Systems Engineering Lab 2

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# **1) Why the Maglev train requires Systems Engineering**

* **Complex & Interdisciplinary:** The system spans electromagnetics (levitation/propulsion), power electronics, embedded control software (guideway frequency/intensity/direction control), communications, civil works (guideway), HMI, and safety/regulatory compliance. **SE** coordinates these disciplines.
* **SMART characteristics:** Real-time sensing/actuation, interconnected subsystems (train–guideway–SCADA–OCC), intelligent control algorithms → demands **structured development** from concept to operation.
* **High risks & costs:** Infrastructure and safety are high-stakes; **risk management** (identify–mitigate–accept–transfer) is essential.
* **Business + Technical needs:** Must satisfy operator economics (capex/opex), timetable headways, energy efficiency, lifecycle costs **and** rider comfort/noise/availability → formal **requirements engineering**.
* **Integration & interfaces:** Train power modules ↔ guideway coils ↔ position sensors ↔ software controllers; tight latency and EMI constraints → **integration planning** and **verification & validation** (V&V) across system/segment/subsystem levels.
* **Project management constraints:** Balance **scope–time–cost–quality**; a **WBS** and milestones keep the program controllable.
* **Quality & compliance:** Safety integrity (e.g., SIL targets), RAM (reliability–availability–maintainability) and environmental impact require **traceable requirements** to design, test, and certification evidence.

# **2) Stakeholders**

1. National/municipal **transport authority / regulator**
2. Railway **infrastructure owner & operator** (OCC/dispatch, maintenance)
3. **Passengers / public** (incl. accessibility groups)
4. **Embedded control software team** (you) & train OEM engineering
5. **Guideway & civil contractors**
6. **Power utility / grid operator**
7. **Suppliers** (sensors, inverters, coils, comms, braking)
8. **Local communities / environmental NGOs** and emergency services

## **2a) How they influence system design**

* **Regulator:** Sets safety, EMC, and environmental limits → drives SIL targets, braking distances, fail-safe states, cybersecurity baselines; imposes verification evidence and certification tests.
* **Operator (OCC/maintenance):** Needs availability (e.g., ≥99.7%), maintainability (MTTR limits), headways, degraded-mode ops → affects redundancy, health monitoring, LRU partitioning, and HMI/diagnostics.
* **Passengers/public:** Requirements for capacity, comfort (vibration/noise), accessibility (platform gap, announcements), usability → shapes carbody dynamics, interior systems, UI/UX and service levels.
* **Software/OEM engineering:** Feasibility and performance constraints (latency, determinism, sensor resolution) → architecture choices (e.g., distributed controllers, RTOS, safety partitions).
* **Civil/guideway contractors:** Tolerances and constructability → coil sectioning, alignment tolerances, expansion joints; affects control algorithms’ robustness to geometry error.
* **Power utility:** Grid connection limits/harmonics/peak power → energy storage, power-factor control, ramp profiles.
* **Suppliers:** COTS part specs and lead times → interface standards, qualification plans, obsolescence strategy.
* **Communities/NGOs/emergency services:** Noise, visual footprint, land use, emergency egress → noise barriers, evacuation walkways, ventilation, incident response procedures.

# **3) Project proposal**

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| **Project Name** | Manglev Train Embedded Control & Propulsion Control System (EPCS) |
| **Start/End date** | 03 Nov 2025 --> 30 Oct 2026 |
| **Objectives** | * Specify and implement real-time embedded control for levitation/propulsion with safe guidance and braking. * Achieve headway ≤ 3 min, max speed ≥ 450 km/h test track, station stopping accuracy ≤ ±15 cm. * Meet safety integrity targets (SIL-rated functions), RAM goals (A≥99.7%, MTBF and MTTR targets), and energy efficiency KPI (≤ X kWh/km at Y pax load). * Deliver complete V-model **requirements → design → integration → verification & validation** with traceability. |
| **Project Manager** | Sakka Mohamad-Mario, Systems Engineering Lead |
| **Project Owner** | City/Regional Transport Authority in partnership with Train OEM |
| **Team Members** | * Systems engineering (requirements, IV&V) control algorithms * embedded SW (RTOS, drivers, comms) * power electronics, sensors & actuators * cybersecurity, safety/RAM * integration & test * configuration management * QA. |
| **Pre-project Decisions & Economic Problems** | * Make/buy analysis for position sensing and inverter stacks; select RTOS and safety-certifiable toolchain. * Business case: reduce travel time vs. HSR, lifecycle cost optimization; capex staged by pilot line. * Key constraints: budget ceiling, grid connection capacity, certification schedule before trial service. |
| **Relationship with other projects** | * Civil works & guideway fabrication; rolling stock carbody & auxiliary systems; * SCADA/OCC; * stations & PSD (platform screen doors); * telecoms; * power supply substations; * cybersecurity SOC integration. |
| **Relevant Social Aspects** | * Accessibility by design, minimal noise/EMF at boundaries, land-use impact, local jobs/training, emergency response coordination, stakeholder engagement and public acceptance. |
| **Annexes** | * WBS, milestone plan, cost analysis, * SWOT (strength: speed/low wear; weakness: dedicated guideway; opportunity: green mobility; threat: public acceptance, supply chain). |

# **4) Social environment diagram**