

Spring 2012

# The Mitsubishi i electric vehicle

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# **The 2012 Mitsubishi “i” (innovative) Electric Vehicle**

*Presented by Matt Dixon, Assistant Professor  
SIUC Automotive Technology  
Spring 2012*

# 2012 Mitsubishi "i"

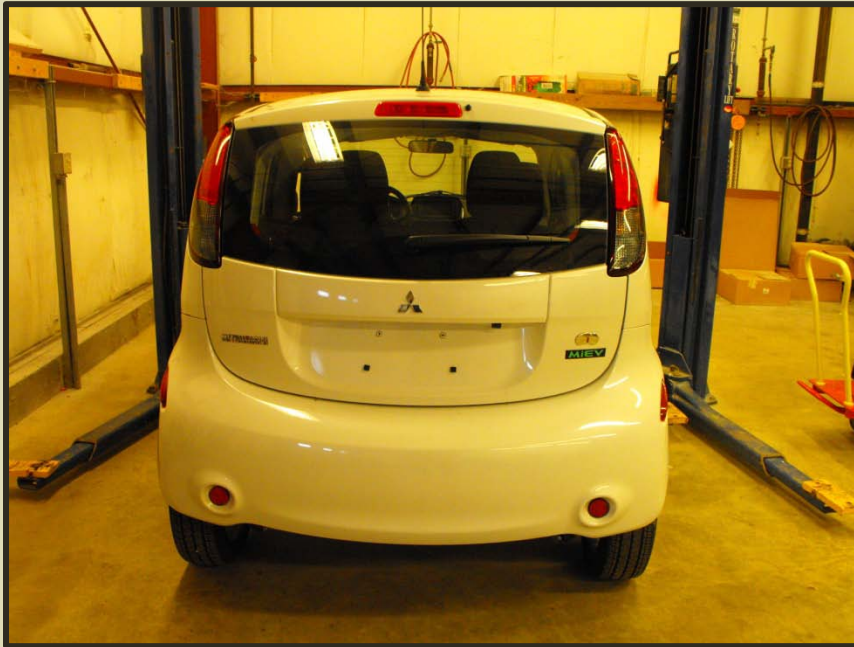
- Rear Drive
- all electric propulsion
- Weighs 2579 pounds
- Been in the Euro/Japanese markets for about 2 years



ES or SE (better) trim levels, SE shown

# 2012 Mitsubishi "i"

Currently qualifies to ride in the "HOV" lane\*



- Seats 4 comfortably
- LED tail lamps
- 6 airbags



- Dual front wipers to meet USA regulations
- Halogen headlamps

# 2012 Mitsubishi "i"

- 112 miles per gallon equivalent, combined range 62 miles
- Lithium Ion battery pack and main drive are warrantied for 8 years/80,000 miles

Location : Loaded

**EPA DOT Fuel Economy and Environment** Electric Vehicle

**Fuel Economy**

**112 MPGe** Subcompact cars range from 10 to 112 MPGe. The best vehicle rates 112 MPGe.

combined city/hwy **126 99 30**  
city highway kW hrs per 100 miles

**Driving Range**  
When fully charged, vehicle can travel about **62** miles

Charge Time: 7 hours (12.8kW)

**You save \$9,850**  
in fuel costs over 5 years compared to the average new vehicle.

**Annual fuel cost \$550**

**Fuel Economy & Greenhouse Gas Rating** (tailpipe only) Smog Rating (tailpipe only)

**1** **10** **10** **10** Best

This vehicle emits 0 grams CO<sub>2</sub> per mile. The best emits 0 grams per mile (tailpipe only). Does not include emissions from generating electricity; learn more at [fuelconomy.gov](http://fuelconomy.gov).

**Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 22 MPG and costs \$12,600 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$0.12 per kWh. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.**

**fuelconomy.gov**  
Calculate personalized estimates and compare vehicles

**8-year 100,000-mile MAIN DRIVE LITHIUM-ION BATTERY WARRANTY**

5<sup>year</sup>/60,000<sup>miles</sup> 7<sup>year</sup>/100,000<sup>miles</sup>  
POWERTRAIN ANTI-CORROSION/PERFORATION

3<sup>year</sup>/36,000<sup>miles</sup> 3<sup>year</sup>/36,000<sup>miles</sup>  
NEW VEHICLE LIMITED WARRANTY ROADSIDE ASSISTANCE

\*See participating Retailer for Limited Warranty and Roadside Assistance terms and conditions.

**GOVERNMENT 5-STAR SAFETY RATINGS**

**Overall Vehicle Score** To Be Rated  
Based on the combined ratings of frontal, side and rollover. Should ONLY be compared to other vehicles of similar size and weight.

Frontal Crash	Driver Passenger	To Be Rated
Based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight.		

Side Crash	Front seat Rear seat	To Be Rated To Be Rated
Based on the risk of injury in a side impact.		

Rollover	To Be Rated
Based on the risk of rollover in a single-vehicle crash.	

Star ratings range from 1 to 5 stars (\*\*\*\*\*), with 5 being the highest. Source: National Highway Traffic Safety Administration (NHTSA). [www.safercar.gov](http://www.safercar.gov) or 1-888-327-4236

**Parts Content Information**

For vehicles in this carline:  
U.S./Canadian Major Sources of Parts Content:  
0% Foreign Parts Content: JAPAN 100%

For this vehicle:  
Final Assembly Point: MIZUSHIMA, JAPAN  
Country of Origin:

Engine: JAPAN Transmission: JAPAN

Note: Parts content does not include final assembly, distribution, or other non-parts costs.

Ship To: (CBA) O'BRIEN MITSUBISHI-NORMAL 15010 1601 FT. JESSE ROAD NORMAL, IL 61761-0899

Sold To: (Same unless indicated)

Cumulative Accessory Weight is **3.9 lbs**

Method of Transport: RAIL Plant/Port of Entry: TACOMA, WA VIN : JA3215H1XCU011454 Route Code : RJ0

Gasoline, license and title fees, applicable federal, state and local taxes and dealer and distributor installed options and accessories are not included in the manufacturer's suggested retail price. This label has been applied to this vehicle pursuant to federal law and cannot be moved or altered prior to delivery to the ultimate purchaser.

**Cumulative Accessory Weight is 3.9 lbs**

Form No. L-200DS-G (11/10)



# 2012 Mitsubishi "i"

- Cost  $\approx$  \$30K
- Federal tax incentive available (\$7500)
- State tax incentives available (varies \$)

2012EV44B1AT5-A03-W1380P

**MITSUBISHI MOTORS**

2012 I-MIEV ES  
5-DOOR HATCHBACK  
DIAMOND WHITE PEARL / BLACK

AC SYNCHRONOUS MOTOR  
1 SPEED TRANSMISSION  
50-STATE EMISSIONS STANDARD

**Optional Equipment**  
QUICK CHARGE PACKAGE  
• DC QUICK CHARGE PORT  
• BATTERY WARMING SYSTEM  
• HEATED SIDEVIEW MIRRORS  
\$700.00

**ELECTRIC MOTOR AND BATTERY**

- 100% ELECTRIC, ZERO EMISSIONS
- 49KW AC SYNCHRONOUS MOTOR
- 16KWH LITHIUM-ION BATTERY
- 120V PORTABLE CHARGER AND CABLE
- 120/240V ON-BOARD RECHARGING SYSTEM
- SINGLE FIXED REDUCTION GEAR TRANSMISSION
- MIEV REMOTE SYSTEM
- 3 MODE DRIVE SELECTOR (D, ECO, B)
- ENERGY METER (CHARGE, ECO, POWER)
- LOW BATTERY WARNING INDICATOR
- BRAKE ENERGY REGENERATING SYSTEM

**COMFORT/CONVENIENCE (cont'd)**

- AMP/DC COMPS HEAD UNIT W/ 4 SPKRS
- HEATED DRIVER SEAT
- POWER DOOR & TAILGATE LOCKS
- POWER WINDOWS & SIDEVIEW MIRRORS
- VARIABLE INTERMITTENT WIPERS
- REAR WINDOW DEFROSTER
- FRONT MAP LIGHTS
- FRONT AND REAR ASSIST GRIPS
- FRONT CUP HOLDERS
- REMOTE KEYLESS ENTRY
- 50/50 SPLIT FOLD-DOWN REAR SEATS
- 12V ACCESSORY OUTLET
- FLOOR MATS

**SAFETY**

- ADVANCED DUAL FRONT AIRBAGS
- FRONT SEAT MOUNTED SIDE AIRBAGS
- SIDE CURTAIN AIRBAGS
- FRONT AND REAR HEIGHT-ADJUSTABLE HEADRESTS
- ACTIVE STABILITY CONTROL (ASC) W/ TRACTION CONTROL LOGIC (TCL)
- TIRE PRESSURE MONITORING SYSTEM
- LATCH SYSTEM FOR CHILD SEATS
- ANTI-THEFT ALARM SYSTEM
- VEHICLE IMMOBILIZER SYSTEM
- HIGH VOLTAGE CUT-OFF SYSTEM
- ACOUSTIC VEHICLE ALERT SYSTEM (AVAS) FOR PEDESTRIANS

**EXTERIOR**

- 15" STEEL WHEELS W/ FULL COVERS
- HALOGEN PROJECTION HEADLAMPS
- SIDE TURN INDICATORS
- COLOR-KEYED OUTER DOOR HANDLES AND SIDEVIEW MIRRORS
- REAR LED TAIL LIGHTS
- REAR INTERMITTENT WIPER AND WASHER

