

THE 21ST CENTURY CAR/MANUFACTURING

Jim Weichel
Owner of an EV for 3+ Years

BACKGROUND

- MSEE from Purdue & Business Training at Penn State, Harvard, & Northwestern
- Software Development and Management Bell Labs 1970-1999
- COO of Data Visualization Company, CTO of Energy Industry Data Supplier and Securities Brokerage
- Consultant to Fermi National Laboratory Open Science Grid
- Currently - Web Design & Developer for 2 non-profits

OUTLINE

- EV Selection Criteria
- Review of the Many EV Choices
- The Greatest Revolution in Autos Since the Model T
- The 21st Century Auto and Auto Manufacturer

5 KEY QUESTIONS

- 1) Can I plug the car in at my residence?
 - No – you will lose a major advantage of an EV
 - Yes – Great an EV should be a wonderful car for you
- 2) How many miles do you drive per day?
 - <100 – 99% of US drivers; almost any EV will work
- 3) Do I want to take long trips in my EV?
 - Yes – You should get an EV >250 mile range; Preferably >300
 - No – Any EV will work
- 4) How comfortable am I with change and new technology?
 - Driving is different, interior/controls may be more computer like. Takes a few weeks to learn.
- 5) Do I need my next car to drive itself due to age/medical conditions?
 - Yes – Tesla is the only current choice

JIM'S CRITERIA FOR EV SELECTION

Here is a list of criteria I suggest for comparing EVs.



First decide if you want mostly an Urban car or you want to take Long Trips.


Cars are expensive, so I want a car I can use for everything.

Pick type of vehicle (Sedan, SUV/CUV, Pickup), then use these criteria:

1. Range must be >250 miles (if only Urban, 150-200 is OK)
2. You have to like the looks (you see it ~every day and should like it)
3. Efficiency (cheaper to operate, lighter car, faster to charge)
4. Features (especially those that affect comfort, easy of use, and your joy of driving)
5. Assistance in driving long trips (makes a big difference)
6. Safety (only this low because most EVs have good safety scores – but still check it)
7. Ease of interacting with Service and recommended Service frequency


MANY CHOICES: HATCHBACKS

Nissan LEAF  






\$19,900
Base MSRP after Incentives

149 miles
electric




MORE

MINI Electric Hardtop 2 Door  






\$22,400
Base MSRP after Incentives

114 miles
electric



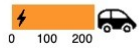
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Nissan LEAF PLUS  






\$24,900
Base MSRP after Incentives

226 miles
electric




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Chevrolet Bolt EV  



\$31,000
Base MSRP after Incentives

259 miles
electric



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NISSAN LEAF





MINI ELECTRIC HARDTOP 2 DOOR



CHEVY BOLT



MANY CHOICES: SEDAN

Polestar 2 Long Range Single Motor  





\$38,400
Base MSRP after Incentives

270 miles electric




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Polestar 2 Long Range Dual Motor  






\$42,400
Base MSRP after Incentives

249 miles electric




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Tesla Model 3 RWD  



\$44,990
Base MSRP after Incentives

272 miles electric



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Tesla Model 3 Performance AWD  




\$58,990
Base MSRP after Incentives

315 miles electric



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Porsche Taycan Performance Battery Plus  






\$80,980
Base MSRP after Incentives

225 miles electric




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Mercedes EQS450+  






\$94,810
Base MSRP after Incentives

350 miles electric




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BMW i4 eDrive40  



\$47,900
Base MSRP after Incentives

300 miles electric



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Tesla Model 3 Long Range AWD  



\$50,990
Base MSRP after Incentives

358 miles electric



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BMW i4 M50  






\$58,400
Base MSRP after Incentives

270 miles electric




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Audi e-tron GT  





\$94,900
Base MSRP after Incentives

238 miles electric




MORE

Tesla Model S AWD  






\$94,990
Base MSRP after Incentives

405 miles electric




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Lucid Air Dream Edition P  



\$161,500
Base MSRP after Incentives

471 miles electric



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VOLVO POLESTAR



TESLA MODEL 3



BMW i4



PORCHE TAYCAN



MERCEDES EQS



AUDI E-TRON GT





TESLA MODEL S




LUCID AIR GRAND TOURING




MANY CHOICES: CROSSOVER

Mazda MX-30 EV  



\$23,770
Base MSRP after Incentives

100 miles electric



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Hyundai KONA Electric  






\$24,200
Base MSRP after Incentives

258 miles electric




MORE

Kia Niro EV  




\$29,890
Base MSRP after Incentives

239 miles electric



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Ford Mustang Mach E California Rt. 1  






\$43,275
Base MSRP after Incentives

305 miles electric




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Audi Q4 Sportback e-tron  






\$45,200
Base MSRP after Incentives

241 miles electric




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Volvo XC40 Recharge Pure Electric  






\$47,800
Base MSRP after Incentives

223 miles electric




MORE

Volkswagen ID.4  



\$29,895
Base MSRP after Incentives

280 miles electric



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Chevrolet Bolt EUV  






\$30,800
Base MSRP after Incentives

247 miles electric




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Ford Mustang Mach E Select  



\$32,595
Base MSRP after Incentives

230 miles electric



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Ford Mustang Mach E GT  






\$52,495
Base MSRP after Incentives

270 miles electric



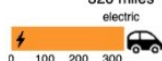
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Tesla Model Y Long Range AWD  






\$56,990
Base MSRP after Incentives

326 miles electric




MORE

Audi e-tron  



\$58,400
Base MSRP after Incentives

222 miles electric



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MAZDA MX-30



HYUNDAI KONA ELECTRIC



KIA NERO EV



VOLKSWAGON ID.4



CHEVROLET BOLT



FORD MUSTANG MACH-E



AUDI Q4 E-TRON



Volvo XC40



TESLA MODEL Y



MANY CHOICES: PICKUPS

- Rivian R1T - Launch Edition 300 mi \$74K (50 delivered)
- Tesla Cybertruck - 250-500 mi \$40K-70K (late 2022?)
- Ford F150 Lightning - 230-300 mi \$40K-\$90k (2022?)
- Chevrolet Hummer - EV Edition 300 mi (2022?)

