Role of Advance Technology & AI in SAFETY

AI presents a paradigm shift from reactive supervision to real-time cognitive safety across India's petroleum infrastructure

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INTRODUCTION

The Challenge: Scale and Human Limitations

BPCL's Extensive Network

3	83+
Refineries	Retail Terminals
53+	23.5K+
LPG Plants	Retail Outlets

The Normalization of Deviance

BPCL's traditional safety framework, heavily reliant on field supervision and periodic audits, faced an inherent limitation: human officers cannot maintain a constant presence across every gantry, tank lorry filling bay, or LPG carousel, 24/7. This persistent oversight gap inadvertently fostered a dangerous pattern: minor safety breaches, such as "just one minute" of skipped PPE or circumventing checks during night shifts, frequently went unaddressed until a critical incident occurred.

Over time, the disconnect between documented safety protocols and on-ground operational practices grew, allowing deviations to become normalized across diverse shifts and numerous locations. Recognizing that human supervision alone was insufficient to effectively monitor millions of safety-critical moments throughout its vast infrastructure, BPCL sought a transformative solution.

THE CATALYST

Jaipur Fire to M.B.L.R

A wake-up call for safety & efficiency in petroleum

Jaipur Fire

2009 — catastrophic terminal disaster

M.B. Lal Committee

118 recommendations on safety & automation

Emergency Response

Mandated automation & response centers

M.B. Lal Committee mandated 118 recommendations focusing on safety, emergency resp., and automation to prevent future disasters.

THE TRANSFORMATION

Automation & AI: Revolutionizing Petroleum

Automation Era

Terminal Automation, Safety PLCs, Real-time Monitoring

automation uses pre-programmed, rule-based systems to execute repetitive tasks.

AI Genesis

Predictive Maintenance, Safety Monitoring, Smart Ops

AI is designed to mimic human intelligence, analyze data, and learn

From reactive safety to proactive intelligence — automation and AI are transforming petroleum operations post M.B. Lal.

From Isolated Systems to Unified Intelligence

Before IRIS, BPCL's safety systems operated in silos—each generating alerts that depended on local officers for closure. This led to response delays, inconsistent enforcement, and no holistic view of safety risks.

CCTV Surveillance

Manual monitoring, limited coverage

VTS Monitoring

Data required manual review

TAS Interlocks

Signals operated independently

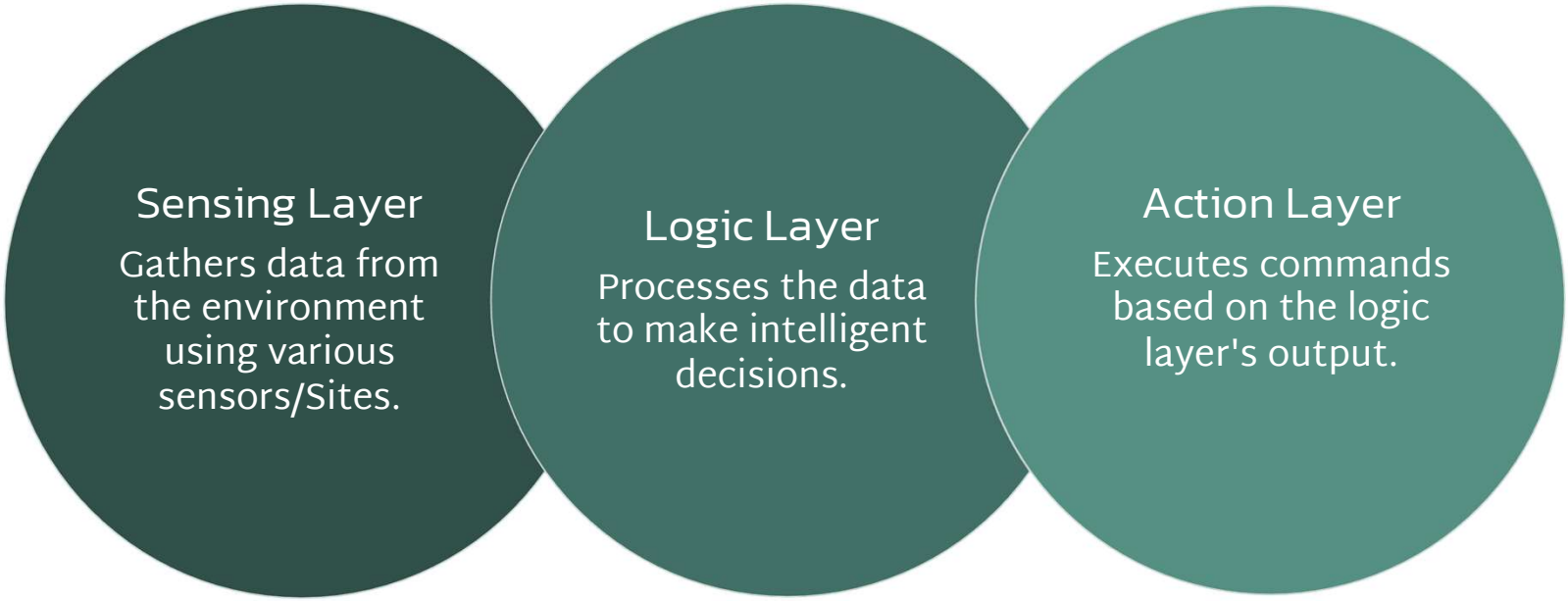
Alert Fatigue

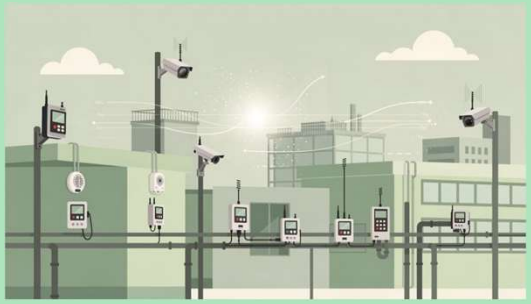
High ticket volume, inconsistent action

ARCHITECTURAL WORKFLOW

The 3 Layer AI Safety Architecture : Sensing → Logic → Enforcement

Modern industrial safety relies on a three-layer architecture that transforms raw sensor data into automated protective actions. This intelligent safety mesh integrates physical sensors, AI-driven logic, and control systems for operational safety and compliance, building a cascading defense mechanism.





1. Sensing

Edge analytics and field sensors convert physical reality into digital signals. This foundational layer captures real-time data from the operational environment.

- **Edge VA:** PPE detection, intrusion alerts, fire monitoring
- **other sensing layer:** Vehicle Tracking Systems, Field sensors, trip and alarm systems

2. Logic

The central correlation engine evaluates incoming data against codified standard operating procedures and risk thresholds to determine appropriate responses.

- **SOP Correlation:** UCVA protocols, VTS integration, loss of communication handling
- **Operability Index:** Real-time plant-level health scoring and risk assessment

3. Action

When risk thresholds are breached, the system automatically intervenes to modify physical infrastructure or fleet operations, ensuring safety compliance.

- **TAS/PLC Control:** Emergency pump trips, automated valve closures
- **SAP/ERP Integration:** Lorry access blocking, automated invoicing suspension

IRIS: AI-Powered Safety Intelligence for Oil & Gas Operations

BPCL's IRIS transforms safety management through AI-driven video analytics, automated interlocks, and real-time monitoring. This comprehensive platform integrates Video Analytics (VA), Terminal Automation Systems (TAS), Vehicle Tracking Systems (VTS), and Automatic Fire Fighting operation into a unified safety envelope that ensures continuous, system-driven assurance across all operations.

