

# Automated Documentation for Open Source Hardware

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4 Februari 2024

Open Hardware and CAD/CAM at FOSDEM 2024

# Goal

Automatically generate IKEA-style **assembly instructions** for Open Source Hardware.

## About me

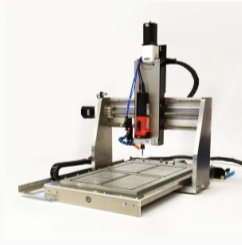
- self-employed software developer / researcher: open source software
  - pieterhijma.net
- currently contract Ondsel
- working on FreeCAD: managing model data
- co-founder of the Open Toolchain Foundation



# Example Open Source Hardware (OSH)

## The Open Lab Starter Kit by InMachines Ingrassia

- 8 machines
- 3 versions each



## Problem

- Documentation is crucial for OSH
  - replication
  - collaboration
- However, documentation is:
  - labor intensive
  - always out-of-date

## Approaches

- Document after the fact
- Document while doing

## State-of-the-art

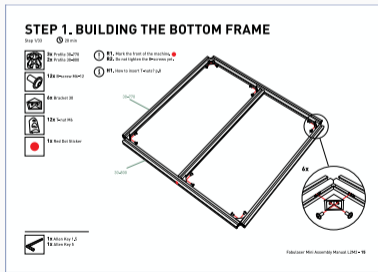
- GitBuilding
  - text oriented
  - lacks a "semantic relation" between the source and documentation

# Our goal

- Integrate **design** and **documentation** process
- Generate assembly instructions automatically
- Support **design evolution**

# The Fabulaser Manual

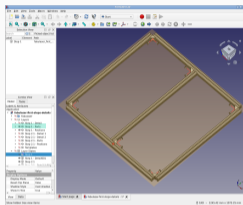
- high quality
- 3 persons, multiple months
- difficult to adapt to new versions