RIVIAN R1T



TESLA CYBERTRUCK



TESLA CYBERTRUCK



FORD F 150 LIGHTNING



HUMMER EV PICKUP



21ST CENTURY CAR/FACTORY

Biggest Revolution in Automobile Since the Model T Ford!

- Electrification – advantages already discussed
- Connectivity – Feature delivery via network, data collection for autonomy
- Autonomy – Tremendous improvement in driving/safety, enjoyable trips
- Vertical Integration of Manufacturing – Including mining lithium & batteries
- Speed of Car Design Changes and Production Line Changes

Auto Company in the 21st Century:

- Online Ordering with NO hassle (literally takes 10 min at Home or Showroom)
- Vehicle Delivery to Home or pick up at Service Center
- Most features implemented in Software
- New features/fixes delivered via Internet
- Service scheduled quickly via App and Mobile Service at your location
- Real world data collection for training neural net for autonomy

THE 21ST CENTURY CAR

Owner Perspective:

- Dramatic improvement in buying experience
- No Maintenance for 2 years (any less is for dealer benefit only)
- Refuel in garage or parking area
- Car features added ~monthly – customer driven & choice
- Longer lifetime (500K to 1M miles for drivetrain)
- Better resale value
- Relaxing trips due to Autonomy features (before full autonomy)
- Actually driving that is Joyful (sports car like in a sedan) due to performance, handling, brakeless driving, etc.

THE ONLY 21ST CENTURY CAR

There are now many very good EVs; but only Tesla builds a 21st Century Car – As judged by the technology and features – Only EV that has all of:

- Improvements and New Features via WiFi (~1-2 updates per month)
- All solid state (e.g. no relays or fuses, few physical switches)
- Extensive, Integrated Supercharger Network → Travel ~Anywhere
- Record Performance for production cars (including >\$2.5M cars)
- Safest cars ever tested by NHTSA (all 4 models are 5 star in all tests)
- Self Driving (Interstate Now; Everywhere in Beta test)
- Energy efficiency of up to ~4 miles/kWh

21ST CENTURY DESIGN/MANUFACTURING

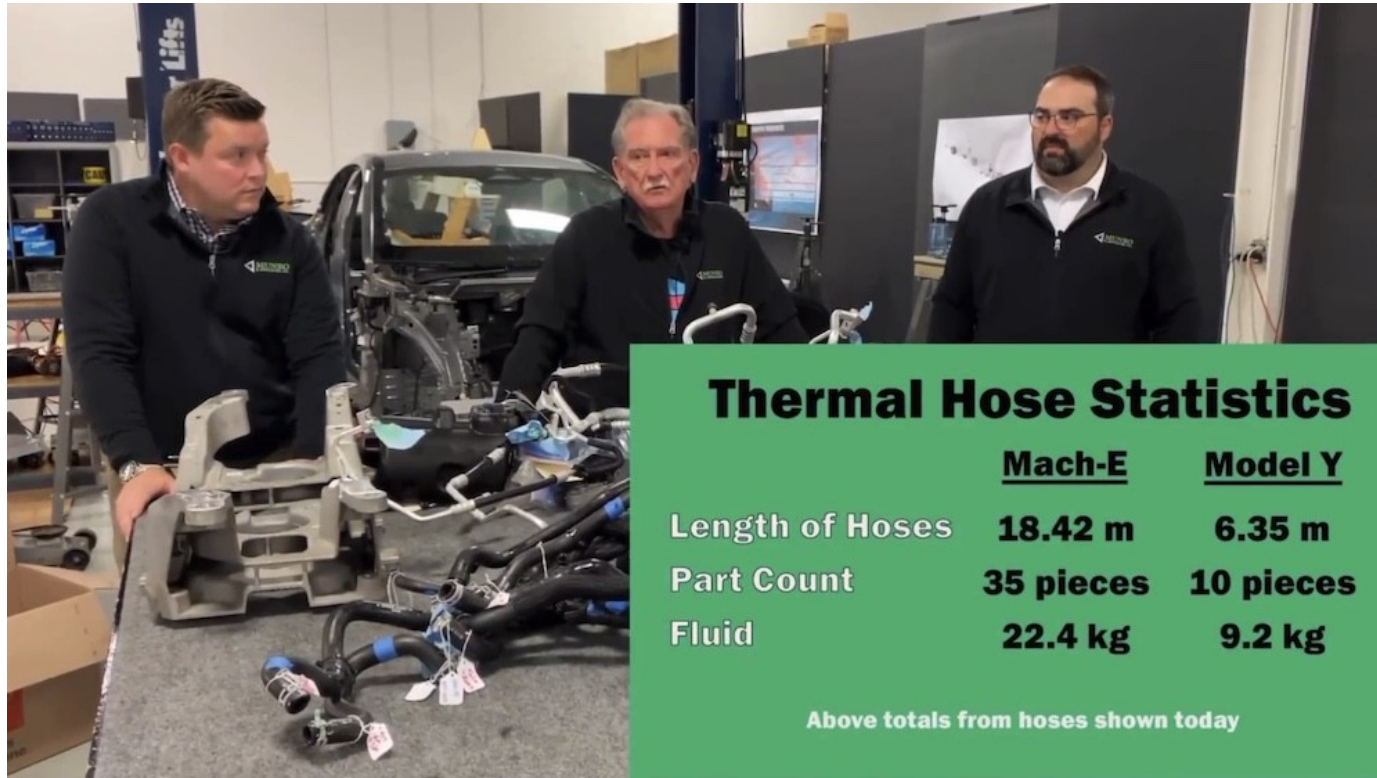
Technology Comparison by Sandy Munro & 3IS: Audi, Tesla, Ford

