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name T. Task Stretcher into ambulance Date

Mental Demand — How mentally demanding was the task? — Very Low / Very High

Physical Demand — How physically demanding was the task? — Very Low / Very High

Temporal Demand — How hurried or rushed was the pace of the task? — Very Low / Very High

Performance — How successful were you in accomplishing what you were asked to do? — Perfect / Failure

Effort — How hard did you have to work to accomplish your level of performance? — Very Low / Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed were you? — Very Low / Very High

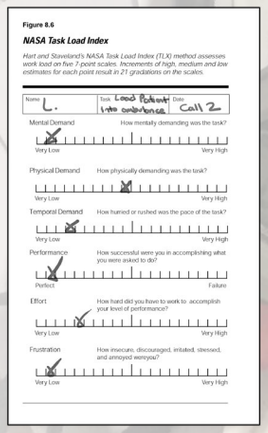


Figure 8.6

NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name L. Task Load Reduction into ambulance Date Call 2

Mental Demand — How mentally demanding was the task? — Very Low / Very High

Physical Demand — How physically demanding was the task? — Very Low / Very High

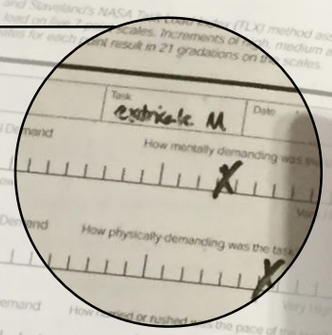
Temporal Demand — How hurried or rushed was the pace of the task? — Very Low / Very High

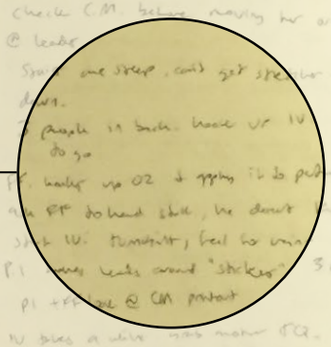
Performance — How successful were you in accomplishing what you were asked to do? — Perfect / Failure

Effort — How hard did you have to work to accomplish your level of performance? — Very Low / Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed were you? — Very Low / Very High

Interviews





Observations

Mixed Methods Comparative Case Study

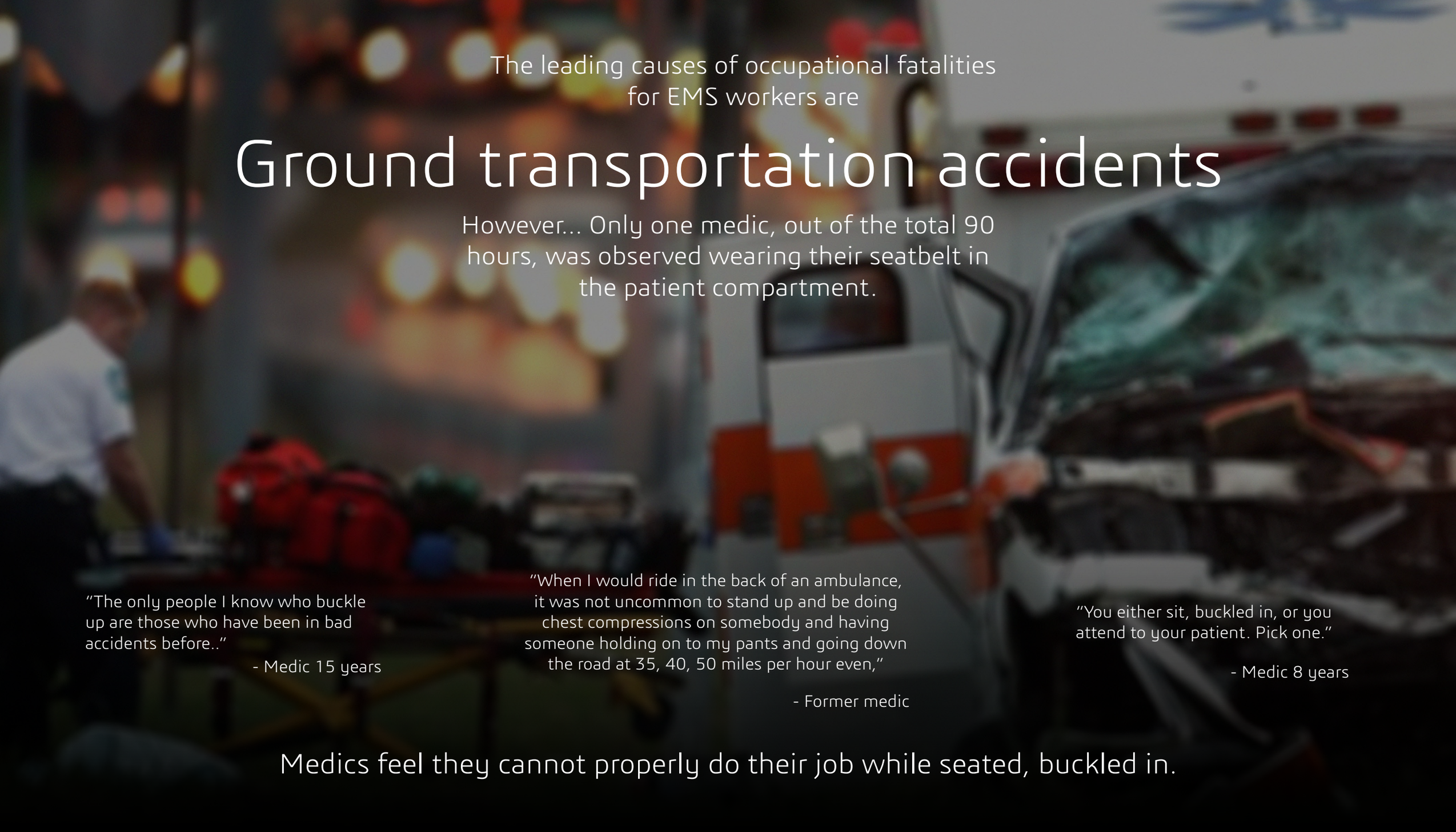
Data Results

Time constraints contributed the most to paramedics' perceived performance. Issues that ate into their time limits had the most harmful impact, such as trying to insert an IV needle into a rapidly dehydrating patient's veins, or waiting for help to arrive to help remove injured patients from a crumpled vehicle.

