# Bridging Requirements and Configurations: A Multi-Level Approach to System Design

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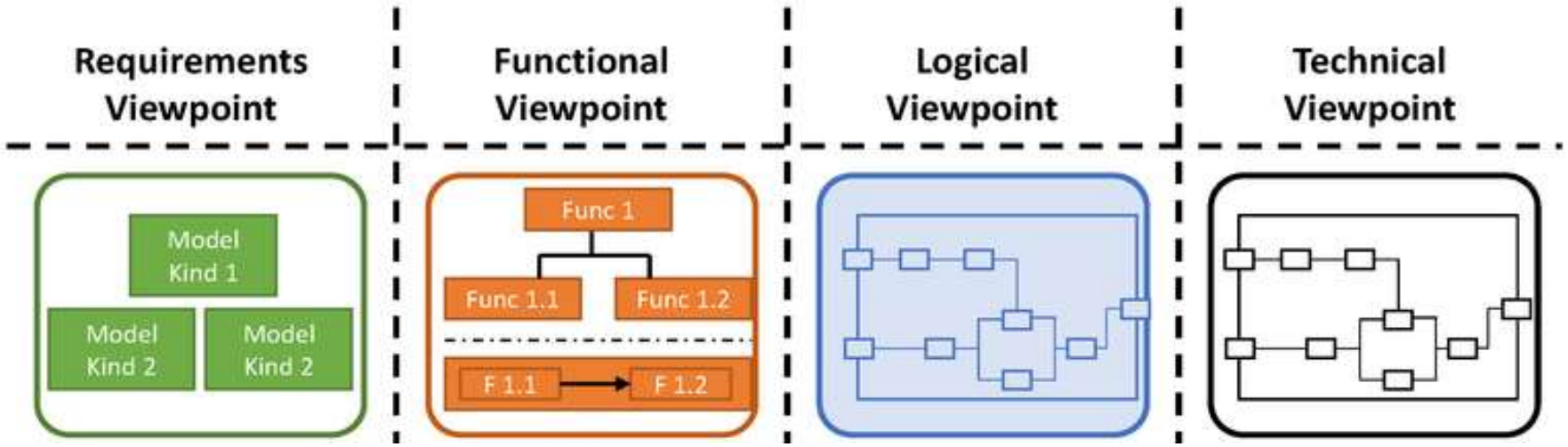
# Motivation

TIER-1 SUPPLIER
OEM
The engine mass shall not exceed $M = 35 \times N_{cyl}$ [kg].
OEM
The engine shall provide a power output of at least $P = 40 \times N_{cyl}$ [hp], where $N_{cyl} \in \{4, 6\}$.
OEM
The engine shall ensure compliance with Euro 6 emissions.

# Motivation

Our motivation is to explore MLM as a means to enable engineers to systematically transform high-level requirements into detailed, variant-specific ones.