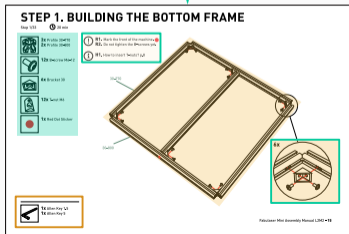
# Automated Documentation: Overview

CAD

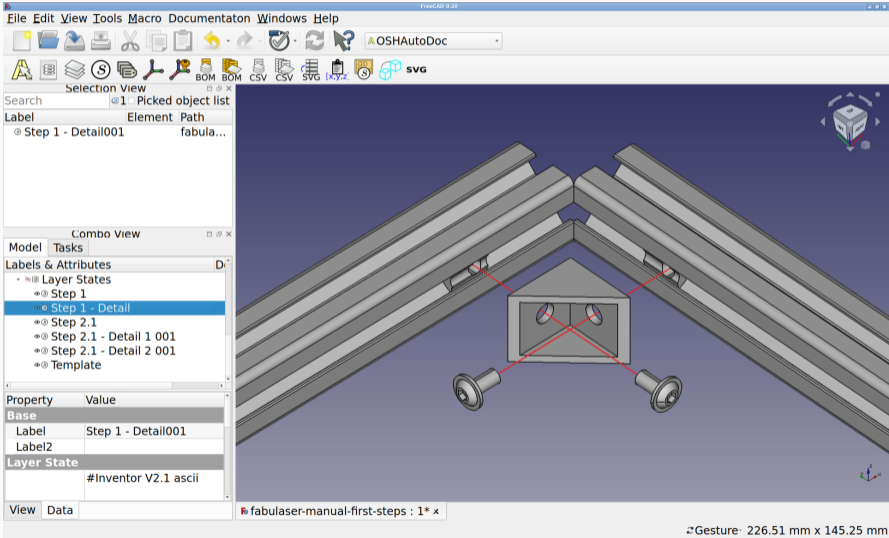


Specification

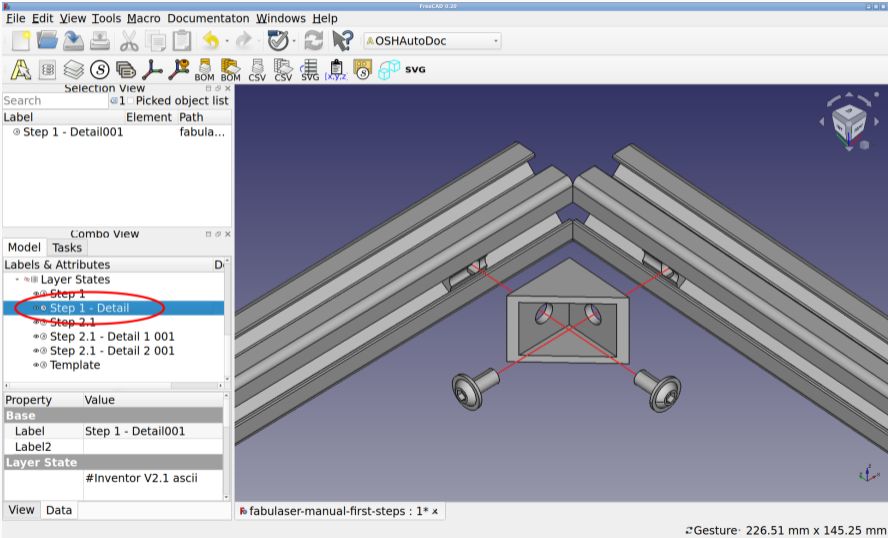
```
#step(Building the bottom frame)
#duration(20 min)
#substep(Step 1 - Parts)
#inspect(5Sec.1)
#highlight({from-pos (430 155 45)
            to-pos (200 325 60)}{Step 1 - Detail})
#remark["column2-3"]{Mark the front of the machine.}
#remark["column2-3"]{Do not tighten the B-screws yet.}
#hoke["column2-3"]{}
#tool["alien key" *1.5*]
#tool["alien key" *5*]
```



# OSH AutoDoc Workbench



# OSH AutoDoc Workbench



```
@step{Building the bottom frame}

@duration{20 min}

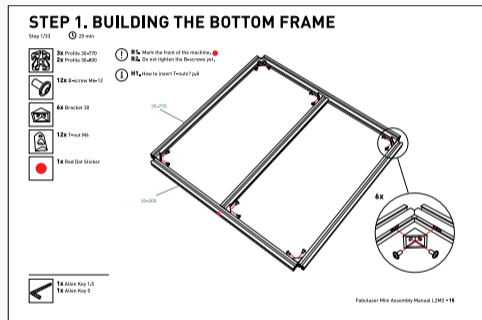
@minibom{Step 1 - Parts}

@image{Step 1}

@highlight[:from-pos (430 150 40)
           :to-pos (100 325 60)]{Step 1 - Detail}

@remark["column2-3"]{Mark the front of the machine.}
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```
@step{Building the bottom frame}
```

```
@duration{20 min}
```

```
@minibom{Step 1 - Parts}
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```
@image{Step 1}
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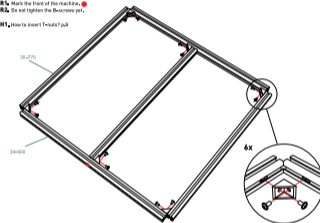
```
@tool["allen key" "1.5"]  
@tool["allen key" "5"]
```

## STEP 1. BUILDING THE BOTTOM FRAME

Step 1033 ⌚ 20 min



- ⚠ Mark the front of the machine. ●
- ⚠ Do not tighten the B-screws yet.
- ℹ How to insert T-nuts? [full](#)



1x Allen Key 1.5  
1x Allen Key 5

FabCaster Mini Assembly Manual L2M2 - 18

# Automated Documentation: Detail

```
@step{Building the bottom frame}

@duration{20 min}

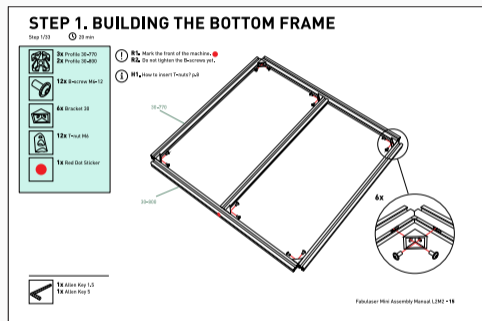
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## STEP 1. BUILDING THE BOTTOM FRAME

Step 103

20 min



3x Profile 30-770  
2x Profile 30-800



⚠ Mark the front of the machine.  
⚠ Do not tighten the B-screws yet.



12x B-screw M6-12



ℹ How to insert T-nuts? full



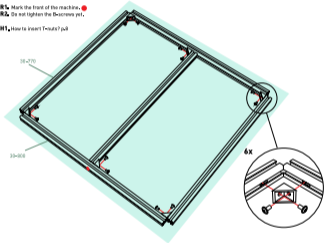
4x Bracket 28



12x T-nut M6



1x Red Dot Sticker



1x Allen Key 1.5  
1x Allen Key 5

FabCaster Mini Assembly Manual L2M2 - 18

# Automated Documentation: Detail

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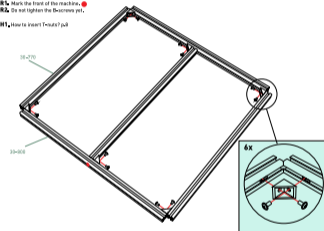
## STEP 1. BUILDING THE BOTTOM FRAME

Step 1/23

20 min



- ⓘ Mark the front of the machine.
- ⓘ Do not tighten the B-screws yet.
- ⓘ How to insert T-nuts?