**BRAKES AND SUSPENSION**

- FRONT DISC BRAKES W/ ABS
- ELECTRONIC BRAKEFORCE DISTRIBUTION
- BRAKE ASSIST
- INDEPENDENT FRONT SUSPENSION W/ STABILIZER BAR
- REAR 3 LINK DE DION SUSPENSION
- ASSISTED ELECTRIC POWER STEERING

**COMFORT/CONVENIENCE**

- AIR CONDITIONING W/ MICRON FILTER
- ELECTRIC CABIN HEATER

**Environmental Performance**

Protect the environment, choose vehicles with higher scores:

**Global Warming Score**

1 10  
Average New Vehicle Cleanest

**Smog Score**

1 10  
Average New Vehicle Cleanest

Vehicle emissions are a primary contributor to global warming and smog. Scores are determined by the California Air Resources Board based on this vehicle's measured emissions. Please visit [www.DriveClean.ca.gov](http://www.DriveClean.ca.gov) for more information. California Environmental Protection Agency

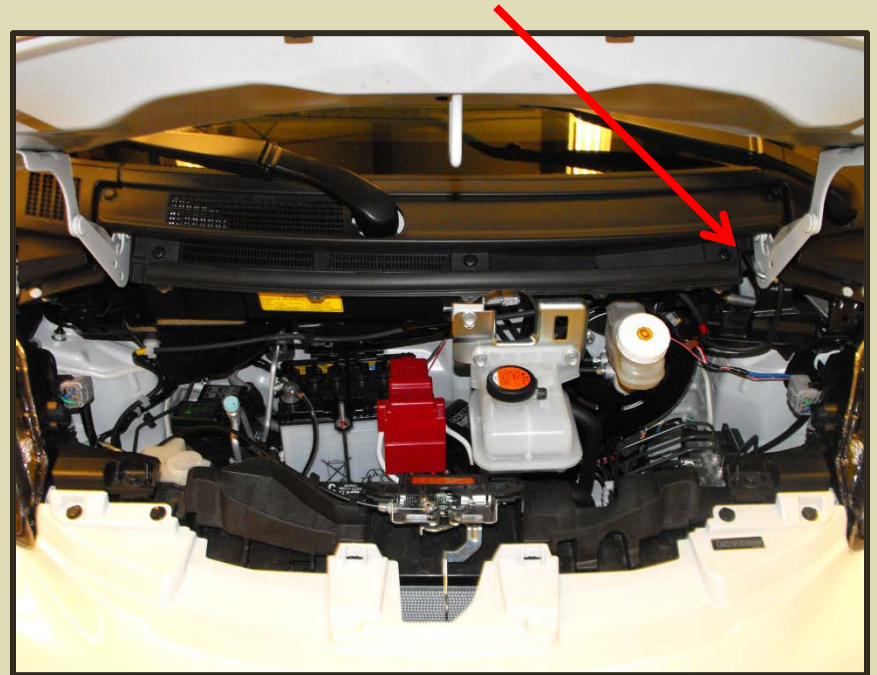
**AIR RESOURCES BOARD**

MSRP\*: \$29,125.00  
Total Optional Equipment: \$700.00  
Subtotal: \$29,825.00  
Destination/Handling: \$850.00  
Total MSRP\*: \$30,675.00  
\*MSRP (Manufacturer's Suggested Retail Price)

Visit us at [www.mitsubishicars.com](http://www.mitsubishicars.com)

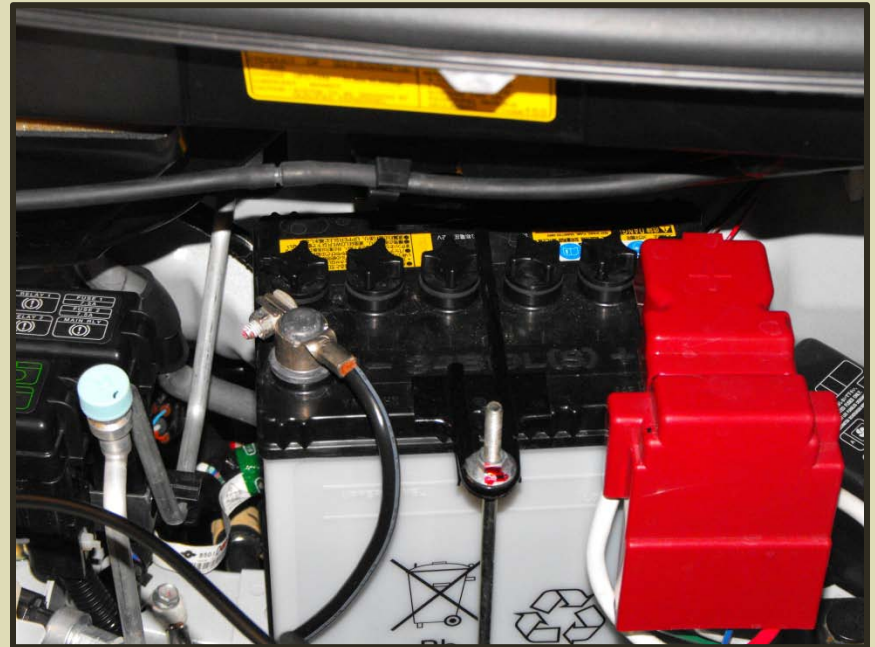
# 2012 Mitsubishi "i"

"prop rod" to hold hood up



# 12 volt battery

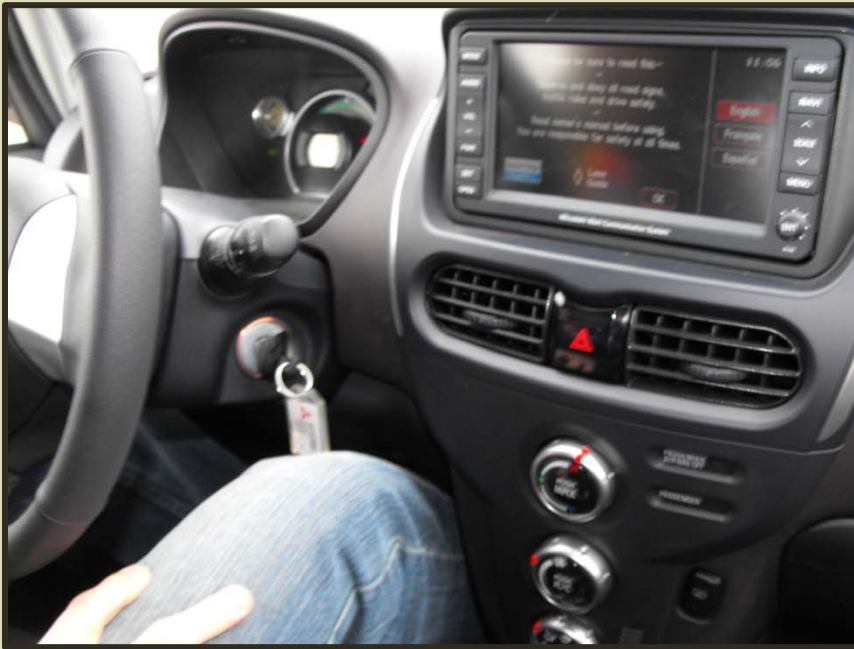
- Located underhood
- Needed to “Ready” the main H.V. system
- 12 v initially powers ECU’s, communication network and ability to activate the H.V. system main contactors



- 280 CCA lead acid battery
- There is no IOD fuse



# 2012 Mitsubishi "i"



- Conventional Key/Lock Cylinder



# 2012 Mitsubishi "i"

- Features a "remote" unit.
- This can be used to precondition the vehicle
- Warm up heater, Start defrosting or turn on A/C etc.
- Can also set up charge times: off peak etc.

