ENGAGE × UNITED THERAPEUTICS · UT 100 ROBOT PROGRAM

Preliminary Technical Scoping Response.

Engage G2–based robotic interventions for fill-finish operations — engineering prototype to pilot to 100-unit production fleet.

RESPONSE DATE	13 August 2026
SOURCE REQUEST	UT 100 Robot Revised Technical Scoping Request, 11 August 2026
REFERENCE PLATFORM	**Engage G2** premium-compute configuration, integrated by MangoBot
REVISION	Revision B — controlled-environment coordination separated from the current scope
DOCUMENT STATUS	Revised draft for technical alignment; not a commercial quotation or qualification statement

> **Executive position:** The Engage G2 is a credible engineering foundation for the manipulation, perception, local compute and secondary-development portions of the program. Revision B focuses on robot capability, task feasibility, tooling, software integration, safety and deployment readiness. Controlled-environment coordination is outside the current scope and will be separately defined if required.

> **Issuance control:** This revision uses the supplier-supplied Engage G2 specification, product pamphlet, user manual and WIP GDK v2.1.0, supplemented by public product sources and engineering judgment. The pamphlet is treated as marketing context and the WIP GDK as integration evidence, not as a production commitment. All lifecycle support, certification statements, prices and delivery dates require written approval from MangoBot after Phase 0 discovery.

01 · EXECUTIVE RESPONSE

Recommended foundation. The recommended starting point is the Engage G2 premium-compute configuration with dual 7-axis force-controlled arms, standard end-effector flange, local high-performance compute, native head and wrist RGB-D sensing, and MangoBot-developed task tooling and workcell controls. The G2 should be treated as a technology platform requiring application-specific integration.

Scope boundary. Controlled-environment coordination is not included in the current implementation plan and will be separately defined if required.

Overall feasibility. The program is feasible enough to proceed to a controlled engineering study. No listed pharmaceutical intervention is classified READY as a complete production behavior today. Native G2 elements are READY inputs; every UT intervention remains ADAPT or DEVELOP and requires TEST and UT INPUT before production claims can be made.

Primary go/no-go conditions. The first program gate must prove workcell access and reach, component-specific grasping, bounded-force behavior, validated recovery, cycle performance, reliable local/offline software operation and the required safety functions.

RESPONSE CLASSIFICATIONS

CLASS	USE IN THIS RESPONSE
READY	Existing G2 capability can be used as an engineering building block without fundamental product development.
ADAPT	Modification or application engineering is required.
DEVELOP	New hardware, software, tooling or validation-oriented engineering is required.
TEST	Physical trial is required before feasibility or performance can be confirmed.

INPUT	UT information, samples, access or acceptance criteria are required.
RISK	A material technical, schedule, regulatory, lifecycle or commercial dependency exists.

RECOMMENDED DECISION

#	ACTION
1	Authorize a 6-to-8-week Phase 0 using UT CAD, task videos, samples, task acceptance criteria and cybersecurity requirements.
2	Prototype three to five representative interventions spanning a rigid part, vial, precision/needle, tubing and EM-plate task.
3	Defer 100-unit, pricing and delivery commitments until the selected tasks pass prototype and production-intent gates.

02 · G2 PLATFORM BASELINE AND EXACT PROPOSED CONFIGURATION

The values below are drawn primarily from the supplier-supplied ENGAGE G2 SPECS and ENGAGE G2 User Manual, with the supplied pamphlet used only for product-positioning context. Both supplied technical documents state 26 active degrees of freedom, resolving the earlier public-source discrepancy for this revision. Final procurement must still reference a released configuration-specific specification.

