T&D Asset Performance Management Solutions

White Paper

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1. Asset Health and Asset Performance Management

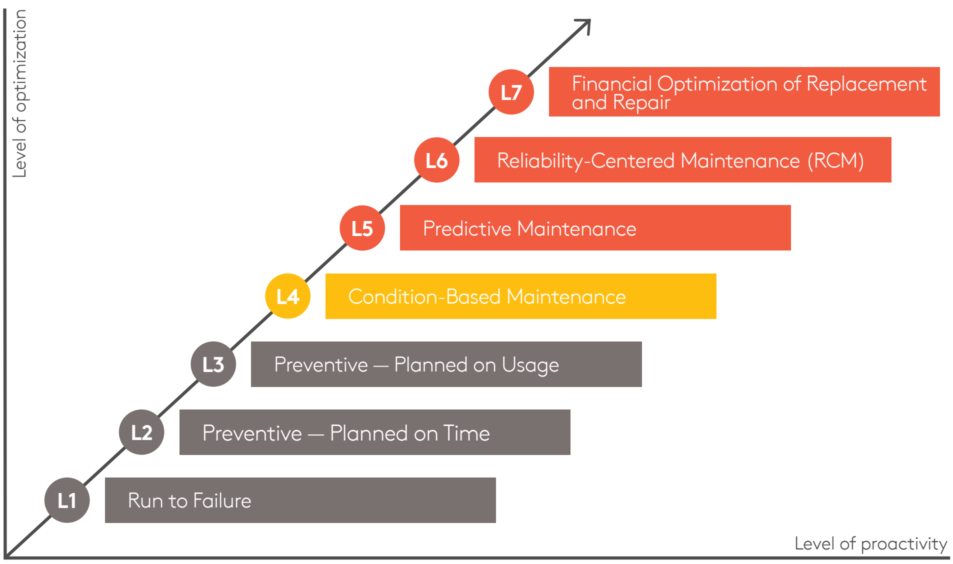
T&D asset-intensive organizations today mostly employ a mix of time-based and run-to-failure maintenance practice together with curative actions (fix-repair model). Asset health is therefore managed mostly with calendar-planned activities in accordance with experience, team know-how and manufacturer recommended practice.

Many of the asset support systems in place fall under the Workforce Management (WfM) or the Maintenance Planning categories. Asset inspection, failure or repair records are normally kept, usually with limited structure. SCADA and Automation systems usually provide asset managers with critical alarms related to faults of critical components and equipment failures but are limited in providing online asset data to ascertain health, as their primary function is system operation. Information silos are usually also in place and consistent usage data is sometimes illusive to many asset managers. Organizations may also have Enterprise Asset Management (EAM) systems in place, usually incorporating asset and maintenance master data together with investment planning, warranty management and other features.

With the advent of both digitalization and increased pressure for asset orchestration, reliability and optimization, condition-based maintenance is now emerging, but its practice is far from systematic within T&D asset-intensive organizations. It is expected that the decreasing cost of sensors, integration, and computing infrastructure together with advances in data processing, communications and analytics will, during this decade, enable operators to profit from digital solutions that integrate asset health algorithms together with online sensor data in quasi-real-time. Such systems will deliver improved and actionable information that effectively increases asset performance and supports decision making, while automating current asset management processes.

Existing asset management maturity models proposed by consulting firms such as the strategic roadmap for asset management and reliability by Gartner, place organizations in different levels of increasing optimization and proactivity (see figure 1). Larger asset intensive organizations tend to have higher maturity, but the industry standard today for leading organizations is Level 3, now shifting into Level 4 with early adopters investing in predictive methods.

Figure 1 - Gartner maturity model for asset management.



Asset performance management is in its essence about managing asset condition, in other words, assess and manage asset health and risk through time, by collecting, aggregating and analyzing data to estimate/predict and inform asset managers or propose data driven courses of action.

2. Implementing Asset Health and Performance Solutions

There are many incentives to implement a digital asset health solution addressing condition based methods: improve asset utilization by reducing downtime; enable controlled overloading; securely extend asset life; reduce maintenance costs by automating routine activities, reducing planned activities and related materials; lower CAPEX expenditure and working capital; minimize risk of catastrophic equipment failures, related collateral costs and emergency repair costs; reduce downtime and its impact on system reliability; but also reduce exposure to safety and environmental issues, reputation, liability, standards compliance and regulation; and, competition. The business value of each incentive is different between organizations as is each asset base and company strategy.