# Typical MBSE approaches

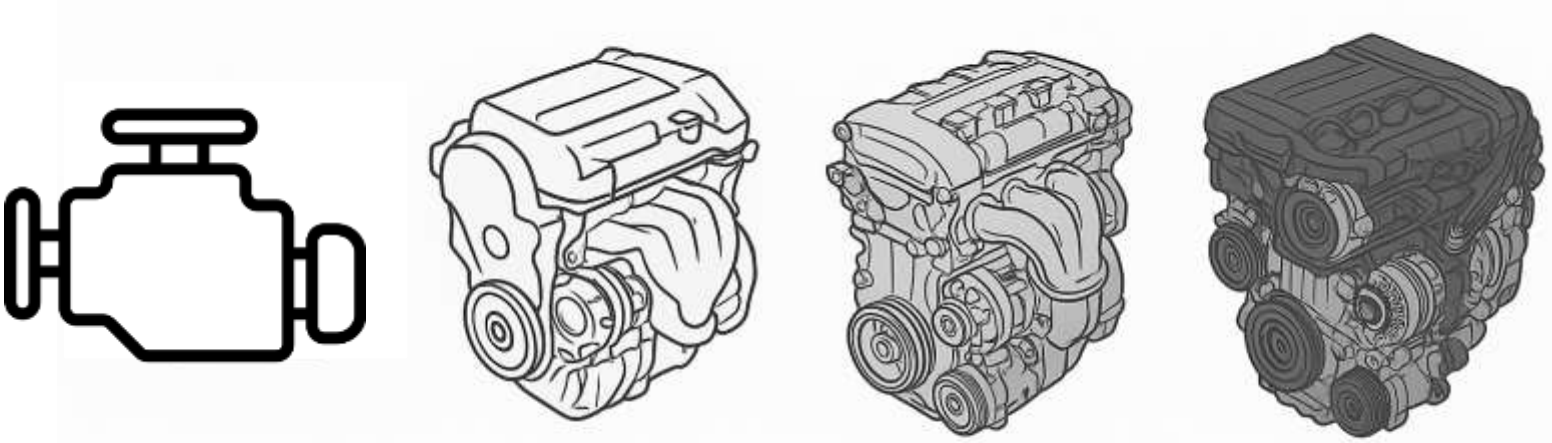



```
// --- Logical definition of the engine type ---
part def Engine {
    attribute power : Real [unit = kW];
    attribute mass  : Real [unit = kg];
}
```

```
