MANTRA

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WHITE PAPER

Small Sensor. Smarter Security.

How modern fingerprint devices achieve accuracy in compact form factors.

Mantra Softech addresses the biometrics miniaturization challenge, enabling enterprise-grade security in compact devices. Our small-area fingerprint sensors, enhanced with proprietary 3-Click / 4-Click multi-capture technology and advanced anti-spoofing, achieve unparalleled accuracy and compliance. Discover how this innovation is revolutionizing secure, miniature biometrics.

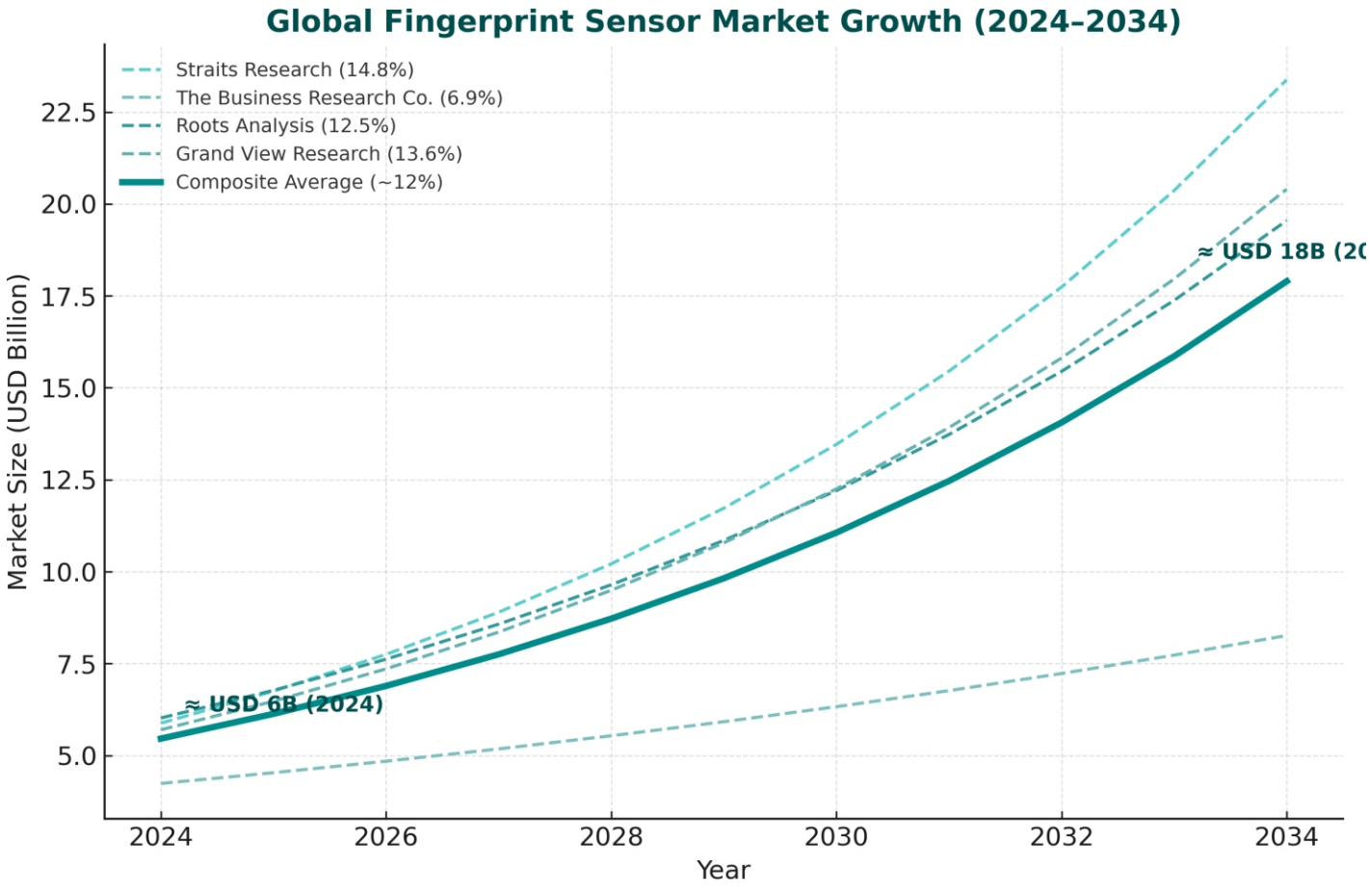
A Mantra Softech White Paper (October 30, 2025)

