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A2.D4.1 Selection of scenarios where to apply long-term AIP digital tools for strategic management. Milestone 1_Conceptualization. [M12]

"Asset MAnagement in the new Digital Twins environment" (AMADIT)

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1. INTRODUCTION

Strategic asset management has evolved significantly in recent years with the introduction of advanced digital tools. Among these, **Asset Investment Planning (AIP)** tools have emerged as key solutions for informed decision making in asset lifecycle management. This paper presents a state of the art on the selection of scenarios where to apply AIP tools for strategic management, within the framework of **Conceptualization (Milestone 1) [M12]**.

This analysis addresses the definition of AIP, criteria for selecting appropriate scenarios, use cases in various industries and future trends. The information gathered is based on academic literature, case studies and relevant industrial experiences.

2. CONCEPTUALIZATION OF AIP TOOLS

2.1 Definition and evolution of AIP

The AIP tools allow the planning of medium- and long-term investments in assets, optimizing the use of financial resources, minimizing risks and ensuring operational sustainability.

2.2 Differences between AIP, EAM and APM

Nowadays companies are complementing Enterprise Asset Management (EAM) or Computer Aided Maintenance Management Systems (CMMS) with different solutions/Apps to gain more capabilities in the management areas mentioned in the previous Section. Gartner [1] distinguishes between three different types of asset management systems on the market: EAM, APM ("Asset Performance Management") and AIP ("Asset Investment Planning") solutions.

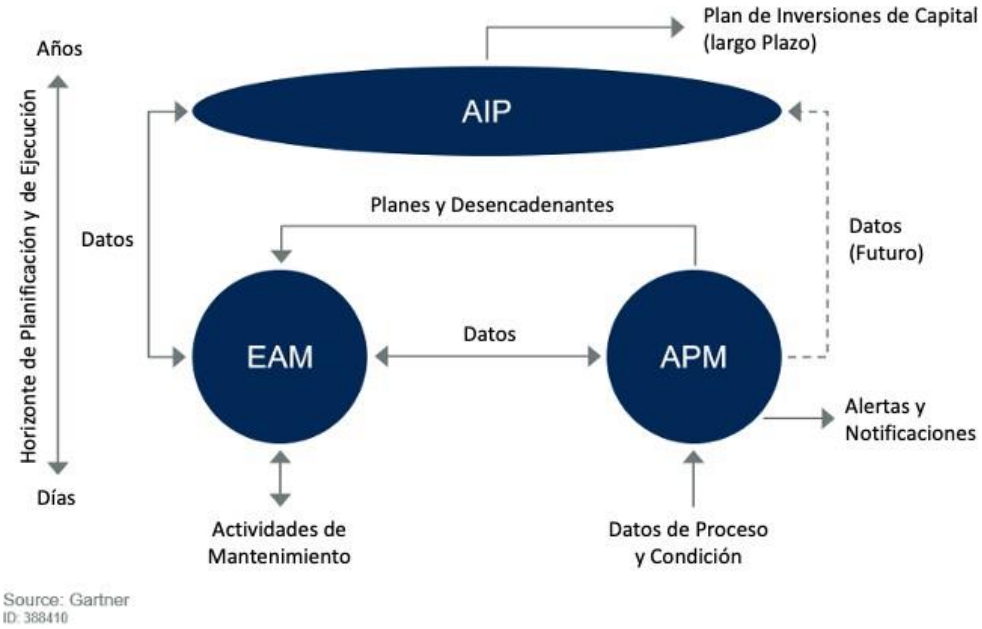

Figure 1. Data flow in advanced asset management systems [1].

APM and AIP benefit from connectivity and digital technologies, often share the same data and use similar predictive analytics, but with different objectives:

- Investments in EAM systems are made to manage asset inventory, configuration and maintenance execution.