// --- Technical instance (a concrete engine variant) ---
part Engine_2_0L : Engine {
    power = 150.0 kW;
    mass  = 220.0 kg;
}
```

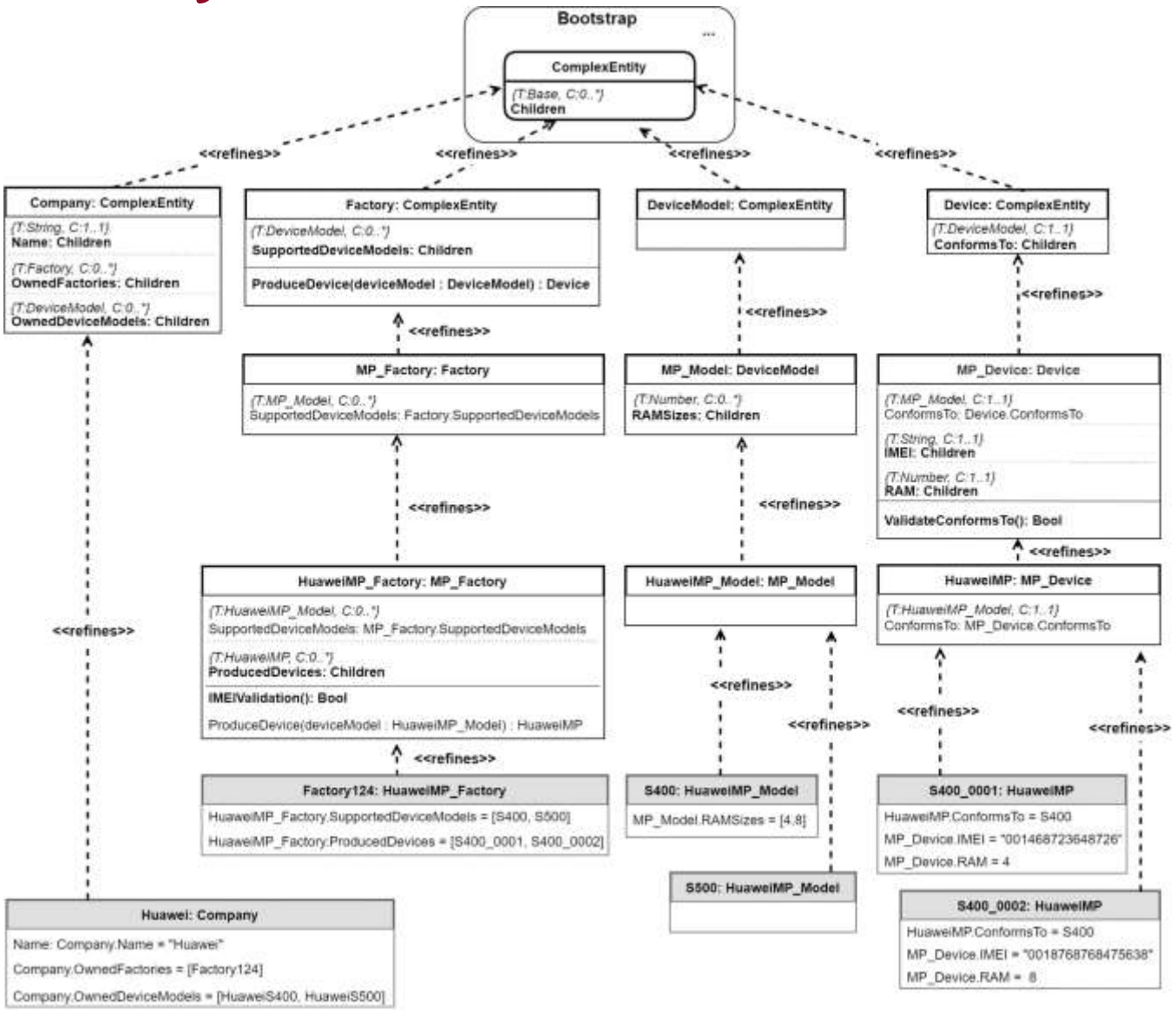
We might want to model the logical-technical transfer in multiple steps.