THE SOLUTION

IRIS: The Digital Nerve Center

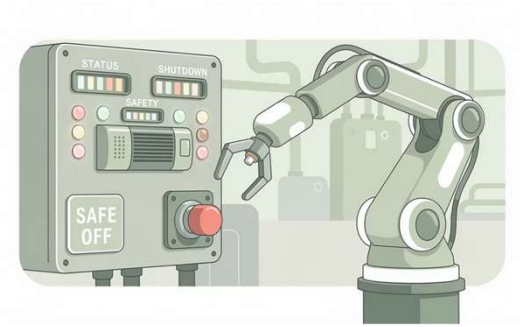
Launched under Project Anubhav, IRIS is BPCL's centralized command and control platform that integrates millions of digital signals per second from IoT sensors, Terminal Automation System (TAS), Vehicle Tracking System (VTS) and CCTV across India into a single unified view for remote monitoring and intervention.

AI Video Analytics

Trained computer vision models continuously monitor safety-critical areas, replacing manual CCTV watching with automated detection of PPE violations, intrusions, and unsafe behaviors

Multi-Modal Integration

Correlates video analytics with VTS, TAS interlocks, and sensor data to create comprehensive situational awareness



Automated Enforcement

When risk exceeds acceptable bounds, IRIS automatically blocks tank lorries in SAP, stops invoicing via ERP—moving beyond alerts to action

Three-Layer Intelligence Architecture

Edge Analytics Layer

GPU-enabled servers ingest RTSP streams over local LAN. Deep learning models detect safety-relevant objects and behaviors in milliseconds.

Command & Control Centre

Correlates video alerts with TAS/PLC interlock status (ROSOV position, ESD health) for higher-order safety logic. Provides unified view of safety across all locations.

Cloud Aggregation Platform

Aggregates alerts from all locations. ADFS authentication enables stakeholder review and documented action on every alert.

CAPABILITIES OVERVIEW

What IRIS Delivers

IRIS provides a comprehensive suite of capabilities across sensing, logic, and enforcement to establish a robust safety stack in industrial environments.

SENSING

Real-Time VA Alerts

Instant detection of unsafe acts (PPE, intrusion) with 5-10s video evidence clips, eliminating manual CCTV monitoring fatigue.

LOGIC

SOP-Driven Correlation

Multi-modal engine that binds VTS, TAS, and Camera events to codified Standard Operating Procedures and RACI matrices.

ENFORCEMENT

Automated Blocking

Direct integration with SAP and TAS to block invoicing when risk thresholds are breached.

PERMITS

UCVA Monitoring

AI supervision for Ultra-Critical jobs (Height, Hot Work) via CWPS integration, ensuring compliance with permit windows.

PLANT HEALTH

Plant-Wide Operability

A unified "Operability Index" that fuses fire protection and interlock KPIs to automatically govern plant readiness.

System Integration Ecosystem

IRIS achieves its comprehensive safety coverage through deep integration with BPCL's operational systems. Each integration point enables a specific safety capability, from permit-based monitoring to automated fleet blocking.

CWPS ↔ IRIS

Ultra Critical Activities: CWPS sends permit details (ID, cameras, timing, WPS flag, approvers) to IRIS via Edge device/web services. IRIS auto-starts/stops UCVA monitoring on designated cameras and alerts if work extends beyond permit time.

TAS/CCC ↔ IRIS

Plant Automation & Interlocks: TAS/PLC systems implement safety interlocks (overfill prevention, ESD sequences, fire/gas detection, earthing failure). CCC monitors interlock health via OPC; IRIS uses this data for safety assessment and can command Plant closures through ERP.

VTS ↔ IRIS

Road & En-Route Safety: VTS sends lorry violation summaries (speed, night driving, route deviations, unauthorized stops) daily for blocking/unblocking workflows.; IRIS sends those blocking request to SAP through WSDL.

CCTV/Edge ↔ IRIS

Loss of Communication: IRIS checks connectivity from Edge devices every hour and from CCTV cameras to Edge every 30 minutes. If data is not received within prescribed windows, "Loss of Communication" alerts are generated and escalated to ensure continuous monitoring coverage. Also monitors PPE.

The Monitoring and Response Loop

Every IRIS safety alert follows a standardized six-stage loop: detection, evaluation, notification, human review, and automated enforcement. This closed-loop approach eliminates gaps that allowed violations to persist in manual systems.

Sensing : CCTV or OT device captures physical or operational state

Inference & Rules : Edge VA models or backend engines classify events against safety rules

Alert Generation : IRIS creates structured alert with metadata and video snippet

Notification : SMS/Email to LIC, HSSE; escalations to TM/State/Regional/HQ per SOP

Human Review : Users review clip, mark True/False, submit ATR to close alert

Interlock Execution : For high severity: IRIS triggers TAS/SAP to block lorries, trip pumps, close valves

SECURITY & COMPLIANCE

Layered Cyber Security Architecture

As IRIS becomes deeply embedded into ESD and interlock workflows, a comprehensive security posture ensures the system enhances safety without compromising OT integrity or exposing critical infrastructure to cyber risk. The architecture implements defense-in-depth across multiple layers.

Secure Transport & Encryption

All web-based access (IRIS portal, APIs) over HTTPS with TLS 1.2+, ensuring encryption in transit for credentials, video snippets, and alert payloads. Web services between CWPS, IRIS, SAP exposed through secure gateways with mutual authentication and certificates.

Identity & Access Management

Central authentication via ADFS/Active Directory enforces strong password policies, account lockout, and MFA. Role-Based Access Control (RBAC) within IRIS: LICs, HSSE officers, TM/State Heads, Regional and HQ roles have clearly separated permissions (view, classify alerts, submit ATR, approve exceptions, configure cameras) aligned with SOP RACI matrices.

Network Segmentation

Edge Analytics Appliances and CCTV reside in OT/plant LAN, segmented from corporate IT network using firewalls and DMZs; only required ports and directions opened to IRIS services. TAS/PLC networks on separate, tightly controlled segments; CCC/IRIS access TAS data via OPC servers or data diodes in DMZ, minimizing direct exposure of critical control systems.

IMPACT & FUTURE

From Reactive to Cognitive: The IRIS Transformation

IRIS represents a fundamental shift in how BPCL approaches safety—moving from reactive incident response to proactive risk prevention through continuous AI-powered monitoring and automated enforcement. The system's impact extends beyond individual alerts to create a culture of accountability and compliance.

Continuous Vigilance at Scale

IRIS provides 24/7 coverage across 83+ terminals, 53+ LPG plants, and thousands of retail outlets—never fatiguing, never missing a moment, and applying consistent safety standards across all locations and shifts.

Closing the Compliance Gap

By integrating CWPS, VTS, and TAS, IRIS closes the gap between procedures and practice—turning unnoticed violations into immediate alerts and automated blocking actions.

Evidence-Based Safety Culture

Video clips and alert data create an objective safety record, enabling data-driven decisions on training, process improvements, and resource allocation—while supporting incident investigations and OISD compliance.

