The Humanoid Actuation Report

Fundamentals, Architectures, Vendors, and the Ten-Year Outlook

Strip away the shell and this is the machine.

Actuation is 40–60% of the bill of materials — the largest single block.

stiff, non-backdrivable

backdrivable, low ratio

Humanoid.guide

Free Preview – What Each Chapter Covers

Report Date: August 2026
Total Length: ~99,000 words · 249 pages · Executive Summary + 15 chapters + appendix
Scope: Motors, gearing, linear actuation, dexterous hands, drive electronics and the actuator supply chain, 2026–2036
Includes: 49 tables · 24 figures · 625 sources

0. Executive Summary

The Executive Summary compresses the full report into the argument a buyer needs in one sitting: the humanoid robot crossed from prototype to product in 2025, and the subsystem that decides what those machines can do and what they cost is not the AI model but the actuator – the motor, transmission, sensors and drive electronics packaged into each of the 28 to 44 joints of a full-size platform. It states the report's organising claim directly, that component cost curves rather than robot announcements are the primary adoption variable, and it explains why the executive summary of a motor-and-gear report is, in effect, a summary of the humanoid market itself.

Four findings carry the argument. The first locates the economic centre of gravity of the machine, and shows why five credible sources that appear to disagree about it are measuring the same thing at different boundaries. The second describes the industry's split into two physical actuation species, names the one body zone where the contest is still genuinely open, and the one place both camps have already converged on the same answer. The third traces the collapse of a supply position held for decades, and identifies what replaced the legal moat once the patents expired. The fourth frames the decade ahead. The summary closes with the report's ten canonical figures – each with its confidence tier and its source – so a reader can quote the numbers without re-reading the chapters. Readers who want the argument before the evidence should start here; the fifteen chapters and appendix that follow are the substantiation. Includes the canonical-numbers table and one figure.

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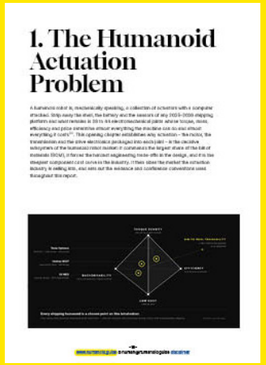
1. The Humanoid Actuation Problem

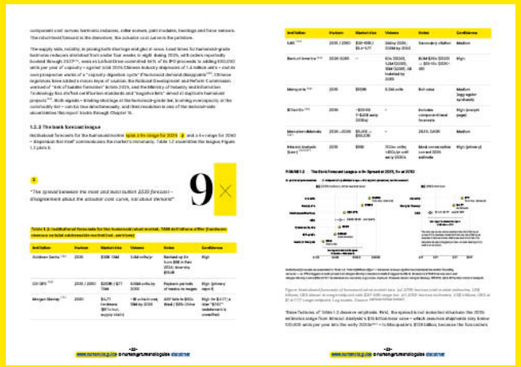
A humanoid robot is, mechanically, a collection of actuators with a computer attached. This opening chapter establishes why that subsystem is the decisive one: it commands the largest share of the bill of materials, it forces the hardest engineering trade-offs in the design, and it carries the steepest component cost curve in robotics. It then sizes the market the actuation industry is selling into, and – unusually for a market report – sets out in advance the evidence rules it will hold itself to, including how conflicting sources were adjudicated and which widely circulated claims were resolved against the record and therefore do not appear as fact anywhere in these pages.

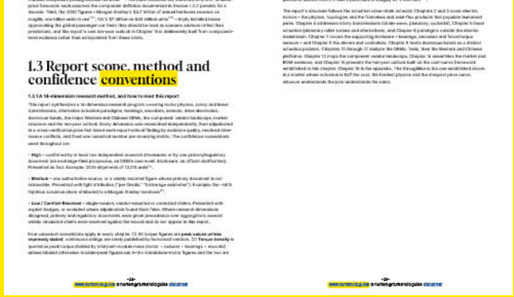
Why Actuators Decide Everything works through actuation's share of the bill of materials and the four-way engineering tension – torque density, backdrivability, efficiency, cost – that no joint design can escape, then adds a fifth selection criterion that appears on no datasheet and is quietly reshaping the industry's hardware choices. Market Context establishes the 2025 shipment base and why the most-quoted vendor figure in the market is disputed by 30 per cent, sizes the actuator market against the robot market, and assembles the institutional forecast league – where the spread for a single year is wide enough to be a finding in its own right, and where the report shows the banks are really disagreeing about one variable rather than about demand. Report Scope, Method and Confidence Conventions explains the fourteen-dimension research programme and the four conventions that make every torque figure in the report comparable. Includes a bill-of-materials comparison table, the full bank forecast league table, and two figures.

