MABEL: Verified Bill of Materials

One fixed core, five choices, three complete builds

MABEL project

31 July 2026

Abstract

This is the audited cost model for MABEL, an open-source mobile bimanual manipulator with a three-module swerve base, two 7-DOF quasi-direct-drive arms, two tendon-driven ORCA hands, an actuated lift–torso–neck body and an integrated perception suite — 56 functional degrees of freedom driven by 59 motors. The bill splits cleanly in two. A **fixed core** of 49 line items — every actuator, every plate, all structure, power and cabling — costs **$7,650** and is identical in every build. On top of it sit **five choices**: onboard compute, wrist cameras, head camera, an optional base depth camera, and the 2-D lidar. Those five span $405.98–$7,022.35, a 17.3× spread that accounts for the entire difference between the cheapest and the most expensive way to build this robot. Three configurations follow: **Essential $8,056**, **Recommended $9,283** and **Maximum $14,721**. Every number here is computed from seven CSV files by one script; none is typed twice. The document also records what the parts list does *not* cover ($528–$1,118 of uncosted hardware), the lines where the parts list and the robot's own firmware disagree, and two arithmetic slips in the July 2026 Build Guide that this rebuild corrects.

Keywords: bill of materials; open-source robot hardware; mobile manipulation; cost analysis; design for replication; build-or-buy.

1 Overview and scope

MABEL's hardware claim is that a research-grade mobile bimanual robot with anthropomorphic hands and an articulated neck can be built from catalog parts, with custom fabrication limited to bent laser-cut sheet metal, printed covers and two-layer distribution PCBs. That claim is only worth as much as the bill behind it. This document is that bill.

The structure that matters. Costing this robot as a single number hides the only decision that moves it. 82% of the Recommended build is a fixed core that no sourcing decision changes; the remaining 17.3× of spread lives in five components chosen after the mechanism is settled. Presenting the bill any other way invites the reader to argue about a total when the real question is which Jetson and which cameras.

In scope. Every physical part needed to build one MABEL: actuators, structure, fasteners, sensing, onboard networking, power, embedded controllers and onboard compute.

Out of scope. Shipping, duties and sales tax; 3-D printed parts and filament; the custom PCBs and their components; labour; the teleoperation headset (a Vision Pro or an iPhone is a client, not a robot part); the development workstation; and training compute. The uncosted physical items are estimated in §9 rather than ignored.

Source of truth. Line items live in `BOM/data/core.csv` and `BOM/data/choices.csv`. Every number, table and figure here — and the data the project website renders — is regenerated from those CSVs by `BOM/tools/build_bom.py` (§10).

2 Method

2.1 Currency

Chinese-vendor parts (the DAMIAO actuators, the OpenArm structure and harness, the Feetech hand servos and their bus boards) are quoted in CNY and converted at a single rate,

$$1 \text{ CNY} = \$0.1434 \qquad (1 \text{ USD} = 6.9724 \text{ CNY}), \tag{1}$$

the rate implied by the parts list's own line reading ¥599 = $85.91. Ten lines depend on it; the Amazon, DigiKey, McMaster, RobotShop and Stereolabs lines do not. If the rate moves, rescale those ten together — one constant in the build script does it.

2.2 Pricing date, and why it matters this month

All prices are as of 31 July 2026 and track the Build Guide edition of the same date, which added printed material to the core and renumbered the choice groups. One event dominates the difference between this edition and the previous one: on **22 July 2026 NVIDIA raised the price of every Jetson module and developer kit**, by between 33% and 101%. The AGX Thor kit went from $3,499 to $5,499 and the Orin Nano Super kit from $249 to $399. The bill as first costed totalled $12,969 with Thor at $3,500; the identical build today is $14,968. Nothing about the robot changed. This is the clearest argument in the document for treating compute as a choice rather than a component.

2.3 Verification protocol

Prices were taken from a vendor page or from the purchase record, and each line was cross-checked against what the repository says is actually installed — the hardware-abstraction layer identifies servos by the model number they report over the bus, the firmware manifest names each microcontroller and its bus, and the MuJoCo model is the canonical geometry. Where a listing label and the code disagreed, both are recorded: lines marked † in Table 2 carry a corrected part number, and the one line marked ∗ is an unresolved conflict (§9). Model numbers, not listing URLs, are given for the Chinese vendors in Appendix A: URLs expire, model strings do not.

3 Where the money goes

4 The fixed core

The core is ordered first and depends on nothing decided later.

Filament is a part, not an afterthought. Section 8 costs the 7 kg of PLA the covers, sensor mounts, trim and ORCA hand structure consume: $120.68 at Bambu Lab's standing bulk price, 25% off 4 rolls or more, which the core carries because the build takes seven. At list the same seven spools would be $160.91 and the core $7,690. Earlier editions of this bill left printed material uncosted and carried it as an estimate; it is a real line now.

