

Machine learning meets set-based design: overcoming complexity and accelerating efficiency in powertrain design

Freddie Mehta, Senior Solutions Manager at Secondmind

Who we are

Headquartered in Cambridge, England with offices in Yokohama, Japan and Detroit, USA.

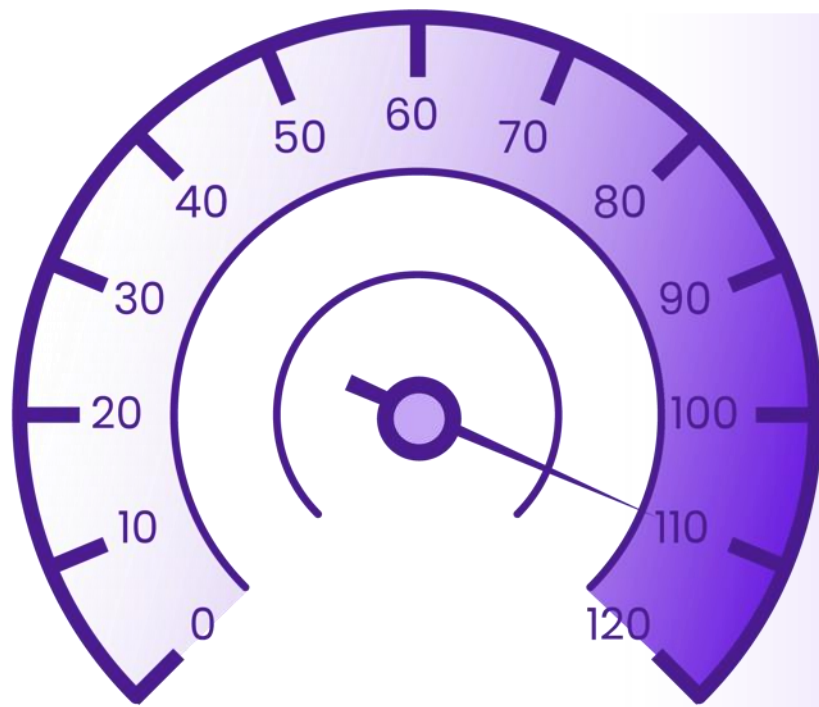
Diverse team with decades of multi-market experience in AI and commercial software development.

World-renowned, award-winning machine learning research and development.

Automotive subject matter expertise across the company



Chinese car makers like BYD are resetting the bar in automotive...

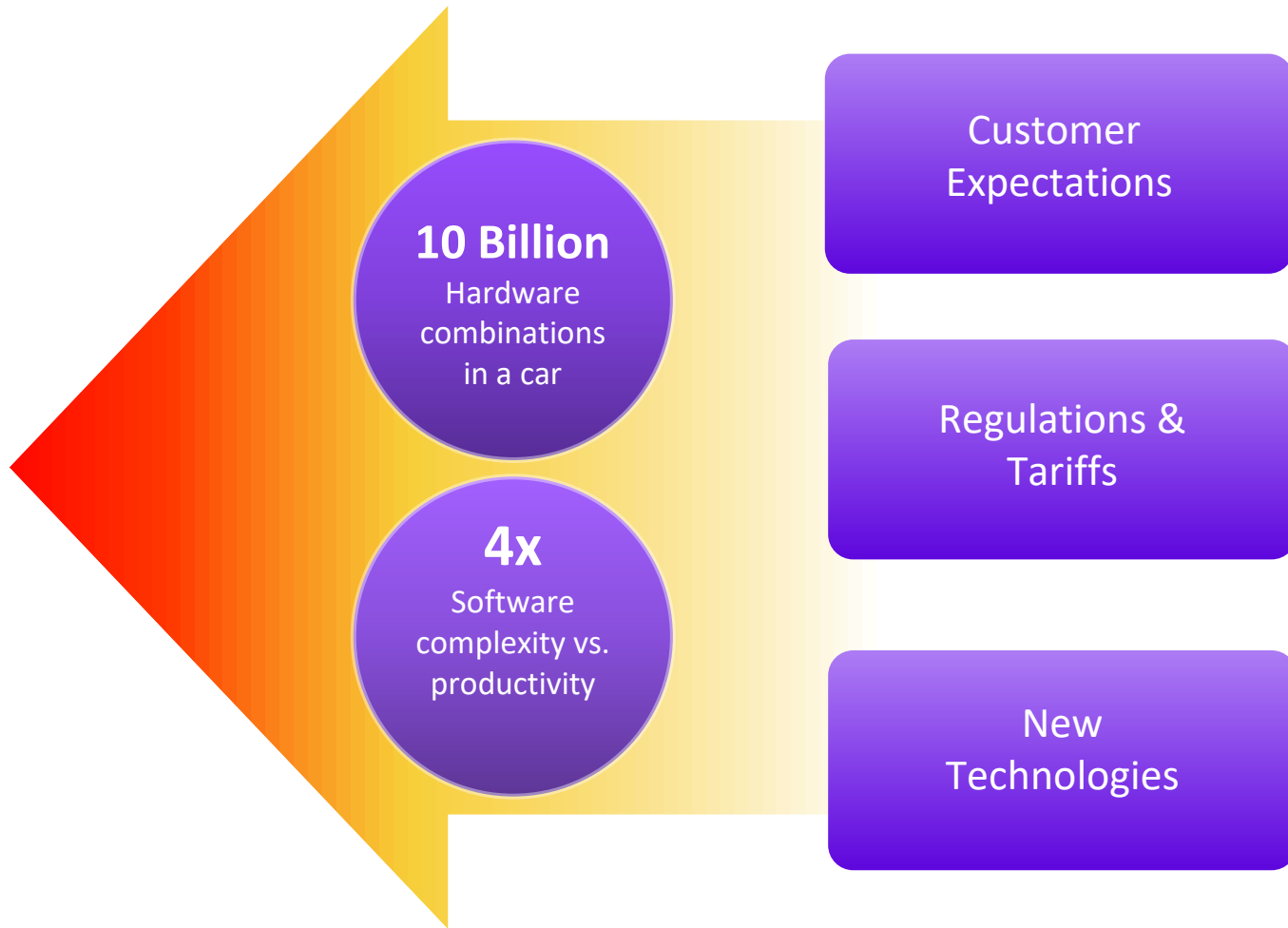


Time-to-market
2 yrs
(others at 4+)

40%
lower costs

Higher quality design &
production

...while the rest of the industry is held back.



“Automotive complexity
has gone from
the *unmanageable*
to the *unimaginable*.”

