CleanWard
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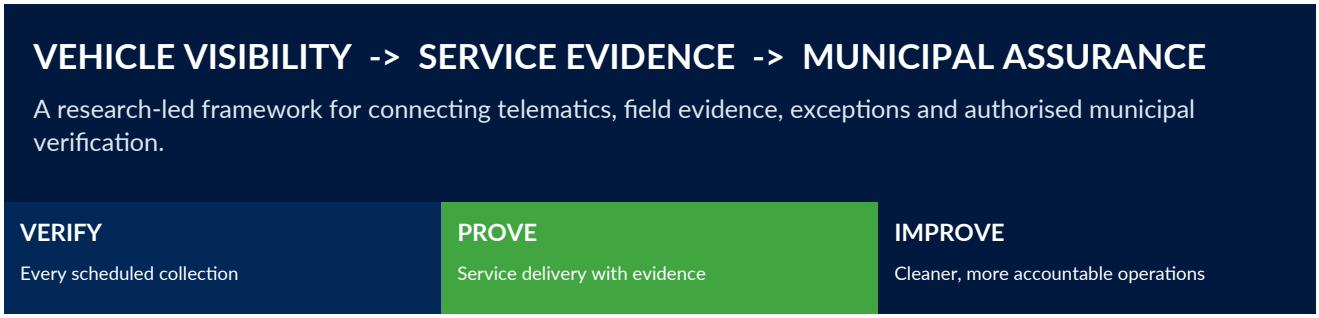
CLEANWARD WHITEPAPER

Beyond GPS: From Vehicle Visibility to Municipal Service Assurance

Why telematics is essential - but not sufficient - for verifiable waste collection.



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ABSTRACT

The next digital step in municipal waste collection

A research-led framework for interpreting vehicle data in the context of public-service obligations, exceptions, verification and accountability.

GPS and modern telematics have transformed fleet visibility. Municipalities can observe vehicle position, route history, speed, ignition, dwell behaviour, geofence activity and, with appropriate hardware, sensor events associated with collection operations. Research on smart waste systems consistently shows the value of GPS, GIS, RFID, IoT and real-time monitoring for route control, collection efficiency and operational visibility [8]-[10].

Yet a municipal waste service is not equivalent to vehicle movement. The public obligation is to deliver an authorised service to a defined area or population according to an approved operating model. The management problem therefore shifts from "Where did the truck go?" to "What service was required, what evidence describes execution, what explains variance, and what conclusion may an authorised municipal official reasonably record?"

CENTRAL THESIS

Telematics provides critical operational evidence. Municipal Service Assurance connects that evidence to the service obligation, preserves exception context, separates evidence from administrative judgement, and retains a traceable record of the outcome.

Research basis. This whitepaper synthesises South African waste-service legislation and standards, AGSA and National Treasury governance guidance, peer-reviewed research on digital waste collection and real-time monitoring, and international municipal digitisation experience. The Municipal Evidence Stack and Service Assurance Maturity Model are CleanWard conceptual frameworks developed from that synthesis.

Waste collection is a public-service system, not only a fleet function

South Africa's legal and policy architecture places domestic waste collection within a municipal service-delivery and environmental-management framework.

Schedule 5B of the Constitution includes refuse removal, refuse dumps and solid-waste disposal among local-government matters [1]. The National Environmental Management: Waste Act establishes the broader statutory framework [2]. National Domestic Waste Collection Standards address, among other matters, levels of service, collection vehicles, communication and awareness, complaints handling and customer-service standards [3], [7].

The National Waste Management Strategy 2020 situates waste management within a wider transition toward waste minimisation, circularity, improved governance and effective implementation [4]. These instruments do not prescribe a CleanWard-type digital architecture. They do establish why municipal waste collection should be understood as a service system with defined responsibilities, users and performance expectations.

Governance environment. AGSA reported that only 39 of 257 municipalities achieved clean audits for 2024-25. Material findings on the usefulness and reliability of performance information were reported at 123 municipalities, while AGSA also identified widespread procurement and contract-management non-compliance [5]. These findings are not evidence about CleanWard or waste collection specifically; they are evidence of the broader importance of credible records, controls and performance information in local government.

