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Integration of GPS-enabled Smart Telematics for Monitoring Subsidized Agricultural Machinery via Government FARMS Platform: A Framework for Manufacturers

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Abstract— *Mechanization improves productivity, reduces labour dependence, and increases operational efficiency. Government subsidy programs aim to accelerate the adoption of agricultural machinery, but verifying proper utilization and ensuring compliance remain challenges. This study presents an industry-driven, pilot-tested framework developed by Agricultural Farm Machinery Manufacturer, integrating GPS-enabled smart telematics with the Indian FARMS (Farmer Assisted Remote Monitoring System) application. The framework focuses on Round Balers deployed under Crop Residue Management (CRM) subsidy programs. Pilot deployment demonstrates real-time monitoring, operational analytics, and compliance verification. Farmers also have access to VIN-based monitoring of their machines. Full integration with the FARMS platform is pending government approval. Key outcomes include transparency in subsidy utilization, optimized machine deployment, predictive maintenance, and evidence-based policy support. The study also addresses technical, economic, connectivity, and legal considerations for implementation.*

Keywords— Agricultural mechanization, GPS telematics, subsidy compliance, FARMS platform, machine utilization, digital agriculture, public–private collaboration.

I. INTRODUCTION

1.1 Need

Subsidized agricultural machinery, such as Round Balers under Crop Residue Management (CRM) programs, often suffers from under-utilization or misuse, limiting the effectiveness of government investment. There is a clear need for a systematic monitoring solution that:

- Tracks actual machine deployment and usage
- Ensures subsidy compliance and accountability
- Provides data-driven insights to manufacturers, policymakers, and farmers

1.2 Problem

Despite substantial subsidies, machinery usage is difficult to monitor due to lack of real-time visibility. Traditional monitoring methods are manual, error-prone, and non-scalable, reducing program effectiveness and limiting evidence-based policy decisions.

1.3 Objective

This study presents a pilot-tested framework developed by Agricultural Farm Machinery Manufacturer, using GPS-enabled smart telematics on Round Balers. The framework is designed to:

- Enable real-time monitoring of subsidized machines
- Support compliance verification and predictive maintenance
- Empower farmers with VIN-based performance tracking
- Prepare for future integration with the FARMS (Farmer Assisted Remote Monitoring System) platform, once government approval is obtained

II. LITERATURE REVIEW

2.1 Telematics in Agricultural Machinery

GPS-enabled telematics capture location, bale size, bale location, moisture content, and other operational parameters. Benefits observed in the pilot include optimized fuel use, reduced downtime, enhanced machine life, and quantification of field work. The pilot focus is on Round Balers due to their high subsidy value and operational traceability requirements.

2.2 Government Initiatives

Pilot projects in Punjab and Tamil Nadu have demonstrated reduced under-utilization of subsidized machinery using GPS monitoring. The manufacturer's pilot confirms the feasibility of real-time monitoring and compliance verification.

2.3 Technology Providers, Subscription, and Connectivity

Provider: Blackbox GPS Technology (an Indian GPS manufacturer)

Subscription Models:

- SIM subscription for data transmission
- Platform fees for dashboards, analytics, and VIN-based monitoring

Connectivity and Reliability:

- Single SIM with GPRS/2G fallback
- Edge buffering ensures offline data collection during connectivity loss
- FOTA (Firmware Over-The-Air) updates available for device maintenance

Impact on Monitoring:

- Minor delays may occur in real-time dashboards during connectivity issues
- Historical telemetry and compliance data remain intact due to edge buffering

2.4 Legal Aspect

Monitoring is limited to subsidized machinery. Explicit farmer consent is required; the practice is legal and compliant with the Digital Personal Data Protection (DPDP) Act, 2023.

III. CONCEPTUAL FRAMEWORK

The framework presented in this study has been developed by Agricultural Farm Machinery Manufacturer, leveraging insights from a pilot implementation of GPS-enabled telematics on Round Balers. It is an industry-driven solution, designed to be practical, secure, and compatible with government platforms such as FARMS, while remaining generalizable to other machinery categories in the future.

3.1 System Architecture

The proposed telematics framework for agricultural machinery monitoring is designed as a four-layer interoperable architecture, as shown in Figure 1, ensuring end-to-end data integrity and compliance with government integration standards.