Oliver Wyman

Secondmind breaks through complexity barriers
to cut time-to-market and reduce development costs
without compromising quality

System Design

50%+

less time to discover
better designs with fewer
simulations

Calibration

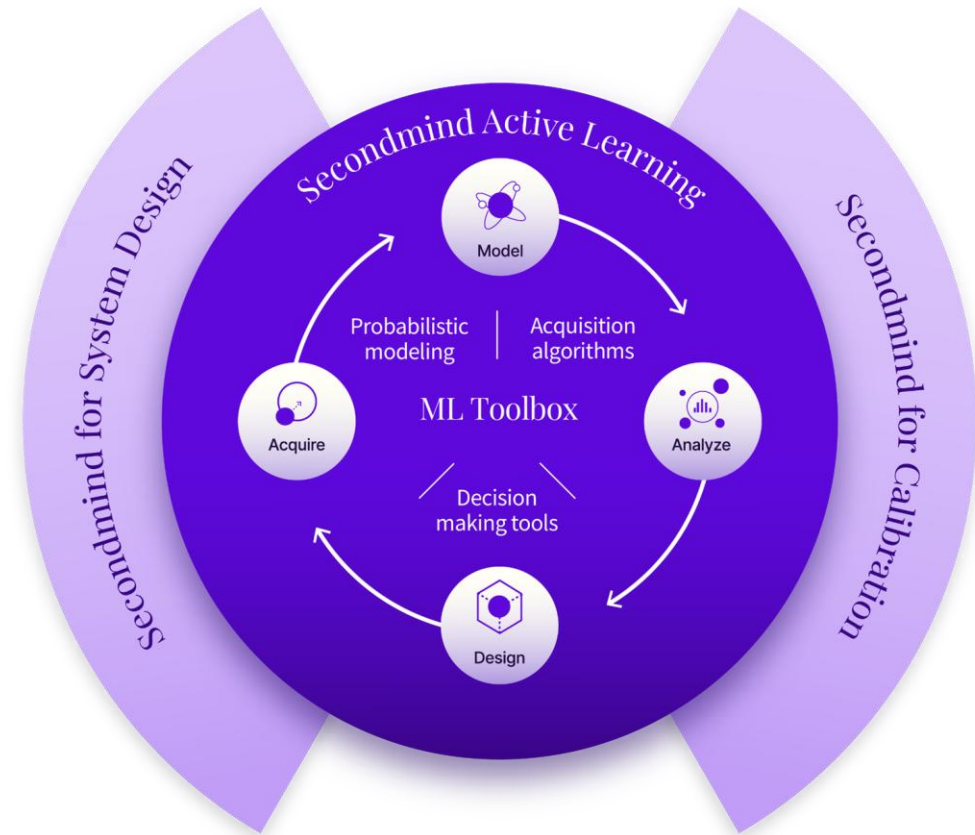
50–80%

less time to calibrate
system performance with
fewer prototypes

Secondmind Active Learning

The advanced AI system that does more with less data

- ✓ **Intelligent, automated experiments**
+ First & only in the market
- ✓ **Best-in-class models**
+ ...that learn
- ✓ **Transparent**
+ Not black box AI
- ✓ **Pioneering data-efficient AI**
+ 80% less data = less time & materials

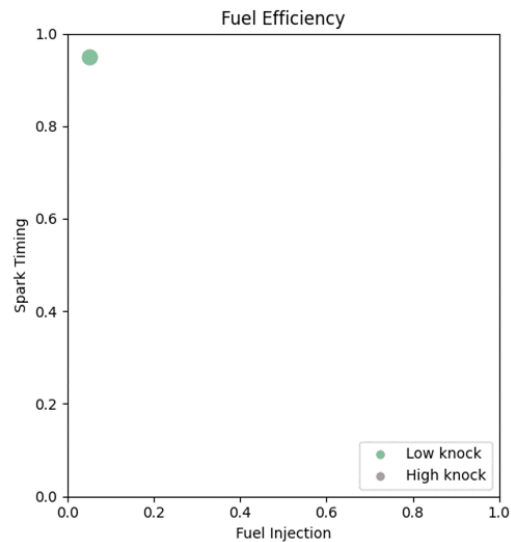


Secondmind Active Learning vs traditional processes

Intelligent, automated Design of Experiments

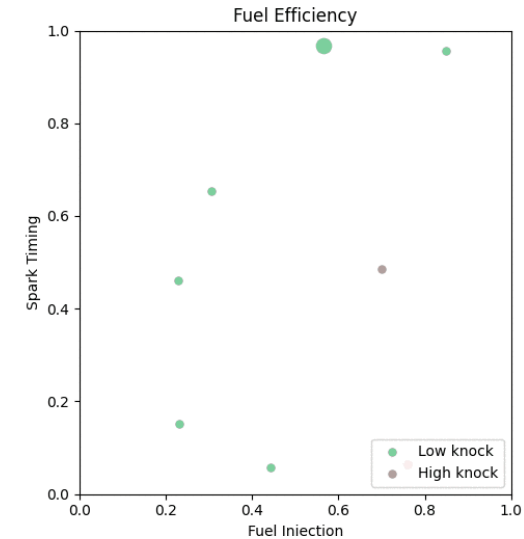
Traditional Design of Experiments Process

Systems with multi-dimensional control parameters require lots of experiments.