What it does	Cost ($)	Share
Actuation	5,879	63.3%
Compute	1,249	13.5%
Structure	1,142	12.3%
Perception	384	4.1%
Power & wiring	295	3.2%
Data & connectivity	249	2.7%
Control & misc	86	0.9%
Total	**9,283**	**100.0%**

Table 1: The Recommended build regrouped by what each part *does* rather than where it bolts on. Actuation — every joint motor, hand servo, swerve module and the lift column — is $5,879 or 63.3%, the largest category by a wide margin, and no sourcing decision changes it.

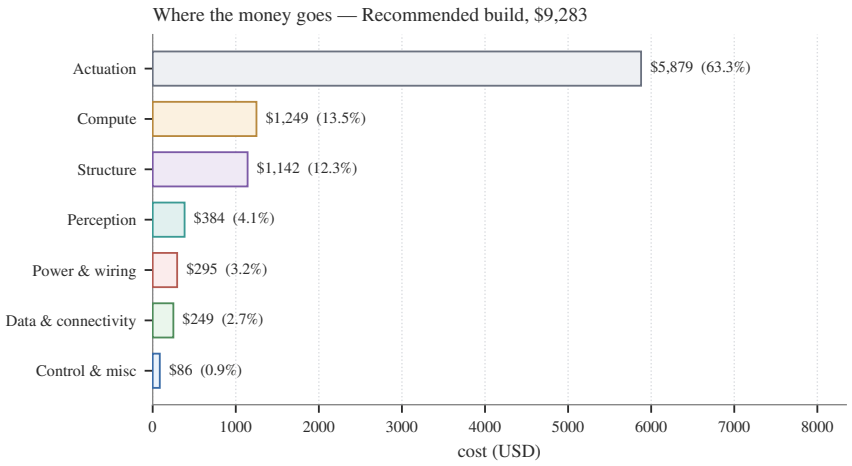


Figure 1: Cost by function, Recommended build. Actuation dominates because cost scales with degrees of freedom; the interesting consequence is at the other end of the scale — see §7.

Table 2: The fixed core: every line identical in the Essential, Recommended and Maximum builds. † part number corrected against the verified vendor listing; ∗ disputed against the repository (§9); ¥ quoted in CNY and converted by Eq. 1.

Ref	Item	Qty	Unit ($)	Ext. ($)
Mobile base				
1.01	REV 3in MAXSwerve Module†	3	275.00	825.00
1.01b	REV MAXSwerve Motor & Controller Bundle†	3	280.00	840.00
1.02	Base sheet metal, lower	1	51.75	51.75
1.03	Base sheet metal, upper	1	195.36	195.36
	subtotal			**1,912.11**
Body / torso				
2.01	FlexiSpot E7 Pro lift column	1	399.00	399.00
2.02	Lift-to-torso adapter	1	59.26	59.26
2.03	Torso output plate	1	55.16	55.16

Table 2 – continued

Ref	Item	Qty	Unit ($)	Ext. ($)
2.04	Body bottom plate	1	33.55	33.55
2.05	Arm mounting plate	2	13.17	26.34
2.06	Neck mounting plate	1	29.05	29.05
2.07	DAMIAO DM10422P torso actuator	1	286.70 ¥	286.70
	subtotal			**889.06**
Arms - both				
3.01	DAMIAO FOCGM43 joint module†	6	85.91 ¥	515.46
3.02	DAMIAO DM4340 joint motor†	4	126.55 ¥	506.18
3.03	DAMIAO DM8009P joint module†	4	272.36 ¥	1,089.44
3.04	OpenArm structural set	1	387.10 ¥	387.10
3.05	Arm harness set†	1	124.06 ¥	124.06
	subtotal			**2,622.24**
Hands - both				
4.01	Feetech HL3915M servo	32	33.70 ¥	1,078.54
4.02	Feetech HL3930M servo	2	51.49 ¥	102.98
4.03	ST/SC bus servo driver board	2	3.97 ¥	7.93
4.04	Bus servo power distribution board	2	2.58 ¥	5.16
	subtotal			**1,194.61**
Neck / head				
5.01	Robotis Dynamixel 2XL430-W250-T∗	1	149.39	149.39
5.02	DAMIAO FOCGM43 neck actuator	1	85.91 ¥	85.91
	subtotal			**235.30**
Structural hardware				
6.01	Aluminium extrusion, cut lengths	1	101.46	101.46
6.02	Extrusion 90 degree corner brackets	1	26.90	26.90
6.03	Extrusion angled plates	1	20.88	20.88
6.04	Metric screw assortment	1	13.99	13.99
6.05	Imperial screw assortment	1	8.99	8.99
6.06	Neodymium magnets	1	11.99	11.99
	subtotal			**184.21**
Electronics, power & cabling				
7.01	SODOLA 6-port 2.5 GbE switch	1	49.99	49.99
7.02	USB expansion board	1	74.99	74.99
7.03	Battery	2	46.81	93.62
7.04	Ethernet twinax cable	1	45.99	45.99
7.05	Wi-Fi antenna cable	2	17.99	35.98
7.06	Power cable, 6XT	1	24.99	24.99
7.07	Buck converter 24 V to 12 V	1	18.99	18.99
7.08	Speaker + USB sound card	1	19.50	19.50
7.09	Power cord extension	1	16.95	16.95
7.10	Fuse box	1	15.99	15.99
7.11	Raspberry Pi Pico	1	15.95	15.95
7.12	Motor driver	1	9.99	9.99
7.13	USB-C to USB-A cable	4	6.99	27.96
7.14	Ethernet patch cable	2	6.99	13.98
7.15	Protective sleeving, 1/2 in	2	8.99	17.98
7.16	Protective sleeving, 1/4 in	1	8.99	8.99
7.18	Custom PCBs	1	*TBD*	*TBD*
7.19	Custom PCB components	1	*TBD*	*TBD*