	ID.4	Model Y	Mach E
12 V Fuses	77	0	88
12 V Relays	7	0	22
Fuse Blocks	3	0	3



21ST CENTURY DESIGN/MANUFACTURING

Technology/Manufacturing by Sandy Munro



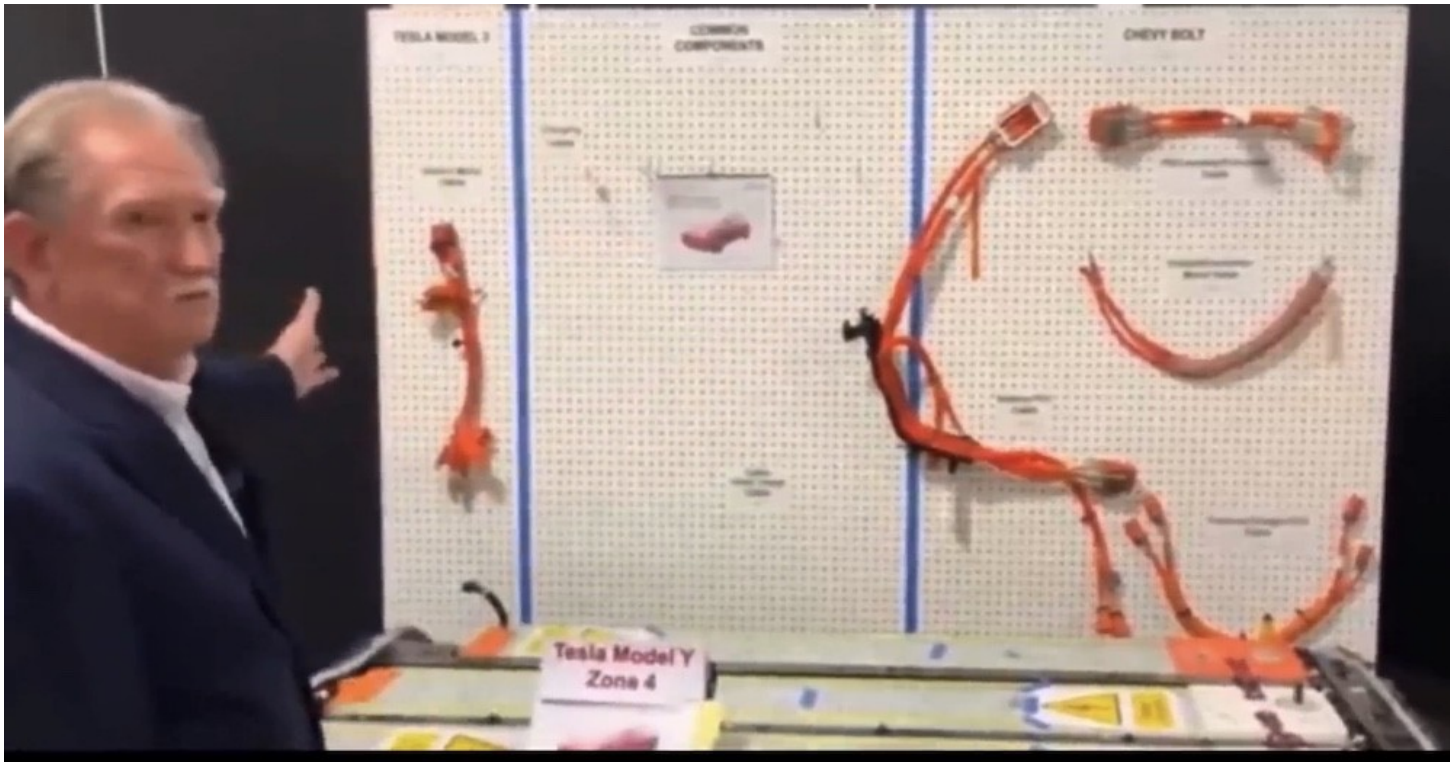
The image shows three men in a workshop setting. They are gathered around a car chassis that has several hoses and components attached. The man on the left is looking at the hoses, the man in the middle is looking towards the camera, and the man on the right is looking at the car. The background shows a typical workshop environment with shelves and equipment.