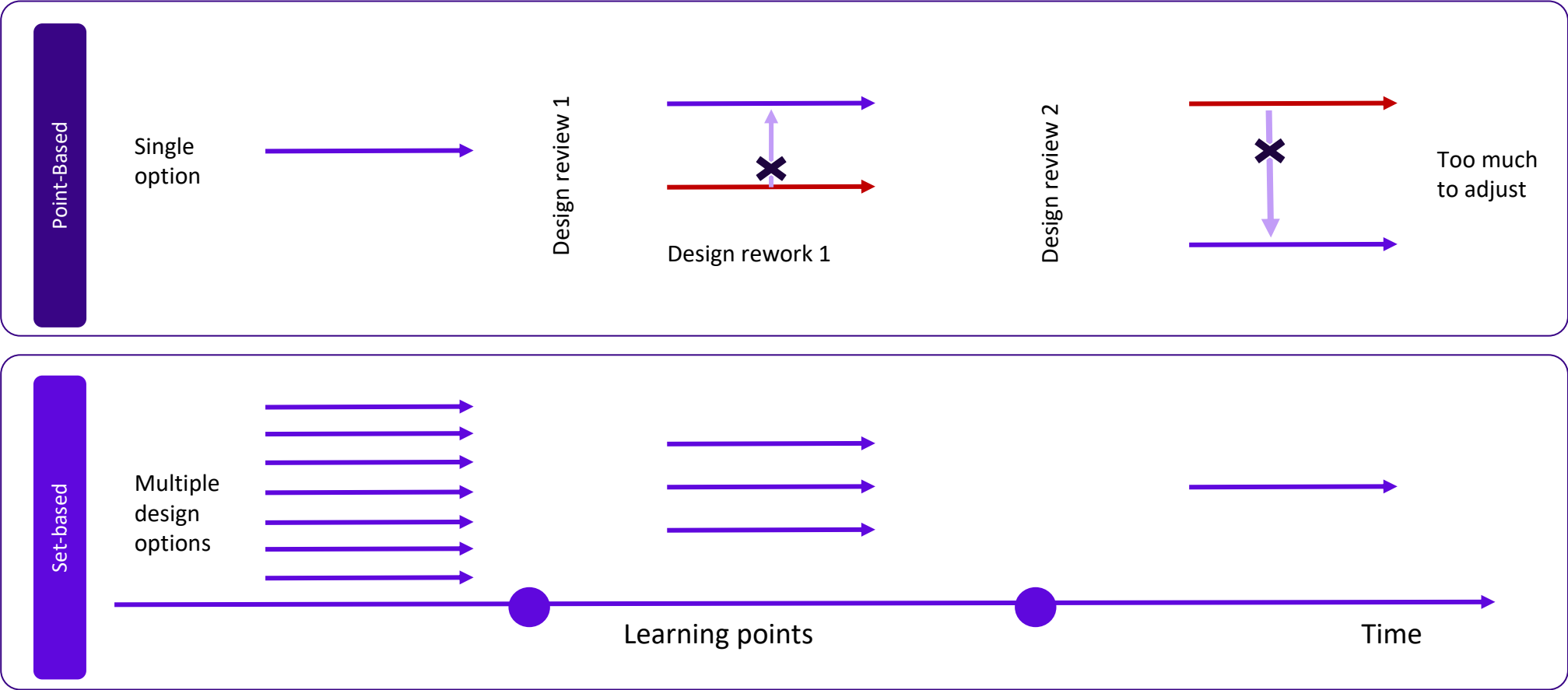


With Secondmind

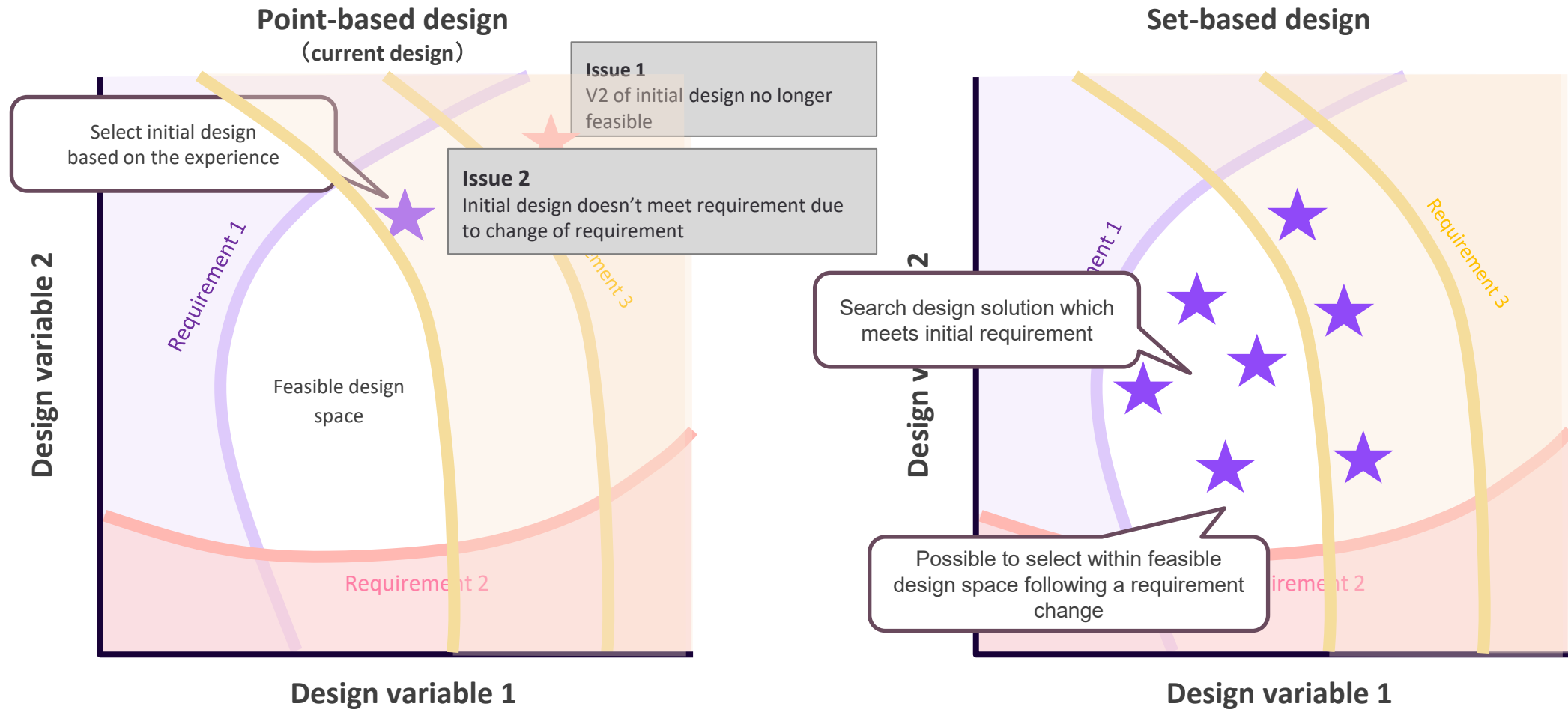
Active Learning dynamically explores necessary control parameter space.



Point-based vs set-based design



Avoiding rework with set-based design



Use case: EV concept design

EV concept design for D segment SUV

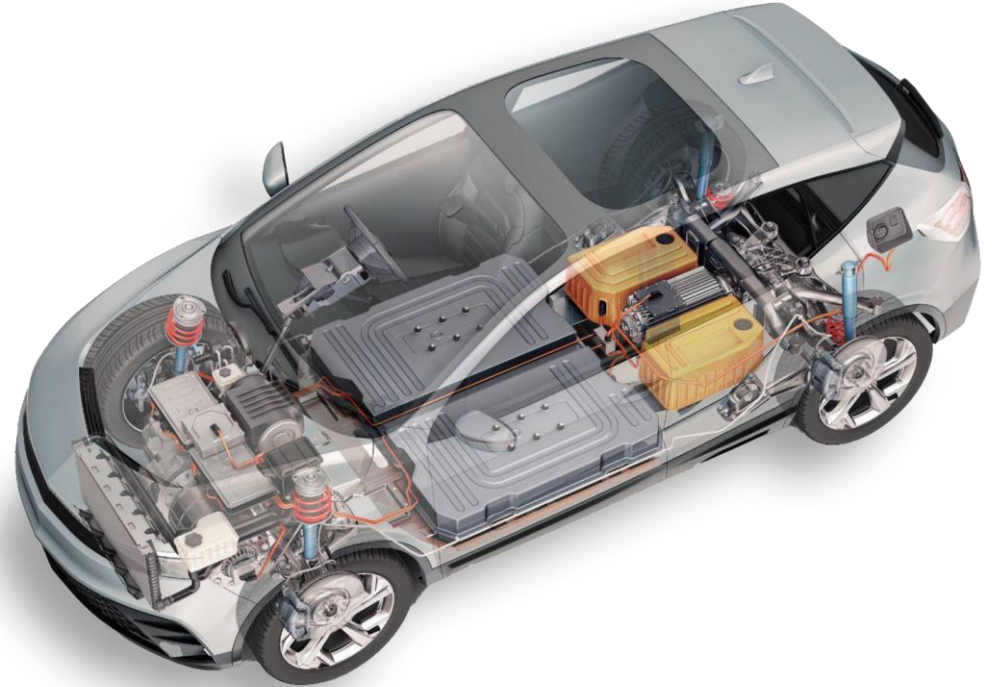
Objective

Select the best electric powertrain from several candidates

Approach

Use Secondmind for System Design to apply a set-based design approach to assess the candidates:

- + Which candidate keeps the best set of designs options (feasible space) available for the rest of the design process?