Table 2 – continued

Ref	Item	Qty	Unit ($)	Ext. ($)
	subtotal			**491.84**
3D printed material				
8.01	Bambu Lab PLA Basic, Jade White†	4	17.24	68.96
8.02	Bambu Lab PLA Basic, Black†	2	17.24	34.48
8.03	Bambu Lab PLA Basic, Light Gray†	1	17.24	17.24
	subtotal			**120.68**
	Core subtotal			**7,650.05**

5 The five choices

Everything below sits on top of the core. Pick one option from each group.

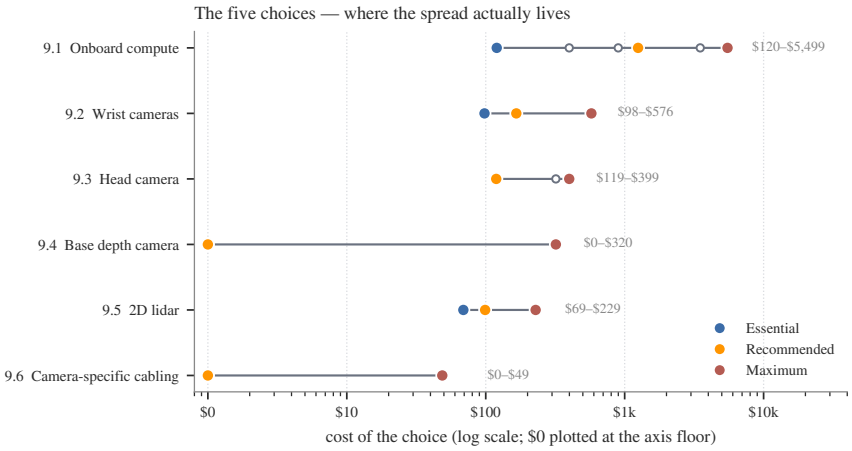


Figure 2: Each choice group's span, with the three build picks marked. Compute is the only group whose range covers more than an order of magnitude, and it is larger than the other four combined at every tier.

8.1 Compute — memory, not TOPS. The policy, cuVSLAM, Nav2 and every camera stream must be resident at once, and the Jetson module is soldered. That makes memory the binding constraint and the choice close to permanent — except that the Orin Nano Super carrier accepts Orin NX modules, so the $399 kit is also a route to 16 GB later. Buy the kit now, swap the module when the policy outgrows it.

8.2 Wrist cameras — the highest-value $68 in the build. The step from 720P to 1200P across the pair is $68 and buys the fine detail a manipulation policy learns from. Dropping the D405s loses metric depth at the wrist, which most RGB-conditioned policies in the UMI lineage never use.

8.3 Head camera. The ZED Mini gives on-board depth and visual-inertial odometry; the IEights pair gives raw synchronised stereo and moves matching onto the host, which costs memory on a

smaller computer. Choosing MMlove wrists and the IEights head for both wrist and head also removes $48.66 of camera-specific cabling — the Micro-B pair and the ZED USB-C run are not needed, which is why cabling appears as its own row in Table 4.

8.4 Base depth camera — the honest optional. A 2-D lidar sees one horizontal plane. It will not see a table edge at torso height, a low pallet or an overhanging shelf. If MABEL only ever drives across open floor the lidar alone is enough and this line is $0; if it works around furniture, add the D435i or expect to hand-annotate keep-out zones in the costmap. On an 8 GB Orin Nano the point cloud competes for exactly the memory the policy needs, and it is the first thing that would have to be turned off anyway.

8.5 2-D lidar. All four options publish a standard `LaserScan` and work with `slam_toolbox` and Nav2 unmodified. The LD19 is a third of the price of the A2M12 and, being direct time-of-flight rather than triangulation, holds accuracy at range better; the A2M12 wins on sample rate (16 kHz against 4.5 kHz), which matters for fast rotation, not for a robot that drives at walking pace.