	<u>Mach-E</u>	<u>Model Y</u>
Length of Hoses	18.42 m	6.35 m
Part Count	35 pieces	10 pieces
Fluid	22.4 kg	9.2 kg

Above totals from hoses shown today

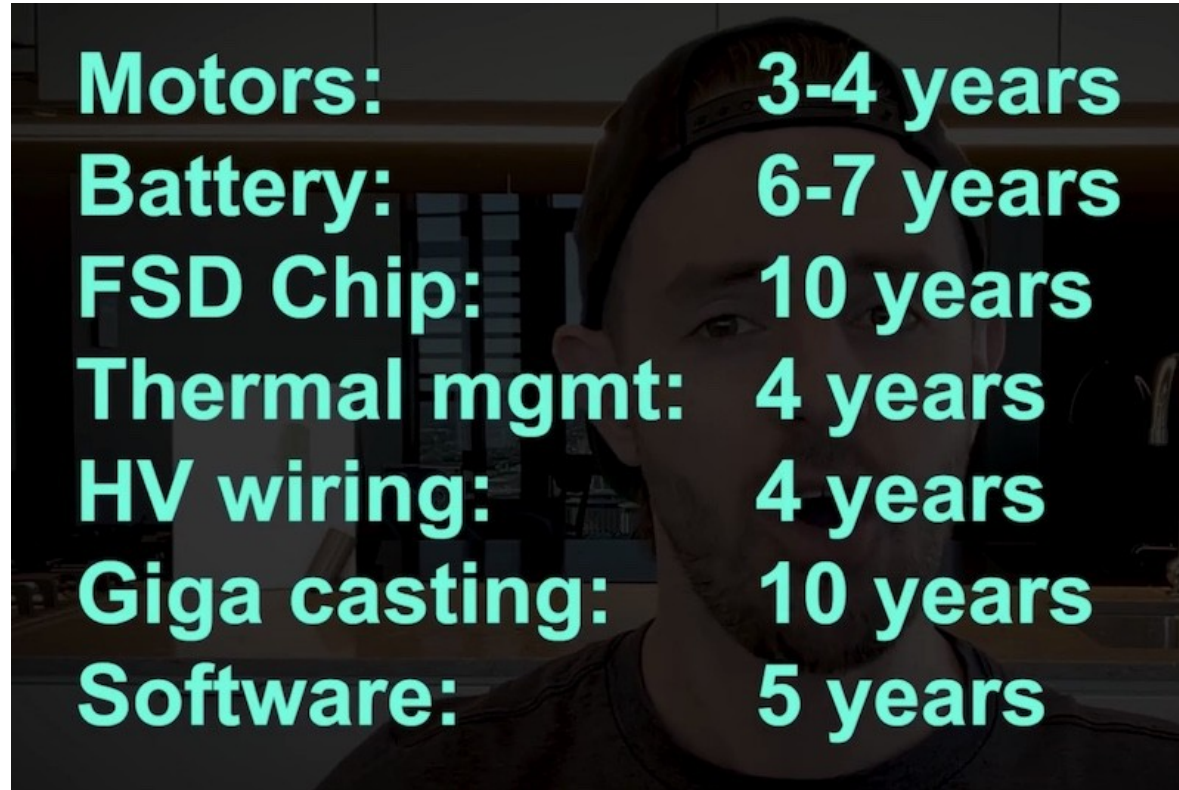
21ST CENTURY DESIGN/MANUFACTURING

Technology/Manufacturing by Sandy Munro – Chevy Bolt vs Tesla



21ST CENTURY DESIGN/MANUFACTURING

Tesla Technology/Manufacturing Lead by Sandy Munro

A man wearing a dark cap and a dark shirt is shown from the chest up. Overlaid on the image in bright green text are technical lead times for various Tesla components. The text is arranged in two columns, with the component name on the left and the lead time on the right.