# Fluid modelling



Concretizing

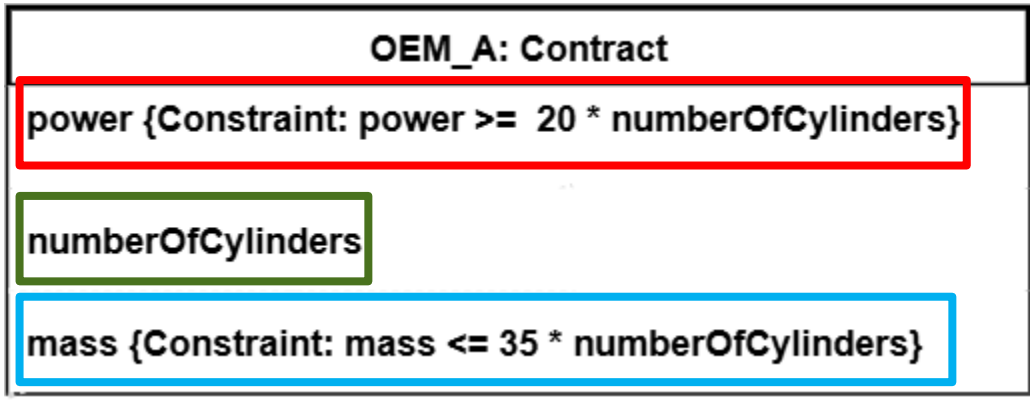
# Level-adjuvant vs. level-blind



# Illustrative example

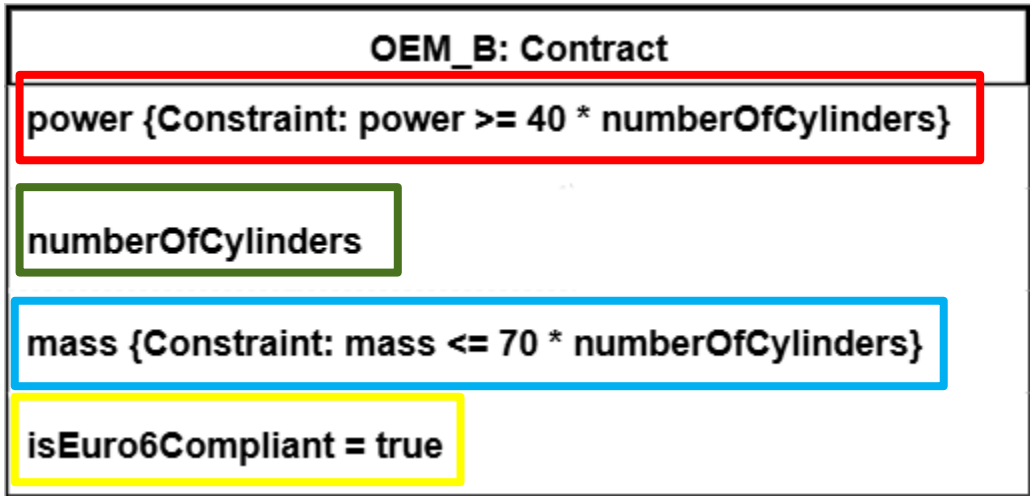
# OEM A Stakeholder requirements

- **OEM_A_REQ_1:** The engine shall provide a power output of at least $P = 20 \times N_{cyl}$ [hp], where $N_{cyl} \in \{4, 6\}$
- **OEM_A_REQ_2:** The engine mass shall not exceed $M = 35 \times N_{cyl}$ [kg].

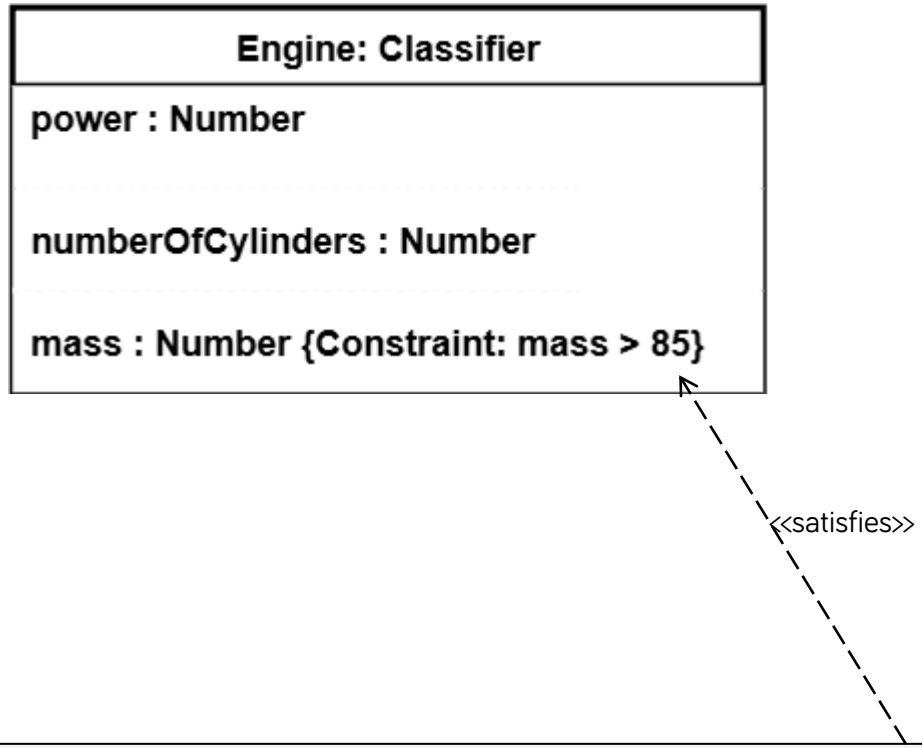


# OEM B Stakeholder requirements

- **OEM_B_REQ_1:** The engine shall provide a power output of at least $P = 40 \times N_{cyl}$ [hp], where $N_{cyl} \in \{4, 6\}$
- **OEM_B_REQ_2:** The engine mass shall not exceed $M = 70 \times N_{cyl}$ [kg].
- **OEM_B_REQ_3:** The engine shall ensure compliance with Euro 6 emissions.