Unfortunately these issues, though important to address when looking at EMS at the organizational level, do not yield very many product design opportunities.

Observational Results

However, in alignment with extensive reviews of existing literature, my observations alone captured another significant problem. This observation was confirmed in followup interviews and analysis of injury data.



The leading causes of occupational fatalities for EMS workers are

Ground transportation accidents

However... Only one medic, out of the total 90 hours, was observed wearing their seatbelt in the patient compartment.

"The only people I know who buckle up are those who have been in bad accidents before.."

- Medic 15 years

"When I would ride in the back of an ambulance, it was not uncommon to stand up and be doing chest compressions on somebody and having someone holding on to my pants and going down the road at 35, 40, 50 miles per hour even,"

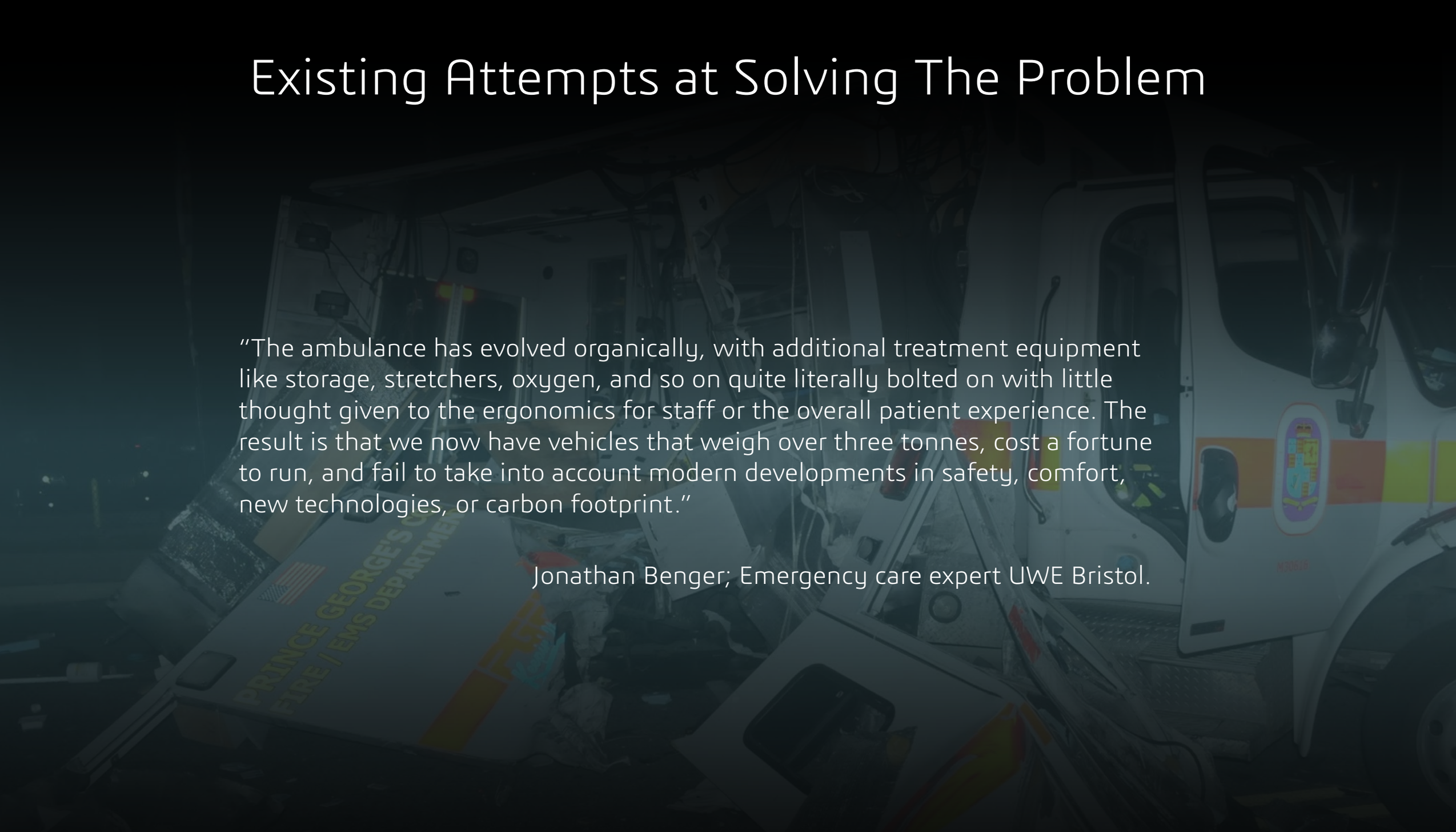
- Former medic

"You either sit, buckled in, or you attend to your patient. Pick one."

- Medic 8 years

Medics feel they cannot properly do their job while seated, buckled in.

Existing Attempts at Solving The Problem



"The ambulance has evolved organically, with additional treatment equipment like storage, stretchers, oxygen, and so on quite literally bolted on with little thought given to the ergonomics for staff or the overall patient experience. The result is that we now have vehicles that weigh over three tonnes, cost a fortune to run, and fail to take into account modern developments in safety, comfort, new technologies, or carbon footprint."

Jonathan Benger; Emergency care expert UWE Bristol.