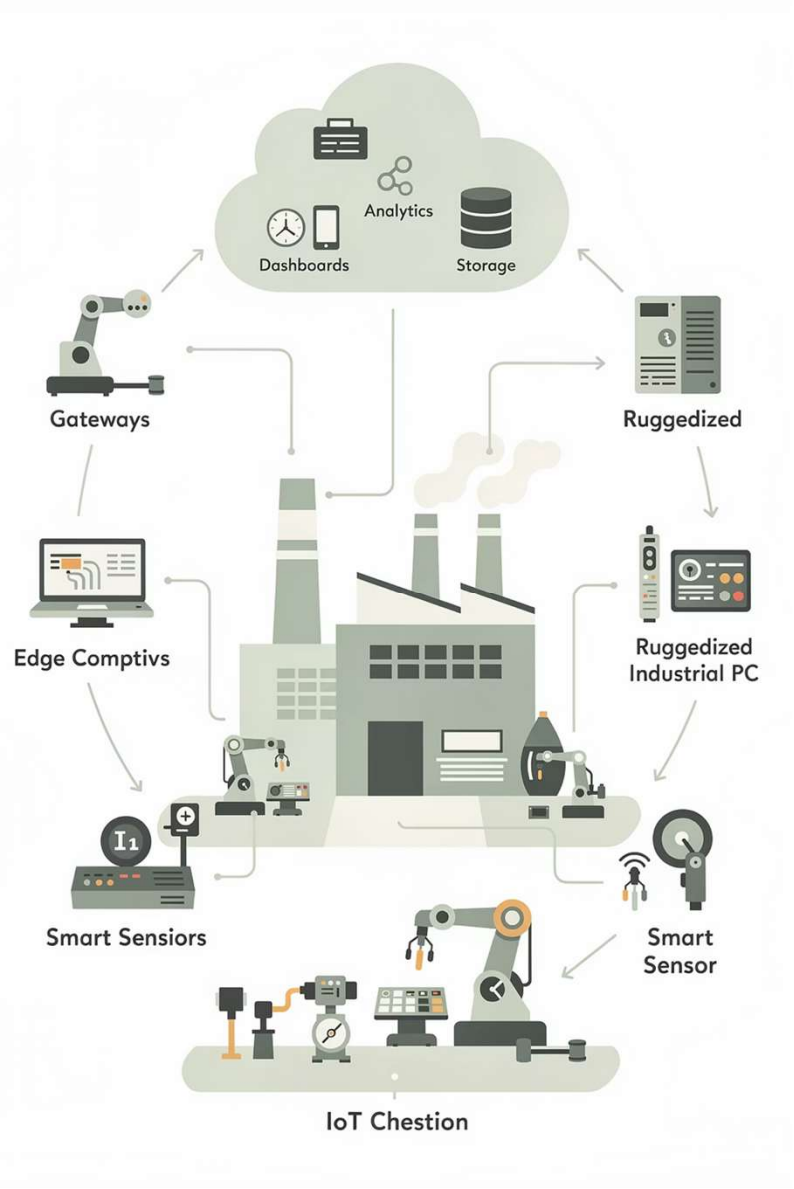
Scalable Foundation for Innovation

IRIS's Edge-Cloud architecture enables continuous evolution—new AI models, sensors, and analytics can be deployed incrementally without disrupting operations, adapting to emerging technologies and changing risk profiles.

AI-Powered CCTV Monitoring in Petroleum Operations

BPCL IRIS VIDEO ANALYTICS

Bharat Petroleum Corporation Limited has transformed safety monitoring across 23,500+ retail outlets, 83 installations, and 53 LPG plants through IRIS—a centralized AI platform that automatically detects violations, security threats, and compliance gaps in real time, eliminating human error and response delays.



TECHNICAL ARCHITECTURE

Edge-to-Cloud Hybrid Architecture

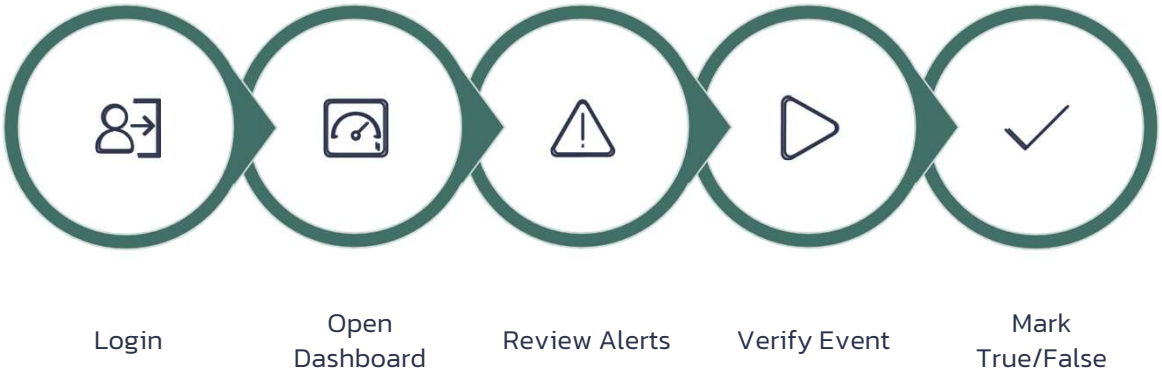
Why Edge Computing?

Processing video at the edge reduces bandwidth by two orders of magnitude. Instead of streaming raw video from thousands of cameras, local AI inference generates only structured alerts and 5-10 second clips for suspected violations.

Architecture Benefits

- Near real-time AI inference with millisecond processing
- Sustainable bandwidth usage across distributed facilities
- Local intelligence with centralized oversight
- ONVIF-compliant CCTV integration

How AI Video Analytics Transforms Safety Monitoring



From Passive Surveillance to Active Intelligence

Unlike traditional CCTV that relies on operators watching screens, AI-powered video analytics continuously scans every camera frame using computer vision and deep learning. The system identifies objects, recognizes unsafe behaviors, and instantly flags deviations—processing over 3 million inputs per second across BPCL's nationwide network.

Each alert includes location data, violation type, and captured evidence, creating a complete audit trail for compliance while enabling immediate corrective action.

Critical Safety Capabilities for High-Hazard Environments

PPE Detection

Automatically identifies missing helmets, safety belts and IFR clothing, raising instant alerts on non-compliance

Fire & Smoke Detection

Recognizes smoke signatures and flame patterns in real time using visual pattern recognition algorithms

Intrusion Prevention

Monitors perimeters & restricted zones for unauthorized personnel entry with instant notifications

Visual Anomaly Detection

Supplements traditional sensors with AI-powered visual monitoring for hydrocarbon leaks

How AI Video Analytics Detects PPE, Fire, Smoke & Gas

AI video analytics uses deep learning to monitor live CCTV feeds, processing 25–30 frames per second to detect objects, classify them, and flag safety violations instantly—no human operators required.

Core Technology

Convolutional Neural Networks (CNNs) purpose-built for image and video analysis

Real-Time Processing

Every video frame analyzed in 0.016 seconds—faster than a human blink

Instant Alerts

Violations flagged with snapshots, location data, and timestamps within one second

TECHNICAL DEEP DIVE

How Video Analytics Works: From Pixels to Action

1

Camera Capture & Streaming

ONVIF-compliant IP cameras at gantries, PHs, TFs, and UC work zones stream RTSP video over the local LAN to Edge Analytics Appliances. Cameras are strategically positioned to cover safety-critical areas with appropriate resolution.

2

Edge AI Inference

Deep learning models (YOLO/Faster R-CNN type detectors and attribute classifiers) run on GPU-accelerated Edge devices to detect people, PPE (helmet, harness, protective clothing), vehicle movements, and zone intrusions in near real-time with confidence scores.

3

Rule Violation Detection

When configured rules are violated—"person in UC zone without helmet," "FE not visible in UC work area,"—the Edge generates structured metadata (event type, camera ID, timestamp, confidence) plus a 5-10 second video clip.

4

Central Aggregation & Correlation

IRIS Core aggregates alerts from all locations, correlating them with permit information (CWPS), TAS interlocks & VTS violation data. Business logic evaluates severity and determines appropriate response.