An asset is not a service

Fleet telematics and service assurance answer related but different classes of question.

Question	Primary domain	Typical evidence	Decision implication
Where was the asset?	Fleet / telematics	GPS position, speed, ignition, stops, geofences, sensors	Establishes observable vehicle behaviour
What service occurred?	Service execution	Telemetry interpreted against route, schedule, checkpoints, field events and exceptions	Establishes how execution compares with the obligation
What does the municipality conclude?	Administrative verification	Combined evidence plus policy, delegation and contract context	Creates an authorised service outcome and triggers subsequent action

Conflating these questions creates two opposite errors. The first is to overstate telematics by treating movement evidence as a complete service conclusion. The second is to understate telematics by pretending location and sensor data cannot provide strong evidence of collection activity. A mature assurance architecture avoids both errors.

A more useful question

Not "Can GPS prove collection?" but "Under what conditions does vehicle and field data become sufficiently contextualised to support a municipal conclusion about the service obligation?"

The Municipal Evidence Stack

Service assurance is best understood as a layered architecture rather than a GPS-versus-platform comparison.

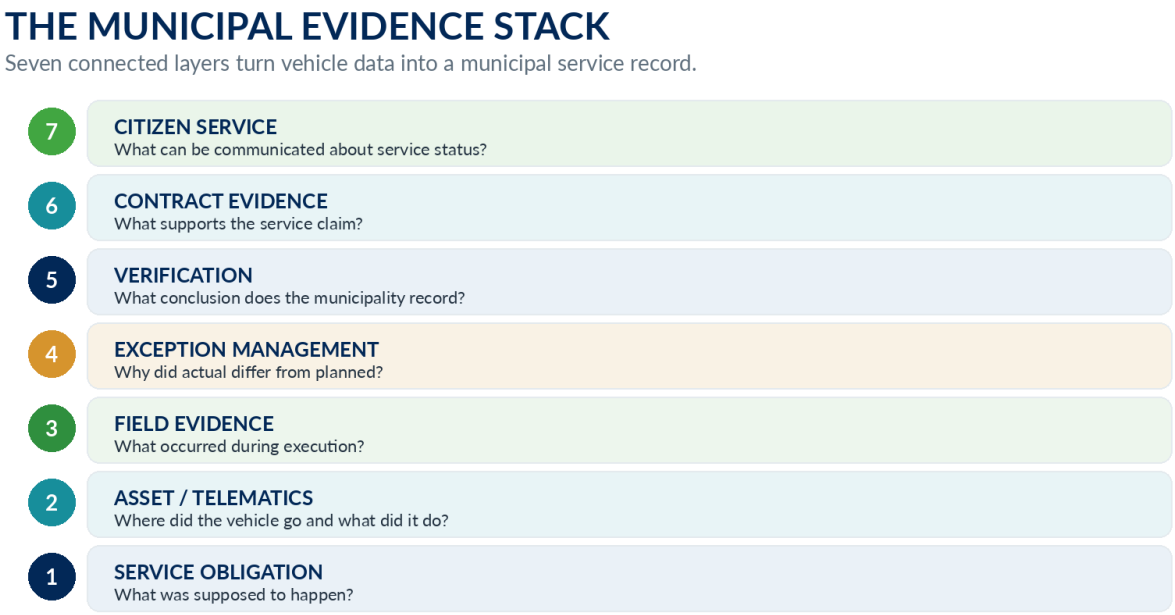

Figure 1. CleanWard Municipal Evidence Stack.

The layers are deliberately separated. A service obligation can exist without telemetry. Telemetry can exist without field evidence. An exception can explain apparent under-performance. Verification is an administrative act, not a sensor output. Contract evidence is assembled for a purpose. Citizen communication draws from the operational record but should expose only appropriate information.

The architecture therefore treats assurance as the quality of the connection between layers - not merely the sophistication of any single technology.

What modern tracking contributes

The literature on digital waste collection supports a strong role for GPS, GIS, RFID, sensors and real-time monitoring.

