

ENGINEERING PROGRESS MANUAL





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Purpose, structure and goal

The Modeling and CAD phase turns the approved concepts and the Robot Requirements Document (RRD) into a complete, accurate digital model that is ready to build.

The end result is a working master assembly with no interferences, together with a bill of materials (BOM) and fabrication files, marking the formal handoff to manufacturing.

1.1 Purpose of the area

The CAD area is responsible for:

- Turning ideas into real physical solutions
- Making sure the design can be built and maintained
- Checking compliance with rules and requirements
- Serving as the technical basis for fabrication

1.2 Roles and responsibilities

CAD / Modeling Lead

Owns the integrity of the master assembly and compliance with standards.

Subsystem designers

Develop and adjust mechanisms within the full robot assembly.

Fabrication Lead

Confirms the design can be manufactured before final approval.

Electronics Lead

Checks space, mounting and wiring routes.

1.3 Philosophy

- Always design in context, never in isolation
- Choose simplicity over complexity
- Design for fabrication from day one
- Avoid late iterations by validating early
- Favor robust solutions that are easy to maintain





Environment setup and CAD standards

2.1 Official platforms

The team models in a hybrid environment that combines collaborative and individual tools, giving flexibility without compromising design integrity.

Approved platforms

Tipo de uso	Plataforma	Propósito principal
colaborativo	Onshape	Diseño centralizado y ensamblaje maestro
individual	AutoCAD, Fusion 360, SolidWorks	Modelado preliminar y desarrollo conceptual

Usage guidelines

Onshape is mandatory for all official robot work because it is the project's single source of truth. All final decisions, integrations and validations happen on this platform.

Individual tools (AutoCAD, Fusion 360, SolidWorks) may only be used for exploratory or personal work; any design that becomes part of the robot must be migrated into Onshape before it is validated.

Using COTS libraries

Commercial off-the-shelf (COTS) parts are mandatory in the workflow. They are added through libraries already loaded in the team environment.

Rules:

- All libraries are loaded before modeling starts
- Commercial parts are never modeled from scratch if a model already exists
- Only official or verified supplier models are used
- All parts stay centralized in the master document

Managing the workspace

All modeling happens in the team's shared documents, which guarantees access, traceability and version control.

Working in local files or outside the collaborative system is not allowed, since it causes loss of control and risks inconsistencies.





Good working practices

- Keep a single master assembly as the global reference
- Use linked documents instead of duplicating files
- Name every part correctly from the moment it is created
- Keep the feature tree organized

2.2 Document structure

The document structure defines how the robot is organized in CAD, giving clarity, scalability and control over the design.