5

Stakeholder Notification & Review

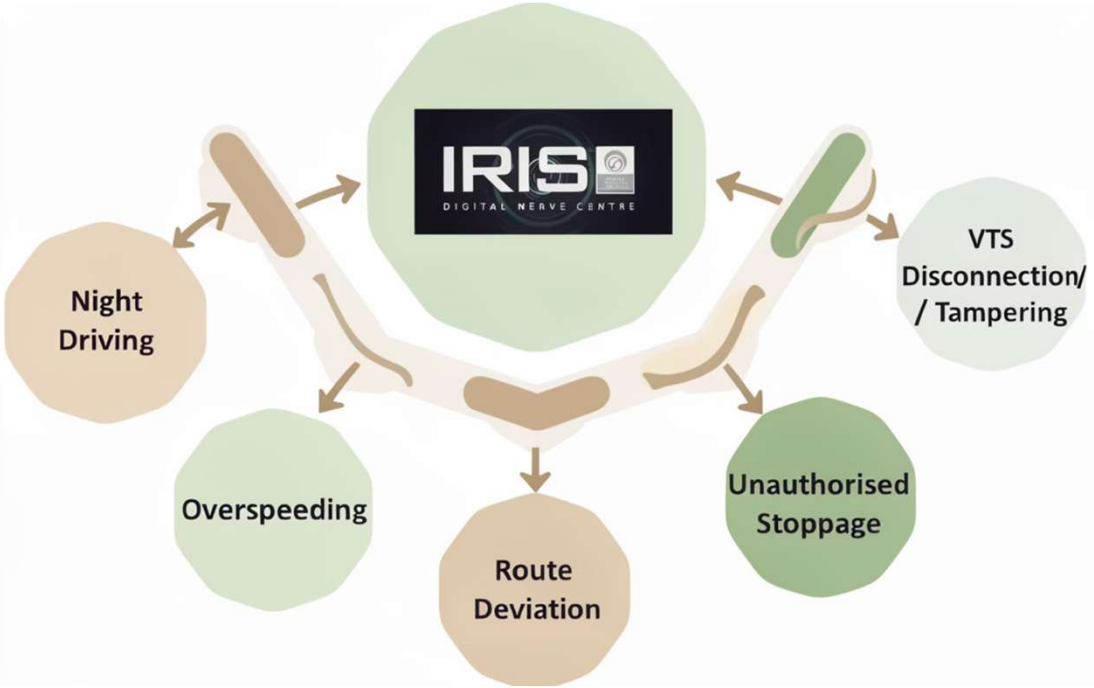
Users access BU-specific VA dashboards via ADFS authentication, review clips with play controls, classify events as True/False, and submit ATR to close alerts. Escalations flows as per RACI matrices.

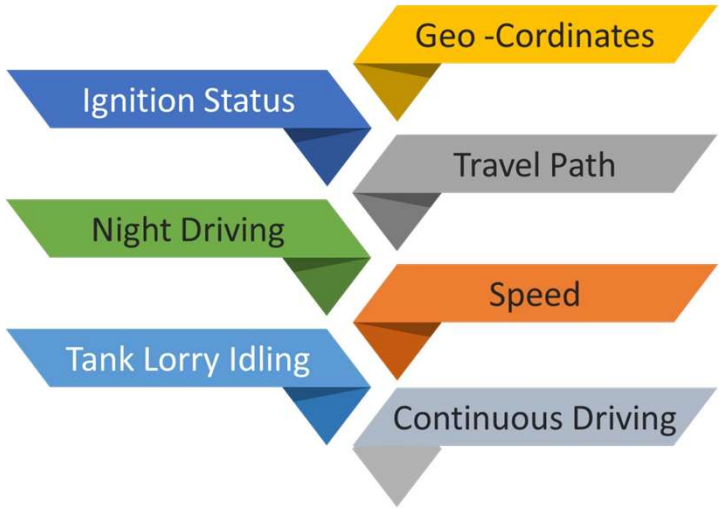
AI-Powered VTS Monitoring in Petroleum Operations

BPCL IRIS VTS ANALYTICS

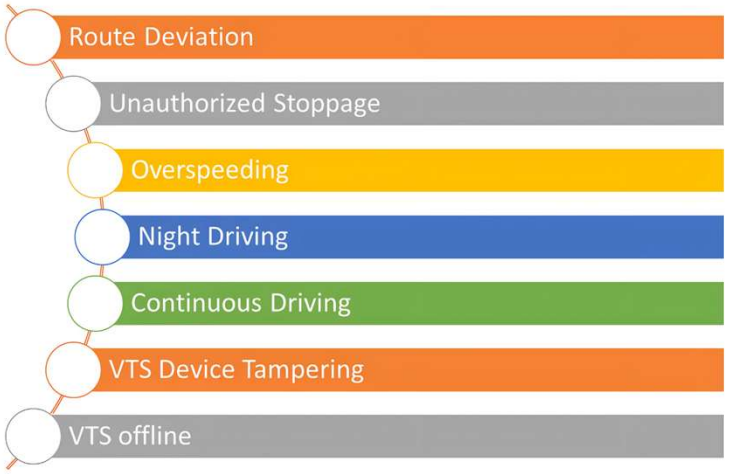
Vehicle Tracking Systems (VTS) powered by Artificial Intelligence are revolutionizing petroleum logistics by enabling real-time fleet monitoring, predictive route optimization, and intelligent driver behavior analysis — ensuring safer and more efficient movement of hazardous petroleum products across the supply chain. With AI-integrated VTS, petroleum companies can proactively detect anomalies, minimize fuel pilferage, automate compliance monitoring, and make data-driven decisions that significantly reduce operational costs and enhance supply security.

VTS Monitoring through AI





Real Time monitoring- Driver Safety Rating



- Driver Panic
- Harsh Turn
- Route Deviation
- Harsh Acceleration
- Speed Violation
- Stoppage Violation
- Harsh Braking
- No halt Zone

Interlock Mails from IRIS

Interlock Activation Alert

**** This email is system generated. Do not reply****

Dear Sir/Ma'am,

This email is to notify you that BPCL IRIS system has received **Night Driving_FirstTime** Interlock **Active** Signal for Asset **Aryaomnitalk - Night Driving** at **Akolner - 1419** at **19-08-2023 09:17:16**

Please note that this Interlock is **Active** because of **Night Driving Vendor:MAHESHWAR TRANSLINES(222709) Vehicle:MH16CC3031 Count:6**. Kindly login to BPCL IRIS Portal https://iris.bpcl.in for a detailed view.

You are kindly requested to **take action within 7 Days** . If no action is taken within this time period, BPCL IRIS system will **escalate the same to sudheerk@bharatpetroleum.in**

Interlock Activation Alert

**** This email is system generated. Do not reply****

Dear Sir/Ma'am,

This email is to notify you that BPCL IRIS system has received **Speed Violation_FirstTime** Interlock **Active** Signal for Asset **Aryaomnitalk - Speed Violation** at **Akolner - 1419** at **07-08-2023 18:46:02**

Please note that this Interlock is **Active** because of **Speed Violation Vendor:MAHESHWAR TRANSLINES(222709) Vehicle:MH25AJ7065 Count:6**. Kindly login to BPCL IRIS Portal https://iris.bpcl.in for a detailed view.

You are kindly requested to **take action within 7 Days** . If no action is taken within this time period, BPCL IRIS system will **escalate the same to sudheerk@bharatpetroleum.in**

⚠ WPS COMPLAINCE

Ultra Critical Video Analytics (UCVA)

UCVA monitors the most hazardous operations in real-time, automatically triggered when permits are approved in the Computerized Work Permit System (CWPS). The system ensures continuous oversight of high-risk activities without manual intervention.

Scope of Activities

- Welding/cutting/grinding in licensed areas
- Work at height or excavation >2m
- Tank cleaning/painting/repair
- IFR deck entry
- Shot blasting operations etc.