Also buttons on the side



- Remote "stick" similar to other Mitsu products

# 2012 Mitsubishi "i"



Level 3 charging door  
(drivers side) lever



Pass side Level 1 or 2  
charging port "gas door"  
lever



# 2012 Mitsubishi "i": Charge ports



- Level 3 charge port driver side



- Level 1 and 2 charge port on Pass side **SAE J1772 SPEC**



# Acoustic Vehicle Alerting System

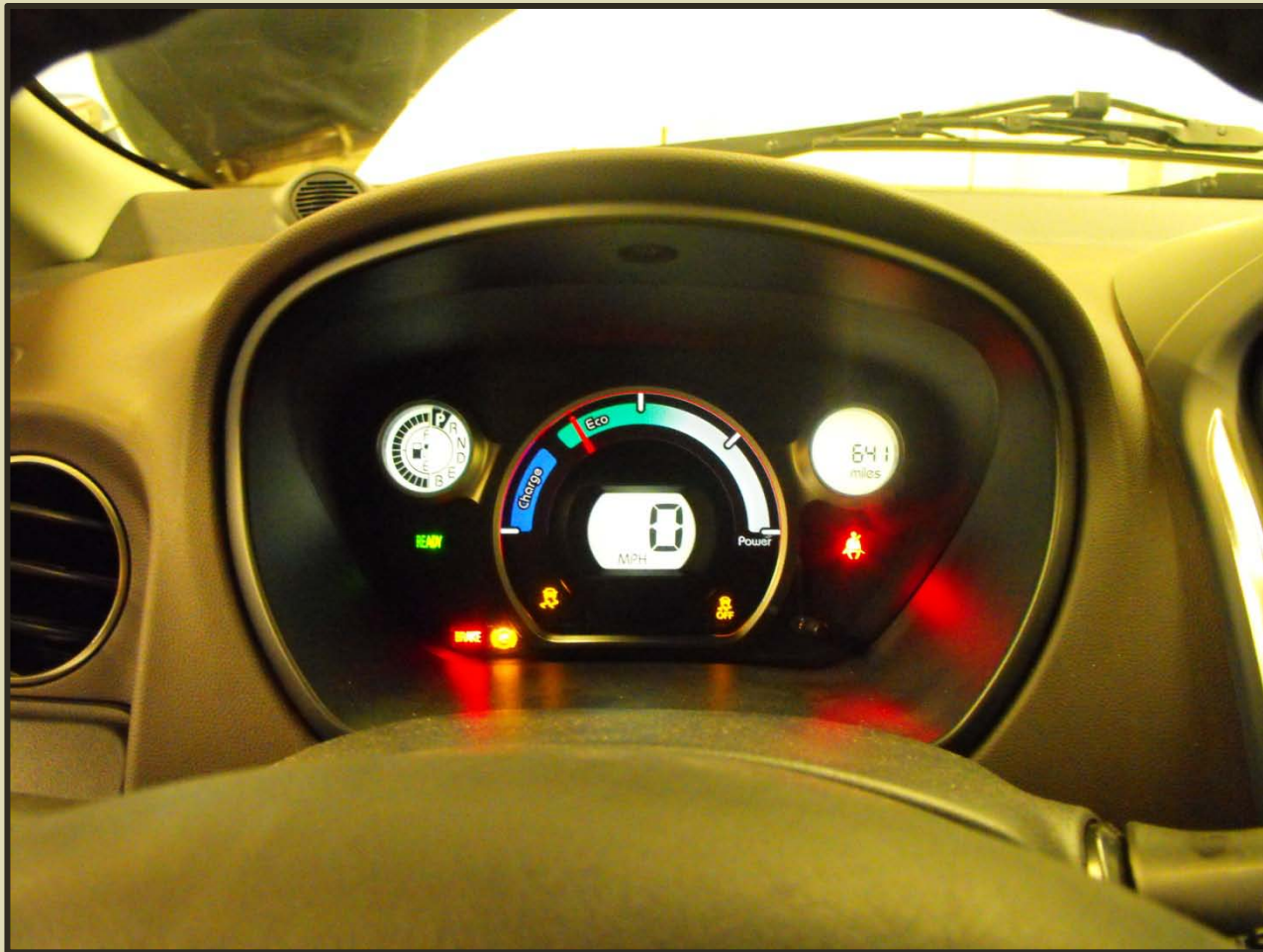
Complies with USA Fed regulations to warn blind pedestrians etc.

“**twirling sound**” comes from an underhood speaker controlled by AVAS ECU

Noise loudest at low speeds about 12 MPH  
diminishes and fades away at 23MPH



# Combination Meter (cluster)



# Combination Meter (cluster)

“fuel gauge”: 16 segments

- Each segment represent 3-5 miles depending on accessories, speed, traffic, temperature and other variables
- “Turtle” icon appears on cluster with extreme depower mode last 1-2 miles



# Tires/wheels

175 65 R15 tires in front

175 60R 15 tires in rear

- Front disc/rear drum
- No spare tire: Inflation kit with “goo” under rear seat



# Transmission Selector

- “P”: needed for “ready”
- R: electric motor spins backwards
- D: “REGEN” only when brakes pressed
- “ECO” mode for max range
- “B” moving down hills, etc. aggressive “REGEN”



# HVAC

- Very important:  
DO NOT use P.A.G. oil !
- USE dedicated A/C RRR machine (no chance of P.A.G.)
- Notice small charge of R134a





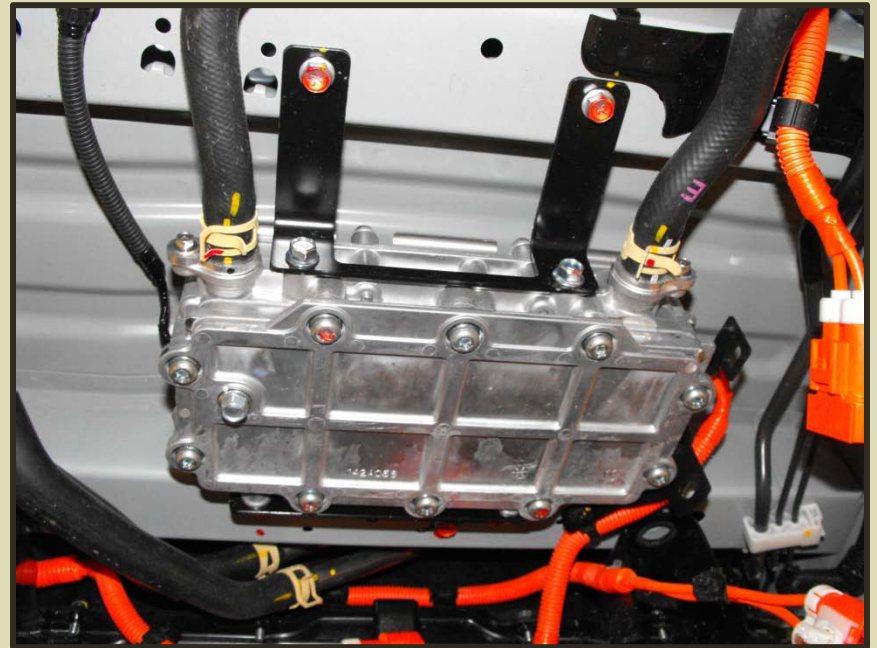
# HVAC

- 330 volt scroll compressor
- 800-860 Watts
- Inverter within compressor body
- Evaporator “fin” sensor large input in controlling compressor speed



# HVAC

- Electric Heater
- Uses up 5,800 watts
- Electric pump with ceramic impeller circulates coolant
- Battery S.O.C. must be 40% or more to operate



# HVAC

- 2 separate coolant systems
- Front: For passenger HVAC system
- Rear: for motor electronics
- Both use Mitsu Blue colored 50/50 pre mix long life coolant



# EV components coolant system

- Passenger HVAC system may be activated to heat or cool the battery pack during extreme temperatures
- Example: @-13F battery requires heating



- Passenger compartment air heats/cools battery pack

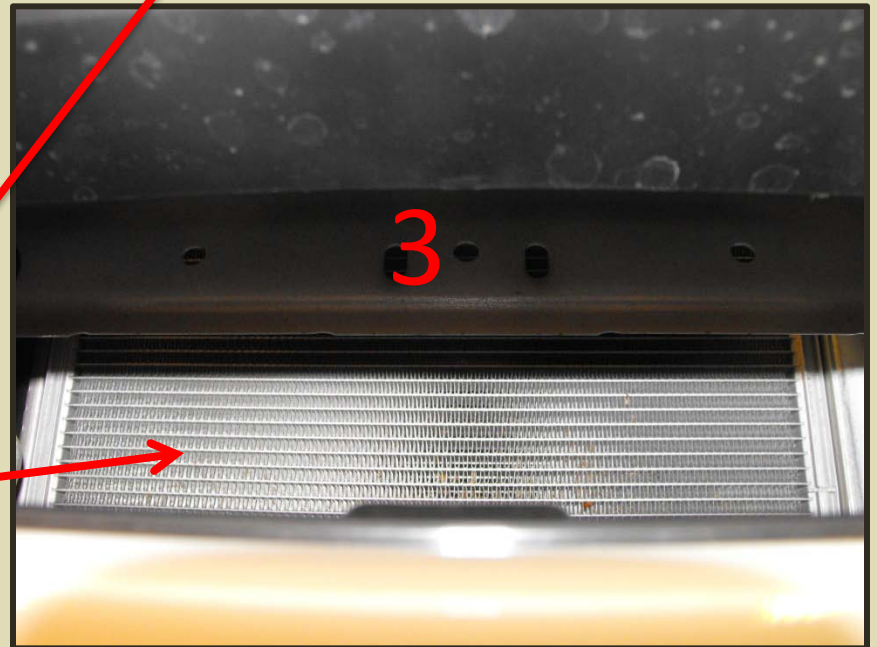
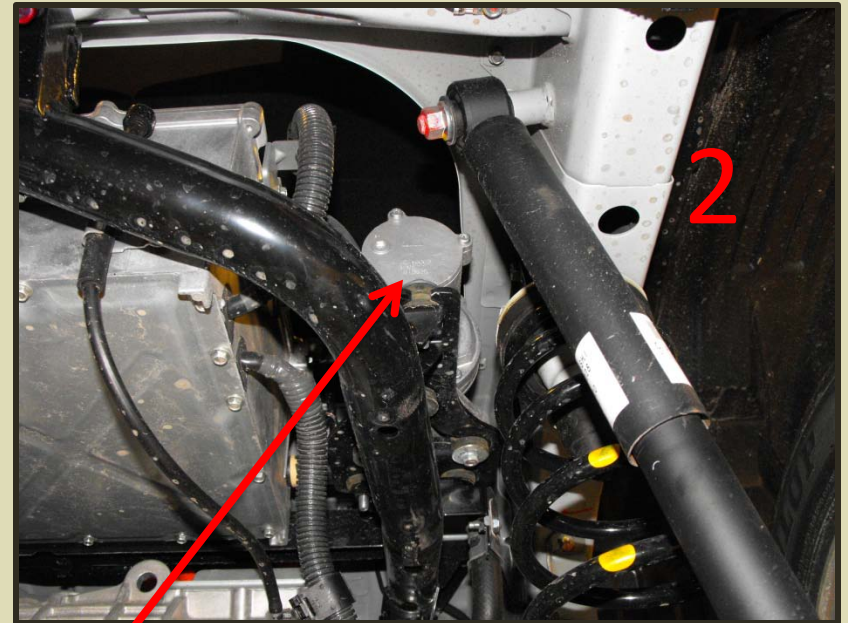
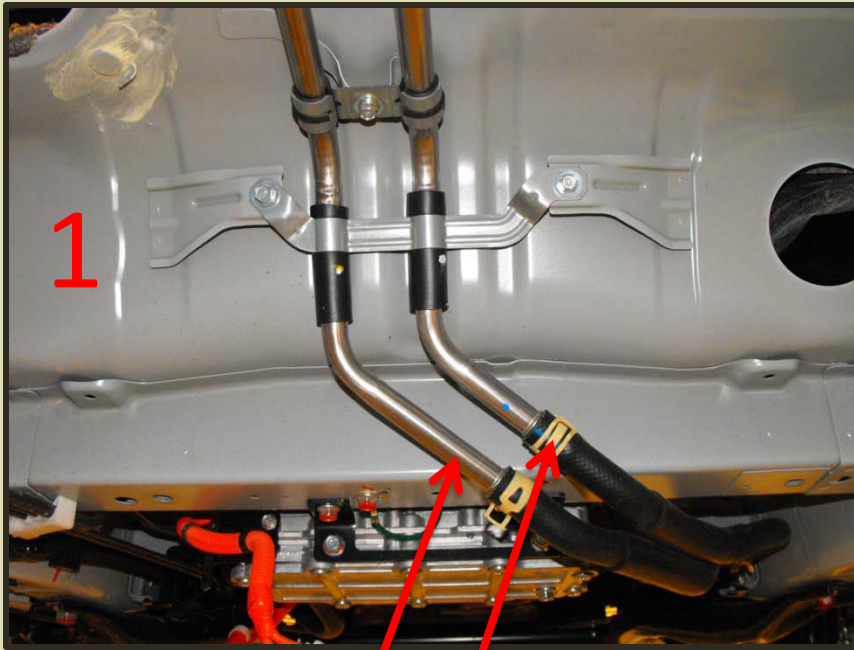
# EV components coolant system