A 2021 comprehensive review of wireless technologies in solid-waste management describes the use of GPS with GIS and RFID for tracking vehicles and drivers and supporting route optimisation [8]. Ali et al. (2024) examine an IoT-assisted vehicle-routing approach in which GPS tracking, sensors and communications support continuous route monitoring and route-performance optimisation [9]. Prata, Simoes and Simoes (2025) report on real-time monitoring using technologies including RFID and GIS within an operational waste-management context, highlighting the role of digital monitoring in improving collection management [10].

Evidence type	What it can contribute	Interpretive limitation
GPS position / route history	Where the vehicle travelled	Does not independently define whether the travelled geography was the authorised service obligation
Speed / ignition / dwell	Operational pattern and stop behaviour	Collection activity may be inferred but context and thresholds matter
Geofence events	Entry, exit and presence in defined areas	A geofence must be correctly defined and linked to the applicable route/service
Digital/analogue inputs	Vehicle equipment or sensor events	Signal meaning depends on installation, calibration and event logic
RFID / tagged containers	Object-level interaction and traceability	Coverage depends on tag deployment and process compliance
Images / field records	Ground-level corroboration and exception evidence	Requires timestamp, user and service-event provenance to remain reliable

Implication. Service assurance should be technology-neutral at the evidence layer. GPS is one evidence source; additional sensors can strengthen assurance where their cost and operational value are justified.

Evidence gains meaning when compared with an obligation

A location trace becomes municipal service evidence only when the system knows what should have happened.

PLANNED VS ACTUAL: WHERE ASSURANCE BEGINS

PLANNED SERVICE	ACTUAL EXECUTION	ASSURANCE QUESTION
Route A / Ward 4	Route A plus deviation	Was the deviation authorised or explained?
Vehicle 12	Vehicle 27 substituted	Was the substitute approved for the service?
07:00 - 11:00	07:18 - 13:05	Was the service window materially affected?
24 checkpoints	21 evidenced	Which locations remain unverified?
Full completion	Partial completion	Is recovery required?
No known exception	Breakdown recorded	Does contemporaneous evidence support the variance?

CleanWard principle: variance is not automatically failure. The key distinction is explained vs unexplained variance.

Figure 2. Planned-versus-actual comparison creates the basis for assurance.

This is why route versioning, date, service window, assigned vehicle, provider, contract context and checkpoints are not administrative clutter. They are the baseline against which execution is interpreted. Without a stable baseline, the system can describe movement but cannot reliably describe variance.

The baseline must itself be governed. If route definitions can be silently altered after execution, the evidentiary value of the comparison is weakened. A mature system therefore retains route and schedule version history so that later reviewers can determine what was authorised at the time of service.

The critical distinction is explained vs unexplained variance

Real-world service delivery is not perfectly deterministic. Assurance systems must recognise legitimate operational disruption without normalising undocumented non-performance.

A breakdown, road closure, unsafe condition, disposal-site delay, vehicle-capacity constraint or authorised substitution may cause execution to differ from plan. The correct assurance logic is therefore not "actual must equal planned". It is "where actual differs from planned, is the variance contemporaneously explained and supported?"

Variance class	Characteristics	Management response
Conforming execution	Observed activity aligns materially with approved plan	Proceed to verification
Explained variance	Execution differs, but a structured exception and supporting context exist	Assess exception under municipal/contract rules; recovery may still be required
Unexplained variance	Material deviation without adequate contemporaneous explanation	Escalate for investigation, dispute or corrective action
Recovered variance	Initial service incomplete, followed by documented recovery	Verify original exception and recovery as linked service events

ASSURANCE PRINCIPLE

Variance is not automatically failure. Unexplained variance is the higher-risk condition because the municipality cannot readily distinguish legitimate operational disruption from unverified non-performance.

A service record must preserve provenance

Digital evidence becomes more useful when its origin, timing, relationship and subsequent modification are clear.