Base project structure

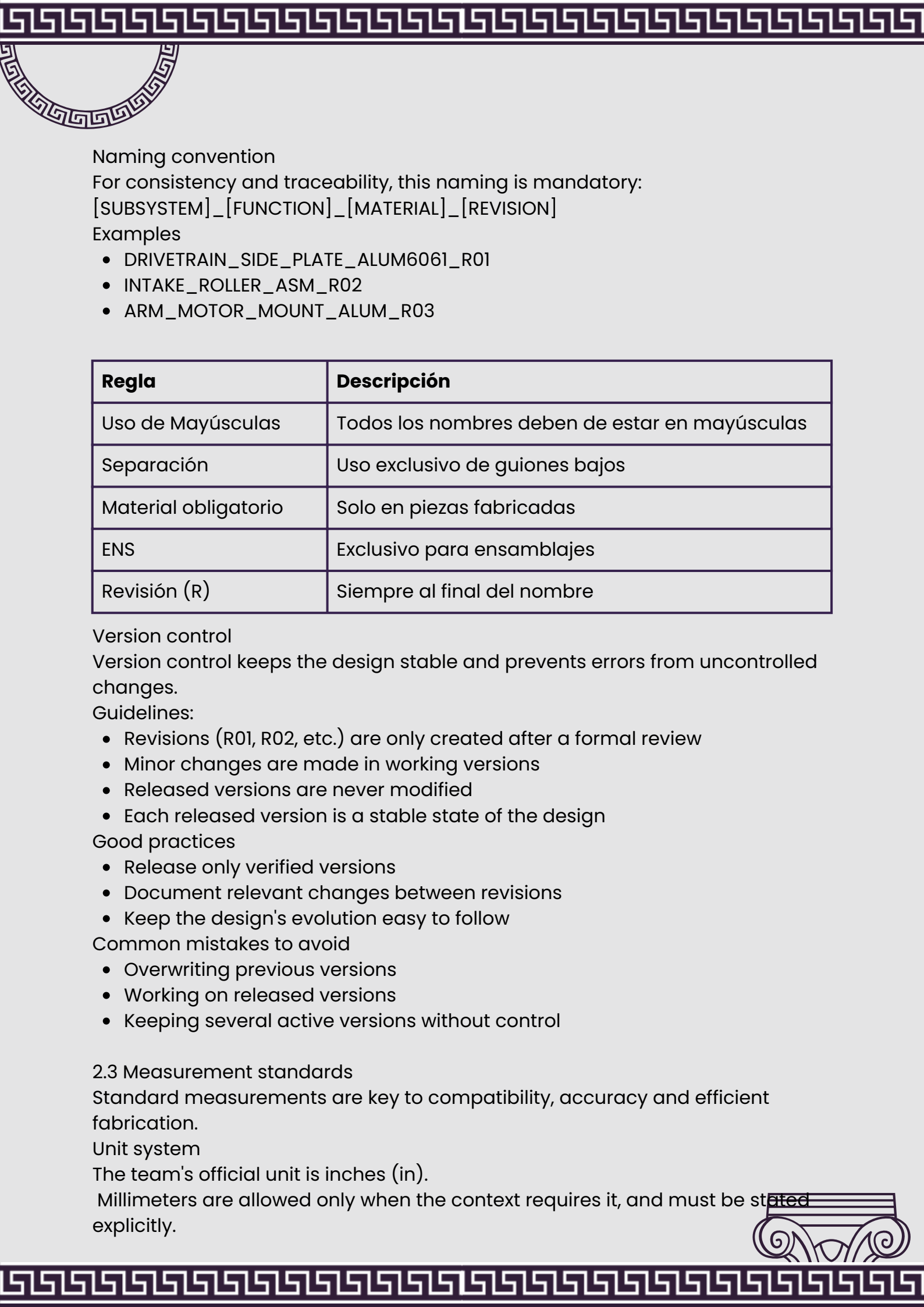
ROBOT_[YEAR]_[NAME]

- |—— 0_REFERENCE_DOCUMENTS
- |—— 1_DRIVETRAIN
- |—— 2_INTAKE
- |—— 3_ELEVATOR_ARM
- |—— 4_SHOOTER
- |—— 5_ELECTRONICS_CHASSIS
- |—— 6_GAME_FIELD
- |—— 7_MASTER_ASSEMBLY

Structure overview

Carpeta	Función principal
0_DOCUMENTOS_REFERENCIA	Contiene reglas, DRR y documentos base del proyecto
1_DRIVETRAIN	Base estructural del robot, punto de referencia principal
2-4_SUBSISTEMAS	Desarrollo de mecanismos principales
5_ELECTRONICA_CHASSIS	Integración de componentes eléctricos y distribución de cableado
6_CAMPO_JUEGO	Elementos del campo para validación de interacción
7_ENSAMBLAJE_MAESTRO	Integración completa del robot y validación final





Naming convention

For consistency and traceability, this naming is mandatory:

[SUBSYSTEM]_[FUNCTION]_[MATERIAL]_[REVISION]

Examples

- DRIVETRAIN_SIDE_PLATE_ALUM6061_R01
- INTAKE_ROLLER_ASM_R02
- ARM_MOTOR_MOUNT_ALUM_R03

Regla	Descripción
Uso de Mayúsculas	Todos los nombres deben de estar en mayúsculas
Separación	Uso exclusivo de guiones bajos
Material obligatorio	Solo en piezas fabricadas
ENS	Exclusivo para ensamblajes
Revisión (R)	Siempre al final del nombre

Version control

Version control keeps the design stable and prevents errors from uncontrolled changes.