There are also multiple vectors of decision making to consider with different reaction/impact time (equipment condition monitoring versus lifecycle management), level of responsibility (unit maintenance versus business planning), asset base applicability (unit versus fleet), etc. The best Asset Performance Management (APM) solution to deploy will depend on the set objectives, as these will require different amounts and frequency of data collection and aggregation, algorithms, target users and enterprise integration needs (existing ERP, WfM or EAM systems).

With increasing level of software and analytics incorporation (and corresponding decreasing level of necessary human intervention and input), asset performance support systems may be classified in four major levels, as per the table below.

Table 1 - Gartner maturity model for asset management.

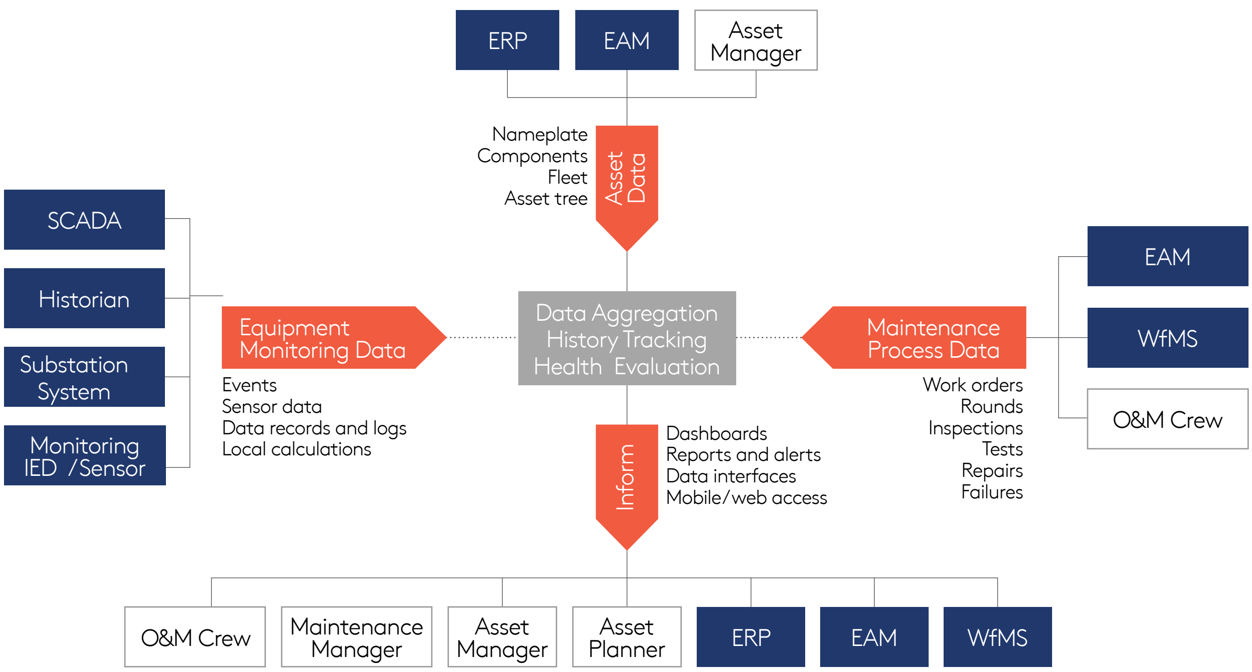
Level 0 **Collect / Describe**	Data collection from key sources (inventory, sensor/monitoring data, inspection data, etc.), data slicing and clean up. Single uniform data/analytical model with consolidated storage. Basic information extraction, dashboarding and reporting.
Level 1 **Diagnose / Alert**	Monitor and predict health with weighting algorithms. Usage of industry standard diagnostic methods such as (ex: IEEE C57-104, IEC 60599, Duval triangle, Roger's ratio, etc.). Monitoring key asset events and data trends with alarming/notifications. Drill-down features to diagnose what and why events happened.
Level 2 **Estimate / Predict**	Rule-based expert systems based on knowledge of asset experts, including heuristics based on user experience. More sophisticated asset models and calculations (a.k.a. digital twins). Predictive methods based on statistical and AI models.
Level 3 **Prescribe / Plan**	Advanced recommendation systems. Automated maintenance planning.

