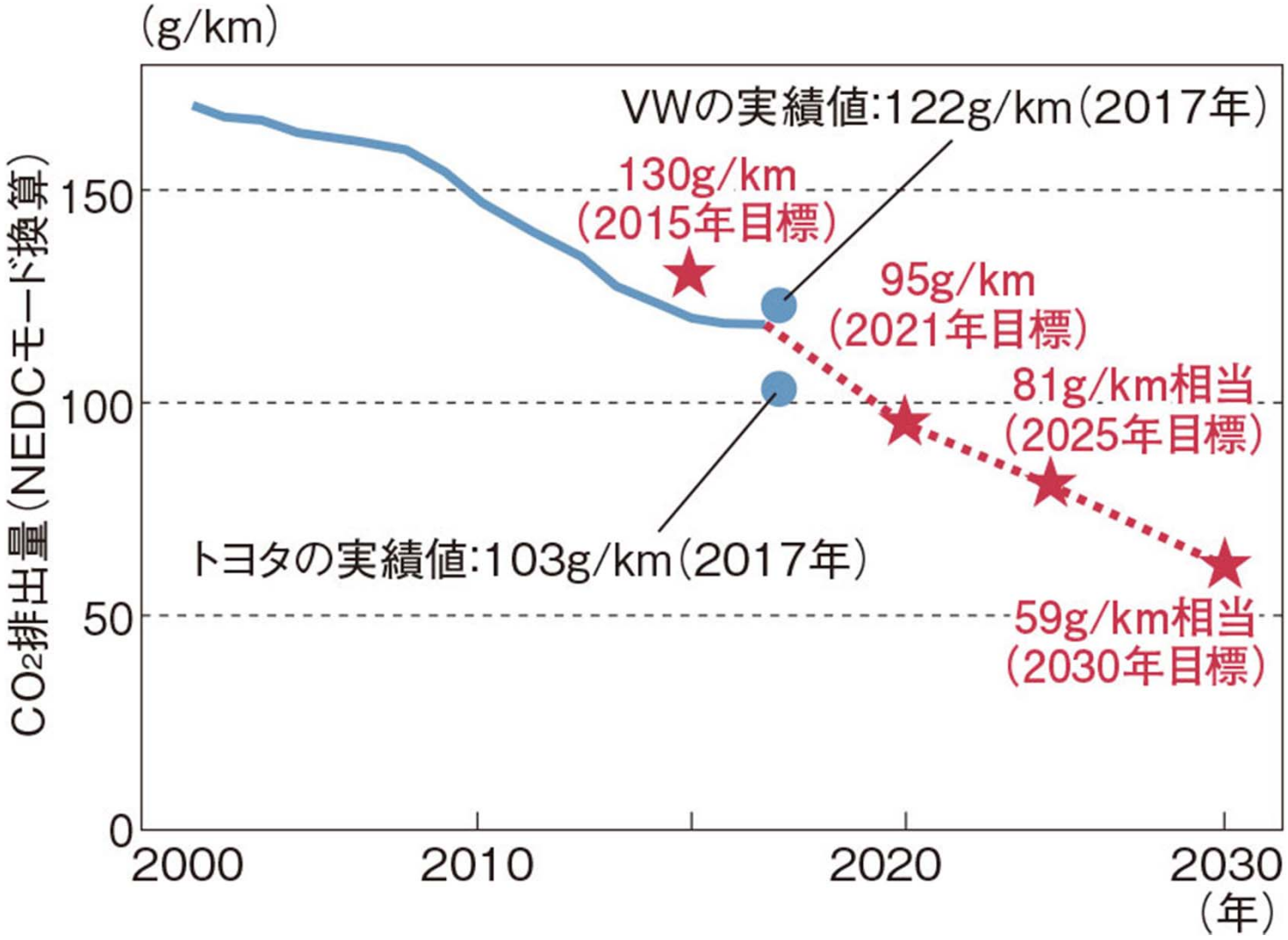
Automotive Industry

https://news.hmgjournal.com/Tech/reissue-future-case

환경규제

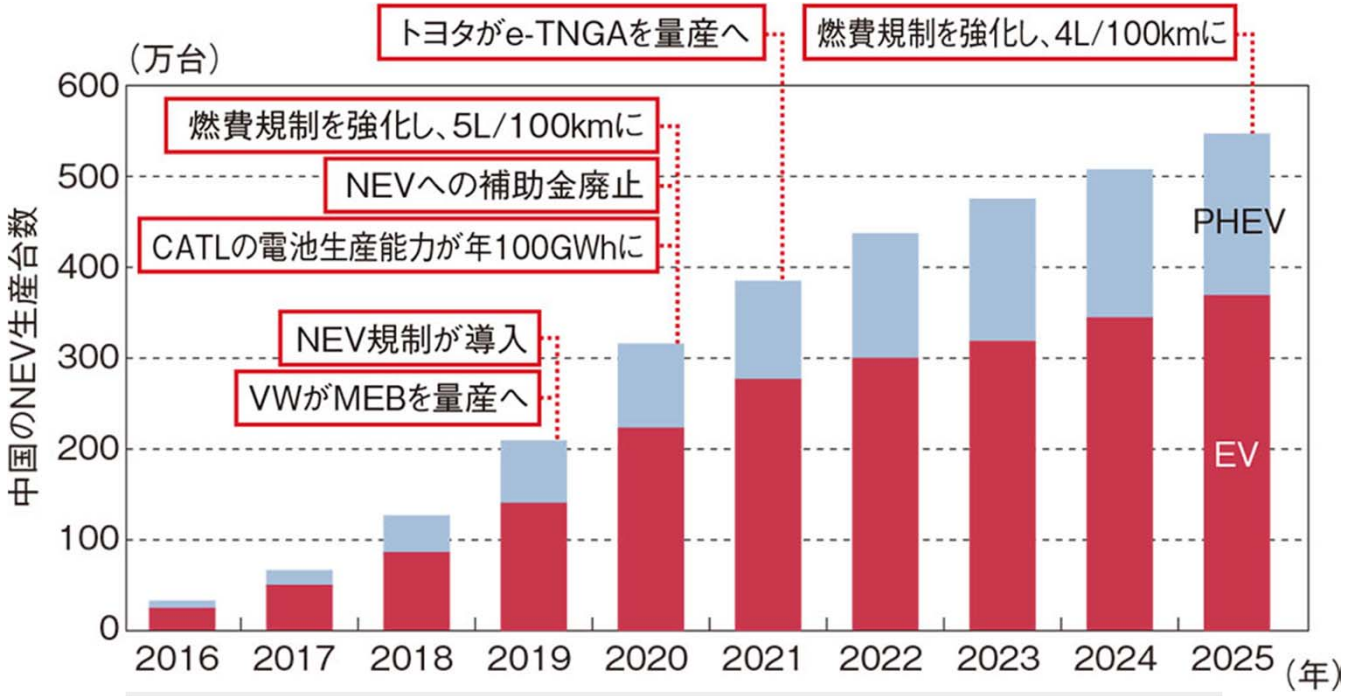
- CAFE(기업별 평균연비 규제): 판매한 차량의 평균연비를 규제
  - 노르웨이, 네덜란드, 영국은 2025년에, 독일은 2030년, 프랑스는 2040년에 내연기관차를 생산 중단하겠다고 밝힘
- ZEV: EV나 FCV의 판매대수를 일정비율로 요구
  - 미국: 2018년부터 친환경차(EV, FCEV) 의무판매비율을 2%로 할당하고 2025년까지 16%로 확대할 계획
  - 중국: 2019년에 친환경차 의무판매를 10%, 2020년에 12%등으로 점차 증가시키되 수소자동차 보조금은 유지하는 한편 전기차 보조금은 축소하는 정책

EU의 CAFE규제: 승용차 CO_2 배출량



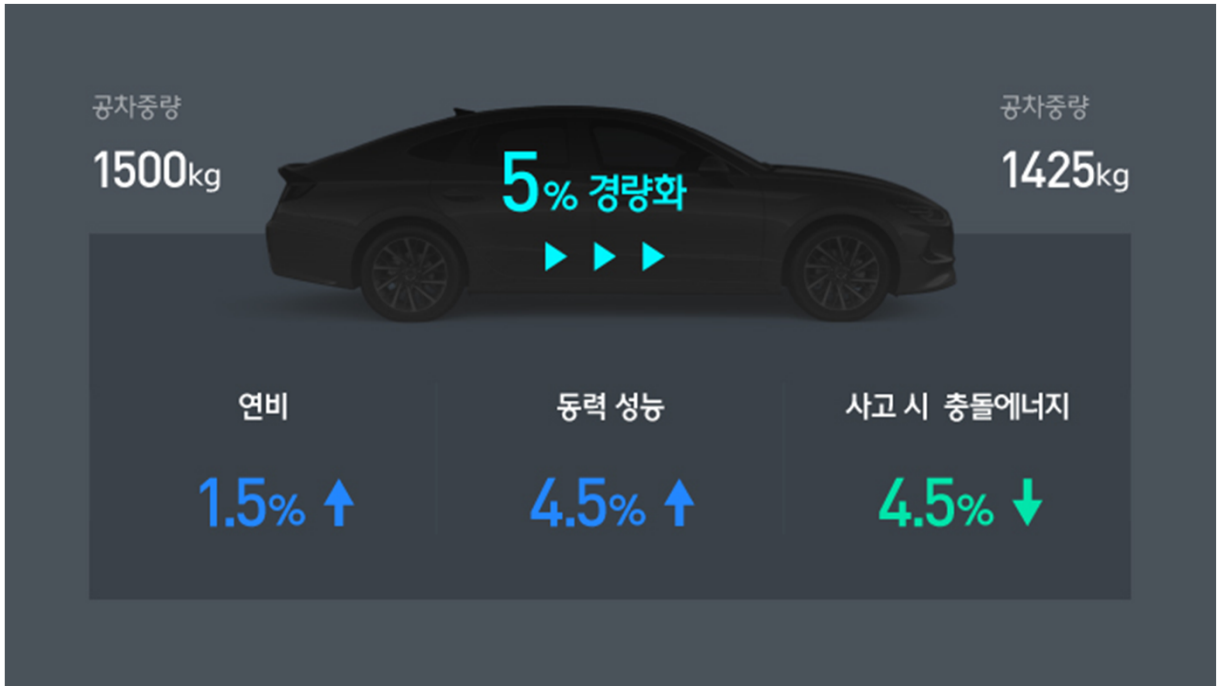
* 2018년 세계 EV시장: 121만대

EV market in China



현대기아차 "신차 중량 5% 줄인다“

- 2019.09.01
- 2014, 7세대 LF 소나타, +45kg
- 2019, 8세대 DN 소나타, -59kg (안전/편의 등 상품성 개선 +27kg)

