Extended Lifetime Evaluation – An OEM Point of View

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Karsten Schmidt-Grethe – Volkswagen

European AEC-Workshop Bordeaux | 09.10.2025

Agenda

01 **Actual Situation and Challenges for an OEM**

02 **Extended Lifetime Evaluation**

03 **Activities of the AEC**

04 **Summary**

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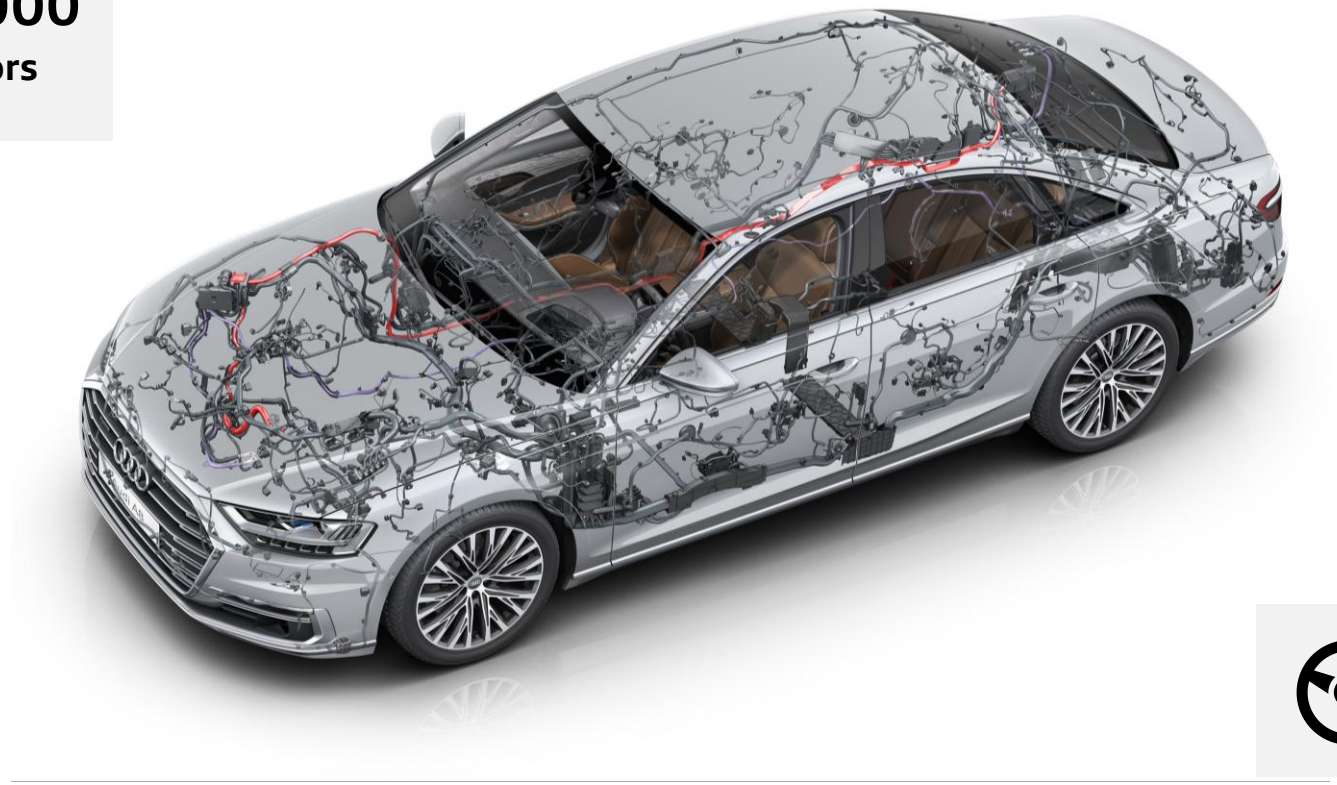
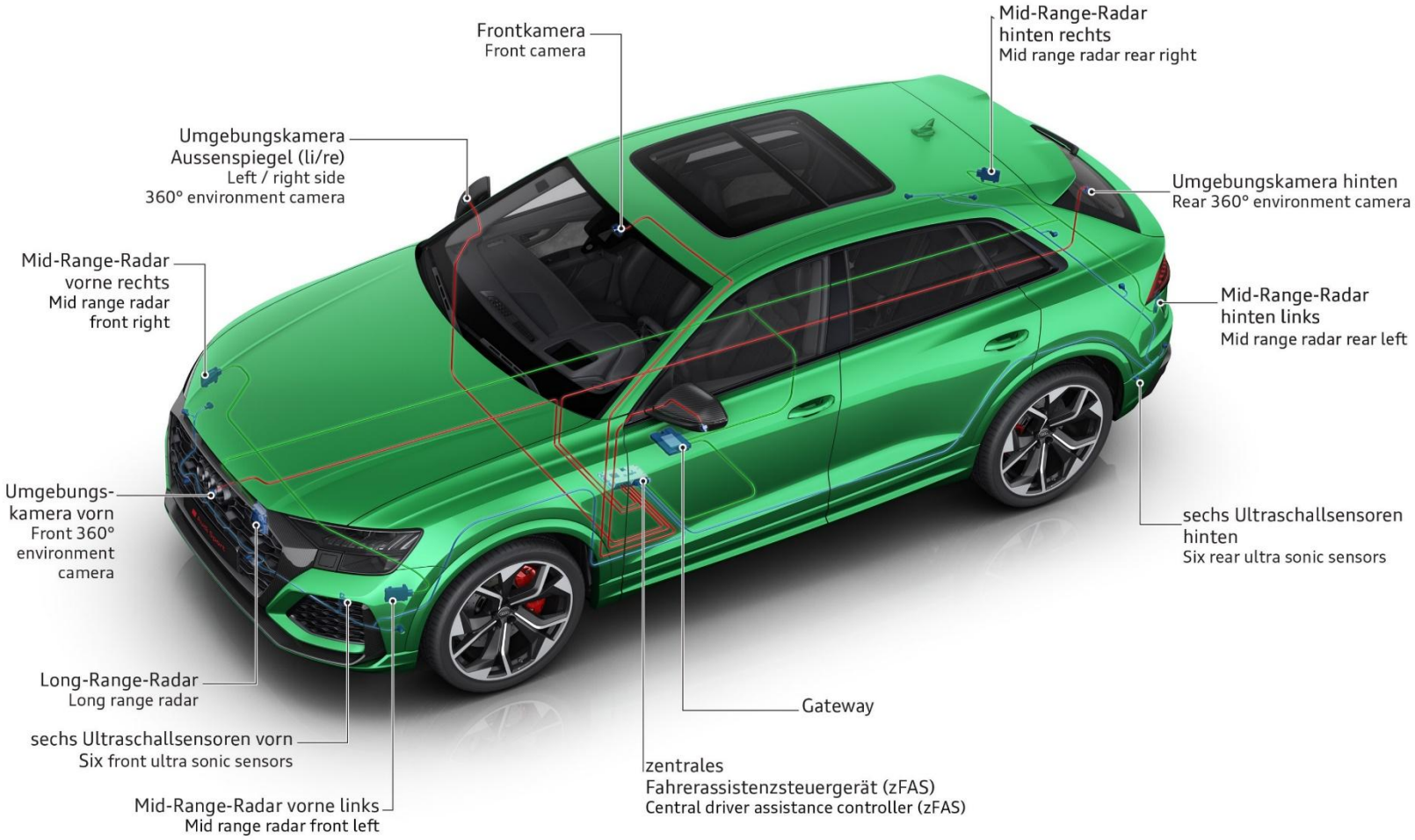
Semiconductors are essential for modern premium cars