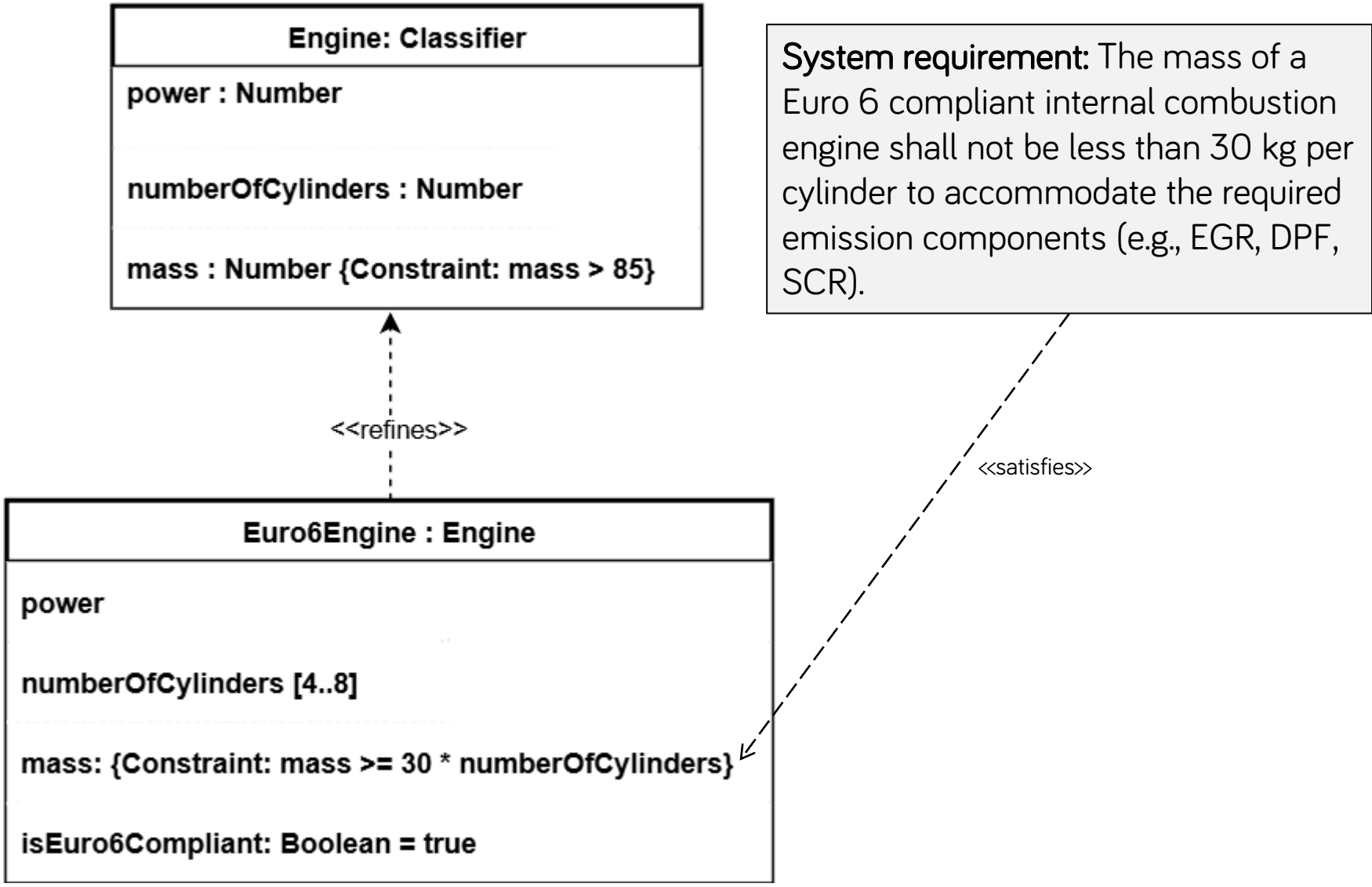


# Illustrative example




**System requirement:** The total mass of the engine assembly shall not fall below 85 kg to ensure structural integrity, manufacturing feasibility, and compatibility with existing systems (e.g., housing).