- If motor control unit reaches 176°F vehicle will enter power down mode
- If traction motor temp reaches 266°F vehicle will enter reduced torque mode



**Reservoir for EV components  
cooling system (Trunk area)  
5.4 quarts**

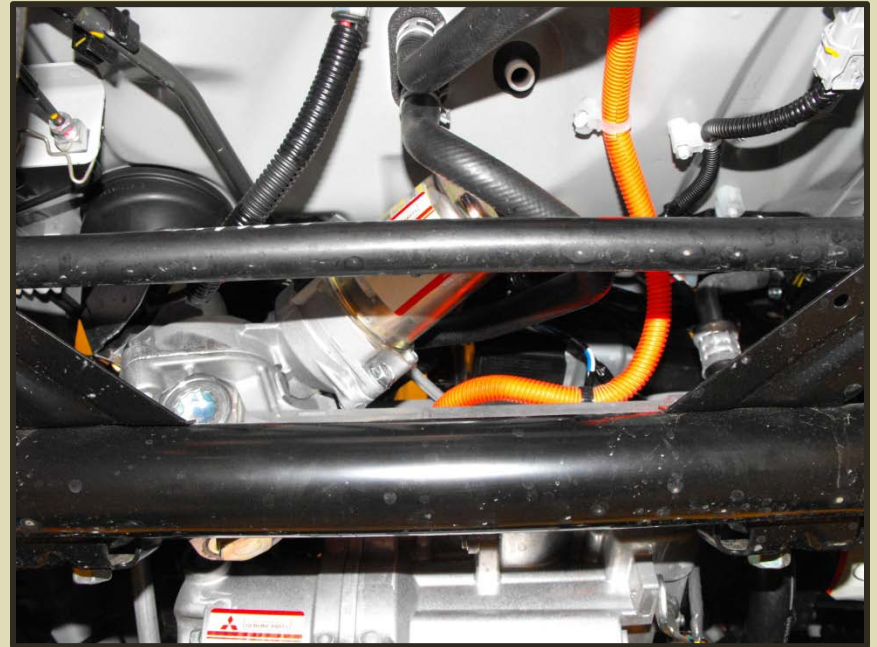




1. Coolant lines that run under length of vehicle
2. Electric coolant pump for EV components
3. Underhood radiator (radiator fan not shown)

# Power Steering

- Electric Power Steering
- Low voltage motor on rack assembly
- Similar to other MITSU products





# Power Steering

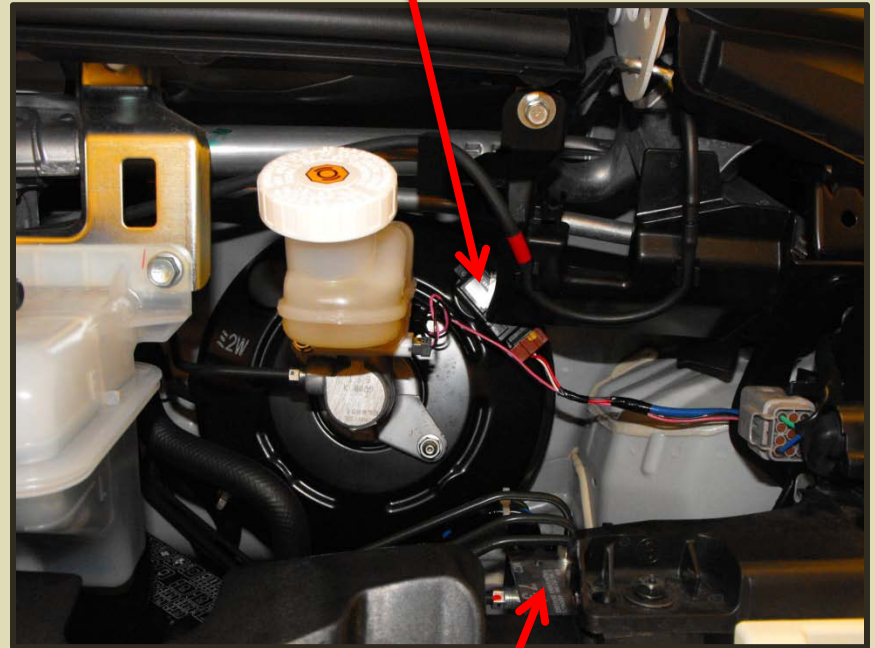
- Vehicle also features cruise control
- Hands free cell device
- Navigation Radio
- Back up camera



# Braking

- Brake system: uses vacuum booster
- Booster has a “M.A.P.” sensor on it
- Conventional DOT 3 fluid
- M/C feeds hydraulic control unit

**3 wire MAP sensor  
on booster**



**H.C.U.**





# Braking

- When M.A.P. sensor senses vacuum depletion, electric vacuum pump runs to recharge the booster



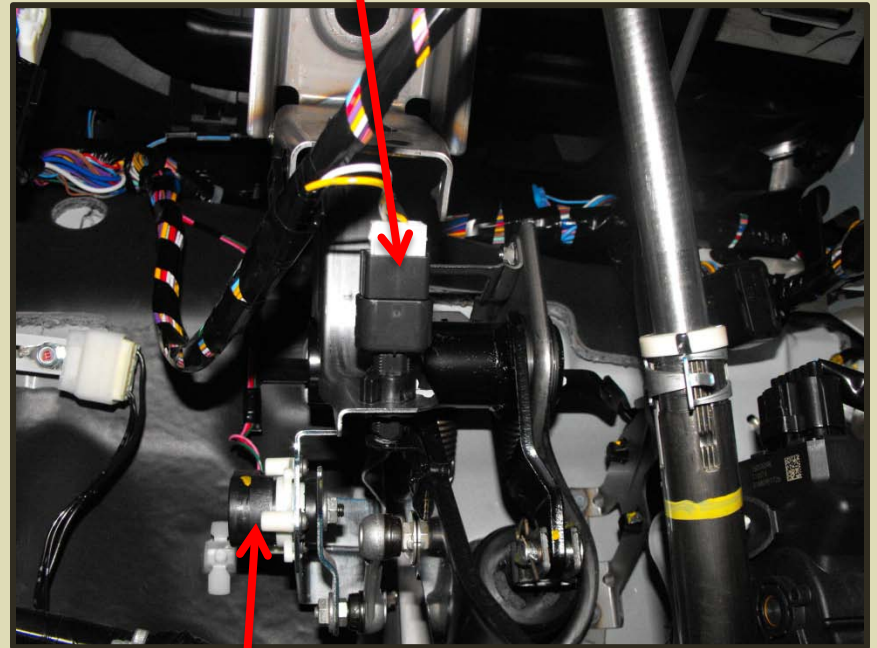
**Electric Vacuum Pump  
(Trunk area): is fairly loud**



# Braking

- Features brake override technology for safety
- Uses brake pedal stroke sensor as input in REGEN strategy
- Replaced as an assembly, must be initialized with MUT 3

**Brake Switch assembly**



**Stroke Sensor  
(from underneath dash)**

# Braking

- Vehicle has ABS, Traction control and Stability system
- Electric drive uses a “smoothing capacitor” to limit launching torque

