//FIRE FIGHTING VEHICLE CONCEPT

Fire may be a devastating and uncontrollable force

Even though extensive research and development has been done, both in the field of fire prevention and fire fighting. On average NOK 3.5 billion is consumed by flames every year in Norway. Additionally, on average, 72 lives are taken yearly. This number is estimated to raise to 100 by 2050 , if severe measures are not adopted.

It is evident that even though there has been an increase in the effort towards making fire-preventive constructions, the trend has also been to introduce both new materials and a greater material volume to furnish these constructions. This has in turn led to an increase in the complexity of the gasses that, during a fire, feed the flames.

The consequences are fires that show a more explosive development and extensive damages, compared to 10 or 20 years ago. According to professional firefighters it is becoming ever more common to arrive at a fire scene that is in a post-flashover state, than earlier.

An additional hazard presented by such fires is the emerging fire gases. The composition of these gasses get more complex and, more often than not toxic, as material complexity increases. This makes the tasks of the smoke-diver even more strenuous as people encountered within the building will have a greater likelihood of being unconscious or dead on discovery. In this hazardous environment it is expected that the men and women of the different Fire Departments perform their duties in order to save both human lives and material values. The firemen are only left with three things to rely on; their own knowledge, their fellow firemen and their equipment.

// SITUATION

//INFORMATION REVOLUTION

In the near future we expect to see various forms of augmented reality entering the fire fighting arena. Already today infrared imaging is available to both smoke-divers and on-scene command. Future projections include on-line capabilities in all response vehicles. This will enable a great enhancement regarding the information that at all time is available to the firefighters and their coordinators. By combining different information carriers and structuring their output both the planning and execution of the fire fighting may be carried out in a more rational and efficient fashion, as well as making the work environment safer for the firemen through better situational awareness.

Interesting technologies include: Temperature sensors in buildings, GPS-tagging of gas-cylinders and other hazardous material, wireless live video/IR-cam feed, telemetry of smoke-divers' health, centralised command and coordination and in-vehicle briefing on the current situation.

// EMPOWERING THE FIREFIGHTER

Extensive use of new materials and technology will lead to lighter, more agile vehicles, capable of performing a number of tasks that today require several vehicles. We envision a divergence from the "mobile toolbox" of today, to a vehicle that empowers the fire-fighter. This can be done through extending the mobility and reach of the firefighter, enhanced protection, information management through augmented reality and more effective fire fighting techniques.

Interesting technologies include: Powered exoskeletons, flexible and lightweight protective clothing, use of robots or robotic implements and the use of partially- or fully automatic systems.

// ACTIVE SAFETY - PASSIVE SAFETY

The natural convergence point to this evolution will be the advent of fire-safe buildings and a higher level of active security embedded in existing constructions. This will greatly reduce the need for fire-fighter intervention and greatly reduce risk to human lives.

Projecting the path to the future

This graphic shows the evolution of the fire-truck as we see it. Clearly marked by three epochs:
Stage 1 - Emphasis on information
Stage 2 - Giving the fire-fighter power
Stage 3 - Constructing to prevent fires

The timescope for the different stages of this development is clearly not fixed. However, based on the rate of replacement in the main fire-departments in Oslo, Bergen, Trondheim and Stavanger, a vehicle usually serves 5-10 years at the primary brigade before being modified, reassigned to a less critical duty or sold off to another department with lower overall activity.

The total service life of the vehicle often exceeds 20 years.

Due to the "longevity" of current (stage 0) fire-trucks, our estimates puts the implementation of the first stage in 3-8 years time. This concept, though feasible in the very near future, will be a part of stage 2.

The technology applied in this concept exists today in one form or another. However, based on current budgets and the cost of this technology today, we do not expect to see vehicles with similar capabilities implemented in the immediate future.

// SCOPE

In what world will this vehicle be put into service?

What are the political, economic, social, technological, environmental and legislative aspects that need to be considered?

According to the UN-report "World water in 2025" water will be a scarce resource. Global warming will increase the demand for artificial irrigation. Three different developments are proposed, known as BAU (Business-as-usual), TEC (Technology, Economy and Private sector) and VAL (Values-and-Lifestyle) . Of these three, only VAL and, to a certain extent, TEC are sustainable. The former representing a change in lifestyle to reduce personal water consumption in developed countries, the latter a development of technology to extract and distribute potable water in water-stressed areas and probably trade of water, even across continents.

Current U.N. estimates expect world population at 7.0 to 9.6 billion in 2025 with a medium prognosis of 8.5 billion. A 2006 EU report projects the loss of as much as 1/2 the arable land in Africa and 1/3 in South-East Asia by 2025 due to global warming. These factors combined may lead to massive migration of refugees to less densely populated areas. The result will be an increase in the population-density and growth of European urban areas.

Even today we have the technology to create materials far stronger and lighter than steel, the common foundation of current heavy vehicles. By implementing composite materials, ceramics, and light-weight alloys we may produce vehicle-platforms that are lighter, stronger and allows for greater flexibility.

The increased stress on conservation of water will lead us to reconsider current fire fighting tactics. We expect a change towards use of foam systems (CAFS), 3D-firefighting and water-mist to effectively maximize the extinguishing potential of water.

Regulation of emission of CO_2 and other climate gasses has already led to the introduction of plug-in hybrid and all-electric personal vehicle platforms. We expect this technology to spread to urban and interurban transportation as well, maybe even to long-distance road-trains.