# Illustrative example



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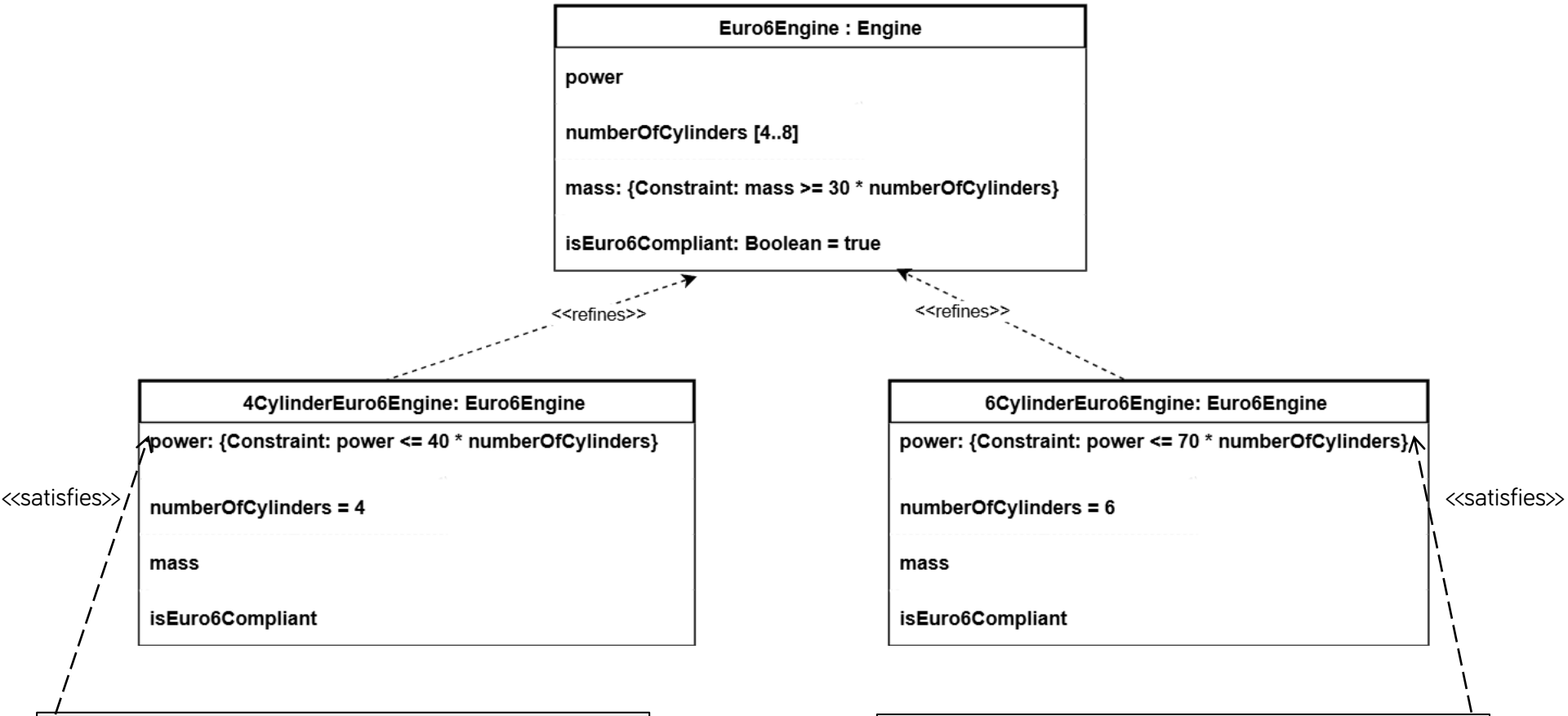
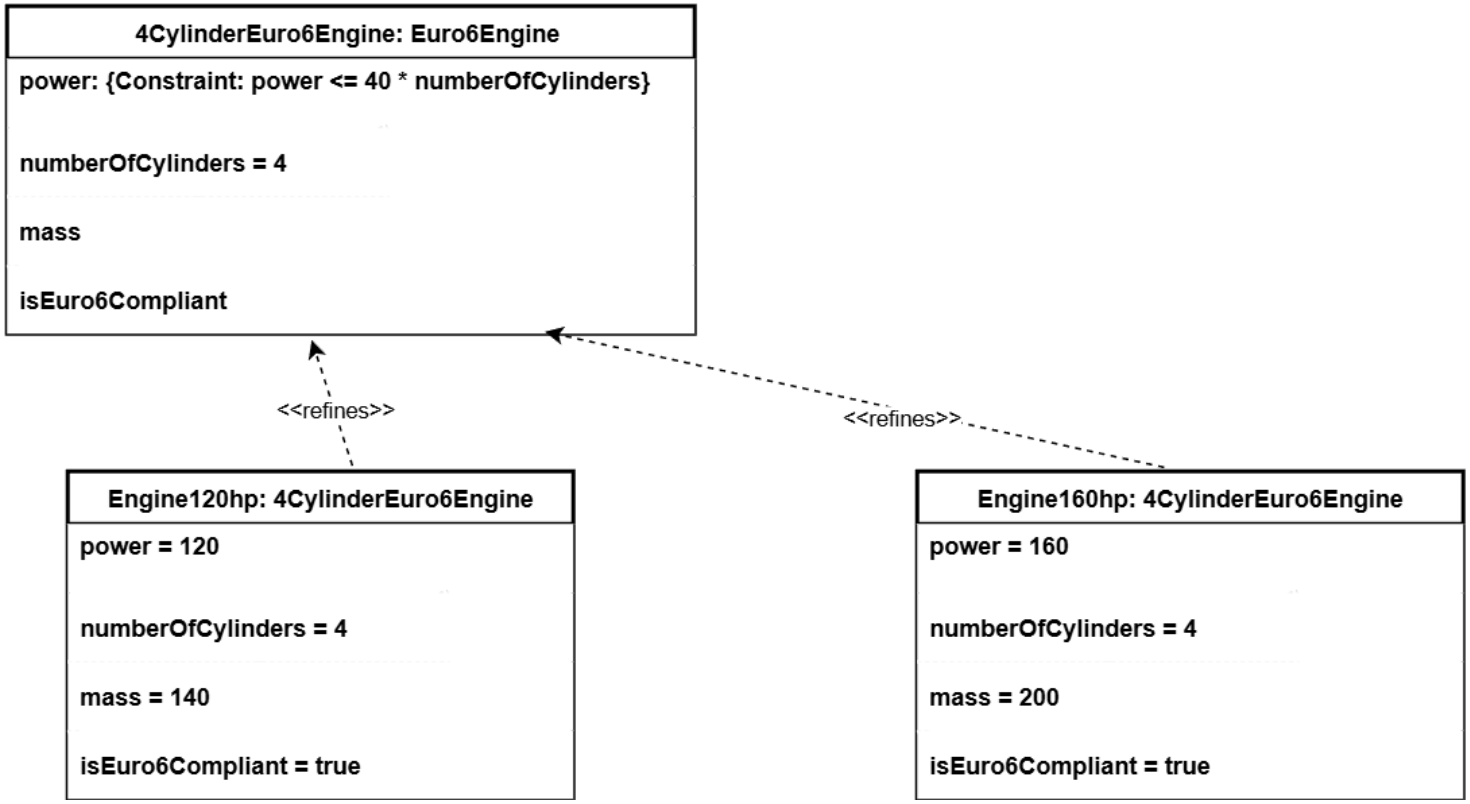