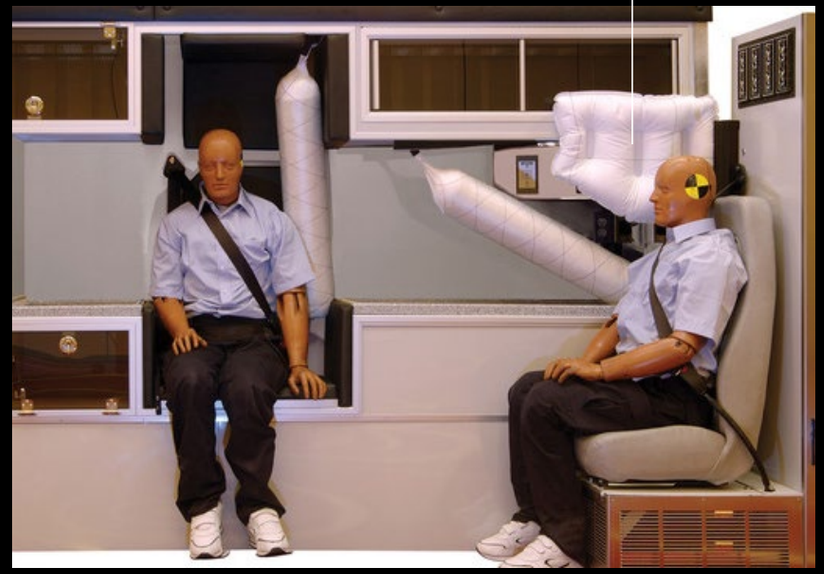
Currently Ambulances are not required to undergo crash tests; manufacturers cite prohibitive costs for why they don’t do them voluntarily.

Some 3rd party organizations have conducted crash tests and found several dangerous areas around the patient compartment. Here we can see a medic in the side chair concussing against an overhead compartment.

Medics in the standing position suffered neck, spine, and hip injuries from being flung across the patient compartment.

But, Incrementally, improvements are being made:

Some companies are incorporating airbags where common impaling injuries occur, particularly around overhead cabinets.



Elimination of overheard compartments reduces opportunities for head-strike injuries. More safe, front-facing "Captains chairs" are replacing standard benches, incorporating 4 and 5 point harnesses.

Medics opinions are mixed, but many still do not buckle up, nor do they like the reduced storage and workspace that the benches provided.

Blinkers and break lights visible from inside the box, to give EMS workers indication of the driver's intentions.

Small changes still following the "tacked on" method of improvement.

However, some companies, like Ferno, are pursuing a more systemic approach

Debuted at the 2015 Dallas EMS conference, this solution aims to solve the problems of "reach" by providing a customizable, modular wall system.

Theoretically, this model allows Medics to move the equipment they need closest to them based on the type of call they respond to.

However, since we know that time is one of the most pressing factors for a medic, it remains to be seen if they will be willing to take time to re-arrange the compartment call-to-call.

This solution seems to ignore instances where medics must be in positions other than sitting to complete necessary tasks such as CPR, and Intubation.

Manufacturers want the medics to stay seated, buckled in,

But these solutions do not take into account ingrained user behaviors.

If medics are going to stand anyway, how can I keep them safe while doing so?

What degree of safety should be achieved?

Currently the seatbelts in the front of the ambulance are rated to withstand high forces

26,689 = 6000

Newtons (unit of force) Pounds of force

Aiming for equivalent numbers could bring safety standards up to be on par with the rest of the unit.

How to achieve that level of protection?

Materials with breaking strength over 6000 lbs

Using proven existing methods and mechanisms

How to ensure medics will use it?

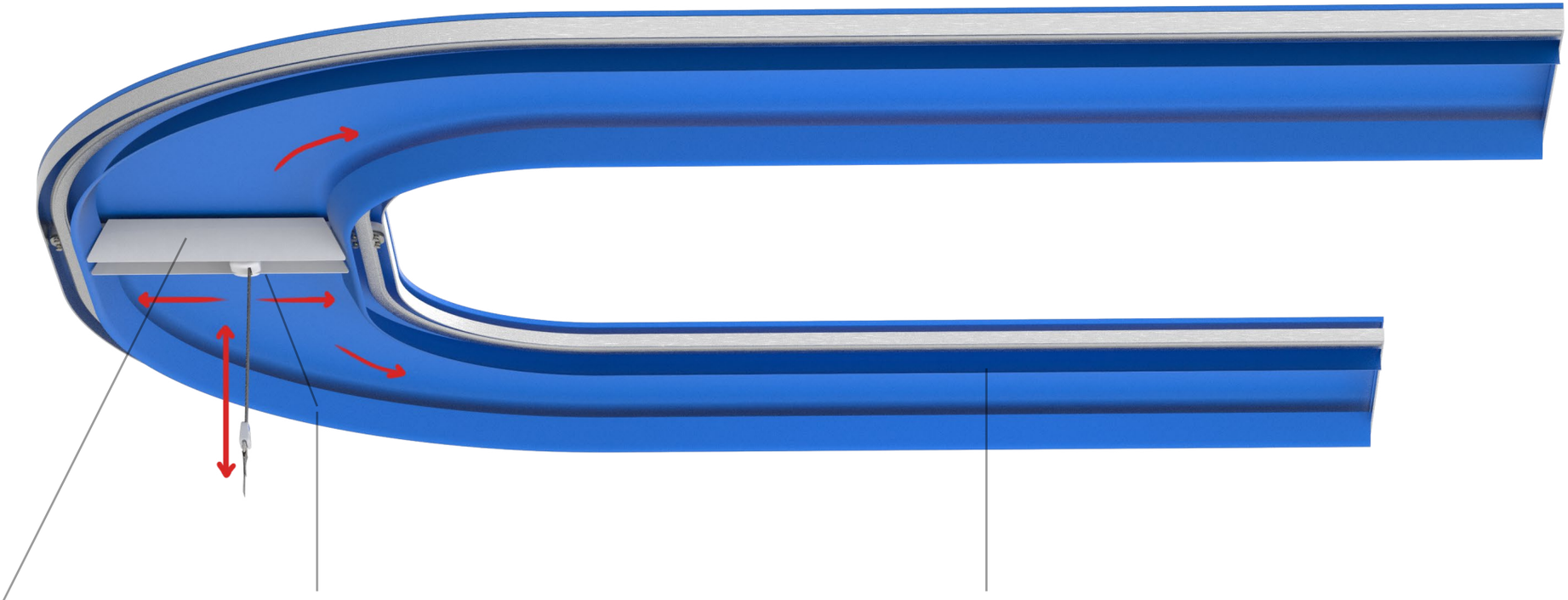
Constant checking in with the users and their values ensures that a collaborative design is achieved- a solution they help build will be more likely to fit their needs and be easily adopted.