Considering today's general industry status, implementing a Level 1 solution with simple predictive methods for critical asset types constitutes, in most cases, a significant step forward in organizational maturity. This would require an initial investment in both monitoring and software support systems as well as change management within the organization, regardless of procurement and implementation strategy. With the increase of APM sophistication the requirements for software modules and local hardware/sensor solutions will increase and become more asset specific, increasing per-unit costs of the global solution. Furthermore, employing sophisticated methods upfront may not directly yield relevant results if company initial maturity is lower. It is also relevant to note that, for most T&D assets, more advanced methods are yet to be proven effective in common industry practice, namely those based on statistical and AI models due to actual restrictions on the availability of historical data, limited number of failures or length of asset lifecycle.

Architectural solutions involve a central software solution (on-premises or cloud-based) providing the consolidated data model, interfaces to data sources, intelligent algorithms and analytics, and a web-based responsive user interface designed to meet the requirements of target user roles, using application specific dashboards and visuals. At the field, Intelligent Electronic Devices (IED) such as intelligent transformer monitors and sensor aggregators provide input data, but solutions including standalone communicating sensors, substation data integrators or centralized SCADA systems or historic constitute relevant data sources. Cybersecurity is hence also a key challenge for APM systems and must be properly addressed by the APM solution.

An APM solution, as a digital intelligence solution, is heavily dependent on data availability and quality, with data size requirements varying considerably depending on applications. In figure 2 an overview of typical data sources is provided. Data inputs are typically of three categories: (i) asset monitoring and online connectivity (a.k.a. sensor and equipment event data), (ii) direct monitoring and business process data (work orders, inspections, tests, repairs and other maintenance actions), and (iii) inventory and asset component information base. Information processing requirements vary from real-time to more static and data history is relevant for temporal correlation. Data quality is also to be considered and information sources can be more subjective (ex: visual inspections) or objective (ex: direct measurements).

Figure 2 - Potential information sources for APM solutions.



As systems integration requirements increase, adoption of standards becomes a relevant enabler. While few information-level standards geared towards T&D asset performance management are in place, two standard frameworks are emerging: IEC 61850 [1] and CIM. IEC 61850 (figure 3) is a communication and information standard that can be used to collect monitoring data, events, files and asset information from the field and CIM is an XML and messaging-based IEC standard [2] (IEC 61968 and IEC 61970) for data model exchange between software applications. Both now provide early support for APM, nevertheless data integration for both real-time online data (sensor data) and more static (inventory, nameplate, inspections, etc.) is a challenge to consider, with a mix of proprietary interfaces and database access methods with usage of standard communication protocols and APIs. Last but not least, asset management frameworks namely PAS/ISO 55000 [3] provide key guidance on driving risk-based and life-cycle cost approaches while aligning the implementation plan with the company business plan.

