Metro Sliding Doors Project

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Cover Page

University: German International University
Course: Mechatronics Lab (MCTR704)
Semester: Berlin Winter 2025
Project Title: Metro Sliding Doors
Project No.: [x]
Student: *TODO*
Instructor/Supervisor: *TODO*
extbfNOTE: Insert logo / project representative photo here.

Image Placeholder (Door System Overall View) – TODO

ableofcontents

1 Project Description (Milestone Requirement)

This section addresses items (a)–(e) of the milestone description. It establishes functional understanding prior to detailed CAD work.

1.1 (a) Functional Overview

The **Metro Sliding Doors** system provides controlled passenger access between train cars/platform and interior space. Two horizontally sliding door panels are actuated pneumatically, ensuring synchronized opening and closing. A third pneumatic cylinder controls a **safety locking mechanism** that physically prevents door movement when the system is deactivated or unsafe conditions are detected (e.g., train not aligned, emergency stop engaged).
Core functions:

- Provide reliable bi-directional sliding motion with smooth acceleration/deceleration via pneumatic actuation.
- Enforce interlocks: doors cannot open unless lock disengages and system is activated from the Master panel.
- Indicate door status locally (per door) and centrally (driver cabin panel) using red/green indicators.
- Support manual override or emergency closing initiated only from Master panel.
- Track door position using reed switches on cylinder end-of-stroke plus optional mid-travel sensors for diagnostics (optional expansion).

1.2 (b) Workpiece (Transferred Object) Description

In this context, the **"workpiece"** is the *passenger passage aperture* controlled by the two sliding door leaves. For mechanical sizing, each door panel must cover half of the total opening width.
extbfAssumed design dimensions (to be validated):

- Clear opening width (full aperture): *TODO e.g., 1400 mm*
- Each sliding leaf nominal width: half aperture + overlap allowance: *TODO*
- Door leaf height: *TODO e.g., 2000 mm*
- Door panel thickness / construction: aluminum frame with tempered glass insert (color: neutral / light tint) – *Confirm*

Color coding (if needed) may use: frame (RAL 9006), glass (clear), safety edges (high-visibility yellow). Replace with actual chosen scheme.
extbfNOTE: Insert detailed dimensional drawing of the door opening and panels here.

Dimensional Drawing Placeholder (Front Elevation) – TODO

1.3 (c) Operating Sequence

High-level sequence from inactive state to cycle completion:

Step 1: System powered; Master panel activation button pressed. Safety lock cylinder retracts (unlock). Green indicators turn ON; red indicators OFF.

Step 2: Operator (driver) or local user presses *Open* command (Master or Slave panel). Both door cylinders retract simultaneously, driving linkages to open panels fully.

Step 3: Fully open confirmation via reed switches (retracted end). Optional timer or passenger sensor monitors dwell period.

Step 4: Close command (Master only) issued. Door cylinders extend, sliding leaves shut. Lock cylinder extends only after doors fully closed to engage mechanical locking pawl.

Step 5: System returns to *secure closed* state; red indicators ON (if deactivated), or remains green if still armed for next cycle without lock engaged (design decision – clarify).

Interlocks:

- Lock must be disengaged before any door motion.
- Closing cannot be initiated from Slave panels.
- Emergency stop forces air dump, cylinders vent, doors remain (design choice: fail-safe close or fail-freeze). *To define.*

1.4 (d) Additional Components for Full Operation

Beyond base cylinders, full system requires integration of:
extbfActuators and Motion:

- 2x Pneumatic double-acting cylinders (door motion) with adjustable end cushioning.
- 1x Pneumatic cylinder (lock actuator).

extbfValves and Air Prep:

- 3x Solenoid-operated 5/2 directional valves (one per cylinder) or manifold with common supply.
- FRL unit (Filter-Regulator-Lubricator) + main shutoff valve + pressure gauge.
- Quick exhaust valves (optional) for faster closing.

extbfSensors:

- Reed switches on cylinder barrels (extended and retracted for each door cylinder and lock cylinder).
- Door edge presence / obstruction sensor (photoelectric or light curtain) *(optional safety enhancement).*
- Panel pushbuttons: Open (Master/Slave), Close (Master), Activate, Emergency Stop.
- Indicator lights: Green (Ready/Active), Red (Locked/Inactive).

extbfMechanical Guidance:

- Linear rails or roller track assemblies for door leaves.
- Linkage brackets coupling cylinder rod to carriage.
- Locking pawl and strike plate assembly.

extbfSafety / Enclosure:

- Protective upper compartment housing cylinders and valves.
- Panel enclosure (added in Milestone 2) reserved space in frame design.

