

BORGWARNER

# Next evolution of a versatile iDM platform with high value 5th generation inverter

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# Motivation

## UniCore iDM Platform with Gen V Inverter

**iDM Platform for low-cost, low power mass market for highest supply chain security**

- **Global mass market** xEV segment for **< 200 kW**
- **Low-cost UniCore iDM Platform** for Majority BEV adaptation
- Lead variant: **400 V** / Option: **800 V** Global  
Today ~20%
- **Common stator** for IPM & EESM for
- **GEN V Inverter** = Ultra-low
- **Flexibl**

Innovators  
(2.5%)

Early Adaptors  
(13.5%)

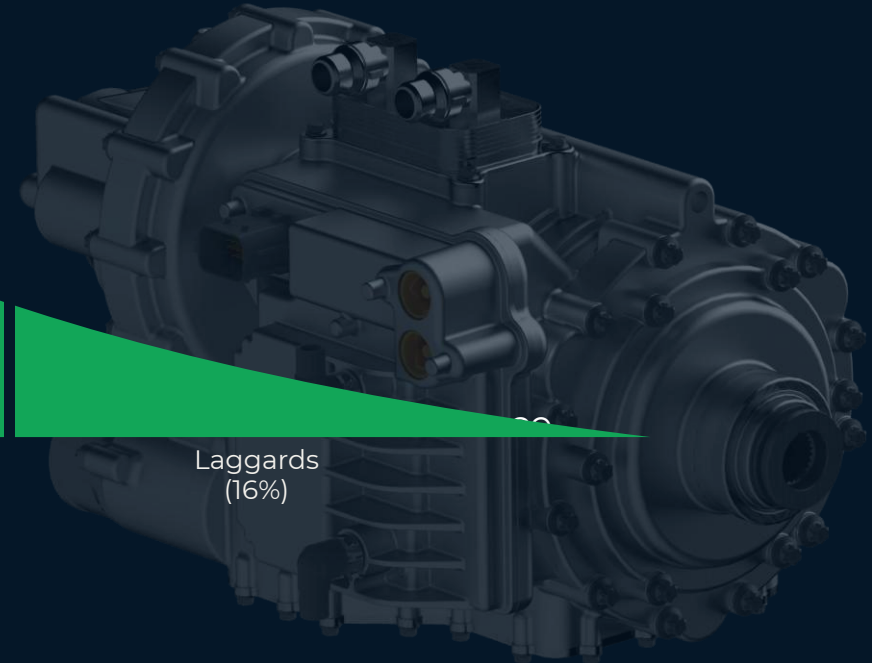
Early Majority  
(34%)

Late Majority  
(34%)

Laggards  
(16%)