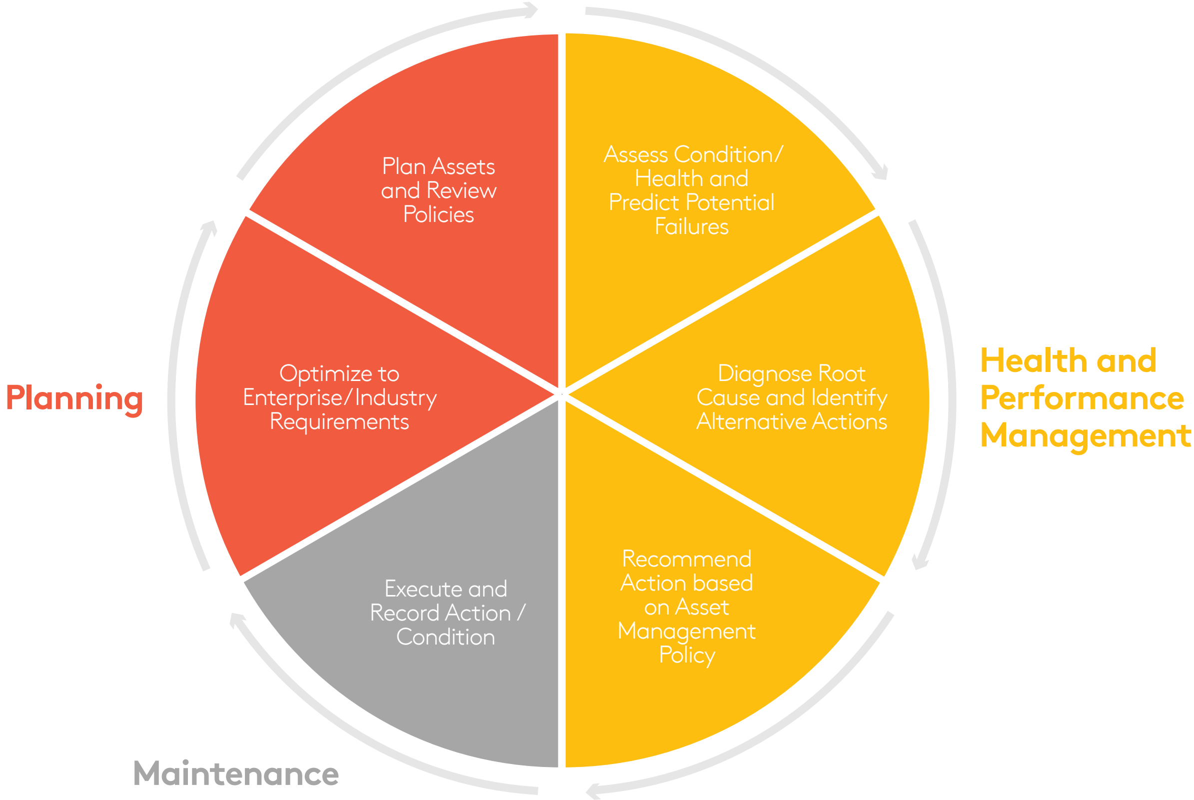
IEC 61850 Power Transformer Model Objects

- YPTR Power Transformer
- SPTR Power Transformer Supervision
- SIML Insulation Medium Supervision
- CCGR Cooling Group Control
- MMXU Electrical Measurement
- ZBSH Bushing
- SPDC Partial Discharge Monitoring
- YLTC Tap Changer
- SLTC Tap Changer Supervision

Figure 3 - Illustration of IEC 61850 power transformer information model.

While an APM solution can deliver valuable insights, value can only be obtained if the action and validation cycle is completed (figure 4).

Figure 4 - Asset management actionable loop (based on ISO 55000, IDC).



The repeating workflow of risk identification, action prioritization and execution becomes even more relevant as the information/analytical flow becomes digital. This means that some level of change is required when introducing APM in the organization, making change management also a key part of implementing a successful APM solution. This commonly means revisiting roles, processes, responsibilities as well as people and skills management