AREA	SUPPLIED G2 BASELINE	PROGRAM RESPONSE
Architecture	Wheeled humanoid; 4-steer-wheel omnidirectional base; folding and lifting torso	READY for engineering; TEST against UT geometry
Dimensions / mass	Height 1,225–1,795 mm; width 640 mm; length 760 mm; mass 185 kg	INPUT floor loads, doors, corridors, docks and glove-port geometry
Work envelope	Variable height 1,225–1,795 mm; published joint ranges for head, waist/leg and seven arm joints	TEST reach and singularities in CAD and a physical mock-up
Degrees of freedom	26 active DOF: 3 neck, two 7-DOF arms, 5 waist/leg and 4 chassis	READY configuration baseline; freeze against released unit specification
Payload	5 kg rated per arm	READY baseline; derate after end-effector integration and validate every task
Position performance	Sub-millimeter-level force-controlled operations	INPUT / TEST: obtain released accuracy specification and build a full task uncertainty budget
Force control	Full-joint arm torque sensing; motion status exposes pose, twist and wrench data in GDK	READY sensing input; TEST calibrated TCP force limits and control behavior
Native perception	Head stereo and RGB-D; two wrist RGB-D cameras; three fisheye cameras; two base LiDARs; eight ultrasonic sensors; IMU	READY for navigation and coarse perception; ADAPT for pharmaceutical close-up vision
Compute	Recommended premium configuration: NVIDIA Jetson T5000, stated as 2,070 TFLOPS FP4	READY compute baseline; benchmark the actual validated application stack
Connectivity	Wi-Fi, Bluetooth, optional 4G/5G and NFC; maintenance hatch includes Internet, PoE and 10G Ethernet plus USB-A/C and DP	READY building blocks; DEVELOP validated integration and cybersecurity controls
Power	Dual 1,652 Wh batteries; about 4 hours; hot-swappable batteries; autonomous charging optional	ADAPT charging/battery exchange to the site operating model
End interface	Standard arm flange; 24 V, two RS-485 channels and CAN-FD at wrist	READY electrical/mechanical basis
Tool change	Standard flange and M8 wrist connector provide 24 V, two RS-485 channels and CAN-FD; an automatic change system is not defined in the supplied documents	DEVELOP validated automatic changer or use campaign-dedicated tools
Environment / protection	Operating environment 0–40 °C and below 80% RH; full-machine IP42	READY standard-platform boundary; any special environment is outside this scope

Safety functions	Joint-power emergency-stop button, wired E-stop interface, obstacle sensing, collision-pair/status reporting and arm torque sensing	READY diagnostic inputs only; DEVELOP independent application safety and site interlocks

PROPOSED G2-BASED BILL OF CONFIGURATION

- G2 premium-compute configuration with NVIDIA Jetson T5000, dual 7-DOF force-controlled arms, 4-steer-wheel base and dual batteries.
- Production end-effector configuration to be selected by intervention family; general-purpose dexterous hands are not the default production tool.
- Two wrist-mounted close-range vision modules plus fixed workcell cameras and controlled illumination where required.
- Repeatable workcell datum or docking system, with tool-center-point and hand-eye calibration fixtures.
- MangoBot workcell edge controller, deterministic recipe engine, UT integration gateway, event historian and independent safety controller.
- Site integration package: controlled tool drawings, cable routing, protected optics, workcell interfaces and defined material-handling process.

03 · WORKCELL DEPLOYMENT REQUIREMENTS

CURRENT-SCOPE WORKCELL REQUIREMENTS

- Confirm geometric reach, approach paths, floor conditions, working clearances, available datums and utilities using UT CAD and a representative physical mock-up.
- Define robot parking, operating and maintenance positions, including operator access, recovery space and emergency access.
- Define the workcell state interface, stop categories, interlocks, permissives, alarms and recovery authorization without assigning AI to the safety path.
- Provide task-specific tooling, fixed or wrist vision, controlled illumination, calibration artifacts and component presentation fixtures as required.
- Confirm cable/network routing, charging or battery exchange, data ownership, update method and local support access for the selected operating model.

04 · TASK-BY-TASK INTERVENTION ASSESSMENT

The matrix is a preliminary engineering classification. Success rates, forces, cycle times and recovery behaviors cannot be confirmed until UT supplies representative samples, videos, work instructions, tolerances and workcell geometry. No task should be released to production solely on the basis of a general G2 demonstration.