Why Fingerprints Still Matter In 2025

Fingerprint authentication is still the most deployed biometric on earth. It's fast, low-friction, and works offline — unlike OTPs or face-in-the-cloud. Governments, banks, workforce management, border control, EV charging, and consumer electronics all continue to standardize on fingerprints for identity, audit trails, and entitlement control.

Global demand is not flattening — it's accelerating:

- The global fingerprint sensor market is projected to grow from roughly USD 6–8 billion in 2024–2025 to ~USD 14–20+ billion by 2029–2033, depending on methodology, with double-digit CAGR driven by payments, government ID, mobility, and IoT.
- Asia-Pacific is the largest region for deployment, led by national ID, eKYC, border security, and access control.
- BFSI, defence / government, and workforce compliance remain highest-value buyers, because they require both identity proofing and traceability (who entered, who transacted, who armed the system).



The New Design Pressure: Miniaturization

But there's a new design pressure: miniaturization.

Devices keep shrinking. You can't always afford a "full finger area sensor" (large capture window, e.g. >12×16 mm). Access terminals, dash-mounted police units, drone ground stations, weapon lockers, time-attendance wearables, in-vehicle ignition authorizers, and handheld PoS units all want biometric-grade trust without dedicating big surface area.

This is where small-area sensors come in.

Real-World Applications

- eKYC tablets and handheld POS devices
- Smart attendance terminals
- IoT and embedded systems
- Access control panels and portable scanners

What is a Small-Area Fingerprint Sensor?

A small-area fingerprint sensor is a compact touch or area sensor (often capacitive or optical) with an active capture region typically below **~10×10 mm**. Instead of imaging the entire fingerprint in one press, it captures only a partial patch of ridges and minutiae. This form factor enables:

Ultra-slim housings
Minimal space requirements for embedded applications

Low power draw
Energy-efficient operation for battery-powered devices

Sealed / rugged IP-rated bezels
Durable protection for harsh environments

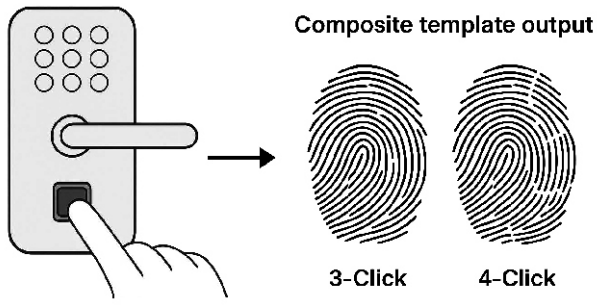
Lower BOM
Cost-effective for high-volume IoT endpoints

Market analysts segment sensors into area/touch vs. swipe, across capacitive, optical, ultrasonic, and thermal modalities, with capacitive and optical touch sensors still dominating embedded access and banking use cases.

Core Challenge

Physics. Less capture area = less ridge data. Less ridge data = higher false reject rate (FRR) or higher false accept risk (FAR) if you simply "loosen the match threshold." That's unacceptable for regulated spaces like defence armouries, payment-grade KYC, or immigration kiosks.

Traditional approach was: "Use a bigger sensor."Modern approach is smarter: **multi-click capture + reconstruction + PAD (Presentation Attack Detection).**



Small-area fingerprint sensor
(sub-10×10 mm active area)

3-Click / 4-Click Multi-Capture Technology

Mantra Softech's 3-Click / 4-Click technology is an enrollment and matching strategy engineered specifically for small-area sensors.