6.000-10.000
Semiconductors /vehicle



Connected
100 ECUs per Car work together

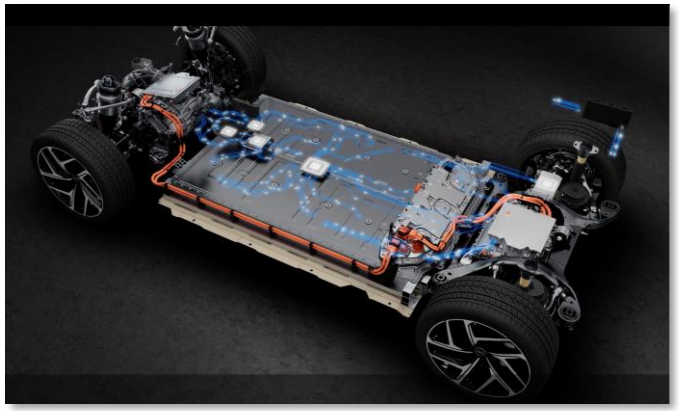
A car has not only CMOS Technology
Example: ADAS

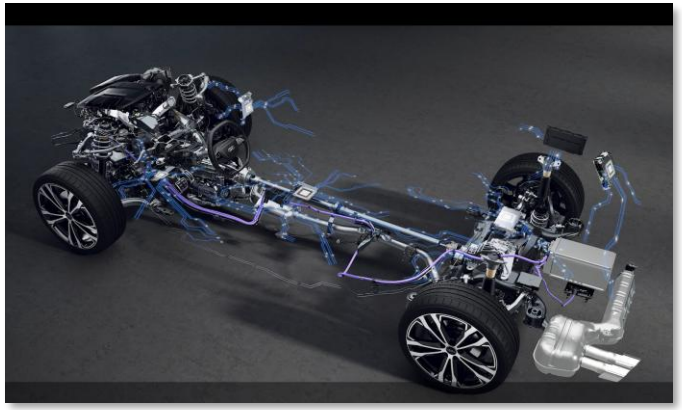


Different Technologies & Different Vendors

Technologies in cars are changing

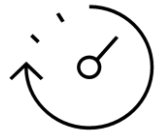
- New vehicle technologies like BEV bring new kind of semiconductors (SiC, GaN) and new operating conditions (i.e. charging) into the car.





