Laser-Cutting Machine System Requirements

Revision history

Rev #	Date	Author	Description
1.0	2026-Apr-15	Asaf Granot	Initial Version
1.1	2026-May-15	Asaf Granot	Initial top-level requirements Top-Level block diagram

Related Documents

Doc #	Title
000-000	Laser-Cutting Machine Product Requirements

Acronyms & Terms

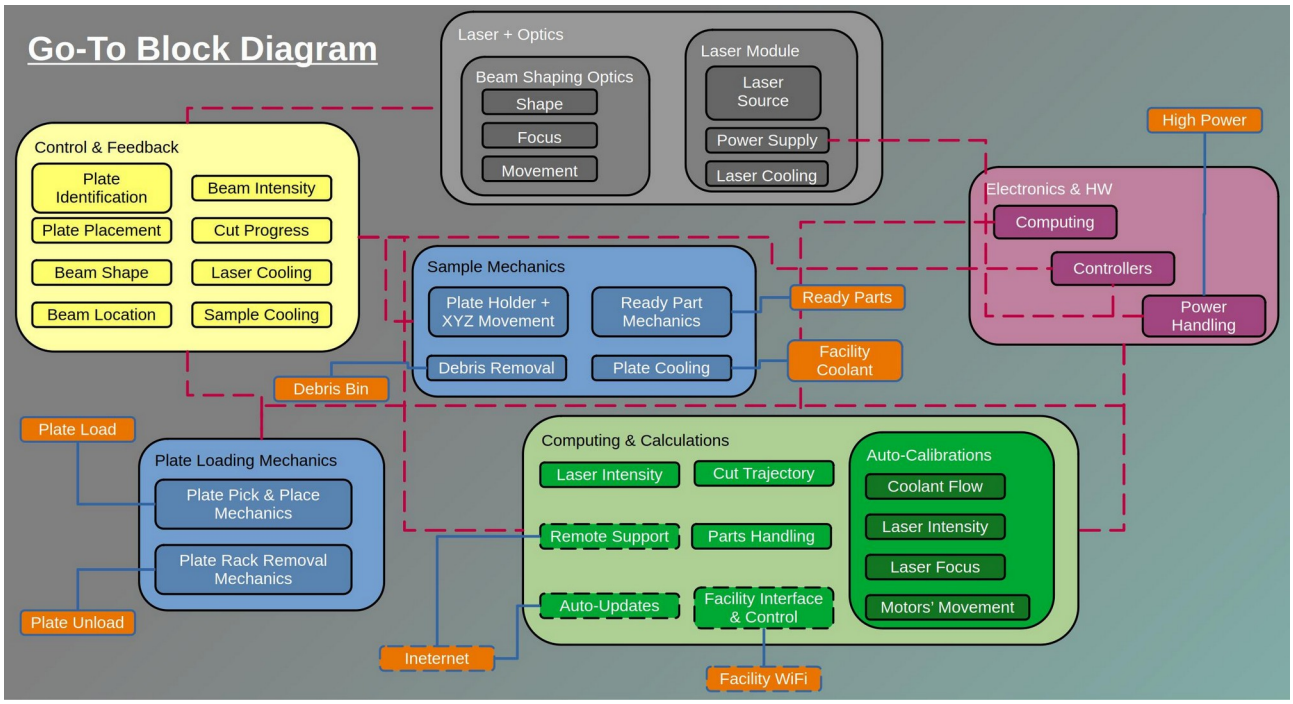
Acronym \ Term	Description
DOF	Depth of Field
TBD	To be decided in later stage of the project

Table of Contents

Table of Contents

Background

The purpose of this document is to detail the requirements for a laser-cutting machine for metal processing.
The machine is meant to cut Aluminum and Stainless-steel accurately, to be integrated in a production line with loading and unloading platforms.
This is the first product in the laser-cutting industry of *System and Optics*, to be integrated with already existing machine-vision based solutions from Product-A and Product-B as feedback and control modules in this laser-cutting product.
The system will have the following modules: Laser & Optics; Control & Feedback; Computing & Calculations; Electronics & HW; Plate Loading Mechanics and Sample Mechanics. See top-level block-diagram is as follows:



1. Laser-Cutting Machine Performance Requirements

1.1 **Metal types**: the system shall support cutting Aluminum.
1.2 **Metal types**: the system shall support cutting Stainless-steel.
1.3 **Metal plate dimensions**: the maximum size of a metal plate shall be 2500mm, 1500mm, 15mm (length, width, thickness).
1.4 **Cutting speed**: the line speed will be no less than 125m cuts per hour.
1.5 **Machine up-time**: machine up-time shall be >99.5% i.e. up to 1 hour downtime per week.

