



Alternatively Powered Vehicles



Aim

To introduce staff to –

- The problems associated with hybrid, electric, hydrogen and gas powered vehicles.



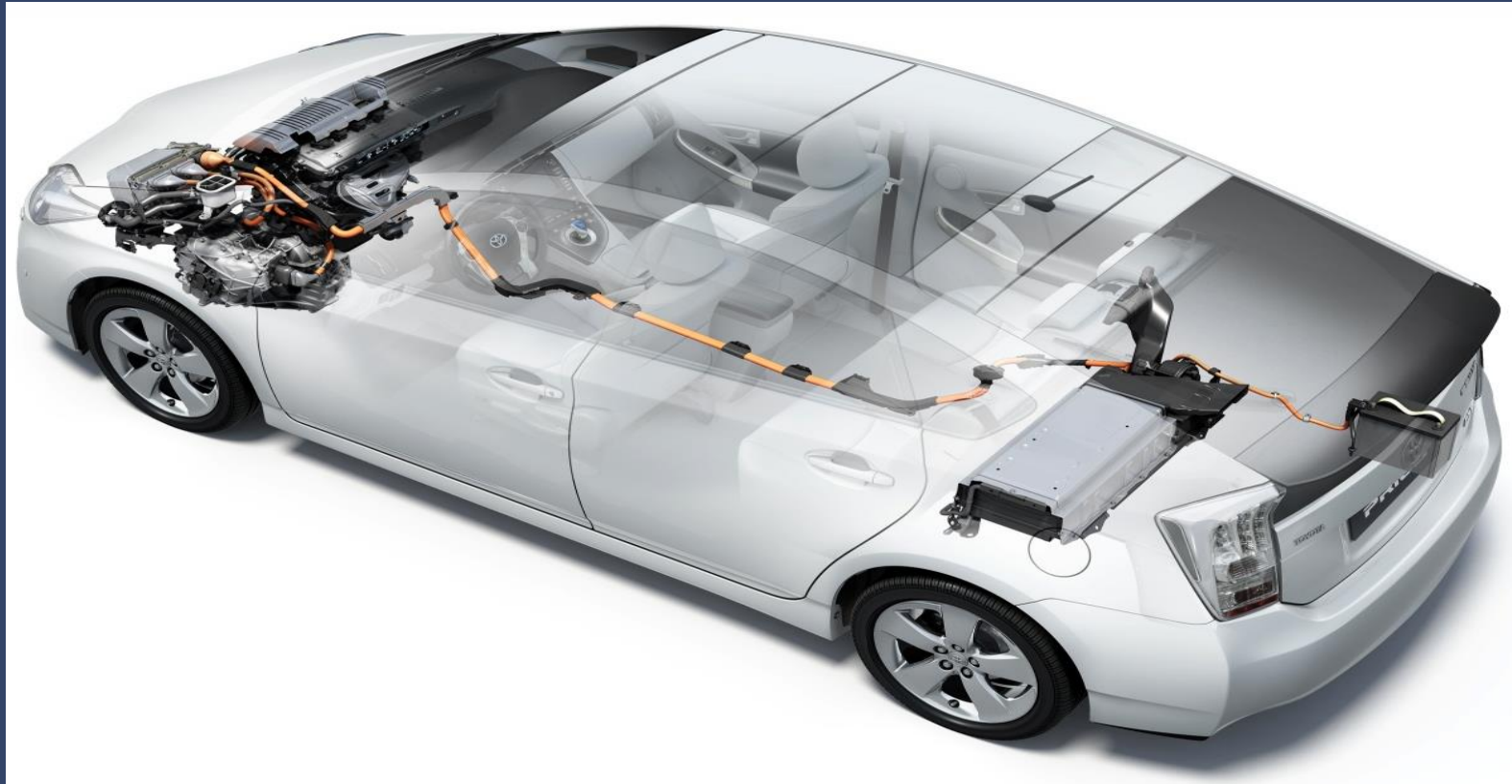
Objectives

At the end of the session personnel will be able to:-

- Identify the various types of alternatively powered vehicles
- State the hazards associated with each vehicle type
- State the safety procedures when these vehicle types are involved in an RTC.

Hybrid Vehicles

Examples - Toyota Prius Hybrid Synergy Drive



Toyota & Lexus are the most numerous hybrids in the UK, although most manufactures have some hybrid models.



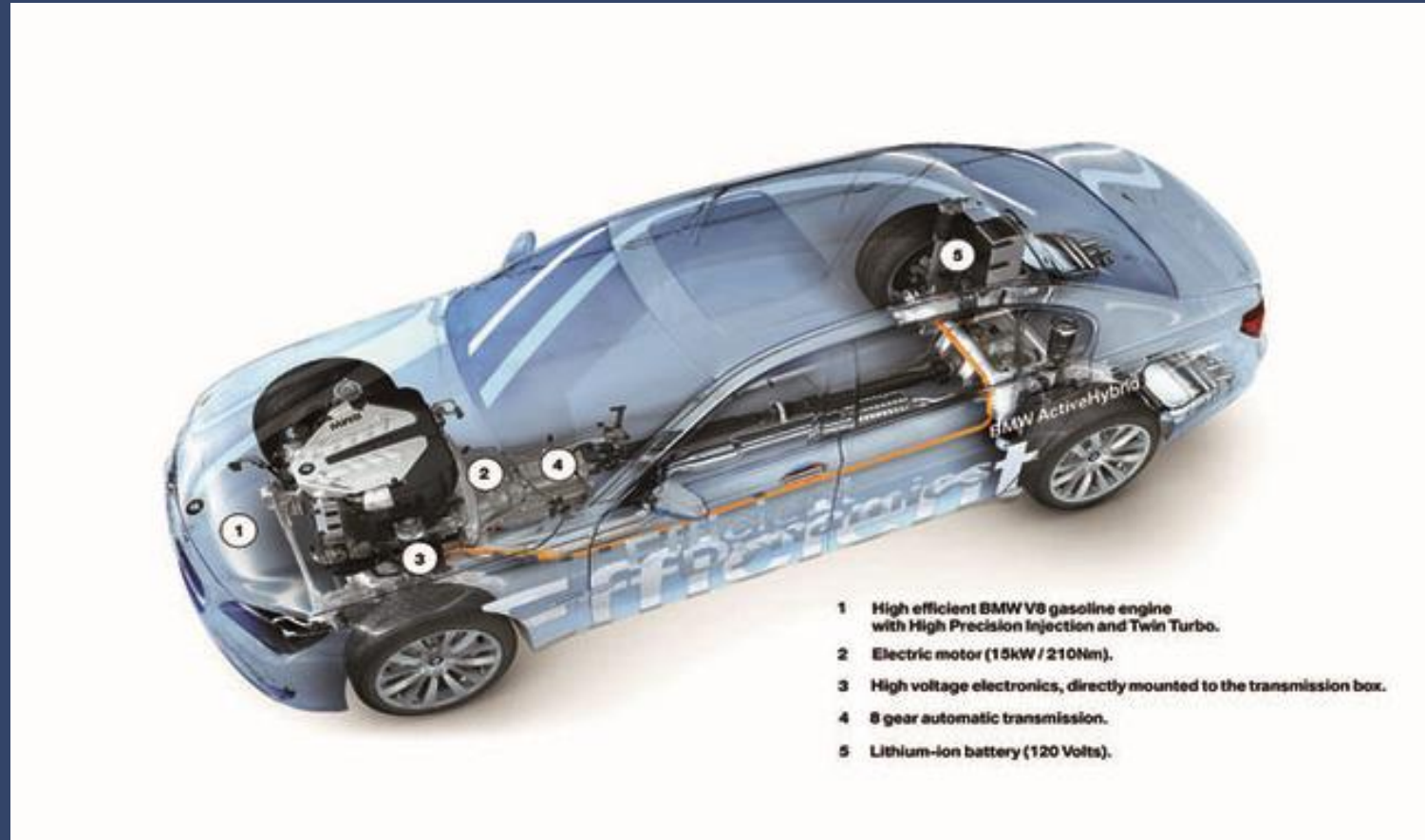
Hybrid Vehicles

Examples - Lexus 200h Hybrid Drive



Hybrid Vehicles

Examples - BMW Active Hybrid – 3,5 & 7 series



Hybrid drives not only limited to small & medium cars.

Hybrid Vehicles

What are they ?

- Hybrid vehicles are a combination of either a petrol or diesel engine with an electric motor/battery. This improves both MPG and emissions

What are the hazards ?

- Battery with high voltage cabling (100v-650v, usually 330v)
- Silent running
- Vehicle still powered – movement and systems still live (ready mode)
- Battery contents can intensify a vehicle fire.

Hybrid Vehicles



Orange high voltage cabling as seen from engine compartment.