How the lidar and the depth camera divide the work. The lidar does localisation and mapping — it is the sensor `slam_toolbox` consumes, and no depth camera substitutes for it well. The depth camera does 3-D obstacle avoidance in the local costmap. They are not interchangeable, but the depth camera is optional in a way the lidar is not: every build here includes a lidar, only Maximum includes the D435i.

Table 3: The five choices, plus the cabling they imply. Every option publishes a standard interface, so any row swaps without touching the mechanism.

Ref	Option	Cost ($)	Build
9.1 Onboard compute	6 options, $120–$5,499		
	Raspberry Pi 5 16 GB	120.00	Essential
	NVIDIA Jetson Orin Nano Super Dev Kit	399.00	
	NVIDIA Jetson Orin NX 8 GB + carrier	899.00	
	NVIDIA Jetson Orin NX 16 GB + carrier	1,249.00	Recommended
	NVIDIA Jetson AGX Orin 64 GB Dev Kit	3,499.00	
	NVIDIA Jetson AGX Thor Developer Kit	5,499.00	Maximum
9.2 Wrist cameras	3 options, $98–$576		
	MMlove AR0144 GS-720P-60fps (×2)	97.98	Essential
	MMlove AR0144 GS-1200P-90fps (×2)	165.98	Recommended
	Intel RealSense D405 (×2)	576.00	Maximum
9.3 Head camera	3 options, $119–$399		
	IEights OG02B10 stereo, 1200P 60 fps, 100 deg HFOV	119.00	Essential, Recommended
	Intel RealSense D435i	319.72	
	Stereolabs ZED Mini	399.00	Maximum
9.4 Base depth camera	2 options, $0–$320		
	Omit - rely on the 2D lidar	0.00	Essential, Recommended
	Intel RealSense D435i	319.72	Maximum
9.5 2D lidar	4 options, $69–$229		
	youyeetoo FHL-LD19	69.00	Essential
	Slamtec RPLIDAR C1	99.00	Recommended
	youyeetoo FHL-LD19 Plus	99.00	
	Slamtec RPLIDAR A2M12	228.63	Maximum

Ref	Option	Cost ($)	Build
9.6 Camera-specific cabling	2 options, $0–$49		
	None needed	0.00	Essential, Recommended
	Micro-B pair + ZED USB-C run	48.66	Maximum

6 Three complete builds

	Essential	Recommended	Maximum
Fixed core (§4)	7,650	7,650	7,650
9.1 Onboard compute	120.00	1,249.00	5,499.00
9.2 Wrist cameras	97.98	165.98	576.00
9.3 Head camera	119.00	119.00	399.00
9.4 Base depth camera	0.00	0.00	319.72
9.5 2D lidar	69.00	99.00	228.63
9.6 Camera-specific cabling	0.00	0.00	48.66
Total	**8,056**	**9,283**	**14,721**

Table 4: Each build is the same $7,650 core plus one option per group. Essential saves $6,665 against Maximum (45%) with an identical mechanism; Recommended saves $5,438 (37%) and keeps the 16 GB that decides which policies run onboard.

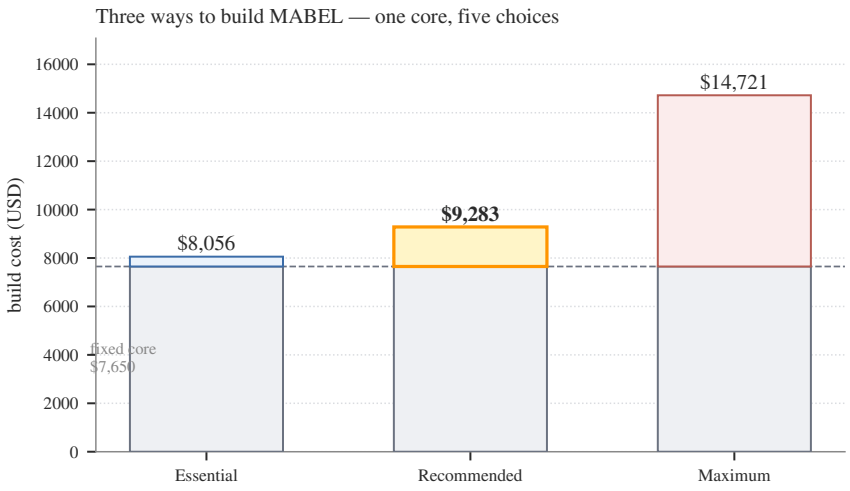


Figure 3: The grey block is the fixed core, identical in all three. Everything above the dashed line is the five choices.

Essential — $8,056. Raspberry Pi 5, 720P global-shutter wrists, IEights stereo head, no base depth camera, LD19 lidar. This is a genuine working robot rather than a stripped one: the mechanism is identical to Maximum, and every difference is a sensor or a compute tier that upgrades later without touching the structure.