Solution: A two-part harness + rail system

The Rail System

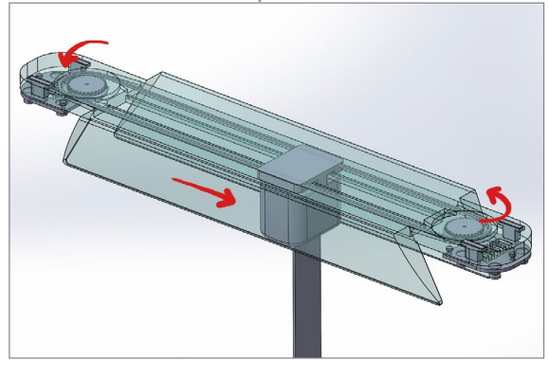
Movement

Movement of the rail system was very important: The system needed to glide with the user without too much resistance as they moved around the patient compartment to prevent accidental locking response and frustration on the medic's part.



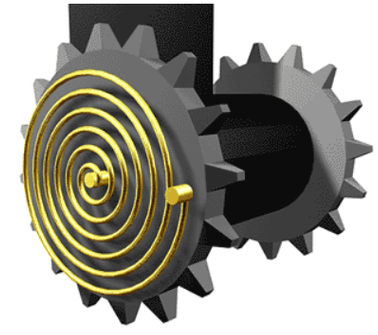
Linear sub-track

Un-tensioned gears and chain arranged as a pulley system, passively being pulled along with the medic's movements



Center spool

The extension and retraction of existing seatbelt mechanisms: a spool and a spring that controls the rotation force, or torque as the spring is deformed (Harris, 2002).



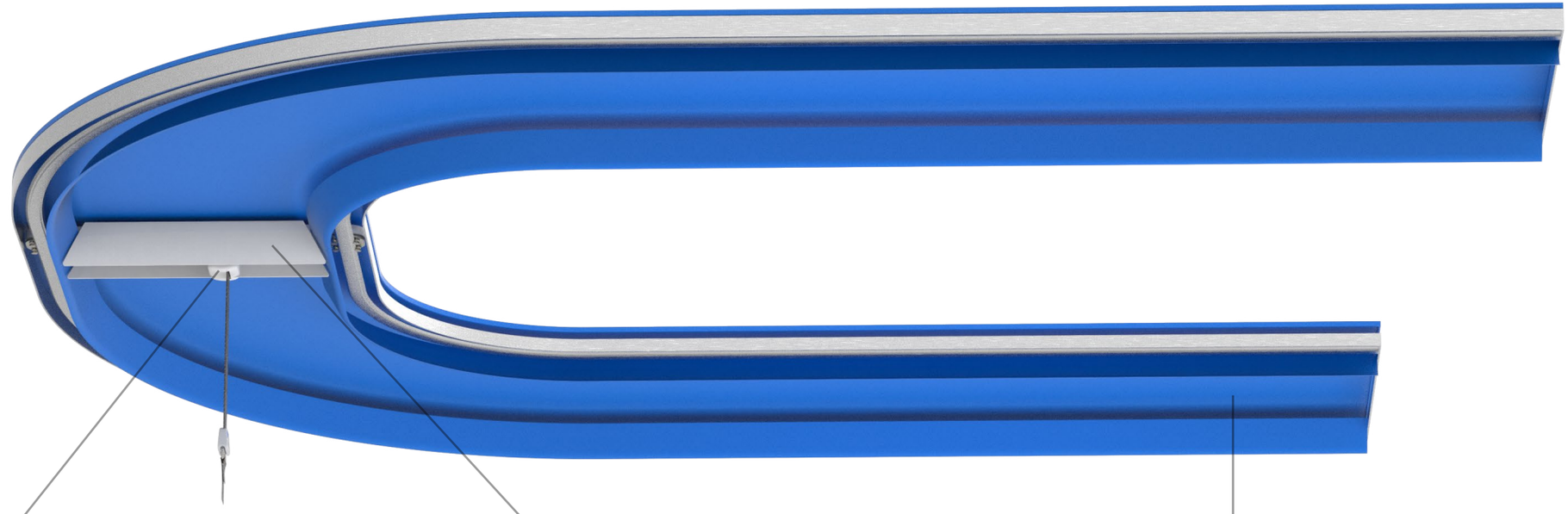
U shaped track

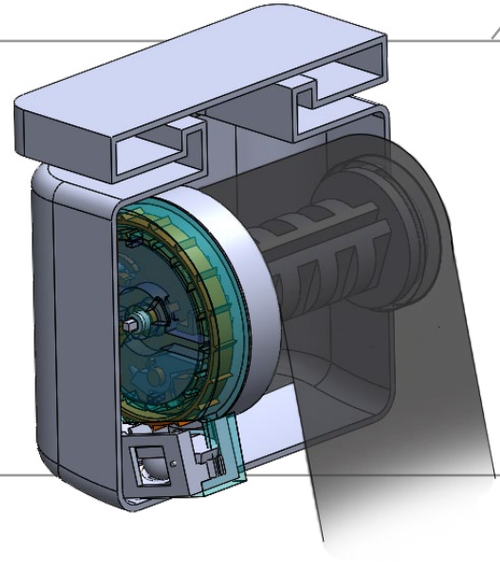
Rail and V-ball bearing system that can navigate both curved and linear paths: female v bearings positioned on opposing sides of a middle track.

The Rail System

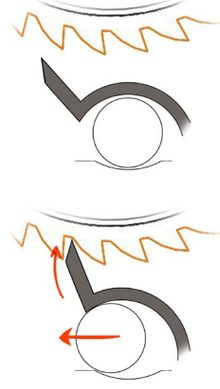
Locking

While the seatbelt assembly system must be able to move smoothly while the medic is in motion, it must also be able to lock instantaneously in the event of turbulence or a sudden change in momentum- such as in a crash. This is the most important feature that will keep the medic safe.





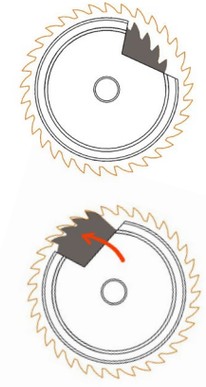
Center spool



Momentum Lock

Rapid acceleration/ deceleration or changes direction,causes the ball bearing to be thrust against its domed housing, causing the lock to be forced up and into the gears.