INTERVENTION	CLASS	PROPOSED G2-BASED CONCEPT	CONFIRMATION REQUIRED
Clear jammed stoppers	ADAPT / TEST / INPUT	Dual-arm force control and wrist vision are useful. Use a stopper-specific parallel micro-gripper or compliant scoop with controlled-force pads and positive part-presence sensing.	Prove grasp without marking, shedding or displacement of acceptable components; define dropped-part recovery and disposal route.
Clear or reposition jammed vials	ADAPT / TEST / INPUT / RISK	Use a shaped compliant vial gripper or under-body support, not an unqualified universal hand. Add fixed macro vision, grip-force limits and breakage detection.	Glass damage, tip-over and broken-vial containment are critical. Test all vial sizes, fill states, line speeds and jam orientations.
Clear or reposition crimp caps	ADAPT / TEST / INPUT	Use a small-part collet, vacuum-assisted tool only if UT permits, or precision parallel gripper with controlled illumination and part-presence sensing.	Confirm cap finishes, reflective surfaces, allowed contact locations and misfeed distributions.
Replace or re-seat liquid lines	DEVELOP / TEST / INPUT / RISK	Dual-arm deformable-object manipulation with tubing-profile jaws, tactile or jaw-force sensing, route fixtures and visual verification of seating.	High variability and occlusion. Prove no kinking, puncture, disconnection or leakage; define post-action integrity test.
Replace, reposition or manipulate filling needles	DEVELOP / TEST / INPUT / RISK	Use a guided collet or needle-specific tool, visual servoing, mechanical alignment feature and strict force/torque envelope. Human approval is recommended during early pilot.	Safety- and quality-critical. Define allowable contact, bend limits, lock verification and recovery from partial insertion.
Place, retrieve and exchange EM plates	ADAPT / TEST / INPUT	Use an under-rim fork or plate-specific parallel gripper, fixed pose fixture, barcode/OCR check and recipe-enforced exposure timing.	Prove lid/plate handling, orientation, labeling, no contact with media, and traceable placement/retrieval.
Reload production components during active campaigns	DEVELOP / TEST / INPUT / RISK	Define each component family and material-transfer path. Use dedicated trays, feeders, tools and recipe controls rather than one generic behavior.	Transfer and replenishment sequence may dominate feasibility. Requires exact components, quantities, presentation and line interfaces.

Defined in-process adjustments	DEVELOP / TEST / INPUT	Implement one validated recipe per knob, lever, latch, setpoint or mechanical adjustment; use tool-specific geometry and closed-loop confirmation.	UT must define authorized adjustments, permitted interfaces, ranges, response time and electronic record requirements.
Production-line clearance	ADAPT / DEVELOP / TEST / INPUT	Combine vision-based inventory/coverage verification with task-specific pick-and-place into a defined reject container. Record before/after images and counts.	Coverage, occlusions and acceptable residue require workcell-specific acceptance criteria.
Manufacturing changeover	DEVELOP / TEST / INPUT / RISK	Sequence validated subtasks for tooling, parts, plates and line adjustments. Use recipe version control and positive identity checks for tools and components.	Scope is too broad for a universal claim. Separate robot changeover from UT equipment changeover and define operator handoffs.
Other interventions	INPUT / TEST / RISK	Apply the same decomposition: access, tool, sensing, forces, tolerance, recovery and evidence. New tasks enter controlled change management.	No blanket feasibility commitment. Each new task requires hazard, quality and validation impact assessment.

> **Prototype task selection:** The first prototype should not attempt all interventions. It should deliberately include one rigid small-part jam, one vial task, one needle/precision task, one tubing task and one EM-plate task, because these span the main manipulation and recovery risks.

05 · HANDS, TOOLS, SENSING AND CALIBRATION

5.1 · PRODUCTION TOOLING POSITION

The supplied user manual identifies optional 10- or 12-actuated-DOF OmniHand configurations and optional two-finger grippers. General-purpose hands may be useful for data collection and early feasibility work. Production should default to dedicated, minimum-complexity tools with controlled geometry and defined failure modes.