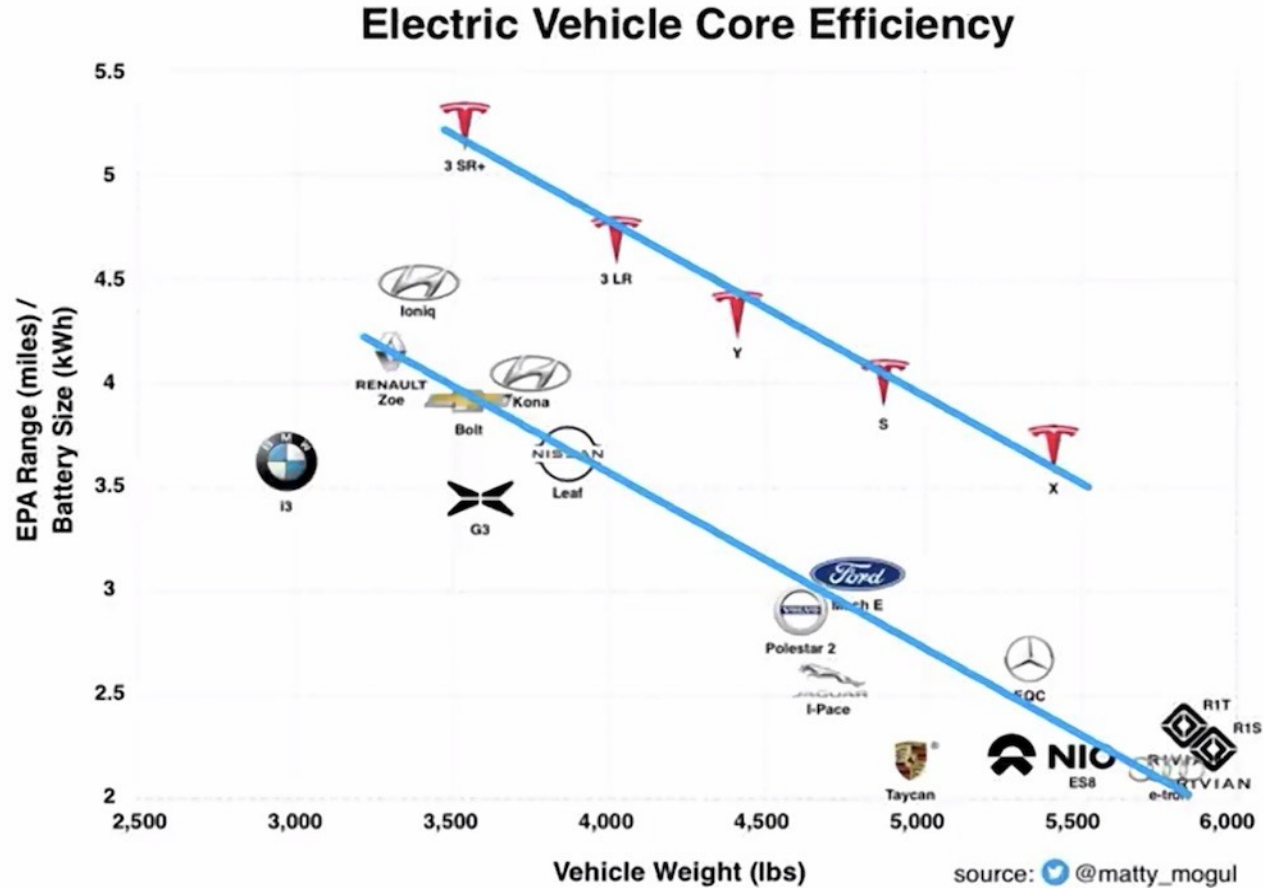
Motors:	3-4 years
Battery:	6-7 years
FSD Chip:	10 years
Thermal mgmt:	4 years
HV wiring:	4 years
Giga casting:	10 years
Software:	5 years

21ST CENTURY CAR - EFFICIENCY

Efficiency Comparison

Model	Battery Size (kWh)	MPGe	Range
Tesla Model Y	75	125	326
Ford Mach-e	88	101	305
VW ID.4	82	97	260
Audi Q4 e-Tron	95	78	218

EFFICIENCY OF EV MODELS



EV DESIGN/MANUFACTURING

Diess (VW CEO) said:

- VW's new ID.4 factory requires 30 hours to build a car
- Tesla factory will build a car in 10 hours

So, the legacy automakers may not be as good as one might expect.

Manufacturing of new designs is hard, even for the big automakers.

- Tesla Model S & X have had many problems over time – especially the Falcon Wing doors on the X.
- Ford Mustang Mach-E has recalls for lack of adhesive on windshield & sunroof and electronics problems
- Chevy Bolt has a major recall on battery packs causing spontaneous fires
- All manufacturers have had software problems

Software expertise at legacy automakers is not very strong; but it has become a the key requirement for cars.