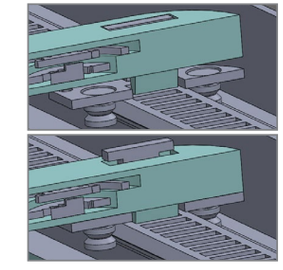
Linear sub-track



Centrifugal Lock

If the spool is spun too rapidly with force, in motions such as yanking the seatbelt, the inner teeth will be spun outwards to catch the outer gears.

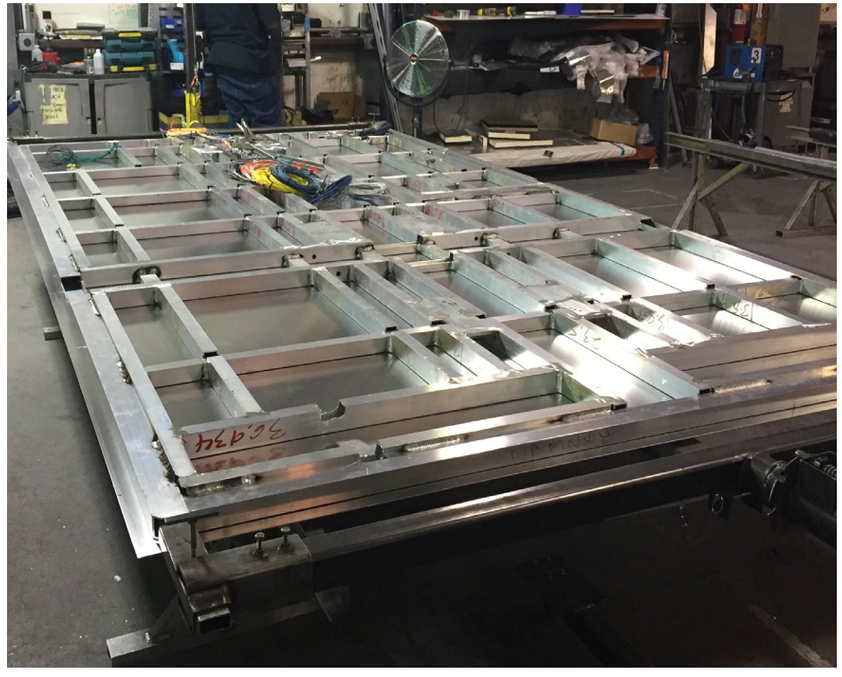
U shaped track

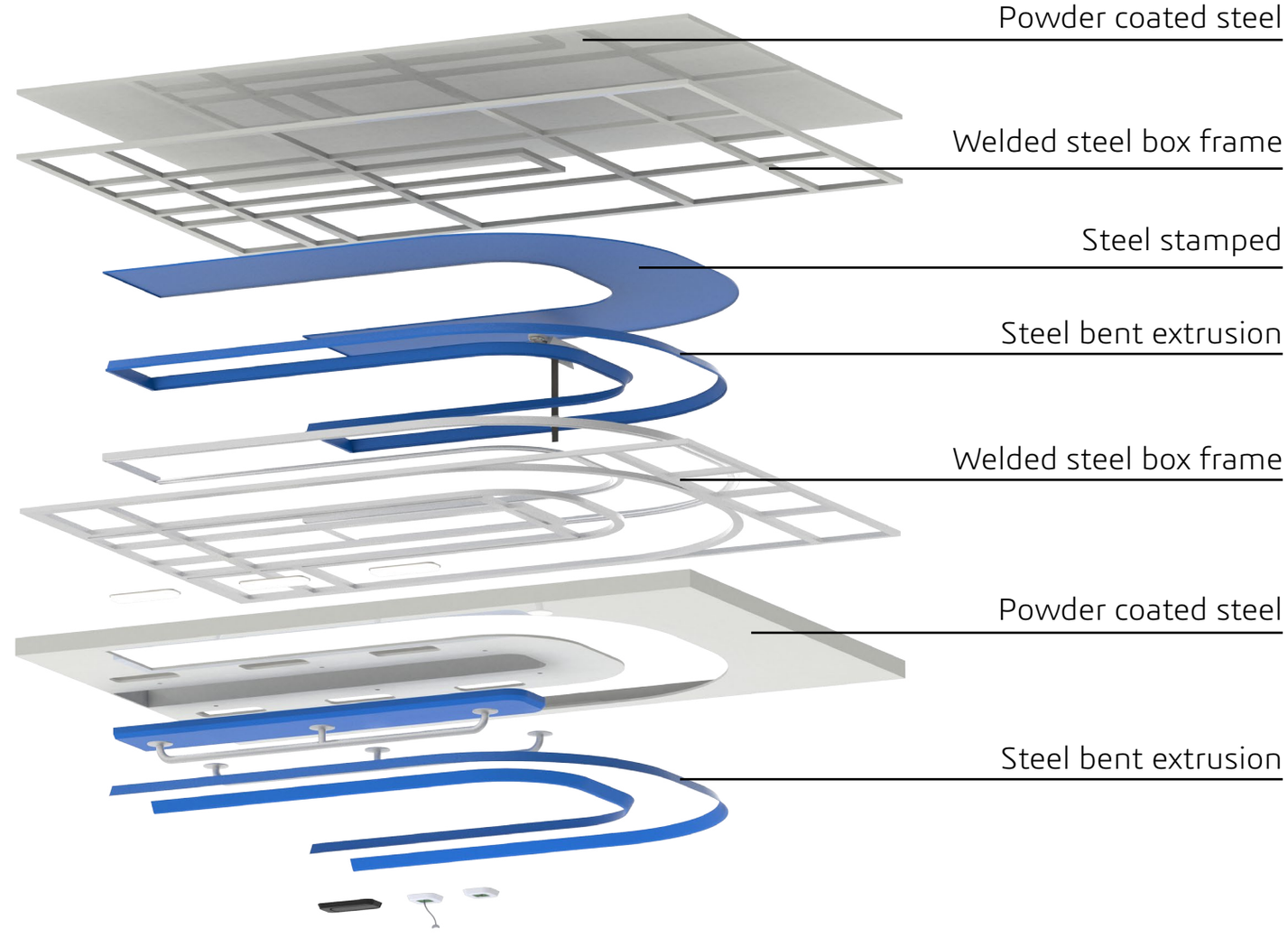


Rail and V-ball bearing system that can navigate both curved and linear paths: female v bearings positioned on opposing sides of a middle track.