Chasm

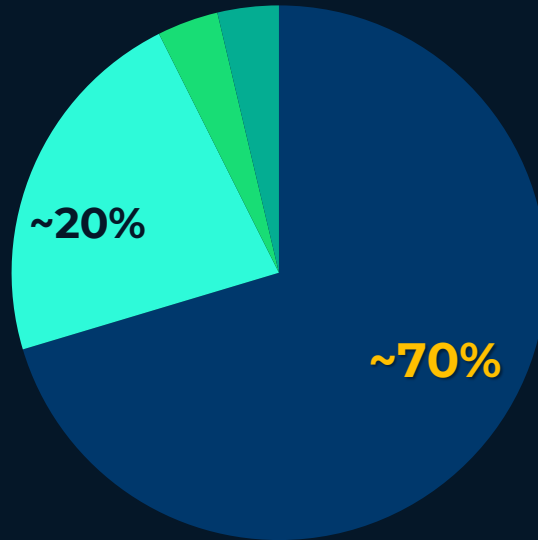
BEV Mass market



# Tier-1 Addressable Market – Production Volume

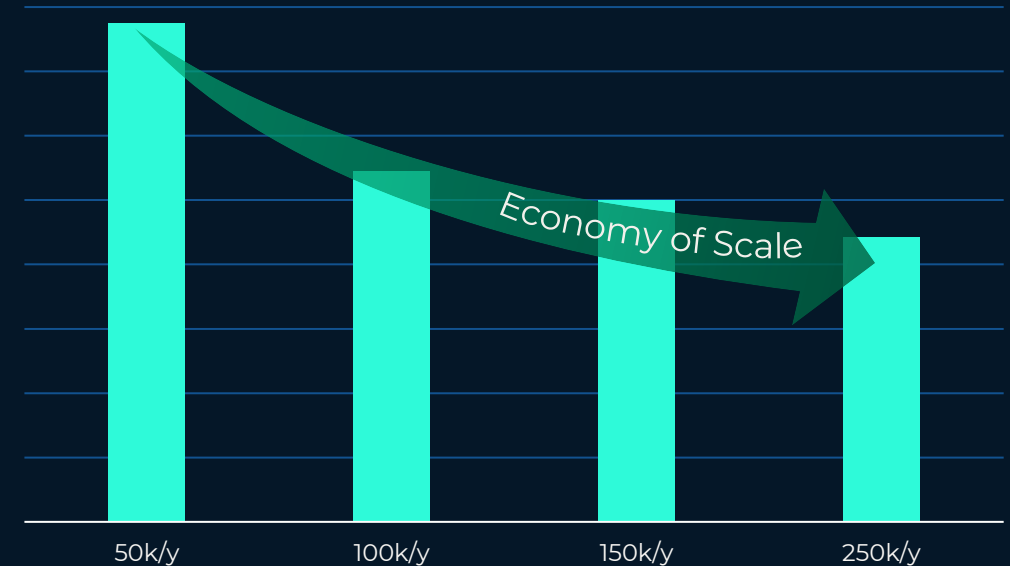
## Annual Volume by Programs Example

■ < 50k/yr ■ <100k/yr ■ <150k/yr ■ <250k/yr



Bundle  
max. 3  
programs to  
fully utilize  
the capacity  
where  
possible

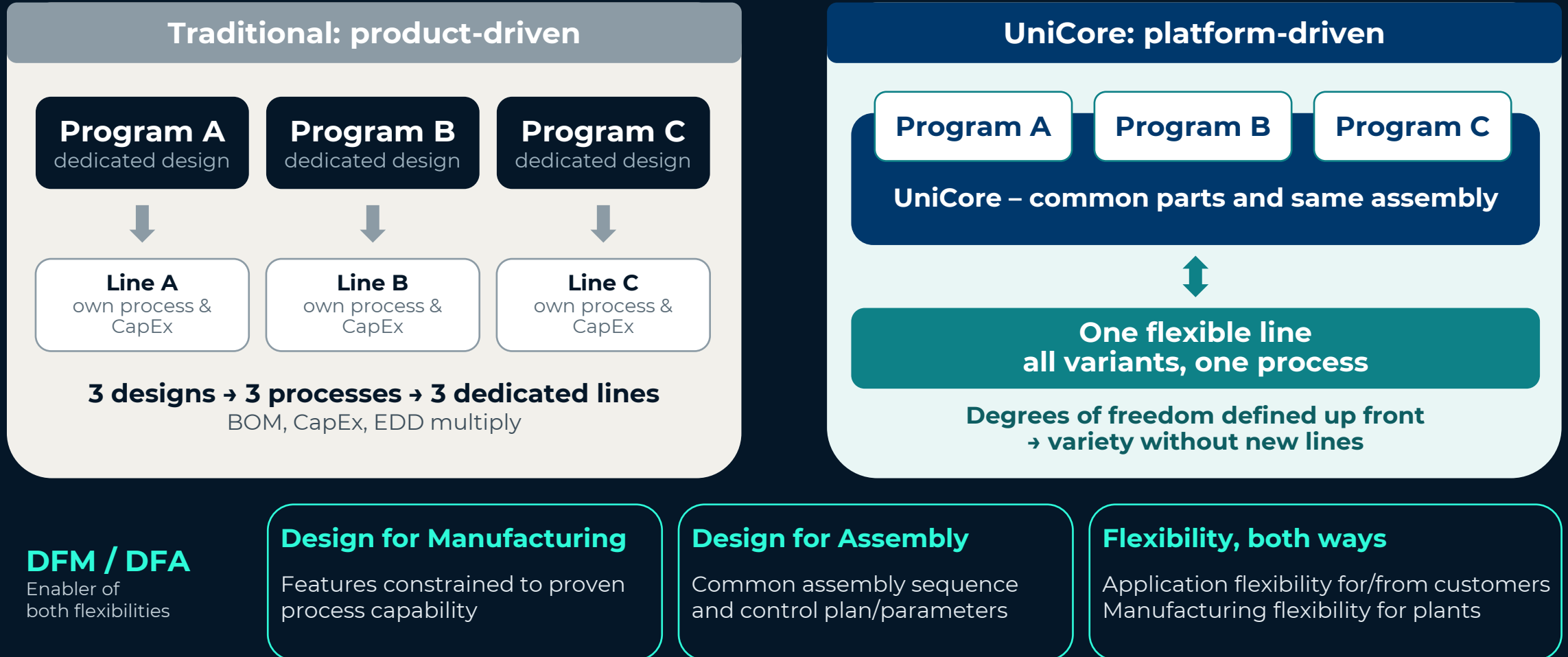
## Mfg. cost sensitivity to flex line capacity



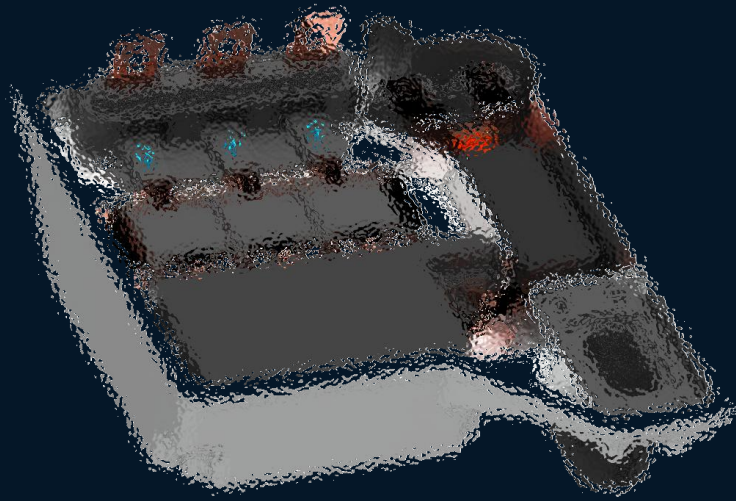
- ▶ Most Tier 1 opportunities are low-volume: single programs rarely reach the 150k/yr
- ▶ Mfg. cost is highly volume-sensitive –unit cost rises sharply as fixed line investment is spread over fewer parts.
- ▶ Bundling programs onto one line improves Economy of Scale to minimize Mfg. cost per unit
- ▶ **Implication:** competitiveness depends on designing the product and the line to be flexible across programs.