COMPONENT	TOOL CONCEPT	REQUIRED SENSING	DESIGN RULE
Stoppers / caps	Small parallel or collet gripper with replaceable shaped pads	Jaw position, motor current/force, wrist F/T estimate, macro vision	Low force, positive presence check, defined reject release
Glass vials	Compliant shaped jaws or under-body support with redundant retention	Grip force, jaw position, fixed and wrist vision, breakage cue	No glass-to-metal contact; safe broken-vial state
Filling needles	Guided collet with mechanical alignment and depth reference	Close-range camera, fixed camera, force/torque, lock state	Constrained motion; no free-hand needle manipulation
Tubing / liquid lines	Profiled soft jaws, routing hook and dual-arm handling	Jaw/tactile force, vision, seating/leak verification	Avoid kink, puncture and over-stretch
EM plates	Under-rim fork or plate-specific gripper	Presence, barcode/OCR, pose vision	No contact with exposed media; recipe-timed handling
Other components	Tool family selected after sample and force study	Task-dependent	No universal-hand production claim

5.2 · TOOL CHANGE AND LIFECYCLE

- For production, choose either campaign-dedicated tools or develop a validated automatic tool changer with mechanical lock verification, tool ID, electrical integrity check and safe failed-change recovery.
- Every tool requires a controlled drawing, materials list, wear limit, calibration method, preventive replacement interval and lifecycle test.
- Replaceable contact pads and other task-specific tool consumables should be controlled and lot-traced where UT's quality system requires it.

5.3 · VISION AND METROLOGY ADDITIONS

Native G2 vision is suitable for navigation, teleoperation and coarse manipulation. Small reflective caps, transparent glass, thin needles and low-contrast tubing require controlled close-range imaging. Recommended additions are task-dependent macro or telecentric cameras, fixed workcell reference cameras, diffuse/coaxial lighting, polarizers where useful, and fiducials or geometric datums outside product-contact areas.

Calibration strategy. Each station should use repeatable docking, a surveyed workcell frame, robot-to-dock calibration, hand-eye calibration, TCP calibration per tool, and a traceable golden artifact. A short automated verification should run at startup and after tool change; full recalibration should be triggered by maintenance, collision, tool replacement or failed drift check.

Precision interpretation. The supplied manual describes sub-millimeter-level force-controlled operations but does not provide a released numeric repeatability or system-accuracy specification. This is not enough to predict the UT task result, which also includes docking, tool, vision, workcell and component uncertainty. Needle and similar tasks should use visual servoing and mechanical guidance, supported by a complete measurement uncertainty budget and representative testing.

06 · SOFTWARE, INTEGRATION, CYBERSECURITY AND FLEET ARCHITECTURE

The supplied Genie 02 GDK v2.1.0 documents local and hybrid deployment on Ubuntu 22.04 x86_64 developer systems. The controller uses DDS by default; ROS 2 Humble access is available through forwarding nodes, with Python and C++ interfaces also documented.

CONFIRMED GDK v2.1.0 INTEGRATION COVERAGE

INTERFACE AREA	REVISION-B ASSESSMENT
Motion and status	Whole-body joint state and position/velocity commands; end-effector state and direct gripper movement; whole-body errors, arm control and E-stop states; motion pose/twist/wrench and collision-pair status.
Perception	Latest and nearest-timestamp IMU, LiDAR point-cloud and camera image retrieval. Camera shape, frame rate and latency statistics are exposed; timestamps are nanosecond-valued for synchronization.
Localization and navigation	Map read/list/switch/remove, SLAM start/stop/status and odometry, plus navigation task state, absolute and relative moves, cancel, pause and resume.
End-effector hardware	Status exposes motor position, velocity, effort, current, voltage, temperature, status and error code; direct command support is shown for a gripper-type end-effector.
Not evidenced by GDK	Safety-rated control, validated recipe/audit-trail functions, role-based access, configuration signing, deterministic real-time guarantees, production rollback, Part 11 controls and 100-robot fleet governance.