- New electronic architectures (zonal) and customer features lead to higher robustness requirements

- Always-on and connected functions need longer semiconductor lifetime



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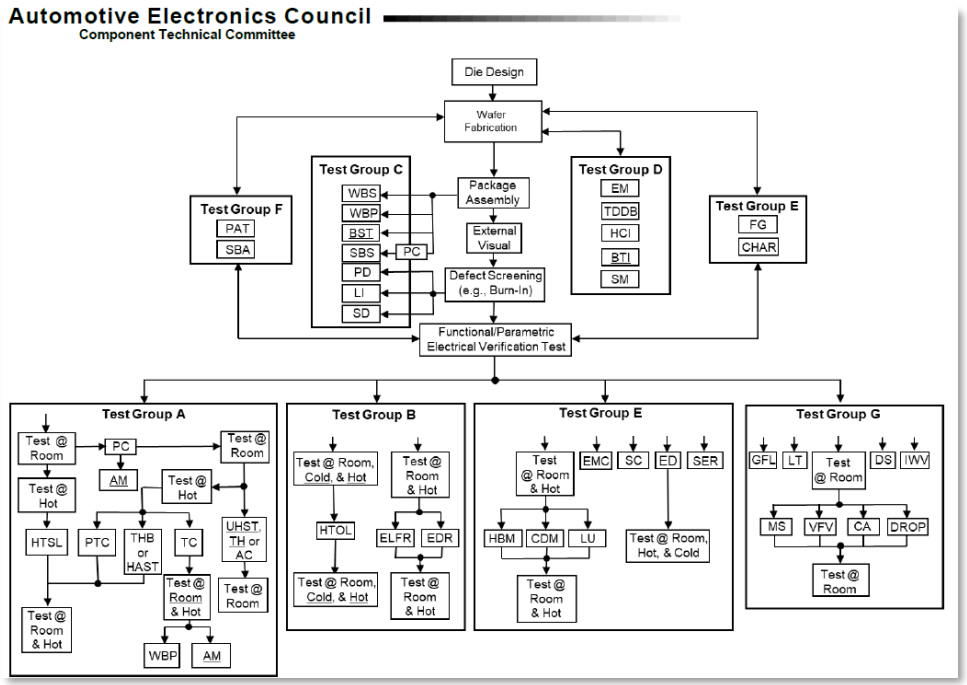
Actual AEC Qualification



Example: HTOL

STRESS	ABV	#	NOTES	SAMPLE SIZE / LOT	NUMBER OF LOTS	ACCEPT CRITERIA	TEST METHOD	ADDITIONAL REQUIREMENTS
High Temperature Operating Life	**HTOL**	B1	H, P, B, D, G, K, F	77	3	0 Fails	JEDEC JESD22-A108	For devices containing NVM, endurance preconditioning must be performed before HTOL per Q100-005. **Grade 0:** +150°C T_a for 1000 hours. **Grade 1:** +125°C T_a for 1000 hours. **Grade 2:** +105°C T_a for 1000 hours. **Grade 3:** +85°C T_a for 1000 hours. HTOL NOTES: 1) HTOL stress times for the appropriate grade Ta are the min requirement; the Tj of the test (measured or calculated) should be available. 2) Tj may be used instead of Ta when performing HTOL provided that Tj of the device under HTOL conditions is equal to or higher than the Tj maximum operating (Tjopmax) of the particular device, but below the absolute maximum Tj. 3) If Tj is used to set the HTOL conditions, the minimum stress of 1000 hours at the Ta of the device is to be shown using activation energy of 0.7ev or other value technically justified. 4) V_{cc} (max) at which dc and ac parametrics are guaranteed. Thermal shut-down of the device shall not occur during this test. **TEST before and after HTOL at room, cold, and finally hot temperature (preferred). An alternate order is to test at room, hot, and finally cold temperature.** 5) If applicable, a drift analysis on the key performance and reliability related electrical parameters after HTOL should be performed to confirm a proper selection of guard bands to meet the data sheet specification. For guidance on drift analysis, refer to AEC-Q100-009.

Table A7.1: Example Basic Calculations for AEC-Q100 Stress Test Conditions and Durations

Loading	Example Mission Profile Input	Stress Test	Stress Conditions	Acceleration Model (all temperatures in K, not in °C)	Model Parameters	Calculated Test Duration	Q100 Test Duration
Operation	t_u = 12,000 hr (average operating use time over 15 yr) T_u = 87°C (average junction temperature in use environment)	High Temperature Operating Life (HTOL)	T_t = 125°C (junction temperature in test environment)	Arrhenius $A_f = \exp\left[\frac{E_a}{k_B} \bullet \left(\frac{1}{T_u} - \frac{1}{T_t}\right)\right]$ Also applicable for High Temperature Storage Life (HTSL) and NVM Endurance, Data Retention Bake, & Operational Life (EDR)	E_a = 0.7 eV (activation energy; 0.7 eV is a typical value, actual values depend on failure mechanism and range from -0.2 to 1.4 eV) k_B = 8.61733 x 10^{-5} eV/K (Boltzmann's Constant)	t_t = 1393 hr (test time) $t_t = \frac{t_u}{A_f}$	1000 hr

Standard AEC qualification covers lifetime up to ~10.000 h.

Good for the past – Insufficient for the future!