- Organizations are willing to invest in APM tools and technologies to reduce corrective maintenance, increase availability and reduce the risk of failure (especially when assets are critical). In addition, APM tools can increase an organization's ability to comply with regulations/regulations related to asset inspections and maintenance. Data capture, analysis, and visualization enable these tools to improve operations and maintenance timelines, as well as identify what maintenance and inspection activities should be performed on assets [1]. The APM market has existed for more than a decade, but the vendor community has recently doubled its investment in R&D [1], which is driving growth rates. The increasing maturity of communications infrastructure in industrial sites is supporting greater adoption of APMs, as well as a wave of CEOs who have launched digital transformation strategies.
- Investments in AIP-type software are made to improve complex long-term tactical and strategic decisions related to CAPEX/OPEX budget allocations and overall asset management planning [2]. AIP tools predict current and future asset performance and link that expected performance to different investment options over a predefined medium to long-term horizon. Investment planning in asset- and process-intensive industries is now more important than ever. The economic downturn has exacerbated this situation, and executives are constantly relying on AIP software to improve these decision-making processes.

We should not confuse APM with AIP; APM is designed to support the safe, reliable and efficient operation of equipment and infrastructure, while AIP is designed to support short- and long-term capital investment decisions. See Verdantix's view of the three types of systems in Figure 2 [2].

Figure 2. Verdantix vision of EAM, APM and AIP software solutions [2].

Some EAM vendors have an APM product strategy, but most rely on partnerships with APM vendors. It seems clear that sales of APM Apps may depend on their compatibility with the existing EAM system.

AIP is most commonly used by local governments and regulated utilities, such as power, oil and gas, but is also increasingly used in other sectors, such as water, transportation facilities and telecommunications, and is of growing interest to the manufacturing and healthcare sectors.

Interestingly, market researchers have found very little overlap between APM and AIP solution providers (see [2] and [3]).

2.3 Main AIP solutions on the market

Examples of AIP solutions include platforms such as **Copperleaf or Cosmo Tech**, which offer advanced analytics and decision modeling capabilities for asset investment optimization (Verdantix.com):

- Copperleaf Decision Analytics: Copperleaf offers one of the most advanced AIP solutions in the market, based on predictive analytics and decision optimization. Its platform allows prioritizing investments in assets considering financial criteria, risks and expected benefits. Companies in sectors such as energy, transportation and utilities use Copperleaf to maximize the value of their assets over time.
- Cosmo Tech offers an advanced AIP solution that relies on digital twin simulations to help companies optimize asset investment planning over time. Its hybrid approach combines data-driven models with advanced simulation techniques to deliver more accurate and adaptive predictive analytics for different scenarios.

Other emerging solutions include platforms developed by companies such as Oracle or Bentley Systems, which offer advanced modeling and optimization capabilities for investment decision making.

3. CRITERIA FOR THE SELECTION OF AIP APPLICATION SCENARIOS

In determining where to apply AIP tools, several key factors are considered:

3.1 Strategic Factors in Asset Management

- Criticality of assets in the value chain.
- Financial and operational impact of investment decisions.
- Digital maturity level of the organization.

3.2 Criticality, asset health and life cycle approaches

- **Asset Health Index (AHI)** models to assess asset health.
- Life Cycle Cost Analysis (**LCC**).
- Evaluation of the impact of life extension strategies.

4. AIP USE CASES AND APPLICATIONS

4.1 Key industry sectors

The sectors with the greatest potential for the application of AIP include:

Infrastructure and transportation: Planning investments in rail, road and airport networks is critical to ensure transportation safety, efficiency and sustainability. AIP tools can be used to assess the current state of critical infrastructure and prioritize investments based on factors such as wear and tear, capacity, demand and associated risks.

- **Railroads:** Decisions on track maintenance and renewal, new train procurement and station modernization can be optimized using predictive models based on asset condition and future demand.
- **Roads:** Planning models that evaluate pavement life, maintenance frequency and budget optimization can be applied to avoid cost overruns on major repairs.
- **Airports:** Airport infrastructure investment planning ranges from terminal modernization to runway and navigation system expansion, ensuring the necessary capacity for air traffic growth.