Integrity control	Purpose	Example
Source attribution	Identify where each fact originated	Telematics API, driver app, supervisor upload, municipal schedule
Timestamping	Place evidence in operational sequence	Exception recorded at 09:42 during Route A
Location context	Associate evidence with service geography	Photo or event linked to checkpoint/ward/route
User attribution	Identify the person or system that created/verified the record	Driver, supervisor, reviewer, automated telematics feed
Version history	Preserve what was authorised at the time	Route v3 active on service date; v4 introduced later
Decision history	Separate source evidence from later administrative judgement	System evidence retained even if verification outcome changes after review
Retention / retrieval	Make records available for later operational or oversight need	Evidence Pack for sampled service event

The goal is not to claim that every digital record is immutable or legally conclusive. The goal is to create a disciplined chain of provenance: who or what produced the evidence, when, in relation to which authorised service event, and how it was subsequently reviewed.

Design implication. Source data should not be overwritten merely because a reviewer reaches a different conclusion. Evidence and decision are separate records with separate provenance.

Software should support judgement - not silently replace it

A service-assurance platform can calculate facts and indicators. The municipality must retain authority over the meaning of those facts under its own rules.

Suppose route coverage is calculated at 92%. Whether that represents satisfactory service, partial performance, an accepted exception, a recovery requirement or a contractual deduction depends on factors that a generic algorithm cannot safely assume: the service specification, local geography, route criticality, contractual tolerances, approved exceptions, delegation and municipal policy.

System may calculate	Municipality may determine
Route coverage percentage	Whether the coverage satisfies the applicable service requirement
Arrival/departure time	Whether a timing variance is acceptable or material
Checkpoint count	Whether omitted checkpoints affect service verification
Sensor event count	Whether the event pattern corroborates the claimed service
Exception timestamp and location	Whether the exception is accepted under policy/contract terms
Recovery evidence	Whether the original non-performance has been adequately remedied

SEPARATION OF DUTIES

The system records what happened. The authorised municipality records what it decided. Both should remain visible in the audit trail.

Why the evidence chain matters at month end

The operational record and the financial transaction should be connected without confusing operational verification with statutory payment authority.

National Treasury's municipal SCM guidance frames supply chain performance as a monitoring process that considers whether proper processes were followed, desired objectives achieved, contract breaches addressed and supplier performance assessed [6]. The MFMA places accountability for municipal financial management and expenditure within a statutory governance framework [11].

For outsourced waste services, the service-assurance opportunity is to create the operational evidence before the invoice becomes a reconstruction exercise. An Evidence Pack can connect the claim to the underlying schedule, vehicle evidence, exceptions, recovery and verification status.

Evidence Pack component	Assurance purpose
Service identity	Establish contractor, contract, route, ward, date and assigned vehicle
Approved baseline	Show what the municipality expected to occur
Execution evidence	Show route movement, checkpoints and relevant field/telematics signals
Exception evidence	Explain material deviation and identify contemporaneous support
Recovery record	Show whether incomplete service was subsequently closed
Municipal verification	Record the authorised operational conclusion and reviewer

Boundary condition. The Evidence Pack supports payment review. It does not instruct the municipality to pay, withhold or deduct. Those decisions remain subject to law, policy, delegation and contract.

Closing the operational loop with residents

Digital service assurance can improve customer communication when complaint handling is connected to what actually happened on the route.

South Africa's National Domestic Waste Collection Standards explicitly include communication and customer-service considerations [3], [7]. International municipal digitisation experience also shows the potential value of linking geospatial service data to municipal dashboards. In Andhra Pradesh, India, a World Bank-supported digital-address/GPS system enabled urban local bodies to monitor whether municipal services including garbage collection had been delivered at an address and to take remedial action in cases of delay [12].

Citizen question	Operational answer enabled by assurance
Was collection scheduled?	Check the approved service calendar and route
Did the vehicle reach the area?	Interrogate route/telematics evidence
Why was my street missed?	Check recorded exception and affected geography
Is the municipality aware?	Check verification/escalation status
When will it be collected?	Check recovery schedule where the municipality exposes that information
Was recovery completed?	Check linked recovery evidence

This shifts complaint handling from ticket creation alone toward service-status resolution. Privacy, security and role-based disclosure remain important: resident-facing information should be derived from the operational record without unnecessarily exposing staff, contractor or vehicle data.

Integration is a design requirement, not a slogan

Municipal environments are heterogeneous. A service-assurance layer should tolerate multiple data sources and progressively deepen integration.