①

Define



②

Active Learning



③

Exploration



④

Decision

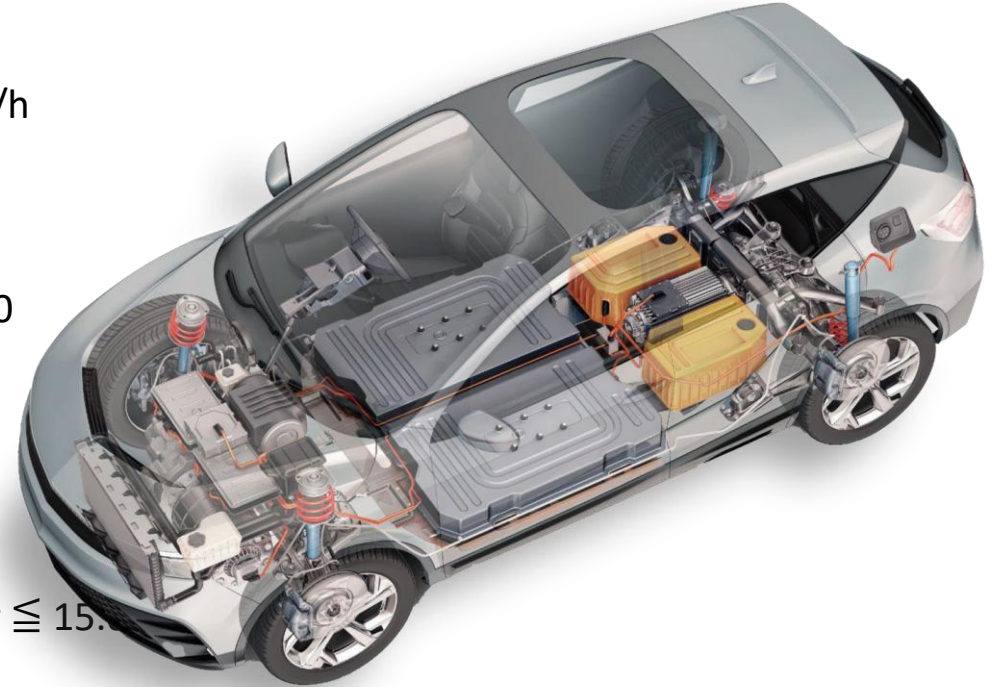
① Define the feasible design space

'Feasible' - Required performance/attributes

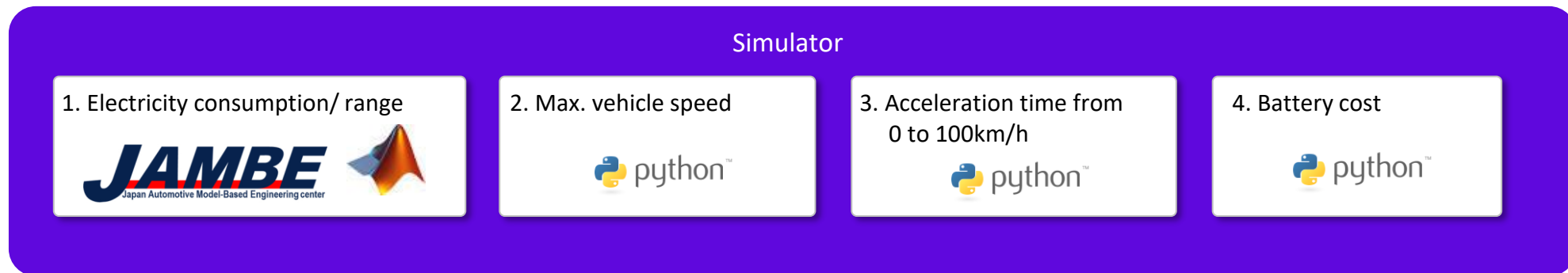
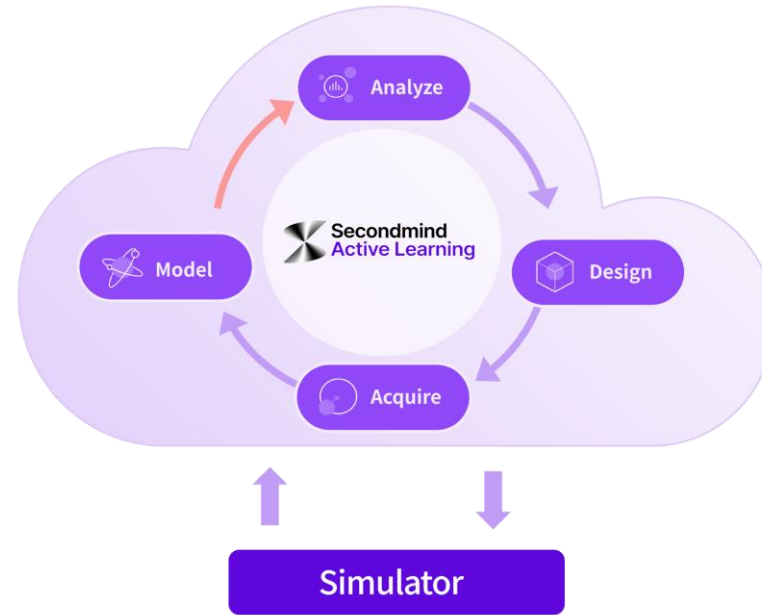
- + Max. vehicle speed $\geq 180\text{km/h}$
- + Acceleration time from 0 to 100km/h $\leq 7.3\text{sec}$
- + Range per charge $\geq 490\text{km}$
- + Electricity consumption (WLTC) $\leq 164\text{Wh/km}$
- + Battery cost $\leq \$11,000$

'Design space' - Design Variables

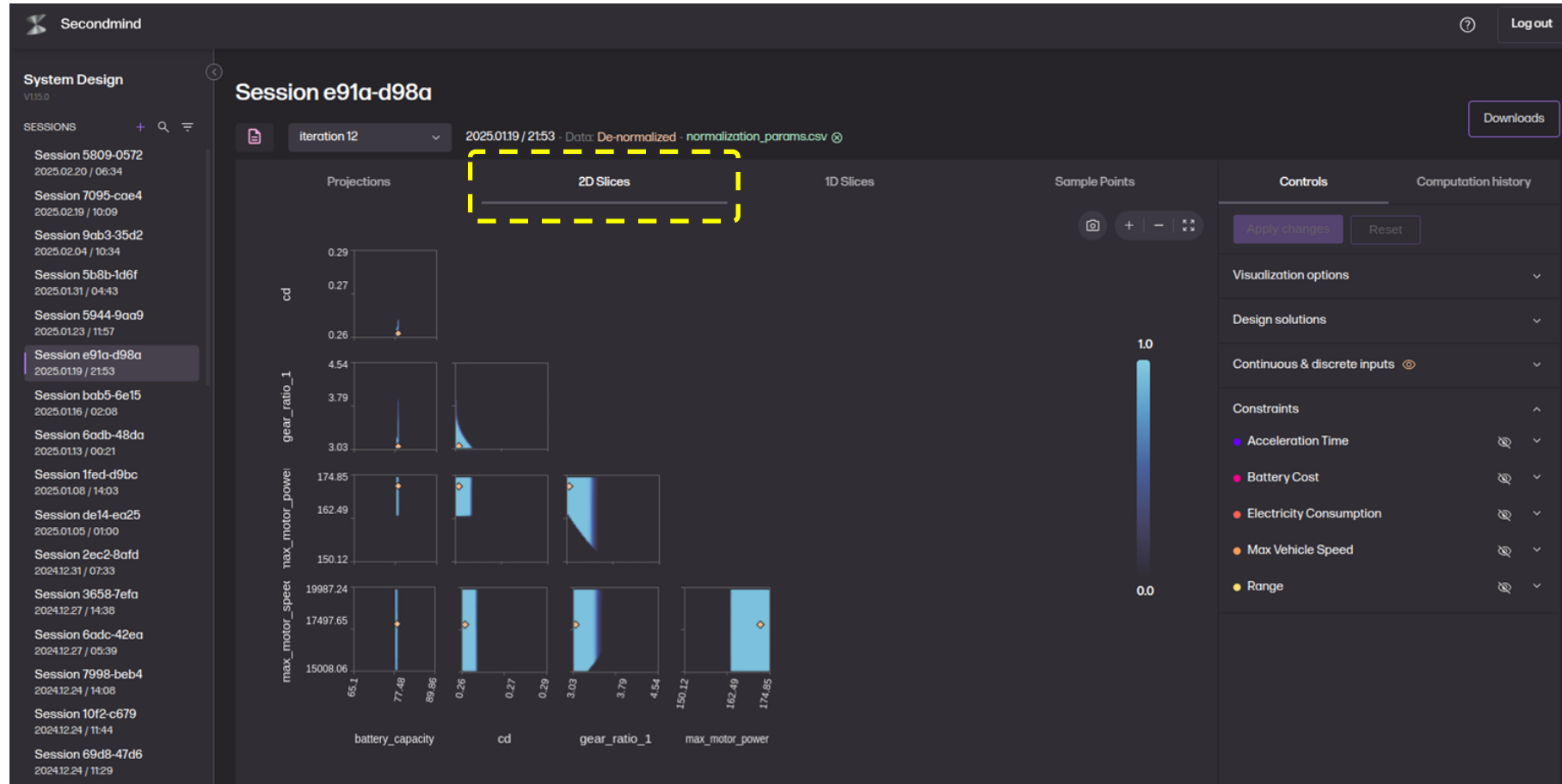
- + CD value (drag coefficient) $0.26 \leq C_d \leq 0.29$
- + Total gear ratio $10.0 \leq Gr \leq 15.0$
- + Battery volume(kWh) $65.0 \leq B_v \leq 90.0$
- + Max motor speed(rpm) $15,000 \leq R_m \leq 20,000$
- + Max motor power(kW) $150 \leq P_m \leq 175$