Seamless Integration into Current Manufacturing Processes

Ambulances now are made by commission, with each ambulance company specifying where they'd like seating, storage, and other features. Manufacturing processes are modular, and the rail system can easily be incorporated into the ceiling assembly before being mounted into the patient compartment.





The Integrated Harness

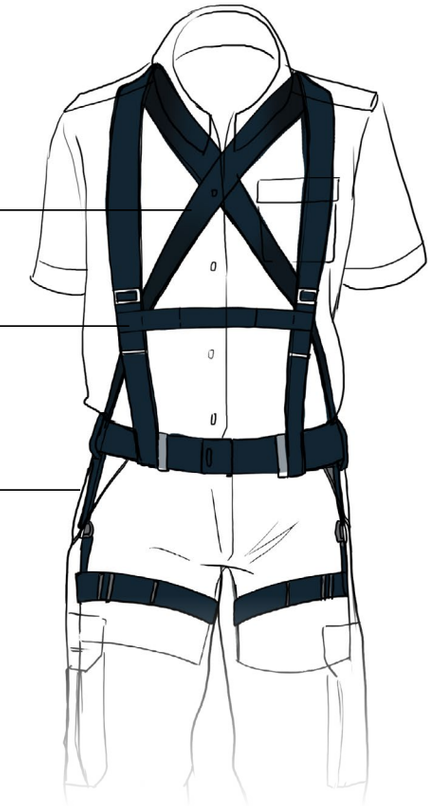
An on-person harness built into the medics' uniform that buckles into an overhead rail system and secondary clip. The advantages are that it is not something "extra" the medic must put on in the morning, and the rail system is out of the way while allowing a greater degree of freedom than conventional seatbelts.

It needed to be integrated into both a shirt and pants element for easy donning, while still being secure as a single unit to dispel force in the event of a crash.

Thinner padding to reduce bulk of shirt

Less bulky adjustment and connection points

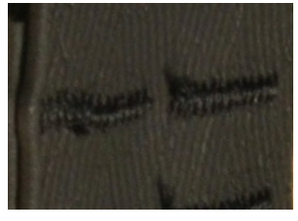
Not a onesie; not something else that the medics need to remember to put on.

