AETEC PTE. LTD.

AETEC PTE. LTD.

INNOVATE. INSPECT. PROTECT.

TECHNICAL PROPOSAL · REV B

Robotic Nomex Honeycomb Assembly

ABB PoWa 20 · Supported handling · Controlled spring tension

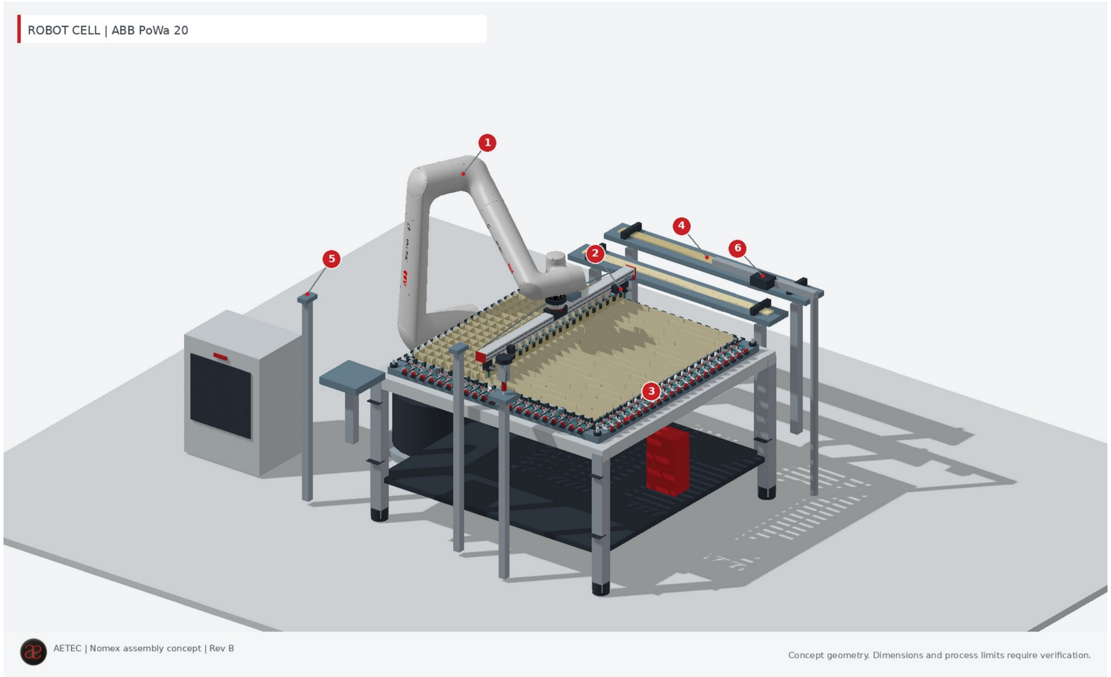


ABB official robot geometry with AETEC concept tooling. Open cell shown for design review.

Prepared for	Document	Date
DSO Project Team	Technical concept / POC definition	09 September 2026
Nominal 1 m × 1 m grid	50 mm pitch · 400 square cells	Revision B

CONFIDENTIAL — FOR CUSTOMER PROJECT DISCUSSION

1. Recommended automation concept

Use one **ABB PoWa 20 cobot** to assemble pre-cut flexible Nomex strips in an open, transferable carrier. A full-length end effector provides distributed support; independent fixed and spring-loaded end clamps keep each strip located through insertion, handover and adhesive processing.

The structure in the supplied photographs is an **interlocking square-cell core**. The process places the A strips first with slots upward, then inserts the B strips with slots downward. This proposal develops that assembly method. The main process risk is local bow or slot misregistration in a flexible strip.

Design item	Rev B basis	Status
Robot	ABB PoWa 20, CRB 1920-20/1.67; 20 kg payload [1,2]	Selected model
Input	Pre-cut Nomex strips; actual grade and condition unknown	Customer basis / verify
Grid span	1,000 × 1,000 between outer wall centre lines	Provisional datum definition
Cell pitch	50 mm centre-to-centre; 20 × 20 cells	Target interpreted as pitch
Paper count	21 A + 21 B = 42 strips; 441 intersections	From provisional grid
Paper height / thickness	50 / 0.13 mm	Model values, unconfirmed
Slot depth / width	25 mm per mating strip / 0.8 mm	Model values, unconfirmed
Blank length	1,060 mm, including 30 mm beyond each outer crossing	Requires incoming allowance
Tension example	T = 0.30 + 0.15 × 2 = 0.60 N per strip	Illustration, not a recipe
Adhesive	Purpose, product, open time and cure still to be defined	Qualification required

What changes in this revision

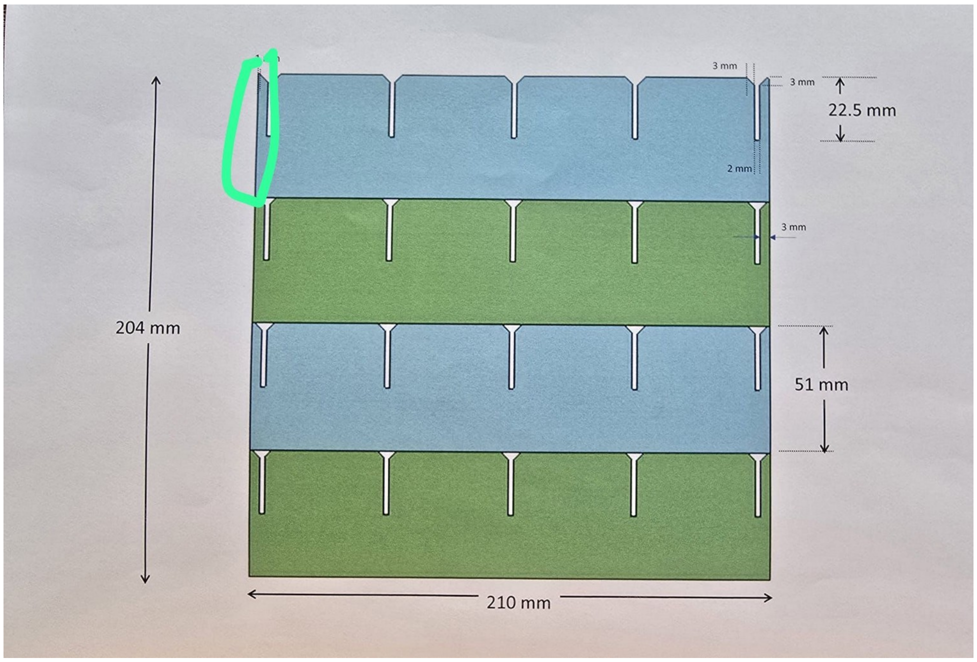
The robot now uses the official ABB PoWa 20 model and kinematics. The design adds full-length vacuum support, retracting soft jaws, separate end-grip zones, an outward-pulling extension spring, a back-off actuator and a controlled transfer of tension to the fixture. The app includes detailed mechanism views and three process flowcharts.