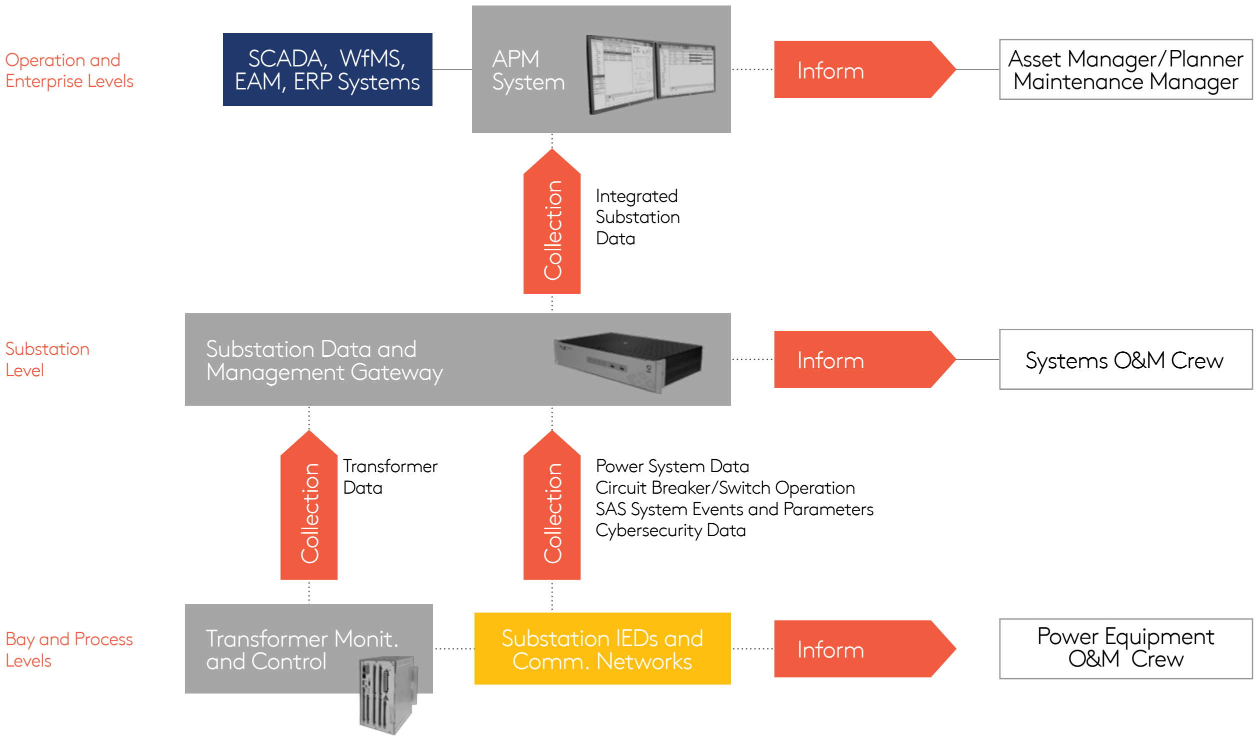
Implementing asset health solutions should therefore be considered a strategic initiative, designed for a specific business case. Successful organizations frequently start small to leverage quick wins, monitoring critical assets or integrating existing siloed data and providing specialized dashboards, building the business case as APM maturity evolves. Incremental approaches with phased implementation, assessment and optimization loops geared to deliver step by step value are commonly preferred as global RCM initiatives may require large budgets and extend in time before actual benefits are capitalized. Establishing an adequate expert partner ecosystem is also key as the market offering is evolving to include not only maintenance providers, but asset specialists, software and equipment vendors with conventional or cloud offering, providers of digital services and others.

There is no one-fits-all technical solution, the best solution depends on the company strategy, structure, partners and asset base, and is both a technical as well as a managerial process.

3. Solutions and Technical Architectures

APM solutions may be deployed with different architectures with different combinations of local dedicated sensors and monitoring devices, substation integrated data collection and central software. Options for cloud based-hosting or on-premises with use of both private or public communication infrastructures may also be considered. In figure 5 a global architecture for substation-integrated T&D APM is presented.

Figure 5 - Global architecture for substation-integrated APM



3.1.
Local Monitoring for Power Transformers

Local transformer monitoring (figure 6) and control solutions enable power transformers to be fully digitized, combining sensor aggregation, asset health assessment and logging with optimized cooling control to deliver local asset intelligence. With minimum configuration and tailored web-based HMI, maintenance teams profit from concise access to transformer condition, both locally or remotely. Current solutions enable multiple deployment options such as standalone, cloud-connected, Substation-connected or substation system-integrated. Connectivity options should include integration with remote APM systems through open communication protocols such as IEC 61850.