See PowerPoint 7a – ‘Hybrid Vehicle Categories’ for further information



Hybrid Vehicles

Built in safety features

- Automatic high voltage safety cut off in the event of an RTC
- Short circuit fuse to cut high voltage power
- Isolated +ve and -ve cabling to prevent electrocution from the vehicles body
- System shut down when ignition is turned off or high voltage fuse / service plug removed.

Note – all of these safety features only shut down the power from the HV battery.

The battery itself will remain energised.

Electric Vehicles (EV's)

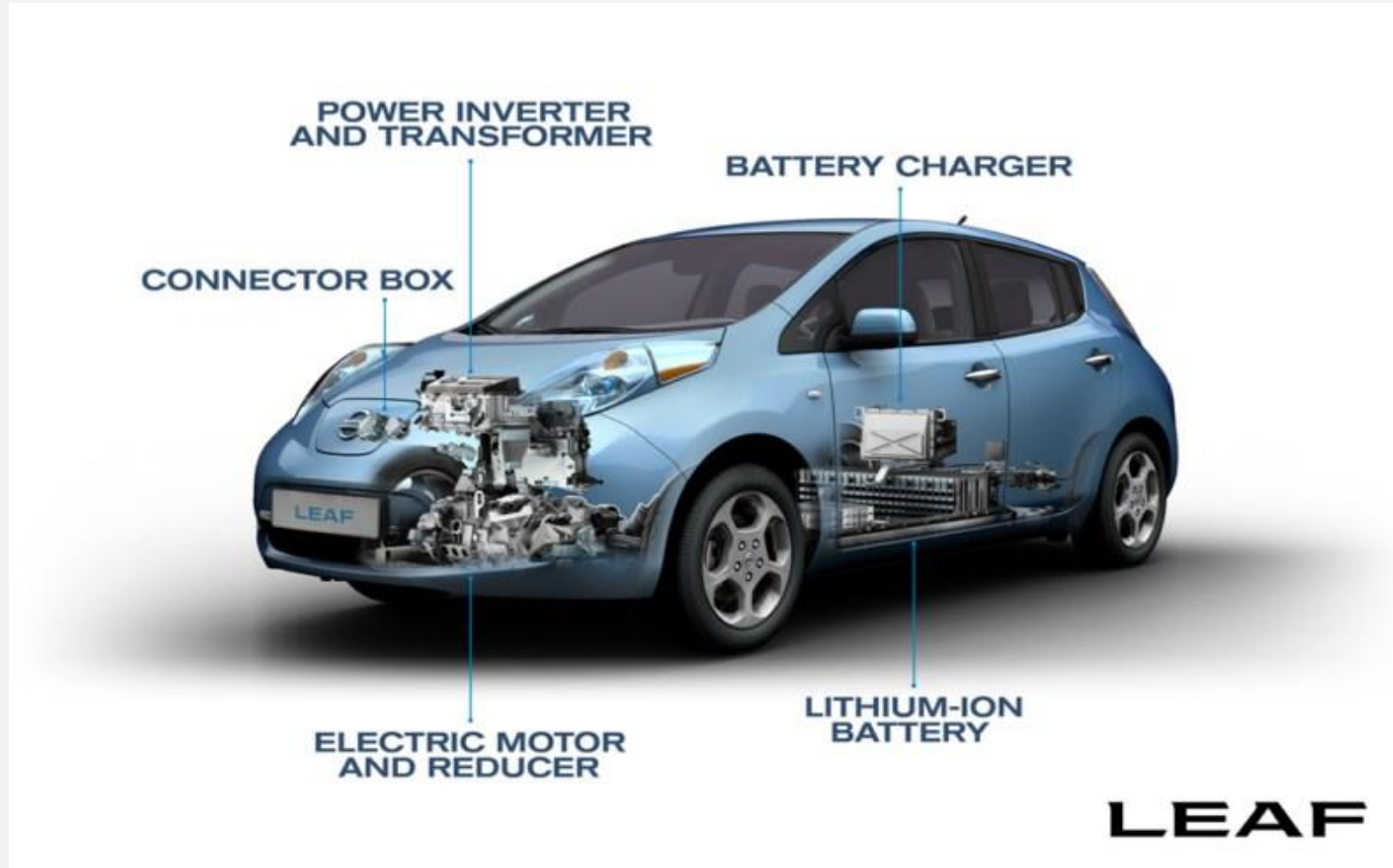
More EV's are on the road than ever, example types include:





Electric Car

Nissan Leaf Electric Car:



Electric Vehicles

What are they ?

- Pure electric vehicles are only powered by an electric motor with a large battery pack usually within the floor pan

What are the hazards ?

- Battery with high voltage cabling (100v-650v, usually 330v)
- Silent running
- Vehicle still powered – movement and systems still live (ready mode)
- Battery contents can intensify a vehicle fire
- Unusual weight distribution if vehicle is in a position other than on all 4 wheels.
- Release of dangerous gases if battery contents is damaged / split
- Energy can be reproduced from the wheel sets if the vehicle is winched / dragged
- Accidental damage to the battery compartment caused by incorrect ramming, spreading, drilling
- Charging cable cannot be released from vehicle when on charge without payment card / phone app

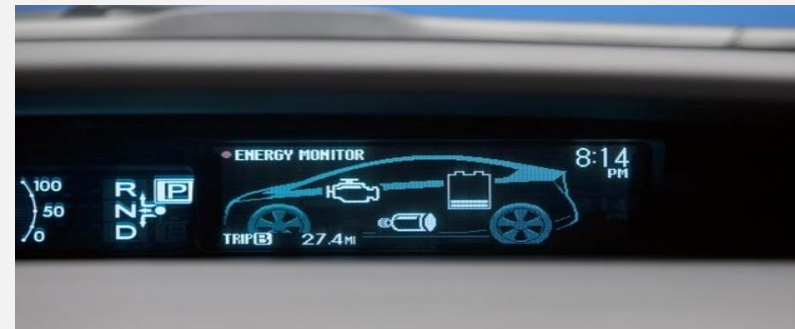


Hybrid & Electric Vehicles

Cable Markings



Typical hybrid dashboard



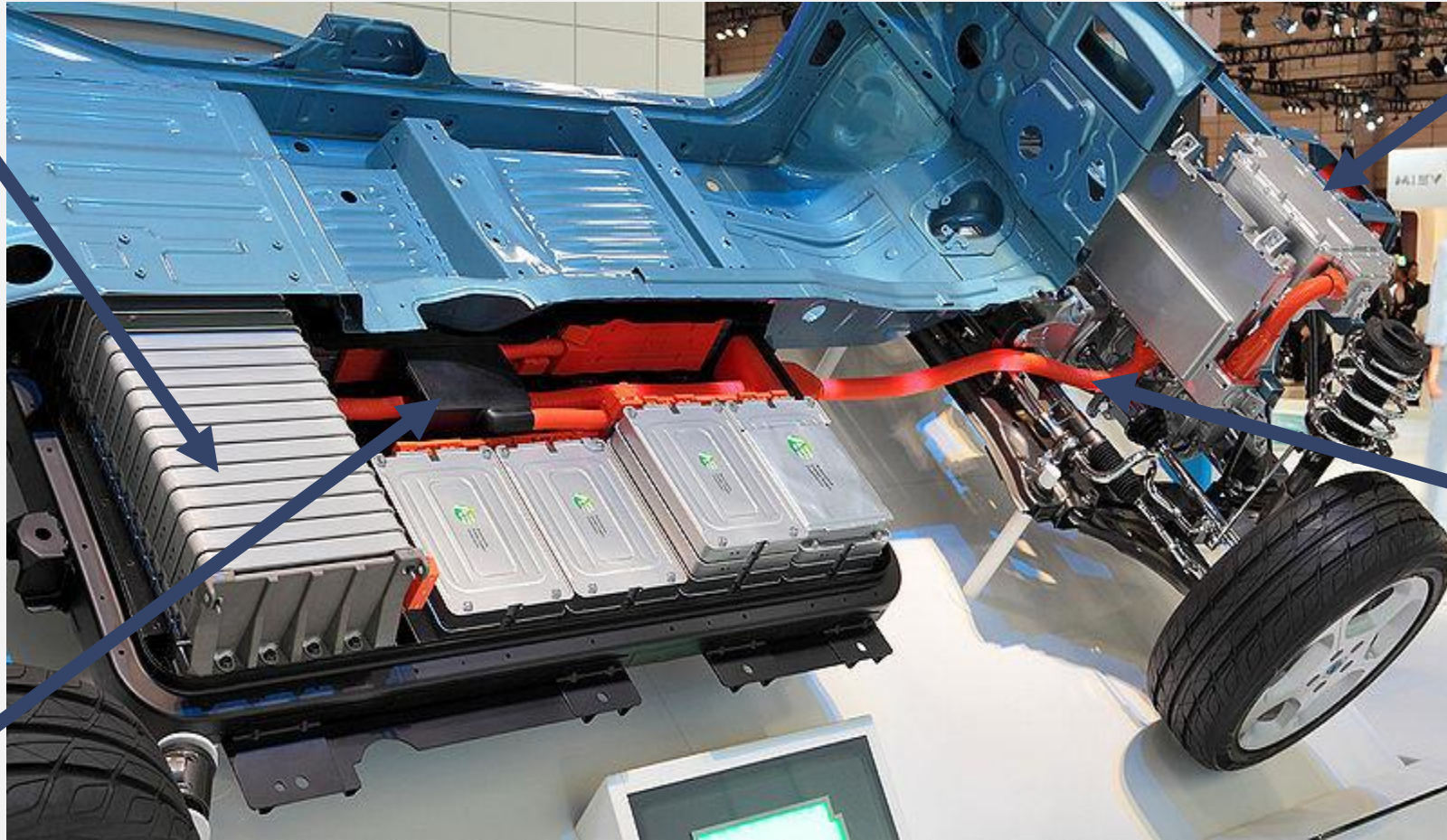
Nissan Leaf electric vehicle dashboard



Electric Car

Nissan Leaf Electric Car:

Battery Bank
/ Cells
Battery Weight
294KG



Motor

High Voltage
Cables

Service / Isolation
Plug

“New” Electric Car Indicators

Charging Port



No Grill or “fake”
Grill with No air flow

Number Plate



Badges



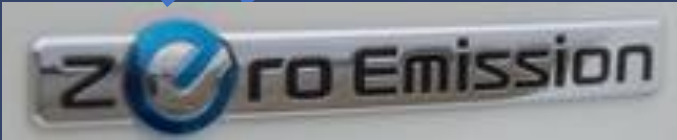


“New” Electric Car Indicators

No Exhaust



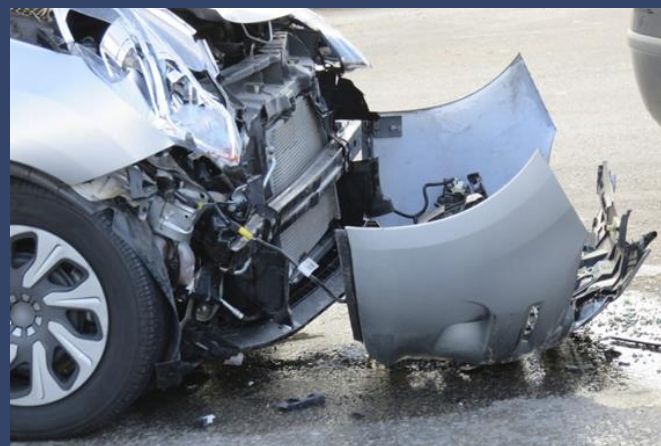
Badges



3 x Levels of EV / Hybrid Impact Collisions

3 x Levels

- Light Collision Impact
- Medium Collision Impact
- Severe Collison



Light Impact Collision Assessment

Light Impact Collision Assessment:

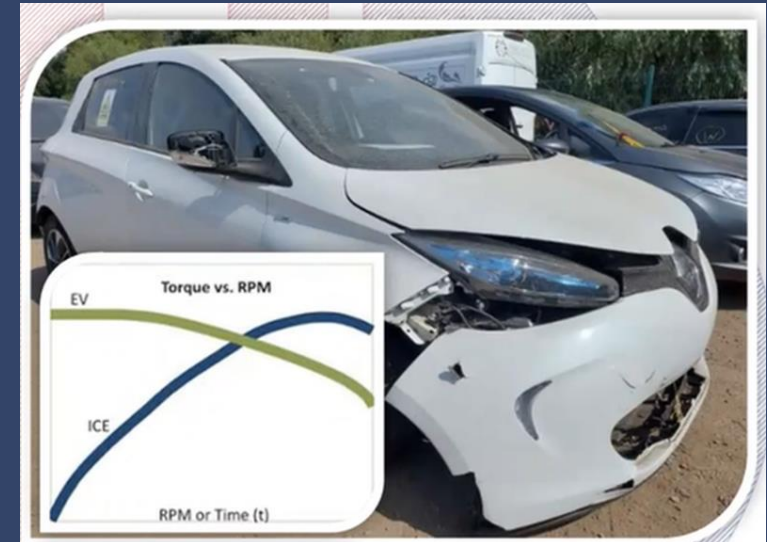
- Light damage to the vehicle panels with shut lines accessible
- SRS & devices remain in a passive state/not deployed
- Vehicle live “Ready” or EV standby symbol lights illuminated
- Lower speed / Lower Impact forces involved (MOI)
- Vehicle is silent and does not appear to be running



Light Collision Impact Risks and Hazards

Risks & Hazards:

- Vehicle is silent, but may be live and can be propelled forward or backwards without indication
- Due to the high torque ranges associated with electric, hybrid and fuel cell vehicles sudden movement will be with a significant force and propulsion
- Risk of Electrocution if you touch the High Voltage Components with out the correct level of PPE
- Standby mode active, approach from safe angles



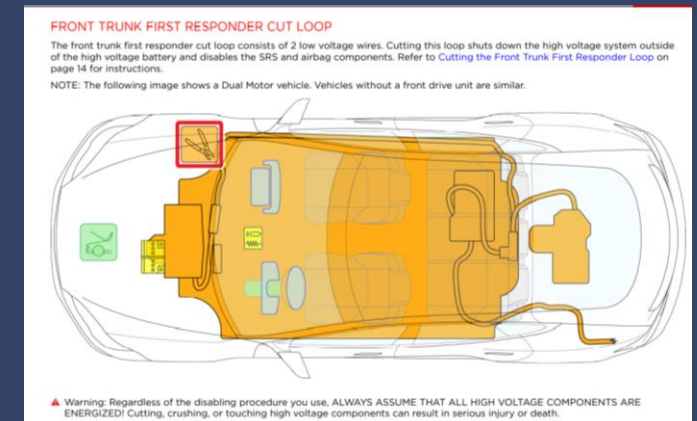
Light Collision Impact Considerations

- Identify Vehicle type
- Use crash data to support information gathering
- Communicate vehicle type to all personnel and other agencies
- Write propulsion type on vehicle
- Approach from safe angles and chock all 4 x wheels
- Apply handbrake and put into “Park”
- Utilise 12 Volt internal electrics to assist with space creation (operate seats, windows, handles, boots etc)
- Remove Vehicle Key or phone
- Perform vehicle shut down procedure: Disconnect low voltage (12V battery) or cut the low voltage emergency responder cut loop to manage the high voltage system
- Residual High voltage system may take time to drain
- Consider monitoring of High Voltage Systems with TIC
- Ensure incident handover sticker is completed



Emergency Responder Cut Loops

- Manufacturers have started to introduce “Emergency Responder Cut Loops” within the EV design
- Use Crash Data to locate cut loop
- This provides crews with an alternative option to disable the High Voltage System
- The cut loop is wired from the LOW VOLTAGE battery feed
- Cutting the loop is the same as disconnecting the 12 Volt Battery
- Cutting the Responder Cut Loop might be an easier way for crews to down power the High Voltage Systems
- Ensure you cut both sides of the loop and remove the section to prevent any accidental connection
- This will break the circuit and assist with down powering the High Voltage System



Medium Collision Impact Assessment

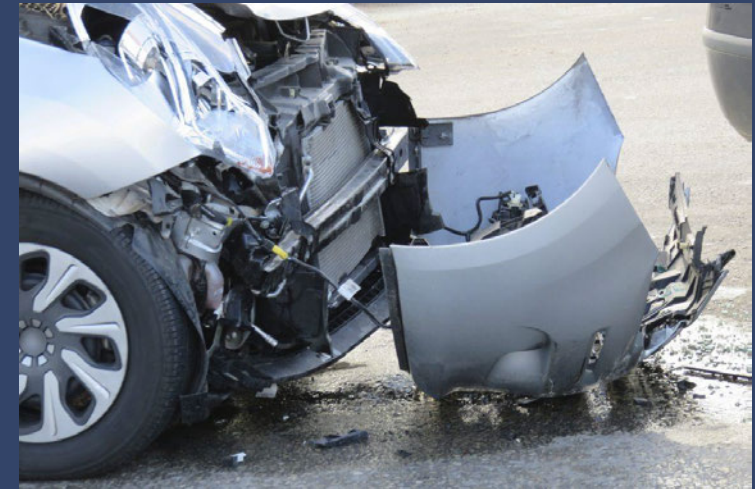
Medium Impact Collision Assessment:

- Medium damage to the vehicle panels with shut lines compressed / damaged, broken glass
- SRS & devices have deployed and airbags are visible
- Vehicle live “Ready” or EV standby symbol lights illuminated
- Higher Speed and Larger Impact forces involved (MOI)
- As a result of airbag deployment the HV control module will lose power and isolate the HV battery.
- Be aware of residual charge left in capacitors
- Crews to remain diligent