// SETTING

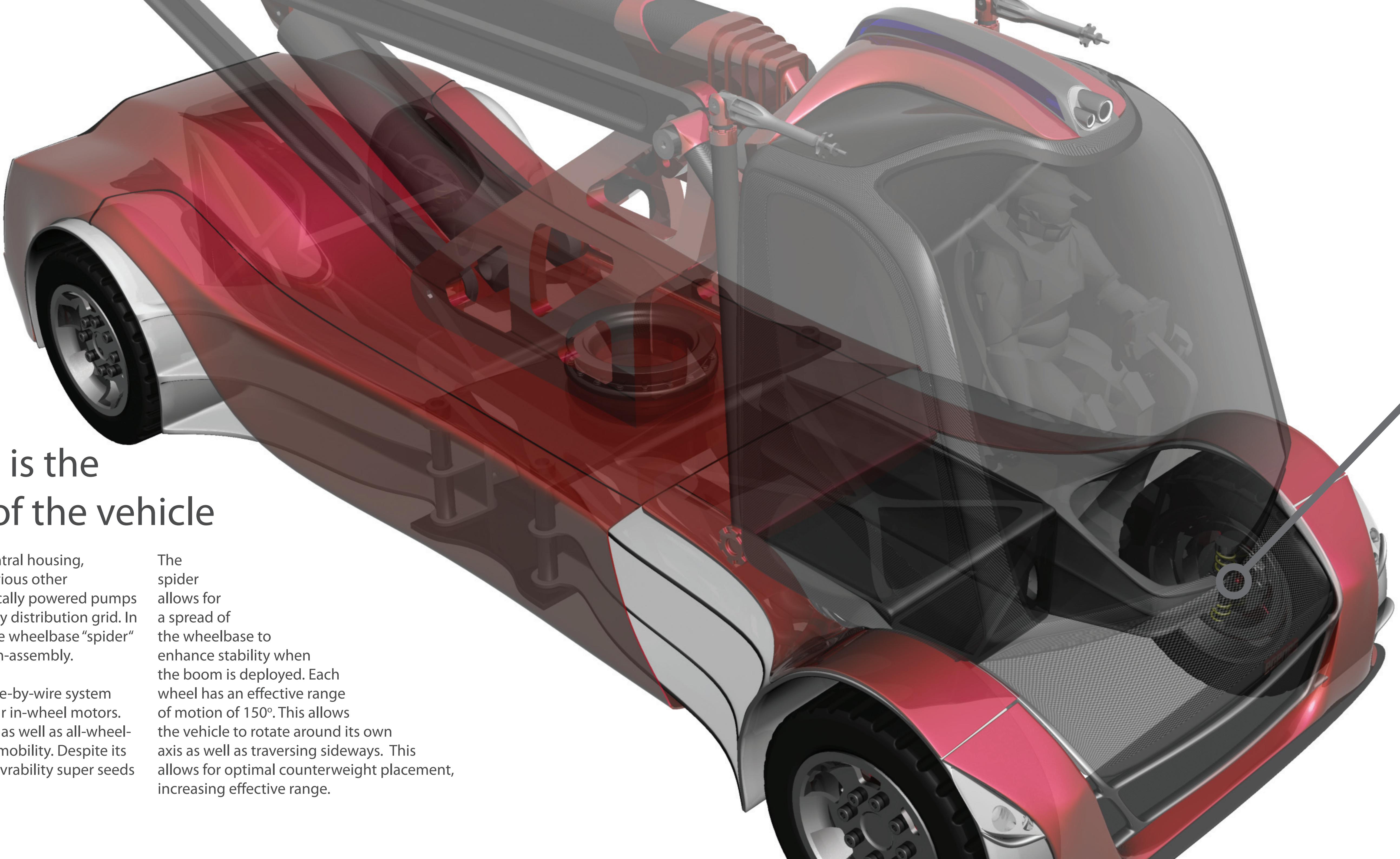
A plug-in hybrid platform enables flexible energy distribution

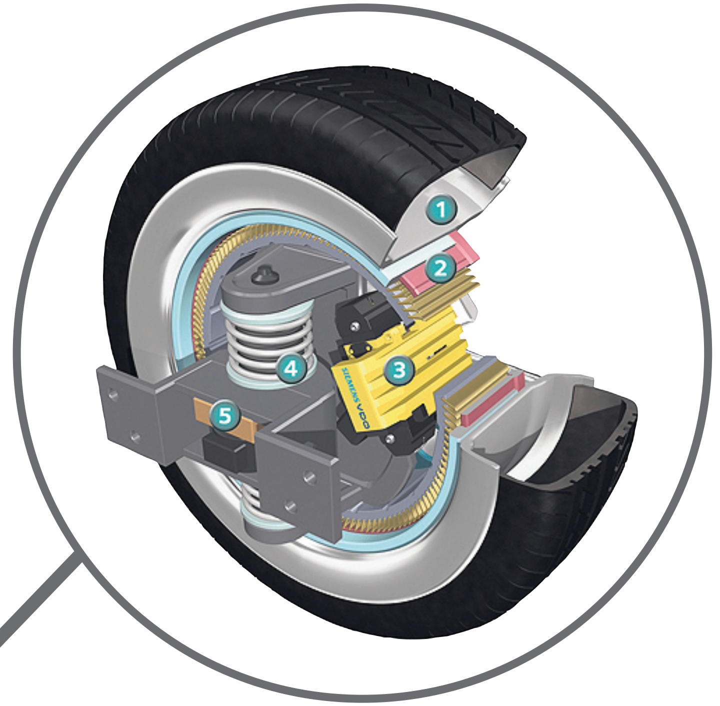
The foundation of this concept is a plug-in battery base with the option to implement fuel-cell or a diesel-electric system to form a hybrid vehicle. Adapting this technology makes it possible to create a highly flexible platform containing a number of hard points where it is possible to tap electric energy for various purposes. The main advantage of this system is its inherent flexibility, both in the type and placement of components to assemble a vehicle that will meet the requirements of the customer.