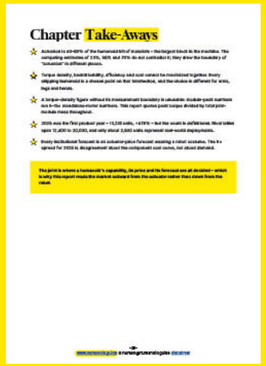

1. The Humanoid Actuation Problem


1.1 Why actuators decide everything


1.2 Market context




1.3 Report scope, method and confidence conventions


Chapter Take-Aways

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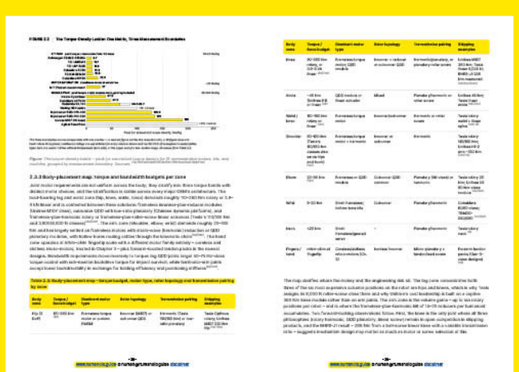
2. Electric Motor Fundamentals for Humanoid Joints

Almost every visible design choice in a humanoid joint – why the motors are wide and flat, why the pole counts are high, why one vendor's leg module looks nothing like another's – follows from a small set of electromagnetic scaling laws. This chapter derives them, then applies them to the parts actually on the market. Its sharper argument is a warning about how those parts are compared: the single specification the industry markets hardest turns out to measure something other than what buyers think it measures, and the chapter gives the one question to ask before any torque-density figure is allowed into a model.

The Physics That Shapes Every Humanoid Joint identifies which motor constant is the honest comparator – it is not peak torque – and settles why the permanent-magnet brushless machine won outright against steppers, induction and switched reluctance, including the one magnet-free topology worth monitoring for reasons that have nothing to do with engineering. Frameless Torque Motors covers the default building block, what the housing-free format actually buys and what it costs inside a sealed joint, Tesla's custom actuator classes, and the Chinese cost disruption now running through the layer at rates that make any published price a snapshot. Benchmarking Real Humanoid Joint Motors puts fifteen motors and modules in one table under one convention label each, and maps torque and bandwidth budgets by body zone – showing which joint is still architecturally undecided and where the money on a humanoid body actually sits. Includes three comparison tables and two figures.



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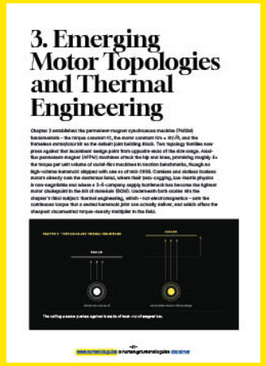
3. Emerging Motor Topologies and Thermal Engineering

Two topology families are pressing on the incumbent frameless motor from opposite ends of the size range: axial-flux machines attacking the hip and knee, and ironless coreless motors that already own the dexterous hand on physics no gearbox can compensate for. But the chapter's real argument is that neither topology is the binding constraint. Something far less glamorous is – and it is also the cheapest performance multiplier left in the machine, available today, at a weight penalty most designers would take without hesitating.

Axial-Flux Motors explains the geometric case, benchmarks it against the one commercial machine everyone cites, and then does what the promotional literature does not: checks the headline density multiple against that machine's own envelope, notes who profits from the claim, and asks how many high-volume humanoids had actually shipped an axial-flux joint by mid-2026. Coreless and Slotless Motors for Dexterous Hands documents why ironless windings own the fingers, the manufacturing barrier that leaves the entire industry dependent on a handful of qualified suppliers worldwide, and what happens to that bottleneck as hand designs push motor counts up by a factor of four. Thermal Engineering as the Binding Constraint quantifies what a sealed joint actually sustains against the torque printed on its datasheet, walks the cooling ladder from conduction to liquid-cooled joints, and explains which rung will reach volume robots first – and why it is not the one making headlines. Includes two comparison tables and one figure.