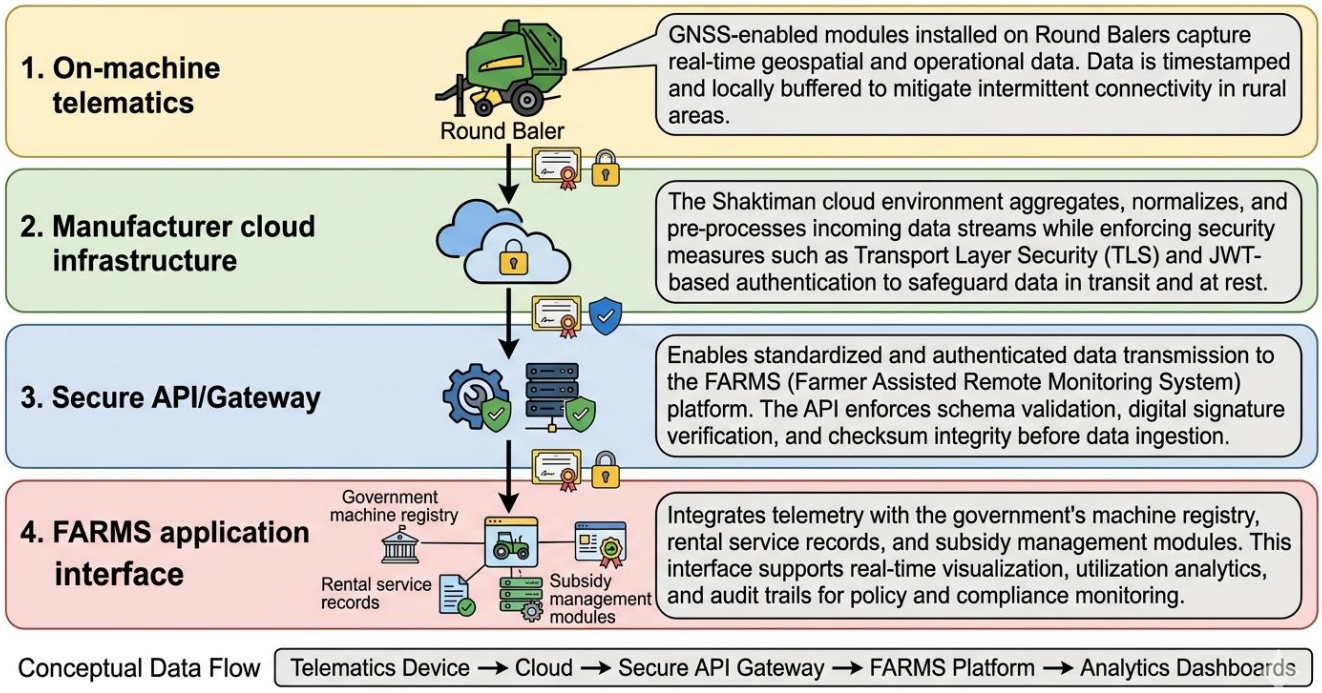

FIGURE 1: Four-layer architecture of the proposed telematics framework

1. **On-machine telematics** – GNSS-enabled modules installed on Round Balers capture real-time geospatial and operational data. Data is timestamped and locally buffered to mitigate intermittent connectivity in rural areas.
2. **Manufacturer cloud infrastructure** – The cloud environment aggregates, normalizes, and pre-processes incoming data streams while enforcing security measures such as Transport Layer Security (TLS) and JWT-based authentication to safeguard data in transit and at rest.
3. **Secure API/Gateway** – Enables standardized and authenticated data transmission to the FARMS (Farmer Assisted Remote Monitoring System) platform. The API enforces schema validation, digital signature verification, and checksum integrity before data ingestion.
4. **FARMS application interface** – Integrates telemetry with the government's machine registry, rental service records, and subsidy management modules. This interface supports real-time visualization, utilization analytics, and audit trails for policy and compliance monitoring.

Conceptual Data Flow:

Telematics Device → Cloud → Secure API Gateway → FARMS Platform → Analytics Dashboards

3.2 Data Schema and Security

The minimum required telemetry dataset includes:

- Unique Device ID
- Machine VIN/Serial Number
- Subsidy Scheme ID
- Timestamp (UTC)
- GPS Coordinates (Latitude, Longitude)
- Engine Hours
- Operation Mode / PTO Status
- Firmware Version

Data governance and security protocols ensure that:

- Access is restricted through role-based authentication
- Retention follows minimal and purpose-bound retention policies
- Farmer data is processed only under explicit consent, in full alignment with the Digital Personal Data Protection (DPDP) Act
- All transactions are logged and auditable to maintain accountability across stakeholders

3.3 Industry-driven Integration Rationale

- **Manufacturer Leadership:** Agricultural Farm Machinery Manufacturers are best positioned to deploy GPS-enabled telematics because they understand machine specifications, operational patterns, and maintenance needs.
- **Standardization:** Industry-led deployment ensures uniform data formats, device certification, and compliance with government standards.
- **Data Accuracy and Reliability:** Manufacturers can ensure proper installation, calibration, and firmware updates (FOTA), minimizing errors in telemetry and ensuring actionable insights.
- **Farmer Engagement:** Providing VIN-based monitoring dashboards directly from manufacturers builds trust, operational transparency, and incentive for proper machine usage.
- **Policy Alignment:** Close collaboration with government platforms, such as FARMS, enables manufacturers to support compliance verification, subsidy accountability, and evidence-based mechanization policies.
- **Scalability:** Manufacturer-led integration facilitates wider deployment across multiple machine types, starting with high-value subsidized equipment like Round Balers.