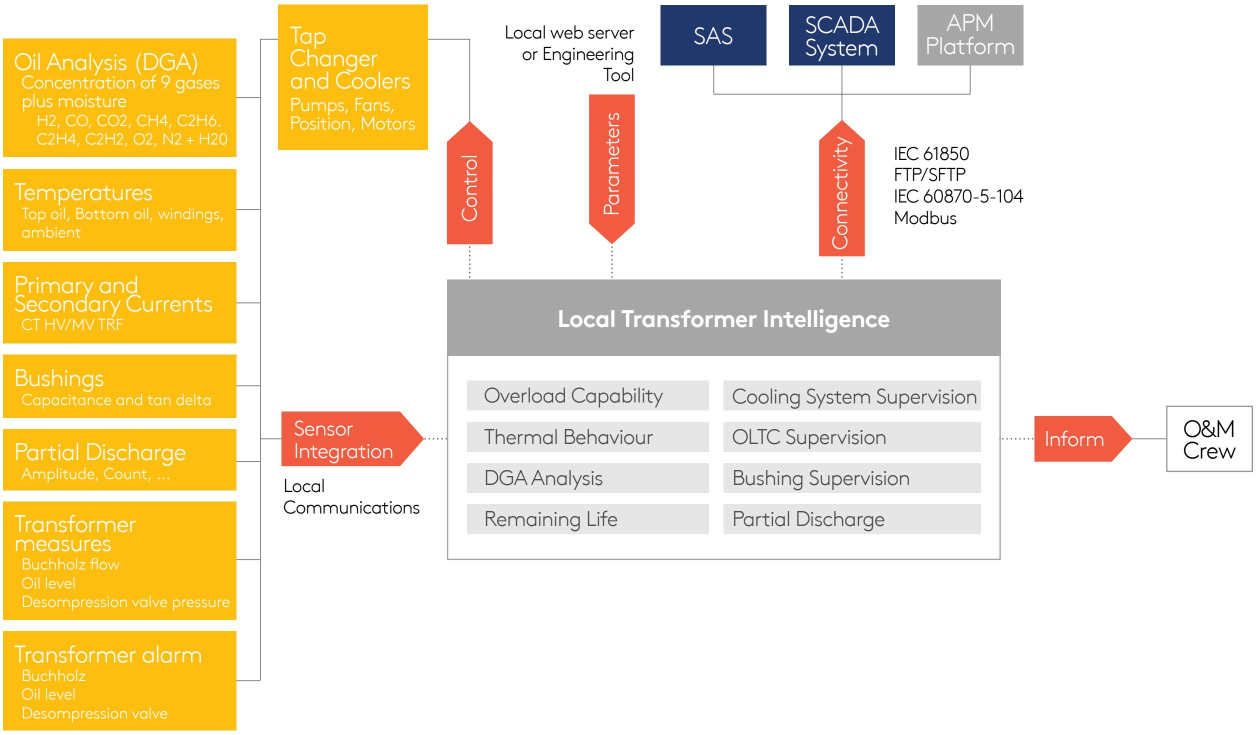


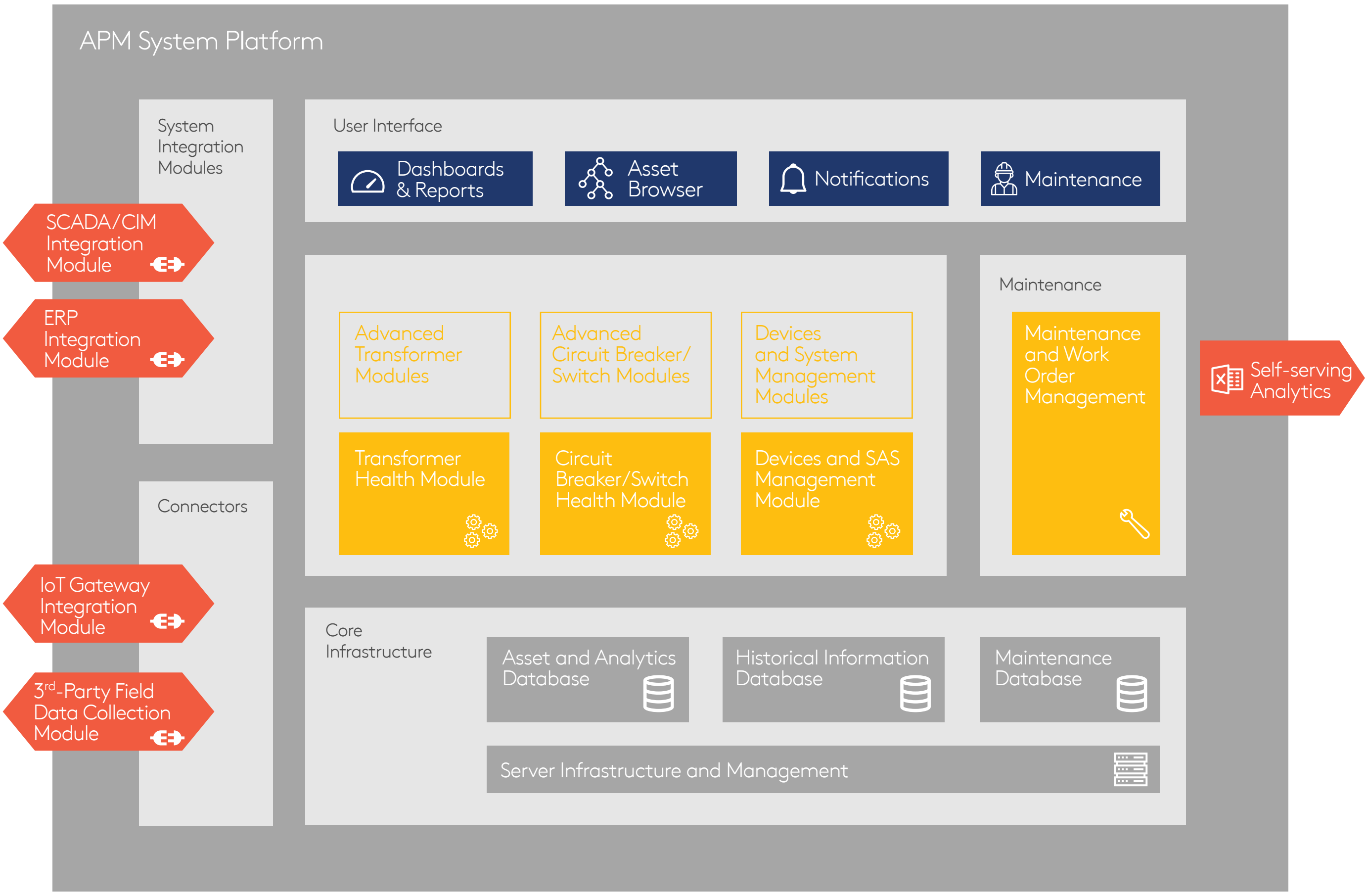
Figure 6 - Local transformer management.

Local functions may include hot spot calculation, overload capability, remaining of life, DGA interpretation, bushing supervision, OLTC and cooling system supervision and control, PD recording, statistics, trending and alarming.

3.2.
Software and Analytics

APM software platforms can be deployed on premises, on cloud or in mixed mode, depending on user requirements (see figure 7 for an overview of key platform components). It is fundamental that APM solutions provide solid data management features including data quality as well as versioned condition, maintenance and asset history and life-cycle data. APM software platforms should include options for self-serving analytics or similar data extraction and analysis tools to harness the power of their data lake capability, giving users flexibility to deliver specific analysis not foreseen in their core applications. Standards-compliant web-based user interface to provide support for any client platform and user mobility are also some of the key requirements.

Figure 7 - Overview of key APM software platform archtecture components.



4. Conclusions

Asset Performance management solutions are emerging to deliver new value to T&D Asset Management, by optimizing asset utilization and reducing maintenance costs. Automating routine activities, optimizing actionable information flow, reducing downtime, minimizing risk of failure or optimizing investment planning are examples of vectors that allow asset owners to lower CAPEX expenditure as well as working capital. Moreover, APM can provide grid operation with controlled overloading options and enable dynamic ratings, effectively improving overall network usage.

5. References

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Rogério Paulo is currently heading the Protection, Automation and Control Division within Efacec and has a background on Strategic Marketing, Product Management and R&D in different projects related to Power Systems Automation and Digital Grids. Has an MsC on Industrial Informatics and BsC on Industrial Electronics and has authored more than 40 peer reviewed papers, articles and reports. He is involved in international standardization activities, being currently an active member of IEC TC57 WG 10 and CIGRE B5.

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About Efacec

Efacec is a T&D asset expert with decades of experience combining technology, engineering, manufacturing and service and also a systems expert capable of delivering best in class solutions to our customers around the world. Efacec is fully committed to the digitalization of the industry and is also renowned for its capabilities as a software expert and an IT/OT integration specialist through decades of activity. Our unique value originates in our ability to combine product portfolio, know-how and capabilities of multiple competence centres and partners.

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