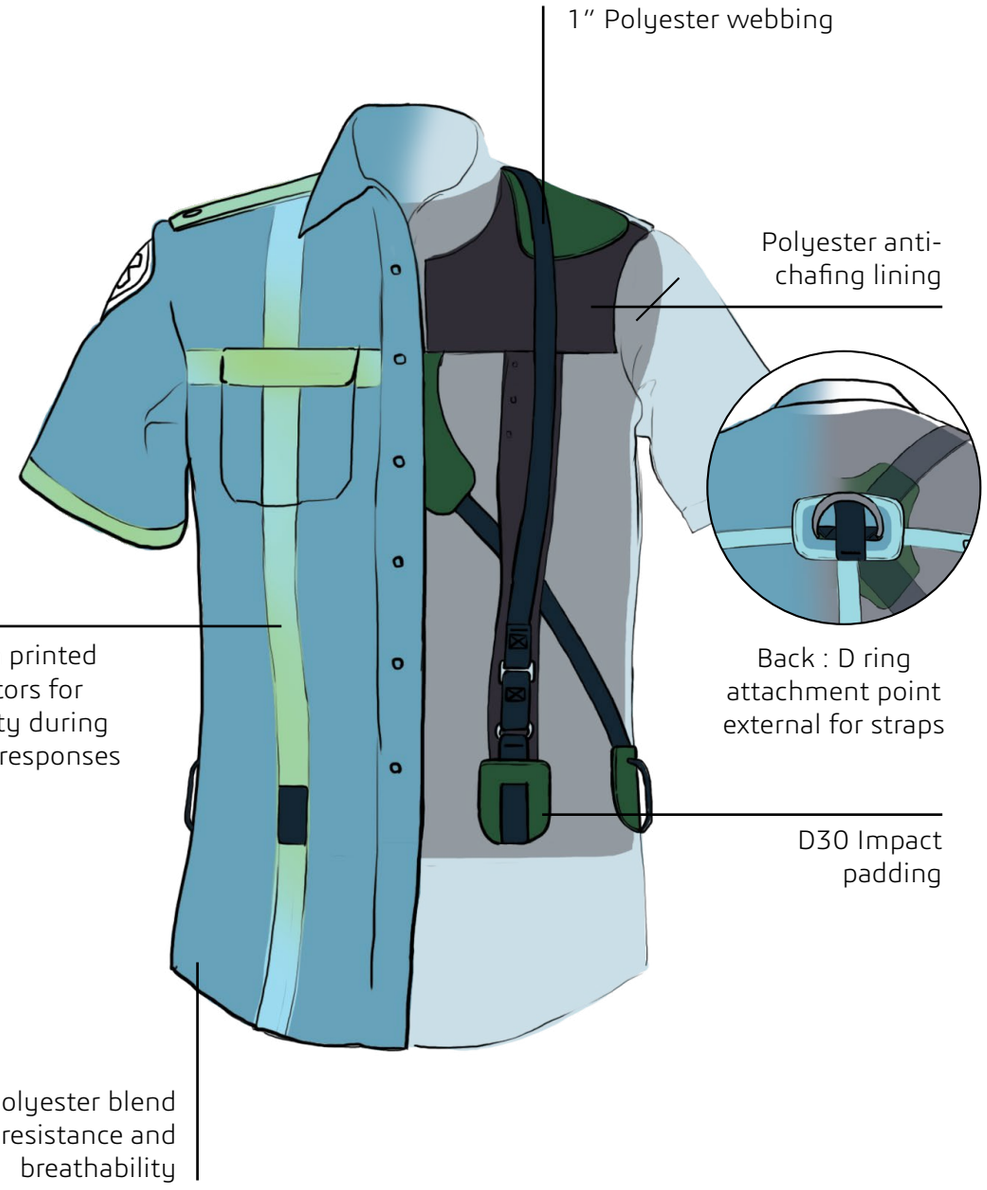


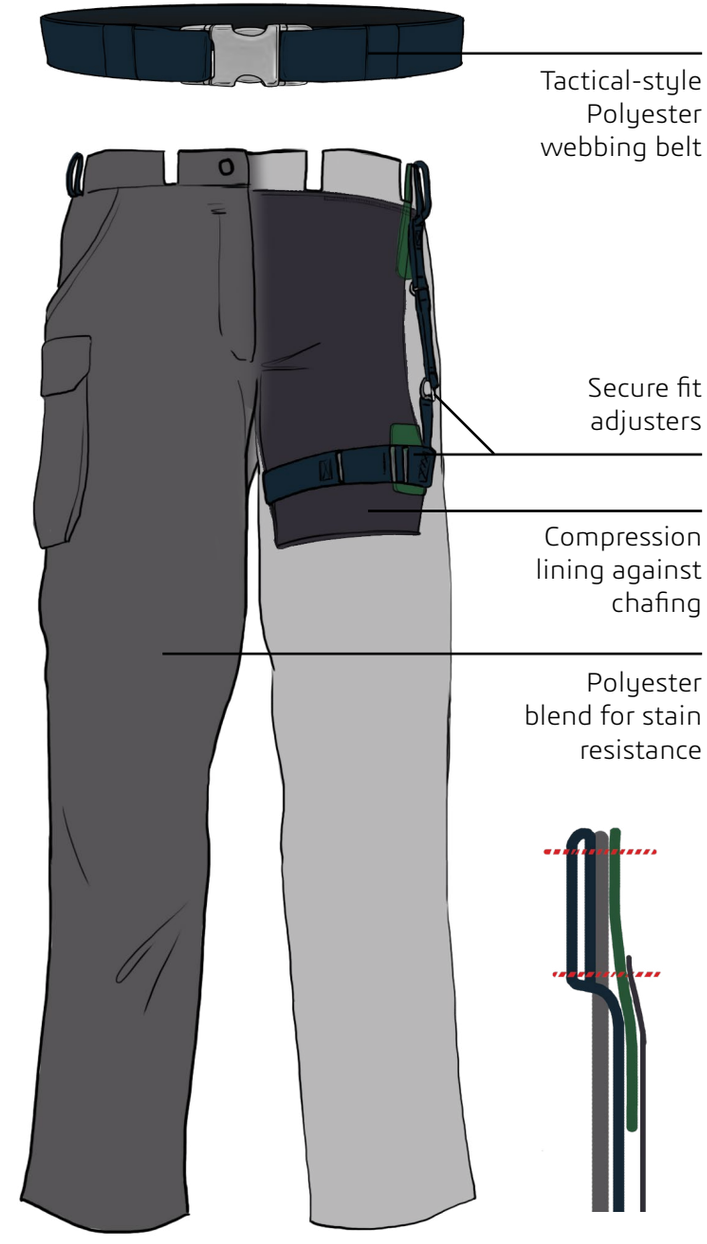
Uniform Construction

The layers of the uniform were carefully considered based on what needed to fit snugly to the body, and what the users preferred to stay loose. Careful consideration of materials and taking into account users' aesthetic preferences were important as well.

Inspiration was taken from parachuting, climbing, and fall harnesses: using tried and true methods of stitching and construction that have been proven to withstand equivalent forces.





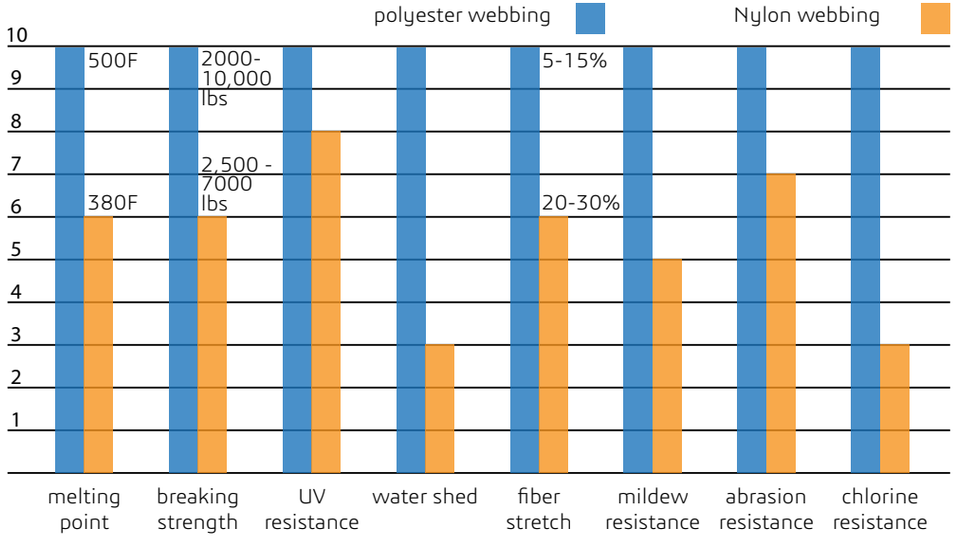


Uniform Material Considerations

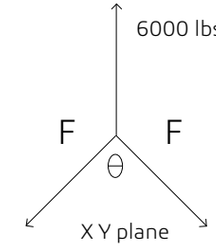
Careful consideration went into choosing the harness material; It needed to have a high breaking strength (6000 lbs in accordance with standards for front compartment seating)and must be abrasion resistant with little fiber stretch. It also had to withstand moisture, since the uniforms must be washed.

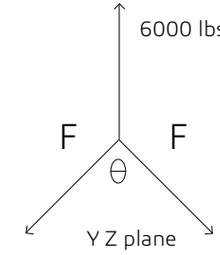
Polyester material proved to meet all those criteria, but thick straps would not do for the integrated harness. Calculations were done to see how thin the straps could be while still maintaining the proper breaking strength, and it was found that because the strops crossed and shared the load, I could go as thin as one inch.