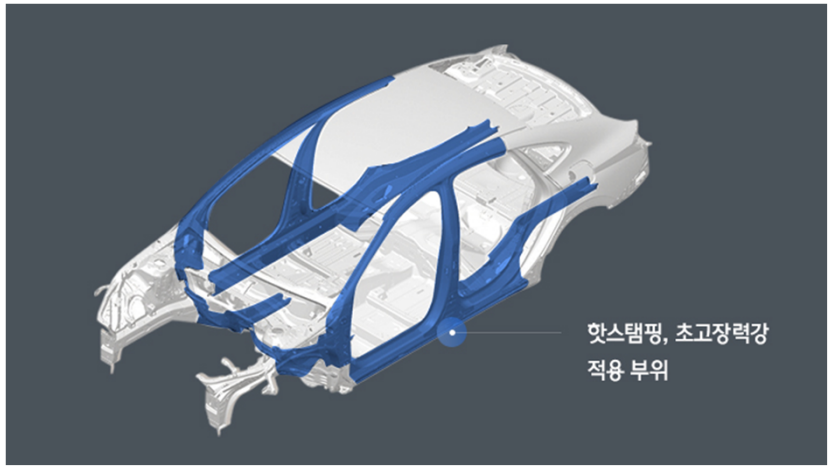


https://www.mk.co.kr/news/business/view/2019/09/684156/

https://news.hmgjournal.com/Tech/현대기아차-경량화기술-추진전략

경량화 비법: 구조 최적화

- 설계 단계에서부터 강성과 경량화, 두 가지 목표
  - 초고장력 강판을 부위마다 두께를 다르게 성형하는 TRB/TWB(Tailor Rolled Blanking/Tailor Welded Blanking) 공법을 통해 차체 언더바디 강성부재를 최적화했고
  - 핫스탬핑 적용부품을 기존 16개에서 21개로 확대 적용
  - 바디 제어기의 기능을 통합해 부품 수도 줄임
  - 하이브리드(-90kg): 배터리 시스템(-16kg, 출력밀도 21%↑)



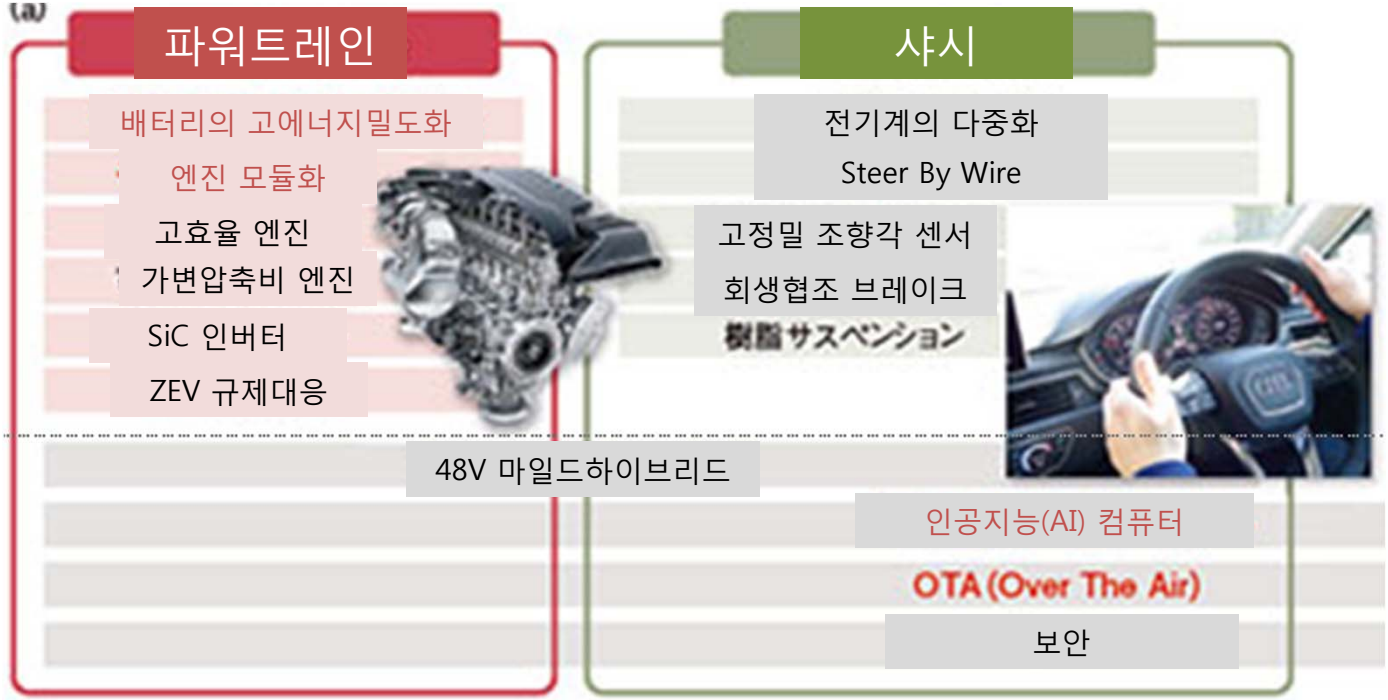
Nikkei Automotive 2017년 5월호

Outline

- Part 1 중대국면에 접어든 기술개발
  - 공통화와 선진성을 구분
- Part 2 기능과 역할의 영역을 초월
  - AI 컴퓨터
  - OTA (Over The Air)
  - HUD (Head Up Display)
  - 배터리의 고에너지 밀도화
  - Modular Engine
  - **부품의 공통화**
  - **초고장력강판**
  - 5G (제5세대 이동통신)
  - 서비스화
  - 북미시장

주목받는 기술 키워드 (1)

- 영역: Powertrain / Chassis / Safety / Body·Information
- 공통: 48V마일드하이브리드, 인공지능컴퓨터, OTA, 보안
- 기계부품(엔진, 골격 등): 공통화→개발효율
- 배터리, 자동운전, OTA, IT등 분야: 선진성→부가가치



주목받는 기술 키워드 (2)

안전

카메라, 레이더
자동브레이크
자동조향
운전자 모니터링
차선변경지원시스템
차선중앙유지시스템

바디 · 정보

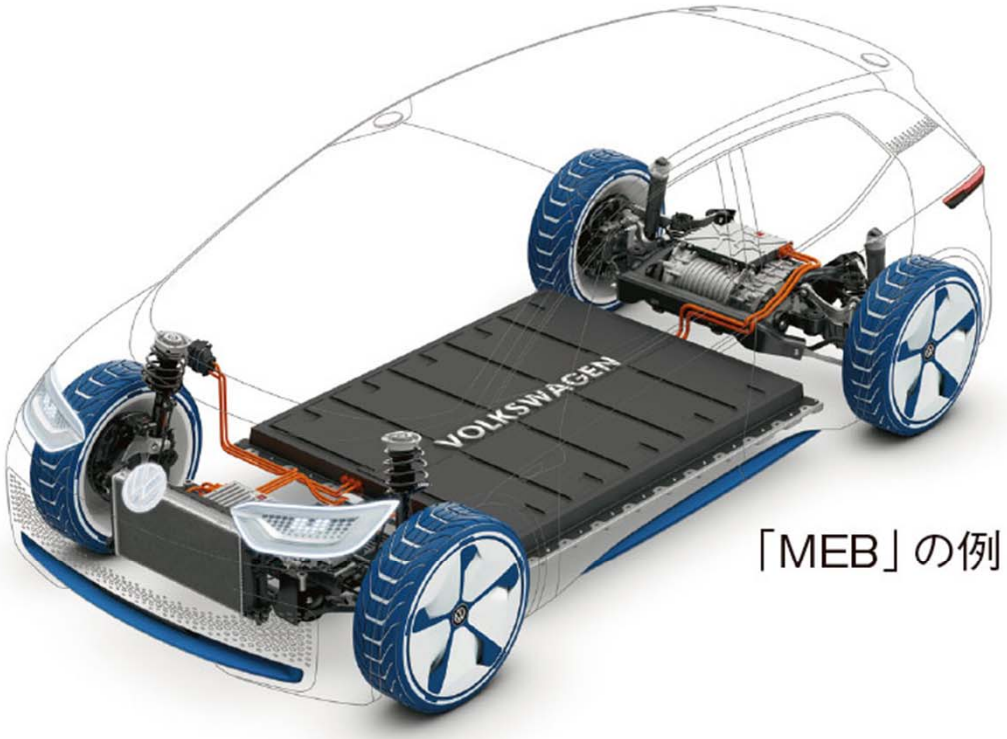
HUD(Head Up Display)
5G(제5세대이동통신) 연계
HMI의 AR(증강현실) 도입
서비스화
EUC간 통신의 대용량화
대형액정디스플레이 (계기판)

(b)

차체

부품 공용화
초고장력강판
Hot Press (열간프레스)
Oblique(경사방향) 충돌대응
CFRP의 back door 채용
외장부품의 무 도장화