1.5 (e) System Understanding Emphasis

Prior to CAD work, verify: sizing of cylinders vs required stroke (half door travel), force calculations (friction + inertia), rail selection load rating, lock mechanism sequence timing, and sensor mapping to control logic. **DO NOT** finalize 3D design until force/stroke assumptions are validated.
extbfNOTE: Insert preliminary engineering calculations (force, stroke, timing) here.

Engineering Calculation Placeholder (Forces / Stroke / Timing) – TODO

Mechanical Actuation Mechanism (Provided Details)

This project uses a **dual rack and single pinion** transmission driven by a **single pneumatic cylinder**. The mechanism is implemented as follows:

- Two parallel racks are mounted horizontally above the door aperture. Each rack is rigidly attached (pinned) to one door leaf.
- A pneumatic cylinder is mechanically connected to *Rack A*. When the cylinder extends or retracts, it translates Rack A linearly.
- A pinion gear engages both racks. Motion of Rack A drives the pinion, which in turn drives *Rack B* in the opposite linear direction, producing synchronized and symmetric door motion.
- The door leaves below run on a bottom rail via **four wheels per door** (two front, two rear), ensuring guidance, load support, and reduced friction.
- End-of-stroke reed switches on the cylinder provide door fully-open and fully-closed confirmations via rack positions (through cylinder travel). Optional mid-travel sensing can be added.
- A **separate locking mechanism** is included and will be described in detail later; its actuation is independent to ensure positive locking when required.

Benefits of this arrangement include synchronized leaf motion from a single actuator, compact packaging within the upper compartment, and straightforward position sensing using cylinder-mounted switches. extbfNOTE: Insert a SolidWorks snapshot of the rack-pinon assembly and the door wheel/rail arrangement.

Mechanism Figures Placeholder (Racks, Pinion, Cylinder Linkage, Wheels on Rail) – TODO

2 SolidWorks 3D Mechanical Design Guidelines (Adapted)

Design will mirror real hardware implementation. Key project-specific guidelines adapting milestone points:

- Ground-seated frame with vertical uprights supporting upper cylinder compartment.
- All pneumatic hardware (valves, FRL, tubing routing) contained within or on rear of frame, not protruding into passenger path.
- Frame width sized by aperture + rail assemblies; height sized by door leaf + clearance + cylinder compartment depth.
- Reserved mounting plane for future control panel (Milestone 2) on side column.
- Clear delineation of stages: (Input = Unlock + Activate), (Operation = Open/Close door motion), (Delivery = Secured locked state ready for next cycle).

- Cylinder orientation strictly horizontal; lock cylinder orthogonal or vertical depending design choice (to finalize).
- Use linear guide rails for door translation; bearings for any rotating shafts (if conversion mechanism used).
- Support layers: base chassis, mid rail support, upper actuator compartment.
- Door position tracking via reed switches; optional mid-stroke sensor mount features integrated.

extbfNOTE: Insert 3D views (isometric, front, side) of assembled model.

3D Isometric View Placeholder – TODO

3D Exploded View Placeholder – TODO

3 Design For Manufacturing (DFM) Report

DFM ensures each custom part is feasible with available processes. Provide per-part manufacturing notes and 2D drawings.

Manufacturing Assumptions

- Frame members: standard rectangular steel/aluminum profiles cut to length, drilled.
- Mounting plates: laser-cut sheet metal (specify alloy, thickness), bent where required.
- Lock pawl: CNC milled or laser-cut + heat-treated (if wear critical).
- Brackets: sheet metal with flange bends, hole patterns for cylinder clevis.
- Rails: purchased linear guide assemblies (COTS).

DFM Part Table

oprule Part No.	Part Name	Material / Specs	Manufacturing Process	2D Drawing Ref.
1	Base frame side upright	*TODO*	Cut to length, drill	*TODO FIG*
2	Upper cylinder support plate	*TODO*	Laser cut + bend	*TODO FIG*
3	Door carriage bracket	*TODO*	Laser cut + bend	*TODO FIG*
4	Lock pawl	*TODO*	Laser cut + mill finish	*TODO FIG*
5	Valve manifold plate	*TODO*	Laser cut	*TODO FIG*
...	...	...	...	...

extbfNOTE: Insert each 2D technical drawing (dimensions, tolerances) following the table.

2D Drawing Set Placeholder – TODO

4 Design For Assembly (DFA) Report

Focus: minimize assembly time, ensure accessibility, reduce fastener count, enable maintenance.

Assembly Strategy

- Modular subassemblies: Frame, Door Panels on Carriages, Actuator Compartment (cylinders + valves), Lock Mechanism, Sensor Harness.
- Fastener standardization: prioritize M6 socket head and self-locking nuts *(verify)*.
- Accessibility: sliding panels removable without disturbing cylinder alignment.
- Cable/pneumatic routing channels integrated in upright profiles.
- Exploded views to illustrate sequence and tool clearance zones.

extbfNOTE: Insert exploded subassembly views and annotated assembly sequence list.