Nomex is treated as a flexible sheet. Material grade, cutting accuracy and conditioning must be established before force limits or production speed are frozen. The proposed spring settings and tool dimensions provide a reviewable starting point for a POC.

2. Nomex and incoming geometry

DuPont describes thin densified Nomex papers as flexible and resilient. Nomex 410 data also distinguish machine and cross-machine directions and show that moisture condition affects mechanical behaviour. These references support flexible-sheet handling; they do not establish an allowable tension for this customer's slotted strip. [3,4]

Resolve the supplied drawing before detailing the slots



Customer-supplied 210 mm coupon drawing. It is not a released 1 m production blank.

The drawing shows **51 mm strip height** and **22.5 mm slot depth**. If 51 mm is the effective assembled height and both mating slots are 22.5 mm deep, their total depth is 45 mm: a **6 mm mismatch** remains. Folded tabs, different A/B cuts or a different effective height may explain it; the photographs alone cannot resolve that detail.

Incoming check	Why it changes the mechanism
Grade, thickness, density / grammage, coating or resin treatment	Sets vacuum leakage, stiffness, grip response and adhesive compatibility.
Machine direction, roll curl and storage / conditioning	Sets repeatable bend and tension behaviour across batches.
Full-length slot map, width, depth, root shape and cut damage	Determines the registration budget and whether vertical interlocking is possible.
Blank length, end handling lands and any folded tabs	Determines whether tool and fixture can grip simultaneously without interference.

3. Robot cell and work envelope

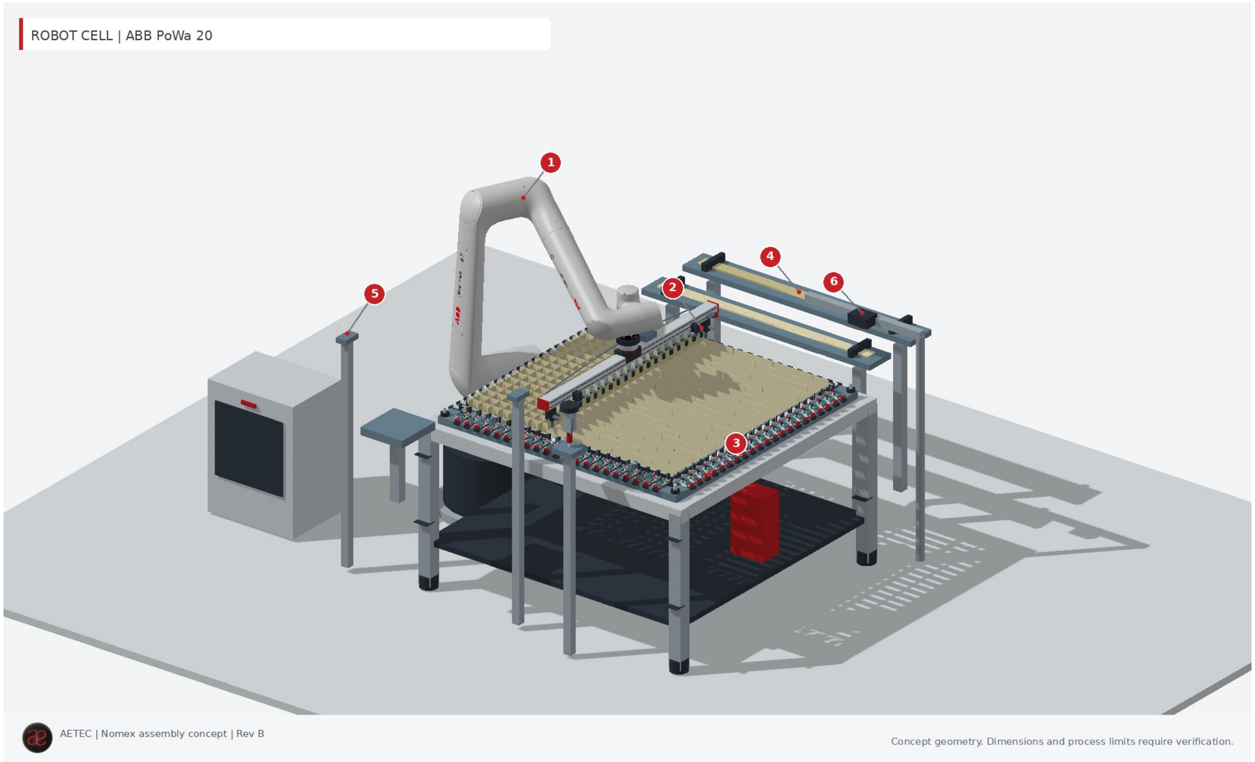


Figure 1. 1 Robot and pedestal; 2 handling tool; 3 perimeter clamps; 4 strip magazines; 5 tool rack; 6 vision head.

Place the robot beside the carrier and keep both keyed magazines in its near workspace. The app positions the robot base at **X −860, Y 300, Z −120 mm** relative to the grid centre on the floor, with the paper base at Y 780 mm. These coordinates are a concept layout, not installation dimensions.

ABB basis	Design implication
20 kg rated payload; 1.67 m wrist reach; 1.82 m flange reach [1,2]	Check the required flange orientation as well as position. A point inside a radius is not sufficient proof of reach.
Official rigid-link GLB and modified DH metadata [5]	The app articulates the actual PoWa 20 links. Sampled inverse kinematics were solved for the illustrated sequence.
Tool, fittings, hoses and paper form the moving load	Validate measured mass, centre of gravity and inertia with the ABB load data and RobotStudio.
Long tool and thin-paper insertion	Commission conservative accelerations and force limits. Complete cell-level collision and protective-function design.

The tool-change approach was moved into a reachable posture range. Remaining engineering includes swept-volume checks around the carrier and magazines, tool-rack docking, hose routing, singularity margins and controller-specific motion validation.