LAYER	REQUIRED FUNCTION	CLASS
Independent safety layer	Emergency stops, safety-rated stop or power removal, docking and site interlocks, zone monitoring and recovery authorization. AI is not in the safety path.	DEVELOP / TEST
Robot integration adapter	A version-pinned GDK adapter for joint/pose commands, tool control, status, sensor streams, SLAM/navigation and bounded timeouts. Do not use direct pose commands without an independent collision and force envelope.	ADAPT / TEST
Workcell recipe engine	Approved state machines, task recipes, preconditions, step-level checks, bounded recovery, electronic event records and alarm handling.	DEVELOP / TEST
Vision and calibration	Object localization, visual servoing, inspection, calibration verification, drift alarms and evidence images where approved.	ADAPT / DEVELOP / TEST
UT integration gateway	Interfaces to filling line, PLC/SCADA/MES or historian through approved protocols and a controlled data model.	DEVELOP / INPUT / TEST
Site fleet manager	Robot identity, approved configuration, deployment rings, health, alarms, spares, maintenance and site-level dashboards.	DEVELOP / TEST
Enterprise support boundary	Optional update repository and remote diagnostics through UT-controlled DMZ; disabled by default; session approval and audit logging.	DEVELOP / INPUT / RISK

REQUIRED SOFTWARE CONTROLS

- Local/offline production operation without a dependency on public cloud services; cloud use, if any, restricted to approved development or support workflows.
- Role-based access, unique identities, least privilege, network segregation, encrypted administration channels, secure time source and UT-approved log retention.
- Controlled software, firmware, model, recipe, tool and calibration versions with approved release records, compatibility matrix and tested rollback.
- Immutable or protected event history for robot state, commands, alarms, interventions, recoveries, software changes and operator approvals; 21 CFR Part 11 controls only where the record/signature use case makes them applicable.
- Deterministic safe-state behavior for loss of network, loss of vision, low confidence, excessive force, unexpected obstruction, dropped component, power interruption and failed tool verification.

- A separate development/training environment; no online model learning or uncontrolled parameter changes in the validated production baseline.
- Software assurance evidence proportionate to risk: requirements, architecture, hazard controls, code and configuration review, test traceability, anomaly records and release approval.

07 · QUALIFICATION, VALIDATION AND SAFETY SUPPORT

MangoBot should support UT's qualification activities through controlled engineering records and test evidence. UT remains the system owner and retains responsibility for validation, batch-release impact, SOPs and regulatory obligations.

EVIDENCE PACKAGE	PROPOSED SUPPORT
Design / DQ support	URS trace matrix, concept and detailed design records, risk assessments, drawings, BOM/materials, software architecture, interface specifications, cybersecurity design, change history
FAT	Hardware inspection, calibration, safety functions, recipes, alarms, interfaces, power/network loss, representative tasks, recovery, logs, document pack and open-punch list
SAT / IQ support	Installed configuration, serial numbers, utilities, network, approved software/firmware/model versions, calibration status, safety checks, documentation and training
OQ support	Operating ranges, recipe controls, alarms, access control, auditability, abnormal conditions, tool changes, recovery modes and calibration checks
PQ support	UT-owned protocol and execution support using production materials, operators, shifts and normal operating conditions
Reliability evidence	End-effector life, cable flex, tool lock, battery/charging strategy, docking repeatability, fault recovery and preventive-maintenance intervals
Safety evidence	Application risk assessment, independent safety validation, stop performance, guarding/zone strategy, tool hazards and applicable US site requirements

PROPOSED ACCEPTANCE GATES FOR DISCUSSION

The figures below are starting points for protocol development, not commitments. UT should set final statistical confidence, sample size and criticality rules.