All-electric drive-by-wire propulsion is made possible by using an in-wheel-motor assembly, performing the duties of suspension, steering and transmission. Thereby eliminating all mechanical transmission, freeing valuable volume and reducing weight. This volume is then available to house necessary equipment, thus making the vehicle more compact and at the same time affording more flexibility. The vehicle may easily be upgraded to adopt new technologies or even modified if it is assigned to an other application.

An all-electric propulsion system is projected to utilize up to 85 percent of the total energy potential whereas current gasoline and diesel engines have a total transmission loss of more than 50 percent. The plug in option makes the platform both flexible, with regard to energy source, and thereby economic in use.

// FOUNDATION





The chassis is the backbone of the vehicle

This chassis consists of a central housing, containing batteries and various other components such as electrically powered pumps and in itself forms the energy distribution grid. In addition it contains a flexible wheelbase "spider" and the mount for the boom-assembly.

An electrically powered drive-by-wire system is implemented through four in-wheel motors. This permits all-wheel-drive as well as all-wheel-steering, greatly increasing mobility. Despite its long wheelbase, its manoeuvrability super seeds current platforms.

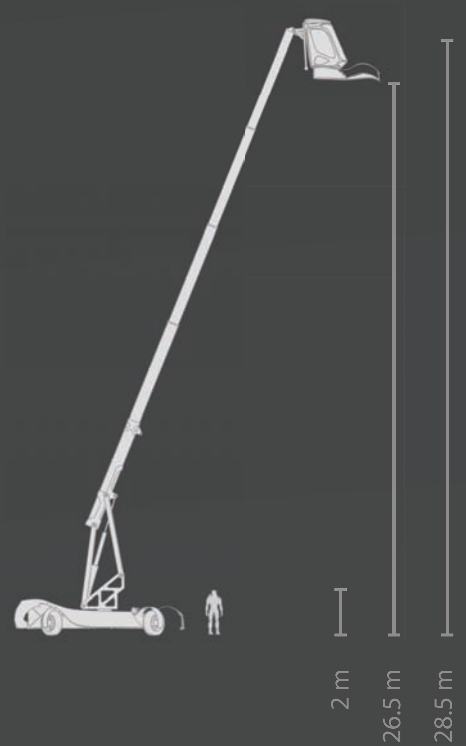
The spider allows for a spread of the wheelbase to enhance stability when the boom is deployed. Each wheel has an effective range of motion of 150º. This allows the vehicle to rotate around its own axis as well as traversing sideways. This allows for optimal counterweight placement, increasing effective range.

// CHASSIS

The "spider"-function increases stability by widening the base of the vehicle, effectively eliminating the need for stabilizers

The 150° range-of motion of the in-wheel motors allow for deployment and retraction of the "spider" even when the vehicle is stationary. It also allows for a "crabbing" motion of up to 60° left or right as well as traversing sideways.

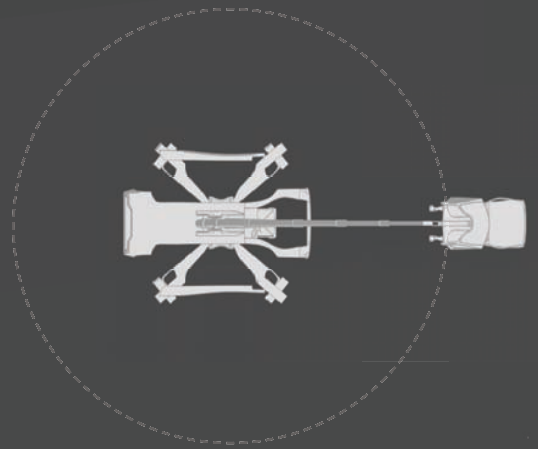
This procedure widens the stance from 240cm to 540cm enhancing stability when the boom is extended.