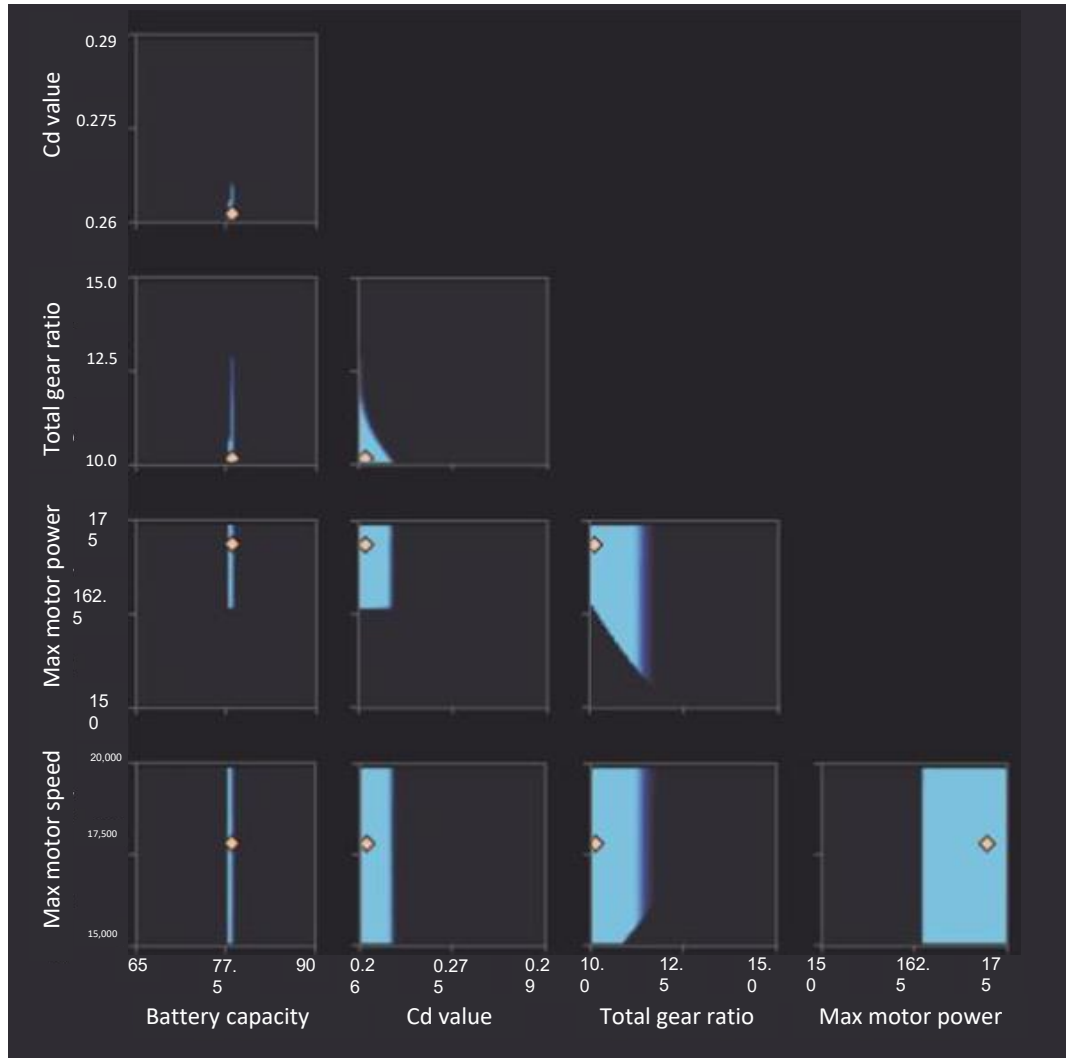
② Secondmind Active Learning



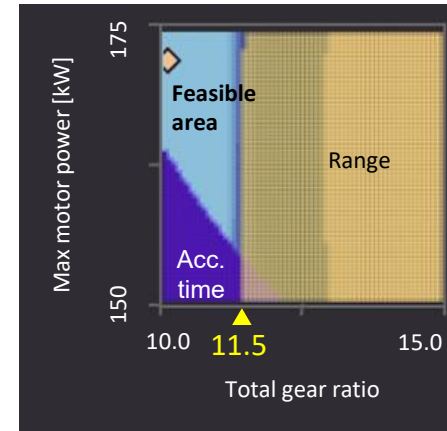
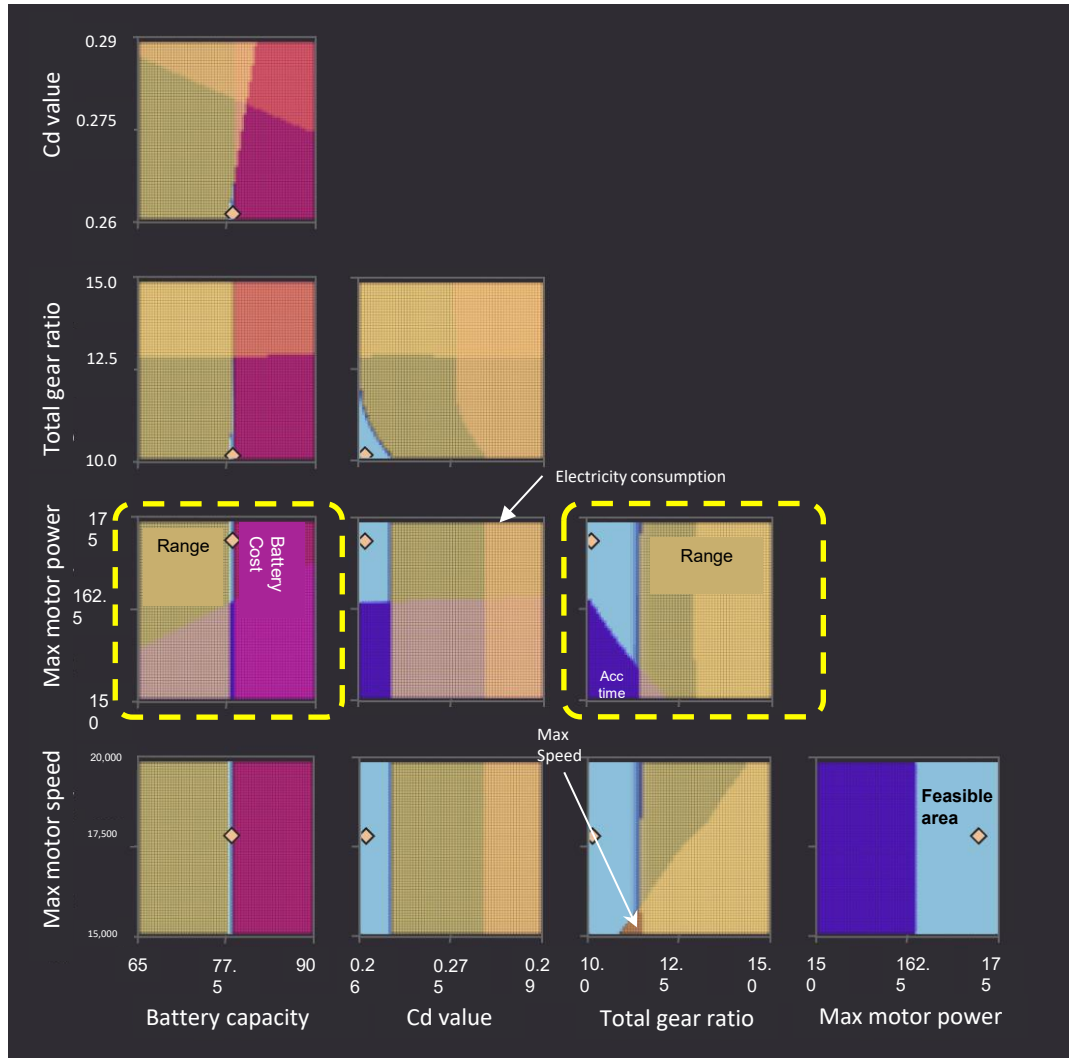
③ Explore the feasible space with 2d slice plots