Medium Collision Impact Risks & Hazards

- Vehicle is silent, but may be live and can be propelled forward or backwards without indication
- Due to the high torque ranges associated with electric, hybrid and fuel cell vehicles sudden movement will be with a significant force and propulsion
- Risk of Electrocution if you touch the High Voltage Components with out the correct level of PPE
- Vehicle may not have shutdown (Electrical Fault)
- Ensure extrication equipment doesn't come into contact with HV Systems or Components
- Avoid Floorplan and undercarriage as damaging these areas may damage the batteries resulting in a thermal runaway event
- Spread weight using blocks when ramming and spreading



Medium Collision Impact Considerations

- Identify Vehicle type
- Use crash data to support information gathering
- Communicate vehicle type to all personnel and other agencies
- Write propulsion type on vehicle
- Approach from safe angles and chock all 4 x wheels
- Apply handbrake and put into “Park”
- Utilise 12 Volt internal electrics to assist with space creation (operate seats, windows, handles, boots etc)
- Remove Vehicle Key or phone
- Ensure Vehicle has performed and that the HV systems are shut down
- If not, Perform vehicle shut down procedure: Disconnect low voltage (12V battery) or cut the low voltage emergency responder cut loop to manage the high voltage system
- Residual High voltage system may take time to drain
- Consider monitoring of High Voltage Systems with TIC & Gas Monitoring
- Ensure incident handover sticker is completed



Severe Impact Collision

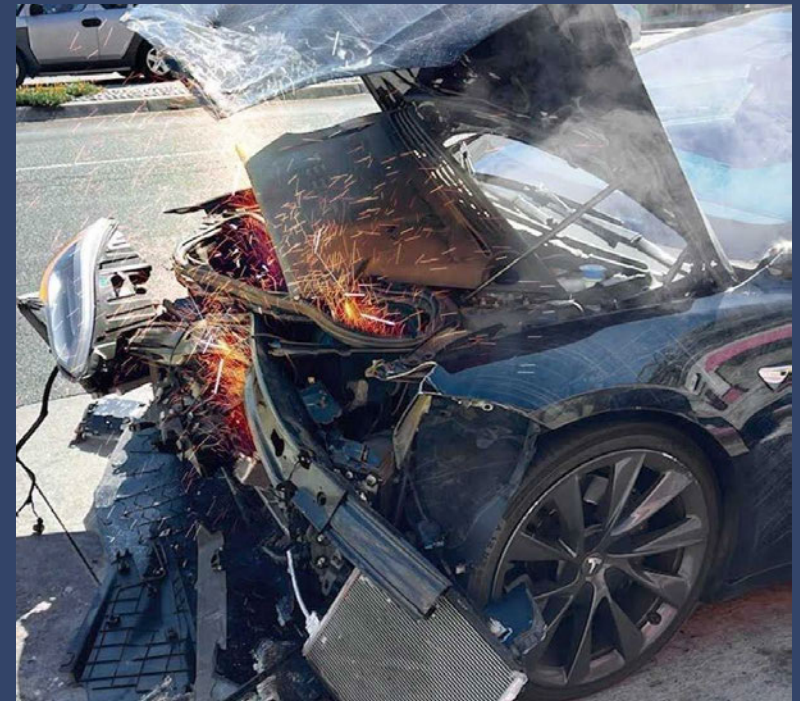
Severe Impact Collision Assessment:

- Severe collision impact causing major damage to the structure of the vehicle
- HV Components will be damaged
- SRS & devices have deployed / activated
- Airbags will be visible after post deployment
- Higher speed / Major Impact forces involved (MOI)
- Lithium Batteries exposed to overheating or penetration from collision damage can lead to a thermal runaway event
- Vapour cloud, smoke, hissing, or crackling noises may be present, this is signs of the batteries overheating
- Visual Spillages and leaks from batteries
- As a result of airbag deployment the HV control module will lose power and isolate the HV battery.
- Be aware of residual charge left in capacitors
- Crews to remain diligent



Severe Impact Collision Risks & Hazards

- Batteries are at risk of going into thermal runaway if battery temperatures exceed 60 degrees. If temperatures reach 100 degrees the batteries are extremely critical.
- Toxic and Flammable compounds are produced if the batteries go into thermal runaway.
- Explosions
- Rapid Fire Development
- Vapour cloud explosion (open windows and doors if possible)
- Electrocution Risk from stranded energy
- Re-ignition after extinguishment.



Severe Collision Considerations

- Identify Vehicle type
- Use crash data to support information gathering
- Communicate vehicle type to all personnel and other agencies
- Write propulsion type on vehicle
- Approach from safe angles and chock all 4 x wheels
- Apply handbrake and put into “Park”
- Utilise 12 Volt internal electrics to assist with space creation (operate seats, windows, handles, boots etc)
- Remove Vehicle Key or phone
- Ensure Vehicle has performed and that the HV systems are shut down
- If not, Perform vehicle shut down procedure: Disconnect low voltage (12V battery) or cut the low voltage emergency responder cut loop to manage the high voltage system

Severe Collision Considerations Continued

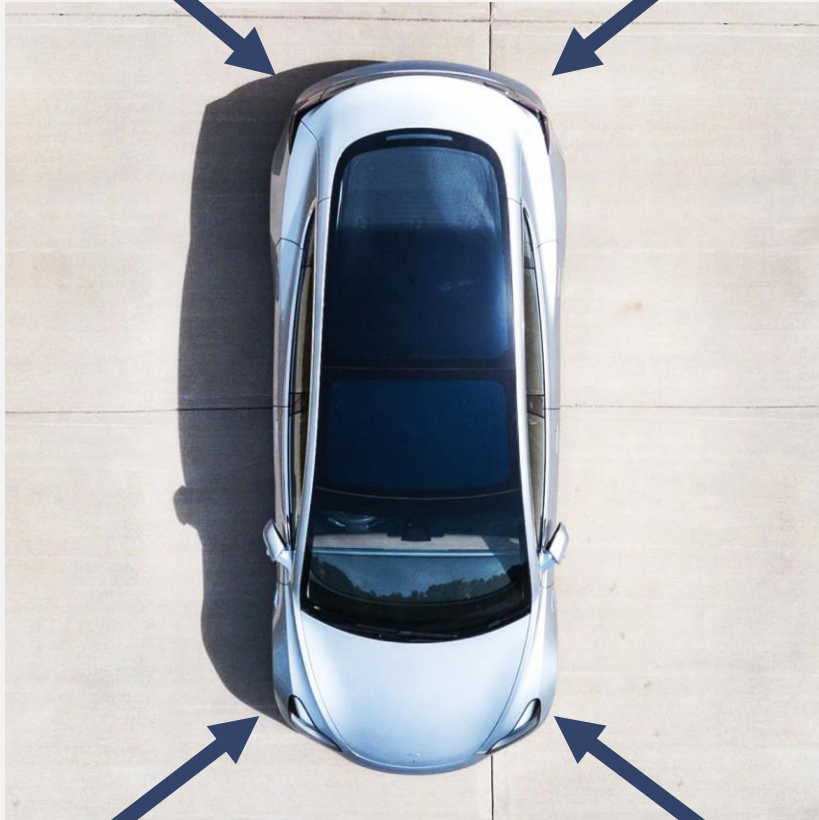
- Residual High voltage system may take time to drain
- Consider monitoring of High Voltage Systems with TIC & Gas Monitors
- Consider BA or RPE
- Establish a viable emergency plan
- Consider an “immediate” extrication of any casualties (snatch rescue)
- Cool batteries using a 45mm jet
- Consider water run off
- Consider raising part of the vehicle to assist with cooling
- Ensure incident handover sticker is completed





Hybrid & Electric Vehicles Safe Approach

Approach Angles



- Do **NOT** approach directly from the front or rear
- Ask Casualty / Driver
 - N - Name
 - A – Age
 - P – Pain
 - Then ask, is the hand / foot break on, ask them to turn off the car
- If Casualty is unresponsive, presume the vehicle is still running and hand / foot break is not engaged
- **CHOCK ALL 4** wheels, approaching from safe angles (as shown to left) (Double²⁹ Chocking with Wedges if 4 x wheel chocks are unavailable)
- **AVOID** depressing accelerator pedal – may start electric motor and vehicle may move
- **ENGAGE** hand / foot brake and put into “Park”
- **ENGAGE** electric handbrake
- **TURN OFF** vehicle, ensure all dash lights of out
- **REMOVE** ignition key (this may be a smart phone) (Do **NOT** give to the police as they sometimes put the keys back on the dash for recovery purposes)
- **INSERT** vehicle charging lead as soon as possible
- **DISCONNECT** 12V Supply (Move seats, lower windows, open doors / boots before disconnecting)



Chocking all 4 Wheels

- Use Caravan chocks to stabilise 2 x wheels (If only 1 pump in attendance)
- Use 2 x Wedges slotted underneath to make another chock
- Ensure all 4 x wheels are chocked / wedged



Electric Seats & 12 Volt System

The seat operating type **NEEDS** to be identified before a plan can be **IMPLEMENTED**.