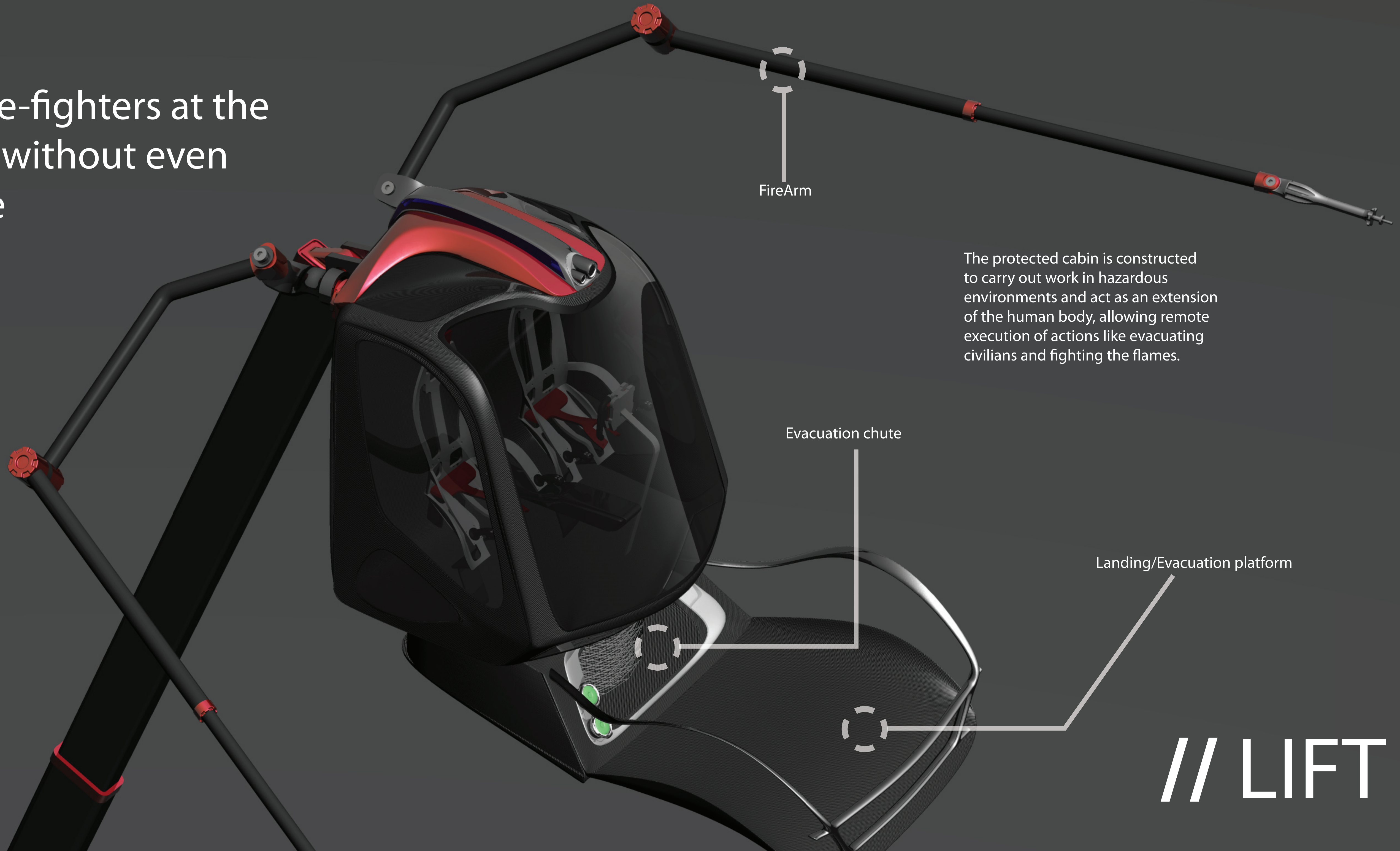


The lift puts the fire-fighters at the heart of the scene without even leaving the vehicle

In order to effectively perform their duties, the fire fighters need protection that does not limit their mobility. The protection of this vehicle enhances the mobility of the firefighter by using a telescopic carbon fiber boom. Providing a maximum working height of over 26.5 meters and eye-level height of more than 28.5 meters.

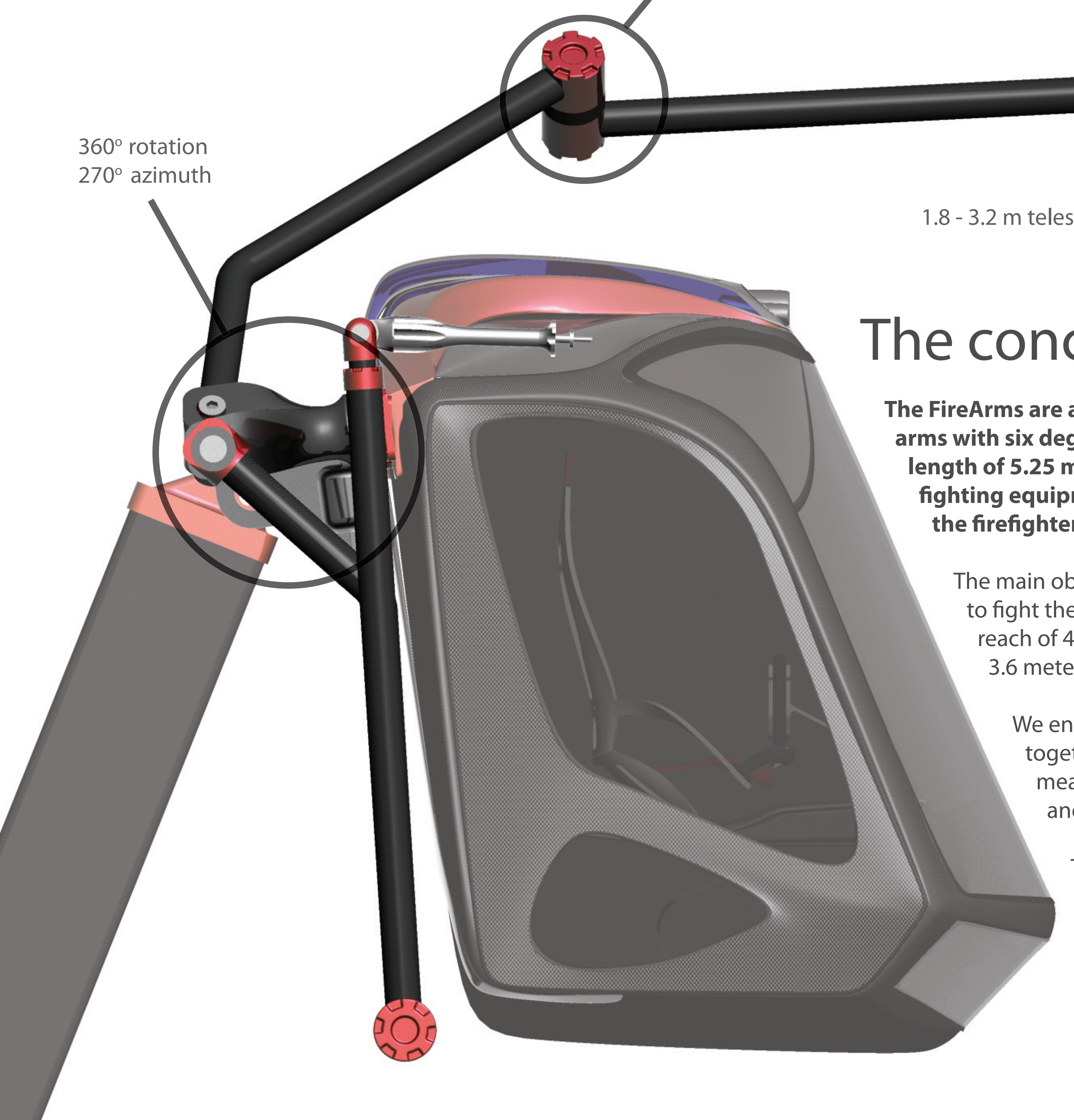
The boom rotates 360 degrees in relation to the base, providing complete freedom with regards to positioning the vehicle.