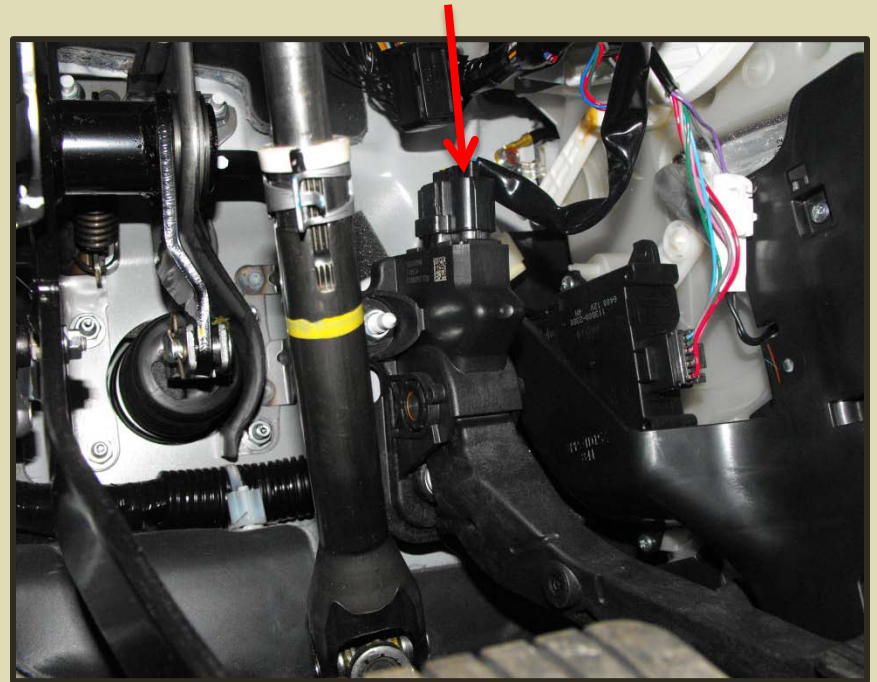


**TRAC/ STAB off switch**

# Accelerator pedal

- A.P.P.S. assembly
- 2 signal wires
- About 1 volt at “idle”
- About 4.5v at “WOT”

**APPS electrical connector**



# Operation: Severe temperatures

**COLD:** at -22°F, vehicle may not be able to “ready up”

Charge time when cold will be greater

EV ECU “wakes up” every 6 hours and monitors temperature

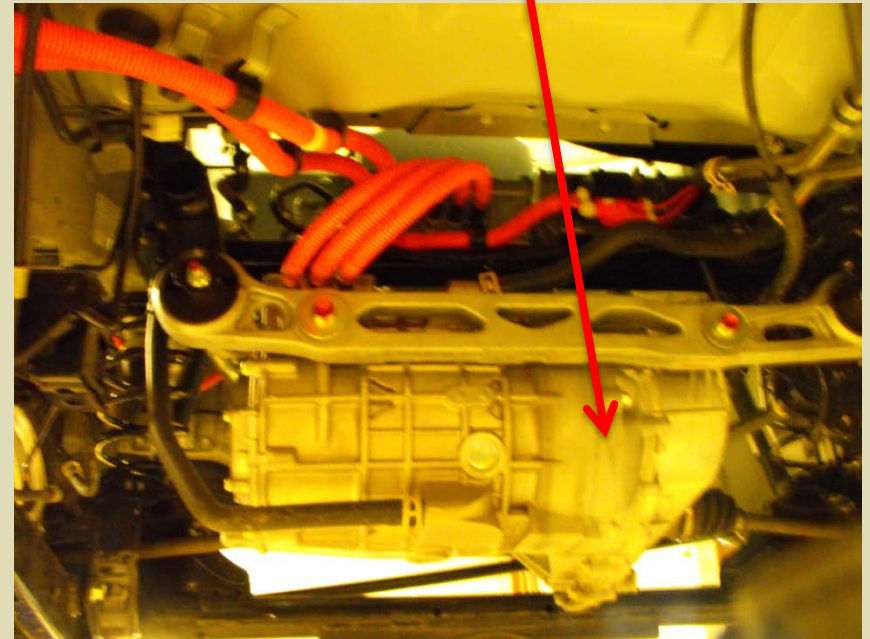
**HOT:** Does not like extreme heat, if placing in paint booth etc. @150°F or more, remove the battery

Severe temperatures may reduce range

# Transaxle

- Mitsubishi **F1E1A**
- Approx. 7:1 gear reduction
- No changing of ratio
- .79 quart capacity of Diamond SP3 to be changed every 2 years for severe service

**F1E1A  
Transaxle**



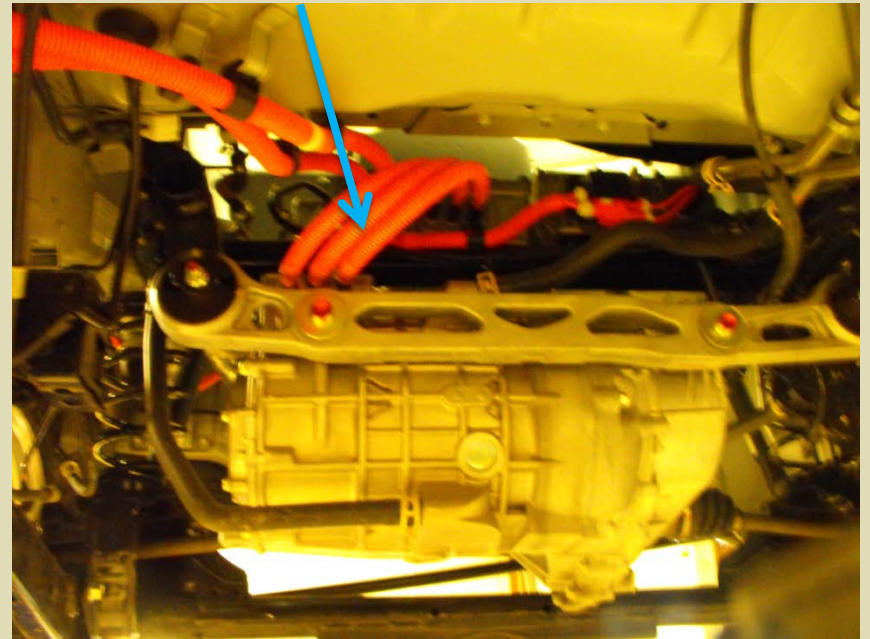
- Unequal length halfshafts



# Motor

- Supplier: Miden
- Rated @ 66 horsepower
- 144 pound feet of torque
- Max speed 9900 RPM
- Resolver monitors RPM

**Orange 3 phase high voltage cables**



- Reduced output if temp reaches 266° F

# Charging

- In addition to high voltage wires that connect car to wall outlet, there are communication lines
- Connection must be secure with proper outlet polarity and ground



- Optional level 2 charger installed

# Proper Sequence

1. Plug into wall outlet first
  2. Then connect to vehicle
- (this will save wear and tear on household outlets)

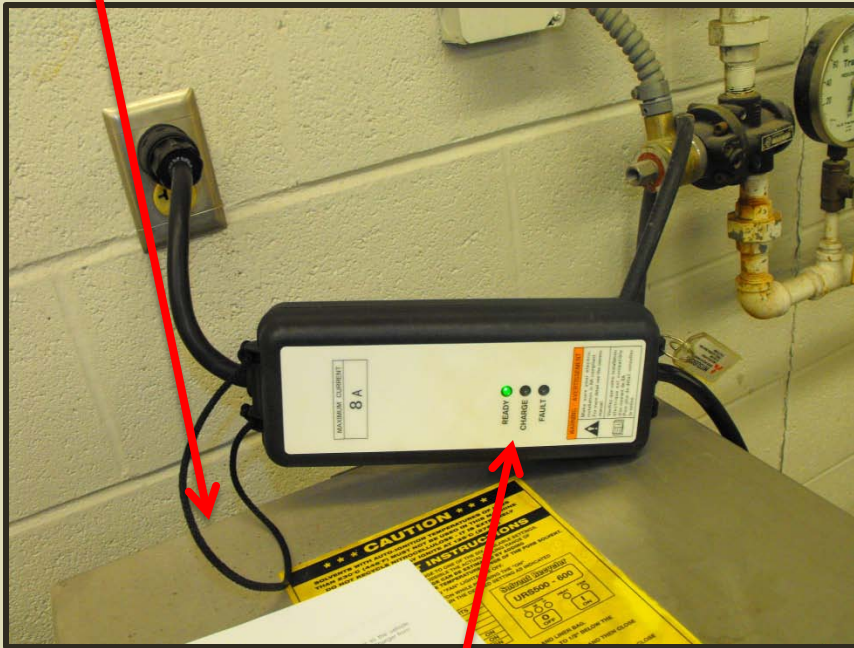
If attempt to move the vehicle with plugged in:

Vehicle will not move

Also an (plug looking) indicator on cluster

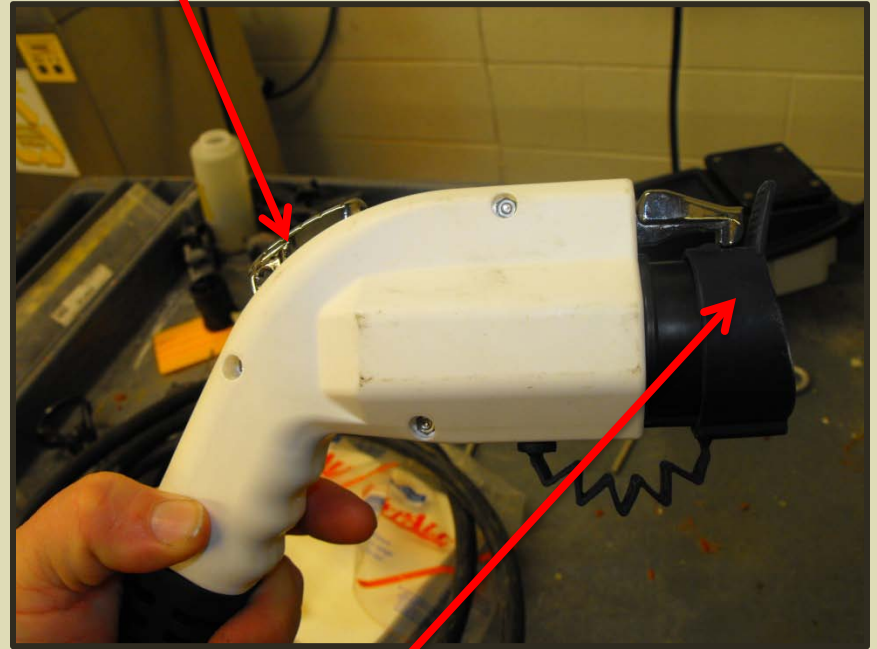
# Charging: Level 1 charger supplied with vehicle