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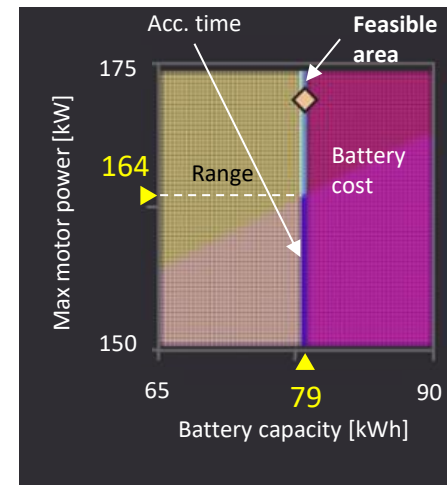
③ Explore the feasible space with 2d slice plots



Total gear ratio < 11.5

Battery capacity = 79 kWh

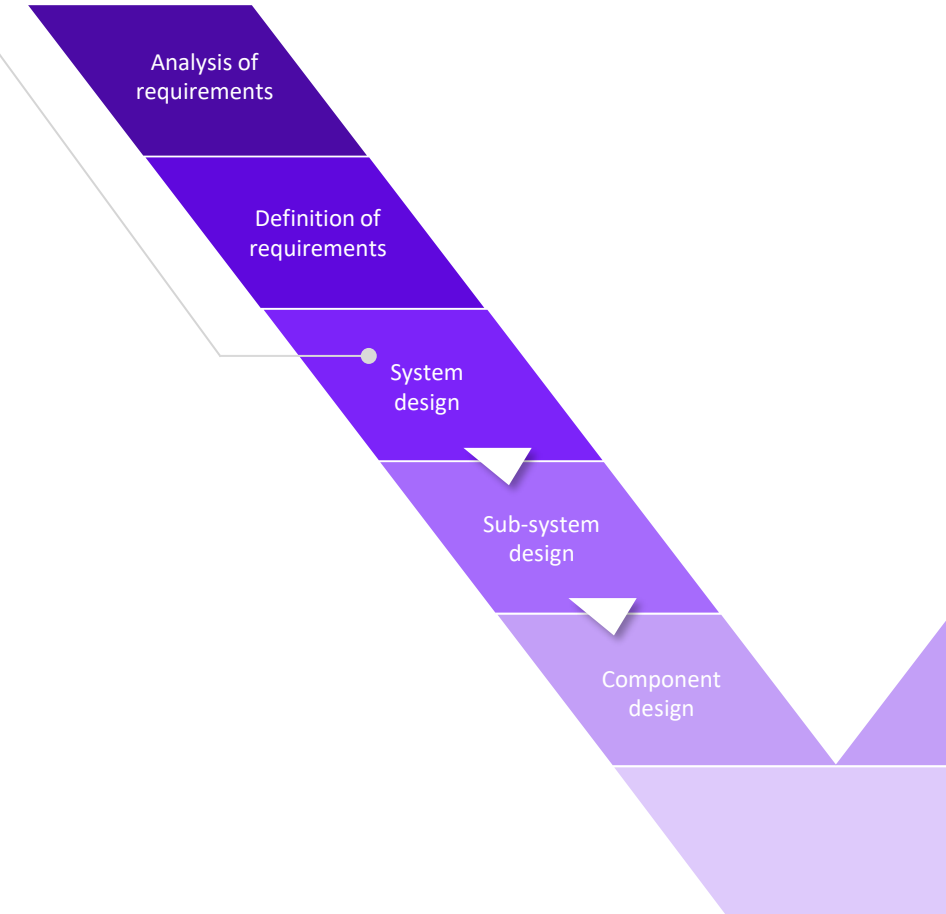
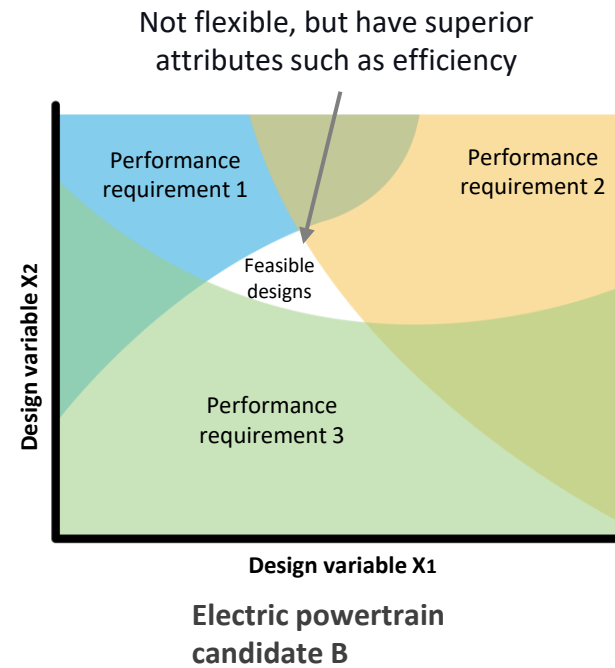
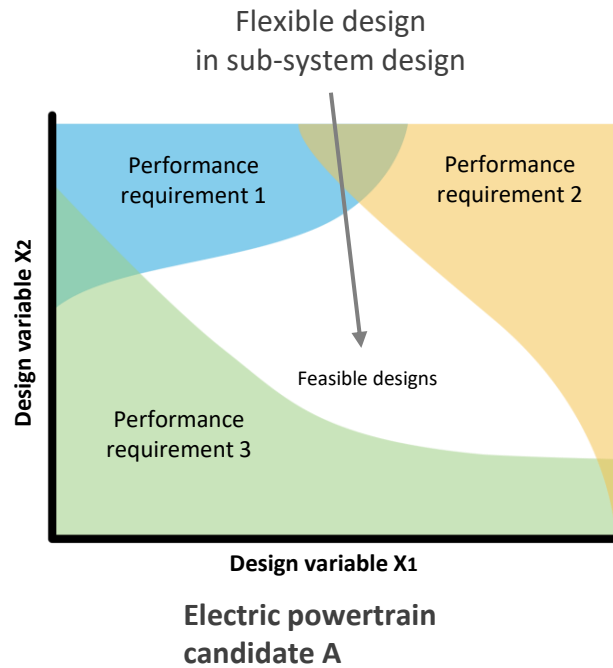
Max motor power > 164 kW