How It Works

Instead of asking the user to place a finger once and assuming we got a full template, we guide them through 3 or 4 rapid touches ("clicks") of the same finger:

01

Click 1

Pad center / main core region

02

Click 2

Slight roll left (or proximal segment)

03

Click 3

Slight roll right (or distal segment)

04

Optional Click 4

Tip / additional oblique angle for edge ridge capture

Each click captures a different partial patch of the same fingerprint. Software fuses these micro-patches into a composite high-resolution template that approximates the discriminative power of a much larger sensor area.

In plain terms: many tiny windows stitched into one strong identity reference.

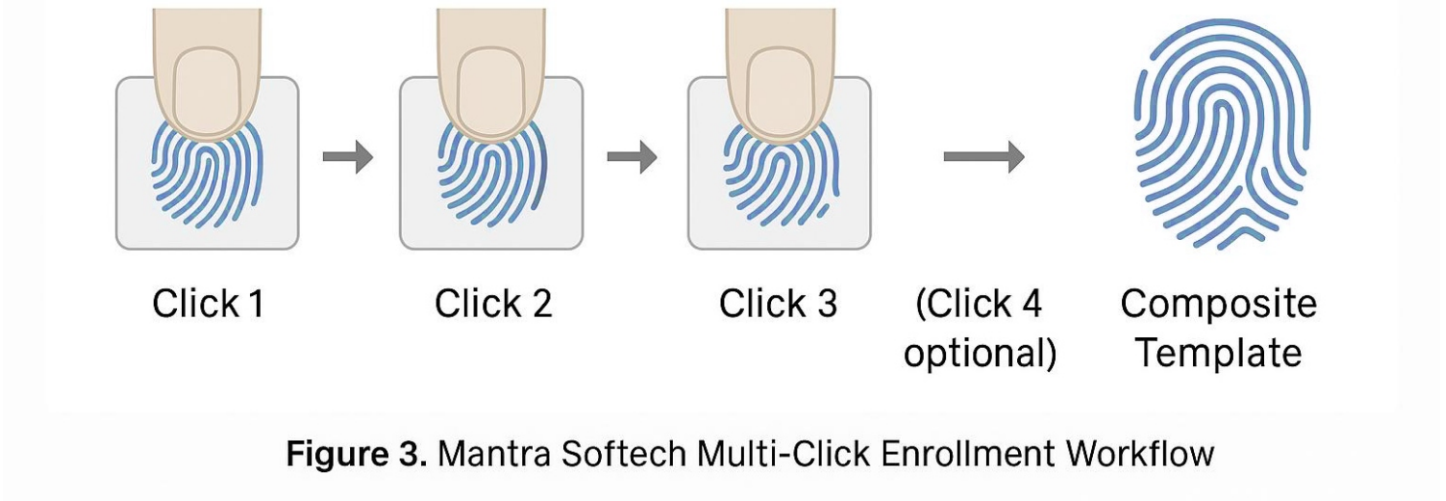


Figure 3. Mantra Softech Multi-Click Enrollment Workflow

Why Multi-Click Matters

Better Accuracy on Tiny Silicon/Optics

Multi-click fusion increases the number and distribution of minutiae points, restoring match confidence to larger-sensor levels even when physical capture hardware is downsized.

Higher Tolerance to Finger Placement in The Field

During daily use (verification), the user may present only part of the finger. Because enrollment already saw multiple angles, the matcher can accept partial matches from any of those "views" without lowering security thresholds.

Faster Enrollment vs Swipe Sensors

Legacy swipe sensors forced the user to drag the finger in one perfect motion — bad UX in dusty or wet environments. Multi-click is tap-tap-tap, which is friendlier for kiosk queues, outdoor turnstiles, gloved security staff, and fatigued industrial workers.

In rugged deployments (construction sites, defence perimeters, oil & gas access gates), fingertips are often dry, cut, or dirty. Multi-click capture statistically increases the chance that at least one contact slab is clean enough to yield sharp ridge detail, which then strengthens the reference template used for future matches.