4. End effector: supported handling

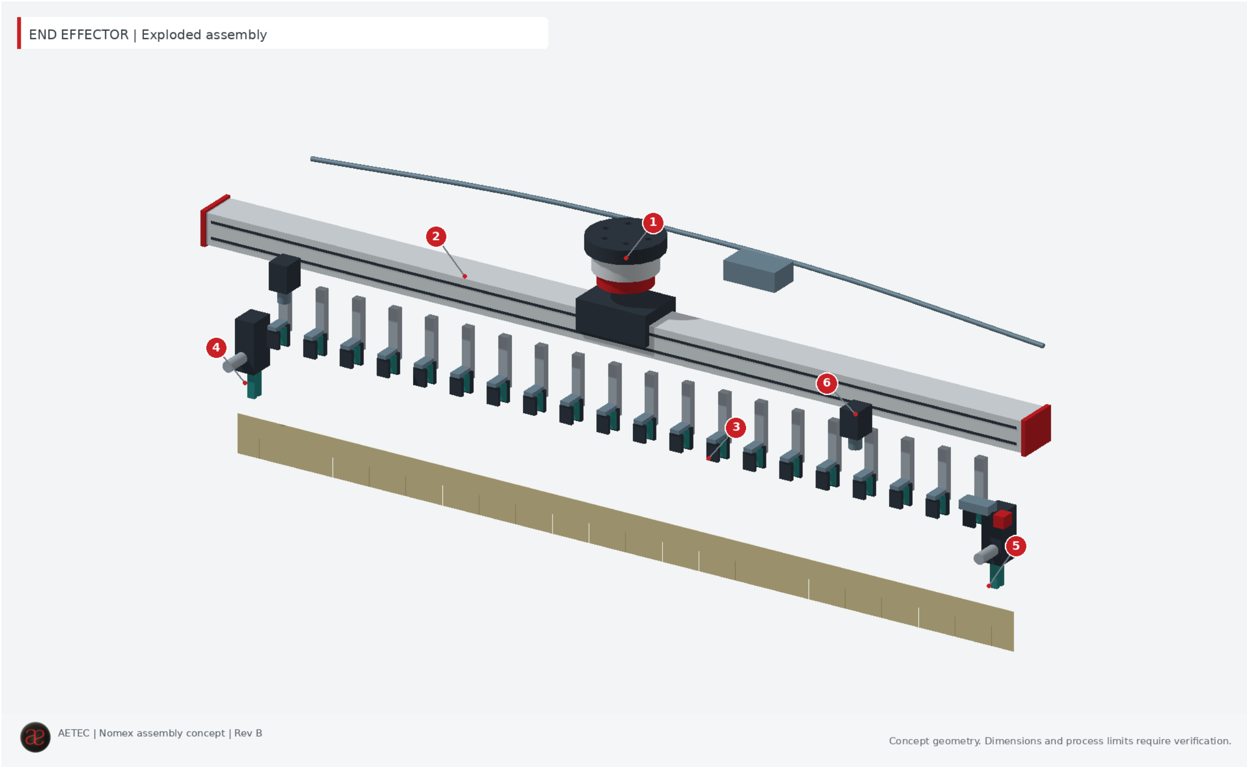


Figure 2. Exploded concept. Callout numbers correspond to the functional modules below.

Ref.	Module	Detail and purpose
1	Adapter, coupler and F/T sensor	Mechanical flange adapter, automatic coupler and a force/torque sensor selected for the insertion load range.
2	1,120 mm rigid beam	Nominal 50 × 40 mm hollow section; keep bending and twist small under acceleration and insertion load.
3	20 support modules at 50 mm pitch	Vacuum pads lift the sheet. Soft secondary jaws and top support lands occupy the spaces between crossing walls.
4	Fixed tool-end grip	Broad pad on an intact 10 mm handling land; sets the tool-side datum.
5	Floating tool-end grip	Guided carriage, low-rate extension spring, back-off and tension confirmation. Tension removes slack.
6	Local cameras and illumination	Check slot positions and paper edge behaviour along the strip; use the overhead view to reference the carrier.

Vacuum pads act on the broad face of the paper. The opposed jaws park clear during pickup and close only after the strip has lifted from the stack. The upper B-strip land remains supported while its downward slots engage the A strips.

5. End-grip zones, pickup and load budget

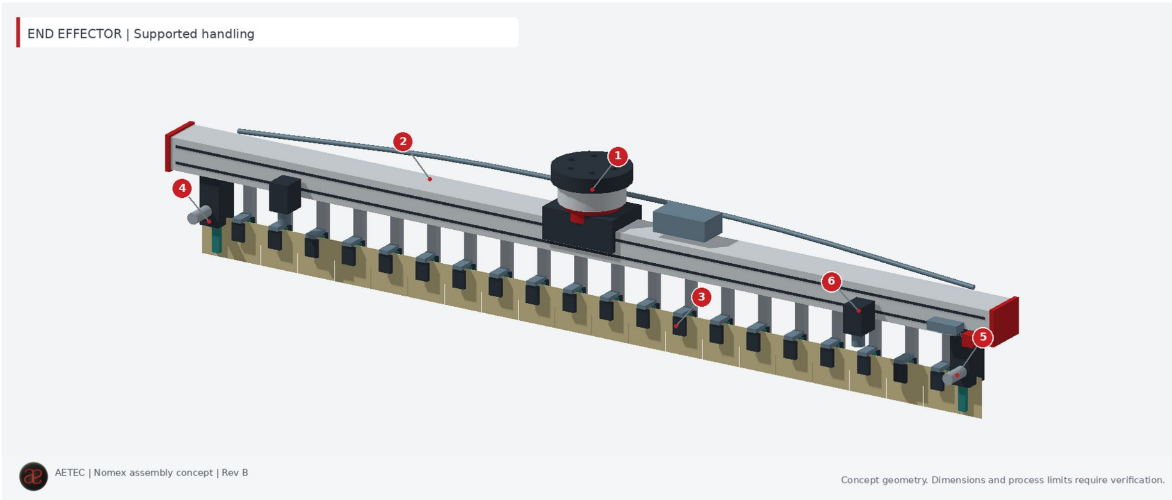


Figure 3. Assembled handling tool. The paper remains supported along the beam during wrist rotation.

The provisional blank extends **30 mm beyond the outermost crossing** at each end. Measured outward from that crossing, the tool uses the **2–12 mm land** and the fixture uses the **20–30 mm land**. The nominal pad-to-pad gap is 8 mm. Moving jaws, carriage travel and positional tolerance must fit inside the remaining clearance. The fixed-side and floating-side geometry is mirrored.

If the delivered strips do not contain these lands, this tool cannot be released as drawn. Develop an alternate edge capture or a removable handling extension, or obtain an agreed blank change. **Do not assume the 3 mm details on the supplied sketch provide a 30 mm grip margin.**

Pickup / handover feature	Implementation detail
Separate before clamping	Zoned vacuum plus single-sheet detection; lift sufficiently clear before the secondary jaws close.
Support without crushing	Compliant, replaceable pad faces; pressure and jaw stroke limited by coupon tests. Avoid cut roots and unsupported paper edges.
Avoid crossing-wall interference	Segmented jaws sit at cell midpoints. Fixture clamp bodies remain below the tool support structure.
Confirm load transfer	The tool maintains support while the fixture grips. Ramp down tool preload before opening its end jaws.