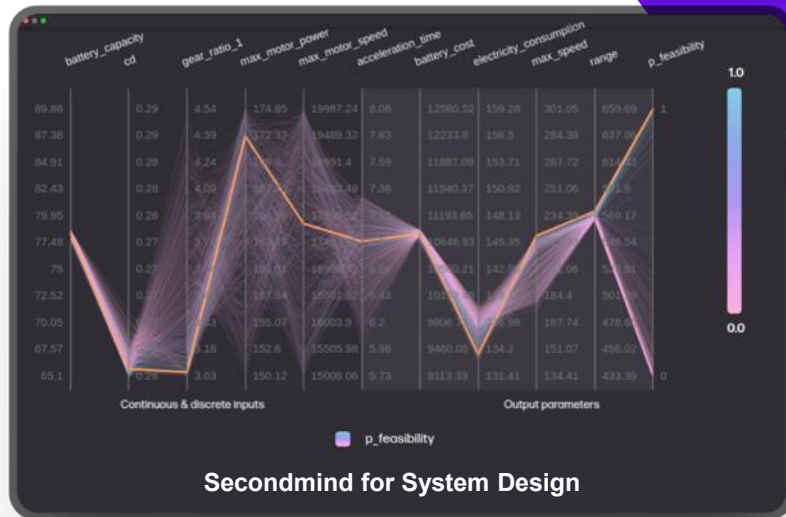
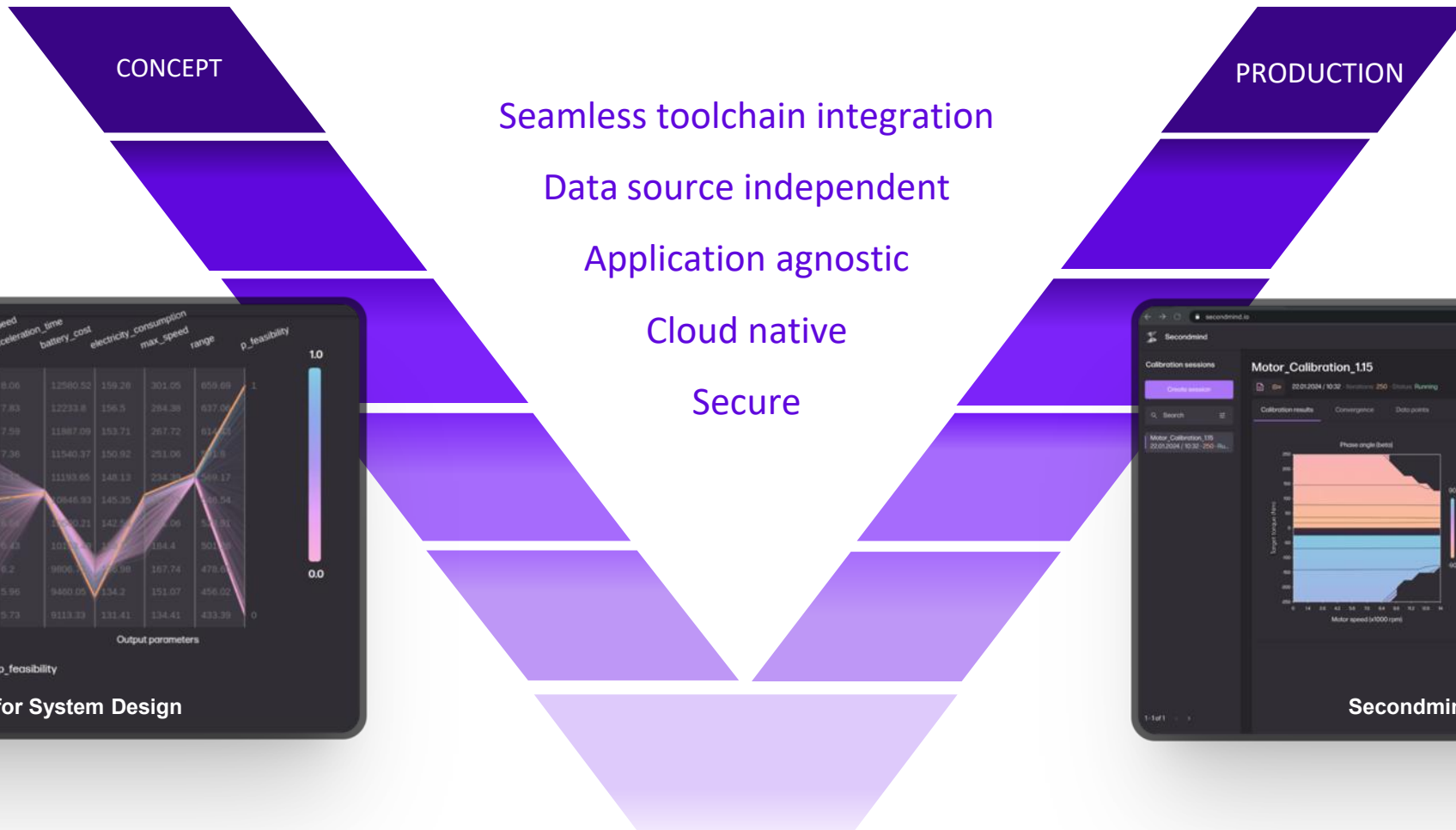
④ Make decisions

Choose the electric powertrain based on the studies

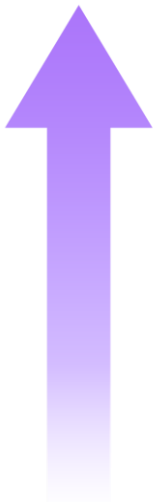
- + Select the candidate which has more flexible design in sub-system
- + Select the candidate with overwhelmingly attractive attributes



Secondmind is the only AI system for model-based engineering delivering value across the V-development process where complexity is exceptional



Discover more



Simulate less



Thank you. Any questions?

Want to learn more?