IV. METHODOLOGICAL APPROACH FOR MANUFACTURERS

The following six-step approach is recommended for manufacturers seeking to implement similar telematics-based monitoring systems:

1. **Device deployment** – Retrofit or embed telematics units, ensuring edge processing to classify field-work versus transport activity.
2. **Data normalization** – Incorporate subsidy identifier and standardize telemetry payload for government APIs.
3. **API integration** – Implement REST/MQTT endpoints or push mechanisms, enforcing message signing and replay protection.
4. **Certification and compliance** – Collaborate with government testing centers (FMTTIs) to ensure acceptance in subsidy programs.
5. **Farmer engagement** – Provide dashboards and advisory services to demonstrate benefits and increase trust.
6. **Analytics and reporting** – Enable utilization heatmaps, compliance dashboards, and anomaly detection for policymakers.

V. RESULTS FROM PILOT IMPLEMENTATION

The pilot deployment conducted by Round Balers under CRM subsidy programs yielded the following key results:

- **Real-time monitoring:** Successful tracking of machine location, operational status, and bale production metrics was achieved across the pilot deployment area.
- **Compliance verification:** The system enabled verification that subsidized machines were being used for intended agricultural purposes within designated operational zones.
- **Operational analytics:** Data on engine hours, field vs. transport activity, and bale production provided actionable insights for both farmers and manufacturers.

- **Connectivity resilience:** Edge buffering functionality ensured no data loss during temporary network outages, with seamless data synchronization upon reconnection.
- **Farmer engagement:** VIN-based monitoring dashboards were well-received by farmers, who reported increased confidence in machine utilization tracking.
- **Maintenance optimization:** Predictive maintenance alerts enabled timely service interventions, reducing unplanned downtime.

Pending government approval for full API integration with the FARMS platform, the pilot demonstrated that the technical framework is fully functional and ready for scaled deployment.

VI. Observed Outcomes and Policy Implications

- **Transparency and compliance:** The system ensures machines are used for intended purposes, reducing subsidy leakage and improving accountability.
- **Operational efficiency:** Rental hubs and individual farmers can optimize machine utilization based on real-time usage data.
- **Predictive maintenance:** Manufacturers can deliver data-driven service interventions, reducing downtime and extending machine life.
- **Evidence-based policymaking:** Aggregated anonymized data can inform allocation strategies, mechanization priorities, and subsidy redesign for government agencies.

VII. Challenges and Mitigation Strategies

Table 1
Challenges and Mitigation Strategies for Telematics Implementation

Challenge	Mitigation Strategy
Rural connectivity	Edge buffering, dual-SIM, LPWAN (Low-Power Wide-Area Network) fallback
Data privacy concerns	Explicit farmer consent, limited retention periods, audit logs
Device heterogeneity	Standardized data schema, certified telematics modules
Cost	Subsidized telematics or public–private partnerships to reduce farmer burden

VIII. Limitations and Future Directions

8.1 Limitations

- Full integration with the FARMS platform is pending government approval, limiting real-time data sharing with policy dashboards at present.
- The pilot was conducted on a single machine type (Round Balers) and may require adaptation for other agricultural equipment categories.
- Connectivity dependency remains a challenge in very remote rural areas despite edge buffering solutions.
- The pilot scale and duration were limited; larger-scale validation is recommended.

8.2 Future Directions

- Expand deployment to additional subsidized machinery types (e.g., tractors, harvesters, seeders).
- Integrate with state-level and national-level agricultural databases for comprehensive policy monitoring.
- Develop farmer-facing mobile applications for enhanced transparency and service booking.

- Explore integration with soil health and crop yield data to correlate mechanization with productivity outcomes.

IX. CONCLUSION

GPS-enabled smart telematics provide a transformative solution for monitoring subsidized agricultural machinery. The pilot demonstrates that even a single-machine focus, such as Round Balers, can yield real-time operational insights, ensure subsidy compliance, and reduce misuse.

Integration with the FARMS platform not only enhances transparency but also enables data-driven governance, allowing policymakers to allocate resources efficiently, optimize mechanization programs, and design evidence-based subsidy strategies.

For manufacturers, adopting secure, standardized telematics systems opens opportunities for predictive maintenance, improved operational efficiency, and stronger engagement with farmers, while ensuring regulatory compliance.

Ultimately, the combination of technology, policy integration, and farmer participation creates a sustainable model for mechanized agriculture, bridging the gap between subsidy intent and real-world utilization, and setting a precedent for scalable, accountable, and efficient agricultural mechanization across India.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research paper.

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