Development of “Hino MELPHA Plug-in Hybrid bus” with combination of Existing HIL and TruckMaker

To make the world a better place to live by helping people and goods get where they need to go - safely, economically and with environmental responsibility - while focusing on sustainable development.
## Company Information

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Hino Motors, Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head Office</td>
<td>3–1–1, Hinodai, Hino-shi, Tokyo, Japan</td>
</tr>
<tr>
<td>Employees*</td>
<td>31,020</td>
</tr>
</tbody>
</table>

### Products

- **Heavy-Duty Trucks**
  - HINO700 series
- **Medium-Duty Trucks**
  - HINO500 series
- **Light-Duty Trucks**
  - HINO300 series
- **Medium & Light-Duty Trucks**
  - HINO600 series
- **Touring Coach**
- **Low-floor Bus**

**Total lineup – Heavy / Medium / Light Duty Trucks and Buses**
We charge of this domain.
Specification of Plug-in Hybrid Bus

Hino Motors started pre-production of the Plug-in Hybrid bus in 2016

External view

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length・Width・Height</td>
<td>8.9m・2.3m・3.0 m</td>
</tr>
<tr>
<td>Passengers</td>
<td>32+1(Driver)</td>
</tr>
<tr>
<td>GVW</td>
<td>10,765kg</td>
</tr>
<tr>
<td>Engine</td>
<td>Max 169kW</td>
</tr>
<tr>
<td>Motor</td>
<td>Max 175kW</td>
</tr>
<tr>
<td>Battery</td>
<td>40kWh(Li-ion)</td>
</tr>
<tr>
<td>Charging</td>
<td>Normal : AC200V</td>
</tr>
<tr>
<td></td>
<td>Rapid : CHAdeMO</td>
</tr>
<tr>
<td>Max Speed</td>
<td>70 km/h</td>
</tr>
</tbody>
</table>
Specification of Plug-in Hybrid Bus

Power train system

Drive mode (Hybrid)

Drive mode (EV)
To be realization above system is important to build up HILS.

First step: easy to build up HILS utilize already product devices.
How to build up effective the HILS

1st step: debug of software process

The 1st HILS have to debug huge algorithm of software.

2nd step: calibration of parameters process

The 2nd HILS is necessary to calibrate vehicle parameters. Target system increases power efficiency and fuel efficiency.

Quicker performance of test maneuvers in all possible conditions and repetition.

2nd HILS has been improved according to 1st HILS and the added TruckMaker.
1st HILS for software debug process

- 1st HILS description
  - TCU
  - VCU
  - ECU
  - METER
  - CLUSTER

Driver operation devices

Target ECU
  - PHV
  - CCU

Product ECU

Plant models

- Work flow of create software
  - start
  - coding
  - implementation
  - specification
  - Verification on HILS
  - revise

Control Desk
2nd HILS for calibration of parameters process

- 2nd HILS description

TCU | VCU | ECU | METER CLUSTER

Plant models

Engine | Cabin | Transmission | Motor/Inverter | Battery

Product ECU

Target ECU

PHV | CCU

Gear position signal

Acceleration pedal signal

Brake pedal signal

Vehicle speed

Driver Condition

Road Data

Target Vehicle Speed

Additional TruckMaker
2nd HILS for calibration of parameters process

The field road data profile

Target vehicle speed profile
For Japanese regulation

Same driver condition

Setting parameters

Target ECU

PHV  CCU

Result of evaluate

Fuel or electricity efficiency

power efficiency
2nd HILS for calibration of parameters process
Exemplary results for simulation precision

Plug-in Hybrid bus stared run service on the field.

Route of bus service
Shopping plaza → station A → shopping plaza → station B → shopping plaza
4.5km         4.5km                4.7km        4.7km        total 18.4km

Results of comparison: fuel & electricity efficiency.

Fuel efficiency (km/L)
- Field data: 6%
- HILS: 6%

Electricity efficiency (kWh/km)
- Field data: 14%
- HILS: 14%
Running of Plug-in Hybrid Bus on the field
## Development time efficiency

### Exemplary development schedule for the prototype

<table>
<thead>
<tr>
<th>Develop Term</th>
<th>1 Month</th>
<th>2 Month</th>
<th>3 Month</th>
<th>4 Month</th>
<th>5 Month</th>
<th>6 Month</th>
<th>7 Month</th>
<th>8 Month</th>
<th>9 Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of validation</td>
<td>Validation in the laboratory</td>
<td>Validation on the vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Previous Process</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consider system</td>
<td>Specification</td>
<td>Design</td>
<td>Debug</td>
<td>Consider system</td>
<td>Specification $\rightarrow$ design $\rightarrow$ HILS</td>
<td>Include calibration</td>
<td>Calibration of parameters</td>
<td>General validation</td>
<td>3 months reduction</td>
</tr>
<tr>
<td><strong>Current process</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Succeeded in reduction of 3 months thanks to removed calibration process with combination of Existing HIL and TruckMaker.
Thank you for your attention
After sheets for reference
3. 走行データ解析

Route of bus service
Shopping plaza → station A → shopping plaza → station B → shopping plaza
4.5km  4.5km  4.7km  4.7km  total 18.4km
2nd HILS for adaption of parameters process

HILS description

TCU  VCU  ECU  METER  CLUSTER

Control Desk

Driver operation devices

PHV  CCU

Target ECU

Work flow for create software

Start  Coding  Implementation  Specification

Verification on HILS

revise

Plant models

Copyright © 2016 Hino Motors, Ltd. All rights reserved.