Preliminary moving-tool budget: 8 kg, including an allowance for coupler/sensor, beam, jaws, end carriages, cameras, valves and hoses. A 1,120 × 50 × 40 × 2 mm aluminium tube is about 1.04 kg before machining; this is only one contributor. The tool’s as-built CAD mass properties and cable loads remain to be established.

For scale, 8 kg acting 0.22 m from an axis produces about 17.3 N·m under gravity. This calculation does not approve a load offset. ABB also limits load inertia; a long beam can be limited by inertia even when its mass is below 20 kg. [2]

6. Carrier and independent holding fixture

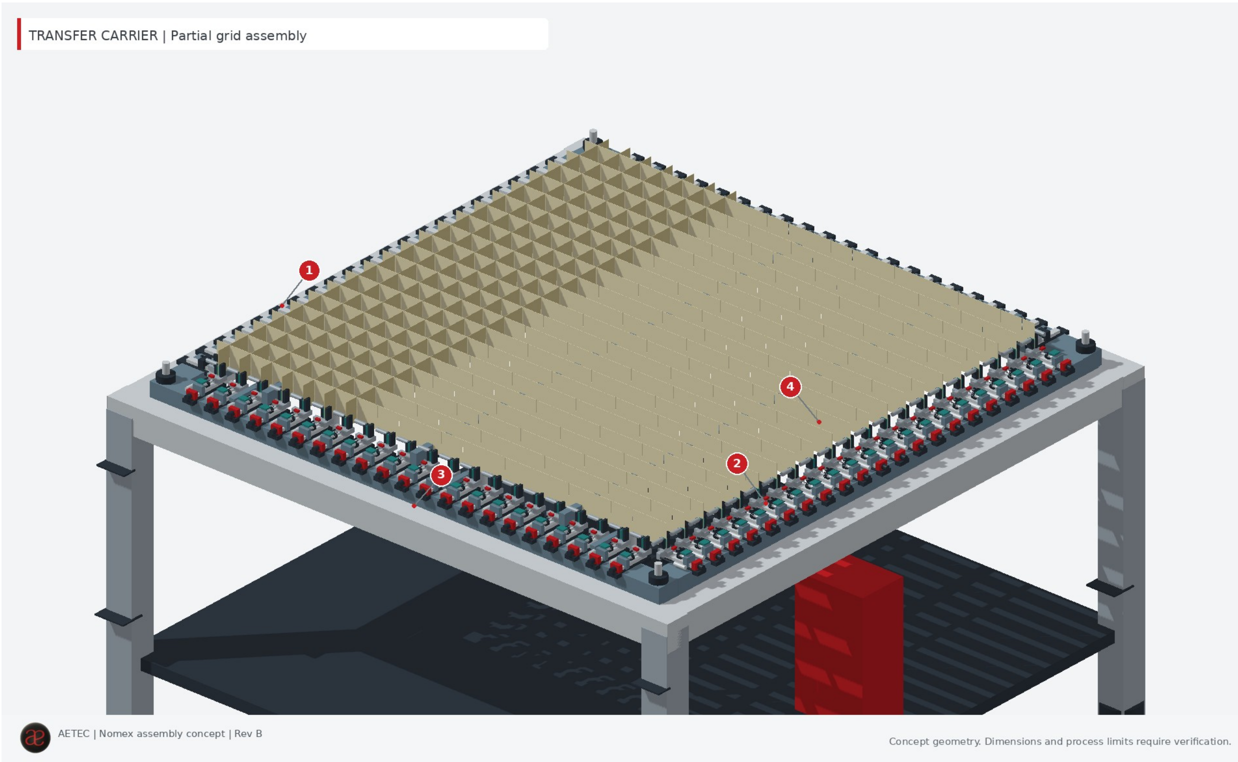


Figure 4. Partial grid on an open carrier. 1 Datum clamps; 2 floating clamps; 3 carrier frame; 4 retractable comb supports.

The carrier provides **42 fixed end clamps and 42 floating end clamps**, one pair per strip. Each floating end has its own spring and guided slide. A shared spring bar would couple the strip loads: a bowed or incorrectly cut strip could disturb its neighbours.

Fixture feature	Design intent
Fixed datum end	Establishes the strip reference without pulling both ends against rigid stops.
Independent floating end	Maintains a limited outward tensile load while taking up slack and accommodating small handling changes.
Retractable comb rails	Support the A walls locally. Their X positions fall between B-strip planes, so the B strips can descend and the combs can lower afterwards.
Open transfer carrier	Three fixed low rails remain flush with the paper base when the combs withdraw. The completed grid stays supported through cure, unclamping and transfer.
Replaceable jaws and release surfaces	Keep adhesive away from moving parts; support cleaning and recipe changes without replacing the whole carrier.

The app shows three retracting comb rails at X −375, −25 and +325 mm, plus fixed carrier supports at X −425, +75 and +425 mm. Their exact number, spacing and top profile depend on the measured paper stiffness. Verify local bow over the full 1 m length; a straight line between the end clamps does not prove that all slots align.