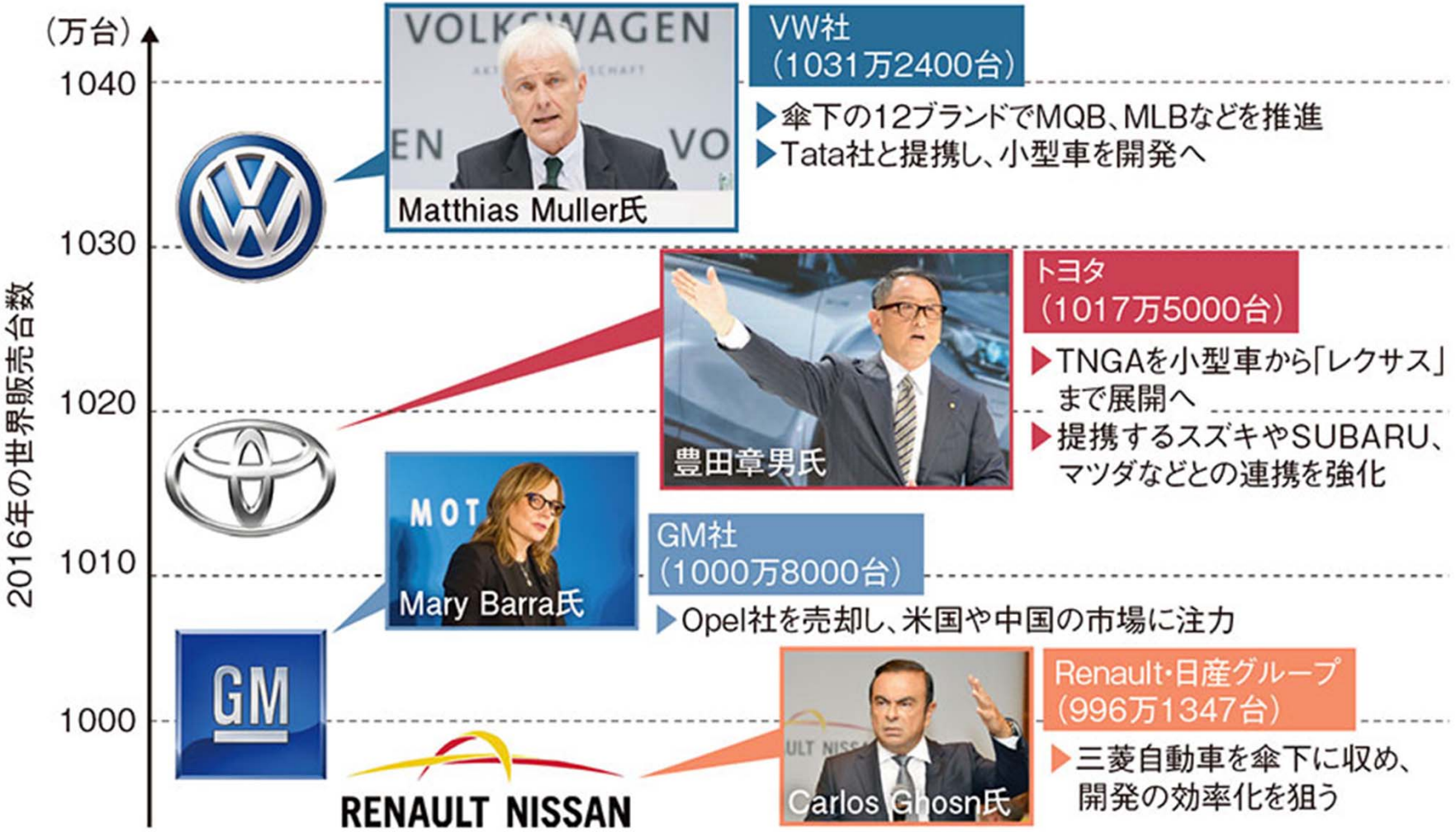
부품공통화: 공통 플랫폼



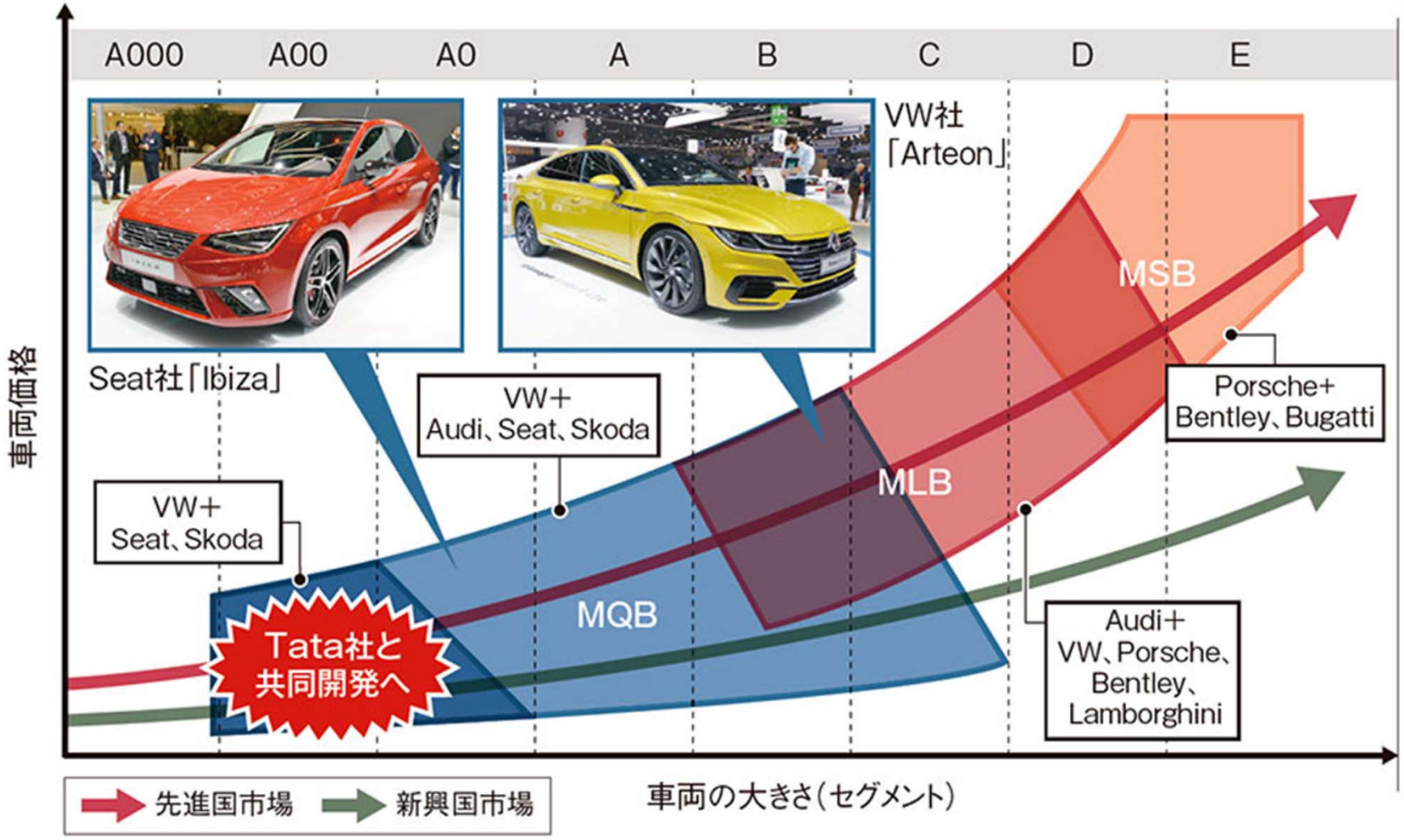
「MEB」の例

- VW社：「MQB」「MEB」など
- トヨタ：「TNGA」
- GM社：「D2」
- Renault・日産グループ：「CMF」
- グループPSA：「EMP2」
- Volvo社：「SPA」「CMA」
- SUBARU：「SGP」

1000만대 클럽

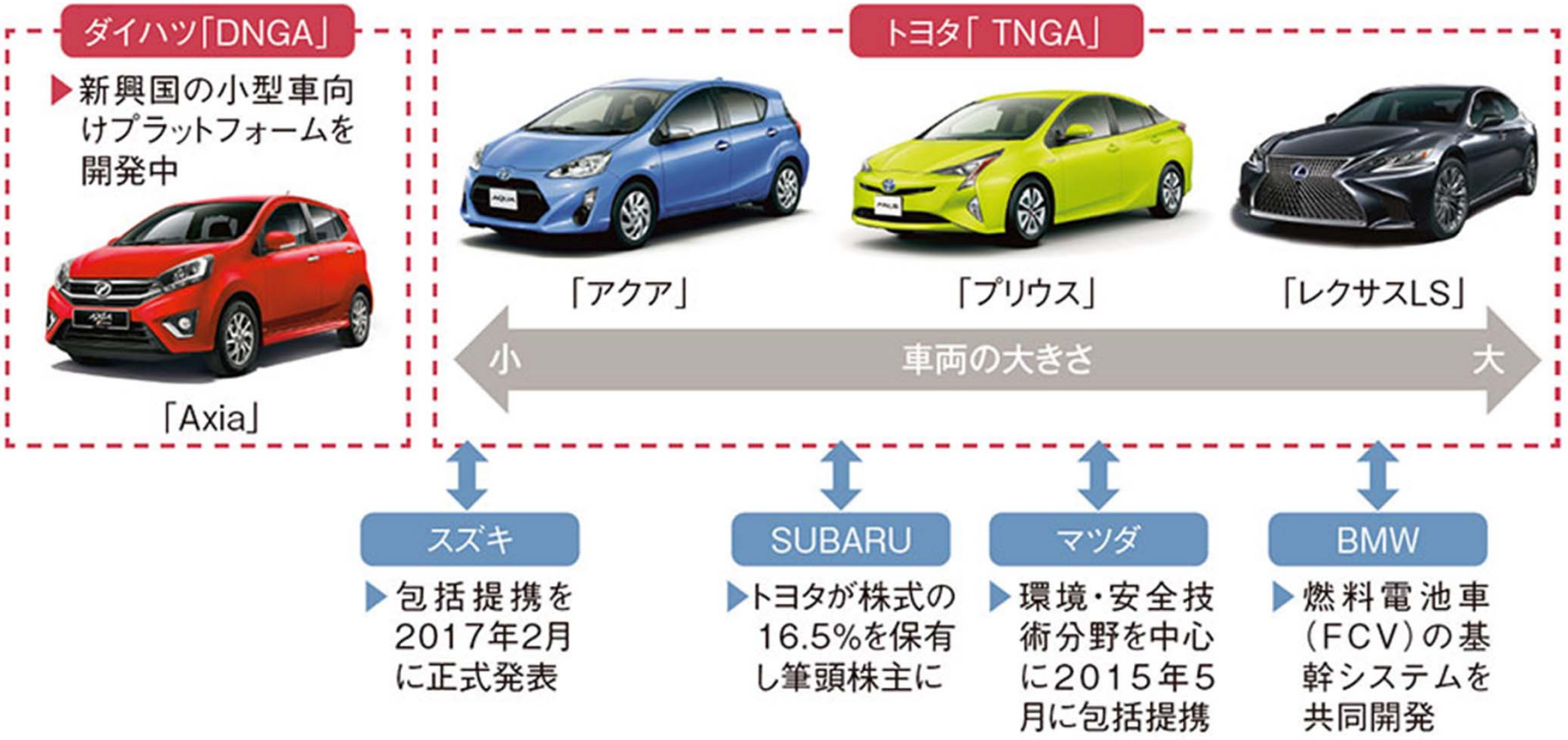

(万台)
1040
1030
1020
1010
1000
2016年の世界販売台数
VOLKSWAGEN
Matthias Muller氏
VW社
(1031万2400台)
▶傘下の12ブランドでMQB、MLBなどを推進
▶Tata社と提携し、小型車を開発へ
豊田章男氏
トヨタ
(1017万5000台)
▶TNGAを小型車から「レクサス」まで展開へ
▶提携するスズキやSUBARU、マツダなどとの連携を強化
Mary Barra氏
GM社
(1000万8000台)
▶Opel社を売却し、米国や中国の市場に注力
GM
RENAULT NISSAN
Carlos Ghosn氏
Renault・日産グループ
(996万1347台)
▶三菱自動車を傘下に収め、開発の効率化を狙う

MQB(2012년)는 5년에 걸쳐 계획달성



Toyota New Global Architecture

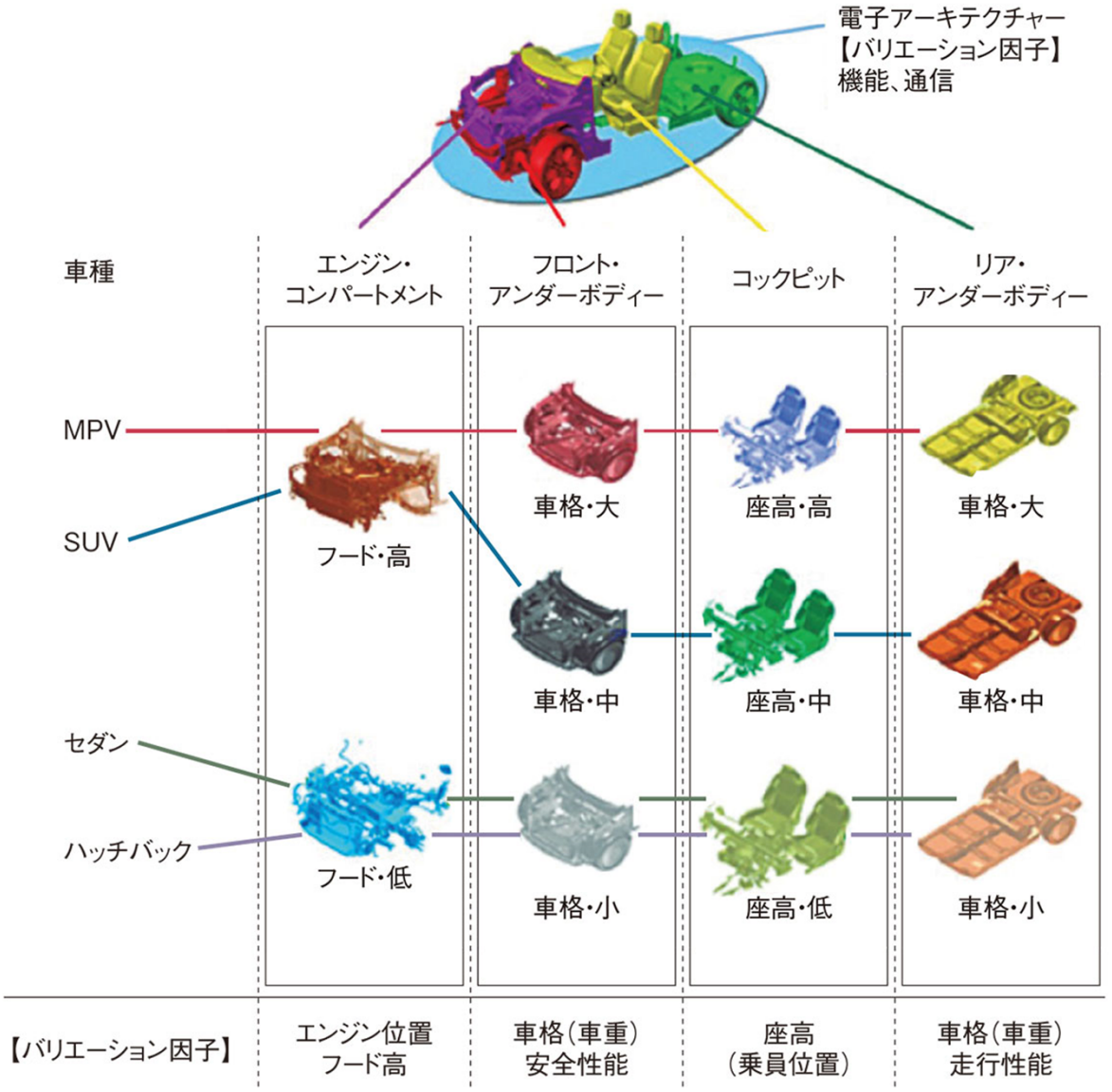
- 토요타 연합(연간 1800만대): Daihatsu 자회사화, Suzuki와 포괄적 제휴, Subaru/Mazda/BMW 등과도 제휴관계