3. Emerging Motor Topologies and Thermal Engineering


3.1 Axial-flux motors


3.2 Coreless and slotless motors for dexterous hands


3.3 Thermal engineering as the binding constraint


Chapter Take-Aways

Get the full Report

4. Rotary Gearing Technologies

The industry never picked a winning reducer, and this chapter argues it never will: strain-wave, planetary and cycloidal are all industrially proven and co-dominant. What converged instead is a pattern – and the pattern turns out to be a map of the body rather than a ranking of technologies. For anyone specifying or sourcing a joint, this is the chapter that shows which failure mode comes with which choice, and which of those trade-offs are moving fast enough to be worth re-checking within a year.

Harmonic (Strain-Wave) Drives sets out the principle and the precision case, then quantifies the weaknesses the datasheets do not lead with – efficiency, flexspline fatigue life, shock tolerance and torsional windup – and shows that one of those costs is paid twice over, in two entirely different line items. It then traces the price collapse from Japanese to Chinese supply, and establishes that what replaced the expired patent moat was not cheap labour. Precision Planetary Gearboxes covers the backlash problem and how far it has closed, the legs' default ratio ranges, and the single watch-item that would attack harmonic's last structural moat in arm joints. Cycloidal and RV Reducers explains why the technology that equips most of the world's industrial robots is nearly absent from humanoids – a weight verdict, not a capability verdict – and identifies three 2025–2026 signals that it may be inflecting. Quasi-Direct Drive and Direct Drive traces the whole commercial module industry back to one research part, prices what mechanical transparency is worth, and states where quasi-direct drive genuinely loses. Master Comparison assembles the canonical reference table of the report and verifies the body-zone pattern across sixteen platforms – including how many of those cells any OEM has actually confirmed. Includes three comparison tables and two figures.

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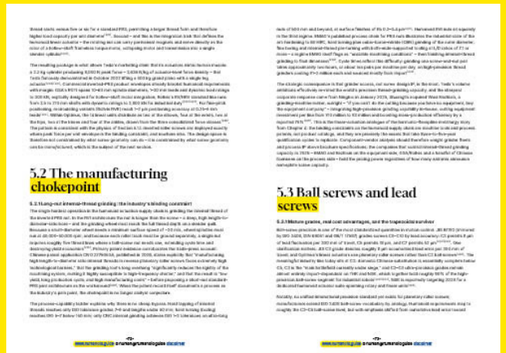
5. Linear Actuation: Planetary Roller Screws and Ball Screws

For joints that must push kilonewtons through a short stroke, the planetary roller screw has become the default among payload-oriented platforms. This chapter argues that the screw's geometry has no secrets left – the real constraint is a single manufacturing operation, and whoever controls capacity for it controls who supplies the humanoid leg. It also does something no other public source does: it reconciles published estimates of the humanoid roller-screw market that disagree by more than an order of magnitude about a year that has already happened.

Planetary Roller Screw Physics establishes the load and life case against ball screws, adjudicates an efficiency dispute in which Western and Chinese sources claim materially different numbers, and explains the integration trick that collapses motor and transmission into one slender cylinder. The Manufacturing Chokepoint identifies the hardest operation in the entire humanoid actuation supply chain, with the patent filing that confirms it in the manufacturers' own words, the capability ladder that explains why it cannot be machined around, and the boldest corporate response to it. Ball Screws and Lead Screws covers precision grades and the localisation front line, and explains why the most primitive screw in the machine survives inside the industry's most watched robot at a small fraction of its neighbour's price. Linear versus Rotary Architecture Choice sets out the three structural costs of going linear, including one sensor bill that cannot be engineered away, and tests the reference design against the industry's own viability thresholds. Supplier Landscape maps the European oligopoly against the Chinese capacity wave and reconciles the forecasts with unit arithmetic. Includes two comparison tables and two figures.


5. Linear Actuation: Planetary Roller Screws and Ball Screws


5.1 Planetary roller screw physics


5.2 The manufacturing chokepoint

5.3 Ball screws and lead screws


5.4 Linear versus rotary architecture choice

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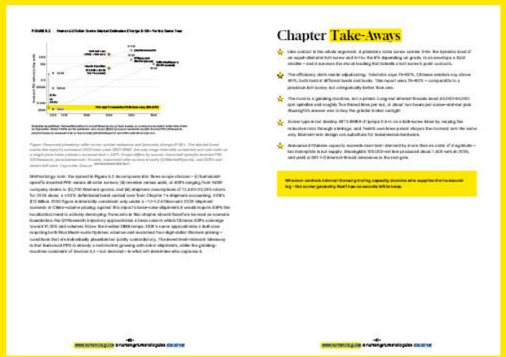
5.5 Supplier landscape


8–36×


Chapter Take-Aways

6. Alternative Actuation Paradigms: Tendon, Series Elastic, Hydraulic, Pneumatic

Four paradigms outside the electric mainstream – tendon drive, series elastic actuators, hydraulics and pneumatics – and only one of them is gaining commercial share. The chapter's organising claim is that actuation paradigms die slowly and at the subsystem level, never whole-body: each survives exactly where its physics is structurally superior. For a buyer deciding where a non-mainstream transmission is worth qualifying, this is the chapter that separates the residual niches worth entering from the ones that are already closed.