The protected cabin is constructed to carry out work in hazardous environments and act as an extension of the human body, allowing remote execution of actions like evacuating civilians and fighting the flames.

// LIFT



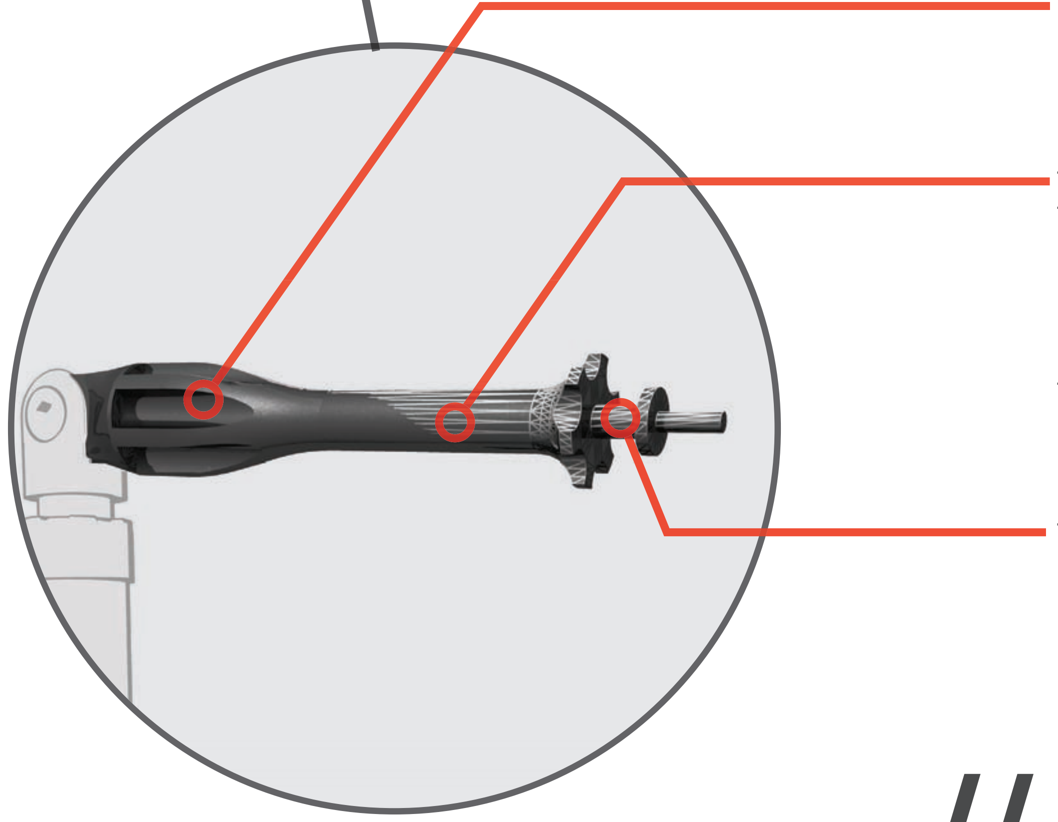
The concept of FireArms

The FireArms are a pair of remotely controlled robotic arms with six degrees of freedom and a total extended length of 5.25 meters. These carry sensors and fire-fighting equipment and effectively extend the reach of the firefighters in the cockpit.

The main objective is to give the firefighters the ability to fight the fire at "an arms length". With an effective reach of 4.5 meters and a stand-off distance of up to 3.6 meters, that's exactly what the FireArms do.

We envision the arms to be particularly efficient together with a cutting-extinguisher or other means of intrusive extinguishing technologies and techniques.

The two arms are controlled by the two operators through a haptic interface. Each operator controls one arm.