# UniCore Production vs. Traditional Production Approach

DFM/DFA links application flexibility to manufacturing flexibility



# GEN V Inverter | Efficiency, Cost, Size focus



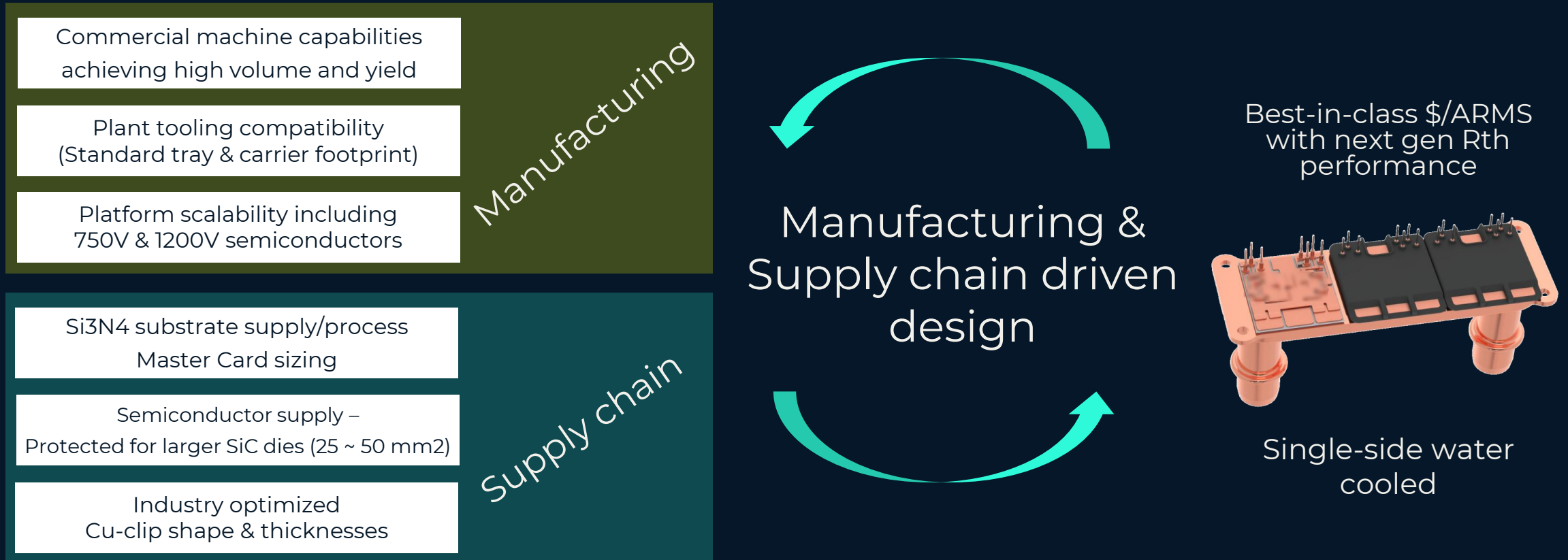
## Highlights

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- ▶ Ultra-low cost inverter platform (GEN V)
- ▶ SiC (WLTC > 99 %)
- ▶ Power cell loop inductance < 7.5 nH (@1 MHz)
- ▶ Ultra lean and compact EE architecture with digital inductive rotor position sensing
- ▶ Single-side cooled, high temperature compatible power module with ultra-low thermal resistance technology (\$/ARMS optimized)