FabCaster Mini Assembly Manual L2M2 - 18



# Automated Documentation: Detail

```
@step{Building the bottom frame}

@duration{20 min}

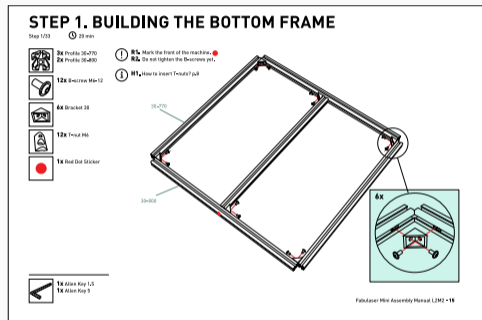
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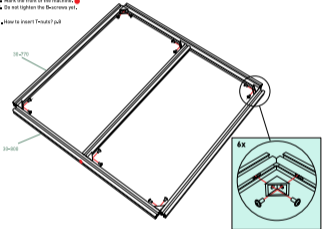
## STEP 1. BUILDING THE BOTTOM FRAME

Step 103 20 min

- 3x Profile 20-770
- 2x Profile 20-400
- 12x B-screw M6-12
- 4x Bracket 28
- 12x T-nut M6
- 1x Red Dot Sticker
- 1x Allen Key 1.5
- 1x Allen Key 5

ⓘ Mark the front of the machine.  Do not tighten the B-screws yet.

ⓘ How to insert T-nuts?  full



FabCaster Mini Assembly Manual L2M2 - 18

# Automated Documentation: Detail

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```

## STEP 1. BUILDING THE BOTTOM FRAME

Step 1/33

20 min



3x Profile 20-770



2x Profile 20-400



12x B-screw M4-12



4x Bracket 28



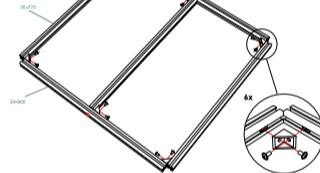
12x T-nut M6



1x Red Dot Sticker

⚠ Mark the front of the machine.  
⚠ Do not tighten the B-screws yet.

ℹ How to insert T-nuts? full



1x Allen Key 1.5



1x Allen Key 5

FabCaster Mini Assembly Manual L2M2 - 18

# Automated Documentation: Detail

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@step{Building the bottom frame}

@duration{20 min}

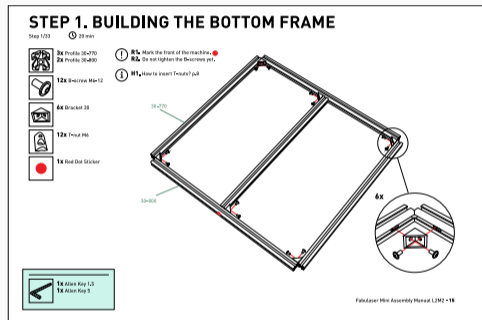
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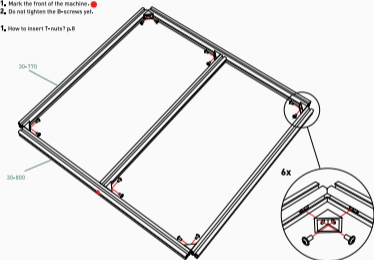
# Results: Comparison to Original

## STEP 1. BUILDING THE BOTTOM FRAME

Step 1/33 ⌚ 23 min



- ! R1. Mark the front of the machine. R2. Do not tighten the B-screws yet.
- i H1. How to insert T-nuts? p.8



Fabulaser Mini Assembly Manual L2M2 - 15

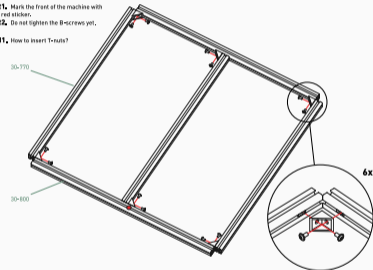
(a) Original

## STEP 1 BUILDING THE BOTTOM FRAME

Step 1/2 ⌚ 20 min



- ! R1. Mark the front of the machine with a red sticker. R2. Do not tighten the B-screws yet.
- i H1. How to insert T-nuts?



Fabulaser Mini Assembly Manual L2M2 - 14

(b) Generated

# Results: Comparison to Original

## STEP 1. BUILDING THE BOTTOM

Step 1/33 ⌚ 20 min



**3x** Profile 30-770  
**2x** Profile 30-800



**R1.** Mark the front of the machine. ●  
**R2.** Do not tighten the B-screws yet.



**12x** B-screw M6-12



**H1.** How to insert T-nuts? p.8



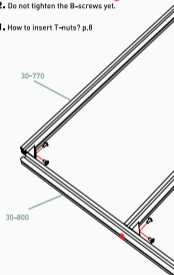
**6x** Bracket 30



**12x** T-nut M6



**1x** Red Dot Sticker



(a) Original

## STEP 1 BUILDING THE BOTTO

Step 1/2 ⌚ 20 min