Tendon and Cable Drive covers the one paradigm gaining share, the polymer-tendon architecture the flagship programmes converged on independently of each other, the fifteen-year gap between the research recipe and its commercial adoption, and the failure modes – creep, stretch, routing – that materials science has mitigated but not solved. It also names the single unverified specification that will re-rate the paradigm one way or the other inside the forecast window. Series Elastic Actuators explains the number that demoted the technology from industry default to niche, why the field's best published bandwidth figure is a decade old, what makes springs specifically expensive in a simulation-first training era, and the one application where the spring does physical work that software cannot virtualise. Hydraulic and Pneumatic covers the April 2024 decision that ended whole-body hydraulics, the company that spent two decades and a nine-figure sum proving the point, and the two contrarians still betting on fluid power – with every claim flagged for what has and has not been independently tested. Variable-Ratio and Variable-Impedance Frontiers examines the one idea here most likely to reach a product, arrived at independently by an academic laboratory and the industry's largest programme. Includes two comparison tables and one figure.

7. Supporting Hardware I: Bearings, Encoders and Torque Sensing

Three component classes that are individually cheap and collectively decisive: joint-output bearings, position encoders, and the torque-sensing chain. Together they add more than a hundred line items to the bill of materials, and two of the three sit at the sharpest points of the industry's supply bottleneck. The chapter's central argument is that force sensing has split into two economies – one that must be purchased and one that comes free – and that which economy a robot lives in was decided several chapters earlier, by its gearbox.

Bearings – The Silent Enabler explains why bearing count is an architectural invariant rather than a design variable, maps a concentrated oligopoly against a fast-closing localisation wave, and identifies the single row in the bearing table that works as the leading indicator for when the rest of it tips. Encoders – Dual-Loop Is Now Standard establishes that the second encoder in a modern joint was never redundancy: the difference between the two readings is a measurement channel in its own right, which is why one vendor now markets it explicitly as a replacement for a component in the next section. It also identifies the one component class whose per-robot content is rising rather than falling. Torque Sensing – The $1,000 Sense vs the $0 Sense prices the sensing tax a stiff drivetrain imposes on itself, exposes a widely circulated sensor count that traces back to a vendor of a competing technology, covers the hidden physical penalty of buying force sensing, and follows the steepest price collapse in the entire humanoid component stack to the point where the whole architectural advantage may quietly disappear. Includes three comparison tables and one figure.

8. Supporting Hardware II: Motor Drivers, Controllers and Power Electronics

Moving from pilots to autonomous fleets transforms cybersecurity from an IT concern into a physical safety imperative: a compromised laptop risks data loss, a compromised humanoid risks physical harm and cascading failure across an entire fleet. This chapter maps the threat landscape as it actually exists today – with documented, published exploits rather than hypotheticals – the regulatory frameworks redefining liability for autonomous physical systems, and the continuity architectures required when automation itself becomes the point of failure.

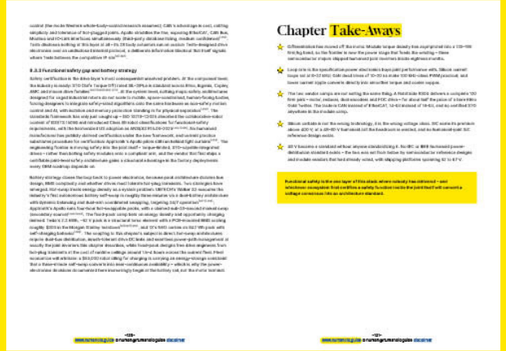
Cybersecurity Threat Landscape covers wormable exploits and fleet-scale propagation, model poisoning and AI manipulation of the training pipeline, and nation-state espionage targeting patterns relevant to vendor selection. Attack Surfaces and Mitigation maps the full surface from teleoperation to cloud, the regulatory mandates now applying, and threat modeling and fleet incident response with specific operational response targets. Liability Frameworks and Insurance compares three jurisdictions across six regulatory dimensions, covers the doctrinal problem that traditional negligence and product liability frameworks pose for learning systems, and traces the insurance evolution from coverage gaps to captive models. Business Continuity and Fleet Resilience covers single points of failure, human backup protocols, and swarm fault tolerance – including what coordination architecture is worth in annual downtime cost for a fleet of a hundred robots. Includes a threat–mitigation mapping table and two figures.