# Single-side Cooled PM with next gen Rth performance

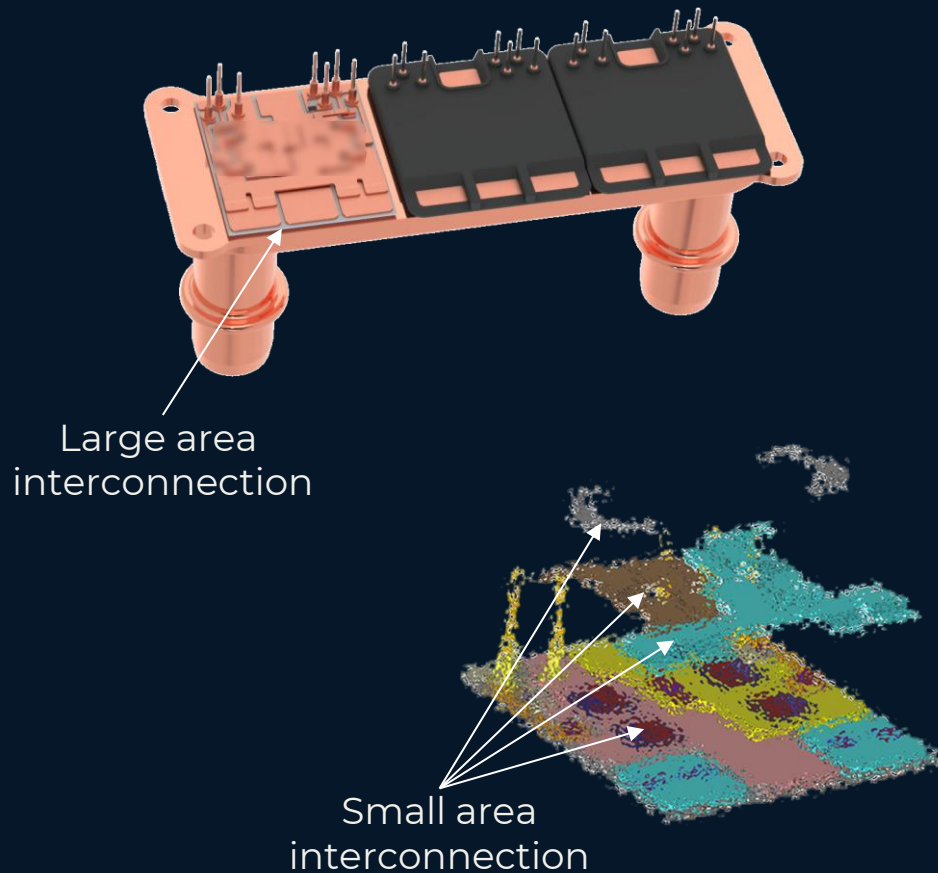
Manufacturing/Supply chain driven design targeting best-in-class \$/ARMS



Focus: Design towards theoretical minimum (# of parts, assembly and EoL steps)

# GEN V Power Module

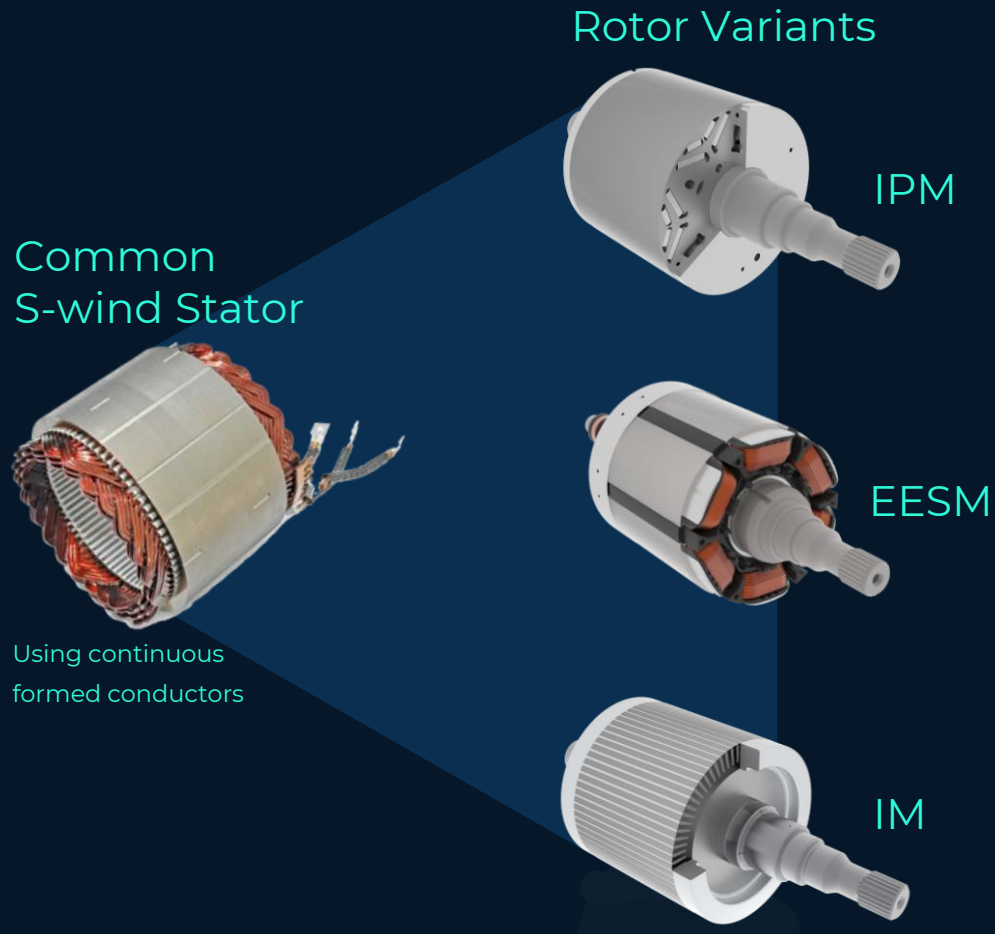
## Single-side cooled with All Copper stack-up ambition



### Selective power module concept development updates

- Power module:
  - Next generation power module concept combining single-side cooling, Cu-sintering and laser welding technologies
  - Designed to support increasing future die sizes, next generation SiC technology @ high temperature (>200degC)
  - Focus on manufacturing scalability, material efficiency, and high-volume production
  - Key technologies include small and large area Cu-sintering and laser welded interconnects
  - Enables a compact inverter platform capable of delivering up to ~700 ARMS (750 V) and ~500 ARMS (1200 V) with compact heatsink form factor to meet higher current density requirements