모듈화

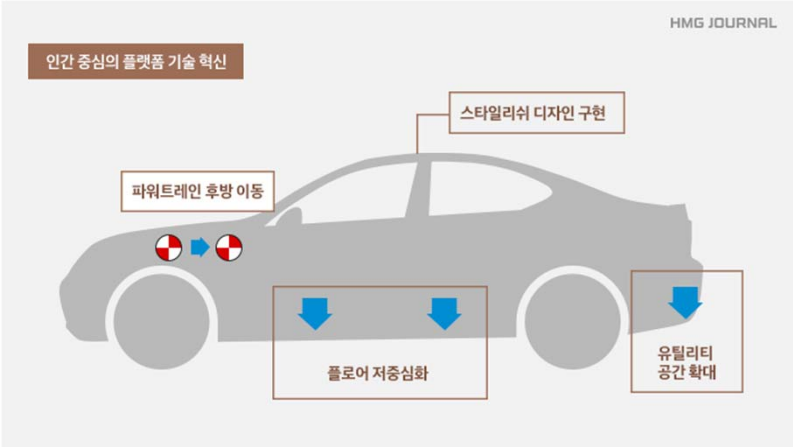
- 여러 개 부품을 조립하는 유닛화가 아님
- 적은 종류의 부품을 조립하여 다양한 제품을 실현하는 방법
  - PC산업 등에서 이전부터 사용
  - 자동차: 부품수 많고 요구되는 품질과 구성요소간 관계가 복잡
- 적은 종류의 요소기술 또는 생산기술로 다양한 제품을 실현하는 아키텍처를 구축하는 것
  - Toyota: TNGA
  - Mazda: common architecture
  - Volkswagen: MQB
  - Renault/Nissan/Mitsubishi: CMF(Common Module Family)

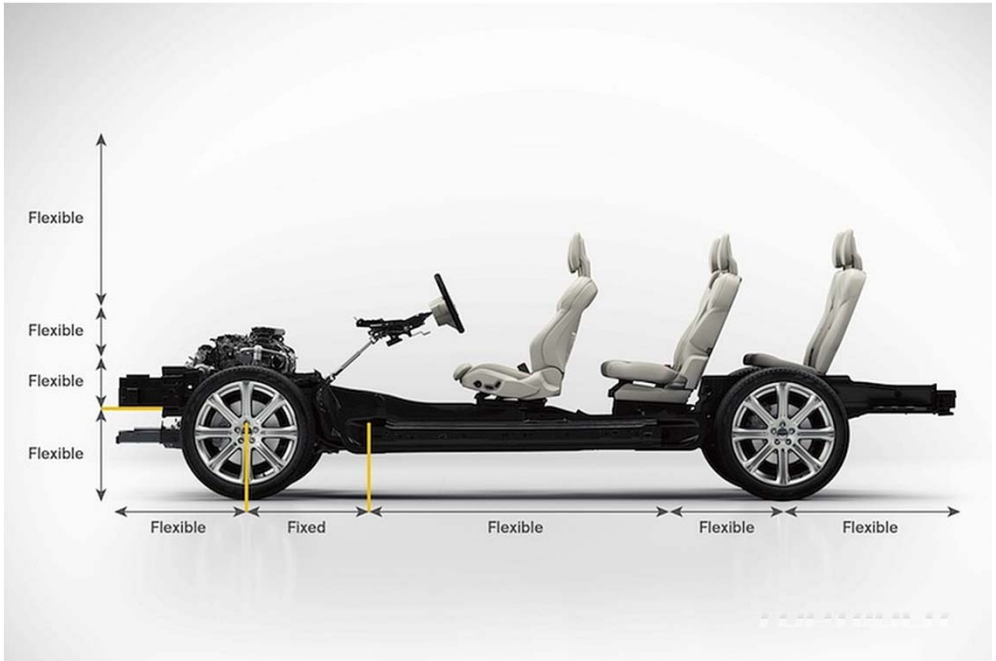
CMF을 통한 차량개발


電子アーキテクチャー
【バリエーション因子】
機能、通信
車種
エンジン・
コンパートメント
フロント・
アンダーボディー
コックピット
リア・
アンダーボディー
MPV
SUV
セダン
ハッチバック
フード・高
車格・大
座高・高
車格・大
車格・中
座高・中
車格・中
フード・低
車格・小
座高・低
車格・小
【バリエーション因子】
エンジン位置
フード高
車格(車重)
安全性能
座高
(乗員位置)
車格(車重)
走行性能

현대기아차 '3세대 플랫폼'

- 플랫폼 전략 키워드: 혁신, 글로벌, 모듈화





https://news.hmgjournal.com/Tech/3세대-플랫폼의-4가지-전략-키워드

Classification of Cars: Space

- Three box car
  - Separated engine/cabin/luggage room design
- Two box car
  - Integrated cabin/luggage room design
- One box car
  - Integrated cabin/luggage room design with under-floor engine

Classification of Cars: Body Styles

Hatch back

Sedan / Notch back

Pick up

MPV

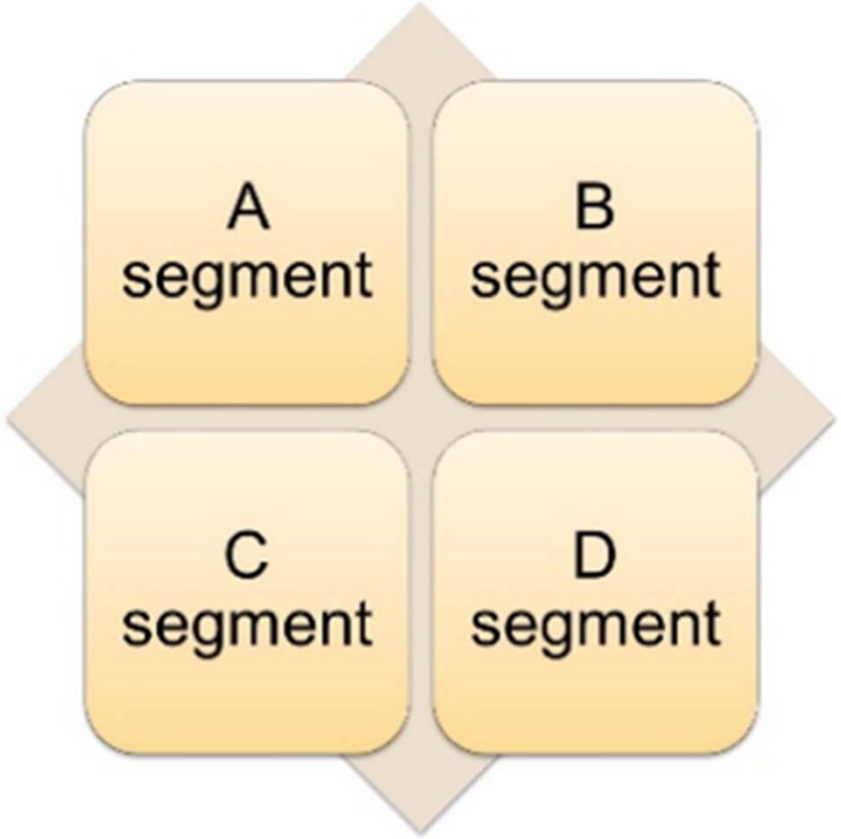
SUV

Station Wagon

Convertible

Coupe

Classification of Cars: Market Segments



초고장력강판(980MPa급 이상)

- 중량증가 억제, 충돌안전성 증가
  - 차량중앙부의 골격: 초고장력강판
  - 차량 전후부의 골격: 저강도 강판 (충격에너지 흡수)
- 냉간프레스재
  - 열처리로 강도 향상, 1.5GPa급까지 실용화
- 열간(핫)프레스재
  - 590~780MPa급 고장력강판을 가열하여 프레스성형 후 금형 내에서 냉각시켜 강도 향상, 가열용 설비가 필요하여 비용은 증가하지만 성형용이 고강도, 1.8GPa급까지 실용화