Real-Time Detection

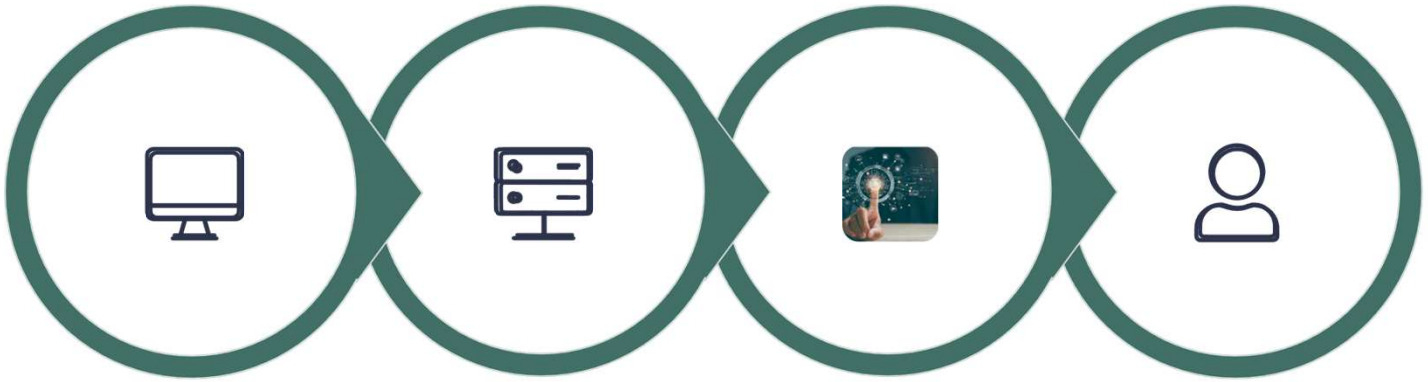
- Missing helmet detection
- Missing safety harness at height
- Fire extinguisher absence
- Fire hose unavailability
- Protective clothing violations
- Camera offline alerts

Automated Response

SMS/Email alerts with video clips sent to LIC and HSSE Officer. Officers must classify events as true/false and submit ATR for true violations. Unresolved alerts escalate to HQ HSSE per defined timers.

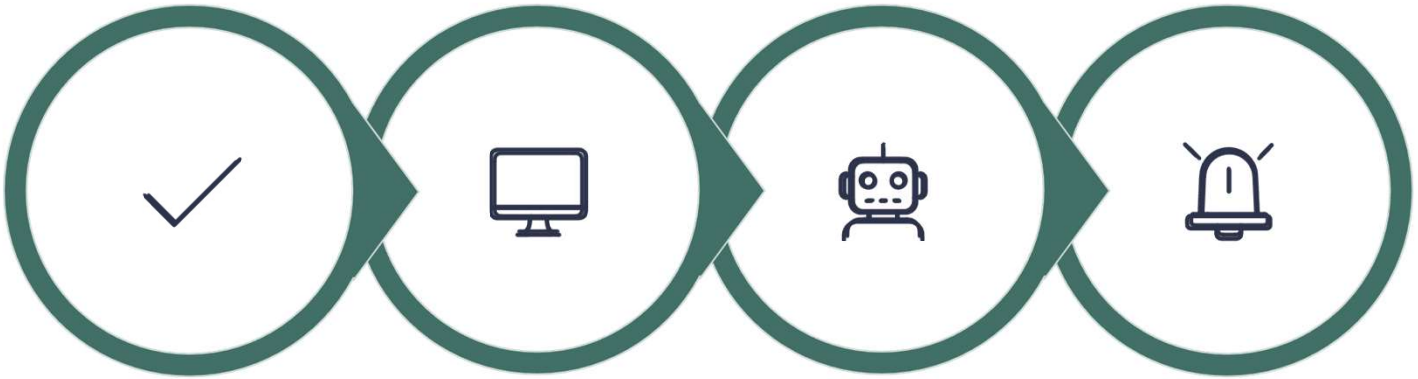
Edge-to-Cloud Architecture: Processing at the Source

IRIS employs a hierarchical Edge-Cloud-Terminal architecture that processes video intelligence at the source, reducing bandwidth requirements while enabling sub-second response times. This design follows modern best practices for industrial AI deployment.



IP CCTV cameras stream to GPU-powered Edge Analytics Appliances that run AI models locally—detecting PPE violations, intrusions, FEs, and equipment in real-time. Only event metadata and short clips reach IRIS Core, cutting network load by 95%.

UCVA Technical Workflow



Permit Approved

Auto Monitoring

AI Violation Detection

Alerts & ATR

This automated workflow ensures that every ultra-critical activity receives continuous AI oversight from permit approval through completion, with human verification and documented corrective action for every detected violation.

SAFETY INTELLIGENCE | AI-POWERED MONITORING

UCVA: Ultra Critical Video Analytics

Automated, AI-driven video surveillance ensuring **fire safety compliance** across critical environments — detecting equipment presence, emergency response readiness, and PPE adherence in real time.

Fire Extinguisher Presence

Real-time detection verifies extinguishers are correctly located, accessible, and intact per **NFPA 10** standards — preventing critical safety gaps before they escalate.

Running Hose Pipe Detection

Monitors active hose deployment to confirm **readiness and immediate response** capability during fire events, ensuring suppression systems are operational when needed most.

Protective Coverall Usage

Identifies personnel wearing appropriate PPE, ensuring compliance with **OSHA** and **EM 385-1-1** safety regulations across all hazardous work zones.

Instant Alerts

AI-powered object recognition delivers actionable insights to safety managers

Zero Human Error

Continuous automated monitoring eliminates oversight gaps 24/7

Regulatory Compliance

Enforces safety protocols to protect lives, property, and certifications

AI in TAS Interlocks – From Field Instruments to IRIS

A clean, five-layer architecture carries real-time instrument status from physical field devices through standardized industrial protocols to centralized intelligence. Each layer adds abstraction and value: field signals become PLC tags, PLC tags become SCADA displays, SCADA tags become OPC-standardized data, OPC data becomes Edge-formatted payloads, and finally Edge payloads become actionable IRIS intelligence.

The 5-Step Data Journey

Field Instruments → PLC

Field devices like ROSOV, MOV, and Hooters are hardwired to PLC input modules. Binary status signals (0/1) are continuously scanned by PLC input cards and mapped to memory tags.

PLC → SCADA (Fast-Tool)

SCADA communicates via industrial Ethernet/Modbus TCP. PLC publishes real-time tag values for live control room displays and alarms, ensuring near real-time monitoring.

SCADA → Matrikon OPC

Matrikon OPC server connects to SCADA, configuring and exposing required tags through a standardized OPC interface. Status values (0/1) becomes accessible for third-party systems.

Matrikon OPC → Edge Device

The Edge Device subscribes to Matrikon OPC server tags, collecting and buffering real-time instrument status. Data is formatted to IRIS requirements for secure and reliable forwarding.

Edge Device → IRIS

Edge transmits processed data to the IRIS central system via secure MQTT/HTTPS. IRIS receives real-time instrument health and valve status for monitoring, analytics, and compliance.

SAFETY ARCHITECTURE

Why This Architecture Matters

End-to-End Digital Thread

Every safety-critical instrument has a traceable digital path from field wiring through PLC → SCADA → OPC → Edge → IRIS. Eliminates manual reporting and ensures instrument health is visible centrally in real time.

Standards-Based Integration

Matrikon OPC layer between SCADA and Edge Device avoids proprietary lock-in. Any OPC-compliant consumer can access the same data, making the system extensible for future analytics or third-party tools.

Edge as OT–IT Gateway

Edge Device serves dual role: OPC client on OT side and MQTT/HTTPS publisher on IT side. Buffers, formats and securely transmits data, ensuring sensitive PLC/SCADA network is never directly exposed to cloud or enterprise systems.

Binary Health Model

Entire chain maintains simple, unambiguous health convention: 0 = Closed/Unhealthy, 1 = Open/Healthy. Consistency from field to IRIS means automated SOP logic can reliably interpret instrument status without translation errors.

Foundation for IRIS Safety Logic

Data powers TAS SOP engine—tank overfill prevention, plant ESD, HCD alarms, earthing-failure interlocks, and Operability Index (OI) calculation that can automatically block pumps and invoicing when safety readiness drops below threshold.

TAS INTEGRATION

Terminal Automation System Interlocks

The TAS SOP for Command & Control Centre defines comprehensive interlocks and emergency shutdown functions that form the foundation of process safety. IRIS integrates with this infrastructure to add behavioral and visual sensing layers.

Overfill Prevention

ROSOV closure on high-level switch activation with 90-day proof test cycles for HLS, radar, servo, and inlet ROSOV health monitoring.

Emergency Shutdown

Plant-wide ESD closes tank ROSOVs, trips pumps, and initiates power shutdown sequences via ESD push buttons with 30-day proof tests.