7. Spring carriage and tension control

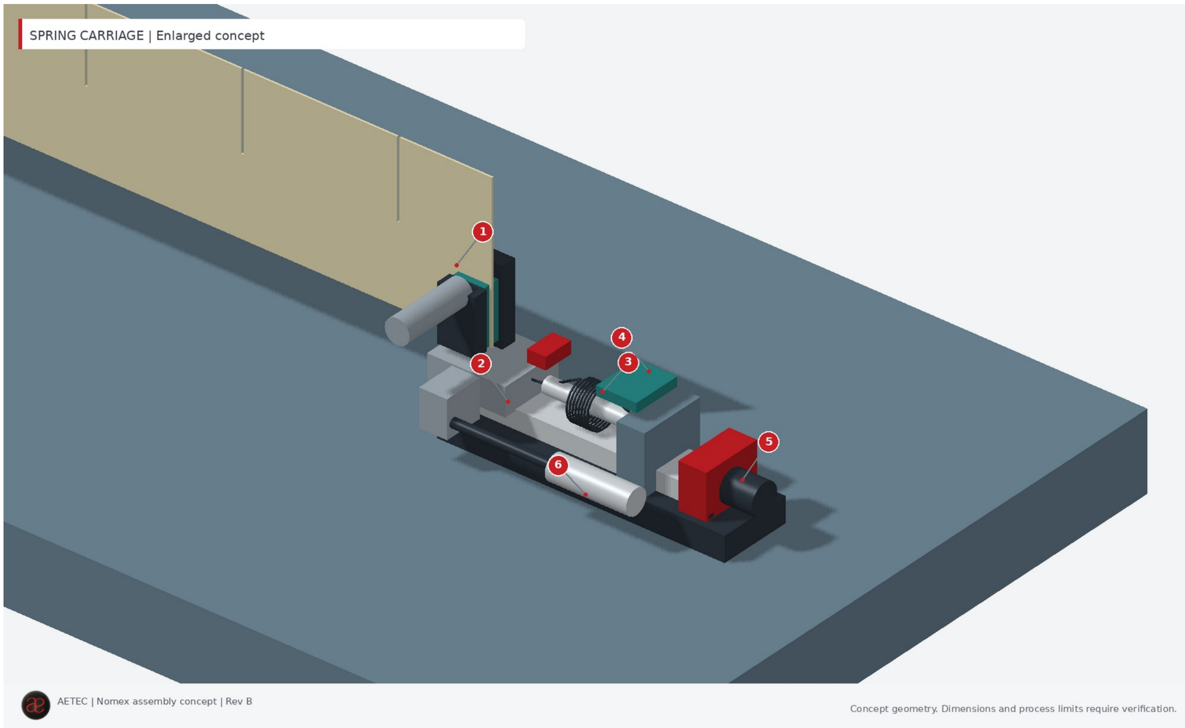


Figure 5. 1 Broad grip; 2 slide; 3 extension spring; 4 displacement sensing; 5 preload / travel stop; 6 back-off actuator.

Use an **extension spring anchored outward** so that it pulls the floating jaw away from the grid. A miniature back-off actuator holds the carriage against the spring while the jaw closes, then releases the load gradually. A compression spring placed behind the carriage on the outer side would push toward the grid unless the force direction were reversed by its mechanism.

Illustration: $T = F_0 + kx = 0.30 + 0.15 \times 2 = 0.60$ N. The strip carries T, with an equal and opposite reaction at each end; it does not carry 2T. Spring extension includes mechanism motion and slack take-up and must not be treated as paper extension.

Concept parameter	Starting point / verification
Spring type	Low-initial-tension extension spring; preload adjustment and positive travel limit.
Rate example	0.15 N/mm. Ideal spring calculation with G 77 GPa, mean diameter 12 mm, wire 0.68 mm and 8 active turns gives about 0.15 N/mm; hooks, initial tension and manufacturing tolerances require supplier design.
Travel shown	0–5 mm mechanism range in the explainer; not an allowable strain range for the paper.
Feedback	Calibrated spring displacement plus grip confirmation. Account for slide friction, hysteresis and sensor drift; use a reference load cell during qualification.
Release	Back off the spring progressively after cure, confirm the carrier supports the panel, then open the jaws.

8. Slot engagement and tolerance budget

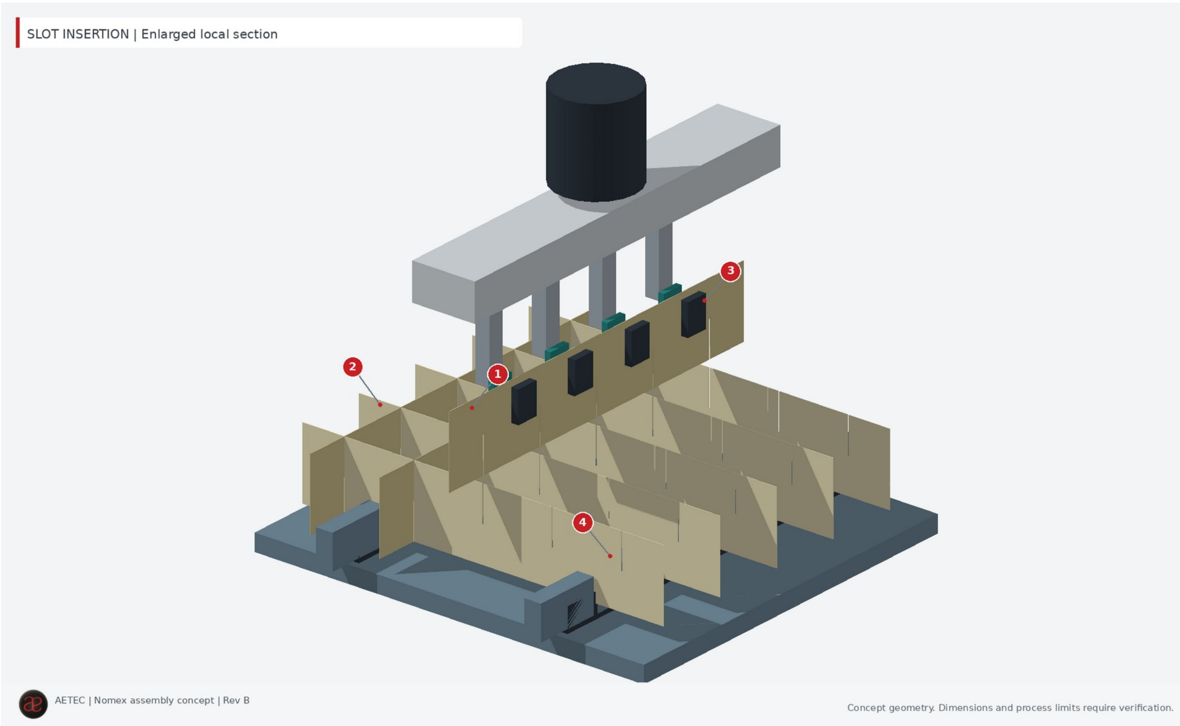


Figure 6. 1 Incoming B wall; 2 A wall; 3 local tool supports between crossing planes; 4 offset comb rails.

For equal-height strips that seat flush, the two slot depths must be compatible with the effective core height. The app uses H = 50 mm and dA = dB = 25 mm. It uses a nominal 0.8 mm slot and a provisional 0.13 mm paper thickness; the displayed wall thickness is enlarged to make the model readable.

The ideal lateral clearance per side is **(0.8 − 0.13) / 2 = 0.335 mm**. A conservative registration budget must include cut error, fixture location, vision residual, local bow and tension-related slot motion. Burrs, tapered cuts and rotation consume further clearance.

Required condition: $|e_{cut} + e_{fixture} + e_{vision} + \Delta L_{tension}| < (\text{slot width} - \text{thickness}) / 2$, with an additional process margin. This is a geometric screening condition, not an insertion-force model.

As an illustration, only 0.05% length change over 1,000 mm moves the end slot by 0.5 mm, already larger than the ideal 0.335 mm allowance. **Do not increase tension to repair a bad slot pattern.** Re-register or reject the strip.