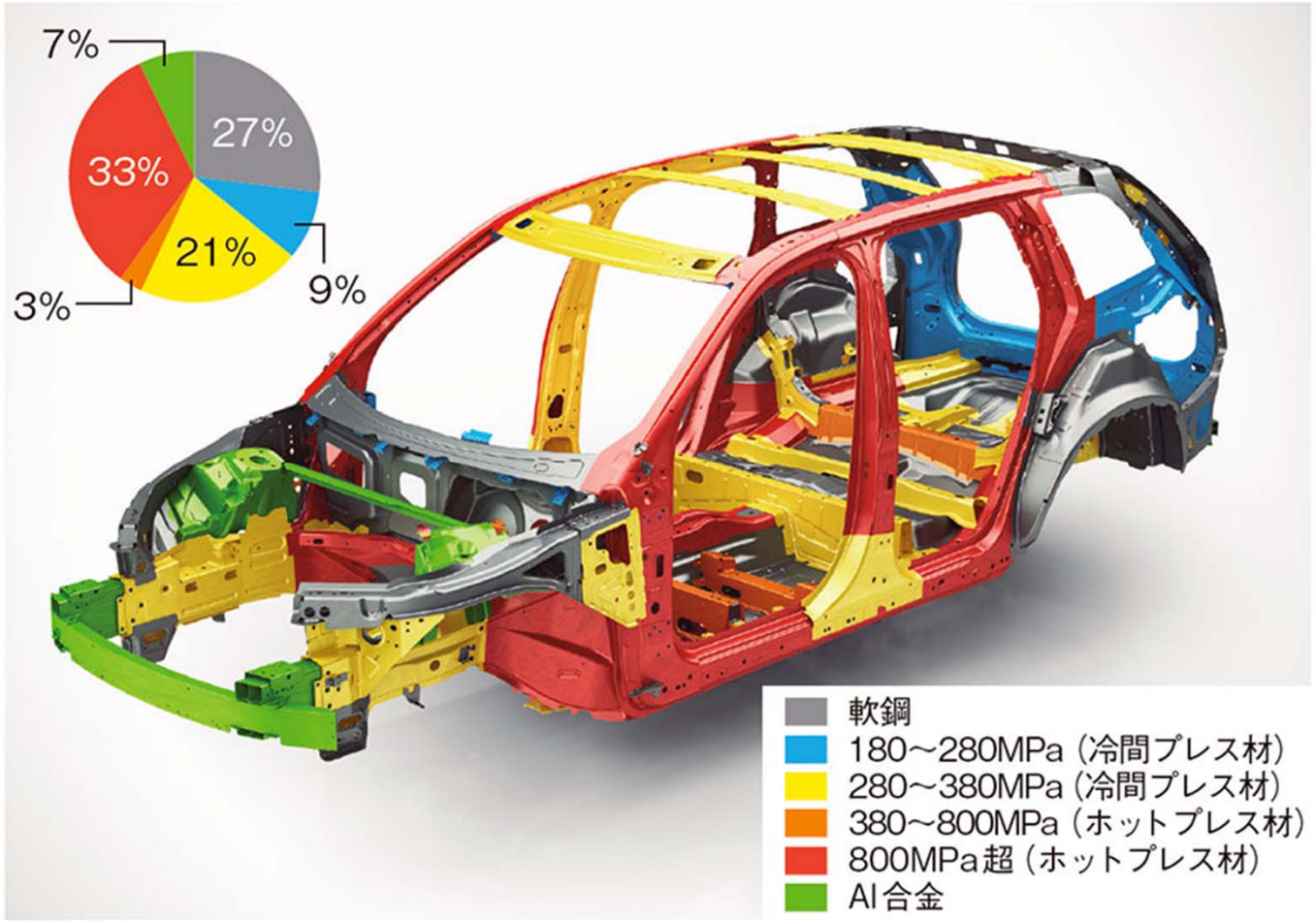
초고장력강판(980MPa급 이상) 적용 차량

メーカー名	車種	発売時期	主な採用部位
Volvo社	XC90 	2016年1月	・380～800MPa級：フロア・クロス・メンバーなど ・800MPa級超：センターピラー、フロントピラー、ルーフレール、サイドシルなど
トヨタ自動車	プリウス 	2015年12月	・1.5GPa級：センターピラーの補強材、クロスメンバー、ルーフレール、トーボードの補強材など ・980MPa級：センターピラーやサイドシル、ルーフの補強材、ドアの補強材、リアバンパーの補強材など
	レクサスLC 	2017年3月	・1.5GPa級：ロア・クロス・メンバー ・1.2GPa級：サイドシル、シート・クロス・メンバー、センターピラー
SUBARU	インプレッサ 	2016年10月	・1.5GPa級：センターピラー、フロントバンパーの補強材、フロントピラーの付け根部分など ・980MPa級：サイドシルなど
マツダ	CX-5 	2017年2月	・1.8GPa級：前後バンパーの補強材 ・1.2GPa級：フロントピラー ・980MPa級：センターピラー、サイドシル
ホンダ	フリード 	2016年9月	・1.5GPa級：フロントピラーの補強材 ・980MPa級：フロントピラー、ルーフレール前部、サイドシルなど
スズキ	ワゴンR 	2017年2月	・1.2GPa級：センターピラー、フロア・サイド・メンバーなど ・980MPa級：フロントピラー、ルーフレール、フロア・クロス・メンバーなど

■：ホットプレス材、■：冷間プレス材

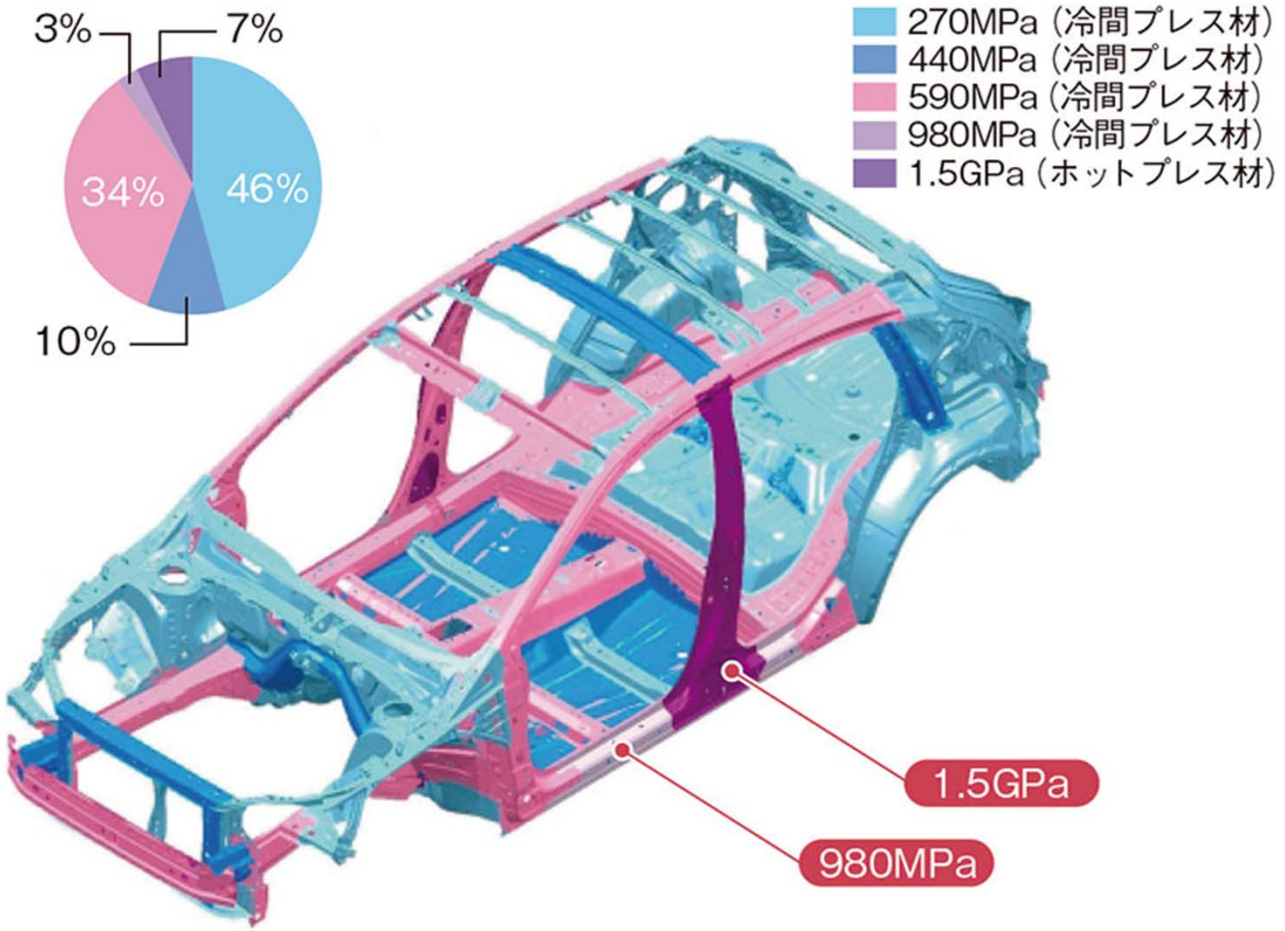
Volvo X90

- SPA: Scalable Product Architecture
- 핫프레스재 사용비율: 7%→36%, 125kg경량화

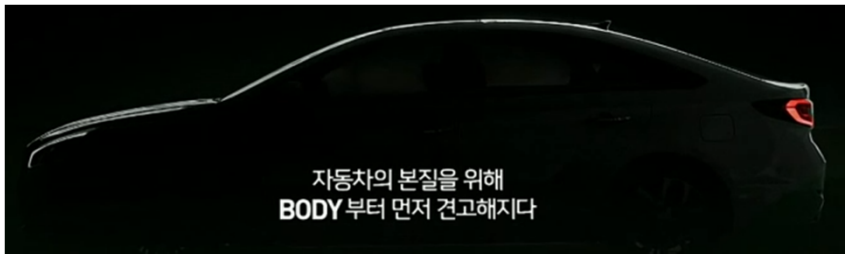


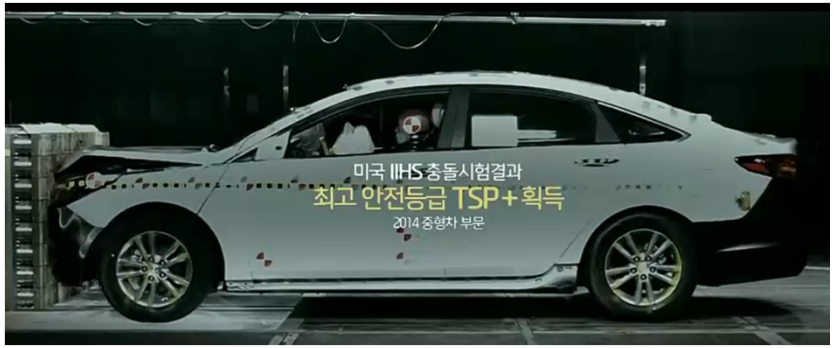
SUBARU

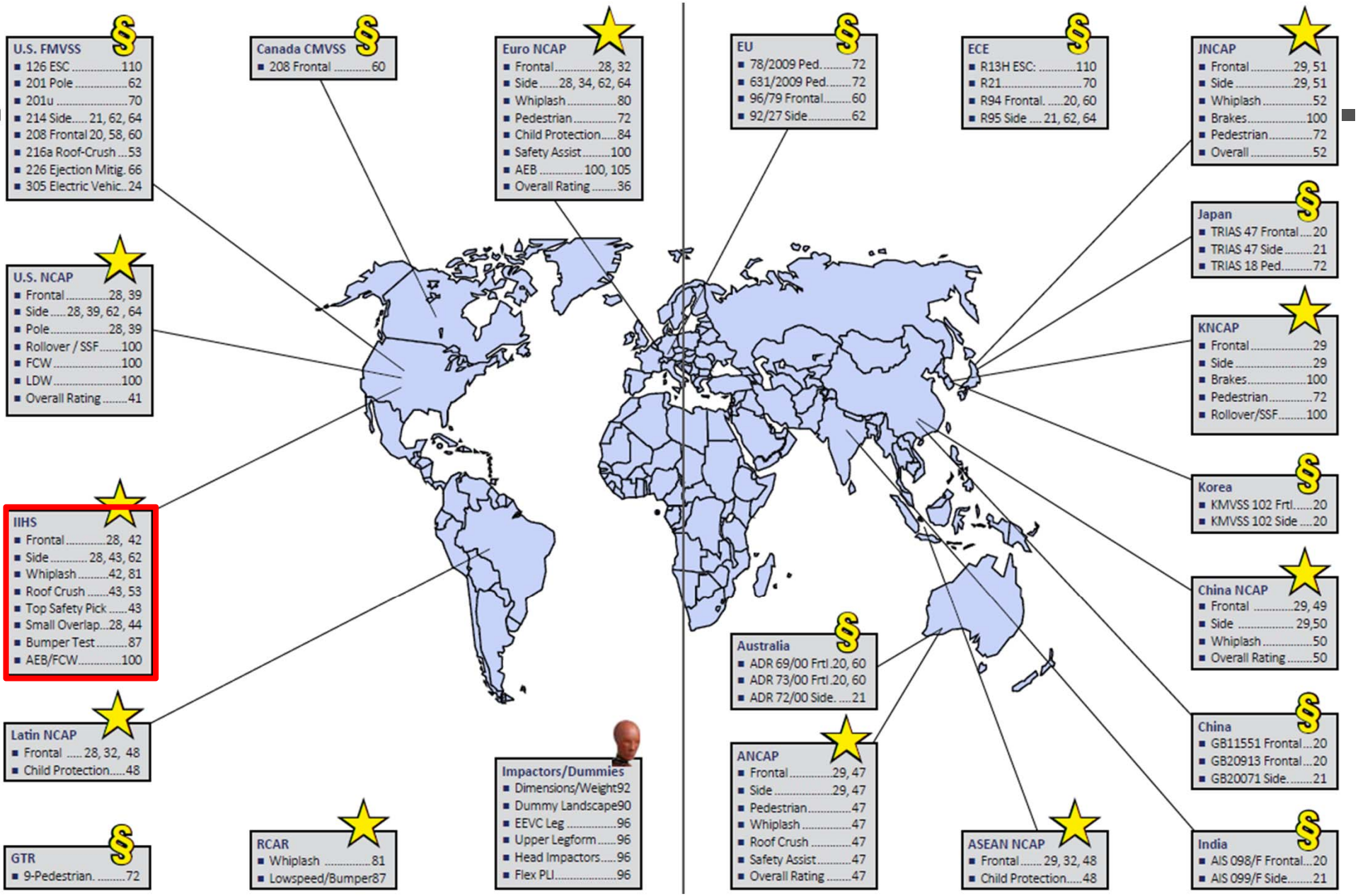
- SGP: Subaru Global Platform
- 440MPa급 이상 사용비율: 45%→54%