Material Comparison



Force Load was calculated to see if high breaking strength would be maintained with the angles I had specified for the harness.





Force Balance

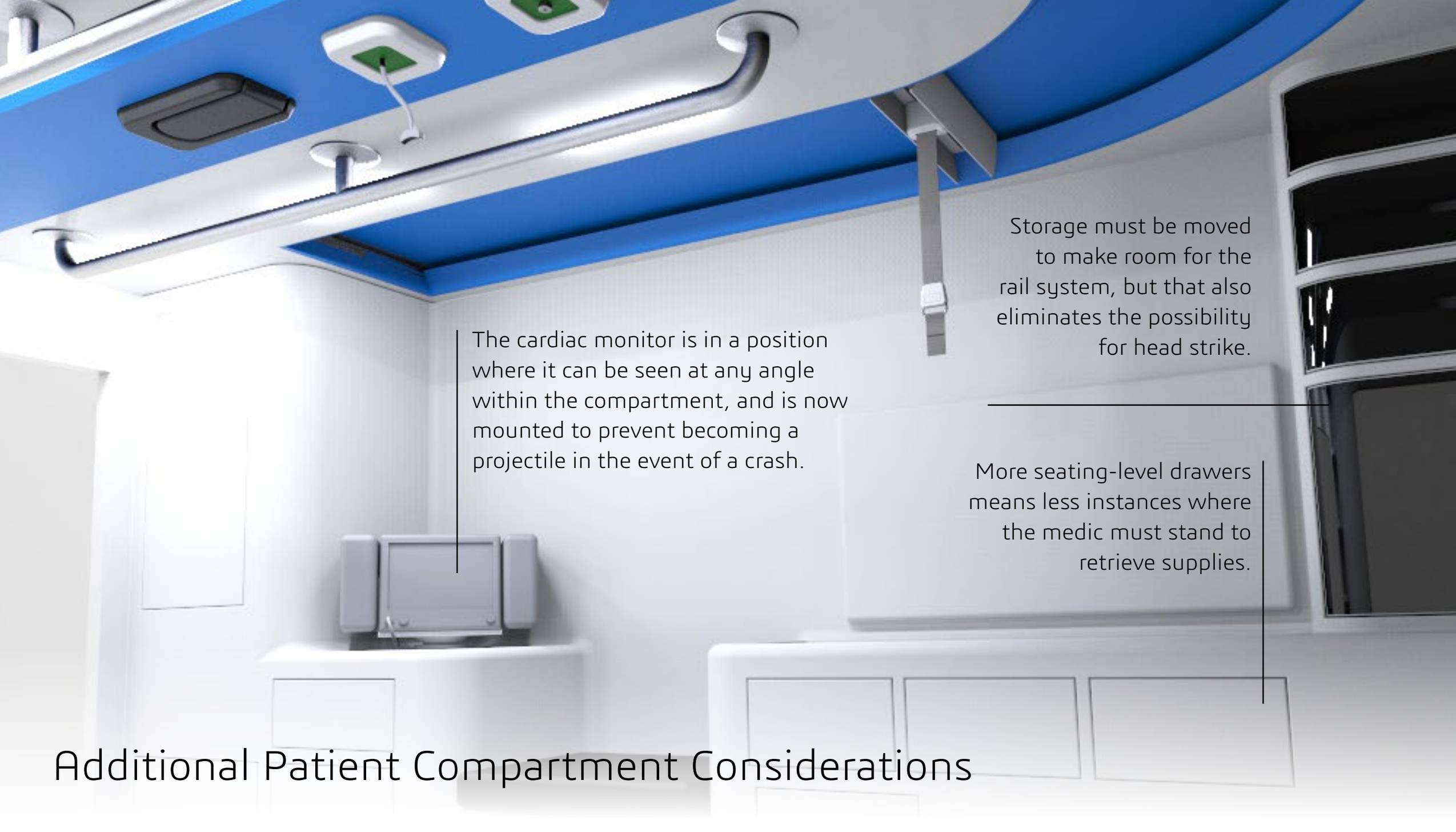
$$6000 = \overbrace{2\,(F\cos\frac{\theta}{2})}^{X\,Y\ plane} + \overbrace{2\,(F\cos\frac{\theta}{2})}^{Y\,Z\ plane}$$

$$6000 = 4\,F\cos\frac{\theta}{2}$$

$$F = \frac{1500}{\cos\frac{\theta}{2}}$$

θ	$\frac{\theta}{2}$	F (lbs)
130	65	3549
120	60	3000
110	55	2615

Type/Width	Thickness	Breaking Strength	Working Load
1 inch	.060 inches	3800 lbs (x2)	1250 lbs
1 ½ inch	.060 - .065 inches	4800 lbs (x2)	1600 lbs
2 inch	.060 - .065 inches	6000 lbs (x2)	2000 lbs
2" (10K- reinforced)	0.085 – 0.090 inches	10,000 lbs	--



Storage must be moved to make room for the rail system, but that also eliminates the possibility for head strike.

The cardiac monitor is in a position where it can be seen at any angle within the compartment, and is now mounted to prevent becoming a projectile in the event of a crash.

More seating-level drawers means less instances where the medic must stand to retrieve supplies.

Additional Patient Compartment Considerations

Value Proposition

This thesis offers to serve as a template within the EMS industry for how to identify and solve user-centered problems that truly address all stakeholders' needs by implementing a transformative application of investigative methods. If EMS equipment manufacturers follow user-advocacy perspectives when developing products and solutions, more meaningful products can be produced that have a higher success rate out in the field.

By implementing a user-centered approach to the problems found within the research stage, this thesis also suggests a viable safety solution that both elevates the safety of the medic while also improving the likelihood for adoption. Long term development and use of this solution can hope to see a decrease in medic fatalities in the event of a crash, keeping them healthy and able to have a longer, more fulfilling career. EMS organizations can also be more assured in their investments, because their workers will stay better able to work for a longer period of time, and ideally adding value to the community service they provide. The public in turn will see the benefit of a solution that allows medics to freely and effectively treat members of the community that call upon them, where they are not hampered in their decision making by the element of danger.

Thank You