Anti-Spoofing and Liveness: Why PAD Compliance Matters

Miniaturization cannot come at the cost of spoof resistance. Presentation Attack Detection (PAD) is now a procurement requirement across banking, defence, and border control, and buyers increasingly ask for conformance with ISO/IEC 30107 (Parts 1–4).

Threat Model

Attackers try to fool sensors using molds, casts, printed ridges, or high-res replicas of latent fingerprints (so-called "gummy finger" attacks). Studies have shown that commercial readers can be vulnerable if PAD is weak or disabled.

Mantra Softech Approach

Hardware-level liveness cues (sweat pore activity, ridge deformation under pressure, capacitance profile, optical scattering response, or thermal diffusion patterns depending on sensor type).

Software anomaly scoring trained on real spoof materials (gelatin, silicone, ecoflex, printed conductive ink, etc.).

Figure 4. PAD / Liveness Decision Flow

Transaction policy logic (for example: if PAD confidence < threshold, escalate to secondary factor like PIN, RFID token, or supervisor override).

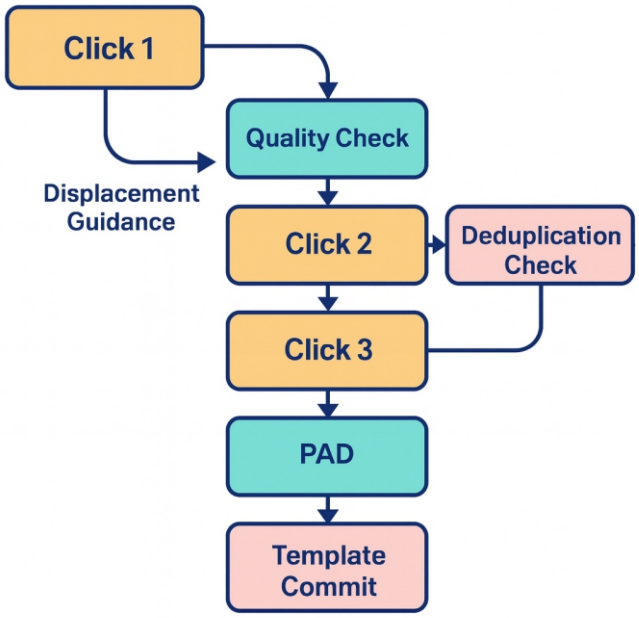
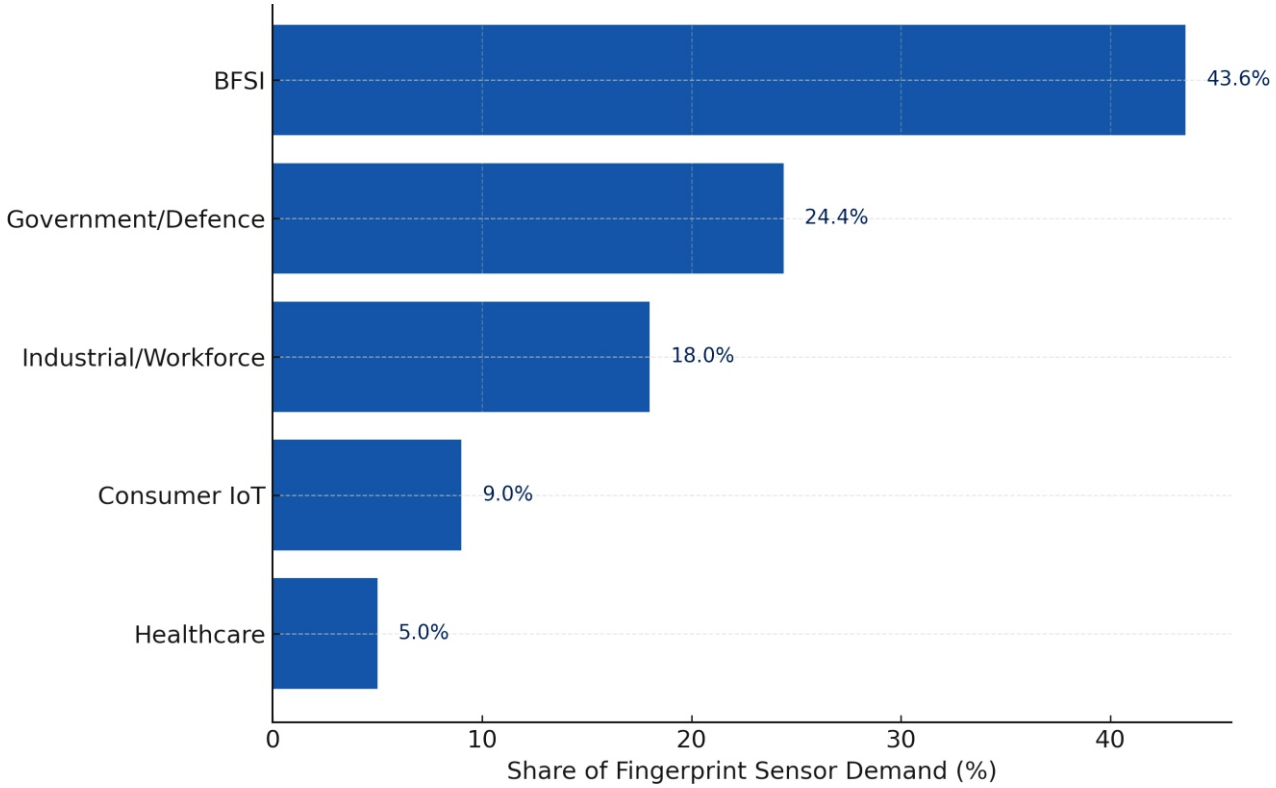