현대자동차 소나타 바디편 (July 2014)






U.S. FMVSS
126 ESC 110
201 Pole 62
201u 70
214 Side 21, 62, 64
208 Frontal 20, 58, 60
216a Roof-Crush 53
226 Ejection Mitig. 66
305 Electric Vehic. 24
Canada CMVSS
208 Frontal 60
Euro NCAP
Frontal 28, 32
Side 28, 34, 62, 64
Whiplash 80
Pedestrian 72
Child Protection 84
Safety Assist 100
AEB 100, 105
Overall Rating 36
EU
78/2009 Ped. 72
631/2009 Ped. 72
96/79 Frontal 60
92/27 Side 62
ECE
R13H ESC: 110
R21 70
R94 Frontal. 20, 60
R95 Side 21, 62, 64
JNCAP
Frontal 29, 51
Side 29, 51
Whiplash 52
Brakes 100
Pedestrian 72
Overall 52
Japan
TRIAS 47 Frontal 20
TRIAS 47 Side 21
TRIAS 18 Ped. 72
U.S. NCAP
Frontal 28, 39
Side 28, 39, 62 , 64
Pole 28, 39
Rollover / SSF 100
FCW 100
LDW 100
Overall Rating 41
KNCAP
Frontal 29
Side 29
Brakes 100
Pedestrian 72
Rollover/SSF 100
Korea
KMVSS 102 Frtl. 20
KMVSS 102 Side 20
IIHS
Frontal 28, 42
Side 28, 43, 62
Whiplash 42, 81
Roof Crush 43, 53
Top Safety Pick 43
Small Overlap 28, 44
Bumper Test 87
AEB/FCW 100
China NCAP
Frontal 29, 49
Side 29,50
Whiplash 50
Overall Rating 50
Australia
ADR 69/00 Frtl 20, 60
ADR 73/00 Frtl 20, 60
ADR 72/00 Side. 21
China
GB11551 Frontal 20
GB20913 Frontal 20
GB20071 Side. 21
Latin NCAP
Frontal 28, 32, 48
Child Protection 48
Impactors/Dummies
Dimensions/Weight 92
Dummy Landscape 90
EEVC Leg 96
Upper Legform 96
Head Impactors 96
Flex PLI 96
ANCAP
Frontal 29, 47
Side 29, 47
Pedestrian 47
Whiplash 47
Roof Crush 47
Safety Assist 47
Overall Rating 47
India
AIS 098/F Frontal 20
AIS 099/F Side 21
GTR
9-Pedestrian. 72
RCAR
Whiplash 81
Lowspeed/Bumper 87
ASEAN NCAP
Frontal 29, 32, 48
Child Protection 48

IIHS (Insurance Institute for Highway Safety)

- Crashworthiness: how well a vehicle protects its occupants in a crash
  - Performance in five tests (Good/Acceptable/Marginal/Poor)
  - Moderate overlap front, Small overlap front, Side, Roof strength, Head restraints & seats
- Crash avoidance and mitigation: technology that can prevent a crash or lessen its severity (since 2013)
  - Front crash prevention systems (Superior/Advanced/Basic)
    - Forward collision warning
    - Autobrake systems: low speed(12mph), moderate speed(25mph)
  - Headlights (Good/Acceptable/Marginal/Poor)
    - reach of a vehicle's headlights as the vehicle travels straight and on curves(800/500-foot radius)

IIHS Safety Awards (2018)

- Top Safety Pick (TSP)
  - Good ratings five crashworthiness tests in the driver-side : small overlap front, the moderate overlap front, side, roof strength and head restraint tests
  - Advanced or superior rating for front crash prevention
  - Acceptable or good headlight rating
- Top Safety Pick+
  - Top Safety Pick criteria, plus
  - Acceptable or good rating in the passenger-side small overlap front test
  - Good headlight rating

New Challenges: New Structural Concepts

Aixam Mega
Mega E-City

BMW
E-mini

Bolloré/Pininfarina
Blue Car

BYD
E6

Daimler
Smart ed

General Motors
Volt

Heuliez
Will

Mitsubishi
i-Miev

Nissan
E-Cube

Reva
G-Wiz

Subaru
R1e

Tesla Motors
Roadster

Th!nk
City

Volkswagen
Twin Drive

???

Electric Cars

ETC/ACC Technical Paper 2009/4
F. Hacker, R. Harthan, F. Matthes, W. Zimmer

New Challenges: New Structural Concepts

www.loremo.com

(Low Resistance Mobile)

New Challenges: Electromobility

Technical Data

Dimensions:	Microcars
Number of passengers:	2 passengers
Vehicle payload:	2 pieces of luggage
Range:	> 100 km
Costs (TCO):	TCO equal to today´s compact cars
Market	Central Europe
Registration	L7E
Maximum speed	120 km/h
Output at wheel	15 kW
Curb weight	500 kg incl. battery
Energy storage	Rechargeable battery + el. Range Extender

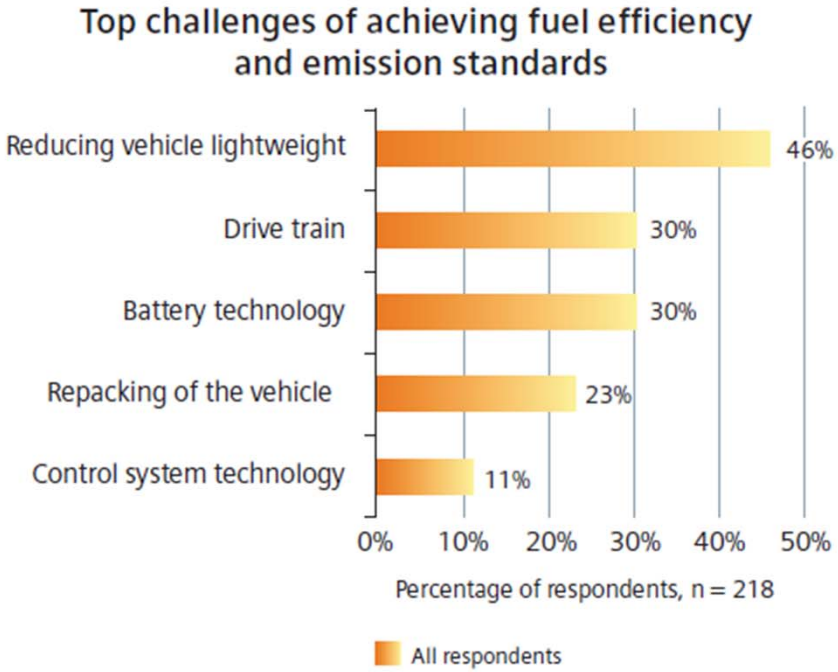
www.mute-automobile.de

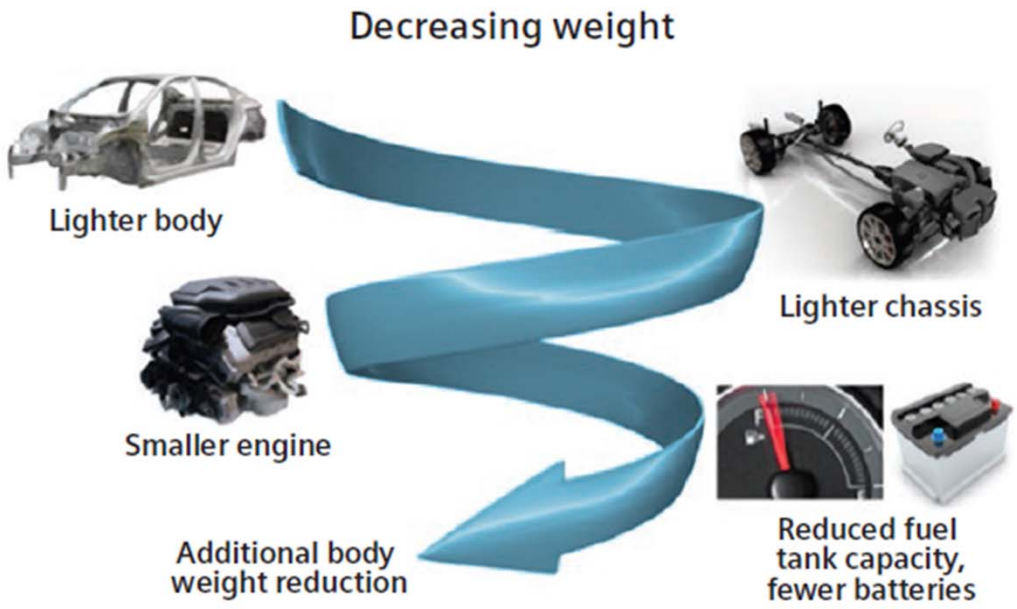
(Technical University of Munich)

New Challenges: New Materials (CFRP)

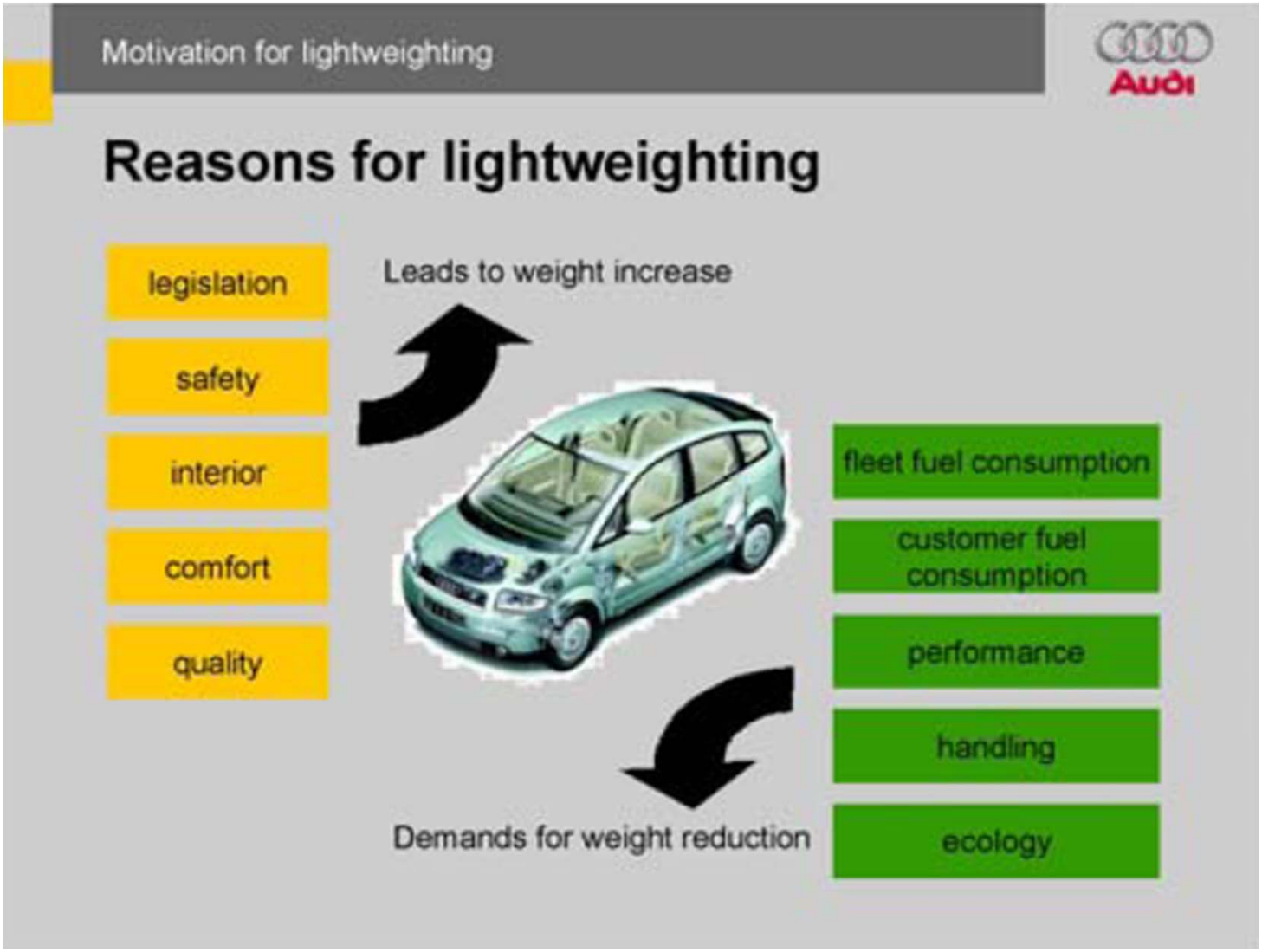
Reducing Vehicle Weight

- Alternative materials and assembly methods
- Fundamental change in vehicle designs
  - Rely more on engineering tools
  - Impact on part manufacturing, assembly, joining → factory