Fire Protection

Rim seal fire detection and suppression on floating roof tanks, plus hydrocarbon gas detection with audio-visual alarms at 20% and 40% LEL.

Earthing Failure

Loading cut-off via batch controllers at TLF/TWFG when earthing failure detected, with complex "4 out of 6" and "2 out of 6" proof test logic.

Layered Safety Architecture

IRIS operates as an additional sensing channel that supplements—but does not replace—core instrumented protection layers (IPL). This defense-in-depth approach aligns with both Process Safety and Occupational Safety requirements.

AI Visual Layer

Behavioral and visual sensing: PPE violations, intrusions, fire/smoke, unauthorized activities

TAS/PLC Layer

Deterministic actuation: pump trips, valve closures, ESD sequences, alarm activation

Integrated Response

Earlier, richer, more behavioral view of risk combined with hardware-based protection

OPERABILITY INDEX

AI's Role in Operability Index & TAS Interlocks

Within the Operability Index (OI) framework, IRIS-enabled AI plant safety interlocks represent a quantifiable parameter under "Safety Systems/Automation" with appropriate corporate weightage. This elevates IRIS from monitoring tool to active interlock supporting system.

TAS Interlock Landscape: 23 SOPs

Standard Operating Procedures for Terminal Automation System define 23 interlock-centric use cases protecting against overfill, loss of containment, ignition, earthing failures, and quality deviations.

Critical Protection (SOP 1–11)

- Tank overfill prevention with ROSOV closure
- Plant ESD and power shutdown
- Rim seal fire protection system
- Hydrocarbon detection with LEL alarms
- Earthing failure loading cutoff
- MOV closure and pump tripping on HLS
- Hooter activation systems
- Dyke drain valve position monitoring

Metering & Quality (SOP 12–22)

- Pulse security and dual pulse alarms
- K factor/meter factor change control
- No flow, low flow, high flow alarms
- Unauthorized flow detection
- Meter overrun protection
- Blend overdose/underdose alarms
- Additive overdose/underdose alarms

Meta Control (SOP 23)

Operability Index composite interlock regulating overall plant availability

What Operability Index Measures

OI is a location-level metric computed by CCC for automated terminals based on weighted parameters representing fire protection readiness and interlock health. When OI falls below desired value, CCC automatically stops pumps and invoicing.

Fire Water (20%)

Quantity as % of OISD requirement; zero contribution if <80%

Supercritical Interlocks (20%)

Weighted average of overfill prevention, plant ESD, RSFPS KPIs

Fire Engines (20%)

Number in auto mode; zero if <3 of 5 or <2 of 3 available

Critical Interlocks (15%)

HCDS, dyke drains, earthing failure logic health

Process Interlocks (10%)

Flow, meter overrun, blend/additive dose interlocks

Foam Quantity (10%)

% of OISD requirement; alert if unchanged for entire quarter

Fire Fighting System (5%)

Pressure >7 kg/cm² at farthest point or jockey pump run signal

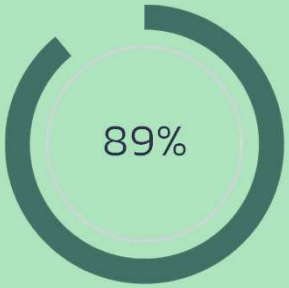
INNOVATION SPOTLIGHT

Operability Index: Plant-Level Safety Readiness

The Operability Index (OI) represents IRIS's most sophisticated use case, combining multiple fire protection and interlock KPIs into a single index that drives automated plant-level blocking and restoration based on safety readiness. This elevates safety from individual alert response to holistic plant state management.

Target OI

All systems operational



Block Threshold

Operations suspended

OI Calculation Components

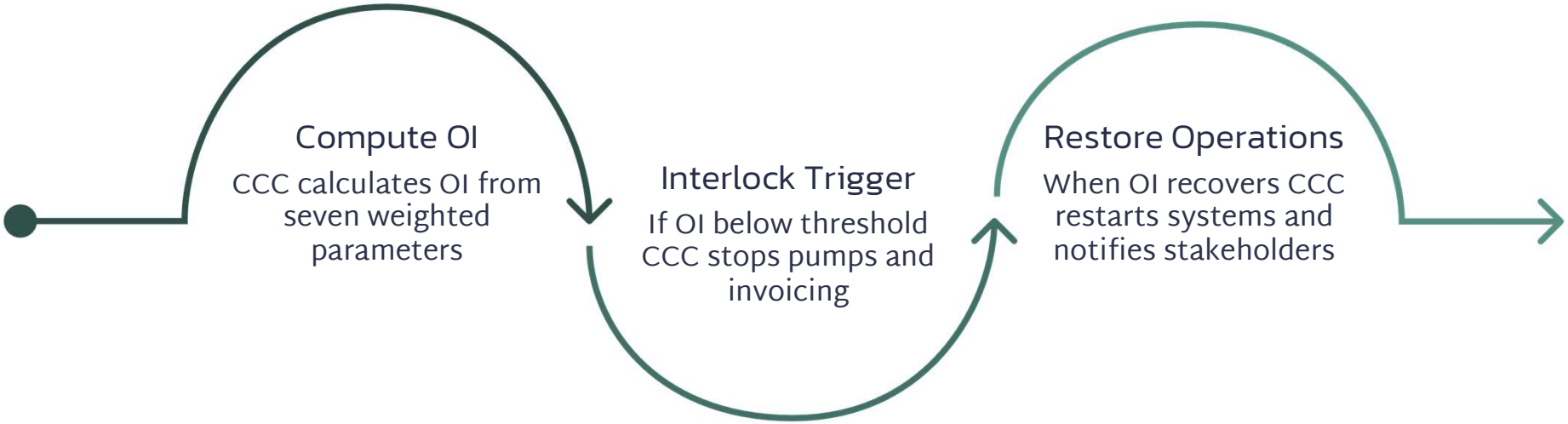
The Operability Index aggregates real-time status from multiple safety systems:

- **Supercritical Interlocks:** Tank overfill prevention, ESD push buttons, ROSOV status
- **Critical Interlocks:** Hydrocarbon gas detection, earthing relay status, flow meters
- **Process Interlocks:** Batch controller parameters, pressure transmitters
- **Fire Protection:** Fire water availability, foam system readiness, fire engine status, hydrant pressure
- **Proof Test Compliance:** All interlocks tested within 30-day windows

When OI falls below the configured threshold, IRIS automatically sends commands to TAS to stop all product pumps and to ERP to stop invoicing. Once OI recovers above threshold, unblock commands restart operations—creating a direct link between safety system health and operational authorization.

OI as Active Interlock, Not Just Indicator

Unlike typical safety dashboards, BPCL's OI is implemented as an interlock (SOP 23) that directly controls plant operations. This design mathematically couples operations to safety status rather than relying on subjective judgment.



This ensures fundamental protective layers must be functional before the plant can operate, regardless of local pressure to meet loading targets.

Proof Testing & Revocation Governance

CCC uses instrument feedback and OPC-based data to verify each interlock's proof test within required intervals. Temporary exceptions require multi-level approval with time-bound, fully auditable trails.

Proof Test Requirements

SOP 1-3 and 5-11 proof tests must demonstrate actual interlock function. Example: HLS activation must lead to ROSOV closure with IRIS receiving status changes. Only then is the interlock considered healthy for OI calculation.

Exception Process (SOP 27a/27b)

Control Room In-charge requests revocation/maintenance exception with ATR and duration. Requires LIC, ROH, Regional Head, and HQ Operations approvals. Auto-reactivates when period expires to prevent indefinite overrides.

OI cannot be "gamed" by manual overrides—any relaxation is time-bound, multi-level approved, and fully auditable, aligning with MOC principles.

Key Takeaways: AI-Driven Safety Transformation

BPCL's IRIS implementation demonstrates how AI, video analytics, and integrated digital workflows transform safety from episodic, people-dependent supervision to continuous, system-driven assurance.