8. Supporting Hardware II: Motor Drivers, Controllers and Power Electronics


8.1 Servo drive fundamentals


8.2 Drive vendor landscape


8.2.1 Vendors premium: the nano-drive tier


8.3 Power semiconductors and bus architecture

Chapter Take-Aways

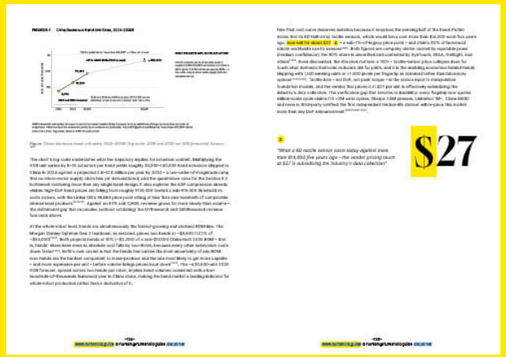
9. Dexterous Hand Actuation

The hand is the industry's second actuation battleground and, by several measures, the harder one: the industry's largest programme describes it as most of the entire engineering problem while accounting for less than a fifth of the bill of materials. This chapter maps a market that has hardened into two commercial species with no consensus winner, and it retires the metric everyone still uses to compare hands – with the evidence that the metric is being padded, vendor by vendor, and the disclosure convention that fixes it.

The Architecture Fork sets force transparency against self-locking: the flagship programmes that converged independently on one answer, against the volume pole industrialising the exact opposite – hands that hold a grasp at zero power and feel nothing. It also documents the entry and disavowal of a major architecture inside a single design cycle. Player-by-Player Hand Technology works the field tier by tier, from the most fully specified force-transparent hand in the market to the open-source builds, across a price spread of well over an order of magnitude – and shows why the force leaders are not the degree-of-freedom leaders. Micro-Actuation Components identifies the single component that decides the entire hand cost curve to 2030, the reason only a handful of companies worldwide can supply it, the Chinese price ladder attacking it, and why the leaders have concluded that merchant supply is inadequate at any price. Hands Economics and the Mass-Production Inflection anchors on units rather than revenue for a reason it makes explicit, tracks the collapse in the price of touch, and shows why the hand's share of cost rises even as its absolute cost falls sharply. Includes three comparison tables and one figure.





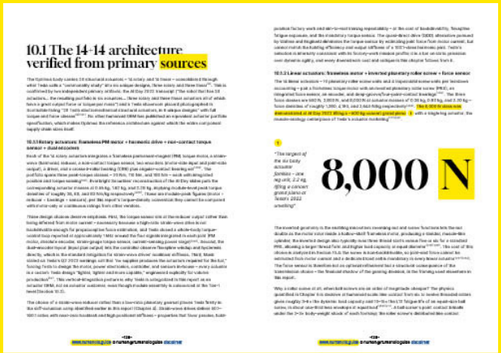



10. Tesla Optimus: Actuation Architecture Deep Dive

Optimus is the only humanoid platform whose complete actuator portfolio sits on the primary record, which is why the entire component supply chain sizes its capacity against it. This chapter reconstructs that architecture from the primary sources, and argues it is really two robots on one skeleton – with a seam at the waist that dictates two supplier chains, two control philosophies and two failure modes. It then does the arithmetic on the target price that everyone quotes and few have checked.

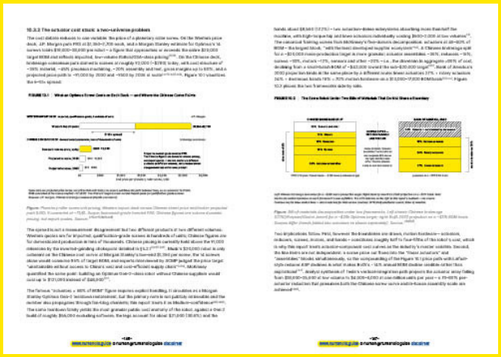
The 14+14 Architecture Verified from Primary Sources documents the six actuator families with their torque, force and mass classes, and derives a torque-density pattern that runs in one direction for the rotary units and inverts for the linear ones – with a clear explanation of why the largest actuator is not the best one. It also settles a persistent six-versus-seven counting dispute at its source. Gen 2 to Gen 3 Evolution shows that essentially nothing in the body has changed in four years and that every change is concentrated in one subsystem, covers the patents published and disavowed within days of each other, and identifies the strongest indirect evidence that the actuators are running at their thermal limit. Supply Chain and Cost Structure maps the named suppliers with an evidence grade against each, separates announced capacity from delivered revenue, and tests the sub-$20,000 bill of materials against Western component pricing – an arithmetic result that reframes the entire cost debate. Engineering Critique covers the compliance problem the roller screw creates, the visible symptom of solving it in software, an honest verdict on whether the approach is wrong, and the one input that no amount of vertical integration can engineer away. Includes three comparison tables and two figures.


