



Journey to 100% Virtual: Vision, Challenges and Expectations



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100% Virtual Vision

Why 100% Virtual?



Speed – get to market faster



Quality – better engineering



Throughput – engineer more products for same money



What is 100% Virtual?



The first vehicle is good enough to sell



We don't learn with hardware as part of our vehicle development process – no prototypes



Driving rigorous engineering up front; everything we do today physically is in scope

Key Aspects

- Move away from correlation to a physical test and toward focus on customer impact.
- New virtual capability needs to be deployed on the critical development path.
- Use hardware to confirm and validate – not find unknowns. How might we find unknowns virtually?

Simulation Tools for a 100% Virtual Process

What Must be True

- **Faster Turnaround of Results**

- Respond at the speed of the design.

Example: overnight results for a full suite of ride and loads events.



- **Robust Solver**

- Models need to run reliably every time.

Allow engineers to focus on physical principles and results analysis.



- **Real Time (RT) Capability**

- Run higher fidelity models in RT without conversions.

Additional efficiency for CAE + expanded capabilities needed for DiL work



- **Lower Entry Barrier**

- More user-friendly interface to allow onboarding non-CAE experts, bringing the 100% virtual vision to its full form.





GM Simulation User Base

Vehicle Dynamics Related Disciplines



Close to **100 direct MBD users in VDDV** currently between Vehicle Dynamics, Loads & N&V



Retirements, regular career moves and organizational changes mean new people using the tools.

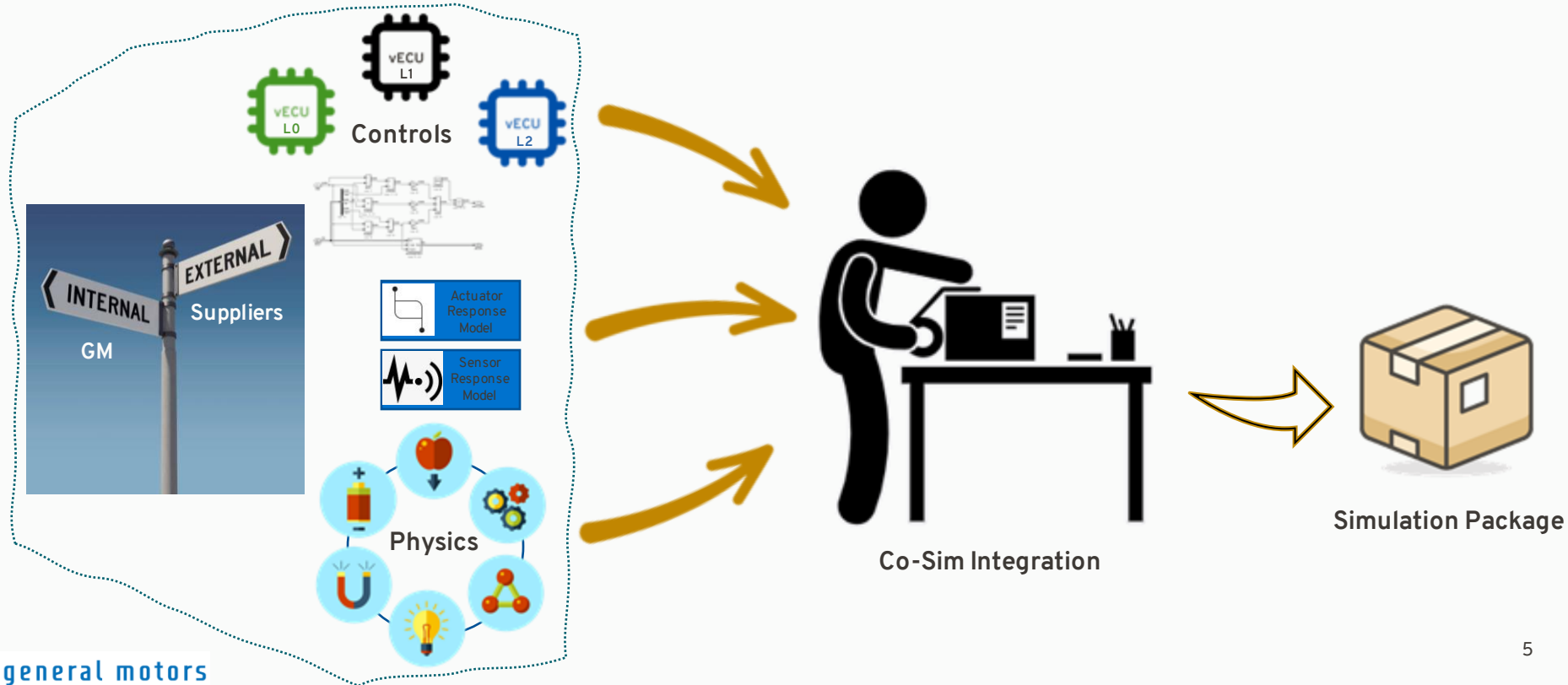
Each year we expect >20% of newcomers.