Insertion control	Response
Entry	Register the full slot pattern, then use a slow, supported vertical approach.
Abnormal force, bow or incomplete seating	Stop descent, retain support, retract in a controlled path and inspect the slot. A low total force alone does not rule out local damage.
Final seat	Confirm height and both end-grip conditions before the tool unloads.

9. Controlled handover to the fixture

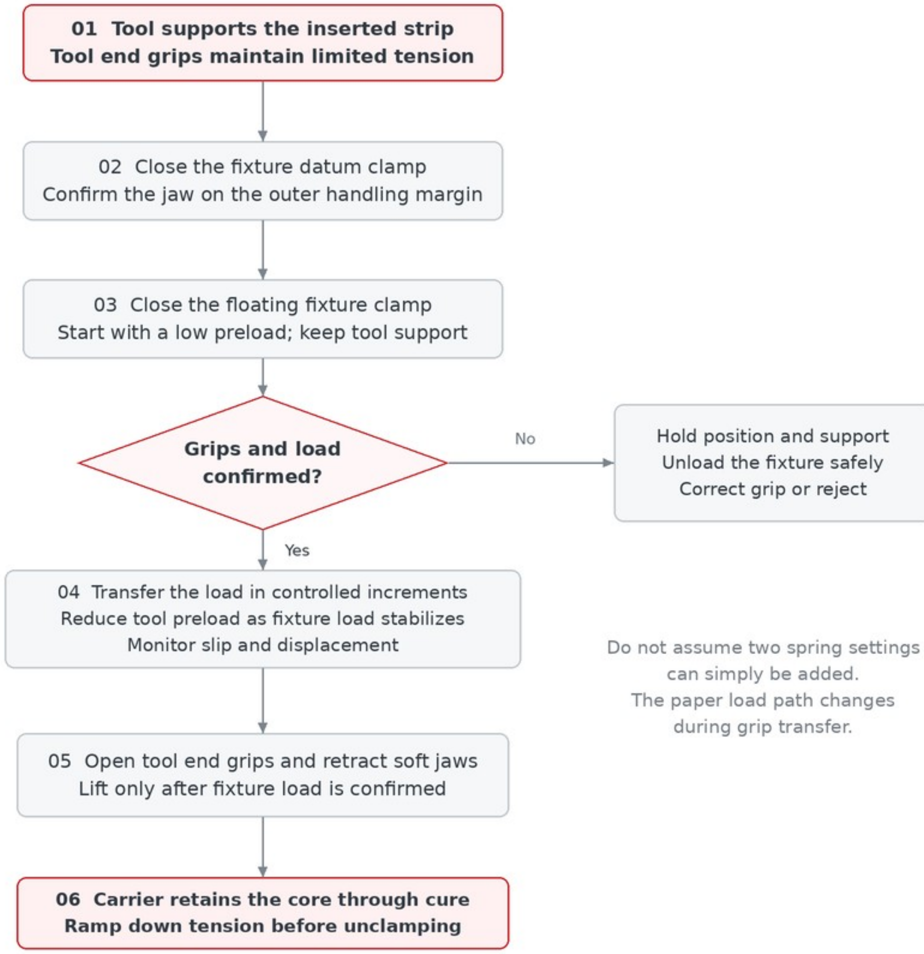


Figure 7. Keep the paper supported until the fixture has accepted the load.

Tool and fixture grips share the paper during transfer. The load path changes as the second set of jaws closes; independently commanding both spring systems to a full preset can create an unwanted local load or movement. Transfer the load in small, monitored increments, then release the tool.

If a fixture jaw slips or its load feedback is uncertain, keep tool support and back off the fixture. Recovery must return to a known grip state. The design should never release all supports in response to an insertion or handover fault.

10. Assembly sequence and recovery gates

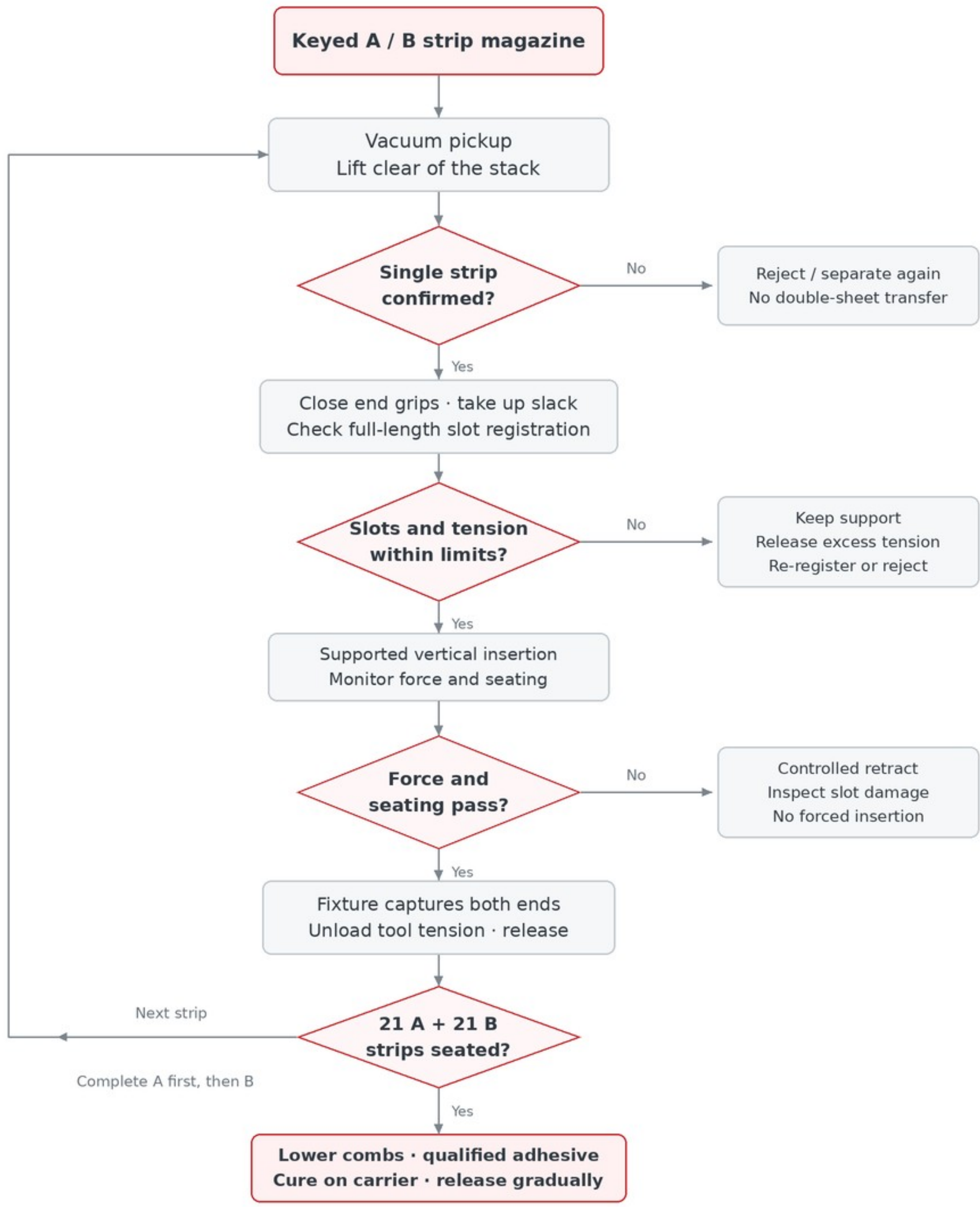


Figure 8. Assemble all A strips first, then B strips. The cycle repeats only after a valid handover.