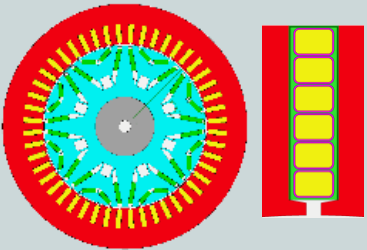
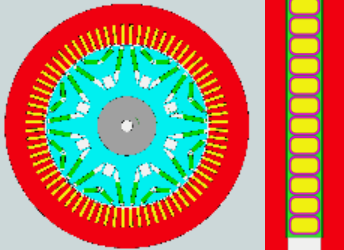
# eMotor | Modularity, Cost, Mfg. Cost focus



## Highlights

- ▶ Uniform iDM housing and rotor shaft design enables integration of **3 different rotor topologies** (IPM, EESM, and IM)
- ▶ Power scaling through stack length adjustment, with **common stator outer diameter**
- ▶ **S-Winding** for compact end turns, faster, and common conductor forming → lower cost
- ▶ **IPM and non-PM rotor** options for excellent supply chain security and flexibility
- ▶ EESM **wet brush** technology for high efficiency and high durability (allows for coaxial gearbox applications)

# Benefits of S-Winding Technology

| HVH                                                                               | S-Winding                                                                                                                    |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
|  | <br>Overall length can be reduced by ~10mm |
| 8p x 48slot                                                                       | 8p x 72slot                                                                                                                  |
| 6CPS                                                                              | 12CPS                                                                                                                        |
| Same Active Stack Height                                                          |                                                                                                                              |
| Exactly Same Rotor Design                                                         |                                                                                                                              |

**HVH: # of conductors and weld points**

| # of Slots | 4 CPS | 6 CPS | 8 CPS | 10 CPS | 12 CPS |
|------------|-------|-------|-------|--------|--------|
| 48         | 96    | 144   | 192   | 240    | 288    |
| 72         | 144   | 216   | 288   | 360    | 432    |
| 96         | 192   | 288   | 384   | 480    | 576    |

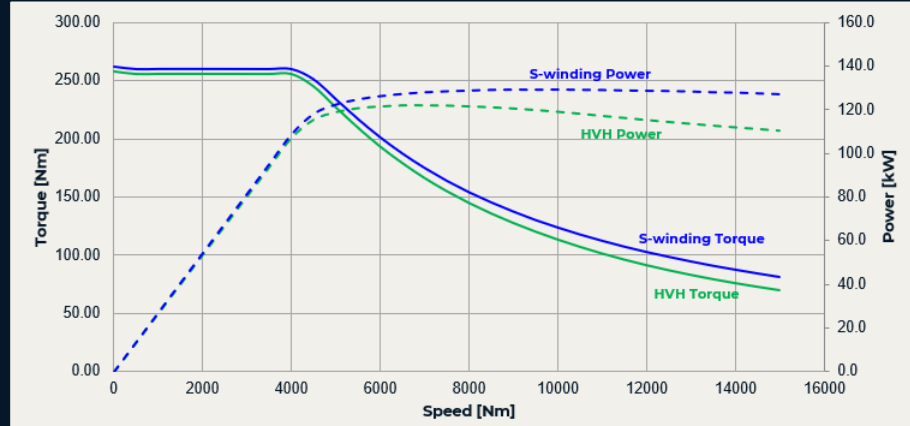
**SW: # of conductors**

| # of Slots | 4 CPS | 6 CPS | 8 CPS | 10 CPS | 12 CPS |
|------------|-------|-------|-------|--------|--------|
| 48         | 12    | 12    | 12    | 12     | 12     |
| 72         | 18    | 18    | 18    | 18     | 18     |
| 96         | 24    | 24    | 24    | 24     | 24     |

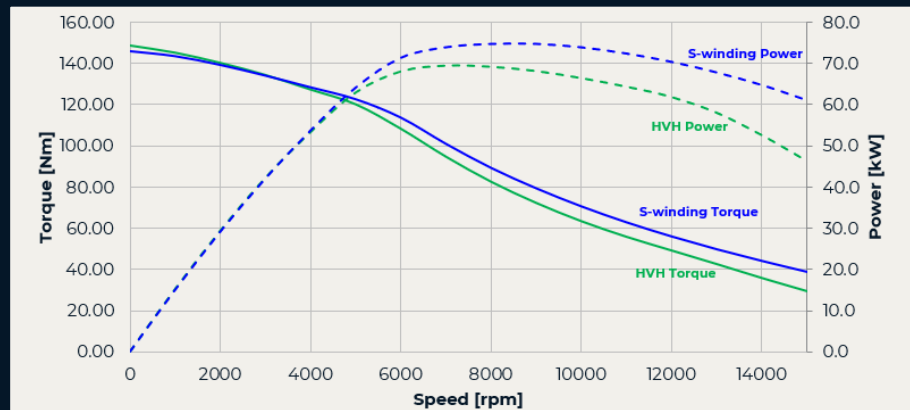
**Reduced length, # of conductors, and weld point for improved packaging and yield**