Manual Seats:

- Check to see if the seat mechanism works by winding the seat early. The seat can be wound back in place if not damaged.

Electric Seats:

- Reinstate the ignition (if safe to do so) and operate the electric seat mechanism
- **LEAVE** the seat in the lowered position.
- Lie the casualty down on the seat or hold in seated position
- If the electrics are now damaged during the space creation phase the seat won't be an issue as it's already down / reclined
- If the seat doesn't operate then the plan should include to remove it by cutting / unbolting



Retracting Door Handles

What are they?

- Door handles that go inside the vehicle when the vehicle is locked and moving.
- Some are (Tesla film) electrically operated by a micro switch
- Some (Range Rover film) can be operated electronically and manually

What are the hazards/options?

- Access may be difficult; crews may need to force entry and open door from inside
- Crews made need to pop handle out of door with a screwdriver / trim removal tool
- Use the key or central locking system to try and unlock the doors



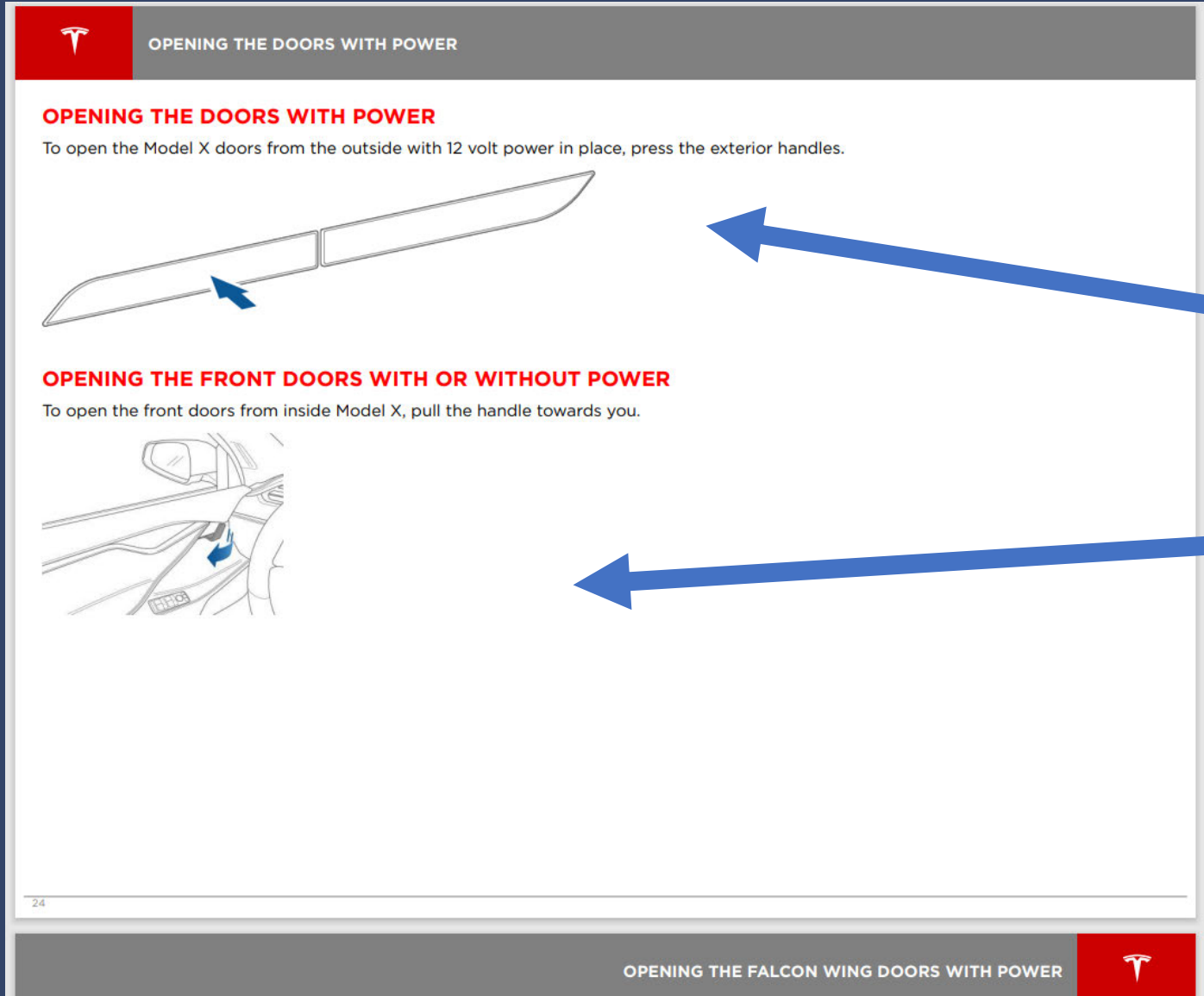
Example Tesla

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Example Range Rover

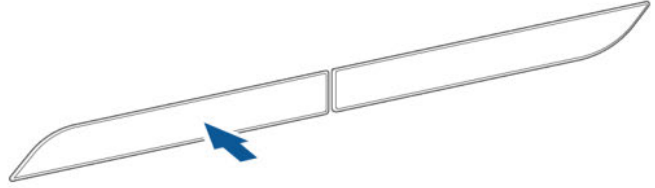
Retracting Door Handles Tesla Example



OPENING THE DOORS WITH POWER

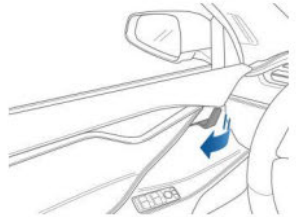
OPENING THE DOORS WITH POWER

To open the Model X doors from the outside with 12 volt power in place, press the exterior handles.



OPENING THE FRONT DOORS WITH OR WITHOUT POWER

To open the front doors from inside Model X, pull the handle towards you.



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OPENING THE FALCON WING DOORS WITH POWER

First Responder
Guidance how to open
with and without power

Retracting Door Handles



Hybrid & Electric Vehicles – Safety Precautions

- **IDENTIFICATION** – vehicle badges, markings, orange cables and high voltage labels, no exhaust on pure electrics, number plate marking, charging points
- **DO NOT** remove the service plug (fuse terminal may be damaged from impact / collision)
- **DO NOT** cut any orange high voltage cabling or battery parts
- **DO NOT** touch any damaged high voltage cables or battery parts
- Ram / Spread on the underside with **CAUTION** due to battery location
- Ram / Spread of foot well with **CAUTION** due to battery location
- **SPREAD** the load using plastic blocks / timber from RSV
- Do **NOT** drill any holes into underside or lower part of vehicle
- **ONLY** lift vehicle on dedicated jacking points (see next slide)
- **CONSIDER** Gas Monitoring if the battery's have been damaged / involved in fire
- **MONITOR** the EV with a thermal image camera (aiming at the under carriage if possible). If battery temperature is above 60 degrees, apply water from a jet to reduce temperature.



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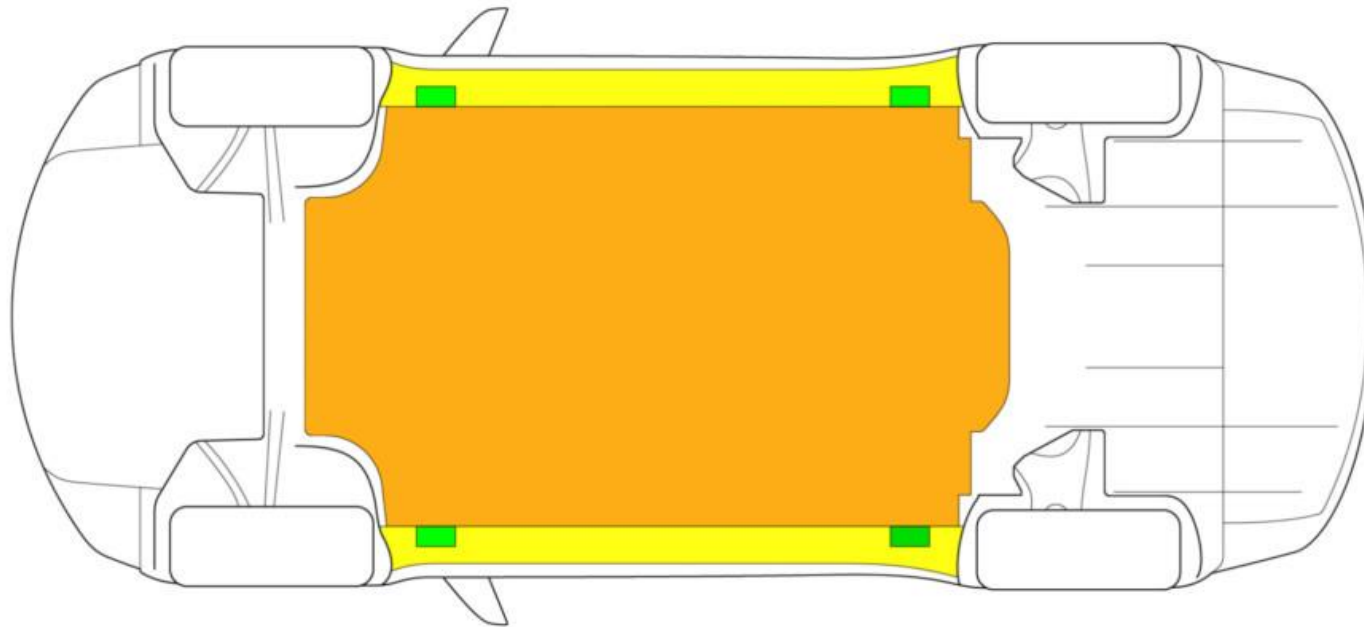