Energy and utilities: The energy sector requires advanced AIP tools to assess key assets in power grids, generation plants and gas distribution systems.

- **Electrical networks:** Planning investments in electrical infrastructure involves optimizing the maintenance of transformers, transmission lines and substations to improve supply reliability and reduce unexpected failures.
- **Generation plants:** Predictive models are applied to decide when to renew turbines, boilers or solar panels, ensuring efficient and sustainable energy production.
- **Gas distribution:** Priority is given to investments in pipeline infrastructure and compressor stations, minimizing the risk of leaks and improving distribution safety.

Manufacturing: In the manufacturing sector, strategic investment planning is crucial to ensure competitiveness and optimize the use of resources.

- **Production lines:** AIP tools help identify when critical machinery needs to be upgraded or replaced, avoiding production interruptions and maximizing operational efficiency.
- **Industrial automation:** Investments in robots and advanced control systems can be planned to reduce operating costs and increase product quality.
- **Maintenance strategies:** Strategies such as predictive maintenance and the implementation of IoT sensors are evaluated to improve equipment reliability and availability.

4.2 Examples of successful implementation

- **Case 1: Power Grid - Using AIP to optimize critical transformer replacement:** Power transmission and distribution companies face significant challenges in managing their transformers, as these assets have a limited lifetime, and their failure can lead to critical power outages. A power grid company implemented an AIP solution to optimize critical transformer replacement planning. Using **predictive modeling**, the tool evaluated the current condition of the transformers based on historical failure data, operating load, environmental conditions, and dielectric oil analysis. Thanks to the AIP solution, the company was able to:

  - **Prioritize replacements** based on the health of the asset and its impact on the power grid.
  - **Optimize the investment budget**, avoiding unnecessary expenses in transformers that were still in optimal conditions.

  - **Reduce the risk of unexpected failures**, ensuring better continuity of power supply.
  - **Improve coordination with suppliers and maintenance teams**, reducing downtime.

- **Case 2: Gas Infrastructure**: **Maintenance planning and investment in gas transmission networks.** Gas transmission networks are strategic infrastructures that require efficient management to ensure a safe and continuous supply. Gas pipelines have a long service life, but are subject to corrosion phenomena, degradation due to use and fluctuations in energy demand. In this context, a gas transmission company faced difficulties in defining **when and where to invest in network maintenance and renewal**, since budgets are limited and must be prioritized appropriately.

4.3 Quantifiable benefits and lessons learned

- Reduction of operating and capital costs.
- Better alignment between investment strategies and business objectives.
- Greater predictability and risk reduction in capital decisions.

5. TRENDS AND CHALLENGES IN THE APPLICATION OF AIP

5.1 Advances in predictive modeling and decision analysis

- Use of artificial intelligence and machine learning.
- Advanced simulations with **Digital Twins**.
- Real-time IoT data integration for improved decision modeling.

5.2 Obstacles to adoption and digital maturity

- Resistance to organizational change.
- Data quality and availability.
- Implementation costs and scalability.

5.3 Future prospects

- Expansion of AIP as a cloud service.
- Possible use of blockchain to improve transparency in asset management.
- Increased automation of decisions through AI.

6. CONCLUSIONS AND RECOMMENDATIONS

This paper has reviewed the state of the art in the application of AIP tools in strategic asset management. It has been identified that the selection of suitable scenarios depends on the criticality of the assets, their life cycle and the ability to integrate with digital systems.

For an effective implementation of AIP, it is recommended:

1. Adopt an approach based on **criticality and asset health criteria**.
2. Integrate AIP with **EAM, APM and Digital Twins** platforms.
3. Prioritize data quality to improve decision making.

4. Overcome organizational barriers with change and training programs.

The future of AIP is heading towards increased automation, AI integration and cloud deployment, which will optimize strategic decisions in asset management.

7. REFERENCES

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