Recommended — $9,283. Orin NX 16 GB, 1200P wrists, IEights stereo head, no base depth camera, RPLIDAR C1. It keeps the memory that decides what runs onboard and spends nothing on sensing that is unlikely to be used. This is the number to quote.

Maximum — $14,721. Jetson Thor, RealSense D405 wrists, ZED Mini head, D435i at the base, A2M12 lidar — everything the original bill specified. 13.5% of the Recommended build is compute; in Maximum that one line is larger still.

Sensing is the most flexible money in the build. Perception falls from $1,523.35 as specced to $383.98 in Recommended and $285.98 in Essential — reductions of 75% and 81%. What makes that flexibility different in kind from the compute decision is that sensing is *four independent decisions rather than one*, and each can be taken on its own: dropping the base depth camera saves $319.72, the head camera $280.00 against a synchronised IEights stereo pair, the wrist pair up to $478.02, and the lidar $159.63. None of it is soldered. Every sensor here is a USB or serial part on an external mount, so a lab can start at the Essential tier and upgrade one position at a time without touching the structure, the loom or any software interface. Compute is the opposite: one soldered decision, made once, with no way back.

7 Why the cost is what it is

7.1 Actuation dominates, and that is structural

Actuation is $5,879 of the Recommended build, 63.3%, and cost here scales with degrees of freedom. No sourcing decision changes it, which puts a hard floor under any version of this robot. Within that floor the numbers are worth stating plainly: the 14 arm actuators average $150.79 each and the 34 hand servos $34.75. **The hands carry most of MABEL's degrees of freedom for 12.7% of the Recommended build's cost** (8.0% of Maximum's). Dexterity is not what makes this robot expensive.

7.2 Compute is the only line that moves by an order of magnitude

Compute is 13.5% of the Recommended build and considerably more of Maximum — more than every actuator in both arms and both hands combined ($3,292.60). It is also the only category that can fall tenfold without touching the mechanism, and, as §2 records, the only one whose price doubled this month for reasons that have nothing to do with robotics.

7.3 Everything else is noise

Batteries are $93.62. Power and wiring, data and connectivity, and control and miscellany together are a few per cent of the build, and there is no saving to find there. The real power question is headroom rather than cost: AGX Orin at 60 W, and Thor well above it, would force a battery redesign that appears nowhere in this document.

7.4 Build or buy: the decision that makes MABEL affordable

MABEL's arms are an OpenArm, built from the same DAMIAO motors the official product uses: 8009P at the shoulder, 4340 through the upper arm and elbow, 4310 at the wrist. The licensed manufacturer sells the finished bimanual system for $6,000 plus $480 US air freight. Sourcing the

Option	Both sides ($)	vs. MABEL
Arms — both sides		
MABEL, built from source motors	2,622.24	—
7 DOF/arm, 6.0 kg peak, DAMIAO 8009P + 4340 + 4310		
OpenArm 2.0 assembled, delivered US	6,480.00	+147%
Same arm, same motors: $6,000 kit + $480 air freight		
OpenArm 2.0 online + ZED top camera	7,300.00	+178%
Card checkout price, camera package included		
AgileX PiPER x2	4,998.00	+91%
6 DOF/arm, 1.5 kg payload, $2,499 each		
Hands — both sides		
MABEL, Feetech bus servos	1,194.61	—
34 servos + driver boards; actuators and electronics only		
ORCA hand, self-built to the ETH BOM	4,915.00	+311%
17 DOF/hand, full material cost, under CHF 2,000 each		
orcahand, ORCA Dexterity	7,000.00	+486%
17 DOF/hand, assembled, $3,500 each		
orcahand touch, ORCA Dexterity	12,200.00	+921%
17 DOF/hand, tactile on all five digits, from $6,100 each		
Allegro Hand	36,861.00	+2986%
16 DOF/hand, direct-drive, about CHF 15,000 each		

Table 5: Sourcing actuators at source rather than inside a finished product. Percentages are against MABEL's own line.

identical motors and CNC set directly costs $2,622.24, **59.5% less**. The premium buys factory assembly, a moulded industrial harness, a flight case, a two-finger gripper with RGB camera, CE and UKCA paperwork and a one-year warranty — not more capability. Against commercial arms in the same class the gap is starker: two AgileX PiPER arms cost $4,998 for 6 DOF and 1.5 kg payload each; MABEL's pair costs 47.5% less, carries one more DOF per arm and lifts four times the load.

The hand comparison needs a caveat, and it should be stated every time. MABEL's $1,194.61 is *actuators and driver boards*. ORCA's CHF 2,000 is a complete material cost including printed structure, tendons, bearings, fasteners and tactile sensors. Adding MABEL's printed parts and hardware would plausibly land near $800–1,000 per hand — still under half the ORCA material cost and a fifth of the assembled price, but the defensible comparison is actuators to actuators, and quoting the raw ratio would not be honest.

7.5 Against the field

At $166 per functional degree of freedom, MABEL is priced comparably to single-arm research kits while providing a mobile base, a second arm, two dexterous hands and an actuated neck.