Longer Lifetime needs special Qualification according to Appendix 7

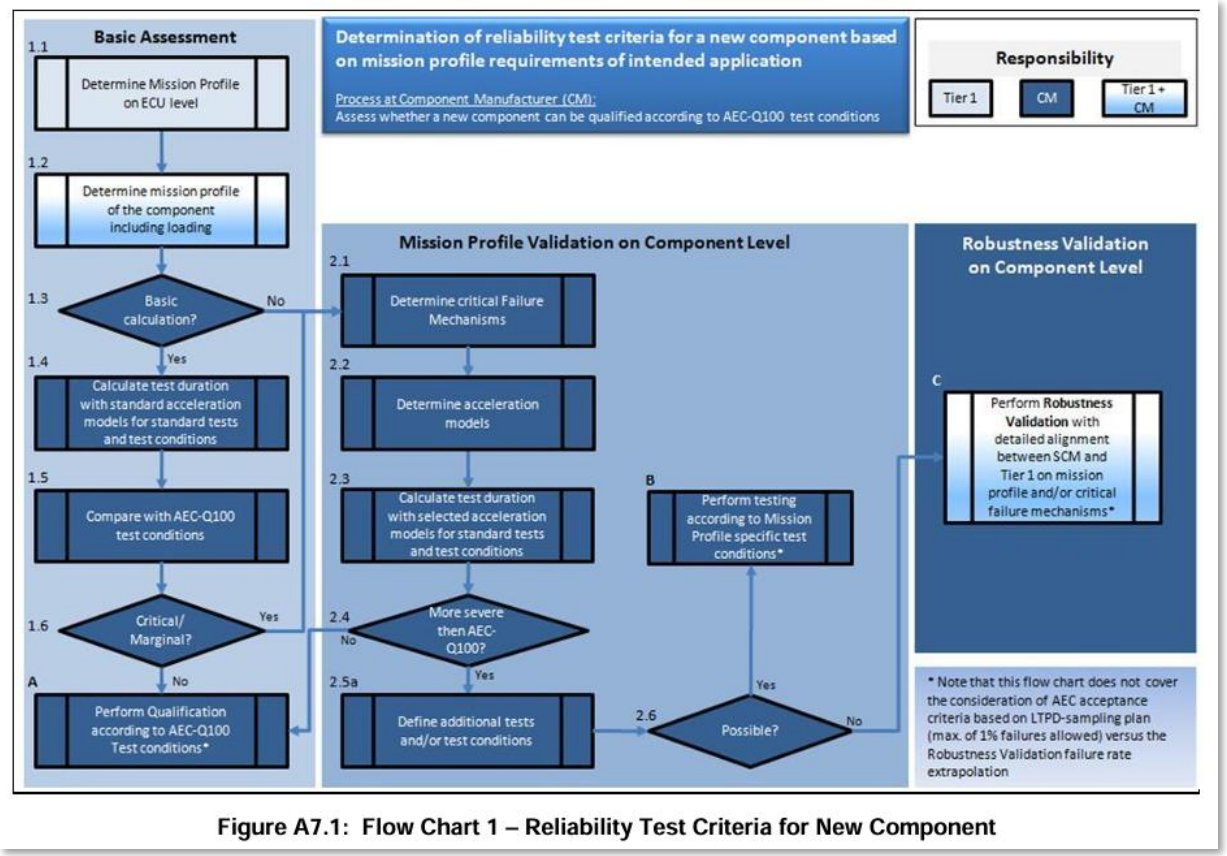


Figure A7.1: Flow Chart 1 – Reliability Test Criteria for New Component

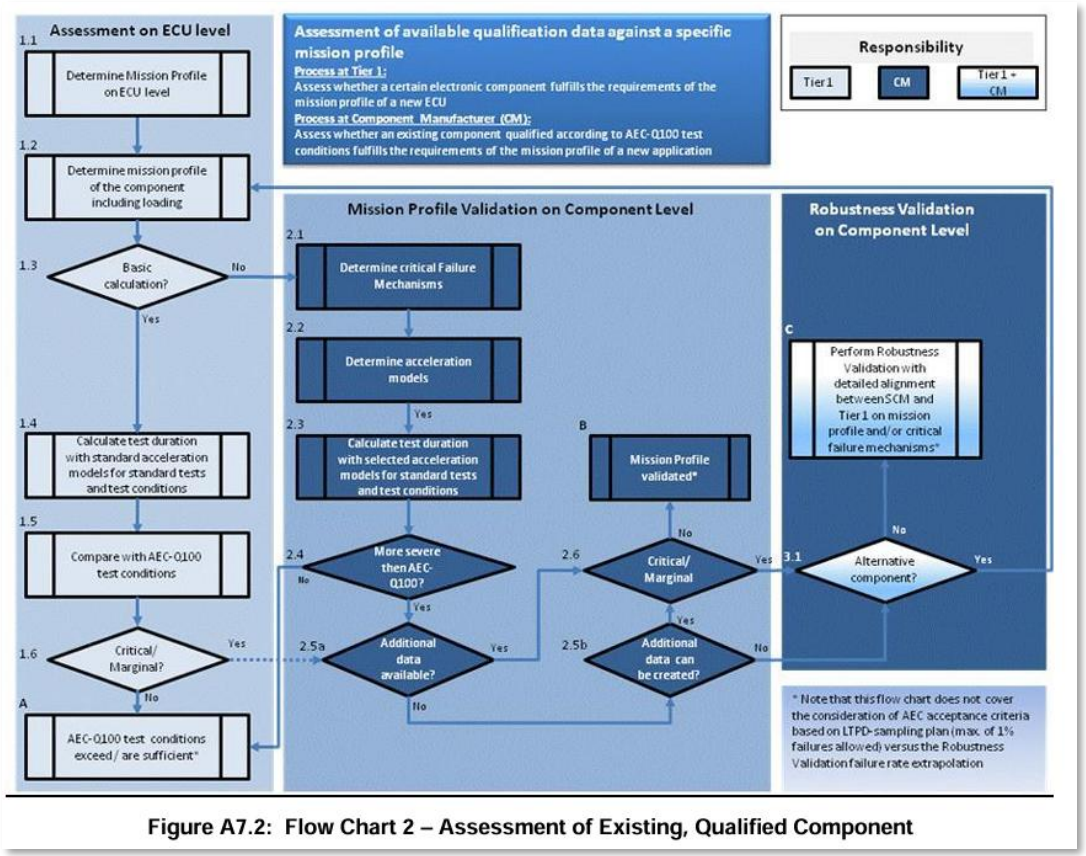
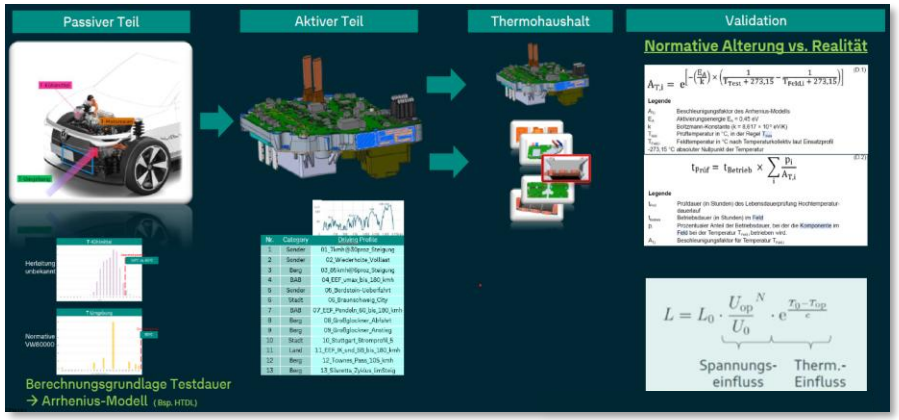


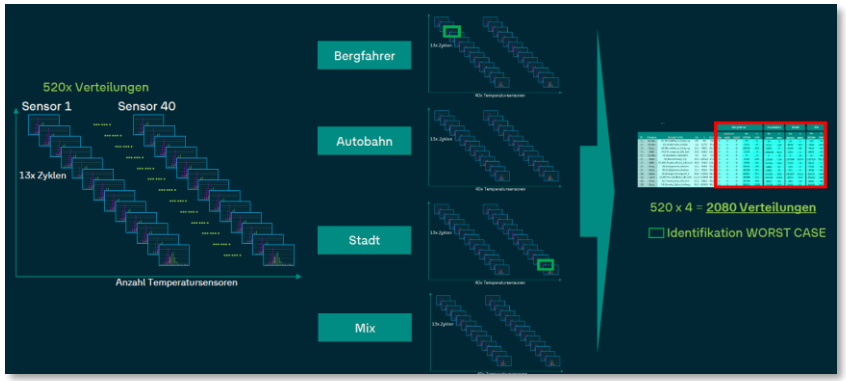
Figure A7.2: Flow Chart 2 – Assessment of Existing, Qualified Component

Appendix 7 should be the exception, but it becomes more and more the usual procedure. That´s not the intention of a standard.

Extended lifetime evaluation like Appendix 7: High efforts for whole supply chain

- Simulation of whole ECU to get detailed stress data





- Evaluation of every semiconductor device, if it will pass lifetime stress

- Additional tests with test cars and longer test time is necessary.

$$$

Which lifetime do we need?
Some practical examples:

ECU	Active Times															Sum active Time ECU [h]
	Drive (Kl 15 on)			Charging			Conditioning			bidi - Charging			Parking (inkl. ON Grid)			
	Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		
		Tmin in °C	Tmax in °C		Tmin in °C	Tmax in °C		Tmin in °C	Tmax in °C		Tmin in °C	Tmax in °C		Tmin in °C	Tmax in °C	
ECU 1	8500	-40	70	13350	-40	60	3800	-40	60	28500	10	55	0			**54150** ✓
ECU 2	8500	-40	85	18980	-40	80	365	-40	85	0			9542	-40	85	**37387** ✓
ECU 3	8500	-40	75	12000	-40	75	3200	-40	75	0			1800	-40	75	**25500** ✓
ECU 4	8000	-40	85				6200	-40	85				800	-40	85	**15000** ✓
ECU 5	8000	-40	85				6200	-40	85				800	-40	85	**15000** ✓
ECU 6	8000	-40	85				6200	-40	85				800	-40	85	**15000** ✓
ECU 7	8000	-40	80				6200	-40	80				800	-40	80	**15000** ✓
ECU 8	8000	-40	80				6800	-40	80				500	-40	80	**15300** ✓
ECU 9	8000	-40	70	30000	-40	65										**38000** ✓
ECU 10	8000	-40	80	12000	10	75	8000	-40	75	28500	10	75	74900	-40	75	**131400** ✗
ECU 11	8000	-40	90	13350	-40	90	3800	-40	90	28500	-40	90	0	0	0	**53650** ✓
ECU 12	8000			30000												**38000** ✓
ECU 13	8000			6200												**14200** ✓
ECU 14	8000			13333			2800									**24133** ✓
ECU 15	8000						6200						39500			**53700** ✓
ECU 16	8000						6200						8300			**22500** ✓
ECU 17	8000			24800			6200									**39000** ✓
ECU 18	8000	-40	130 (600s - 140°C)	13350	-40	75										**21350** ✓

With an active time of 55.000 h, 95% of all use cases will be covered. ✓

Proposal for lifetime grades

	TempGrade0 150°C	TempGrade1 125°C	TempGrade2 105°C	TempGrade3 85°C
Life Time Grade 0 Full Active **131.400 h**				
Life Time Grade 1 Charging **55.000 h**				
Life Time Grade 2 Extended Basic Functions **16.000 h**				
Life Time Grade 3 Basic Functions **8000 h**	AECQ	AECQ	AECQ	AECQ

EXAMPLE

Standardized Extended Lifetime Requirements (SELR)

One Qualification can cover different grades.

Standardized Extended Lifetime Requirements (SELR)

- set of few Standardized (umbrella) Mission Profiles
- cover most new use cases
- extract standardized extended test conditions

Using SELR combines the advantage of easy to communicate and developing requirement optimized products

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Definition of new standards

Wide Bandgap Semiconductors (SiC, GaN)

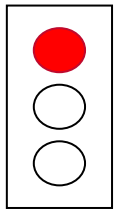
- Discussion since 2017 ongoing
- Products are in the market, no AEC-standard available
- No transparency from the AEC working group regarding to schedule, milestones and goals for WBG

Extended Lifetime Evaluation

- Discussion since 2017 ongoing
- Products are in the market, no AEC-standard available
- No transparent AEC schedule with clear milestones and goals for extended lifetime evaluation