2. Laser-Cutting Machine Architecture

2.1 General

2.1.1 **Max BOM costs**: 150,000$US.

2.1.2 **Machine dimensions**: 95cm width, 195cm height, length TBD.

2.1.3 **Plate batch size**: the system shall support up to 25 plates in each raw material batch.

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2.2 Laser & Optics

2.2.1 **Cut line resolution**: <17.5um in order to support 35um feature size.
2.2.2 **Laser source wavelength**: the laser wavelength shall be 1070-1080nm.
2.2.3 **Laser source power**: the laser source will provide power of up to 12kW.
2.2.4 **Laser source power increments**: the laser assembly will have a 2.5% +/- 0.1% increment power capabilities i.e. [2.5%, 5%, 7.5% etc.].
2.2.5 **Beam focus**: the laser beam shall have focus range of 75mm
2.2.6 **Beam DOF**: the laser beam DOF shall be 15mm for resolution 30lp/mm at MTF > 60%
2.2.7 **Beam shape**: the optics shall support different beam shape at the target plane.
2.2.8 **Laser safety**: with closed covers the machine shall be categorized Laser Class 1.
2.2.9 **Laser safety**: with open covers for the service area the machine shall be categorized Laser Class 1.
2.2.10 **Laser safety**: with open covers for the laser and optics service areas as well as the target internal service area the machine shall be categorized Laser Class 4.
2.2.11 **Laser Cooling**
2.2.11.1 **Active cooling**: the laser system shall have active cooling, to support eviction of residual the power consumption.
2.2.11.2 **Liquid cooling coolant**: the liquid cooling coolant for the laser cooling shall be room temperature water.

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2.3 Sample Mechanics

2.3.1 **Sample movement**:...
2.3.2 **Sample Cooling**
2.3.2.1 **Active cooling**: the sample shall have active cooling

2.3.2.2 **Liquid cooling coolant**: the liquid cooling coolant for the sample cooling shall be room temperature water.

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2.4 Plate Loading Mechanics

2.4.1 **Batch height**: batch max height shall be 495mm. Min single-plate-batch height is 0.5mm.

2.4.2 **Auto plate loading**: the plates will be loaded one-by-one from the plate platform to the machine.

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2.5 Electronics & HW

2.5.1 **Laser source power**: the laser source power will be 480VAC to support 12kW power.

2.5.2 **Optics focus motors**: the motors power supply for optical focus control shall be 12VDC 0.5A.

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2.6 Control & Feedback

2.6.1 Power Control & Feedback

2.6.1.1 **Power measurement**: the laser power measurement will be via a laser power meter split-off from the main beam.

2.6.1.2 **Power measurement accuracy**: the power measurement shall be accurate up to +/-0.5% of the real power of the beam. Real power of the beam shall be measured by an Ophir Optronics power meter or equivalent.

2.6.1.3 **Power increments**: the power control shall support 2.5%+/-0.1% power increments or better.

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2.6.2 Cooling Control & Feedback

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3. Laser-Cutting Machine Top-Level Flow

3.1 Main Material Flow

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3.2 Calibration Processes Flow

3.2.1 **Power Auto-Calibration**: the laser power will auto-calibrate periodically for power verification.

3.2.2 **Motors Auto-calibration**: the motors shall have an auto-calibration and homing procedure to run periodically.

3.3 Error Handling

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4. External Interfaces

4.1 Communication Interfaces

4.1.1 **[Optional] Facility WiFi connectivity**:...

4.1.2 **[Optional] Internet connectivity**:...

4.2 Mechanical Interfaces

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4.3 Electric Interfaces

4.3.1 **Electricity power inlet**: the system’s main power inlet shall be high-power 480VAC.