Guidelines:

- Revisions (R01, R02, etc.) are only created after a formal review
- Minor changes are made in working versions
- Released versions are never modified
- Each released version is a stable state of the design

Good practices

- Release only verified versions
- Document relevant changes between revisions
- Keep the design's evolution easy to follow

Common mistakes to avoid

- Overwriting previous versions
- Working on released versions
- Keeping several active versions without control

2.3 Measurement standards

Standard measurements are key to compatibility, accuracy and efficient fabrication.

Unit system

The team's official unit is inches (in).

Millimeters are allowed only when the context requires it, and must be stated explicitly.





Fabrication standards

Elemento	Especificación
Material principal	Aluminio 6061
Espesor estándar	1/8" (0.125")
Perfiles comunes	tubos 1x1, placas planas

Standard tolerances

Aplicación	Medida recomendada
Tornillo #10-32	0.196"
pasador 1/4"	0.257"

Key principle:

Every design accounts for real fabrication tolerances and avoids ideal fits that cannot be reproduced physically.

Dimensioning guidelines

Design for how the robot actually works, not for unnecessary theoretical precision.

- Avoid overly precise dimensions
- Prefer standard sizes available in the workshop
- Stay consistent across the whole robot
- Use symmetry whenever possible

Good practices

- Define critical dimensions at the start of the design
- Check measurements against real parts
- Design around the tools the team has
- Minimize the need for manual adjustments

Common mistakes

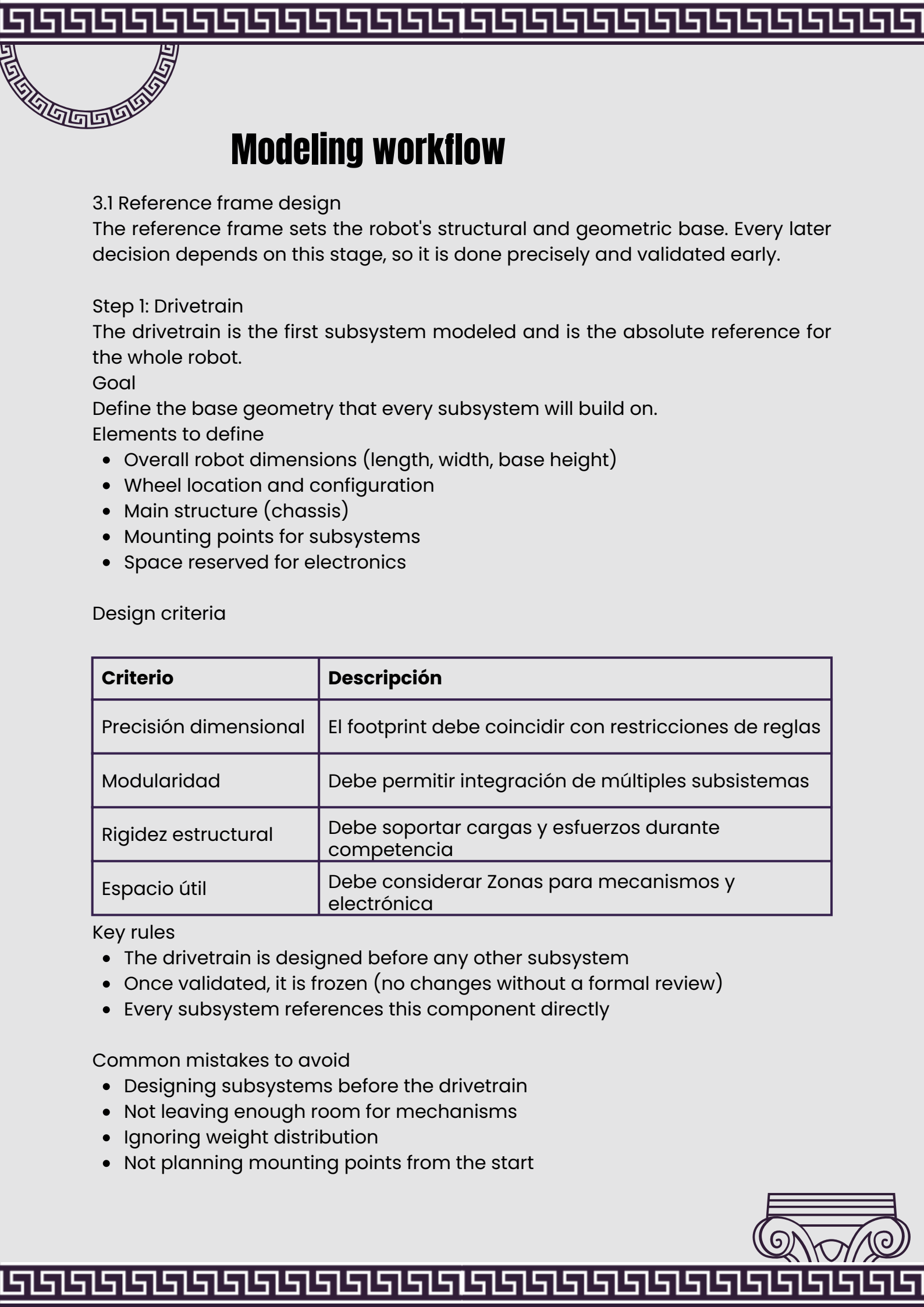
- Mixing units without control
- Designing without tolerances
- Using materials the team does not have
- Relying on manual fixes during fabrication