GATE	PROPOSED EVIDENCE THRESHOLD
Engineering feasibility	100% geometric access to selected targets; bounded force; no collision; at least 85% successful end-to-end cycles over a minimum 100 representative trials per selected task; no critical product damage or quality event.
Production-intent verification	At least 90% task success over a minimum 1,000 representative cycles per task, or a stricter UT-defined target; all failures detected and driven to a defined safe state; tool-life and drift limits demonstrated.
Pilot	UT-defined sustained production performance across representative shifts and campaigns, no unresolved critical safety/quality deviations, approved support response, stable software baseline and complete validation evidence.
Design freeze	Controlled BOM and approved alternates, released drawings, software/firmware/model/recipe baseline, supplier controls, test specifications, service plan, spares and accepted pilot evidence.

> **Safety standard caveat:** ISO 10218-1:2025 and ISO 10218-2:2025 are useful robot and integration baselines, but they do not resolve every pharmaceutical application requirement. The current program covers robot-system safety engineering; other environmental requirements are separately scoped.

08 · PROTOTYPE-TO-100-UNIT PROGRAM

A staged program is recommended. Phases may overlap after the workcell architecture and task boundaries are stable. Timing starts after contract, complete inputs and access; it excludes UT approval delays, site shutdown windows, separately scoped environmental/interface work and long-lead facility changes.

PHASE	PLANNING DURATION	MAIN OUTPUTS	EXIT GATE

Phase 0 — Discovery and architecture	6–8 weeks	CAD and reach study; intervention decomposition; sample/force study; workcell interface definition; cybersecurity and validation plan; prototype SOW and budget	Architecture and prototype scope approved
Phase 1 — Engineering feasibility	12–16 weeks	1–2 engineering G2 units; mock-up dock; five representative tasks; early tooling/vision; data collection; baseline reliability and recovery	Selected tasks pass feasibility gate
Phase 2 — Production-intent engineering	16–24 weeks	Production-intent tools and fixtures; fixed vision/calibration; safety and workcell controls; software and lifecycle evidence	Production-intent design authorized for pilot
Phase 3 — Pilot build, FAT and site deployment	24–32 weeks	Recommended 3–5 pilot units; controlled build; FAT; SAT/IQ/OQ support; operator and service training	Pilot released for sustained evaluation
Phase 4 — Pilot evidence and design freeze	6–12 months	Sustained campaigns, reliability growth, maintenance and spares evidence, deviations closed, supplier and BOM freeze	Production design freeze
Phase 5 — 100-unit manufacture and staged rollout	12–18 months	Production validation, staged lots, site commissioning, spares, fleet configuration, service readiness and change control	100 accepted units across agreed sites

> **Indicative overall program:** A responsible planning assumption is approximately 16–22 months to production design freeze and 28–40 months to complete a staged 100-unit deployment. This is a planning range, not a committed schedule, and excludes separately authorized environmental/interface work or extensive new intervention scope.

MANUFACTURING, DEPLOYMENT AND SUPPORT POSITION

- The G2 platform has public evidence of industrial deployment and group-level volume manufacturing. This supports platform scalability, but it does not demonstrate repeatable manufacture of the final UT-specific integrated system.
- The 100-unit release requires a controlled production BOM, approved alternates, supplier-change notification, incoming inspection, calibration, end-of-line test, software imaging, serialized configuration record and retained FAT evidence.
- US deployment requires trained local commissioning and field-service capacity, remote support rules, spares locations, escalation SLAs and a long-term parts/software support contract.
- Initial spares planning should consider a 3–5% critical rotable pool and at least one complete contingency unit per operational site, then be optimized using pilot reliability data.
- Rollout should use controlled waves such as 5–10, 20–25, 25–30 and the balance, with an evidence review before each wave rather than a single 100-unit release.