# Benefits of S-Winding Technology

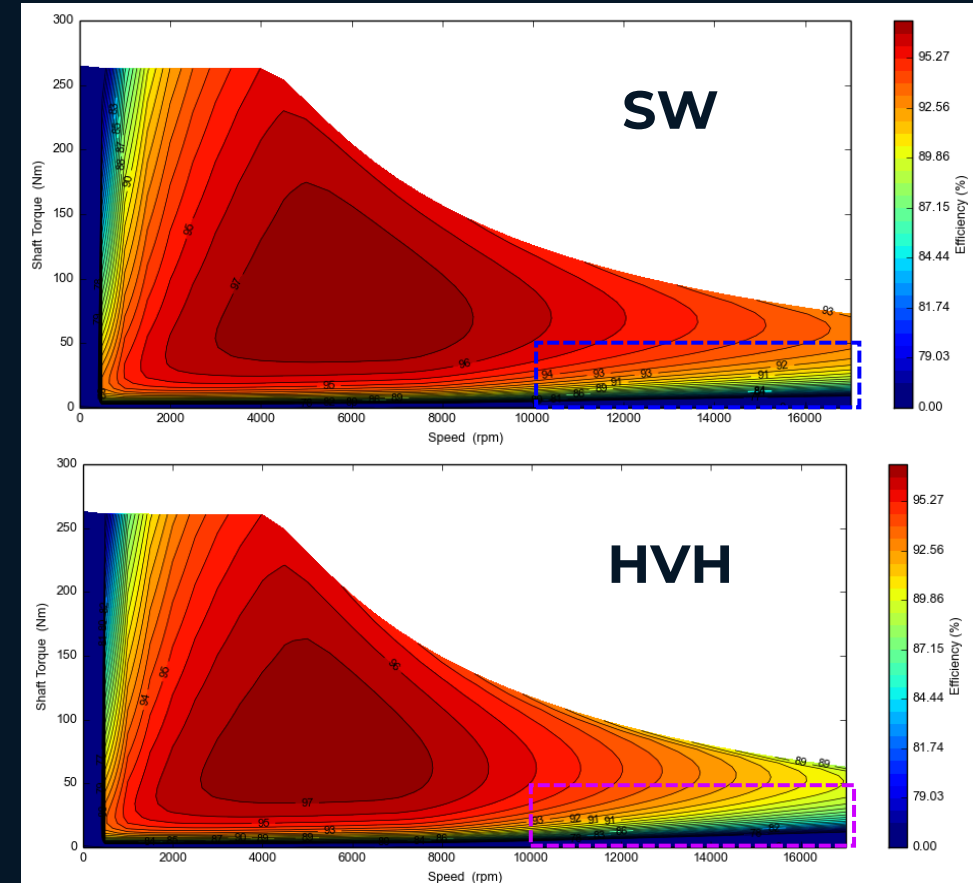
## 5% Higher Peak Perf. @ high-speed range



## 10~20% Higher Continuous Performance

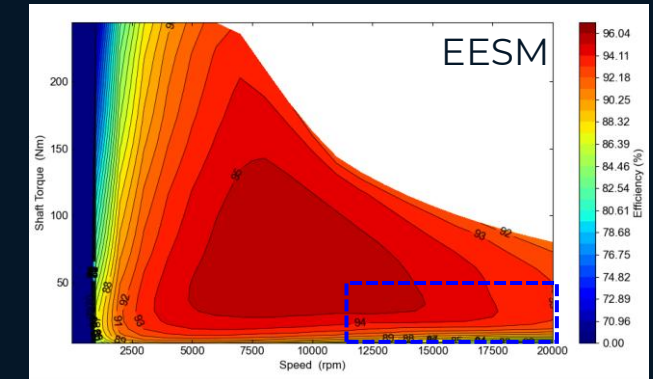
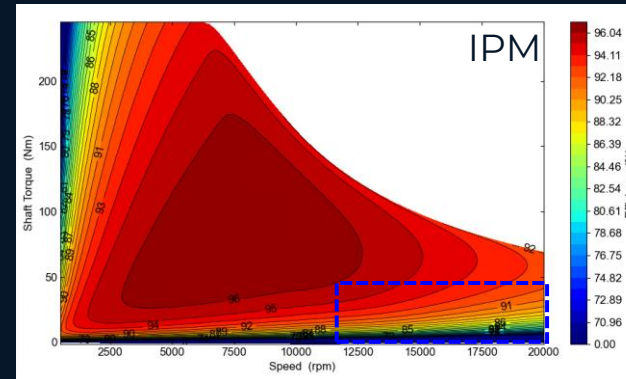
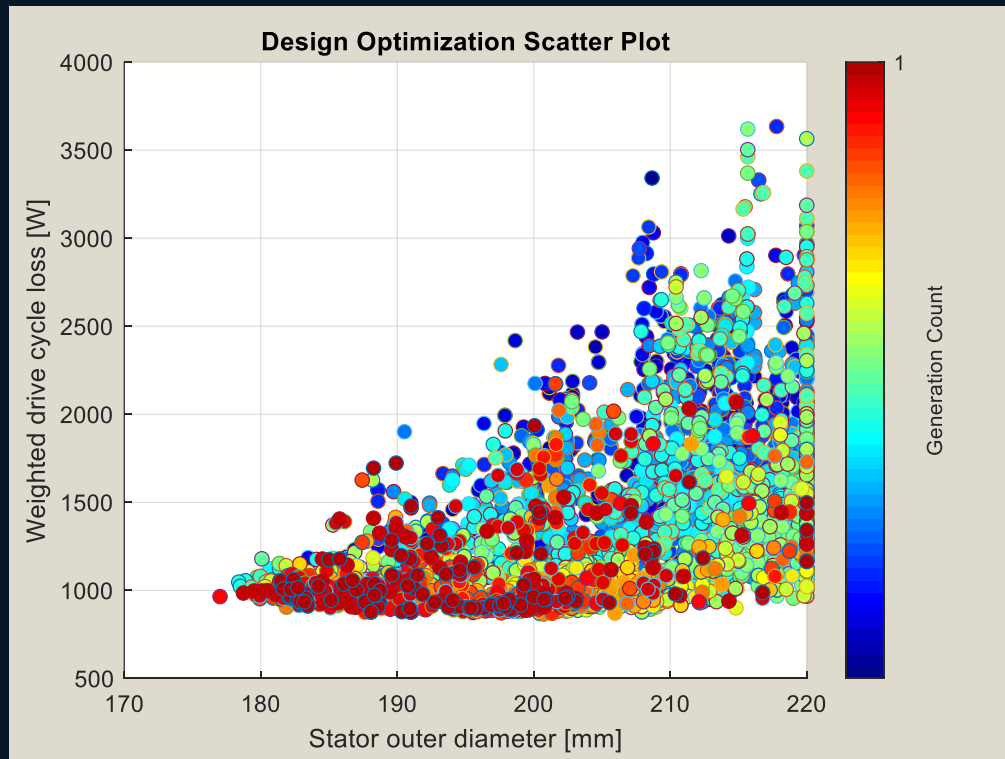