**12x** T-nut M6



**R1.** Mark the front of the machine with a red sticker.  
**R2.** Do not tighten the B-screws yet.



**12x** B-screw M6-12



**H1.** How to insert T-nuts?



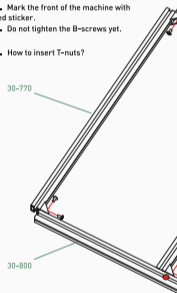
**6x** Bracket 30



**3x** Profile 30-770



**2x** Profile 30-800



(b) Generated

# Results: Comparison to Original

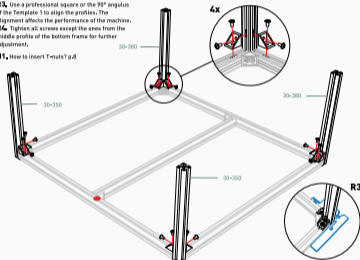
## STEP 2.1 ATTACHING THE CORNER PROFILES

Step 2/23 ⌚ 30 min

- 2x Profile 30-380
- 2x Profile 30-250
- 16x B-screw M6-12
- 16x T-nut M6
- 8x Bracket 30

**R3** Use a professional square or the 90° angle of the Template 1 to align the profiles. The alignment affects the performance of the machine.  
**R4** Tighten all screws except the ones from the middle profile of the bottom frame for further adjustment.

**H1** How to insert T-nuts? p.8



- 1x Allen Key 1.5
- 1x Allen Key 5

- 1x Square or
- 1x Template 1

Fabulaser Mini Assembly Manual LZM2 - 14

(a) Original

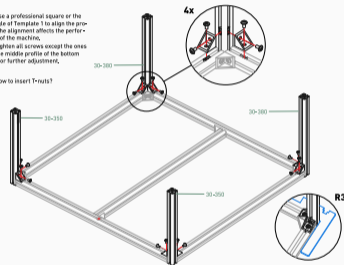
## STEP 2.1 ATTACHING THE CORNER PROFILES

Step 2/2 ⌚ 30 mins

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- 2x Profile 30-380
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**R3** Use a professional square or the 90° angle of Template 1 to align the profiles. The alignment affects the performance of the machine.  
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**H1** How to insert T-nuts? p.8



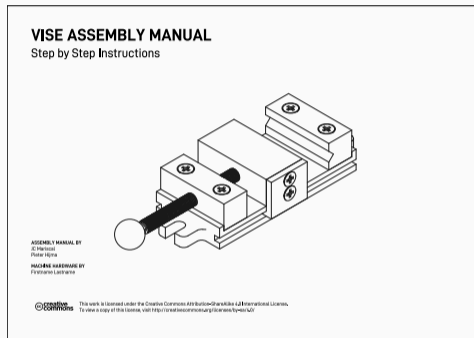
- 1x Template 1

- 1x Allen Key 5
- 1x Allen Key 1.5

Fabulaser Mini Assembly Manual LZM2 - 15

(b) Generated

# Results: Indication Time



Machine	Nr. Steps	Time to Complete
Vise	6	24 minutes
Vertical Lathe	5	26 minutes



## Going from Version $n$ to $n + 1$

- Minor changes do not require action at all
- If actions are required, they are limited in scope
  - limited set of abstractions

## Collaboration

- J.C. Mariscal-Melgar - Helmut Schmidt University
- Daniele Ingrassia, Marc Kohlen, Liane Sayuri Honda - InMachines Ingrassia

## Past funding

- EU funding in the context of the INTERFACER Project - [interfacerproject.eu](http://interfacerproject.eu)
- funded by NGI-DAPSI Open Call #3 as part of the OKH-P&IA Project

Our research proposes a novel solution to the **Documentation Update Problem** in the **collaborative environment** of Open Source Hardware.

[osh-autodoc.org](http://osh-autodoc.org)

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