Why we standardize

Proper standardization gives us:

- Compatibility between subsystems
- Fewer fabrication errors
- Faster, more accurate assembly
- Easier maintenance





Modeling workflow

3.1 Reference frame design

The reference frame sets the robot's structural and geometric base. Every later decision depends on this stage, so it is done precisely and validated early.

Step 1: Drivetrain

The drivetrain is the first subsystem modeled and is the absolute reference for the whole robot.

Goal

Define the base geometry that every subsystem will build on.

Elements to define

- Overall robot dimensions (length, width, base height)
- Wheel location and configuration
- Main structure (chassis)
- Mounting points for subsystems
- Space reserved for electronics

Design criteria

Criterio	Descripción
Precisión dimensional	El footprint debe coincidir con restricciones de reglas
Modularidad	Debe permitir integración de múltiples subsistemas
Rigidez estructural	Debe soportar cargas y esfuerzos durante competencia
Espacio útil	Debe considerar Zonas para mecanismos y electrónica

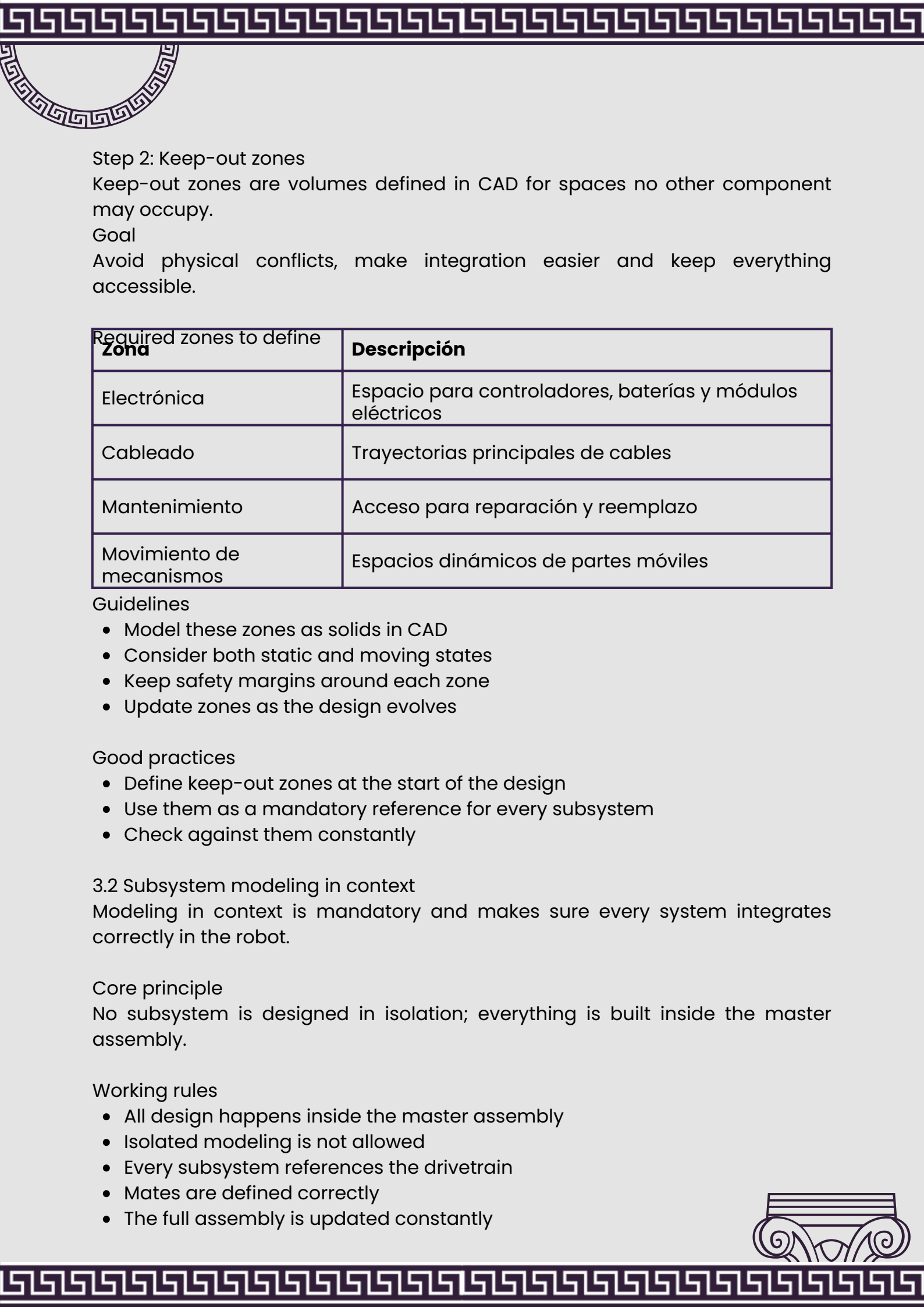
Key rules

- The drivetrain is designed before any other subsystem
- Once validated, it is frozen (no changes without a formal review)
- Every subsystem references this component directly

Common mistakes to avoid

- Designing subsystems before the drivetrain
- Not leaving enough room for mechanisms
- Ignoring weight distribution
- Not planning mounting points from the start





Step 2: Keep-out zones

Keep-out zones are volumes defined in CAD for spaces no other component may occupy.

Goal

Avoid physical conflicts, make integration easier and keep everything accessible.

Required zones to define Zona	Descripción
Electrónica	Espacio para controladores, baterías y módulos eléctricos
Cableado	Trayectorias principales de cables
Mantenimiento	Acceso para reparación y reemplazo
Movimiento de mecanismos	Espacios dinámicos de partes móviles

Guidelines

- Model these zones as solids in CAD
- Consider both static and moving states