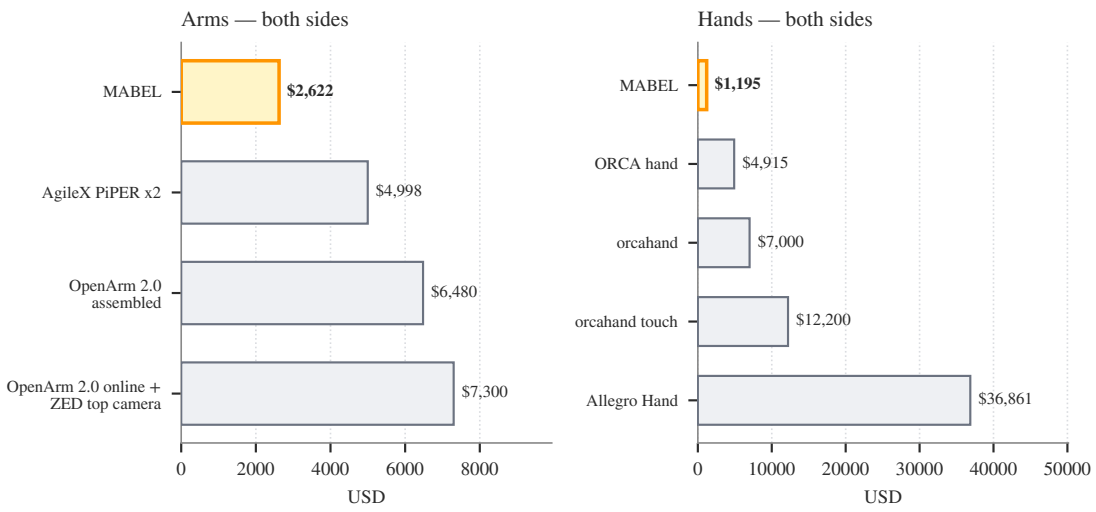


Figure 4: Arms and hands against the assembled alternatives. The hand comparison is *not* like-for-like — see the caveat below.

7.6 The ten lines that carry the build

The ten most expensive lines of the Maximum build carry $11,728 — 79.7% of it. The other 45 items total $2,993. If the goal is to change what this robot costs, those ten are the only lines worth arguing about.

8 Machined parts, and the case for a group buy

Seven parts are not bought off a shelf. Upload each DXF or STEP to an online sheet-metal service and select the operations listed; quotes are 5052 H32 aluminium at 2.0 mm (0.080 in). *Hardware insertion* means PEM nuts or standoffs pressed in at the fabricator, *tapping* means threaded holes cut there rather than on the bench, and *dimple forming* raises a shallow boss for fastener clearance.

Part	**Qty**	**×1**	**×2**	**×10**	**×50**	**×100**	**×1000**
Base sheet metal, lower	1	51.75	38.05	27.59	26.39	25.98	24.54
Base sheet metal, upper	1	195.36	156.42	112.94	97.49	88.30	85.82
Lift-to-torso adapter	1	59.26	40.69	28.93	25.15	22.42	17.99
Torso output plate	1	55.16	36.62	25.70	22.77	21.87	19.29
Body bottom plate	1	33.55	22.29	15.73	12.81	11.44	8.97
Neck mounting plate	1	29.05	19.21	13.86	10.93	9.74	7.60
Arm mounting plate	2	13.17	13.17	9.42	7.56	6.64	5.26
Full set per robot		**450.47**	**339.62**	**243.59**	**210.66**	**193.03**	**174.73**

Table 6: Machined set with volume pricing. One set costs $450.47; ten sets cost $243.59 each, a 46% reduction, because setup and tooling dominate at quantity one.

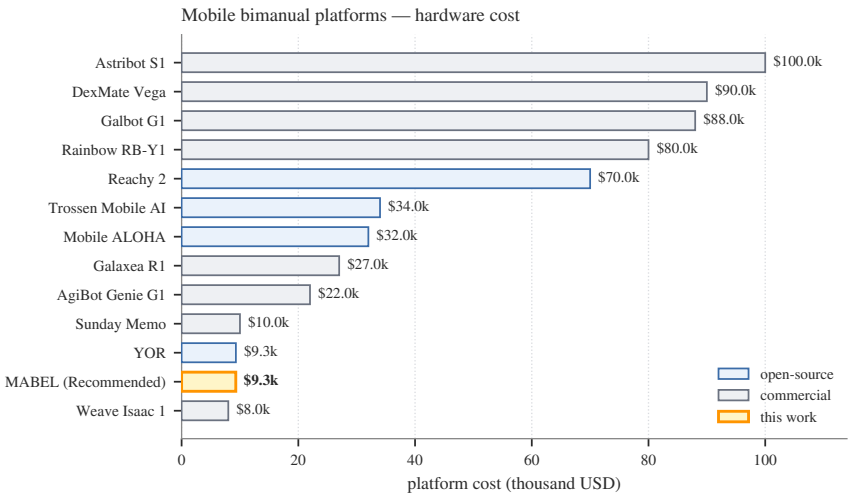


Figure 5: MABEL (Recommended) against surveyed mobile bimanual platforms. Peer prices are manufacturer-stated or retail-listed; commercial platforms are frequently inquiry-only, so this supports an order-of-magnitude argument rather than a precise ranking.