# Illustrative example




$\texttt{mass} \geq 85\,\text{kg}$ (internal constraint from the supplier) ✓
$\texttt{mass} \geq 30 \times 4 = 120\,\text{kg}$ (Euro 6 constraint) ✓
$\texttt{power} \leq 160\,\text{hp}$ (system constraint from the supplier) ✓

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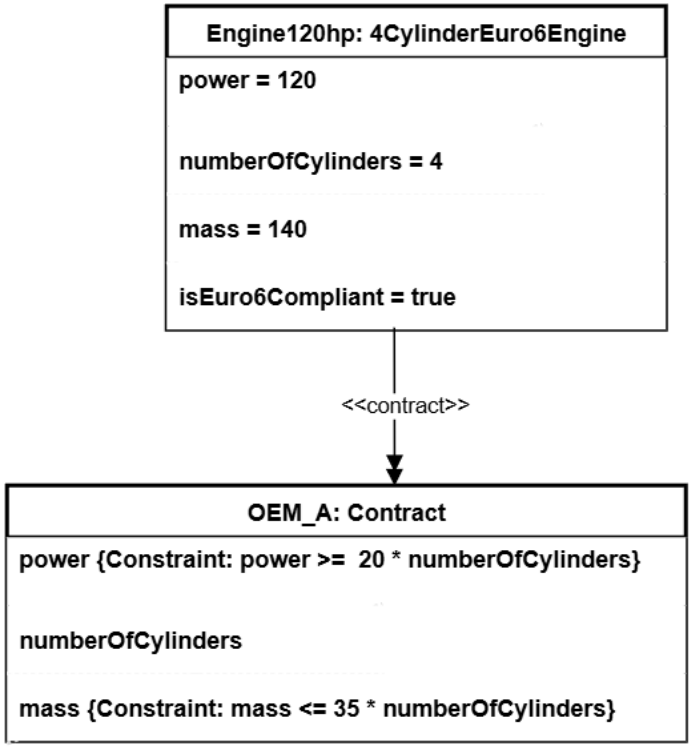
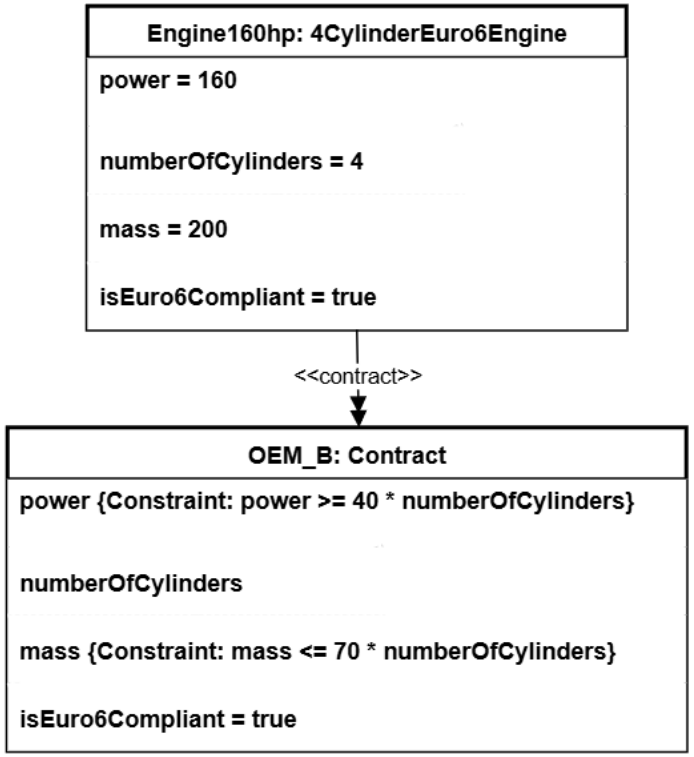
# Illustrative example




$$\texttt{power} \geq 20 \times N_{\text{cyl}} = 80 \quad \checkmark$$
$$\texttt{mass} \leq 35 \times N_{\text{cyl}} = 140 \quad \checkmark$$




$$\texttt{power} \geq 40 \times N_{\text{cyl}} = 160 \quad \checkmark$$
$$\texttt{mass} \leq 70 \times N_{\text{cyl}} = 280 \quad \checkmark$$
$$\texttt{isEuro6Compliant} = \texttt{true} \quad \checkmark$$

# Conclusions

- Multi-level refinement enables the reuse of model components and constraints across different configurations
- Constraint propagation
- The approach facilitates early requirement conflict detection and resolution

# Future work

- Extend the method by aligning it more closely with SysML v2-based tooling environment
- Explore how cross-hierarchy relationships can be formally modeled and integrated into the current methodology
- Evaluate the applicability of the methodology in potency-based (level-adjuvant) MLM approaches

# Thank you for your attention!