DIGITAL EARLY WARNING ARCHITECTURE FOR ECONOMIC RESILIENCE IN CAPITAL INTENSIVE ENTERPRISES

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Abstract. This paper presents a compact digital architecture for early warning in capital-intensive industrial enterprises. The proposed design connects accounting, treasury, operations, and maintenance data to a common validation layer and a management dashboard. Each warning signal is linked to a threshold, an accountable owner, and a predefined response. The architecture is intended for enterprises that must monitor liquidity, debt exposure, operating continuity, and asset condition at the same time. It can be introduced gradually without requiring a complex artificial intelligence model at the initial stage.

Keywords: economic resilience, early warning, digital dashboard, industrial enterprise, risk monitoring, management decision.

Introduction

Capital-intensive enterprises operate with long-lived assets, large investment programmes, and significant financing needs. A financial report explains the outcome of a completed period, but managers also need timely signals about conditions that may weaken future operations. Delayed receivables, rising short-term payments, exchange-rate exposure, maintenance backlogs, and lower asset availability can develop in different systems. If these signals are reviewed separately, management may recognise a combined problem too late.

The purpose of this paper is to outline a practical early-warning architecture that converts dispersed enterprise data into accountable management actions. The method is conceptual. It combines risk-management principles with the logic of business intelligence and performance monitoring. The design focuses on data flow and decision responsibility rather than on a complex predictive algorithm.

Proposed architecture

The architecture contains four connected layers. The source layer collects data already generated by accounting software, treasury records, operational control systems, maintenance applications, and human-resource systems. The validation layer checks completeness, reporting date, unit of measurement, and reconciliation with the authorised source. The analytical layer calculates a limited set of indicators and compares them with approved thresholds. The decision layer records the owner, deadline, and response attached to each warning.

Table 1

Layers of the digital early warning architecture

Layer	Main task	Minimum output
Data sources	Collect financial, treasury, operating, and asset records	Dated and traceable input
Data validation	Check completeness, consistency, and reconciliation	Verified dataset
Analytics	Calculate indicators and compare them with limits	Green, amber, or red signal
Decision	Assign an owner and response	Recorded management

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workflow	deadline	action

Source: developed by the author.

A useful dashboard should remain selective. The financial block may include unrestricted cash coverage, operating cash flow, leverage, interest-service capacity, and overdue receivables. The market-risk block may show foreign-currency debt and the share of variable-rate borrowing. The operational block may include asset availability, unplanned outages, maintenance completion, and energy losses. The system should display both the current value and the direction of change because a deteriorating indicator can require attention before it reaches a formal limit.

Every indicator needs a documented definition. The document should identify the data owner, source system, calculation rule, update frequency, threshold, and responsible decision-maker. Without these fields, a dashboard can display attractive graphics while leaving the organisation uncertain about which number is authoritative or who must respond. Data quality is therefore part of the control design, not a separate technical issue.

Warning levels can be introduced through a simple traffic-light rule. Green means the indicator remains within the approved operating range. Amber signals deterioration or proximity to a limit and requires explanation. Red means the threshold has been breached and activates a defined response. The response may include a liquidity forecast update, revision of the borrowing plan, accelerated collection of receivables, maintenance reprioritisation, or escalation to the risk committee. Thresholds should be reviewed when the business model, tariff regime, financing structure, or asset base changes.

Application considerations

The architecture can be implemented in stages. The first stage uses a small number of indicators and controlled spreadsheet or business-intelligence reports. The second stage connects these reports directly to enterprise resource planning and operational systems. Predictive models may be added only after data definitions, historical series, and governance procedures become reliable. This sequence reduces the risk of automating inconsistent information.

For an electricity transmission enterprise, the dashboard should combine debt-service requirements with unrestricted cash, receivable collection, grid availability, planned maintenance, and investment execution. The grid operator's independently audited disclosures for 2024 illustrate why this integration matters: financing and cash information are material, while the enterprise must also sustain a capital-intensive network. A financial warning should therefore be interpreted together with its operational cause and consequence.

The architecture does not replace professional judgment. A threshold is a prompt for investigation, not proof that a loss will occur. External shocks, regulatory decisions, and data delays may change the meaning of an indicator. Management should retain the assumptions behind every signal and document any decision to override it.

Conclusion

A digital early-warning system becomes useful when it connects verified data with a specific decision process. The proposed four-layer architecture provides a feasible starting point for capital-intensive enterprises: existing source systems feed a validation layer, a limited analytical dashboard generates signals, and each signal activates an accountable response. Enterprises should begin with clear definitions and ownership before adding advanced analytics or artificial intelligence. This approach supports earlier intervention while keeping the model transparent and auditable.

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