System / data source	Role in the assurance architecture	CleanWard relationship
GPS / telematics	Vehicle and sensor evidence	Consume via API/file/event integration where available
GIS / route planning	Authorised service geography	Reference route, ward and checkpoint definitions
Driver / crew workflow	Field execution and exception evidence	Capture structured service events
Contract management	Obligation, SLA and provider context	Associate service events with relevant contract information
Finance / ERP	Invoice and payment workflow	Provide evidence/status integration where justified
CRM / call centre	Citizen complaint and service enquiry	Link service status and recovery to complaint handling
Identity / access management	User authority and accountability	Apply role-based access, reviewer authority and audit trail

The architecture should also support degraded connectivity. Waste collection often occurs in areas where mobile coverage is variable; field workflows should preserve locally captured evidence and synchronise when connectivity is restored, while clearly distinguishing device-captured time from server-received time.

Technology neutrality. CleanWard's conceptual model does not depend on one tracking vendor, one sensor type or one municipal ERP. The assurance record should survive changes in underlying technology providers.

From visibility to intelligence

Municipalities do not need to implement every layer at once. Capability can mature incrementally.

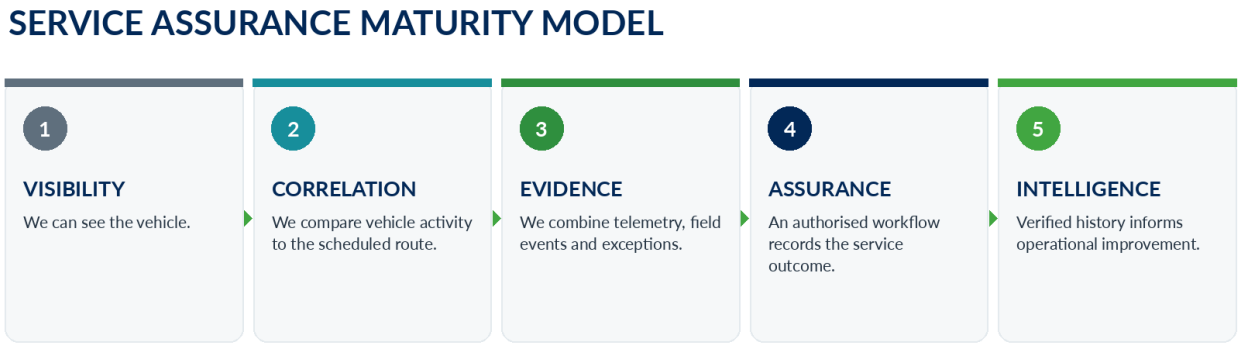

Figure 3. CleanWard Service Assurance Maturity Model.

Stage 1 is already common: vehicle visibility. Stage 2 adds correlation with approved routes and schedules. Stage 3 enriches the record with field and exception evidence. Stage 4 introduces authorised verification. Stage 5 uses accumulated verified service history for operational, contractual and strategic intelligence.

This maturity path reduces the risk of over-engineering an initial deployment. It also creates a practical procurement strategy: prove the service record first; add sophisticated optimisation, predictive analytics and additional sensors only where the evidence demonstrates value.

What a serious pilot should test

A credible service-assurance programme needs explicit success measures and explicit recognition of what technology cannot guarantee.

Measure	Research / operational question
Service Evidence Completeness	Can the required record be consistently assembled for scheduled service events?
Unexplained Variance Rate	How often does actual execution materially differ without adequate exception context?
Verification Turnaround	How quickly does an authorised municipal outcome follow execution?
Evidence Retrieval Time	Can a complete sampled record be produced quickly for management or audit review?
Recovery Closure Rate	Are missed/partial services actively followed through to documented closure?
Complaint-to-Route Correlation	Can citizen complaints be reconciled with the operational record?
Invoice-Support Completeness	Can sampled claims be traced to structured service evidence?