The nozzle type may be changed to fit client requirements. We envision a multi-purpose nozzle which comprises of a mixing chamber/pressure chamber, a pre-heater and a variable-geometry nozzle.
This unit is specialized for 3D-firefighting.

The mixing/pressure chamber allows for rapid change between the different modes: Foam, water-mist, water-cutting and traditional spray/stream.

The preheating chamber allows for preheating the water. This is especially useful in conjunction with water-mist. A steam-pressure above 30% of 1 ATM, will displace enough oxygen to render the air inert (O_2 < 15%). The saturation pressure of steam in air exceeds 30% above70°C.

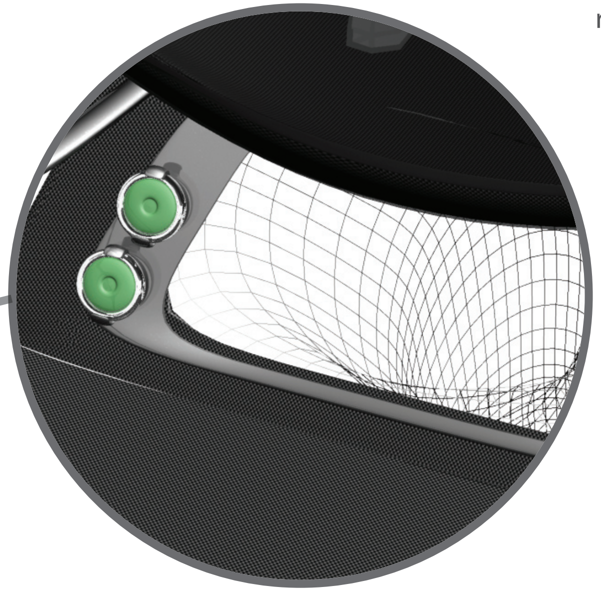
To fight a kindling fire in a confined low-temperature space, steam may be more efficient than water-mist.

The variable-geometry nozzle allows for adjustment of droplet size and spread-pattern to ensure that the water is used as effectively as possible.

// FIREARMS

The platform provides a quick way to safety, but also an elevated entry-point

Though intended for life-saving through evacuation, it is also possible to use the platform as a means of entry, providing an entry point for smoke-divers at up to 26.5 meters. A height that corresponds to the 7th or 8th floor. This saves time and air, resources that are in demand among smoke-divers.



The evacuation chute is a safe and effective escape route, enabling mass evacuation in minutes.

It requires no training to use and has an evacuation potential of more than 10 persons per minute. The chute is faster than a ladder, it gives the evacuees a greater feeling of safety and, with minor modification, it is even possible to evacuate unconscious persons safely and rapidly.

The technology is in wide-spread use on off-shore installations and in some various high-rise buildings as a mean of public evacuation.

The evacuation chute is contained in compartment underneath the cabin. This is exposed when the platform is extended. For coordination purposes and efficiency it is favorable, but not necessary, to have an evacuation-supervisor on the platform.

// PLATFORM

The Bionic fireman

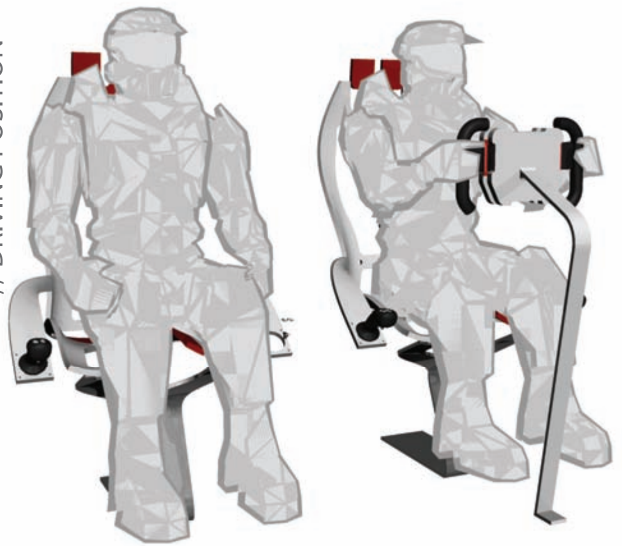
One of the main objectives with this concept has been to link the fire fighter closer to his equipment.

A fire fighter is committed to carry out his work in a hazardous environment with only his clothing, his helmet and his knowledge of fires to protect him. Therefore, instead of developing yet another passive fire engine, our objective has been to develop a vehicle that acts more as an extension of the fire fighter rather than a mobile toolbox.

A similar approach has been applied to the Rosenbauer Panther, protecting the fire fighters from airport fires while at the same time increasing efficiency.