Notice tether string provided with the level 1 charger



**CCID** Charging Circuit Interrupting Device; LED's :Ready, Charge, Fault

Release button



Tethered flap cover to protect against the elements

# Level 1 charger

- 18 foot cord, optional 25 foot
- Level 1: maximum of 8 amperes
- Onboard charger steps up 120 volts AC to approx. 370 volts DC
- 0%-100% charge time is 22.5 hours
- When hooked up, blower fan in battery comes on for 3-5 seconds



# Level 2 charger

- Level 2 charger connects to 240 volt outlet
- Optional : \$995-\$1172 plus installation
- Reduces 0% to 100% charge time to 6.5 hours



**Note: aftermarket charger shown**

# Level 3 charger

- Currently rare
- 125 amp rating
- Cost about \$60K
- Charge time reduced to 30 minutes

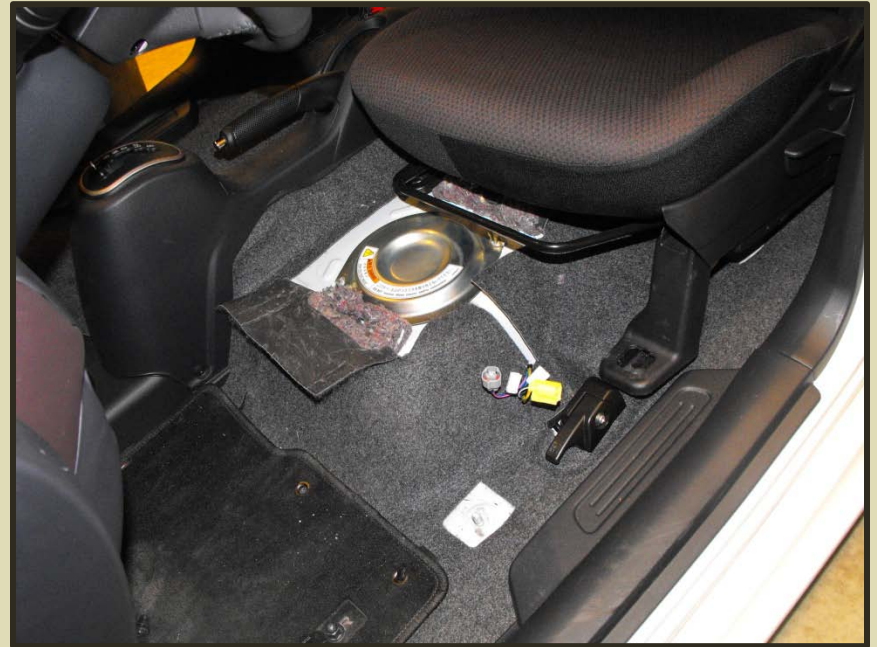
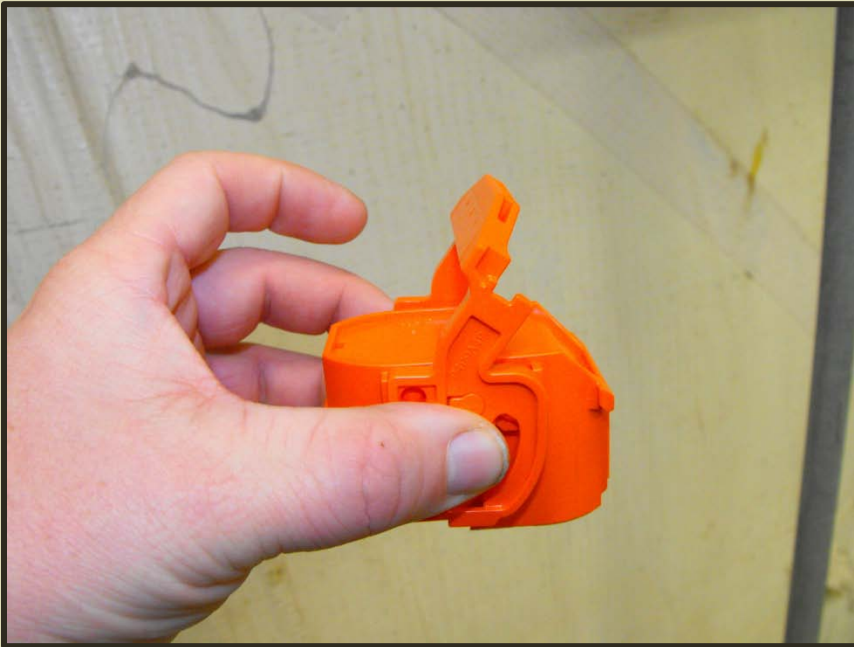
# On board charger

- Onboard charger communicates with charging plug, manages battery charge
- Also acts as a DC to DC converter to step the 330V battery down to 14 volts to operate accessories and charge 12v battery

**On Board Charger**

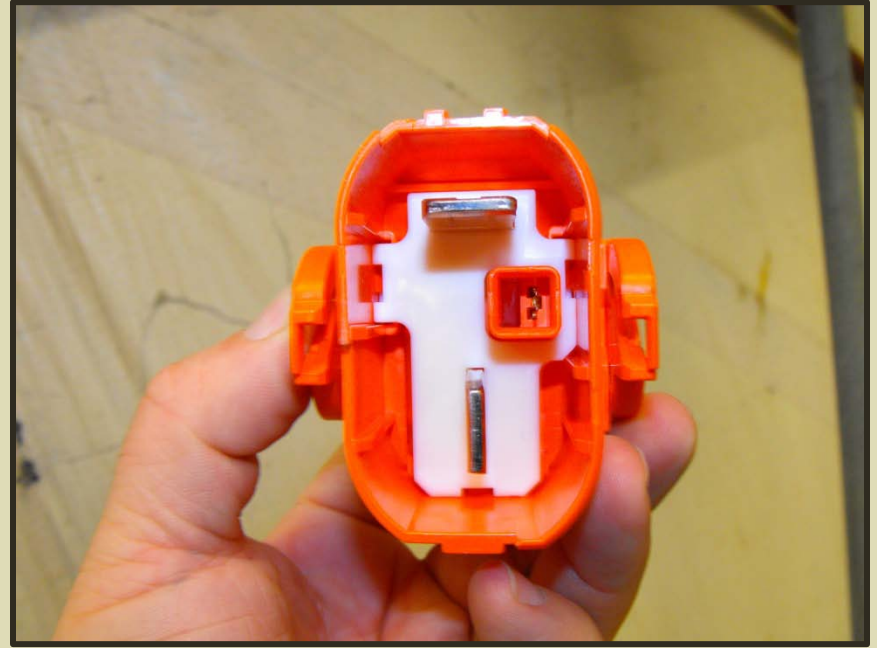
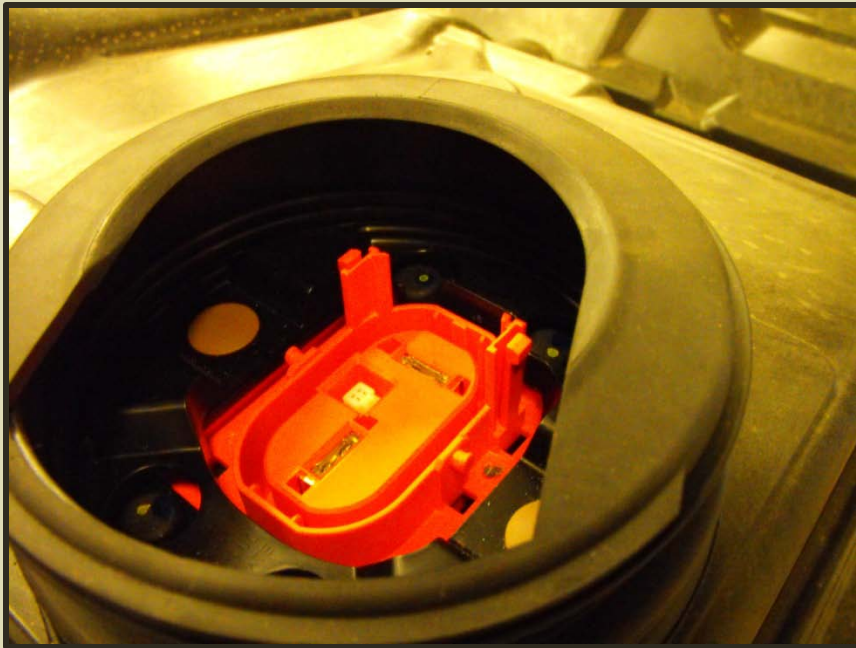


Service plug: Remove front driver seat first, **must have HV gloves on!**





# Service Plug removed



# Safety equipment : High voltage service

- Linesmen 1000v rubber gloves and leather protectors: Replace or recertify @6 months
- Rubber boots for working on wet floor etc.
- Also make sure DVOM and leads are CAT 3 certified



# Safety equipment : High voltage service



# Safety equipment : High voltage service

- Special insulated 10mm socket: if cracked/over torqued a black line will appear