Future Chiplet Standard

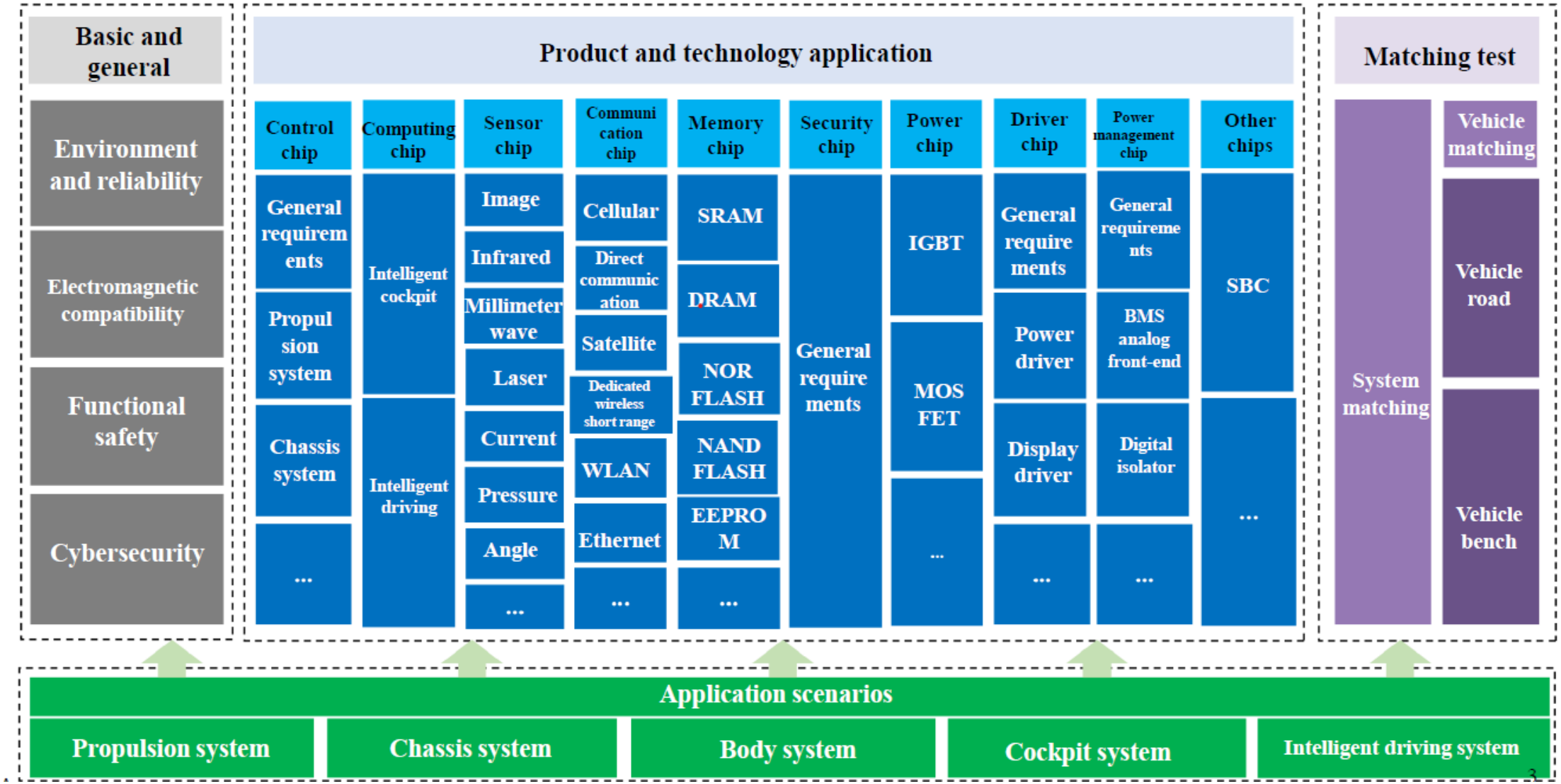
- No information available



Speed of the AEC

China Car Chip Standard System (C3S)

Car-Chip Standard System Technical Structure



China Car Chip Standard System (C3S) - Timeline

Dec 2023

MIIT* announces the guideline of tech. standards for automotive chips in China

Dec 2025

1st planned milestone
30 standards formulated

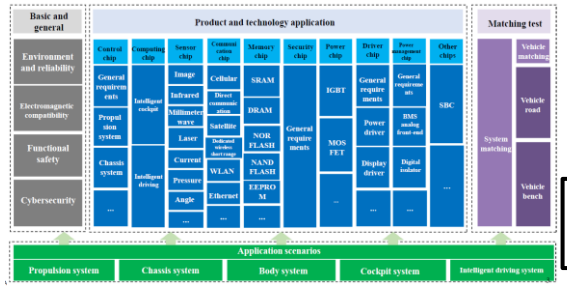
Dec 2026

Interim milestone
50-60 standards formulated

Dec 2027

final planned milestone
76 chip + 1 chiplet standards formulated

2023 | 2024 | 2025 | 2026 | 2027 | 2028



Jan 2024

MIIT* released the guideline

Sep 2025

11 drafts released for comments
~ 6 months approval period for final publication

	Draft release	#	Standard		Nature
1	KW18 end April	19	**204-1**	Technical Specification of Cybersecurity for Automotive Chip 汽车芯片信息安全技术规范	GB(/T)
2	KW24 mid. June	20	**301-1**	General Technical Requirements and Testing Methods for Automotive Control Chips 汽车控制芯片通用技术要求及试验方法	QC/T
3	KW24 mid. June	23	301-4	Technical Requirements and Testing Methods for Control Chips of Automotive Chassis sys 汽车底盘系统控制芯片技术要求及试验方法	QC/T
4	KW27 end June	41	304-3	Technical Requirements and Testing Methods for Chips of Automotive Satellite Positioning 汽车卫星定位芯片技术要求及试验方法	QC/T
5	KW31 end Juli	15	201-14	Reliability Verification Method for Automotive Semiconductor Devices 汽车半导体器件可靠性验证方法	QC/T
6	KW31 end Juli	16	201-15	Reliability Verification Method for Electrical/Electronic Modules of Automotive Chips 汽车芯片电气/电子模块可靠性验证方法	QC/T
7	KW31 end Juli	63	307-3	Tech Requirements & Testing Methods for Power Modules of Electric Vehicles - Part 2: SIC 电动汽车用功率模块技术要求及试验方法第2部分 碳化硅	QC/T
8	KW31 end Juli	65	307-5	Tech Requirements &Testing Methods for Power Discrete Devices of EV - Part 2: SIC 电动汽车用功率分立器件技术要求和试验方法第2部分 碳化硅	QC/T
9	KW31 end Juli	62	307-2	Technical Requirements and Testing Methods for Power Modules of Electric Vehicles - Part 1: IGBT电动汽车用功率模块技术要求及试验方法第1部分 IGBT	QC/T
10	KW31 end Juli	64	307-4	Technical Requirements and Testing Methods for Power Discrete Devices of EV - Part 1: IGBT 电动汽车用功率分立器件技术要求和试验方法第1部分 IGBT	QC/T
11	KW31 begin Aug	50	304-12	Technical Requirements & Testing Methods for Chips of Auto Ethernet 100Mbps Physical Layer Interface (PHY) 汽车以太网100Mbps物理层接口(PHY)芯片技术要求及试验方法	QC/T

China will release standards in a very fast way!

*** MIIT** Ministry of Industry & Information Technology department of P.R. China

AEC Cooperation with an OEM

- **Only review role for new standards**
- **Review after AEC ballot always too late**
- **Remarks will be implemented in best case in the next revision**
- **No possibility to actively influence AEC**
- **The AEC leadership does not respond to official requests from the OEM**

The cooperation between OEMs and the AEC must be improved!