- Keep safety margins around each zone
- Update zones as the design evolves

Good practices

- Define keep-out zones at the start of the design
- Use them as a mandatory reference for every subsystem
- Check against them constantly

3.2 Subsystem modeling in context

Modeling in context is mandatory and makes sure every system integrates correctly in the robot.

Core principle

No subsystem is designed in isolation; everything is built inside the master assembly.

Working rules

- All design happens inside the master assembly
- Isolated modeling is not allowed
- Every subsystem references the drivetrain
- Mates are defined correctly
- The full assembly is updated constantly





Recommended workflow

- Import or link the drivetrain
- Define geometric references
- Model the subsystem in context
- Check integration in real time
- Adjust for interferences or constraints

Quality criteria

Criterio	Descripción
Integridad del modelo	Sin errores en piezas o ensamblajes
Definición completa	Sin sketches incompletos o sub definidos
Integración	Correcta relación con otros subsistemas
Colisiones	Sin interferencias no intencionadas

Validation rules

- No sketches with open or undefined lines
- No parts in an error state
- All mates are stable
- The assembly moves the way it will in real use

Common mistakes

- Modeling parts without references
- Designing subsystems outside the assembly
- Ignoring interferences until late
- Not updating the master assembly

3.3 Design for manufacturing and maintainability

Design does not end in CAD; the robot has to be buildable, easy to assemble and maintainable in real competition conditions.

Core principles

Simplicity

Less complexity means fewer errors and easier fabrication.

- Prefer fewer parts that do more
- Avoid needlessly complex solutions
- Reduce joints and fasteners





Accessibility

The robot must allow fast, efficient maintenance.

- Critical parts are easy to reach
- Repairs never require removing several subsystems
- Leave room for tools

Standard materials

The design matches the team's real resources.