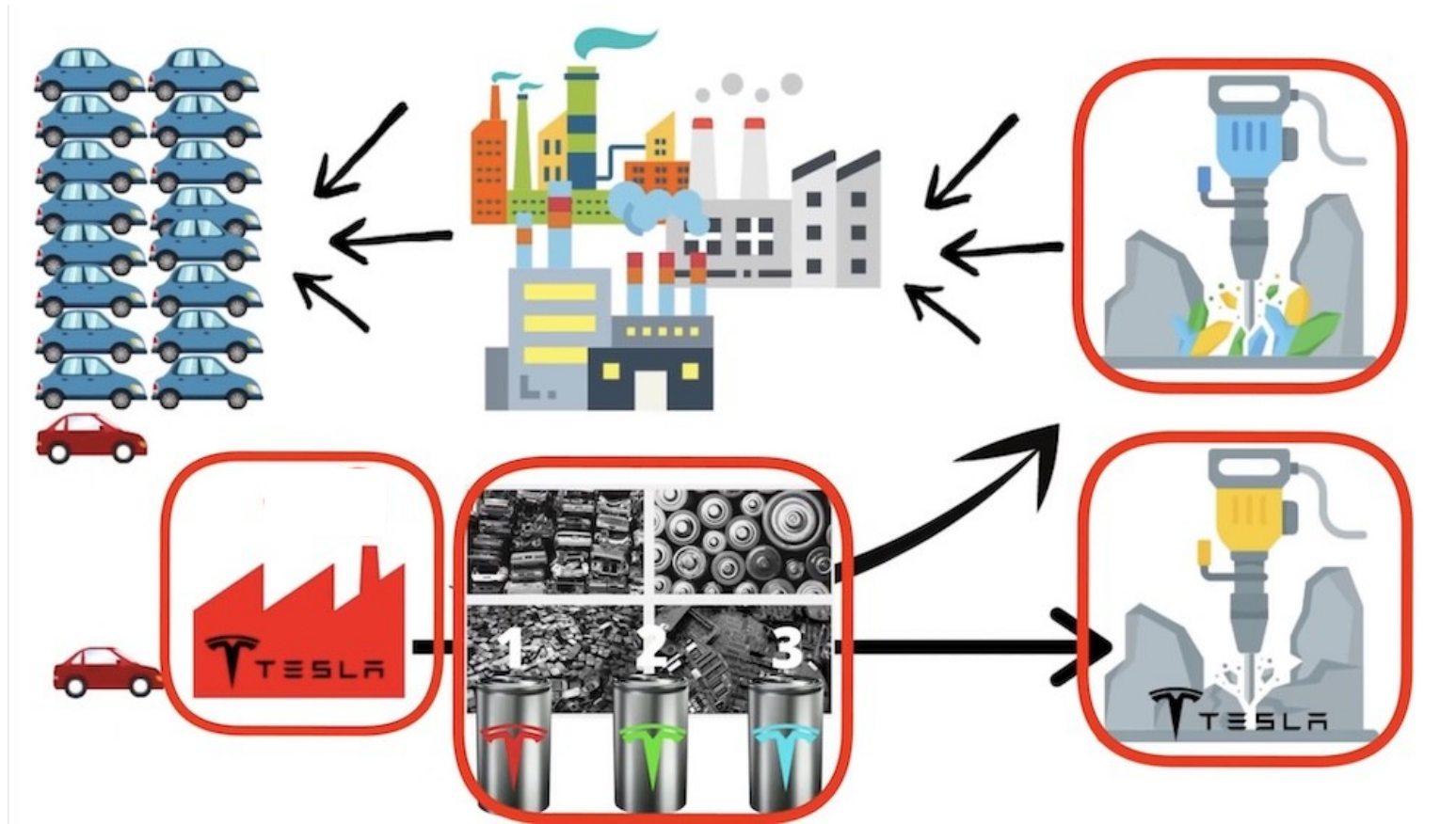
21ST CENTURY MANUFACTURING

But the lead is not the only problem:

- Legacy makers mostly change cars & production lines 1 time per model year
- Tesla is making an average of 13 changes in their cars per WEEK!
- Tesla production line changes 27 times per WEEK!
- VW has a goal to reduce production time from 30 hours to Tesla's 10 by 2026

So, by the time any legacy manufacturer “catch up” in a several years, Tesla may be even farther ahead

MANUFACTURING – VERTICAL INTEGRATION



TESLA: THE 21ST CENTURY CAR

Sample Owner Perceived Technology/Features

CR: Tesla average owner satisfaction is 88, next highest brand is 79, Audi/BMW are 70:

- Car unlocks/locks automatically (no fob or key required)
- Car turns on/off automatically (no button)
- Car automatically opens/closes garage door
- Uses AI to operate rain sensing wipers
- Automatically heats/cools cabin at a specified time
- Looks on your calendar to set Navigation destination
- Many things can be controlled by voice – never had to type destination
- Records video all around car when parked (saves video if threat detected)
- Fully drives itself on limited access roads (requires monitoring)
- Summon car from parking lot to you
- Entertainment while driving: FM radio, streaming music, podcasts, Spotify, TuneIn

TESLA: THE 21ST CENTURY CAR

New Features Added Since Purchase (selected):

- 3% Efficiency Increase
- Increased charging rate from 100kW to 150kW to 250kW
- Automatic mirror folding/unfolding in garage & parking lot
- Automatic garage door closing/opening
- Dog mode – Keep cabin comfortable when unoccupied
- Schedule time to leave – charged and cabin comfortable
- Automatic routing to next appointment on calendar
- Automatic capture of last minute of video if horn is sounded or a crash
- Security mode with camera video automatically captured if threatened
- Live Security view remotely from Phone
- FSD – Summon car to you from parking lot; Navigate on Autopilot (highway; beta city)
- Joe Mode – Quiets notification gong (for sleeping children)
- Entertainment – While Parked: games, chess, backgammon & Hulu, Netflix, Youtube
- Force routing using waypoints

EXAMPLE TECHNOLOGY: AC VENTS



TESLA: THE 21ST CENTURY CAR

Sample Quality/Hardware Items:

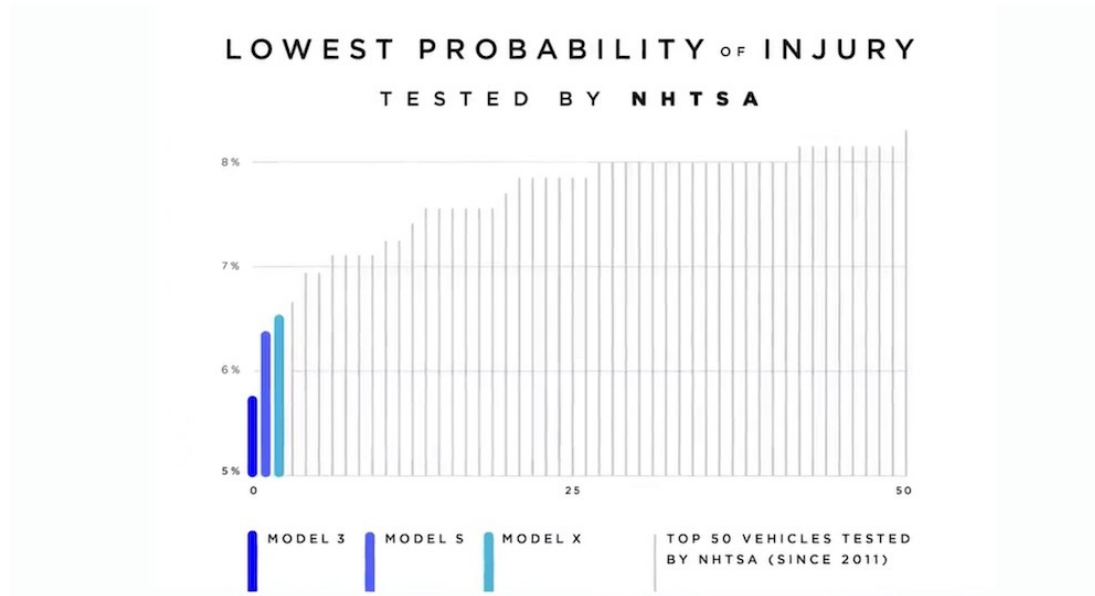
- Most comfortable seats in any car I have driven (not true for my wife)
- Best car sound system I have heard (better than 5.1 home system)
- Very clean interior design (few buttons/switches, louvers, etc.)
- Roof is all glass (but no heat from sun & stronger than steel)
- Large display for info/map/self driving visualization of environment
- Ride is a bit harsh (tradeoff with handling and weight of 4000#)
- Huge amount of storage for mid sized sedan