Layered Safety Envelope

UCVA, VTS enforcement, loss of communication detection, and TAS/PLC interlocks on a common platform create evidence-rich, multi-layered protection supporting OISD compliance and OI objectives.

Embedded in SOPs

AI works best when embedded into existing SOPs and permit systems—not as a parallel gadget—so every AI alert links directly to accountability, escalation, and documented corrective action.

Human-AI Partnership

AI provides earlier, richer behavioral insights while humans verify, classify, and document actions. This partnership ensures technology enhances rather than replaces human judgment and expertise.

AI-Enabled Safety Use Cases

IRIS implements multiple AI-driven safety monitoring capabilities across operations. Each use case combines visual sensing, inference engines, and automated response protocols to create a comprehensive safety net.

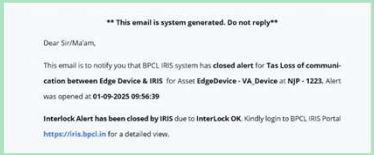
The table above summarizes key technical implementations, detection methods, and response protocols for each safety use case deployed across BPCL facilities.

Key AI-Enabled Safety Use Cases

IRIS proactively addresses critical safety scenarios through continuous AI monitoring and automated response mechanisms.

Use Case	Technical Logic in IRIS	Safety & Governance Impact
PPE Compliance 	Edge models perform person detection + attribute classification on helmets, harnesses, protective clothing within defined Regions of Interest (ROIs). If a Person is detected in a UC work zone and attributes such as Helmet, Harness, or Protective Clothing are missing, IRIS generates a VA alert along with a short video snippet.	Eliminates normalization of PPE violations by generating near real-time evidence and forcing ATR closure by LIC/HSSE officer, thereby strengthening day-to-day behavioral safety.
UCVA via WPS Integration 	CWPS transmits work-permit details (Permit ID, camera list, start/end date-time, WPS flag, status) to IRIS via web services. For approved ultra-critical permits (welding/cutting/grinding, working at height, tank cleaning/repair etc.), IRIS automatically activates **Ultra-Critical VA** on the selected online cameras for the permit window.	Provides automated, camera-based supervision for high-risk jobs, ensuring helmets, harness, fire extinguishers, fire hose are present, and that the activity does not overrun the approved work-permit time without escalation and justification.
Work-Beyond-Time Detection	If LIC does not indicate "Close UCVA Monitoring" in CWPS by the approved end time, IRIS automatically generates a **Work Beyond Time** alert at the exact permit end time. Cameras continue UC monitoring until closure; IRIS escalates via SMS/Email to role-holders at configurable intervals (15, 30, 60 minutes) until ATR is submitted and UCVA is closed.	Prevents silent extension of high-risk work without formal approval, enforces discipline in permit closure, and ensures leadership visibility whenever UC jobs extend beyond their risk-assessed window.

Key AI-Enabled Safety Use Cases

Loss of Communication – TAS, CCTV, Edge, VTS, EM Locks  ** This email is system generated. Do not reply** Dear Sir/Ma'am, This email is to notify you that BPCL IRIS system has **closed alert** for **Tas Loss of communication between Edge Device & IRIS** for Asset **EdgeDevice - VA_Device** at **NJP - 1223.** Alert was opened at **01-09-2025 09:56:39** **Interlock Alert has been closed by IRIS** due to **InterLock OK**. Kindly login to BPCL IRIS Portal https://iris.bpcl.in for a detailed view.	IRIS periodically pings each integrated subsystem: Edge–IRIS (hourly), CCTV–Edge (every 30 minutes), TAS–IRIS (hourly), fortnightly VTS data drops (on 17th and 2nd), and EM-locking streams (every 15 minutes). If communication is not received within the defined window, IRIS generates "Loss of Communication" alerts, notifies role holders	connectivity before relying on the automated safety envelope. This closes a critical blind-spot where systems may appear healthy while actually not communicating with IRIS
VTS-Based Tank Lorry Safety Governance  Vehicle Tracking System 15516 13480 1710 3164 Inactive TLS 406 59 59 150 Vehicles Distance Consumer Vehicles	IRIS ingests VTS violation data and aggregates them into **repetitive violation counts** over each fortnight. >5 violations for speed/ night-driving /power-disconnect or >10 for route/unauthorized stoppage in a fortnight are counted as 1 repetitive violation; counters are maintained for the entire contract period and drive logic for auto-blocking, exception workflows, and auto-unblocking of lorries via SAP integration.	Shifts road-safety enforcement from manual log-book checks to data-driven governance—ensuring habitual violators are blocked for defined punishment periods and can only be unblocked via structured ATR and exception approval, thereby reducing road-transport risk.
VA-Assisted Incident Investigation & Evidence	Every VA alert (PPE, UCVA, intrusion, man-down, camera-offline, Work Beyond Time, VTS–linked events) is stored with timestamp, camera ID, permit ID (if UCVA), violation type, and a 5–10 second clip. These clips can be filtered by BU/location/date and downloaded from IRIS dashboards to support investigations and periodic management reviews	Replaces anecdotal investigations with evidence-based reviews, reduces disputes on "who did what," and provides a rich corpus for learning, training, and continuous improvement in safety procedures.

Case studies on Advance Use of Technology & AI

1. **Automatic Fire actuation System** : Advanced protection for petroleum storage terminals through integrated detection, automated response, and intelligent control systems
2. **Real Time Earth Monitoring System** : Continuous Monitoring of critical earth pits of the location using AI for enhancing electrical safety

Automatic Fire Fighting System for Petroleum Terminals

- Integrates multiple layers of protection into one intelligent platform.
- Fire and gas detectors / RSFPS continuously monitor tank farms.
- SIL-certified PLC processes inputs and executes pre-programmed response sequences.
- Automatically detects fire or gas release and instantly activates appropriate suppression measures.
- Suppression measures include opening sprinkler rings for cooling, deploying foam systems, and triggering medium expansion foam generators.
- SCADA/HMI interfaces provide real-time visualization, alarm management, and comprehensive event logging for all actions..

CORE COMPONENTS

Main System Components

Detection & Sensing

Rim seal fire alarms for floating roof tanks, quartzoid thermal bulbs that burst at 79°C, and hydrocarbon detectors monitoring gas concentrations at configurable LEL thresholds

Alternatively, Using CCTV-EDGE interface for detection of smoke and fire

Actuation Hardware

Electro-pneumatic actuators on butterfly and globe valves controlling sprinkler rings, foam lines, and MEFG systems with Auto/Manual modes and full status feedback at the PLC/IRIS end.

Control & Logic

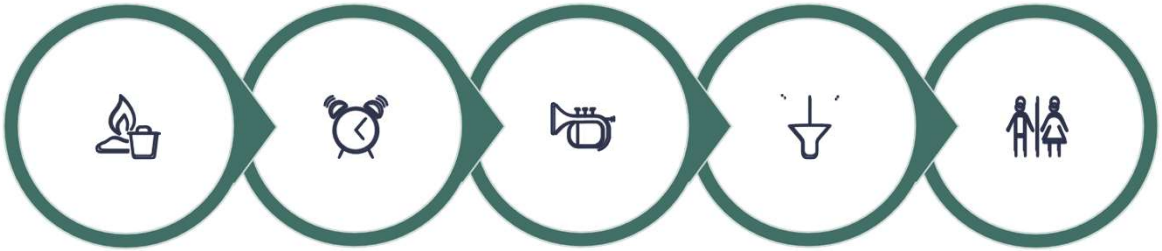
Dual redundant SIL-2/SIL-3 M580 PLC system with remote I/O modules in ring topology, managing detection voting, interlocks, valve sequencing, and automated reset protocols

SCADA & Interface

Comprehensive HMI with tank farm graphics, color-coded incident visualization, alarm annunciation, sequence of events tracking, and role-based access for engineers and operators