The illustrated sequence contains all 42 strip placements. The PLC recipe should identify each strip family and row, store the last confirmed state, and prevent a restart from treating a partly inserted strip as complete. Recovery procedures require commissioning on real blanks.

11. Adhesive application and cure

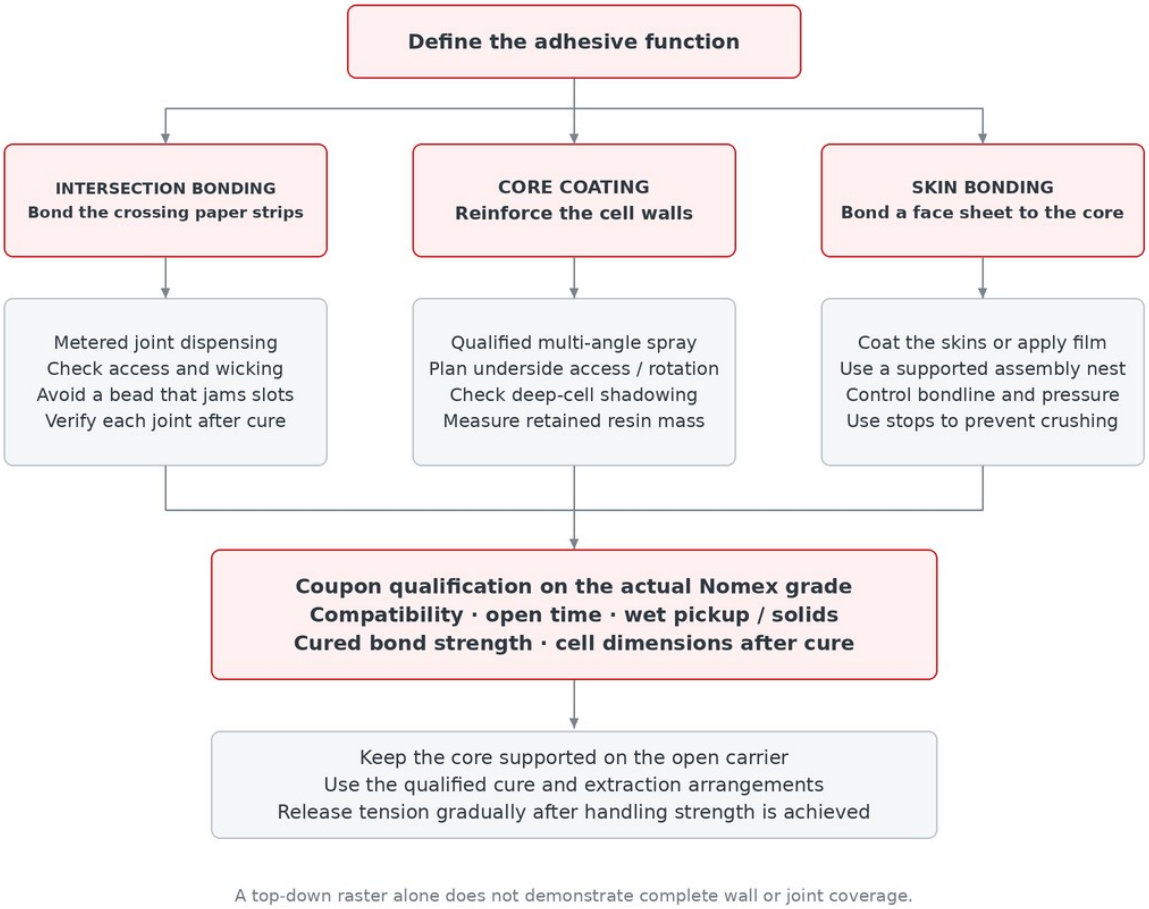


Figure 9. Select the route from the function of the adhesive, then qualify it on the actual material.

The requested “rain” or spray application can be investigated for coating the assembled core. A single overhead pass can leave lower walls and intersections shielded by the cell geometry. Plan the required nozzle angles, overlap, underside access and carrier movement, then verify retained material and bond quality on sectioned coupons.

A metered industrial spray valve is one candidate for repeatable application; its actual suitability depends on the adhesive viscosity, solids, required pattern and cure. Manufacturer equipment information is a starting point, not confirmation that an adhesive will bond this Nomex. [6]

Measure during qualification	Reason
Wet pickup, solids and retained cured mass	Relates nozzle settings to the material actually left on the core.
Joint / wall coverage, bond strength and cell dimensions	Reveals shadowing, weak areas, wicking and cure-related distortion.
Open time, cure time, handling strength and extraction needs	Defines the station sequence, carrier retention time and spray enclosure requirements.

12. Controls, sensing and recovery

Function	Suggested signal / mechanism	Action on failure
Single-strip feed	Vacuum per zone plus a suitable single/double-sheet sensor	Return or reject; do not rotate a loose double feed.
End gripping	Jaw-closed confirmation and controlled normal force	Retain distributed support; retry within an agreed limit.
Tool tension	Floating-slide displacement and a calibrated tension signal	Back off; do not use extra tension to force registration.
Slot registration	Overhead reference plus local slot/edge views	Re-register or reject before insertion.
Insertion	External F/T sensor, robot position and local vision	Stop and retract on an abnormal force–displacement signature.
Fixture acceptance	Datum and floating jaw feedback, spring displacement	Keep tool support until the holding state is confirmed.
Comb withdrawal	Up/down sensors and path interlock	Prevent carrier transfer while a comb remains engaged.
Tool exchange	Coupler lock and tool identity	Prevent automatic motion with an unconfirmed tool.
Adhesive	Pressure / flow or mass monitoring, recipe and purge state	Hold or quarantine the carrier for a missing application.
Cure and release	Cure recipe completion and handling-strength criterion	Keep the carrier supporting the panel.
Carrier movement	Carrier present, located and clamped	Prevent assembly on an unlocated carrier.