9 Open items: what is unresolved and what is uncosted

A bill that hides its gaps is not a bill. Three kinds of item are recorded here and deliberately kept out of every total above.

The swerve line, itemised. Earlier editions carried $675 per module, the sum as paid, against a REV product page that prices the module at $275 and states that motors, controllers and framing are not included. This edition itemises the line at REV's catalogue: the 3in MAXSwerve module (REV-21-3005, $275) and REV's own motor and controller bundle for it (REV-15-2992: a NEO, a NEO 550 and two SPARK MAX, $280), $555 per module and $1,665 for three — $360 less than the lump, which covered nothing the line named. Both are linked from the table, so a reader orders exactly what moves.

The neck servo conflict. The bill lists one Dynamixel 2XL430-W250-T. The hardware-abstraction layer disagrees with evidence: the Dynamixel driver maps the model number the servos report over the bus and records that MABEL's neck reports model 1090, an XC330-T181, and the hardware configuration says there are two of them, pitch and roll. Both sources cannot be right. Ten minutes at the robot with the bus scanner settles it.

Two microcontrollers are uncosted. The firmware manifest names two Teensy 4.1 boards — one runs the swerve base over UDP to the REV SPARK CAN bus, the other runs the arms, torso and neck at 500 Hz across three DAMIAO CAN buses. Neither appears on the parts list, and without them the robot has no low-level control at all.

Where the gaps leave the total. Carrying the estimated range, the Recommended build becomes $9,811–$10,401. A prospective builder should budget the Recommended number plus that range plus shipping and duties, which for the Chinese-vendor block are not trivial.

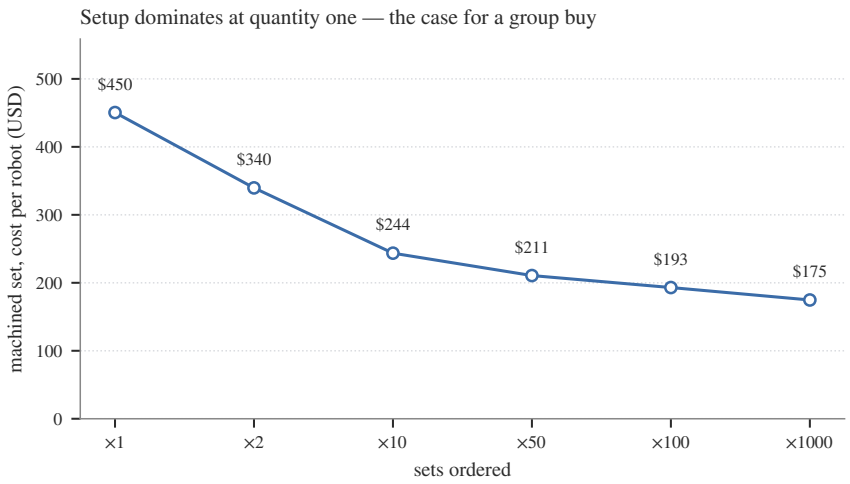


Figure 6: Cost per robot of the machined set against order quantity. This is the easiest saving in the whole build for a lab making more than one, and it is also why the upper base plate costs nearly four times the lower one at similar size: four bends, dimpling, insertion and tapping against a plain laser cut.

Two arithmetic errors, found and closed. An earlier edition of the Build Guide stated that the ten largest lines carried $11,496.72 (88.6%) against a printed share column summing to 80.8%, and attributed a perception figure of $362.96 to the Essential build when it is the Recommended build's. Both were caught by recomputing from the line data and both are corrected in the edition this document tracks. They are recorded here rather than deleted because the mechanism that caught them — deriving every published figure from one CSV rather than transcribing it — is the reason this folder exists.

10 Implementation and usage

```
cd BOM
python3 tools/build_bom.py   # CSV -> figures, LaTeX tables, JSON, website bundle
make                         # generated/*.tex -> mabel_bom.pdf
```

`build_bom.py` reads seven CSVs under `data/`, converts currency by Eq. 1, resolves each build by selecting the option tagged for its tier, computes every subtotal, span and share, writes six vector figures and eight LaTeX fragments, emits `generated/bom_summary.json`, and publishes the bundle the website renders. It hard-codes no totals: changing a price in a CSV changes the abstract of this document.

Adding an option. Append a row to `choices.csv` with its `choice_id` and, if it belongs to a named build, that build's tier. The tables, the span figure, the build totals and the website configurator all pick it up on the next run.