Example: Tesla Model S “Lift Areas”

LIFT AREAS

The high voltage battery is located under the floor pan. A large section of the undercarriage houses the high voltage battery. When lifting or jacking, only use the designated lift areas, as shown in green.

▲ Warning: DO NOT USE THE HIGH VOLTAGE BATTERY AREA TO LIFT OR STABILIZE MODEL S.



-  Appropriate lift areas
-  Safe stabilization points for a Model S resting on its side
-  High voltage battery

Use crash data to gain vehicle information

- If you need to lift the car, lift in the dedicated lifting areas.
- This is to avoid the battery components in the vehicle undercarriage
- Consider this image when ramming onto the undercarriage
- Short Extension Ladder for Subsequent Stability
- Do NOT drill into the undercarriage



Volvo XC40 Electric Car





Tesla Example Why Not to Spread / Ram from floor pan

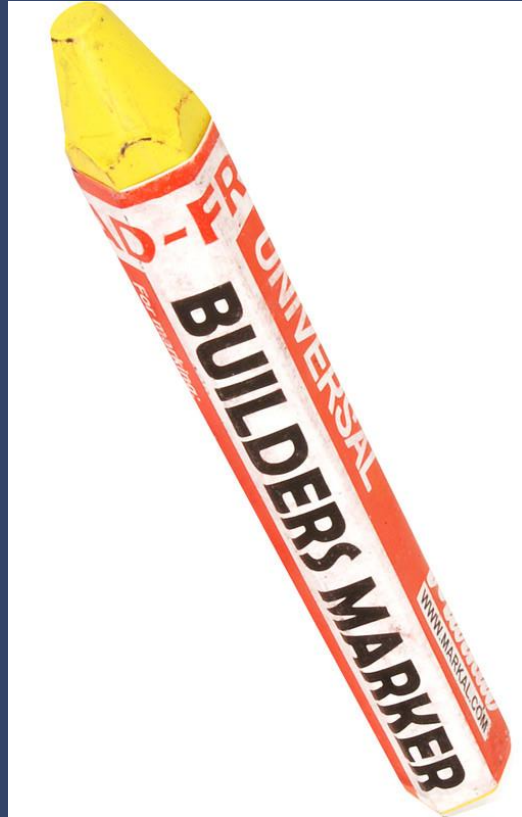
PUSHING ON THE FLOOR PAN

The high voltage battery is located below the floor pan. Never push on the floor pan inside Model X. Doing so can breach the high voltage battery, which can cause serious injury or death.





Chalk Pens / Markers



- Propulsion Type
- Safe Cut Marks
- Tyres / Wheels when lifting

Hybrid & Electric Vehicles

Safety precautions

Both hybrid & electric vehicles can remain live for up to 5 minutes after the high voltage system has been turned off



**Due to unusual weight positions subsequent stabilisation must be used as soon as possible.
(For an electric car on its roof, 4 x Stabfast / Paratech Supporters may be required or Airbags to level the car)**



Example: Tesla Model S Collision and Fire



- We can see:**
- **Solid Undercarriage**
 - **Limited stability points**

Example: Tesla Model S Collision and Fire

- We can see the B Post is Solid and Supporting well
- What if we remove it though?
- Stability problems
- Possible collapse of undercarriage
- Heavy weight above crews
- Access via screen and A posts?





Example: Tesla Model S Collision and Fire



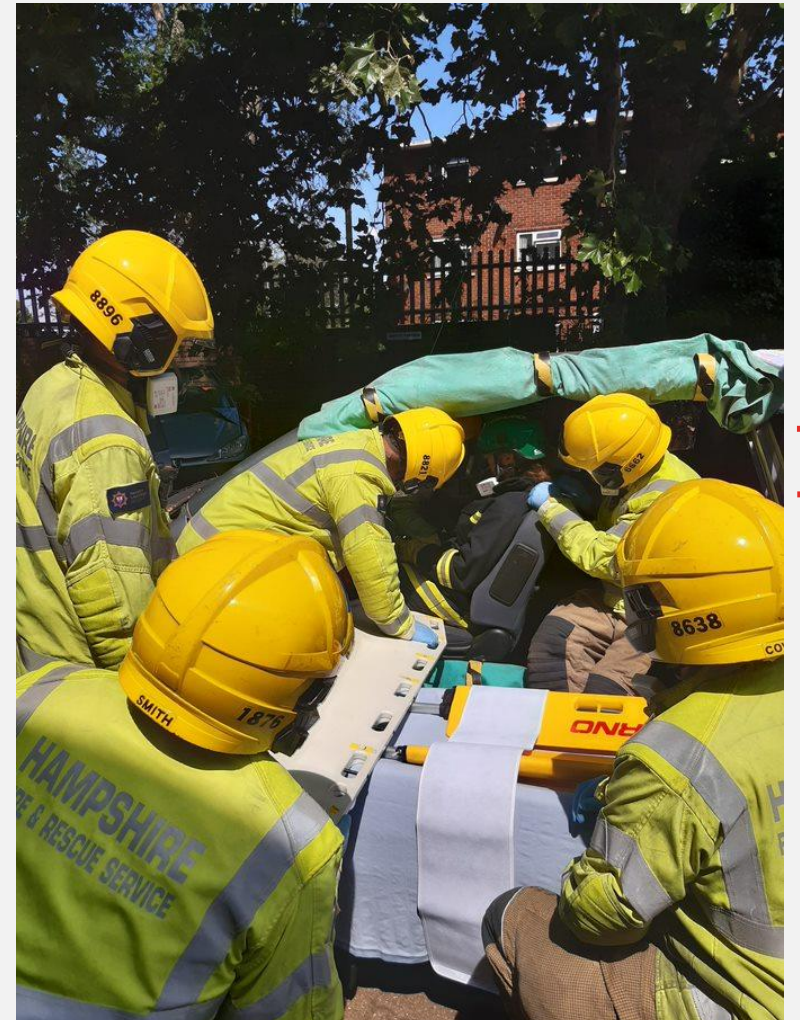


Numbered Longboard & Longboard Use





Numbered Longboard & Ambulance Trolley





Numbered Longboard & Ambulance Trolley





Numbered Longboard & Ambulance Trolley



How is this mini powered ?



Discuss

- Visual Indicators?
- Badges?
- Condition?
- Number plate?
- Crash Data?



Converted Electric Cars



Converted Electric Cars

Car owners and manufactures are now converting conventional petrol and diesel vehicles into electric vehicles.