Separate the robot motion from process permission

The robot performs transfer and supported approach moves. The cell controller owns the strip recipe, grip-state transitions, tension permissives, force limits and recovery state. A pause must retain the paper safely; a reset must not blindly advance to the next row.

Choose sensors from the physical trials

A 20 kg cobot’s available torque signals do not by themselves establish enough sensitivity for a fragile slotted sheet. Select the external sensor range and resolution after measuring the insertion forces, including the tool’s weight and acceleration effects. Local vision is still needed because a single bent cell wall may not create a large total force.

For the POC, instrument the active grip pair directly. For a full carrier, low-cost displacement sensing on each floating carriage can reduce sensor cost, provided the spring, friction and zero point are calibrated and independently checked.

13. Simulation scope and cycle estimate

Delivered app view	What it demonstrates
Robot cell	Official ABB link geometry and sampled kinematic motion, both magazines, all 42 placements, carrier, combs and schematic tool exchange.
End effector	Assembled and exploded views of the beam, sensor stack, support zones, fixed and floating end grips.
Tension fixture	One complete strip and an enlarged spring carriage; adjustable preload, rate and spring travel.
Insertion detail	A correctly pitched local section showing jaws between crossing walls and comb rails offset from B planes.
Process flow	Assembly and fault recovery; controlled tension handover; adhesive route selection.

The animation is a **kinematic process demonstrator**. Flexible bow is illustrative; it is not finite-element analysis. Spray appearance does not calculate coverage, wetting or cure. Playback speed is independent of a production cycle-time commitment.

Validation completed and still required

The model's forward kinematics reproduce the ABB reference geometry, and numerical inverse kinematics resolve the sampled poses within the chosen standard joint limits. The sequence was revised to remove large configuration changes in tool exchange. This does not validate collisions, dynamics, cable routing, payload data, protective functions or real insertion forces.

The next simulation stage should import the final tooling CAD and measured tool load into RobotStudio, check every swept volume, then run the confirmed controller and process interlocks. Use measured flexible-strip properties for a separate contact/buckling study if the POC exposes a persistent insertion problem.

A transparent cycle-time model

Tpanel = 42 × tstrip + tcomb/transfer + tadhesive + retries + any cure time occupying the assembly station. As an example only, 8 s/strip + 35 s comb/transfer + 60 s adhesive gives **431 s, or about 7.2 min**, before retries, replenishment and cure occupancy. This is a planning assumption, not a demonstrated cycle time.

First optimize support and repeatable insertion. Then measure the actual event times, move cure onto supported parallel carriers where appropriate, and assess batch loading. Full-strip batch insertion should only be considered after individual placement is reliable.

14. POC plan and design release inputs

POC stage	Test article and measurements	Decision before advancing
1 · Material and one-strip handling	Actual 1 m blanks; grade / thickness; slot map; pad slip; vacuum leakage; tension versus bow; repeat pickup and handover trials.	Select grip materials and a supported tension range without slot distortion.
2 · Small interlocking core	Nominal 300 × 300 mm, 6 × 6 cells and 7 A + 7 B strips; measure insertion force, local buckling and grip transfer.	Freeze support geometry and the fault/recovery sequence.
3 · Full-size assembly	Nominal 1,000 mm grid with 21 A + 21 B strips; record accumulated registration error, cycle events and defect locations.	Demonstrate repeatable full-length insertion and dimensional control.
4 · Adhesive and cure	Actual adhesive and paper; compare application routes, retained mass, bond quality and dimensions after cure.	Select the application/cure recipe and required carrier retention.
5 · Integrated robot trial	Final tool mass properties, RobotStudio checks, controller logic and physical dry runs followed by material runs.	Release the cell only against agreed performance and protective-function criteria.

Proposed POC measurements

Use at least 30 pickup/handover attempts for each selected initial condition and a small series of full panels to expose systematic errors. Record first-pass feed and insertion success, rejected strips, peak force, tension drift, slot motion, panel geometry before/after cure, adhesive mass and event times. These sample sizes support development; they do not establish production yield.

Input to freeze	Required information
Blank definition	Released A and B CAD, effective core height, slot width/depth/tolerance, full length and grip margins.
Nomex specification	Grade, thickness / grammage, machine direction, surface treatment and allowed conditioning.
Finished product	Whether 50 mm means pitch or clear cell opening; whether 1 m includes the outside walls; dimensional and bond / strength acceptance criteria.
Adhesive and output	Glue/resin product and purpose, cure requirement, handling strength, target output and replenishment method.

For the current 0.13 mm model, a 50 mm pitch gives approximately **49.87 mm clear opening**. With 20 clear openings of 50 mm and 21 walls of 0.13 mm, the outside size would be **1,002.73 mm**. These definitions must be reconciled before releasing a 1 m fixture.

15. Deliverables, references and next release

The package contains a static web app with local 3D assets, motion data, engineering views and this proposal. The editable Word document follows the established AETEC company template. The proposal and app use the AETEC round logo and red/black/grey identity.

Cloudflare handover

Upload the supplied ZIP, or the extracted folder containing index.html, using Cloudflare Pages Direct Upload. The app requires no build command or backend; its JavaScript, robot model, logo and flowcharts are included locally. A modern browser with WebGL is required for the interactive 3D views. [7]

To preview the extracted package locally, serve the folder through a static web server. Opening index.html directly as a file may prevent the browser from loading modules and motion data. The included PDF remains available independently.

Source register

[1] ABB — PoWa collaborative robot family and model specification

Basis: PoWa 20 model identity, rated payload and wrist/flange reach. Retrieved 09 September 2026.

[2] ABB — Product specification CRB 1920, 3HAC097952-001, Rev A

Relevant pages: 26–27 dimensions/flange; 59–69 load and inertia; 72 reference workspace. Actual tool load and controller configuration require verification.

[3] DuPont — Characteristics of Nomex for insulation

[4] DuPont — Nomex 410 technical characteristics

These material references do not identify the supplied grade or qualify the proposed adhesive and tension limits.

[5] ABB — Official CRB 1920-20/1.67 GLB, 9AKK108473A0633, Rev A

Robot geometry © ABB. AETEC fixture and end-effector meshes are concept geometry created for this proposal.

[6] Nordson EFD — 781S general-purpose spray valve

[7] Cloudflare — Pages Direct Upload

Customer inputs: the supplied cut-strip drawing, interlocking-core illustrations and manual assembly photographs. The next release should replace provisional blank dimensions and process settings with measurements from the actual Nomex and adhesive.