# Safety equipment : High voltage service

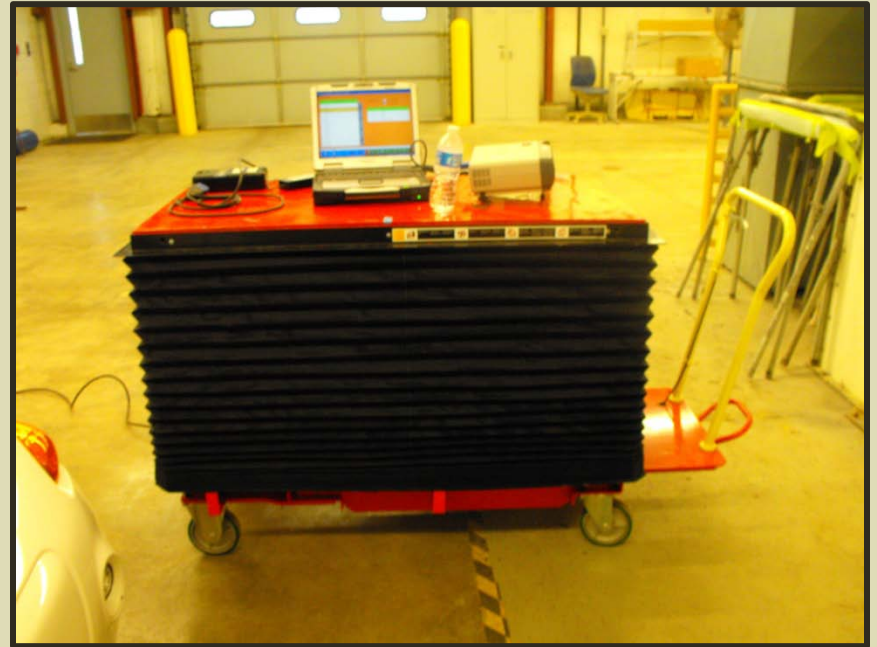
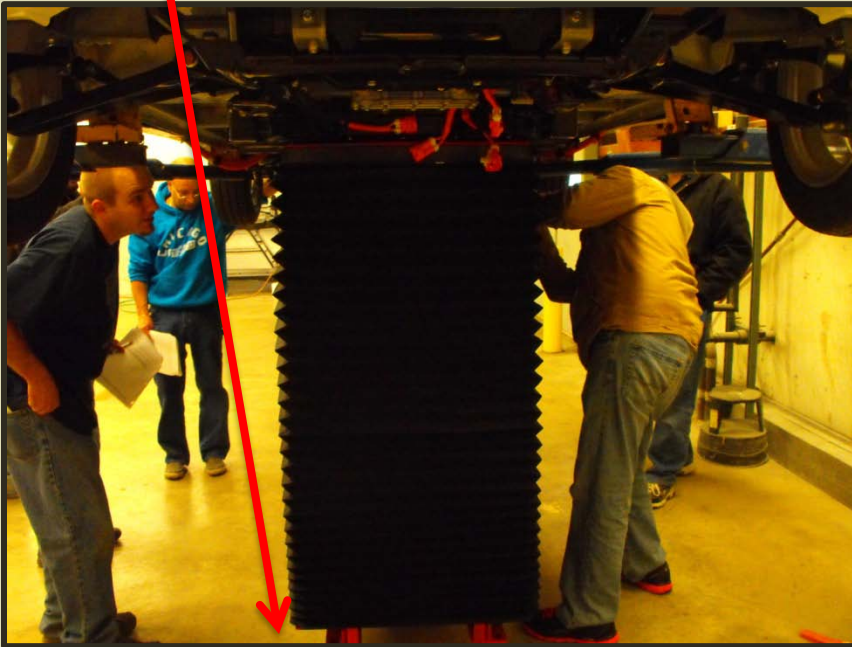
- Alignment tools for removing the battery assembly with the special fixture tool



# Safety equipment : High voltage service

Battery pack weighs 530 lbs:  
need fixture!

Mark position of fixture on floor for  
reference



- If Battery R+R needed, zone office is contacted and special lifting fixture is delivered



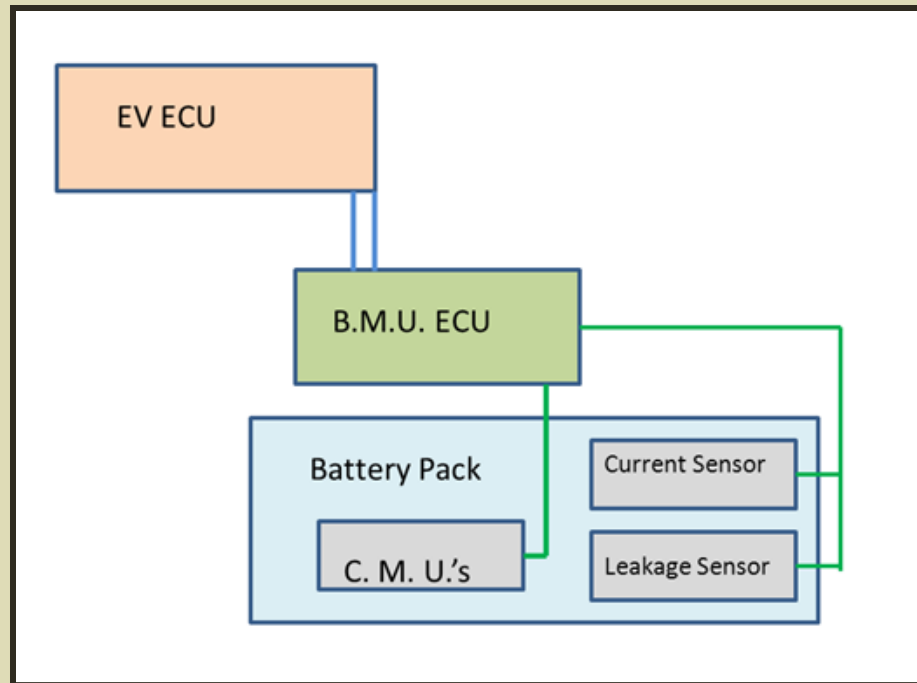
# Lithium Ion Battery Pack

- 88 total cells @ 3.75v each wired in series
- Cells are in “**modules**”
- 10 modules of 8 cells and 2 modules of 4 cells
- 330-360 volts at full charge
- Each module monitors temperature, voltage and balance
- The BMU is an ECU on CAN high speed that monitors for “electrical leakage” and battery current
- BMU controls ventilation fan

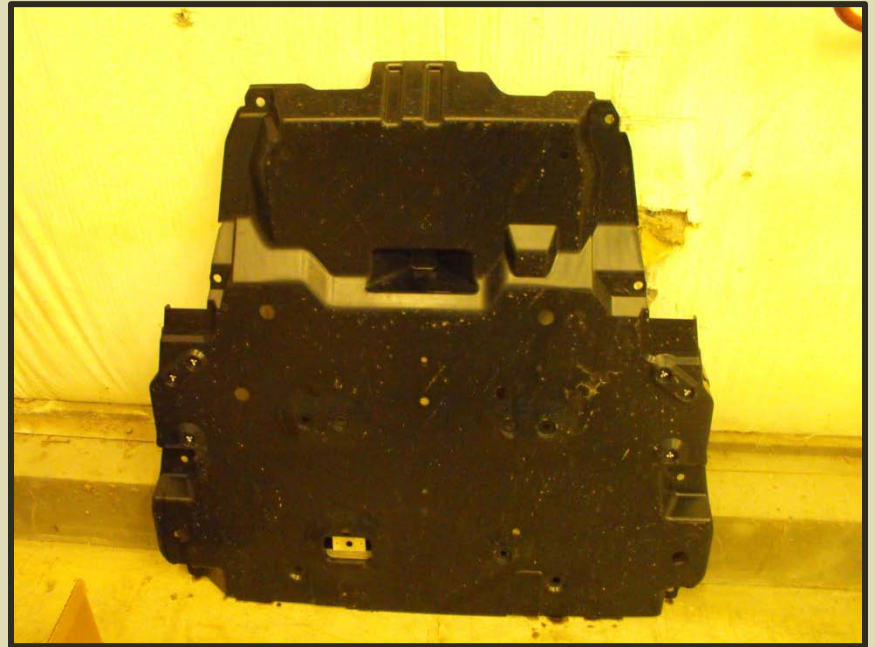
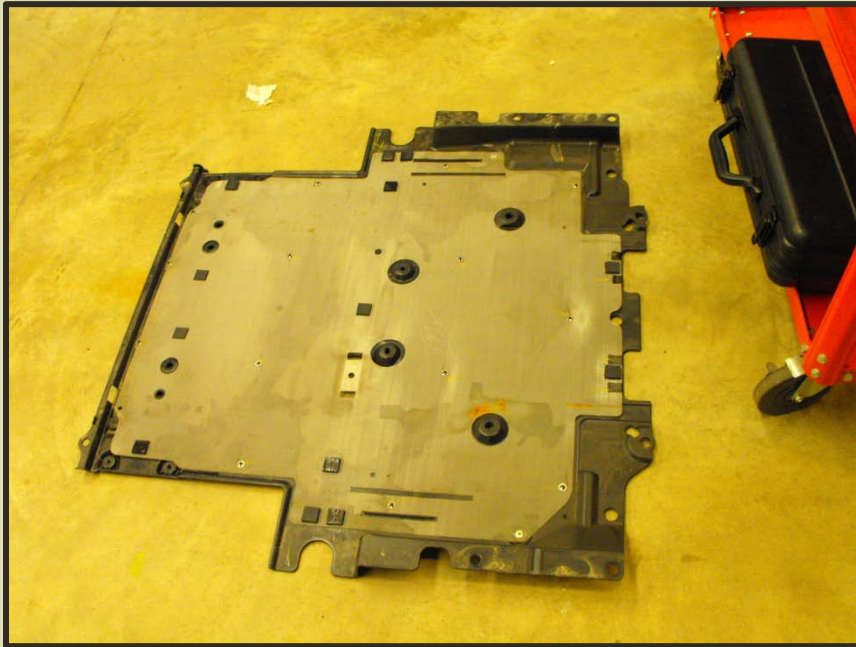