- Use materials already in inventory
- Avoid hard-to-find materials
- Stay consistent across the robot

Robustness

The robot must handle competition conditions without failing.

- Minimize weak points
- Design solid joints
- Account for dynamic loads and impacts

Efficient maintenance

The design allows quick repairs at competition.

- Fast part replacement
- Accessible fasteners
- Modular design when possible

Principles summary table

Principio	Ampliación Rápida	Beneficio
Simplicidad	Menos piezas, menos uniones	Menos fallas
Accesibilidad	Acceso directo a componentes críticos	Reparaciones rápidas
Materiales estándar	Uso del inventario existente	Fabricación existente
Robustez	Diseño estructural sólido	Mayor confiabilidad
Mantenimiento	Diseño modular accesible	Mejor desempeño en competencia

Common mistakes to avoid

- Designing without thinking about fabrication
- Creating mechanisms that are hard to assemble
- Ignoring maintenance in the pits
- Overcomplicating simple solutions





Quality control

4.1 Simulations and checks

Quality control in CAD makes sure the design works, can be built and meets every requirement before it goes to manufacturing.

This phase is mandatory and is done systematically on the full master assembly.

1. Interference analysis

Interference analysis finds physical collisions between parts of the robot.

Goal

Make sure every mechanism can operate without unwanted physical conflicts.

Guidelines

- Check interferences in every operating position (extended, retracted, in between)
- Evaluate both static and moving states
- Check how subsystems interact

Acceptance criteria

Tipo de interferencia	Estado permitido
Colisiones no intencionadas	
Contactos funcionales	
Topes mecánicos	

Good practices

- Simulate each mechanism's full range of motion
- Check tolerances in critical areas
- Re-check interferences after every major change