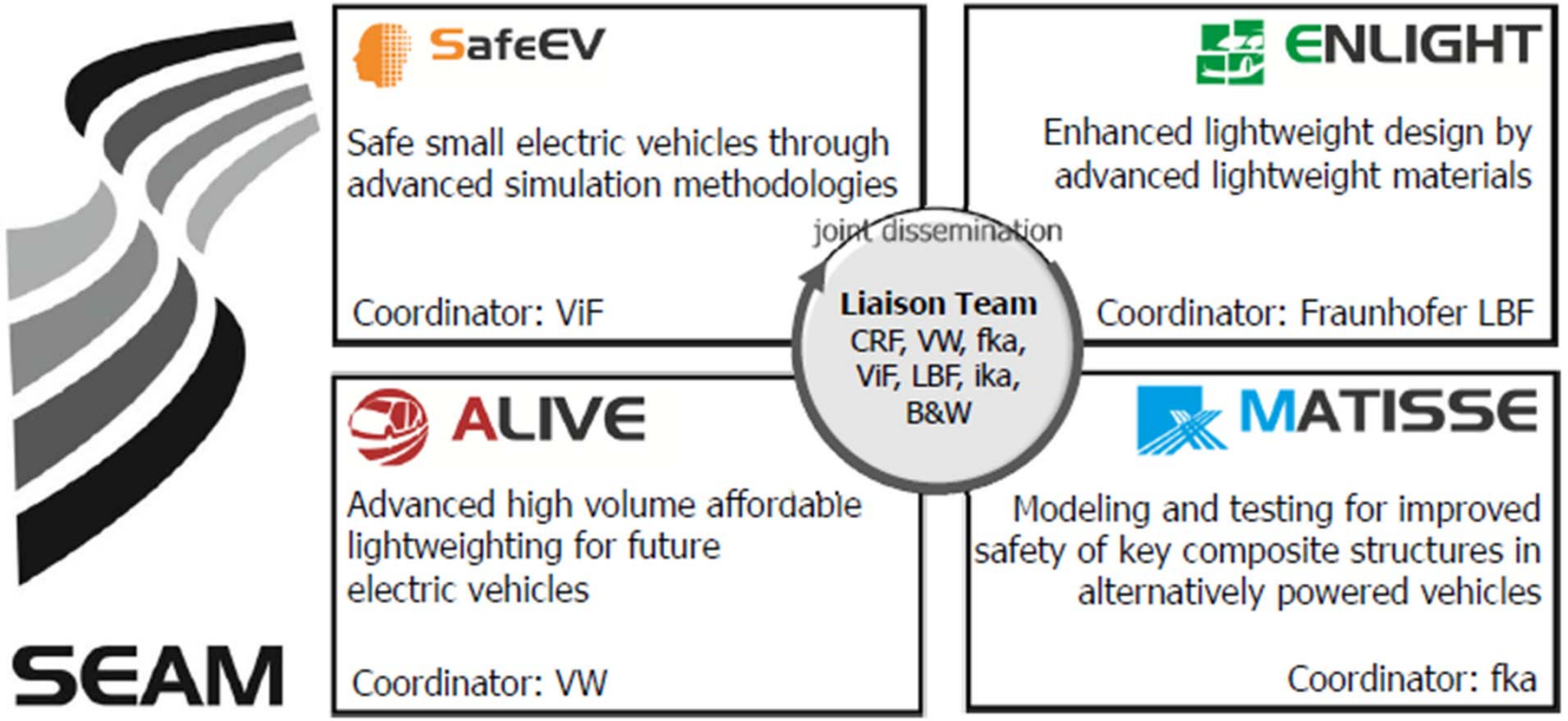


Lightweight Development



EU: SEAM Cluster

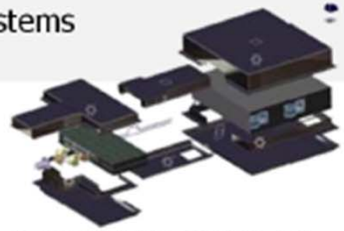
- Safe Efficient Advanced Materials
  - Biggest European RTD-cluster on lightweight design
  - Cluster duration: 2012/10~2016/09
  - 47 partner from 10 countries, about 19M € funding



EU: Concept

SmartBatt

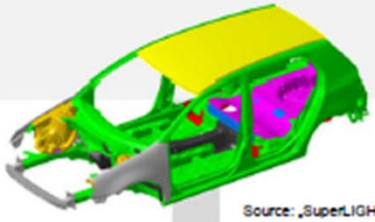
- Fully integrated battery housing
- Lightweight battery concept
- New materials for battery systems



Source: Fraunhofer IWF, „SmartBatt" project

SuperLIGHT-Car

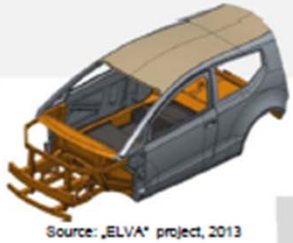
- Economic demonstration of multimaterial vehicle structures for high-volume produced combustion cars



Source: „SuperLIGHT-Car" project, 2009

ELVA

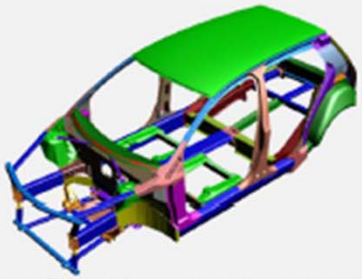
- Concept of light BiW for EV´s
- Space frame design
- Modularity in battery and BiW design



Source: „ELVA" project, 2013

ALIVE

- High volume
- Low weight
- Low costs



Source: M. Kurz , Volkswagen Group Research, K-EFFG/L, 2013

ENLIGHT

- medium volume
- Novel materials
- Low weight

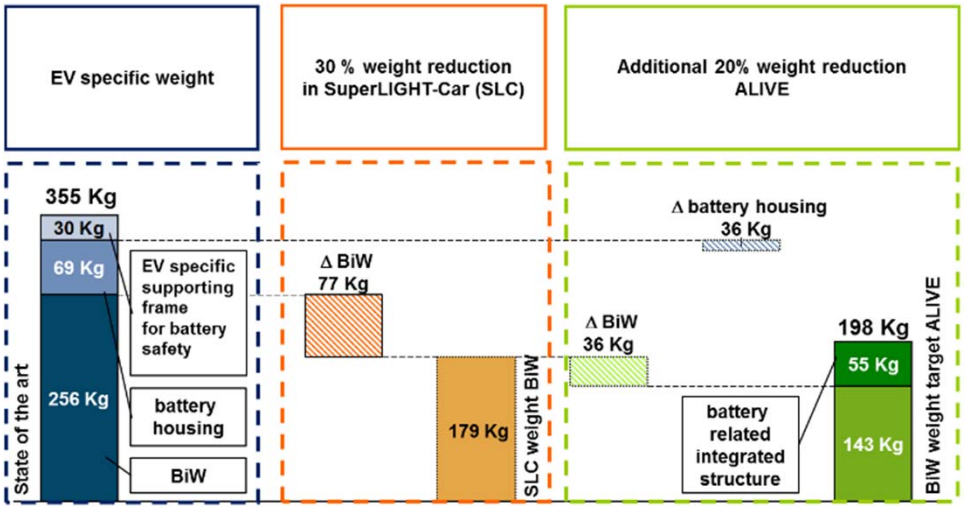
MATISSE

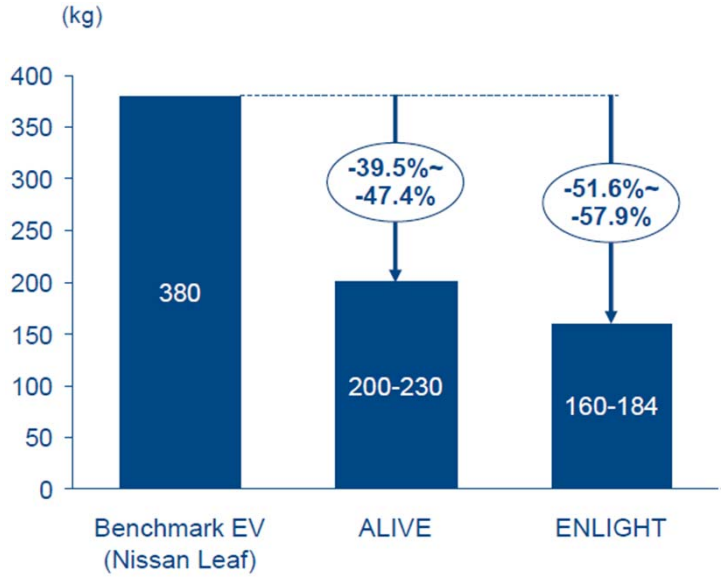
- Modeling and testing
- Safety of composite structures

SafeEV

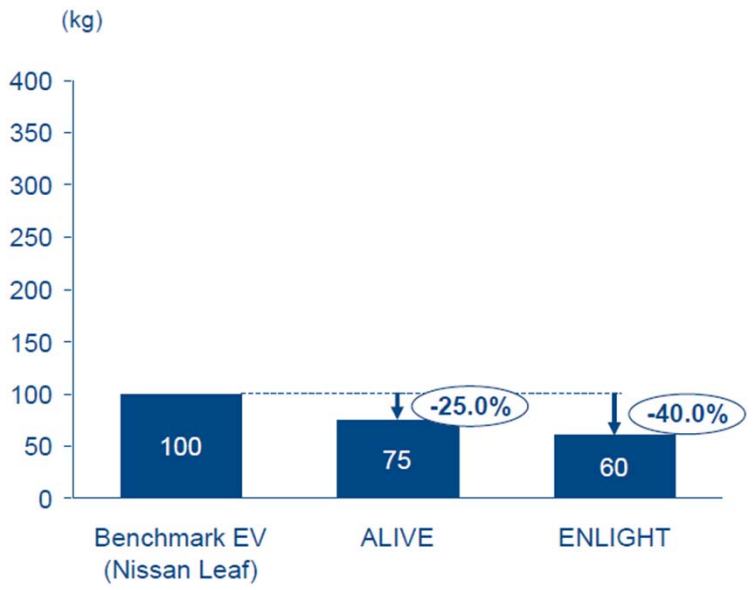
- Modeling and testing of small EVs
- Safety of vulnerable road users