## Higher Efficiency @ high-speed range



Higher peak & continuous performance, efficiency at high-speed range

# Common Stator Optimization – IPM & EESM



- Stator size optimized for drive cycle loss
- IPM achieves ~0.5% higher drive cycle efficiency than EESM
- EESM achieves ~7% higher power at max speed than IPM
- EESM achieves ~2% higher constant speed efficiency (120kph)

**Two rotor technologies (IPM and EESM) achieving comparable efficiency and performance**

# Geartrain | Modularity, Cost, Reusability focus

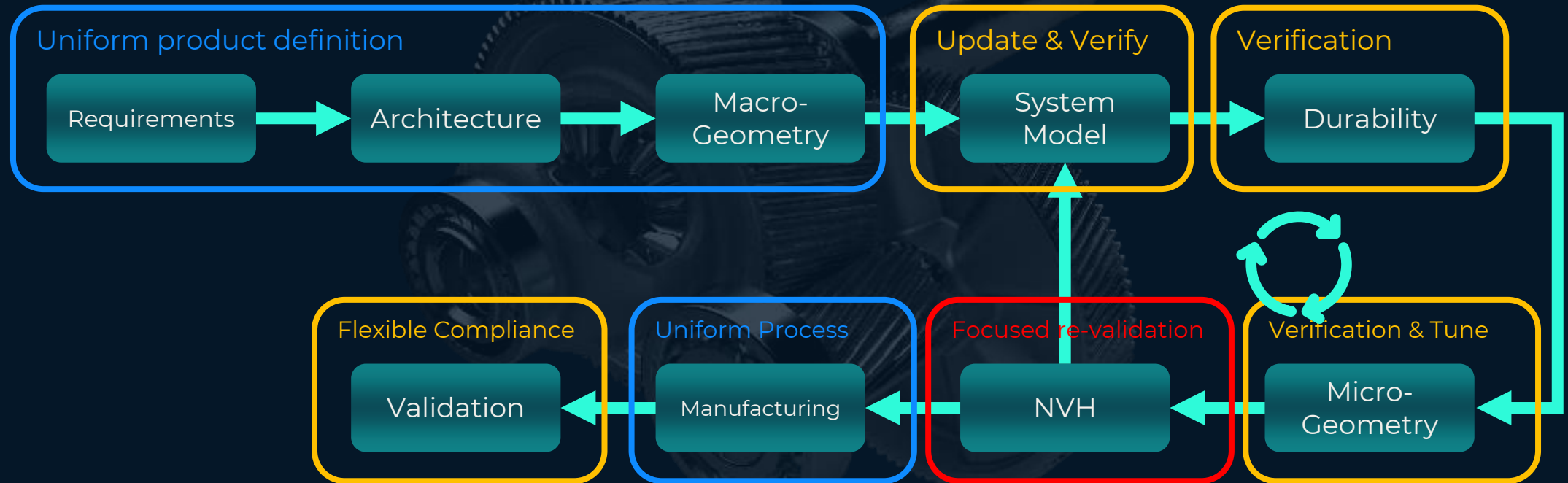


## Highlights

- ▶ **Flexible Layshaft** architecture enabling multiple gear ratios with a common shaft center distance (parallel layshaft and concentric layshaft)
- ▶ 3 Gear ratio portfolio: **11 ~ 14**
- ▶ Common gearbox package supporting **up to ~4000Nm** axle torque
- ▶ **Uniform center distance, bearing locations**, and interfaces across ratio variants
- ▶ Compact **welded differential housing** for packaging and mass optimization
- ▶ **Dry-sump lubrication** concept with targeted oil spray cooling
- ▶ Uniform platform approach reducing **Engineering Design & Development and manufacturing cost**