Exploded Subassembly Views Placeholder – TODO

5 Mechanical Component List

Comprehensive inventory per milestone instructions.

oprule No.	Name	Description / Function	Qty	Notes / Datasheet Ref.
1	Pneumatic cylinder (door left)	Actuate left sliding door	1	Stroke *TODO*
2	Pneumatic cylinder (door right)	Actuate right sliding door	1	Stroke *TODO*
3	Lock actuator cylinder	Engage/disengage lock	1	Stroke *TODO*
4	5/2 solenoid valve	Control left door cylinder	1	Coil voltage *TODO*
5	5/2 solenoid valve	Control right door cylinder	1	Coil voltage *TODO*
6	5/2 solenoid valve	Control lock cylinder	1	Coil voltage *TODO*
7	FRL unit	Air preparation	1	Model *TODO*
8	Pressure regulator gauge	Pressure monitoring	1	Range *TODO*
9	Reed switches	End-position sensing	6	2 per cylinder
10	Linear guide rail	Door leaf translation	2	Length *TODO*
11	Door carriage assembly	Supports door leaf	2	Bearing type *TODO*
12	Door panel (leaf)	Barrier component	2	Material *TODO*
13	Lock pawl	Mechanical lock interface	1	Hardened? *TODO*
14	Strike plate	Receives lock pawl	1	*TODO*
15	Indicator lights (Green)	Status active	2	Voltage *TODO*
16	Indicator lights (Red)	Status inactive	2	Voltage *TODO*
17	Master panel buttons	Open/Close/Activate	3	Type *TODO*
18	Slave panel buttons	Local open	2	Type *TODO*
19	Emergency stop	Safety shutdown	1	Standard *TODO*
20	Tubing (various diam.)	Pneumatic connections	m	Diameter *TODO*
21	Fittings (elbow, T)	Air routing	Set	Count *TODO*
22	Fasteners (M6 bolts)	Structural joints	Set	*TODO*
23	Fasteners (M8 bolts)	High-load joints	Set	*TODO*
24	Cable duct / channel	Wiring/pneumatic mgmt	As req.	Length *TODO*
25	Valve manifold plate	Mount valves	1	Material *TODO*
...	...	...	...	...

extbfNOTE: Attach PDF datasheets for all purchased components in Appendix (placeholder

below).

Datasheets Appendix Placeholder – TODO

6 Pneumatic Position-Step Diagram

This diagram defines sequence control states of the three cylinders.
State notation: LDC (Left Door Cylinder), RDC (Right Door Cylinder), LC (Lock Cylinder).
extbfLegend: EXT = Extended, RET = Retracted.

oprule Step	LDC	RDC	LC	Event / Sensor Condition
0	EXT (Closed)	EXT (Closed)	EXT (Locked)	System inactive (Red ON)
1	EXT	EXT	RET (Unlocked)	Activate pressed (Green ON)
2	RET (Opening)	RET (Opening)	RET	Open command; door travel start (Reed mid optional)
3	RET (Open)	RET (Open)	RET	Both door cylinders retract reed switches ON
4	EXT (Closing)	EXT (Closing)	RET	Close command; lock stays disengaged until doors closed
5	EXT (Closed)	EXT (Closed)	EXT (Lock engage)	Door closed sensors ON, lock extends
6	EXT	EXT	EXT	Cycle complete; ready for next activation

extbfNOTE: Insert graphical pneumatic step diagram here.

Pneumatic Step Diagram Graphic Placeholder – TODO

7 Milestone Deliverables Checklist

- Project description (Section 1) – *Drafted*
- 3D views of mechanical design – *Pending CAD* (Placeholder inserted)
- Mechanical component list – *Initial list provided; refine quantities*
- DFM report + 2D drawings – *Framework ready; drawings pending*
- DFA report with exploded views – *Framework ready; views pending*
- Pneumatic position-step diagram – *Tabular sequence provided; graphic pending*
- SolidWorks 3D design files – *To include in ZIP upon completion*

8 Appendix

A. Datasheets

NOTE: Insert PDFs (referenced externally) or summary tables for each purchased component.

Datasheet Collection Placeholder – TODO

B. Engineering Calculations

NOTE: Force sizing for cylinders, friction coefficients, air consumption estimates.

Calculation Sheets Placeholder – TODO

C. Risk and Safety Notes

Preliminary safety considerations: pinch points at door edges, emergency stop circuit design, pneumatic pressure limits. Detailed FMEA optional in later milestone.
NOTE: Insert safety assessment here.