// HUMAN FACTORS

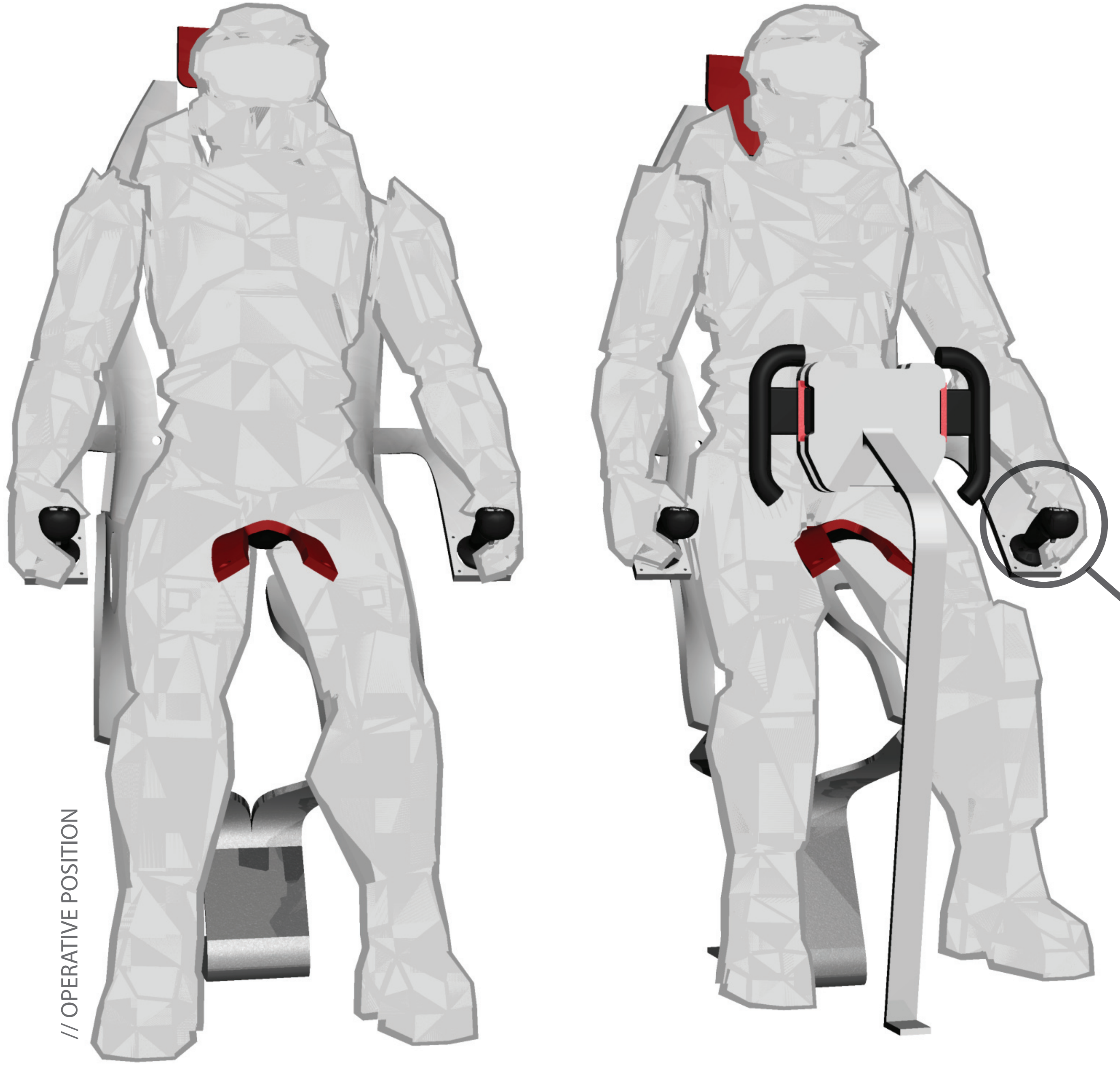
// DRIVING POSITION



Working position adapts to the user

To help fire fighters perform optimally, this vehicle allows them to work in a more-or-less upright posture. In addition to giving the user better overview, the upright position also makes it easier to commit to the situation as adrenalin levels are naturally heightened. The firefighter is put face-to-face with the fire, so to speak.

To ensure a flexible and stable working posture when in the upright position, the seat is constructed to emulate a motorbike saddle. This feature improves lateral stability by working as a support to the upper thighs and reduces strain.