Figure 3: Mantra Softech Recommended Multi-Click Enrollment Workflow

ISO/IEC 30107-3 sets out how to test and report PAD performance, and ISO/IEC 30107-4 defines evaluation profiles for mobile-class devices.

Our roadmap aligns sensor modules and firmware to meet or exceed these benchmarks so customers in BFSI, defence, and border management can satisfy audit and regulatory pressure.

Key Industry Use Cases for Small-Area + Multi-Click Sensors



1. Defence / Critical Infrastructure

- Armory lockers, weapon issue counters, and command-room access panels require strong access control tied to an auditable identity trail ("who unlocked what, when").
- Small-area sensors allow embedding biometric locks directly on compact enclosures, flight cases, or portable radio racks instead of routing everything through a wall-mounted terminal.
- Multi-click enrollment supports rough, damaged fingers from field personnel without downgrading FAR/FRR.

National defence and border security agencies worldwide are adopting fingerprint biometrics and demanding PAD-compliant hardware to defeat spoofing, in line with stricter access governance and insider threat controls.

2. Banking / BFSI / Fintech

- Biometric POS, micro-ATM, and teller assist terminals in rural or agent-led banking can integrate compact readers.
- Embedded small-area sensors help meet eKYC, withdrawal authorization, and high-value transaction approval requirements without large peripherals.

BFSI is forecast to contribute a dominant share of fingerprint sensor demand in 2025 because banks need strong, fast identity proofing at the edge of their networks.

3. Workforce Management & Time-Attendance

- Wearable or palm-sized attendance terminals for distributed workforces (construction sites, logistics yards, maritime crews, remote energy assets).
- Employers and facility managers are moving from badge-swipe to biometrics to prevent "buddy punching" (co-workers clocking in for each other) and to meet compliance/audit demands in regulated industries.
- Multi-click enrollment increases template robustness for workers with worn or dirty fingertips, reducing failed punches and support tickets.

4. IoT / Smart Access / Embedded Control

- EV charging station unlock
- Smart door locks and lockers
- Drones / autonomous ground units
- Industrial HMIs (unlock machine control panels, log maintenance access)

The Internet of Things is exploding (tens of billions of connected devices projected before 2030), and OEMs are under pressure to secure each node without adding bulky biometric modules. Small-area + multi-click capture gives them biometric grade trust in <1 cm^2.