10. Tesla Optimus: Actuation Architecture Deep Dive


10.1 The 14-14 architecture verified from primary sources


10.2 Gen 2 → Gen 3 evolution


10.3 Supply chain and cost structure




10.4 Engineering critique


Chapter Take-Aways

11. US, European and Other Western Humanoid OEMs

Outside Tesla, every major Western humanoid OEM designs its own actuators in-house – not from ideology, but because no qualified supply chain existed at any price when these programmes were architected. The chapter's uncomfortable finding is how little of that work is public: the entire Western joint-torque record consists of a handful of numbers, and the largest programmes, including every robot in a paying commercial pilot, publish none of them. Its forward call is that the in-house era was a supply-chain necessity rather than an equilibrium, and it names what is already ending it.

Figure AI covers the most transparent Western disclosure – which turns out to be labels in a teaser video rather than a datasheet – what its torque ratios reveal about the robot it is not building, and the industry's most documented classification controversy about what is actually inside its joints. Boston Dynamics documents the hydraulic-to-electric pivot, an on-record claim about the electric successor that should have been bigger news than it was, and the automotive Tier-1 now co-developing its actuators. Apptronik traces the most credible actuation lineage in the West back to a peer-reviewed NASA platform, and tests an efficiency claim against the physics of its own drivetrain. Agility Robotics explains what its spring architecture actually buys, and why its silence is the chapter's most damning evidence. Sanctuary AI covers the lone hydraulic holdout and the claim that would rewrite hand actuation if it survives independent testing. 1X Technologies documents the deepest vertical integration in the West and an accusation about specification inflation that cuts both ways. The Rest of the West presents the only rigorous peak-versus-continuous torque figures published for any humanoid – and what those ratios imply about everyone else's headline numbers. Includes four comparison tables and one figure.


11. US, European and Other Western Humanoid OEMs


1.51×


11.2 Boston Dynamics


11.3 Apptronik


11.5 Sanctuary AI


11.7 The rest of the West

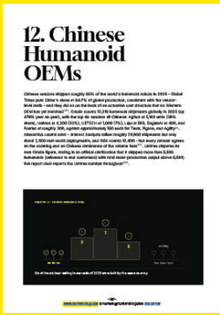

50%


Chapter Take-Aways

12. Chinese Humanoid OEMs

Chinese vendors took all six top places in 2025 humanoid shipments. This chapter argues that the lead is an actuation-cost outcome rather than an actuation-performance one, and traces it to two things: vertical integration at the top, and a merchant module layer underneath that externalised actuation research and development into a supplier price war. It also identifies the gap running through the whole flagship tier – a specification every vendor in the top group has left unpublished, and the one company whose disclosure suggests how large it really is.

Unitree covers the depth of the vertical integration, what it does to selling price and gross margin simultaneously, the headline torque-density figure and the measurement convention that makes it comparable to nothing, and the one teardown account that contradicts the official documentation. Agibot explains why the volume leader is also the least vertically integrated, where its supply concentration creates a single point of failure, and which architecture it ships that no other high-volume Chinese vendor does. UBTECH presents the highest published motion-system share of hardware cost for any humanoid in delivery, itemised by joint group – including which limb costs more per joint and the sleeper line item that already exceeds an entire arm's budget. Fourier, Kepler, EngineAI covers three parallel bets: exoskeleton-derived servos with a peak-torque progression worth reading as marketing as much as engineering, the first commercially shipped Tesla-architecture humanoid and what its screw content actually costs, and the one vendor publishing the specifications everyone else hides. The Long Tail and What It Signals covers the cheapest humanoid on the market and how it got there, why disclosure runs inversely to volume, and the module economy that is the real Chinese moat. Includes four comparison tables and one figure.