Converted Electric Cars should be treated the same as new electric cars with the added control measures / features:

- Converted Electric Vehicles might not have any badges or number plates to denote electric
- Converted electric vehicles may have an exhaust to make the car look classic / retro
- Crash Data might not recognise the vehicle as electric
- Battery Location could be anywhere due to vehicle being converted



Lithium Batteries

Year 2010

3000
Electric
Cars on the
UK Roads

Year 2021

340000
Electric
Cars on the
UK Roads



EV Gas Monitoring Consideration

Gases which **can/may** be released when the lithium battery is damaged / leaking:

- CO₂ - Carbon Dioxide
- CO - Carbon Monoxide
- HCl - Hydrochloric Acid Gas
- HF - Hydrofluoric Acid Gas





- OIC / RTCT Consideration to place gas monitoring in EV if the batteries have been damaged after an RTC / Fire
- Consideration putting near EV if working in a tunnel / enclosed Car Port / Garage / Car park, where the gases wont be able to dissipate into the atmosphere
- PPE / Decontamination Consideration










Handover Stickers

WARNING! HAZARDS PRESENT

 **DANGER**
HIGH VOLTAGE SYSTEMS
MAY BE LIVE!

 Hampshire
& Isle of Wight
FIRE & RESCUE SERVICE

		YES	NO
	HIGH VOLTAGE SYSTEM ISOLATED	<input type="checkbox"/>	<input type="checkbox"/>
	BATTERY SYSTEMS ISOLATED	<input type="checkbox"/>	<input type="checkbox"/>
	IGNITION FULLY OFF	<input type="checkbox"/>	<input type="checkbox"/>
	PETROL	<input type="checkbox"/>	<input type="checkbox"/>
	DIESEL	<input type="checkbox"/>	<input type="checkbox"/>
	OTHER <input type="text"/>		
	UN-DEPLOYED SRS SYSTEM	<input type="checkbox"/>	<input type="checkbox"/>

(USER INFO - TICK APPROPRIATE BOX)

Incident Number

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Patient Report Form

A ePRF **MUST** be completed every time a patient / casualty is assessed / treated by HIOW FRS. This includes extrication. If all we did at an RTC was extricate the casualty on a longboard then a ePRF must be completed as we have assisted with the treatment plan for the patient.

If no casualty details are present and no observations were conducted, we can still complete the ePRF. You can write in the summary box, for example.

“Casualty treated by SCAS, the casualty was extricated by the use of a long board. The casualty was extricated by a side removal in the foetal position. Crews then assisted in transferring the casualty from the longboard to a scoop”.

Electric Scooter / Bike Fires

Electric Bike Fire in lift



Electric Scooter Fire in lounge



Electric Car Fires



- Additional Considerations:**
- Min 24 Hour Battery Cooling
 - Road Surface
 - Recovery
 - Scrap Yard Handover
 - Long Delays
 - Contamination
 - Water run off
 - Smoke Plume
 - Water Supplies

Electric Car Fires



What will the
future look
like?



EV Car Fire Blankets

- Could be used as a “Fixed Installation” if available
- Can buy the OIC time to make a plan
- Can assist with making a firebreak
- Gases will be produced and may not vent
- Will **NOT** extinguish the fire fully, but will compress





Example Car Fire Blanket Deployment



RSV Capability at EV Incidents

Equipment:

- Go Jacks (EV's cannot be moved unless ignition is on and neutral is selected)



- Front Mounted Winch (to assist moving EV)



- Timber (4 x 4) (to spread the load when ramming / spreading from floor pan)



- Large Wheel Chocks (to support stabilisation)



- Cable Avoidance Tool (CAT Scanner) (to assist in identifying if the EV is live)



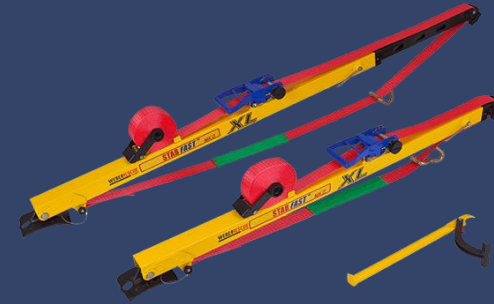
RSV Capability at EV Incidents

Equipment:

- Gas Monitoring Equipment (to assist in identifying gases if lithium battery cases have been damaged)



- Stab Fast Extra Large (to assist with EV's on their sides)



- Paratech (to assist with stability)



- Air Lifting Units (Airbags) (to lift the EV but spread the load)



- Trolley Jack (to assist with lifting)





EV in Water

- Due to weight being at the bottom of EV in undercarriage, the event of sudden movement is reduced
- If the vehicle has been damaged, consideration should be given to battery state / electric shock risk
- Approach from a safe position, the use of tethered “Sleds” should be considered as a recovering tactic



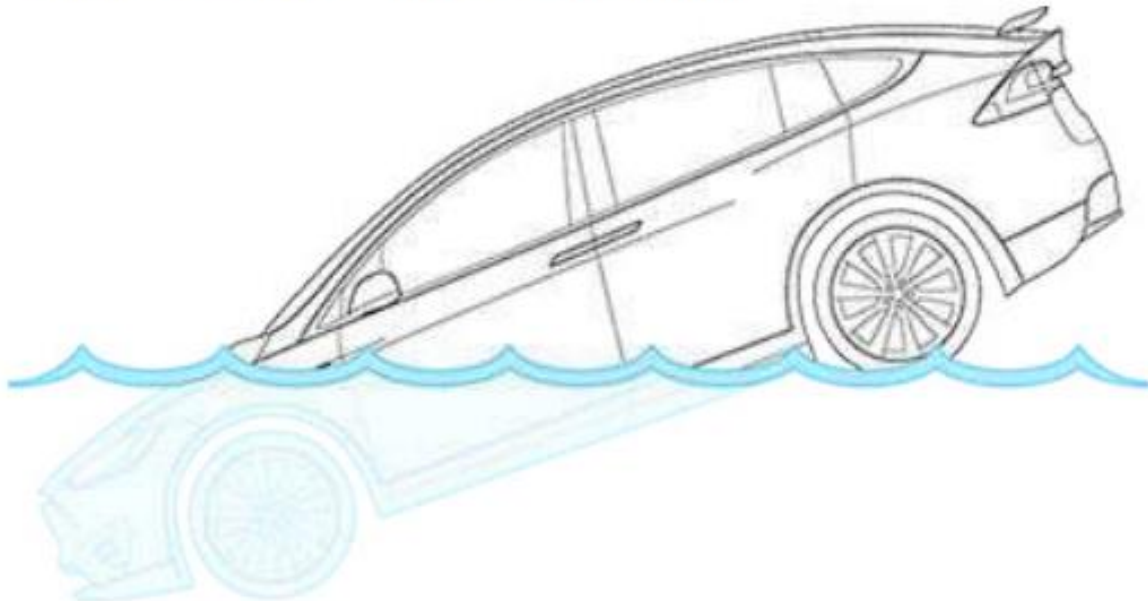
EV in Water Tesla Example



FULLY OR PARTIALLY SUBMERGED VEHICLES

FULLY OR PARTIALLY SUBMERGED VEHICLES

Treat a submerged Model X like any other submerged vehicle. The body of Model X does not present a greater risk of shock because it is in water. However, handle any submerged vehicle while wearing the appropriate PPE. Remove the vehicle from the water and continue with normal high voltage disabling.



⚠ Warning: Handling a submerged vehicle without appropriate PPE can result in serious injury or death.