Volkswagen Group is an electronic company

NO. 28/2023

Volkswagen Group Technology develops complete drive system for electric cars

- In addition to the battery and electric motor, in future th powerhouse of the Group will also develop pulse inverte management systems
- The development of a complete drive offers efficiency an up to 20 percent more efficiency through the optimal cor individual components
- Group-wide activities in the a mponents
- l is to achieve technological lea y here, too, we rely on our inte

12 April 2023

New drive for the all-electric ID. family: more performance and higher efficiency

- Significantly more power and torque
- ID. models can benefit from longer ranges
- Volkswagen will introduce the new drive in the fourth quarter
- Production at the Volkswagen Group Com Kassel (Germany)

Wolfsburg – The next electric drive g or the ID. family is now being launch the APP5 wheel drive, Volkswagen's electric m will rece a completely newly developed power unit. In future, it will offer high performance combined with improved efficiency for the ID. models. The ID. family will therefore benefit both in terms of power and Volkswagen is planning to deliver the first vehicles with the new drive generation in a 210 kW (286 PS) version from the end of the year.

Audi startet in Győr Produktion von Elektromotoren für die PPE

MediaInfo — 07.11.2023 — Ingolstadt/Győr

neu entwickelten elektrischen Antriebe in der Audi Q6 e-tron Baureihe

Döllner: „Győr ist prädestiniert für die Produktion der beso und Elektromotoren für die PPE"

eitende fertigen im Dreischic etrieb Motoren für die Premium Platform Electric (PPE)

Home Automotive › VW kauft Halbleiter direkt beim Hersteller

Automotive

29. Aug. 2023 | 09:30 U

reiche Wertschöpfungskette

VW kauft Halbleiter direkt beim Hersteller

Mit einer neuen Beschaffungsstrategie will der Volkswagen-Konzern die Versorgung mit elektronischen Bauteilen und Halbleitern sicherstellen. Schlüsselelemente sind eine transparente Wertschöpfungskette und genaue Kenntnis der verwendeten Bauteile.

Nachhaltigkeit

Erste Batteriefabrik von Volkswagen in Mission SalzGiga

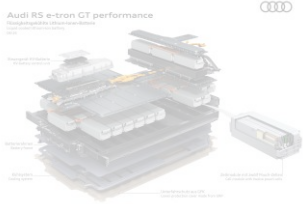
30.09.2024

Im norddeutschen Salzgitter entsteht die erste Gigafabrik des Volkswagen Konzerns. Ab 2025 wird hier die neue Einheitszelle produziert, die auch im kleinsten ID. Modell zum Einsatz kommen soll. Das Werk, in dem bisher Verbrennungsmotoren gebaut werden, entwickelt sich zum wahren Batterie-Hub – inklusive Recyclinganlage.

Text ***Reto Neyerlin***
Fotos ***Volkswagen***

Leistungsstärker, kompakter und intelligenter: die Hochvoltbatterie für die Premium Platform Electric

MediaInfo — 18.03.2024 — Ingolstadt



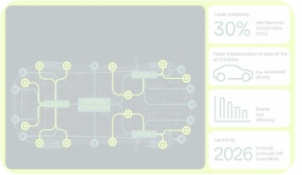
- Komplett neu entwickelte Hochvoltbatterie mit höherer Energiedichte benötigt v
- Zwölf Module mit 180 prismatischen Zellen, intelligentem Thermomanagement
- Batteriestruktur macht bei der Batteriemontage größere Stückzahlen in kürzerer

nce

NO. 123/2024

Faster, Leaner, More Efficient: Rivian and Volkswagen Group Announce the Launch of their Joint Venture

- **New joint venture (JV) with a total deal size of up to $5.8 billion combines the strength of both partners to create cutting-edge software and electronics architectures and scale the electric vehicle platforms and architectures.**
- **Engineers join the JV to create electric architec Software Defined Vehicles (SDV).**
- **JV to be co-led by Wassym Bensaid (Rivian) an**
- **Oliver Blume, CEO Volkswagen Group: "The pa in strengthening our global competitive and te**
- **Rivian CEO RJ Scaringe: "We're thrilled to see outside Rivian – this is an important enabler to**



In the future: The Cooperation between the AEC and the OEMs must be transformed!

Members of the AEC

- Members with limited relevance to automotive semiconductors
- Some members are neither Tier 1 suppliers nor IDMs
- OEMs, as end customers and market introducers, are not represented
- But: OEMs are increasingly designing and manufacturing electronics in-house
- The AEC charter is no longer fit for purpose

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Summary

- **Speed of the AEC is insufficient!**
- **There is a big gap between AEC standards and market requirements**
- **New standardization organizations publish standards in a faster way**
- **Cooperation between AEC and OEMs has to be improved**

Outlook

- **OEMs are considering their own standards**
- **Will AEC stay the relevant automotive standardization organization in the future?**
- **Change from AEC as leading standardization organization for automotive semiconductors to another organization could be possible**
- **AEC should think about its future role, work and cooperation**

- **Is there an interest of AEC to intensify the cooperation with Volkswagen Group (as OEM and Tier1)?**

Thank you

Audi Vorsprung durch Technik