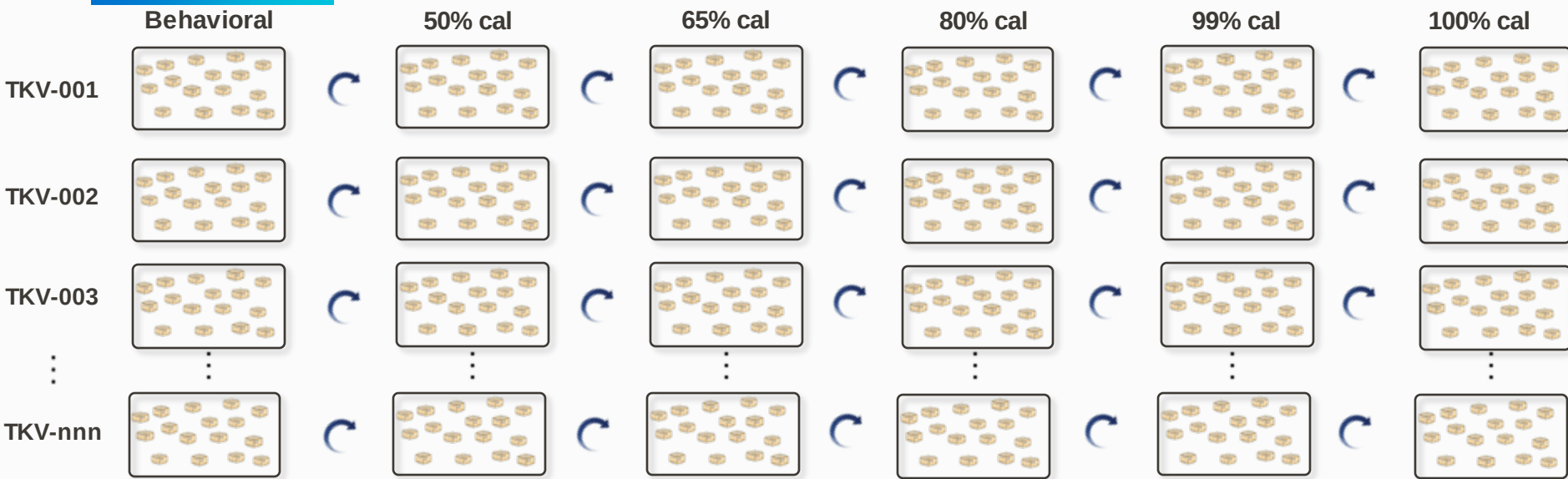
100% virtual vision: **hardware teams** (labs & road) expected **to use virtual tools directly**. Number of potential users increases by an order of magnitude.

**Tools that
are easy to
learn and use
are critical!**

Co-Sim Integration Overall Concept



Simulation Complexity Landscape



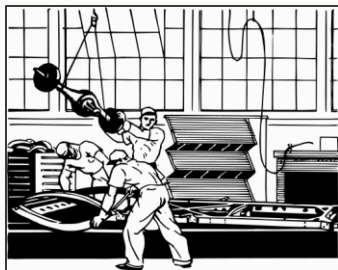
- Number of unique packages impacted by number of body styles, propulsion configs, suspension configs, and tire combinations.
- Early development can use fewer TKV's to bookend performance, but calibration and validation activities cannot ignore unique cal's.
- WMBT: **increased throughput** of TKV's + using production hardware for final check only (check ≠ development).
- While not a full factorial exercise, the creation and coordination/update of all packages within a program is still a major task.

Supplier Integration in a 100% Virtual Environment

Prototype Assembly

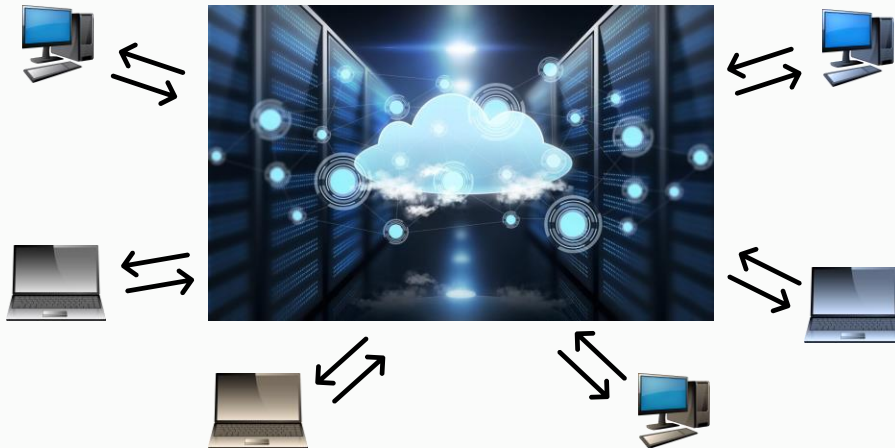
Supplier System Tuning, Calibration & Validation using borrowed time with vehicle

Current Process



- Integrated tuning and calibration only possible after vehicles are available.
- Increased risk for late findings and delays.
- Does not allow for much time compression.

100% Virtual Process



- Integrated tuning and calibration possible from day 1.
- Main issues can be found and fixed much earlier in the process.
- Improves concurrent engineering, with further gains in time compression.

Key Challenges and Solutions in Sight

- **Some technical solutions need to become mainstream**
 - Example of computing access for virtual co-development between OEM and suppliers → fast connection remote solutions under development.
- **IP protection needs attention**
 - Risk levels same as traditional process when virtual infrastructure is properly implemented (encrypted data, secure access, etc).
- **Rigor with virtual deliverables**
 - In a 100% virtual development process, virtual assets need to be executed first, and with same rigor as physical parts.
- **Enabling Virtual Exploration**
 - What is the equivalent of driving a vehicle around in a 100% virtual environment? New processes required to help find unknowns virtually.



Final Considerations

- New reality of virtual development requires update tools and processes: what was acceptable until recently in terms of quality, speed and robustness is no longer sufficient to support a faster 100% virtual development process.
- Tools need to be flexible to connect to and support multiple workstreams besides the original domains they were developed for. Little space for siloed solutions.
- Real time capability without model reduction is extremely relevant. Full compatibility with current and future industry standards for co-simulation (FMI/FMU, AUTOSAR) to allow for open connectivity with different tools is equally critical.
- All partners in the vehicle development ecosystem need to be able to work cohesively towards these goals. Everyone wins when everyone else realizes the benefits of the 100% virtual development model.



Thank you