Gas Powered Vehicles

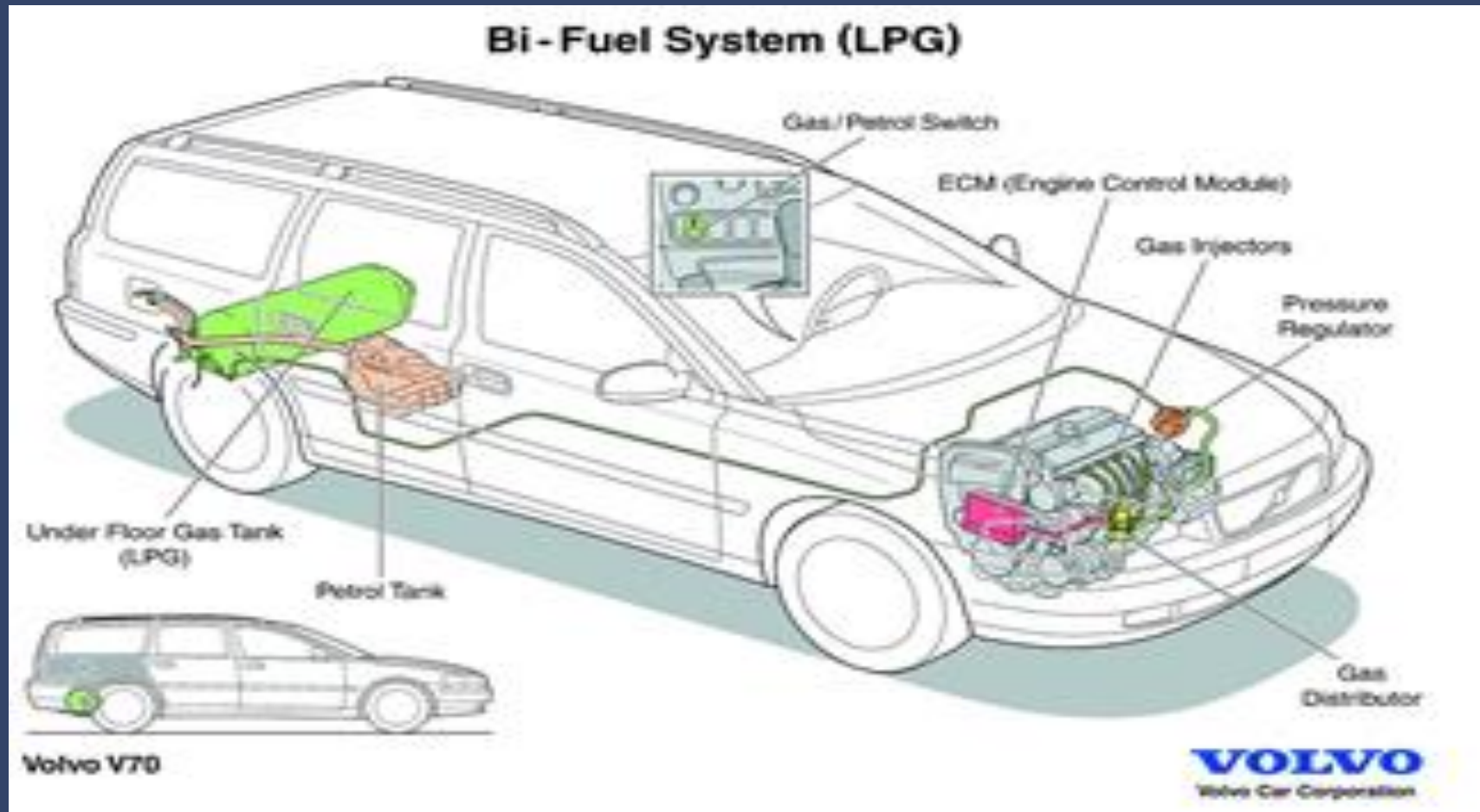
Examples – VW Golf conversion



Gas powered vehicles may run on **LPG (Propane)**, **CNG (compressed natural gas)** and **LNG (liquefied natural gas)**. They will all have the generic term bi-fuel when used with a standard petrol/diesel engine.

Gas Powered Vehicles

Examples – Volvo conversion



Gas Powered Vehicles

What are they ?

- Gas Powered vehicles are usually powered by a normal petrol/diesel engine but supplemented with an Gas tank that the driver can switch to
- May also be known as 'autogas'

What are the hazards ?

- Gas leak that may ignite
- Causing a gas leak when cutting/spreading
- Vehicle fire may cause the gas tank rupture
- Gas tank pressure relief valve operating causing a jet of flame in a vehicle fire
- The various gases used have different properties – some are heavier than air, flammable ranges are different.

General

- **25m** inner cordon, any operations within this area must be fully risk assessed
- Do not approach directly from the front or rear
- Identification – Second filler cap, tank in boot
- Chock wheels as per standard procedures
- Ensure ignition is off and no dashboard lights are displayed
- Ignition key removed
- A gas leak may have a distinct smell of ‘rotten cabbage’
- No naked flame / source of ignition
- If safe to do so isolate gas tank.

Gas Powered Vehicles – safety precautions

Leak only

- BA, engine switched off, isolate leak & shut off, ventilate

RTC only

- Avoid cutting / spread around tank or gas lines

Leak & RTC

- As above & disperse vapours, avoid any procedures that would cause sparking until isolated & vapours cleared.

Gas Powered Vehicles – safety precautions

Fire

- Although Autogas perform the most conversions in the UK other companies are known to do them also
- Autogas conversions incorporate many safety features – pressure relief valves, non return valves etc
- Avoid 7 meter area around sides and rear as this will be the path of flame jet travel
- Treat as gas cylinder.



Gas Powered Vehicles



This film is old but highlights all the modern day risks

Hydrogen Vehicles

Hyundai Tucson





Hydrogen Vehicles

Toyota Mirai



The Toyota Mirai is the first mass production Hydrogen powered vehicle available in the UK.

Hydrogen Vehicles

What are they ?

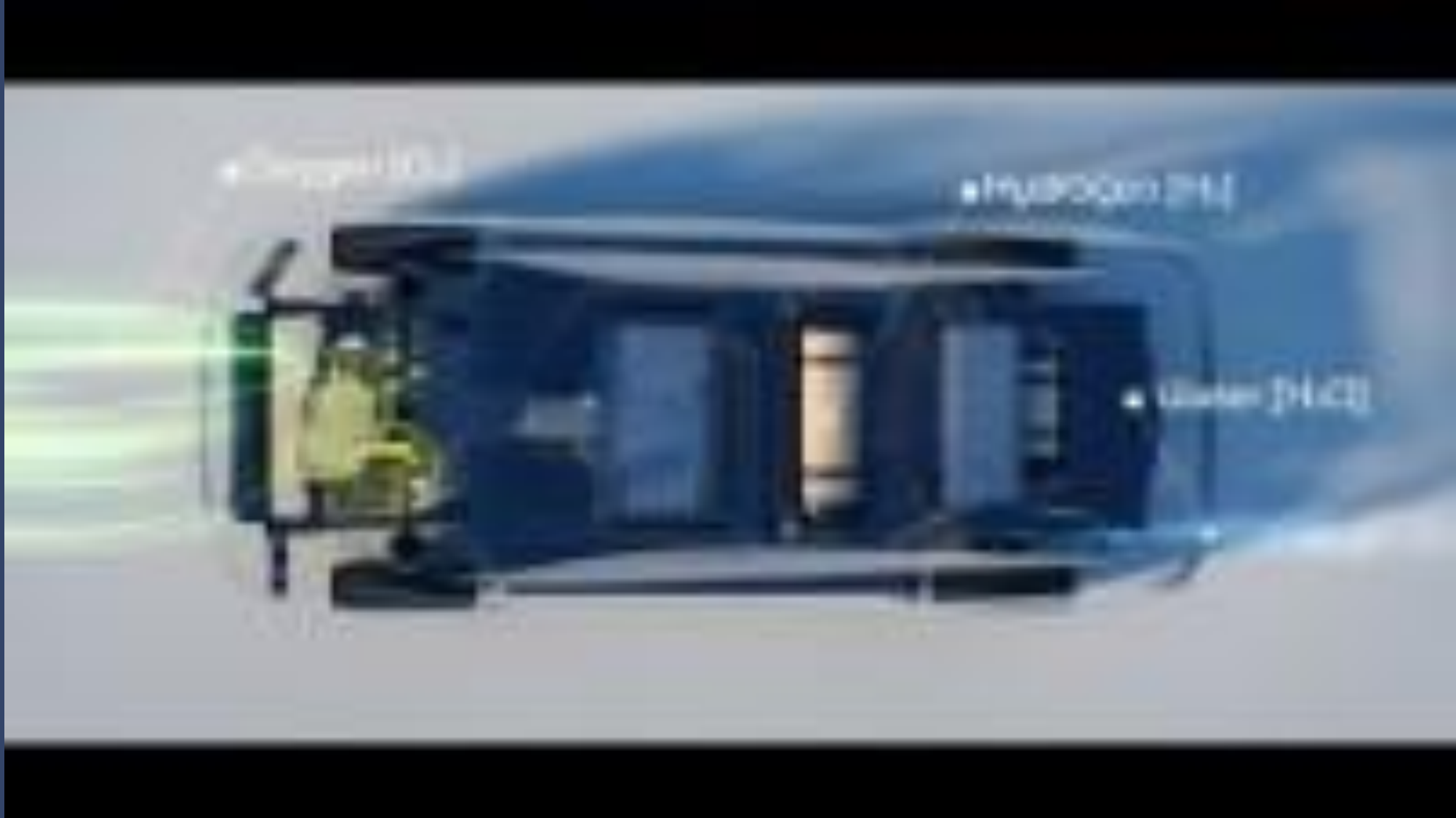
- Hydrogen vehicles have a tank of hydrogen that when combined with a fuel cell and oxygen produce electrical power to drive the vehicle
- They are still very rare in the UK but are deemed as the future technology for vehicle propulsion

What are the hazards ?

- As they use both electric power and stored gas they pose the same problems as hybrid, electric and LPG vehicles
- They also have the additional hazard of a chemical reaction and therefore a HazMat risk.



Example: Toyota Mira





Hydrogen Vehicles

Hazards from a DIY hydrogen conversion



General

- **25m** inner cordon, any operations within this area must be fully risk assessed
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- Chock wheels as per standard procedures
- Ensure ignition is off and no dashboard lights are displayed
- Ignition key removed
- No naked flame / source of ignition
- If safe to do so isolate hydrogen tank.



**Hampshire
& Isle of Wight**
FIRE & RESCUE SERVICE

**Hampshire & Isle of Wight
Fire & Rescue Service**

Version control

Quality Review System	Title: Alternative Powered Vehicles
Reference number:	Owner: [REDACTED]
Author: [REDACTED]	Status: published
Publication:	Publication date:
Authorised by: Each version is to be signed off by the owner.	Version number:
Address: Add link of SharePoint folder that the master is saved in	
Note: A printed document is no longer a controlled document	

Amendments:

- September 2021 – New PP Format
- Slides 15 – 22 added/amended