- CR claims quality is relatively low, but doesn't share scoring weights....
- CR also shows Tesla's have very high owner satisfaction

TESLA: THE 21ST CENTURY CAR

Safety

- Tesla Models (S, 3, X, Y) are the top 4 safest cars ever tested by NHTSA
- Model 3 & Y won the Insurance Institute of Highway Safety (IIHS) top safety pick+



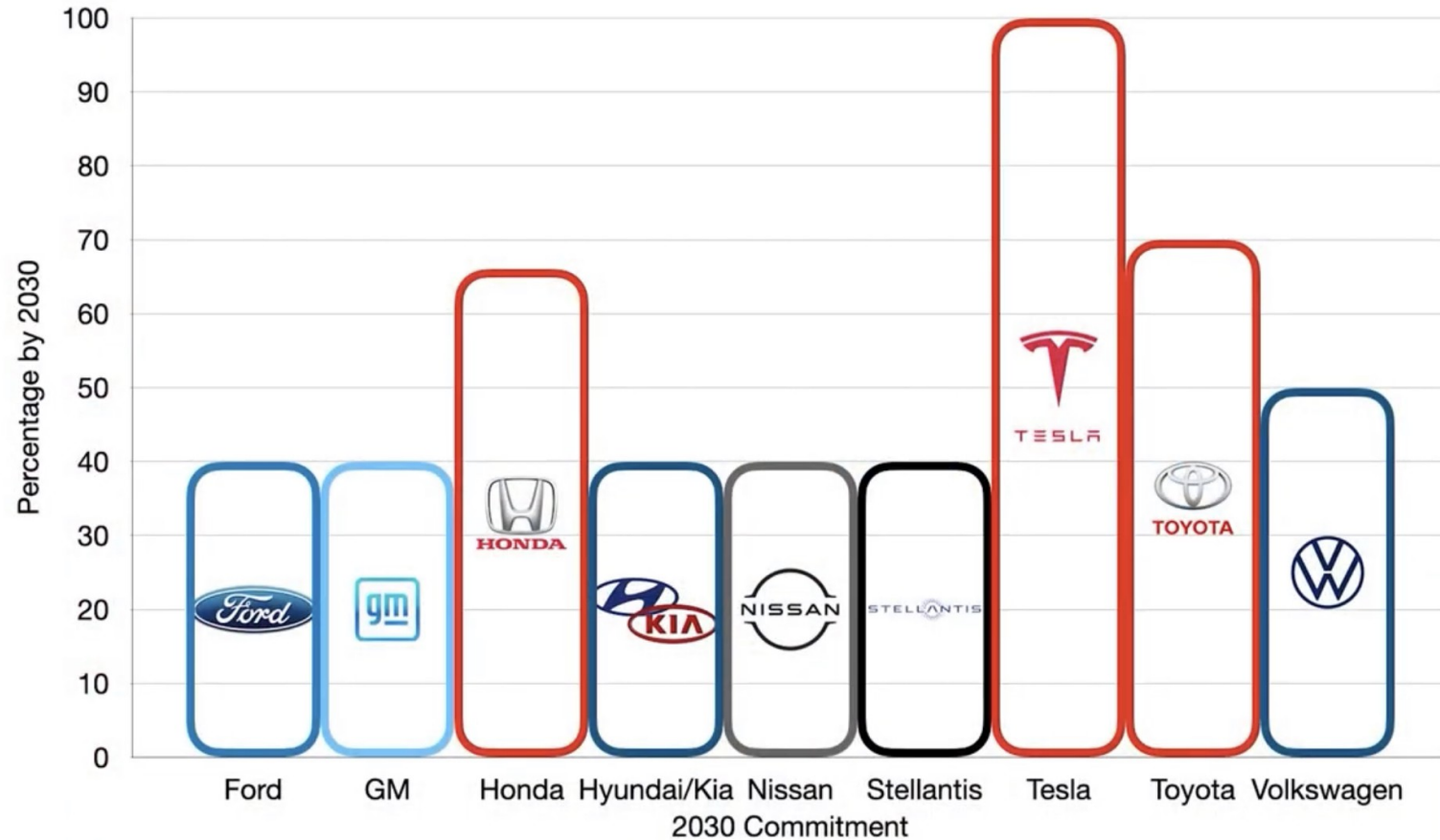
CHINA IS THE COMPETITION

China has more EV companies than any other country
Just looking at the top 10 in sales in 2021:

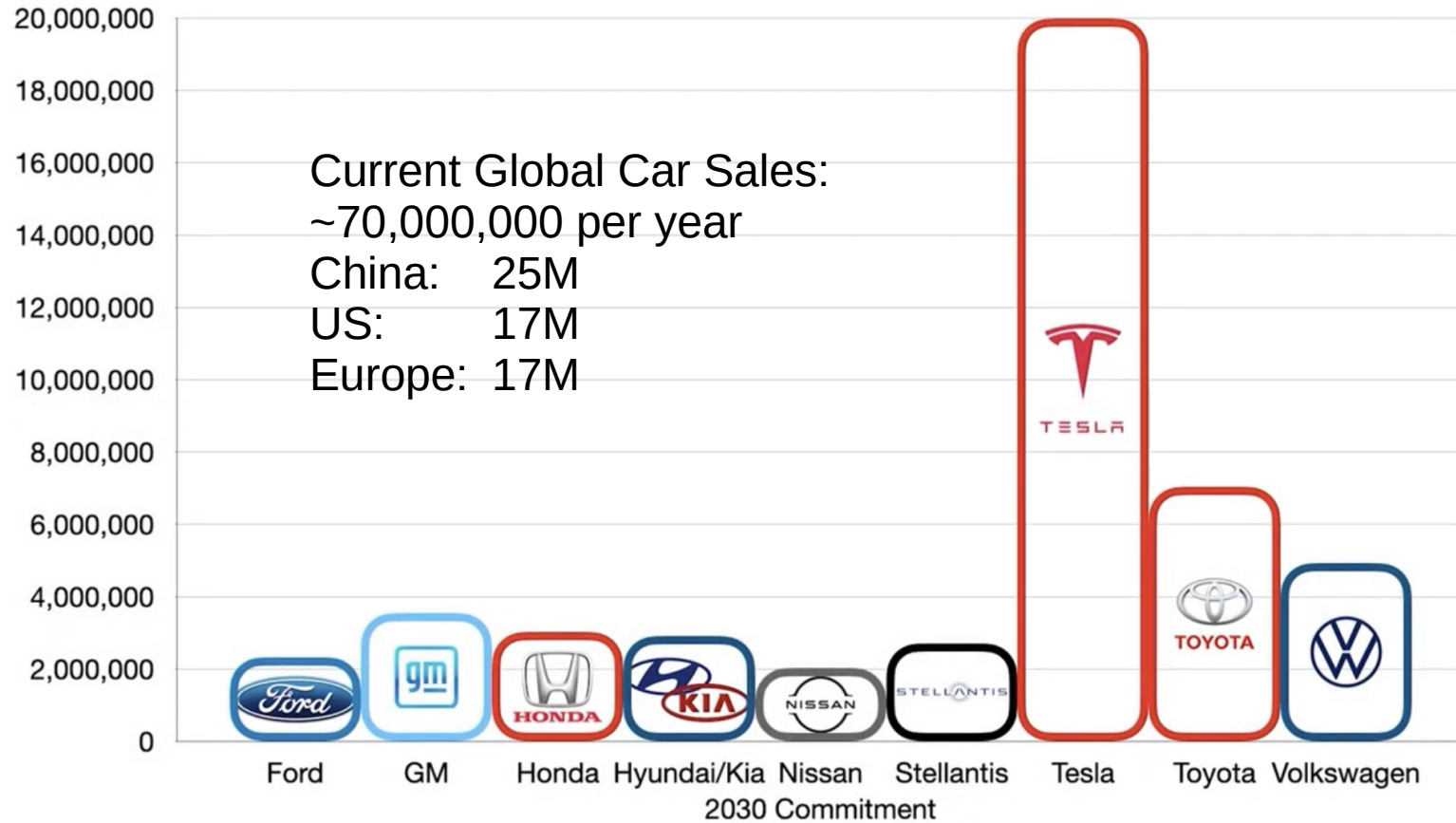
- SAIC – 500,000 (Hongguang Mini - not legal in US) – 1st (\$6000)
- Tesla – 2018 – 500,000 (Models 3 & Y) – 2nd & 3rd (200,000 for China)
- BYD Auto – 2003 – (Han & Qin Plus DM-i) – 4th & 5th
- Li Auto – (Li One) – 6th
- Changan – (BenBen EV) – 7th
- GAC Motor spinoff – (Aion S) – 8th
- Chery – (eQ) – 9th
- Great Wall Motor – (Ora Black Cat) – 10th

- NIO – 2014 – EV maker with 5 models & presence/sales in 6 countries – modeled after Tesla

AUTOMAKER GOALS %EV+HYBRID



AUTOMAKER GOALS – TOTAL EV+HYBRID



USEFUL LINKS TO MORE INFO

EV Car Comparisons

<https://plugstar.com/cars> (Just enter your zip code & choose BEV)

https://cars.aps.com/cars/?filters=body_type%3Dcrossovers-and-suvs

EVs ARE THE FUTURE

My Advice:

Do not buy a new car without taking test drives of equivalent, available EVs

Be aware that an EV will take some retraining
EV Design really matters

1000 Free Supercharging Miles for both of us
if you decide to order a Tesla and use this link:

<https://ts.la/jamesd62050>

Q&A