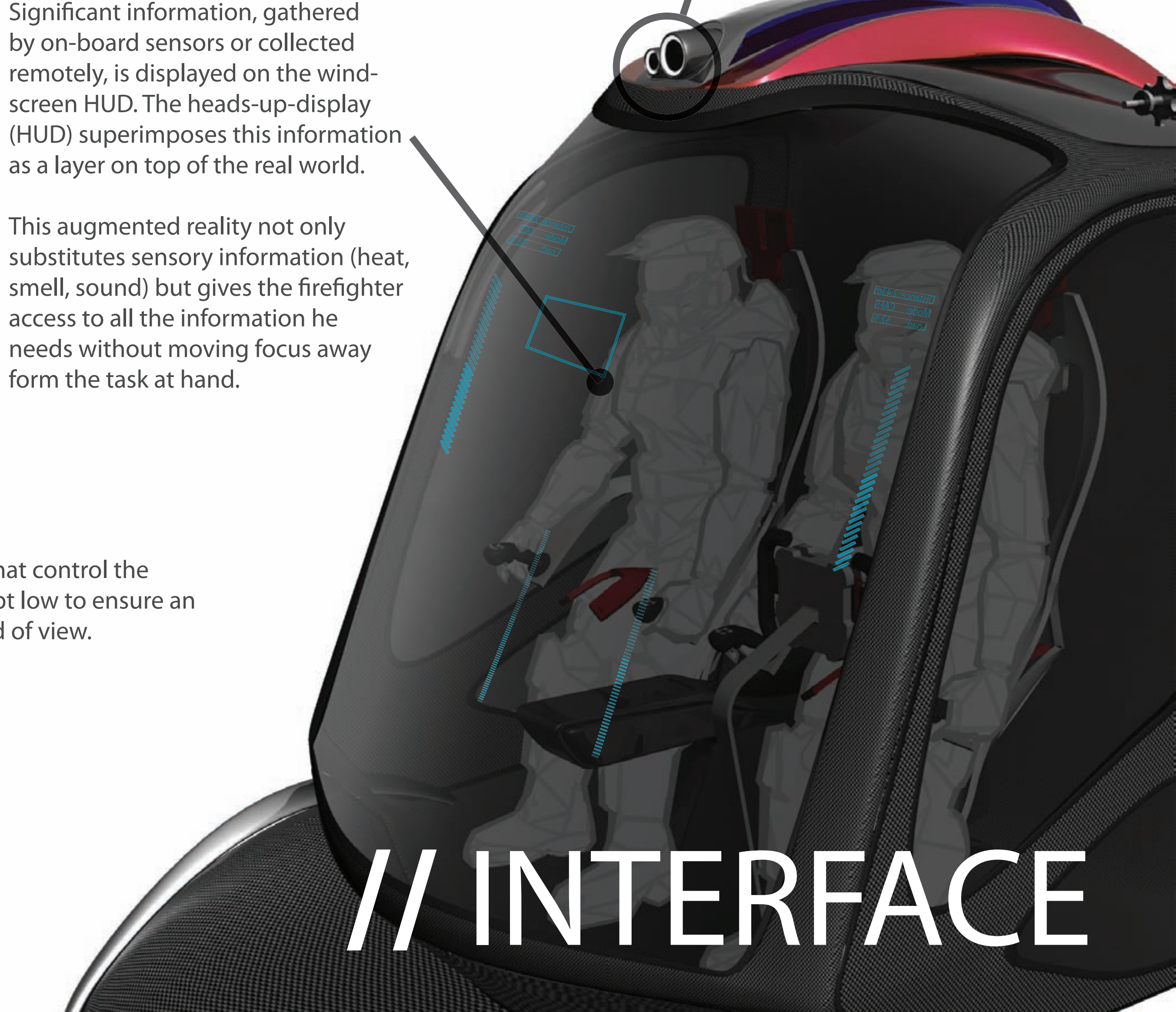
// OPERATIVE POSITION

In addition to housing the emergency lights, the "Mohawk" also contains a high-definition video camera and IR-sensors. This information is used to increase situational awareness. Sensor-information and video-feed is shared between the vehicles and on-site command.

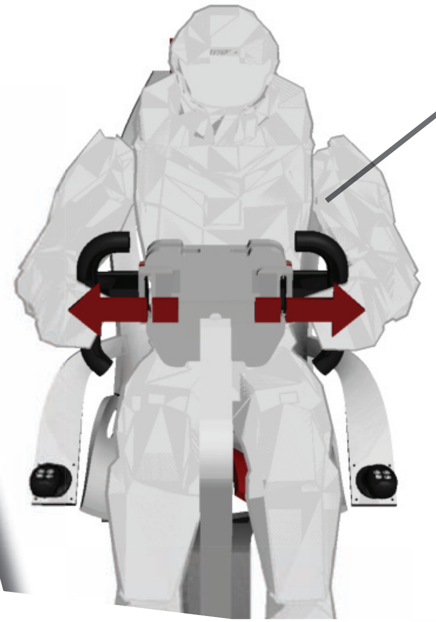
Significant information, gathered by on-board sensors or collected remotely, is displayed on the wind-screen HUD. The heads-up-display (HUD) superimposes this information as a layer on top of the real world.

This augmented reality not only substitutes sensory information (heat, smell, sound) but gives the firefighter access to all the information he needs without moving focus away form the task at hand.

The interfaces that control the FireArms are kept low to ensure an uncluttered field of view.



// INTERFACE



Simultaneously pulling the two handlebars outwards, alternates the interaction of the vehicle. This mode allows the operator to position the spread.

Managing two distinct tasks

Flipping the handlebars inwards and pushing them forward locks the rotation around the x-axis. This also activates the vertical manipulation mode for of the cabin.

// VERTICAL MANIPULATION MODE

To communicate the multi modal purpose of this vehicle, the most direct link between the machine and its operator has also been given a multi modal interface. The main operator of the vehicle has to manage two very distinct tasks, namely to drive the vehicle itself in transit, as well as operating the boom on-site. In addition, the main operator may also be obligated to control the left FireArm. It is therefore critical to physically separate the controls to ensure that the operator has to take deliberate actions in order to ensure that only the intended action is carried out.

// INTERFACE

Form and Function

A fire engine is not an asset if operated incorrectly. Although the engines are manned 24 hours a day by trained personnel, the equipment is often operated by different users.

To limit the cognitive load of each user, it has become more common to encode the interface of the fire engines. The encoding in this concept has been taken a step further, by also coloring the valves and connection points that the fire fighters operate most frequently.

The shape of the vehicle emphasizes functional areas through its swept lines and visually "flowing" shape. The rear bulge not only balances the vehicle aesthetically, it also contains counterweights and/or optional equipment along with hoses and cables.

For this concept we have fitted the vehicle with an electric water-pump. Below the bumper, a smaller compartment houses the winch. The flexibility of the platform enables upgrading as new demands rise and/or new technology is available.

// EQUIPMENT

This booklet is an abridgement of the master-thesis "*Concept development of rescue vehicles*" undertaken at The Norwegian University of Science and Technology (NTNU), Institute for Product Design, spring 2008.

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