09 · MAJOR RISKS, LIMITATIONS AND REQUIRED UT INPUTS

RISK	RATING	WHY IT MATTERS	REQUIRED MITIGATION
Workcell access and reach	High	185 kg mobile geometry, 640 × 760 mm body and moving arms may not fit or reach every target.	CAD reach study, physical mock-up and task-path validation before tool freeze.
Needle, tubing and glass tasks	High	Sharp, fragile and deformable items create product, quality and recovery hazards.	Dedicated tools, mechanical guides, force limits, redundant confirmation and statistically meaningful testing.
Autonomous exception handling	High	Unbounded recovery can convert a minor jam into a quality event.	Approved state machines, stop-and-escalate behavior, remote/human approval in pilot, no uncontrolled recovery.
End-effector change	Medium-High	The supplied set does not define a qualified automatic tool changer or hot-change procedure.	Campaign-dedicated tools or newly developed validated automatic changer.
System precision	Medium-High	The supplied set makes a sub-millimeter task-positioning claim but gives no released numeric repeatability or system-accuracy specification.	Released specification, datum strategy, visual servoing, guided fixtures and calibration uncertainty budget.
Cybersecurity and lifecycle	High	The published G2 security support period is much shorter than the expected fleet lifecycle.	Contractual extended support, vulnerability SLAs, SBOM, update/rollback and end-of-life obligations.
100-unit replication	High	Volume manufacture of standard robots does not prove repeatable replication of the UT-specific integrated system.	Production validation, supplier controls, serialized test evidence and staged rollout.

US certification and service	Medium-High	Public sources do not establish the required US application certification or field-service model for this configuration.	Define applicable codes, NRTL/site requirements, importer/integrator roles and US service organization in Phase 0.
Scope expansion	High	The phrase 'other interventions' can create an open-ended development program.	Freeze named use cases per release; add new tasks through priced, validated change control.

UT INPUTS REQUIRED BEFORE A FORMAL PROPOSAL

INPUT GROUP	SPECIFIC INFORMATION OR ACCESS
Workcells	Native CAD and drawings for filling equipment, line clearances, target locations, available mounting/docking points, floor loads and utilities.
Tasks	Videos, SOP/work-instruction steps, current human interventions, intervention frequency, response-time and cycle-time expectations, allowed recovery actions and priority ranking.
Components	Representative samples and controlled specifications for every vial, stopper, cap, needle, tubing, plate and other component, including allowable contact zones, tolerances and damage criteria.
Forces and quality	Required insertion/extraction/seat forces, maximum allowable forces, critical quality attributes, broken-vial and dropped-part procedures, and defect/reject criteria.
Integration	Filling-line state model, PLC/SCADA/MES interfaces, approved protocols, I/O list, alarm philosophy, network zones, latency/availability requirements and offline-operation rules.
Cyber and data	Identity/access, encryption, remote support, logging, retention, backup, SBOM, vulnerability, patching, export and cloud restrictions.
Validation	UT engineering standards, URS/DQ/FAT/SAT/IQ/OQ/PQ templates, computer-system assurance approach, traceability and document approval requirements.
Commercial / rollout	Target sites and lines, deployment sequence, shutdown windows, service levels, warranty expectations, spares philosophy, training populations and lifecycle horizon.

10 · COMMERCIAL RESPONSE AND QUOTATION BASIS

Commercial status: Formal prices cannot be responsibly supplied from public information or before UT inputs define the architecture and task scope. MangoBot should issue a binding quotation only after Phase 0, with Engage-backed product pricing, support commitments and controlled assumptions. The table below is the required quotation structure, not a price offer.

COMMERCIAL LINE	INCLUDED SCOPE	PRICING STATUS	QUOTE PREREQUISITE
Base production robot	Engage G2 premium-compute body, dual force arms, batteries/charger, standard interfaces, selected support package	100-unit volume quote	Configuration and Incoterms fixed
Hands / tools	Per task-family design NRE, prototype tools, production tools, change system, spares and lifecycle tests	Quote by tool family	Samples, forces and tool-change model fixed
Vision / calibration	Cameras, lighting, fixtures, metrology, software licenses and recurring calibration equipment	Quote by workcell type	Workcell and precision budget fixed
Software / integration	Recipe engine, interfaces, logs, fleet, cybersecurity, validation evidence and third-party licenses	Quote after architecture	UT integration and cyber requirements approved
Prototype program	Recommended 1–2 engineering units plus engineering, mock-ups, samples and test services	Fixed-price or time-and-materials proposal after Phase 0	Five prototype tasks selected
Pilot program	Recommended 3–5 production-intent units, FAT/SAT, site integration, qualification support and training	Quote after prototype gate	Pilot sites and acceptance criteria fixed
100-unit manufacture	Staged production, serialized records, FAT, warranty, acceptance and delivery	Volume quote after design freeze	Forecast, sites, delivery waves and acceptance fixed