5. Border / Travel / Immigration

- Mobile ID verification kits carried by field officers or immigration staff.
- Rugged handhelds that must be small, battery-efficient, and spoof-resistant in outdoor checkpoints.

Contactless or semi-contact capture is becoming popular at airports and border kiosks as governments roll out biometric Entry/Exit programs and want fast throughput with high PAD assurance. Our roadmap blends compact touch capture with optional contactless assist modules for hybrid deployments.

Technical Challenges

Even with multi-click fusion, miniaturization is non-trivial. The main barriers are:

Signal-to-noise on a tiny die or optical window

Lower surface area means smaller raw image patches. If ambient conditions (dust, sweat, glare) interfere, each patch must still be reconstructable.

User guidance / UX

If you ask the user for 3–4 taps, you must guide them (LED blink, on-screen prompt, haptic buzz) and score whether each tap captured new ridge regions vs. duplicates. Bad UX = bad enrollment = higher false rejects later.

Computation at the edge

Many IoT endpoints run on low-power MCUs. Template fusion, minutiae extraction, and PAD scoring must run locally or semi-locally without cloud dependency, especially for defence, border, or offline rural finance.

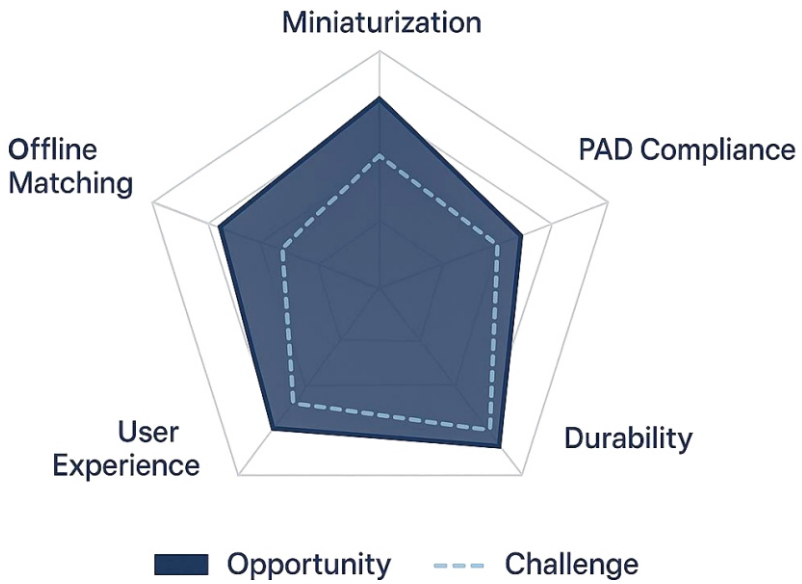
Regulatory proof

Buyers are now asking not just "Does it work?" but "Show me PAD conformance, show me ISO/IEC 30107 test results, show me audit logs." The sensor vendor must provide verifiable test data.

Durability and contamination

Small sensors are often flush-mounted on outdoor panels, smart lockers, vehicle dashboards, or turnstile columns. They must survive UV, rain, abrasion, sanitizer chemicals, fuel/grease, etc., without losing ridge clarity.

Opportunity vs Challenge Radar for Small-Area Sensors



Opportunity & Future Trendlines

a) Biometric by Default IoT

Manufacturers of smart locks, EV charging stations, portable payment terminals, etc., are moving from PIN-only to "PIN + biometric." Fingerprint is attractive because it's mature, auditable, and already trusted by regulators in finance and law enforcement. That pushes demand for tiny, embeddable modules with bank-grade matching.

b) Contactless + PAD

Airports and high-throughput border control are racing toward touchless capture and real-time PAD, aligned with ISO/IEC 30107-3/4 testing. We anticipate hybrid modules: a very small contact sensor (for deterministic, template-quality enrollment) plus a near-contact or contactless reader (for rapid verification in motion). This model reduces queuing friction and surface hygiene concerns.