# BMU ECU

12 cell monitoring units keep track of voltage and temperature of cells, report to BMU ECU



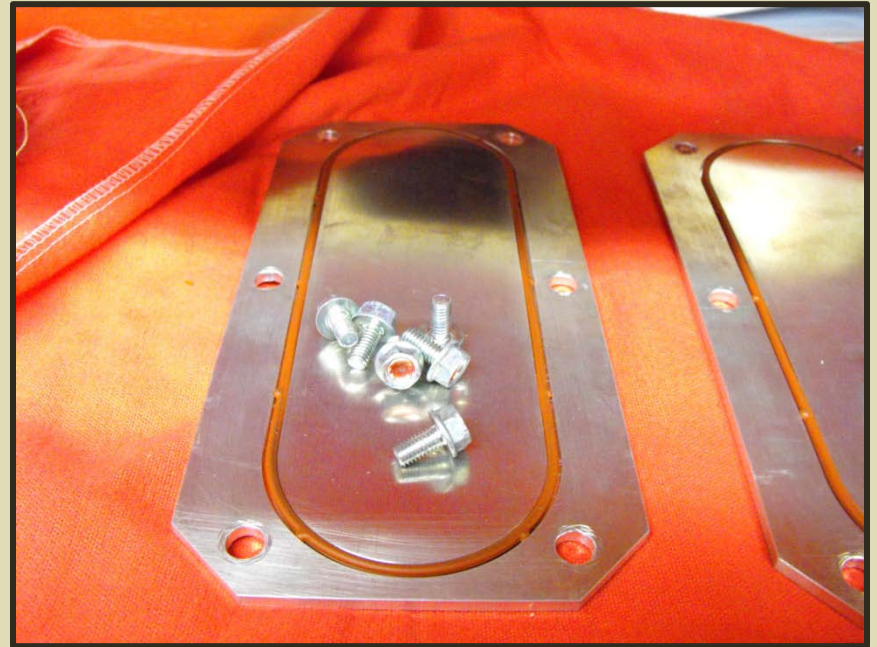
# Battery pack: Covers vehicle underbody





# Battery Pack

- After plastic covers are removed and HV gloves on, these covers are removed
- These cover the high voltage connections to the battery pack



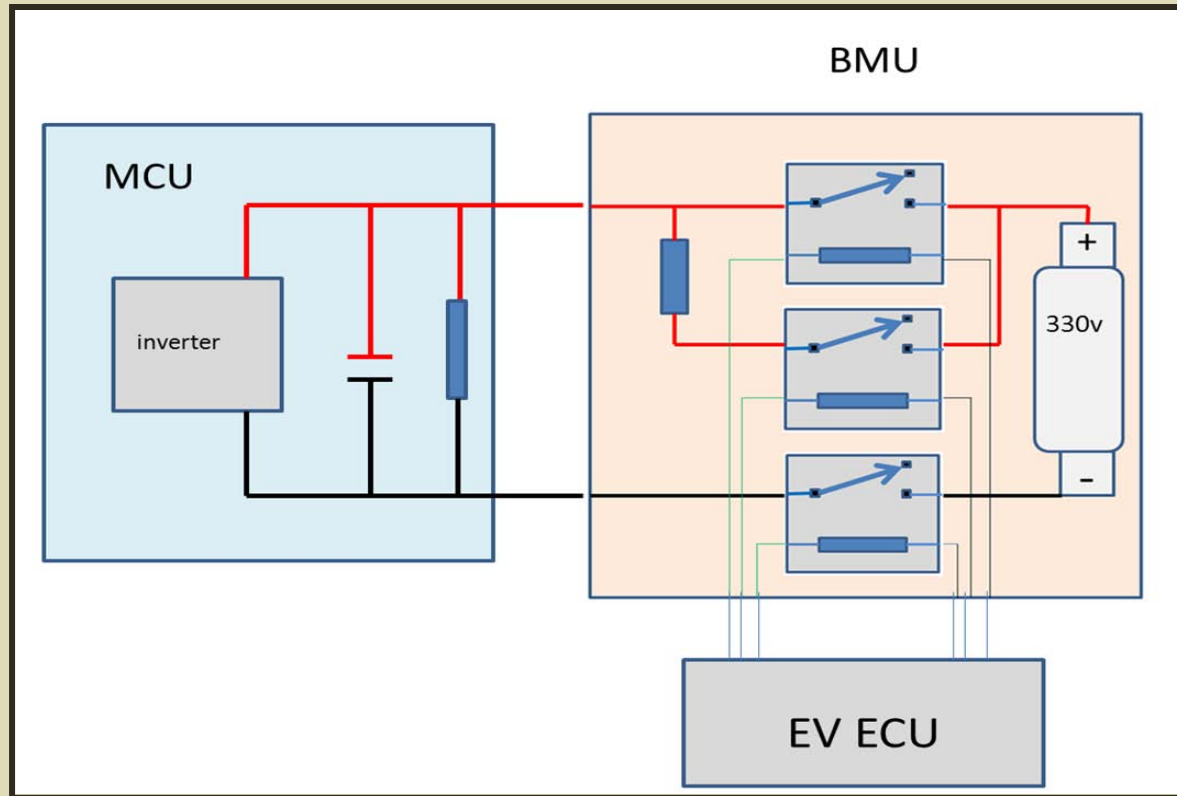
# Battery Pack

- Battery pack has no liquid coolant
- Air inlet is under passenger front seat
- Blower motor controlled by BMU

**Blower motor and air outlet**



# Battery Pack



- Main Contactors (Relays) are in the battery pack
- Controlled by EV ECU
- If Airbag ECU detects impact, Contactors are opened

# Battery Pack

- Battery shipped to dealer in crate
- Eyelets with battery, lifting strap, forklift required to place pack on lifting fixture
- Battery must be recycled



- 8 year/80,000 mile warranty
- date code is on battery pack



# Battery Pack: State of charge

- There is a .05 volt max allowed between cells
- A wrench symbol appears on cluster if battery conditioning is necessary
- Cell monitoring units and BMU work to keep cells equal



# MCU (Motor Control Unit)

- Inverter in MCU ECU  
Converts DC from battery pack to AC voltage using IGBT's
- 3 phases on motor stator:  
U V W
- Voltage: determines torque
- Frequency: Determines speed



- MCU also contains smoothing condenser
- Current sensors on U and W phases

# ECU interaction

- EV-ECU is the most important however BMU, MCU, and onboard charger ECU all work as a team along with other ECU's



# Technician Diagnostics

- Vehicle equipped with high speed CAN
- Laptop based MUT 3 is factory scan tool
- DTC's, Data Stream, initialization, actuators etc.

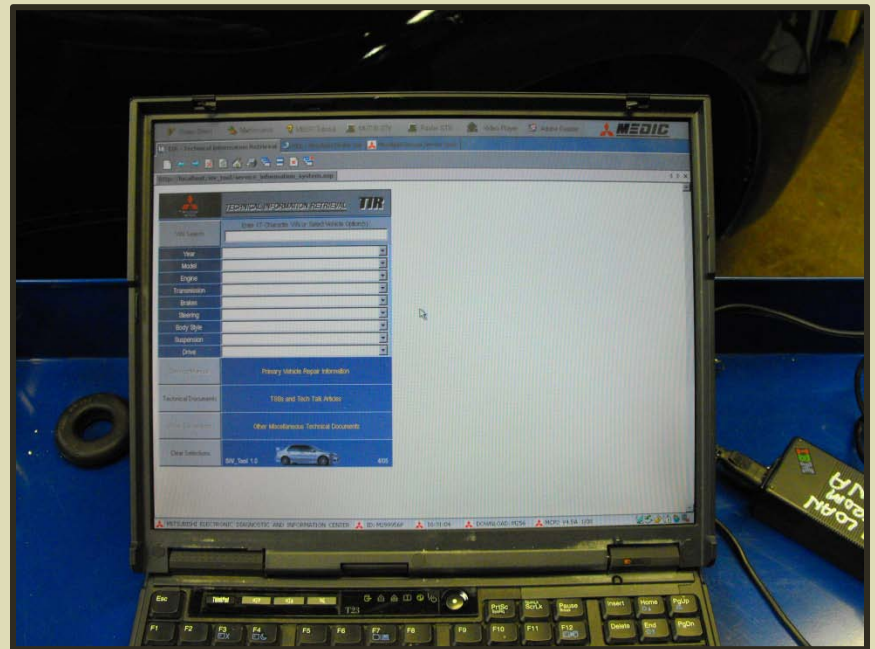


**MUT 3 interface**

# Technician Diagnostics



Multi Use Tool (MUT) 3



MEDIC Factory Service Information

# Driving the “i”

- Spirited Acceleration
- Speed limited in Reverse to 12 MPH
- Top speed is reported to be 80 MPH





# **Thank you to:**

Mitsubishi Motors Corporation

Dan Sherman, MMC, SIUC Automotive  
Technology Advisory Committee

Rick LaVarta, MMC instructor

**Questions?**