12. Chinese Humanoid OEMs


12.1 Unitree – the vertical-integration price leader


12.2 Agibot – the volume leader


12.3 UBTECH – the industrial incumbent

64.6%

12.4 Fourier, Kepler, EngineAI

12.5 The long tail and what it signals

¥9,998

Chapter Take-Aways

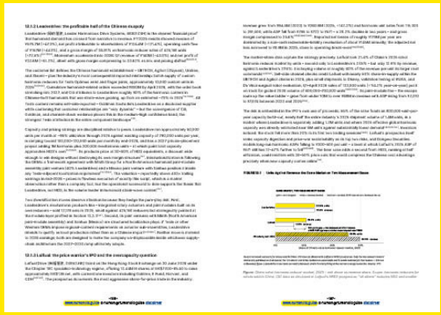
13. The Component Vendor Landscape

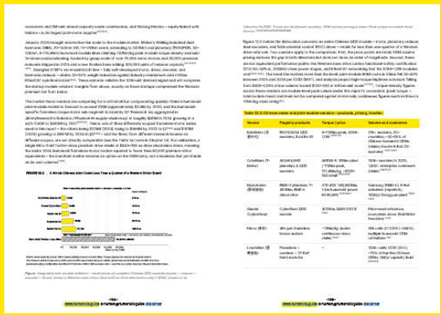
The supply base consolidated in 2025–2026 into four recognisable blocks, and this chapter argues that utilisation rates and margin direction – not order announcements – are the honest scoreboard. It opens on a single comparison: two companies, same year, same market, same product, opposite income statements. It also applies three explicit corrections to claims circulating widely in the secondary literature, and establishes the sourcing discipline that governs every supplier attribution in the report.

Reducers – Japan vs China works through the incumbent's worst year in modern history and whether it is a trough or a decline, the profitable half of the Chinese duopoly and its strongest supply attribution, and the price warrior whose IPO prospectus is effectively the overcapacity question in a single document – including the one statistic that quantifies exactly what it is paying for volume. Within the same section, the RV and planetary tier covers the anti-incumbent whose industrial business is thriving while its humanoid position remains a toehold, a widely repeated capacity claim that does not survive checking, an ownership fact that is wrong across the internet, and the supplier with the weakest financials despite sitting inside two of the largest humanoid programmes. Motors and Integrated Joint Modules separates a Western tier that leads on specification from a Chinese tier that leads on volume, follows the price-reset event that created the module class and where its team went next, and identifies the single largest disclosed module-supply agreement in the world. Screws, Bearings, Sensors and Drivers consolidates the cross-references into one pattern that repeats across five component classes – and states how far behind the reducer template each of them is running. Includes four comparison tables and two figures.


13. The Component Vendor Landscape


13.1 Reducers – Japan vs China






13.3 Screws, Bearings, Sensors, and Drivers: Consolidated Cross-References


Chapter Take-Aways

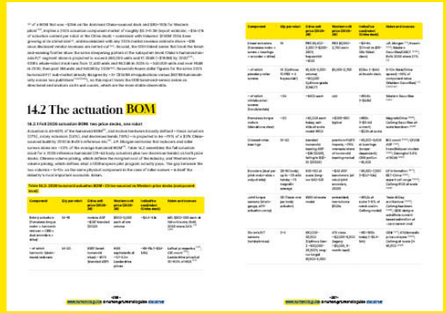
14. Market Sizing, BOM Economics and Cost Curves

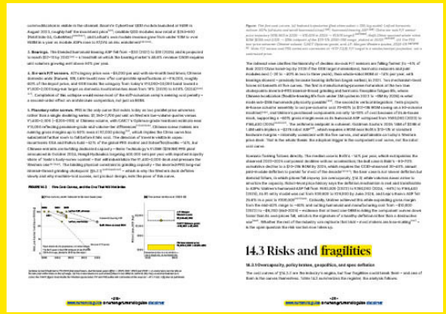
Every prediction about humanoid robots is really a prediction about a small number of falling component prices. This chapter inverts standard market-sizing practice: it treats the cost side as the dependable half of the outlook – readable straight off filings and prospectuses – and the demand side as the speculative half, where estimates for a single year span nearly an order of magnitude. The consequence is uncomfortable and stated plainly: the capacity being built today is sized against the least verifiable number in the report.

Market Size Triangulation shows what happens when a research house and the vendor itself count the same shipments, why component markets grow faster than robot units, which single forecast in the field is prospectus-grade and what it implicitly bets, and which component's revenue growth is a treadmill rather than a business. It also runs a bottom-up sanity check that quietly disqualifies several published market sizes. The Actuation BOM presents the same robot under two price decks that do not share a boundary, locates the value hiding in components nobody talks about, identifies a sixth cost curve the literature has not acknowledged, names which bill-of-materials block deflates fastest and which resists, and sets out the five curves that decide everything – each already measurable, with the margin evidence showing how much further they can fall. Risks and Fragilities assembles the register – overcapacity read off a filing, policy that flipped from accelerator to brake, export controls, and the gap between units shipped and units actually deployed – and reaches a verdict on what all of it has actually done to the price trajectories so far. Includes three comparison tables and two figures.numbers. Includes four comparison tables and one figure.