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Senior Solutions Manager

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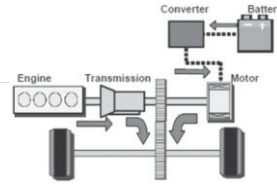
Download
our white paper



Our Impact on System Design

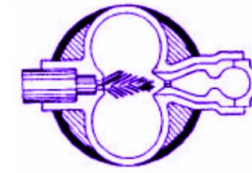
Powertrain Architecture concept design

- + Select the best electric powertrain from several candidates to fulfil architecture requirements
- + **80% reduction** in the number of simulations; enabled exploration of more innovative designs



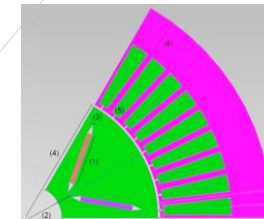
Combustion Chamber design optimization

- + Explored **3.5X** more designs in **50% less time** spent on expensive CFD analysis
- + Found design combinations previously **undiscovered**
- + **Exceeded** Fuel Economy (**BSFC**) target while adhering to emissions thresholds



Electric Motor design

- + Utilising existing Structural FEA and EMAG CAE tools to reduce the number of simulations required by **81% (3k vs 16k runs)**
- + Reduction in Rare-Earth magnet volume while meeting targets
- + Inspire new design direction



REQUIREMENTS
ANALYSIS

REQUIREMENTS
DEFINITION

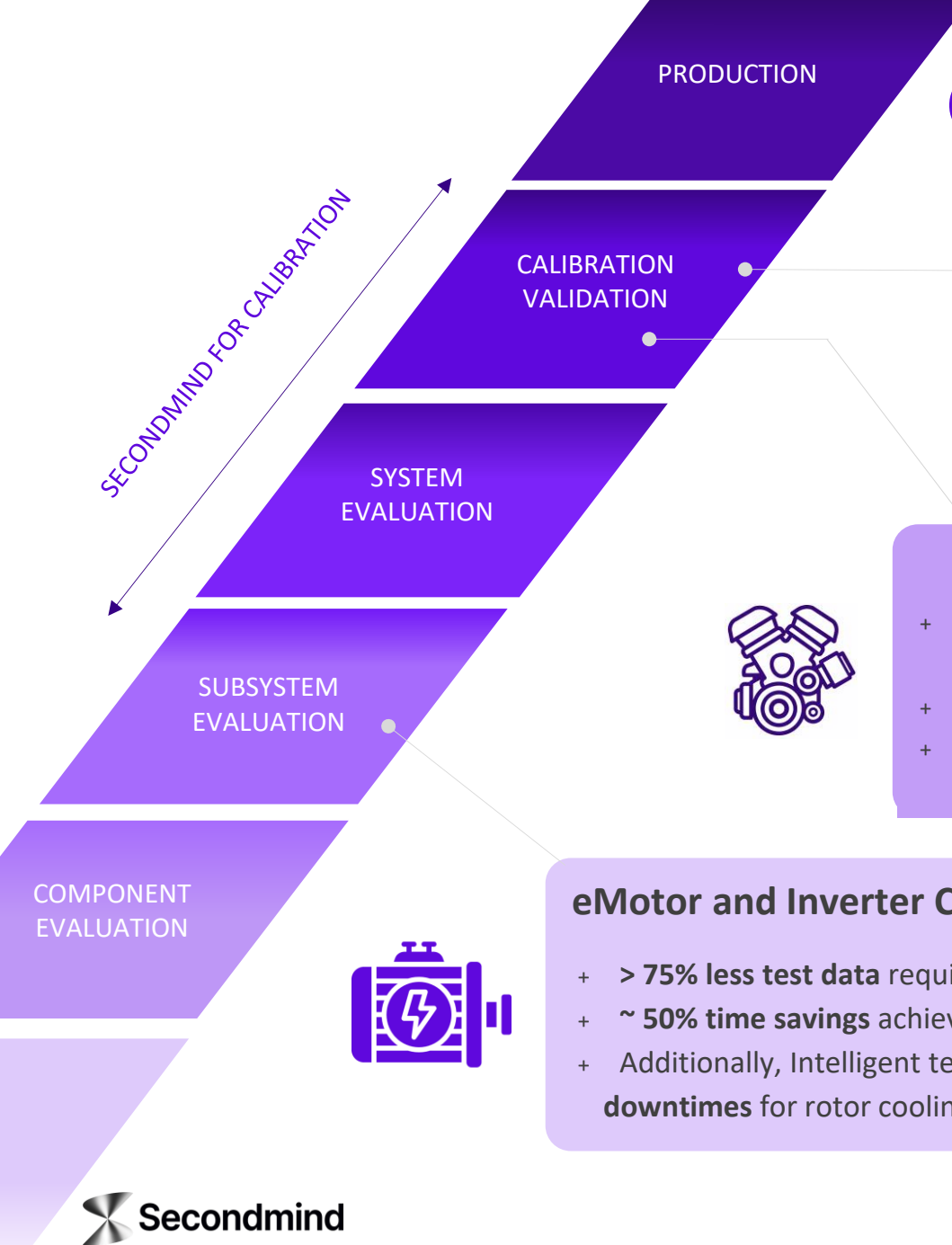
SYSTEM DESIGN

SUBSYSTEM
DESIGN

COMPONENT
DESIGN

SECONDMIND FOR SYSTEM DESIGN

Our Impact on Calibration Optimization



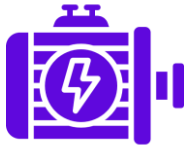
Heavy Duty Diesel Engine Calibration

- + **Simultaneous** optimization of **6 to 10 variables** to minimise BSFC and meet emission thresholds
- + **73% fewer test** points to achieve optimised maps
- + Could not be improved with subsequent manual tuning



Petrol Engine Calibration Optimization

- + Time & Data heavy petrol engine calibration with poor model accuracy with existing tool-set (noise & complexity)
- + Intelligent data gathering led to **50% fewer data** points reqd.
- + 1/5 reduction in engine **prototype requirements** and **35% lower specialist resource** requirements

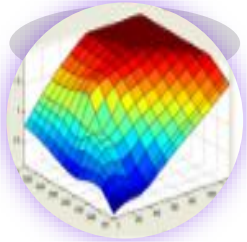


eMotor and Inverter Calibration

- + **> 75% less test data** required to reach optimum calibration
- + **~ 50% time savings** achieved to reach profile optimum
- + Additionally, Intelligent temperature control algorithm **minimised downtimes** for rotor cooling

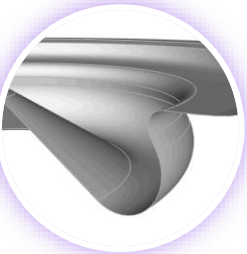
Applications of Secondmind tools range from 1d modelling & CFD to thermal system management & calibration

Complex simulation, design or calibration processes can be enhanced using Secondmind



Powertrain Calibration

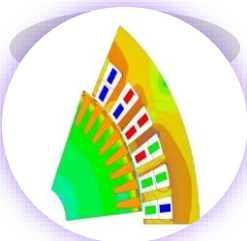
Intelligently select most apt points to run & reduce PT Calibration resource & dyno usage by ~ 45% to 70%



Complex System Design Exploration

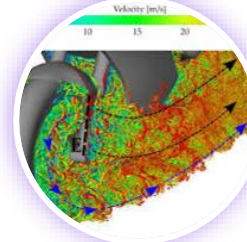
(eg Combustion Chamber, radiator / cooler, sizing components)

Generate greater number of valid, feasible designs to achieve targets and attribute trade-offs faster



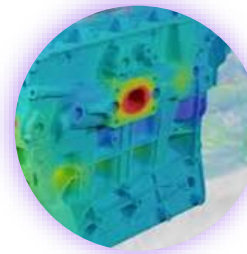
Hybrid & Emotor -Design Optimization

Optimise your e-Motor across various aspects i.e. magnetic performance, structural & thermal stability



Multidisciplinary Design & Optimization

Work across multiple simulators and significantly cut development times while obtaining more feasible designs



Chassis structure design space exploration

Complex interaction between Various forces, loads & other systems such as tires & Suspension.



Total Powertrain Optimization

Optimize system sizing, selection and layout for maximum performance and reliability across concept to calibration