c) Multi modal Fusion in The Edge Device

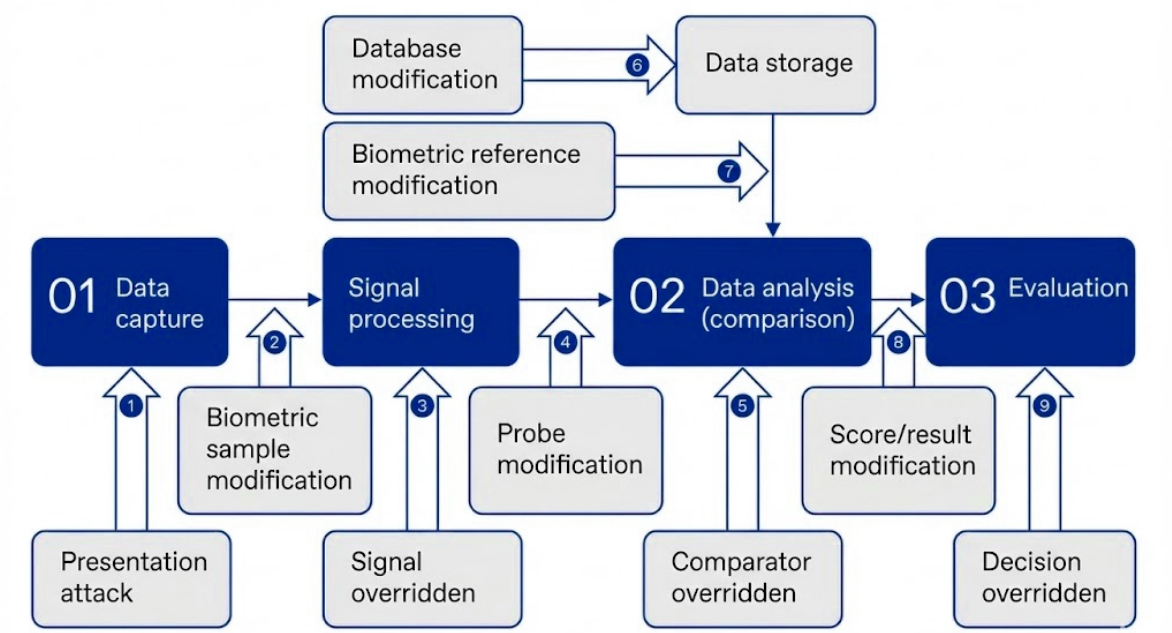
Future rugged terminals will combine:

- Fingerprint (Who are you?)
- Face / iris or badge (Are you present now?)
- Context / geolocation / timestamp (Should you be here now?)s.

This layered trust is already showing up in defence logistics, ATMs, and high-assurance workforce compliance, and will likely become mandatory for mission-critical access — especially where physical risk or financial liability is high.

d) Policy-Grade Audit Trails

Regulators, auditors, and insurers increasingly want non-repudiation: proof that a specific, living human triggered an action at a specific time. That's not just cybersecurity — it's also safety, fraud liability, and chain-of-custody. **Fingerprint biometrics with PAD and tamper-proof logging answers that need.**



Mantra Softech Value Proposition

Mantra Softech designs, builds, and integrates biometric systems across banking, national ID, access control, defence, workforce management, and embedded IoT. Mantra portfolio includes high-accuracy optical and capacitive fingerprint modules, AI-driven anti-spoofing engines aligned with ISO/IEC 30107 PAD guidance, and rugged access/time-attendance devices adopted by BFSI, government programs, and critical infrastructure in high-compliance environments.

What Makes Our Small-Area Sensor Platform Different

Custom Form Factor

We engineer compact sensors (sub-10×10 mm capture windows) to fit constrained enclosures — EV chargers, weapon lockers, handheld field terminals, smart locker doors, industrial HMIs — without redesigning the entire housing.