The website mirror. `bom_summary.json` is what the public BOM page renders, so the page and this document cannot disagree. Both PDFs — this one and the Build Guide — are published alongside it.

11 Limitations

- **Marketplace prices are not catalog prices.** The Amazon and Taobao lines are as-purchased and will drift; several camera and lidar options are street-price estimates, marked as such in the guide they came from. This is why the document is dated rather than evergreen.
- **No shipping, duty or tax.** For the CNY block in particular these are a material fraction and are entirely absent.
- **One robot, no spares.** The tendon-driven hands are the highest-wear subsystem on the platform, and a working data-collection programme will consume spare servos, tendon and fingertips.
- **The open items in §9 are open.** Two of them — the swerve content and the neck servo — are unresolved conflicts, not estimates, and one changes what a reader receives when they order.
- **Estimates are labelled but still estimates.** Every range in Table 7 is a judgement, not a receipt.
- **Peer prices are heterogeneous.** Figure 5 mixes manufacturer-stated prices, retail listings and third-party reports.
- **The build-or-buy hand row is not like-for-like**, and is flagged wherever it appears.

A Verified Chinese-vendor prices

Every CNY line with the price actually paid. Model numbers are the strings to search on — listing URLs expire, model numbers do not. Three lines were bought below list; the DM8009P is the one worth knowing about, at ¥1,899 against a ¥2,529 list price, a 25% discount worth $90.38 per motor and $361.52 across the four the arms need. DAMIAO pricing moves, so treat these as what was achievable rather than guaranteed.

References

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[8] MABEL project. *Repository: firmware manifest, hardware-abstraction layer configuration, and canonical MuJoCo model*, 2026.

Kind	Item	Estimate ($)
correction	**Neck servo identity** The BOM carries 1x Dynamixel 2XL430-W250-T at $149.39. mabel_hw/drivers/dynamixel.py records that MABEL's neck reports model 1090 = XC330-T181, and config.py:665 says there are two of them, pitch and roll. 2x XC330-T181-T is $206.78. Ten minutes with the bus scanner settles it.	—
gap	**Teensy 4.1 microcontrollers** firmware/CLAUDE.md names two: one runs the swerve base over UDP to the REV SPARK CAN bus, the other runs the arms, torso and neck at 500 Hz across three DAMIAO CAN buses. Neither is on the parts list, and without them the robot has no low-level control.	63
gap	**ORCA hand structural kit** The list buys 34 servos but no frame, tendon, bearings, tensioners or fingertip pads. The guide's own build-or-buy page estimates $800-1,000 per complete hand against $597.30 of actuators.	300–600
gap	**Custom distribution PCBs** Lines 7.18 and 7.19 are marked TBD; the guide budgets $100-300 at JLCPCB for boards plus components. No gerbers are released under hardware/ yet.	100–300
gap	**USB-CAN adapter (bench)** firmware/can_up.sh auto-detects a gs_usb or slcan dongle. Optional in the finished robot, required for bench bring-up.	25–45
gap	**Hardware E-stop switch + contactor** The safety docs describe a hardware E-stop that de-energises actuators independently of the host. The OpenArm harness set (3.05) includes an e-stop, so this may already be covered.	30–80
gap	**Head microphone** A speaker is costed; the paper describes head microphones for telepresence.	10–30
	Uncosted hardware, estimated	**528–1,118**

Table 7: Corrections still open against the parts list, hardware that is on the robot but costed nowhere, and two arithmetic errors in the July 2026 Build Guide that this rebuild corrects.

Model	List (¥)	Paid (¥)	USD	Lines
DAMIAO FOCGM43 joint module Motor with integrated driver · v1.1 (V3)	650.00	599.00	85.91	3.01, 5.02
DAMIAO DM4340 joint motor Motor with integrated driver · 9 N·m rated	899.00	882.33	126.55	3.02
DAMIAO DM8009P joint module Motor with integrated driver · V4	2,529.00	1,899.00	272.36	3.03
DAMIAO DM10422P torso actuator Motor with built-in dual inductive encoder	—	1,999.00	286.70	2.07
OpenArm structural set Dual-arm structural set · CNC 7075 + stainless	—	2,699.00	387.10	3.04
OpenArm harness set Harness + hub + e-stop + power adapter board + PSU	—	865.00	124.06	3.05
Feetech HL3915M servo HL-3915-C001 · 12 V · 14 kg-cm · dual-shaft	—	235.00	33.70	4.01
Feetech HL3930M servo HL-3930-C001 · 12 V · 35 kg-cm · dual-shaft	—	359.00	51.49	4.02
ST/SC bus servo TTL driver board Bundle 1: TTL Adopter (A)	28.00	27.65	3.97	4.03
ST/SC 5264 splitter board TTL-5264 8P Hub (A)	—	18.00	2.58	4.04

Table 8: Verified unit prices, converted by Eq. 1. Quantities are in Table 2.