EU: ALIVE → ENLIGHT





FRAME



HANG-ON

US: WorldAutoSteel

ULSAB
UltraLight Steel Auto Body

1998

ULSAC
UltraLight Steel
Auto Closures

2000

ULSAS
UltraLight
Steel
Auto
Suspensions

2000

2008~2012

FutureSteelVehicle

Nature's Way to Mobility

ULSAB-AVC
Advanced Vehicle
Concepts

2001

US: FutureSteelVehicle (2009~2012)

FSV 1 **A-/B SEGMENT** **4-DOOR HATCHBACK** **3700 mm LONG**	**Plug-in hybrid drive** **PHEV-20** Electric range: 32 km Total range: 500 km Max. speed: 150 km/h 0 – 100 km/h: 11 – 13 s BIW weight: 176 kg	**Battery electric drive** **BEV** Total range: 250 km Max. speed: 150 km/h 0 – 100 km/h: 11 – 13 s BIW weight: 188 kg
FSV 2 **C-/D SEGMENT** **4-DOOR SALOON** **4350 mm LONG**	**Plug-in hybrid drive** **PHEV-40** Electric range: 64 km Total range: 500 km Max. speed: 161 km/h 0 – 100 km/h: 10 – 12 s BIW weight: 201 kg	**Fuel cell electric drive** **FCEV** Total range: 500 km Max. speed: 161 km/h 0 – 100 km/h: 10 – 12 s BIW weight: 201 kg

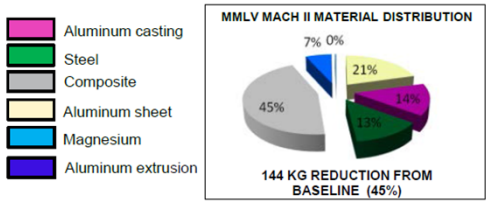
	ICE 1 2010	ICE 1 2020	HEV 1 2010	HEV 1 2020	FSV 1 $PHEV_{20}$	FSV 1 BEV	ICE 2 2010	ICE 2 2020	HEV 2 2010	HEV 2 2020	FSV 2 $PHEV_{40}$	FSV 2 FCEV
Body Non-Structure	245	190	215	190	190	190	302	210	257	210	210	210
Body Structure	272	241	272	237	173	190	337	298	337	303	198	175
Front Suspension	59	40	62	45	40	45	73	49	76	55	51	44
Rear Suspension	53	39	61	37	26	35	65	45	73	44	52	34
Steering	17	17	17	17	16	16	21	21	21	21	19	19
Brakes	38	31	40	33	29	32	47	37	49	40	37	34
Drivetrain	222	197	297	252	215	78	274	244	359	304	261	177
Fuel, Battery, Exhaust	48	55	104	105	98	347	59	68	125	127	178	114
Wheels and Tires	78	59	68	55	38	44	96	72	80	73	70	61
Air Conditioning	32	42	27	33	36	36	40	52	35	46	47	47
Electrical	55	63	55	66	63	58	68	78	68	82	83	93
Bumpers	26	21	23	24	20	23	33	25	31	28	26	22
Closures	54	48	49	44	46	46	67	59	62	55	48	48
TOTAL	1199	1044	1290	1138	990	1,137	1,483	1,260	1574	1388	1279	1079

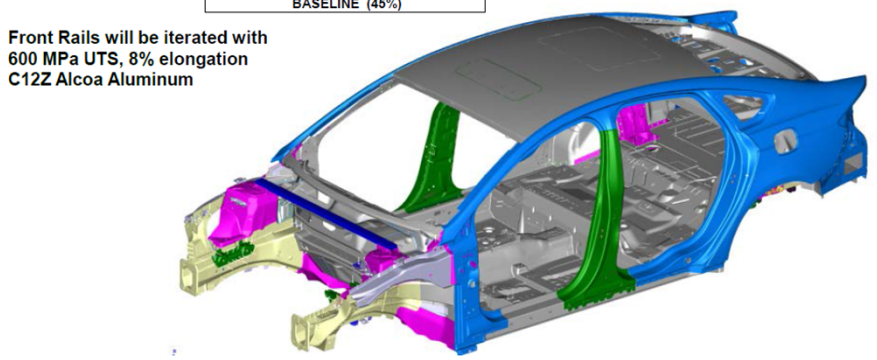
FSV-1 BEV mass target: 190kg (-35% of [ULSAB AVC(268) + update(22)])

US: MMLV Project

- Timeline: 2012-Feb ~ 2015-Sep
- Budget: DOE ($10M), Vehma/Ford ($10.3)
- 5인승 CD 세그멘트 차량을 기본차량(2013 Ford Fusion) 대비 성능, 안전성을 유지하면서 중량저감
- Body Exterior and Closure, Body Interior and Climate Control, Chassis, Powertrain, Electrical

- **Mach-I: 23.3% (364kg) 중량 감소 (부품, 시스템)**
  - 기존에 사용 가능한 재료와 생산공정
  - 비용 고려없이 벤치마크 확립
  - 시작품 제작, 제한적인 테스트
- **Mach-II: 40% 중량 감소 목표**
  - 고등 재료와 공정 사용
  - 기술적 갭 확인



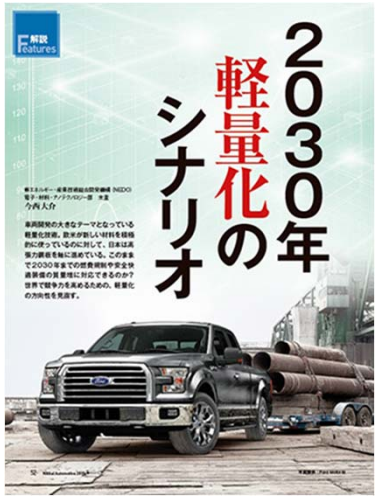


MMLV

Multi Material Lightweight Vehicle

PMT Description	2002 Taurus	2013 Fusion	MMLV Mach I DESIGN FINAL	MMLV Mach I Prototype Planned	MMLV Mach II Design Targets (PRELIM)	MMLV Mach II Design Status (4 Mar '14)
Body Exterior and Closures (kg)	**574**	**594**	**456**	**489**	**237**	**355**
Body-in-White	n.a.	326	250	251		183
Closures-in-White	n.a.	98	69	88		56
Bumpers	n.a.	37	25	31		24
Glazings - Fixed and Movable	n.a.	37	25	25		21
Remainder - trim, mechanisms, paint, seals, etc.	n.a.	96	87	94		70
Body Interior and Climate Control (kg)	**180**	**206**	**161**	**191**	**137**	**116**
Seating	n.a.	70	42	61		34
Instrument Panel	n.a.	22	14	15		11
Climate Control	n.a.	27	25	27		11
Remainder - trim, restraints, console, etc	n.a.	88	80	88		60
Chassis (kg)	**352**	**350**	**252**	**269**	**144**	**212**
Frt & Rr Suspension	n.a.	96	81	85		66
Subframes	n.a.	57	30	44		19
Wheels & Tires	n.a.	103	64	58		57
Brakes	n.a.	61	49	50		43
Remainder - steering, jack, etc.	n.a.	33	29	32		27
Powertrain (kg)	**350**	**340**	**267**	**299**	**190**	**181**
Engine (dressed)	n.a.	101	71	101		64
Transmission and Driveline	n.a.	106	92	54		38
Remainder - fuel, cooling, mounts, etc.	n.a.	133	104	143		79
Electrical (kg)	**67**	**69**	**59**	**66**	**53**	**47**
Wiring	n.a.	28	25	28		23
Battery	n.a.	14	8	10		8
Remainder - alternator, starter, speakers, etc.	n.a.	27	26	27		17
Total Vehicle (kg)	**1523**	**1559**	**1195**	**1313**	**761**	**911**
Weight save w.r.t. 2013 Fusion			**23.3%**	**15.7%**	**51.2%**	
Weight save w.r.t. 2002 Taurus			**21.5%**	**13.8%**	**50.0%**	

Japan: NEDO



- 유럽, 미국: Al합금, 수지재료 등 적극 활용
- 일본: 기존 고장력강판에 의존, 신재료 전환 필요

* BMW전기차 “i3” CFRP

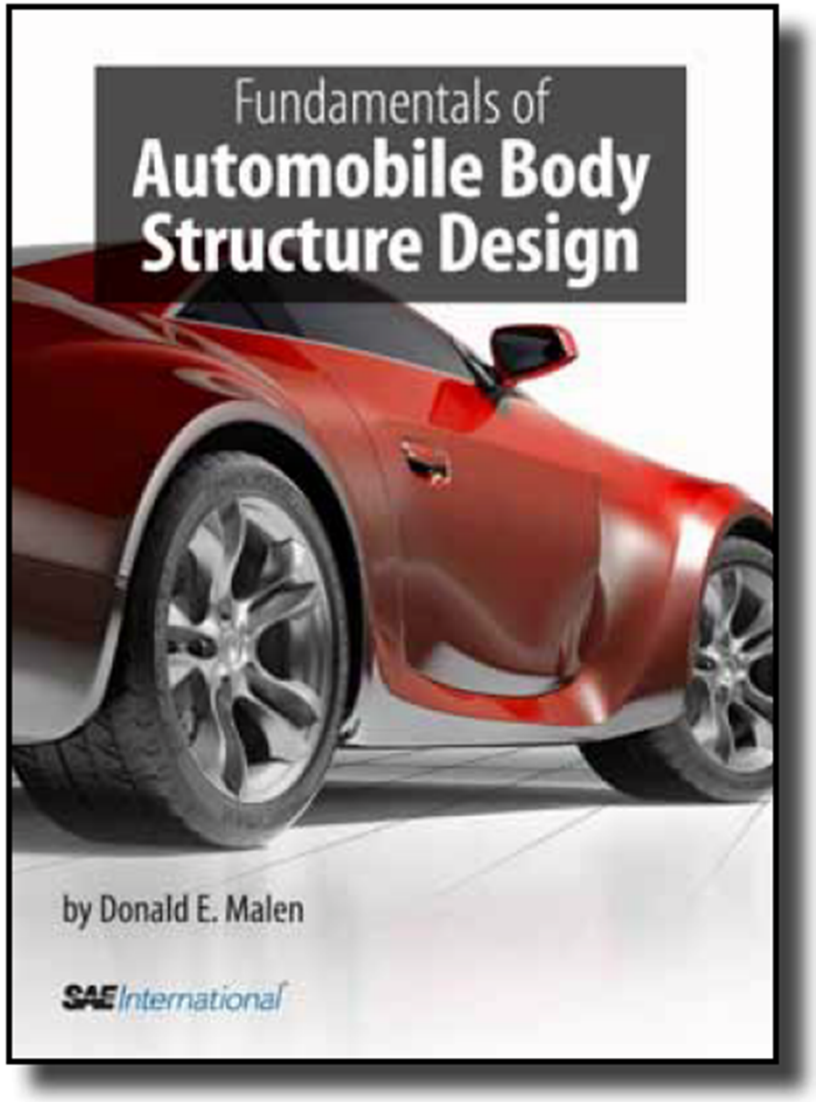
* Ford 픽업트럭 “F-150” Al합금

* Mercedes-Benz “C-class” Al합금

신에너지산업기술종합개발기구(New Energy and Industrial Technology Development Organization)
Arthur D. Little

Textbook (2011)

- This book will provide readers with a solid understanding of the principles of automobile body structural design, illustrating the effect of changing design parameters on the behavior of automobile body structural elements.
- Emphasizing simple models of the behavior of body structural systems rather than complex mathematical models, the book looks at the best way to shape a structural element to achieve a desired function, why structures behave in certain ways, and how to improve performance.



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