EMERGENCY RESPONSE

Automatic Fire Response Sequence



Fire Detection | System Alert | Valve Activation | Suppression Deployment | Normalization & Reset

Response time reduced from minutes to seconds through complete automation of firefighting procedures

Instant Protection Actions

- Foam lines and daughter tank outlets activate for fire suppression
- Exposure protection: 3 LPM rings open on tanks within R+30m radius
- 1 LPM rings activate on remaining tanks per fire-fighting matrix
- Visual tank coding: red for incident, blinking orange/yellow for exposure zones
- All plant hooters sound while SCADA logs complete event sequence

Measurable Safety Advantages

<1s	100%	24/7
Response Time	Consistency	Protection Coverage
From detection to suppression activation, eliminating manual intervention delays	Pre-engineered strategy execution following fire-fighting matrix specifications	Continuous monitoring with dual redundant systems ensuring zero downtime

Zero Human Error

Eliminates confusion in valve selection and removes stress-induced mistakes during critical incidents

Enhanced Personnel Safety

Remote firefighting capabilities keep operators away from hazardous zones during emergencies

Complete Documentation

Comprehensive alarm logs, sequence of events, trends, and MIS reports support continuous safety improvements

Real-Time Earth Monitoring System

Implementation at BPCL Location for Enhanced Electrical Safety and Operational Excellence

PROJECT OVERVIEW

Project Background & Critical Objectives

The Challenge

Depots operates as a critical petroleum storage and distribution hub serving the nation. In hazardous petroleum environments, effective grounding systems are essential for preventing electrical hazards, dissipating lightning strikes, and managing fault currents. Traditional periodic testing methods cannot detect real-time degradation of earth grids, creating potential safety gaps in daily operations.

The Solution

Implementation of a continuous, real-time monitoring system that tracks earth grid resistance 24/7. This proactive approach enables immediate detection of ground system degradation, supports condition-based maintenance decisions, and significantly enhances overall operational safety and reliability across the facility.

Continuous Monitoring

Real-time surveillance replaces periodic manual testing

Early Warning System

Immediate detection of earth grid degradation

Proactive Maintenance

Data-driven maintenance scheduling based on actual conditions

Enhanced Safety

Superior protection against electrical hazards and lightning

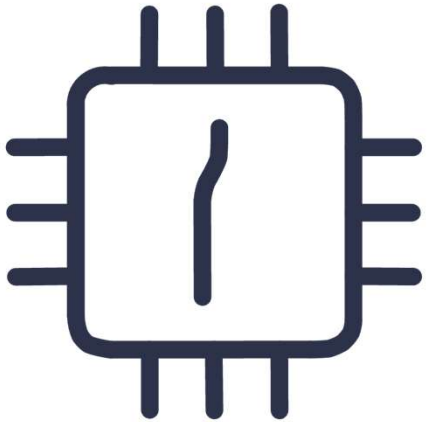
TECHNICAL DETAILS

How the System Works: Hardware & Data

Earth Monitoring System (EMS) uses three main parts to constantly check the earth grid. This setup makes sure we get exact, reliable information right away to help with safety and maintenance decisions.

Sensors & Wires

We place sensors (electrodes) in each earth pit. The first is at 10 meters, then others are 5 meters apart. An 800-meter cable connects all these sensors to gather full information.



Control Boxes

Each box can check three earth grids at once. These controllers are in important spots like the Control Room and MCC Panel Room, covering six earth pits.

Display Units

The control boxes send data to these display units. They collect, process, and show the information locally. These units record data with times and can create charts of resistance levels for you to download and check.

How Data Moves & Is Checked

The smart earth monitoring system works using IoT. It combines advanced sensors, easy connections, and smart local processing to give clear, useful information for key systems.

Sending & Reading Signals

The control box sends a small electrical signal through the sensors into the ground. It then measures the returning signal to correctly figure out how much resistance the earth grid has.

Sending Data

The resistance numbers from the three earth pits are quickly sent over an 800-meter cable network straight to the main display unit.

Seeing & Saving Data Live

The display unit shows live resistance numbers and constantly saves data with timestamps. This data is key for looking at trends, checking past records, and meeting rules.

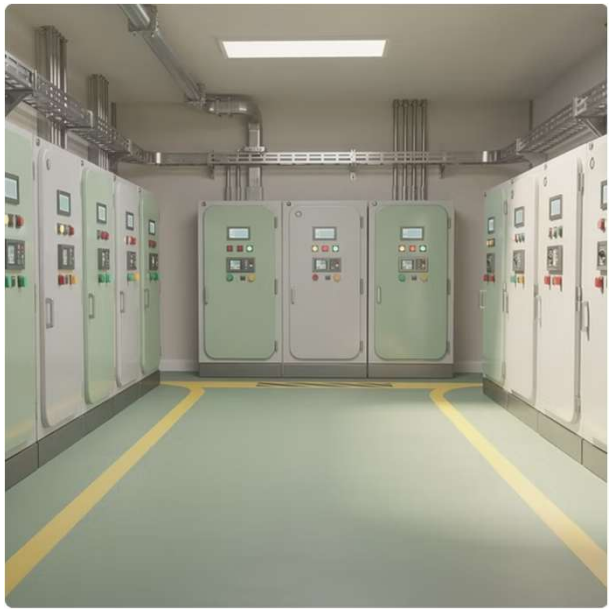
Warning System

The system has a built-in alarm. It automatically sends alerts and messages if earth grid resistance goes above safe levels. This allows for quick action.

SYSTEM ARCHITECTURE

Installation Sites & Technical Configuration

The Earth Monitoring System utilizes the industry-standard Wenner Four-Point Method for accurate resistance measurement, with 800 meters of cable infrastructure connecting all monitoring points.



Technical Specifications

- Firmware: v5.2 and v15.5
- Controller Card: v1.2
- Vendor: M/s RF Bytes
- Electrode Spacing: 10m initial, 5m subsequent

Measurement Method

Wenner Four-Point technique injects current through outer electrodes while measuring voltage between inner electrodes, calculating resistance with high accuracy and real-time display capability.

CURRENT STATUS

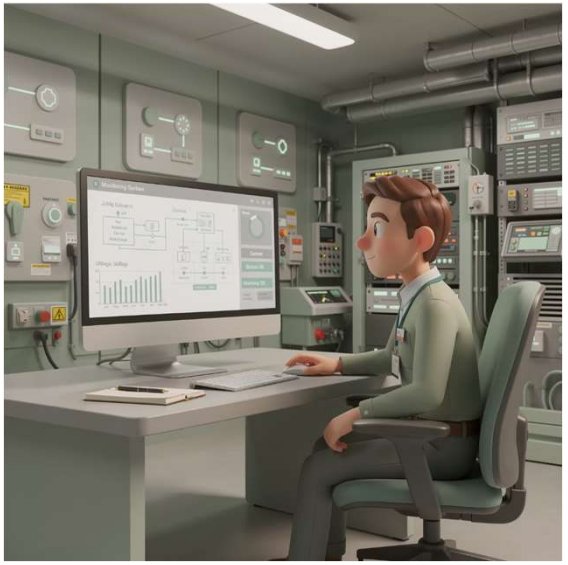
System Performance & Corrective Actions

MCC Panel Room: Fully Operational

All controllers and edge devices are functioning correctly with earth pit readings consistently within acceptable limits (< 1 Ohm). Data logging, trending, and real-time monitoring are operating as designed, providing continuous visibility into ground system integrity.

Control Room: Optimization in Progress

Hardware installation is complete and basic monitoring is functional. However, external interference from AC units, transformers, and other control room equipment is causing harmonic noise that affects measurement accuracy. The dense concentration of electrical equipment creates electromagnetic interference at frequencies that corrupt the monitoring signal.



Issue Identified

Harmonic noise from VFD drives, transformers, and electrical equipment causing measurement interference

Solution Designed

Frequency change component card to operate at alternative frequency away from interference sources

Thank You

I appreciate your time and attention today.