Edge-Class Matching + PAD

We embed minutiae extraction, fusion, match scoring, and spoof/liveness checks directly on the device or on a trusted local controller. You get millisecond decisions, offline operation, and auditable logs — critical for defence, BFSI, attendance compliance, and border/field verification.

3-Click / 4-Click Enrollment Stack

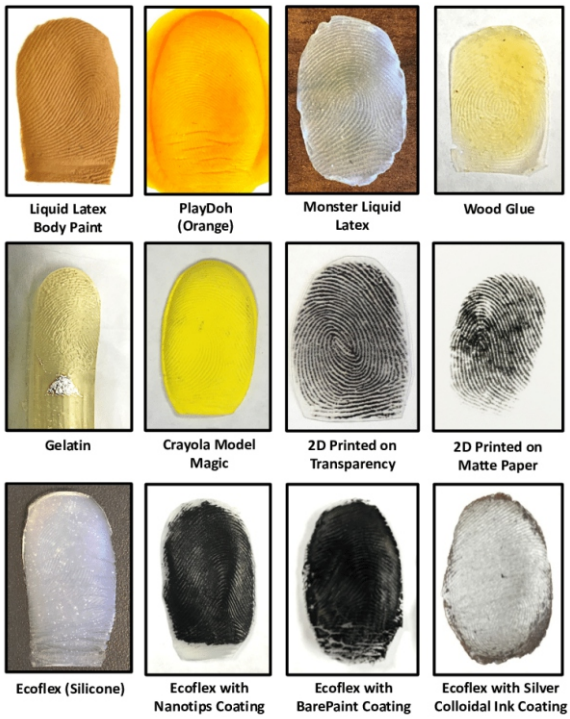
Our guided multi-click capture fuses multiple ridge patches into one composite reference template. Result: large-sensor accuracy using a physically smaller sensor surface.

Standards-Driven Trust

Our roadmap aligns with ISO/IEC 30107 PAD testing practices (Parts 1, 3, and 4) to help customers prove resistance to presentation attacks and satisfy regulators and auditors.

Scalability for Industry Rollouts

Whether you are deploying 50 rugged terminals in a refinery gate or 50,000 biometric nodes across a national banking network, Mantra supports manufacturing scale, field support, firmware lifecycle, and integration into attendance/payroll, access control, eKYC, or commandand-control dashboards.



Conclusion

The market is clear: fingerprint biometrics are not going away — they're getting embedded everywhere. The global fingerprint sensor market is on track for sustained double-digit growth through 2030 and beyond, powered by BFSI, defence, government ID, edge IoT, and border automation.

But the winning designs are no longer the "big glass platen" desktop readers of the past. **The future is compact, rugged, power-efficient, and audit-grade.**

Mantra Softech's Small-area Fingerprint Sensor Platform, Combined With 3-Click / 4-Click Multi-Capture Enrollment, Delivers:

- near full-size accuracy from a sub-10×10 mm sensor
- spoof and liveness defence aligned with ISO/IEC 30107 PAD expectations
- offline-capable, audit-ready identity proofing at the physical edge
- form-factor flexibility for defence kits, banking terminals, industrial controls, lockers, vehicles, and IoT endpoints

In Short : We Make High-trust Identity Possible Where Big Sensors Physically Cannot Fit.

If you're designing hardware that needs human-grade access control in a space smaller than a thumbnail, Mantra Softech can build that sensor, harden it against spoofing, and integrate it into your product lifecycle — from prototype to mass deployment.

Sources: The Business Research Company. Global Fingerprint Sensor / Biometric Authentication Market Analyses, regional deployment trends (Asia-Pacific leadership in national ID, BFSI, workforce compliance), access control, and identity traceability drivers (2024–2025). Straits Research. "Fingerprint Sensor Market Size & Outlook 2025–2033." MarketsandMarkets / comparable industry trackers. ISO/IEC 30107 (Parts 1, 3, 4). Independent academic and industry spoofing studies. HID Global and other border/air travel industry advisories on biometric Entry/Exit modernization (2024–2025).

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