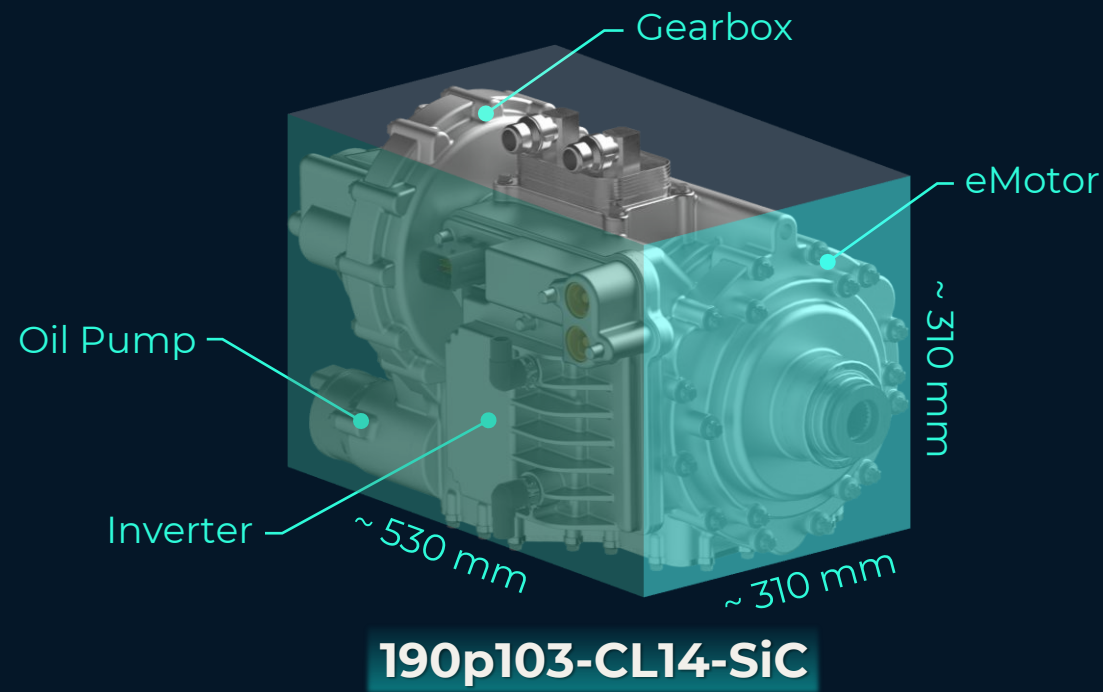
**Common Assembly Form-Factor & Simplified Engineering Development Effort**

# Adaptation geartrain design work - Reusability



**Design effort can be reduced significantly compared to dedicated design per application**

# UniCore iDM



## Degree of Freedom

- Gear Ratio: 3 options
- Geartrain: 2 types
- Rotor: 3 types
- Stack length: Variable (x)
- Semiconductor: 2 types

$3 \times 2 \times 3 \times (x) \times 2 =$

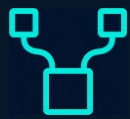
36x

Theoretical Configurations

|                      |                         |                            |
|----------------------|-------------------------|----------------------------|
| <b>Vehicle</b>       | Voltage <b>460</b> Vdc  | 300 ———— ◆ ———— 550        |
|                      | Power <b>150</b> kW     | 70 ———— ◆ ———— 170         |
|                      | Torque <b>3500</b> Nm   | 1700 ———— ◆ ———— 4100      |
|                      | Speed <b>1400</b> rpm   | 1300 —◆— 1700              |
| <b>GenV Inverter</b> | Current <b>400</b> Arms | 200 ———— ◆ ———— 400        |
|                      | Semiconductor           | <b>SiC</b>                 |
|                      |                         | Si                         |
| <b>eMotor</b>        | Power <b>150</b> kW     | 80 ———— ◆ ———— 170         |
|                      | Torque <b>250</b> Nm    | 150 ———— ◆ ———— 290        |
|                      | Stator OD               | <b>190 mm (S-wind)</b>     |
|                      | Length <b>103</b> mm    | 90 ———— ◆ ———— 110         |
|                      | Rotor Types             | EESM                       |
|                      |                         | <b>IPM</b>                 |
|                      |                         | IM                         |
| <b>Geartrain</b>     | Ratio <b>14.6</b>       | 11.6 ———— ◆ ———— 14.6      |
|                      | Layout Type             | <b>Concentric Layshaft</b> |
|                      |                         | Parallel Layshaft          |

# Innovating BorgWarner UniCore iDM

Affordable propulsion to accelerate BEV adoption without performance sacrifices



## Uniform platform for mass-market BEVs

Common motor and geartrain interfaces support multiple vehicle needs and reduce redesign.



## Efficiency and cost designed together

Gen V SiC inverter, S-winding motor and reusable geartrain target compact, efficient drives.



## Manufacturing scale with supply flexibility

Shared processes combine program volumes; rotor and semiconductor options strengthen supply resilience.

## What's Next

Mission profile  
base safety  
factor

Adv. Housing  
material

Polymer lube  
circuit module

Twin pump

Digitalized E/E  
architecture

X-in-1

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