Limitations that should be acknowledged

- Telematics data can be incomplete, delayed, incorrectly configured or unavailable; assurance quality cannot exceed evidence quality.
- A sensor event does not automatically prove every dimension of service quality; its meaning depends on installation and operating logic.
- Digital evidence does not replace the need for sound route design, fleet availability, staffing, contract management or operational leadership.
- A platform cannot guarantee audit outcomes, legal compliance or contractor performance; it can improve the record available to those responsible for those outcomes.
- Citizen-facing transparency requires careful treatment of privacy, security, operational sensitivity and POPIA obligations.
- Automated thresholds should be configurable and reviewable; they should not silently become de facto municipal policy.

The next step after vehicle visibility

The strategic shift is from tracking an asset to assuring a municipal service.

Research and operating practice support the value of GPS, GIS, RFID, IoT and real-time monitoring in waste collection. These technologies make vehicle operations more visible and can improve routing, monitoring and operational control [8]-[10]. The institutional challenge begins where raw operational evidence must be interpreted against an authorised public-service obligation.

Municipal Service Assurance adds that interpretive architecture. It connects the plan, execution evidence, exceptions, recovery and authorised verification while retaining provenance and the distinction between source evidence and municipal judgement.

THE CATEGORY DEFINITION

Municipal Waste Service Assurance is the structured process through which a municipality connects an approved waste-service obligation to evidence of actual execution, records deviations and exceptions, applies authorised verification, and retains a defensible operational record of the outcome.

CleanWard is designed to provide this layer without replacing specialist telematics, finance, GIS or customer-care systems. Its role is to make those systems more useful to the service-delivery question that ultimately matters: what was supposed to happen, what happened, why did it differ, what was verified, and what action followed?

CleanWard perspective: GPS tells you where the truck went. Service assurance establishes what that journey means for the municipal service obligation.

Selected legal, policy and research sources

References are selected for relevance to the conceptual framework; they do not imply endorsement of CleanWard by any cited institution or author.

[1] Constitution of the Republic of South Africa, 1996. Schedule 5B.

[2] Republic of South Africa. National Environmental Management: Waste Act 59 of 2008.

[3] Department of Environmental Affairs. National Domestic Waste Collection Standards. Government Notice 21, Government Gazette 33935, 21 January 2011.

[4] Department of Forestry, Fisheries and the Environment. National Waste Management Strategy 2020. Government Notice 56, Government Gazette 44116, 28 January 2021.

[5] Auditor-General South Africa. Consolidated General Report on Local Government Audit Outcomes 2024-25. Tabled 24 June 2026.

[6] National Treasury. Supply Chain Management: A Guide for Accounting Officers of Municipalities and Municipal Entities. Chapter 8: Supply Chain Performance Measurements.

[7] Oelofse, S.H.H. (2011). Understanding the National Domestic Waste Collection Standards. CSIR / WasteCon-related publication record.

[8] Akram, S.V., Singh, R., Gehlot, A., Rashid, M., AlGhamdi, A.S., Alshamrani, S.S. & Prashar, D. (2021). Role of Wireless Aided Technologies in the Solid Waste Management: A Comprehensive Review. Sustainability, 13(23), 13104. DOI: 10.3390/su132313104.

[9] Ali, B., Javed, M.A., Alharbi, A.A.K., Alotaibi, S. & Alkhathami, M. (2024). Internet of Things-Assisted Vehicle Route Optimization for Municipal Solid Waste Collection. Applied Sciences, 14(1), 287. DOI: 10.3390/app14010287.

[10] Prata, J., Simoes, C.L. & Simoes, R. (2025). Improvements to Municipal Solid Waste Collection Systems Using Real-Time Monitoring. Sustainability, 17(4), 1405. DOI: 10.3390/su17041405.

[11] Republic of South Africa. Local Government: Municipal Finance Management Act 56 of 2003.

[12] World Bank (2020/2021 results feature). Cities in India Bet on Digitization for Better Services: Andhra Pradesh municipal GIS, digital addressing and GPS-enabled monitoring of services including garbage collection.

[13] World Bank Independent Evaluation Group (2022). Transitioning to a Circular Economy: An Evaluation of the World Bank Group's Support for Municipal Solid Waste Management, 2010-20.

CleanWard

CleanWard is a South African municipal technology platform focused on Municipal Waste Service Assurance. The platform connects municipalities, waste-service providers and residents through one operational record - from schedule and execution to exceptions, verification, recovery and reporting.

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