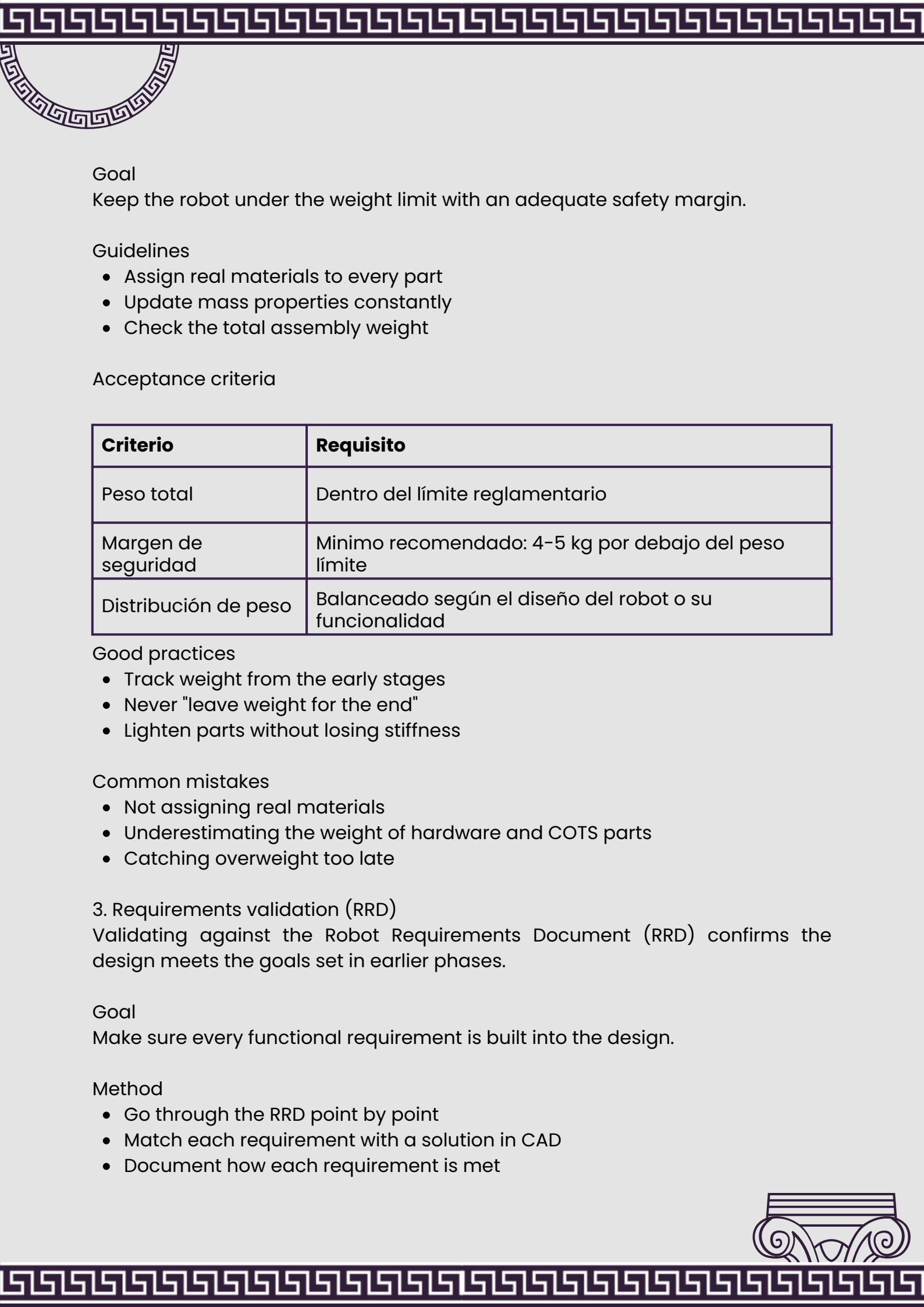
Common mistakes

- Checking only the starting position
- Ignoring small interferences
- Not considering how the system really moves

2. Weight analysis (mass properties)

Weight analysis keeps the robot within competition limits and protects its performance.





Goal

Keep the robot under the weight limit with an adequate safety margin.

Guidelines

- Assign real materials to every part
- Update mass properties constantly
- Check the total assembly weight

Acceptance criteria

Criterio	Requisito
Peso total	Dentro del límite reglamentario
Margen de seguridad	Minimo recomendado: 4-5 kg por debajo del peso límite
Distribución de peso	Balanceado según el diseño del robot o su funcionalidad

Good practices

- Track weight from the early stages
- Never "leave weight for the end"
- Lighten parts without losing stiffness

Common mistakes

- Not assigning real materials
- Underestimating the weight of hardware and COTS parts
- Catching overweight too late

3. Requirements validation (RRD)

Validating against the Robot Requirements Document (RRD) confirms the design meets the goals set in earlier phases.