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4.4 Coolant Interface

4.4.1 **Coolant inlet**: the coolant inlet shall be a 3inch hose inlet of room temperature water at the flow of 15L/min.

4.4.2 **Coolant outlet**: the coolant outlet shall be a 3inch hose inlet of water up to a temperature of 74^{o}C at the flow of 15L/min.

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4.5 GUI Interface

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5. Internal Interfaces

5.1 Interlocks

5.1.1 **Laser safety interlocks**: the machine covers for the laser and optics service areas as well as the target internal service area shall have interlocks to shutdown the laser in case of open-covers with a physical administrator key override.

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6. SW Features

6.1 SW Alerts

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Design Guidelines

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Future Features

1. The next generation is to support a 25mm thick metal plate.
2. N+2 roadmap include cutting Titanium.

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Requirement Tracking Table

Req #	Req Title	Originate From	Comments
1.1	Metal type	Product 000-000 #1	
1.2	Metal type	Product 000-000 #1	
1.3	Metal plate dimensions	Product 000-000 #2	
1.4	Cutting speed	Product 000-000 #12	
1.5	Machine up-time	Product 000-000 #14	
2.1.1	Target BOM cost	Product 000-000 #4	
2.1.2	Machine dimensions	Product 000-000 #15	Length TBD – currently footprint can be bound by mechanical design
2.1.3	Plate batch size	Product 000-000 #13	
2.2.1	Cut line resolution	Product 000-000 #3	
2.2.2	Laser source wavelength	Product 000-000 #1	
2.2.3	Laser source power	Product 000-000 #2	Aluminum max thickness derives the max power.
2.2.4	Laser source power increments	Product 000-000 #2	The increments were “calculated” in the POC of the laser unit
2.2.5	Beam focus	Sysreq 2.1.3	Positioning errors in the focus direction etc.
2.2.6	Beam DOF	Sysreq 2.1.3	May require extended DOF solution of some kind or a scanning beam
2.2.7	Beam shape	Sysreq 2.2.2	Beam shaped TDB
2.2.8	Laser safety	Sysreq 2.2.3	Best practice
2.2.9	Laser safety	Sysreq 2.2.3	Best practice
2.2.10	Laser safety	Sysreq 2.2.3	
2.2.11.1	Laser Cooling – Active cooling	Sysreq 2.2.3	
2.2.11.2	Laser Cooling – Liquid cooling coolant	Sysreq 2.2.3	
2.3.1	Sample movement	Sysreq 2.1.3	
2.3.2.1	Sample Cooling – Active cooling	Sysreq 2.2.3	
2.3.2.	Sample Cooling – Liquid	Sysreq 2.2.3	

	cooling coolant		
2.4.1	Batch height	Product 000-000 #13	Max height = 15mm x 25 + 5mm spacers
2.4.2	Auto plate loading	Product 000-000 #13	
2.5.1	Laser source power	Sysreq 2.2.3	
2.5.2	Optics focus motors	Sysreq 2.2.5	
2.6.1.1	Power measurement	Sysreq 2.2.3	
2.6.1.2	Power measurement accuracy	Sysreq 2.2.4	
2.6.1.3	Power increments	Sysreq 2.2.4	
2.6.2	Cooling Control & Feedback – …	...	
3.1	Main Material Flow – …	...	
3.2.1	Calibration Process Flow – Power Auto-Calibration	Product 000-000 #11	
3.2.2	Calibration Process Flow – Motors Auto-calibration	Product 000-000 #11	
3.3	Error Handling – …	...	
4.1.1	Facility WiFi connectivity	Product 000-000 #23	Optional
4.1.2	Internet connectivity	Product 000-000 #23	Optional
4.2	Mechanical Interfaces – …	...	
4.3.1	Electricity power inlet	Sysreq 2.5.1	
4.4.1	Coolant inlet	Sysreq 2.2.11.2	
4.4.2	Coolant outlet	Sysreq 2.2.11.2	
4.5	GUI Interfaces – …	...	
5.1.1	Laser safety interlocks	Sysreq 2.2.3	
6.1	SW Features – SW Alerts	Sysreq 3.3	