14. Market Sizing, BOM Economics and Cost Curves


14.1 Market size triangulation


14.2 The actuation BOM


14.3 Risks and fragilities


Chapter Take-Aways


Chapter Take-Aways

15. Ten-Year Outlook 2026–2036: Technology Winners and Vendor Predictions

Whole-market point forecasts are worthless, and this chapter says so before making any. What it argues is forecastable is mechanism: which actuator physics wins which body zone, which vendor structure each layer converges toward, and which cost curve gates adoption. Every prediction is built the same way – a mechanism grounded in a sourced trend, a base, bull and bear framing where the question is quantitative, and a dated trigger indicator that would falsify it. The result is less a forecast than a watch-list with dates on it.

Technology Trajectory by Body Zone establishes that the actuation war is now being fought in exactly one zone, gives the two triggers that would settle it either way, and covers the cheapest torque multiplier available and the sleeper mechanism that could blur the whole distinction. It explains why the incumbent arm technology survives despite expired patents, and why the report explicitly declines to make the prediction the market has been circulating about its largest customer. It calls the hand architecture war already over, and identifies the swing variable in the supporting stack whose commoditisation would produce an outcome precisely opposite to what most observers expect. Vendor Predictions covers duopoly consolidation with the scenario in which the displaced incumbent's share paradoxically rises, the race to become the Tier-1 of humanoid actuation and who is currently leading it, and the venture category that is about to stop existing. Wildcards and Watch Items names the largest single wildcard, the largest unpriced risk in the entire industry, the leapfrog technology that would bypass the deepest moat in the supply chain, and how geopolitics is quietly selecting for particular physics. Synthesis then draws the eight cross-verified insights of the whole report into a single argument. Includes three comparison tables and two figures.


11. US, European and Other Western Humanoid OEMs


1.51×


11.3 Apptronik


11.5 Sanctuary AI


11.7 The rest of the West


11.6 IX Technologies


50%


Chapter Take-Aways

16. Appendix: Glossary and Master Comparison Tables

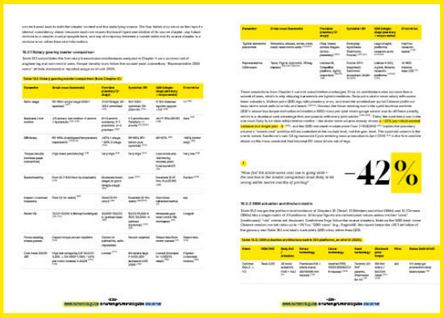
The appendix is the report's reference layer, built to be used on its own. It introduces no new claims: every cell reuses the exact figure and citation index of its source chapter, which makes the tables double as the report's internal consistency check. What it adds is adjudication – figures carry confidence tiers, genuine conflicts are dual-reported rather than editorially resolved, and claims that failed cross-verification are corrected with a note or excluded outright. A row can be lifted and cited on its own without losing the qualification that makes it defensible.

The Glossary defines fifty-one terms, convention-locked to the report's own numbers, each with a chapter pointer – including the three definitions whose misreading corrupts everything downstream of them. The Master Tables consolidate the rest. A rotary gearing master comparison sets five transmission architectures against eleven engineering and commercial axes on one page, with a note on which row is most likely to be stale within twelve months of printing. An OEM actuation architecture matrix puts thirty platforms side by side on rotary, linear and hand technology plus disclosed torque, price and status – Western and Chinese in a single grid, with the disclosure gap immediately visible. A vendor directory covers seventy-five suppliers by component layer, each carrying an explicit exposure tier that tells you whether a supply claim is disclosed revenue or a channel check. A canonical numbers cheat-sheet gives thirty metrics with confidence tiers and citations, including a short list of figures that are simply wrong in the wider literature, with the correct values. The appendix closes by stating which market-circulating claims it refused to publish, and why. Includes four master tables plus the glossary.


16. Appendix: Glossary and Master Comparison Tables


16.1 Glossary


16.2 Master tables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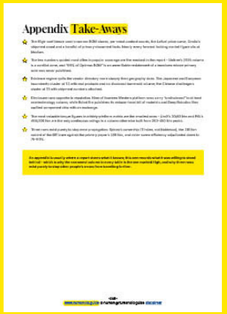
30 Nm


Appendix Take-Aways

Thank you!

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