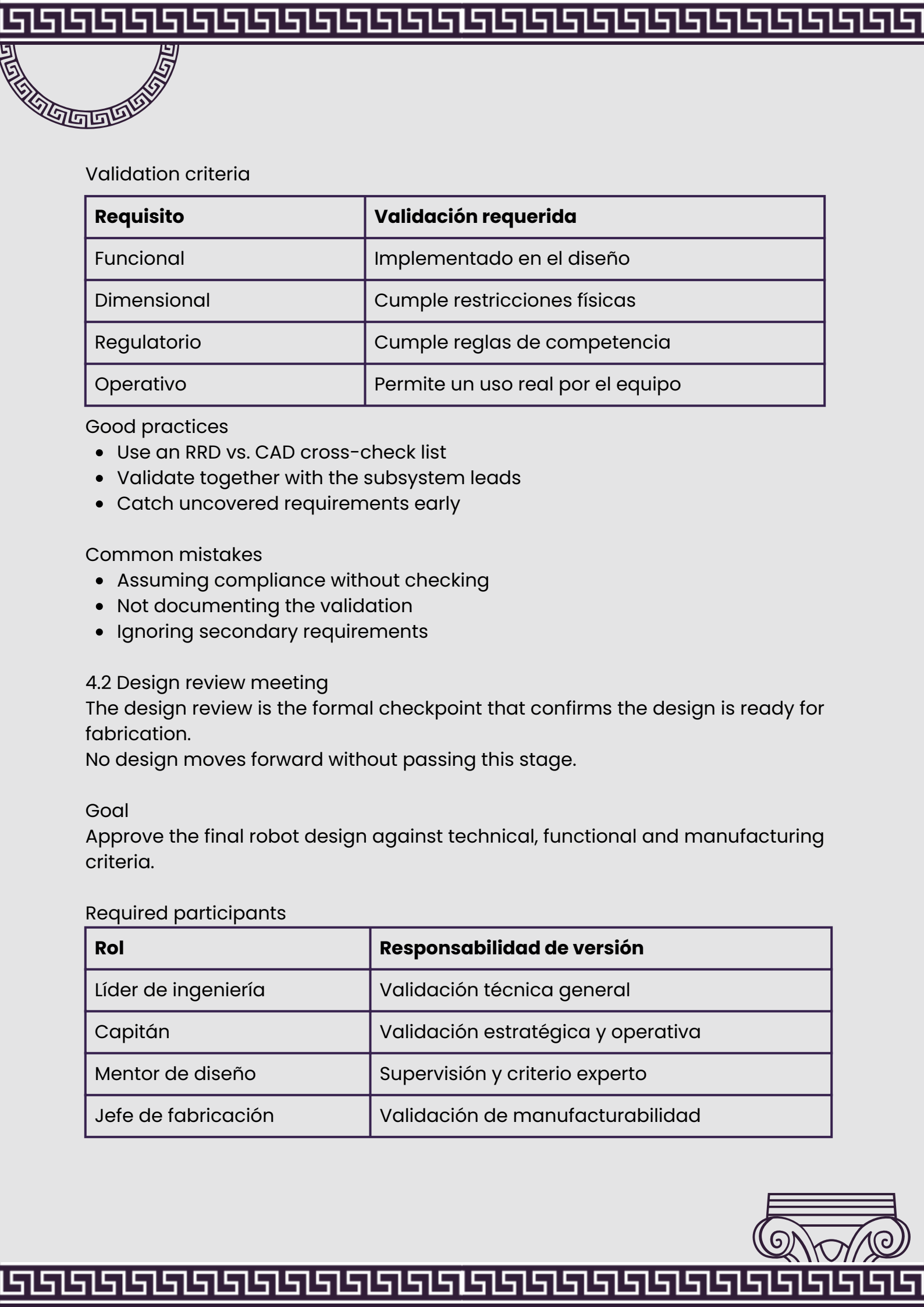
Goal

Make sure every functional requirement is built into the design.

Method

- Go through the RRD point by point
- Match each requirement with a solution in CAD
- Document how each requirement is met





Validation criteria

Requisito	Validación requerida
Funcional	Implementado en el diseño
Dimensional	Cumple restricciones físicas
Regulatorio	Cumple reglas de competencia
Operativo	Permite un uso real por el equipo

Good practices

- Use an RRD vs. CAD cross-check list
- Validate together with the subsystem leads
- Catch uncovered requirements early

Common mistakes

- Assuming compliance without checking
- Not documenting the validation
- Ignoring secondary requirements

4.2 Design review meeting

The design review is the formal checkpoint that confirms the design is ready for fabrication.

No design moves forward without passing this stage.

Goal

Approve the final robot design against technical, functional and manufacturing criteria.

Required participants

Rol	Responsabilidad de versión
Líder de ingeniería	Validación técnica general
Capitán	Validación estratégica y operativa
Mentor de diseño	Supervisión y criterio experto
Jefe de fabricación	Validación de manufacturabilidad



Meeting structure

1. Present the master assembly
2. Walk through each subsystem
3. Review simulations and validations
4. Risk analysis
5. Go through the RTM checklist
6. Decide: approve or adjust

Approval checklist (RTM: Ready To Manufacture)

Criterio	Estado requerido
Requisitos cumplidos	Completo
Interferencias	Sin conflictos
Peso	Dentro del límite
Lista de materiales	Completa
Archivos de fabricación	Listos y verificados
Documentación	Actualizada

Possible outcomes

Resultado	Acción requerida
Aprobado	Se libera para fabricación
Aprobado con cambios	Ajustes menores antes de fabricar
No aprobado	Rediseño parcial o completo

Records and traceability

- The approval is documented
- The design version (RXX) is recorded
- Evidence of the review is saved

Good practices

- Arrive with the model fully prepared
- Do not use the meeting to "finish the design"
- Present clear, structured information
- Include evidence of validations

Common mistakes

- Arriving without complete validations
- Leaving out people who are responsible
- Approving designs without critical review
- Not documenting decisions