Deployment and support	Commissioning, training, travel, preventive maintenance, remote/local support tiers and SLAs	Annual and per-site quote	US service model and coverage hours fixed
Spares and lifecycle	Critical rotables, tools, batteries, calibration items, software and hardware support	Fleet package and annual support quote	Reliability model and lifecycle term fixed

RECOMMENDED CONTRACTING SEQUENCE

- **Phase 0 discovery:** fixed scope and capped fee, producing the architecture decision, prototype SOW, risk register, schedule and budgetary estimate.
- **Prototype:** milestone-based NRE plus hardware, with defined task and production-intent test gates and clear ownership of custom IP, data and tooling.
- **Pilot:** production-intent equipment and site services, with UT-approved acceptance protocols and a design-freeze decision after sustained evidence.
- **100-unit framework:** volume bands, forecast and cancellation rules, approved configuration, change notification, warranty, cybersecurity/lifecycle support, spares, SLAs and staged acceptance.

11 · SCOPE BOUNDARIES AND ASSUMPTIONS

- Controlled-environment coordination is outside the current scope and will be separately defined if required.
- UT owns SOPs, batch records, process validation, regulatory submissions and release decisions.
- Task feasibility, cycle time, success rate, force, precision and reliability remain unconfirmed until tested against UT-controlled inputs.
- The supplied GDK v2.1.0 is marked WIP and supports technical scoping only; API stability, permissions, real-time behavior, update compatibility and production support require a controlled Engage commitment.
- The schedule is a planning range. Price, tax, duty, travel, site work, certification, third-party licenses and support are not offered in this draft.
- Any new intervention after the released task list is a controlled change with technical, validation, cost and schedule impact assessment.

12 · SOURCE REGISTER

Sources were reviewed through 13 August 2026. Revision B gives priority to the supplied technical specification and user manual for the baseline, uses the supplied WIP GDK for integration scoping and treats the pamphlet as non-binding marketing context. All supplied documents remain subject to configuration and revision control before contract release.

- **United Therapeutics / MangoBot source request.** UT 100 Robot Revised Technical Scoping Request, dated 11 August 2026 (client-supplied PDF).
- **ENGAGE G2 SPECS EN.** Supplier-supplied three-page product specification used for dimensions, mass, 26 active DOF, sensors, range of motion, payload, chassis, batteries, compute, connectivity, secondary-development support and IP42.
- **ENGAGE G2 User Manual.** Supplier-supplied 42-page manual used for operating environment, product construction and interfaces, optional hands/grippers, emergency-stop and power interfaces, teleoperation, data collection and upgrade workflow.
- **Genie 02 GDK v2.1.0 User Manual [WIP].** Supplier-supplied 92-page developer manual used for DDS, ROS 2 Humble, Python/C++, motion/status, end-effector, sensor, map, SLAM and navigation interface scoping. WIP status is retained as a program risk.
- **ENGAGE G2 Product Pamphlet.** Supplier-supplied marketing pamphlet used only for non-binding product-positioning context and cross-checking feature categories.
- **Engage G2 official product references.** Supplemental product-positioning, industrial-deployment and simulation-asset references held under the Engage × MangoBot program document register.
- **Defined Support Period.** Published security-update support period for the G2 platform, held under the program document register.
- **ISO 10218-1:2025 and ISO 10218-2:2025.** Industrial robot and robot-application safety baselines; published scope limitations noted in this response.