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**Startups using Artificial Intelligence for Project Portfolio Management**

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"Quando la tempesta sarà finita, probabilmente non saprai neanche tu come hai fatto ad attraversarla e a uscirne vivo. Anzi, non sarai neanche sicuro se sia finita per davvero. Ma su un punto non c'è dubbio. Ed è che tu, uscito da quel vento, non sarai lo stesso che vi è entrato".

(Murakami, Kafka sulla spiaggia)



# **Index**

## Acknowledgements

### 1. BTO Research

1.1. An overview

1.2. Company methods

1.3. Provided services

### 2. Literature review

#### 2.1. Project Management

2.1.1. What is Project Management

2.1.2. Main Project Management steps

#### 2.2. Project Portfolio Management

2.2.1. What is a portfolio?

2.2.2. What is Project Portfolio Management?

2.2.3. Project Portfolio Management processes

### 3. Artificial Intelligence

3.1. Artificial Intelligence basics

3.2. Artificial Intelligence for Project Portfolio Management

### 4. Artificial Intelligence powered Startups for Project Portfolio Management

4.1 ClickUp

4.2 Aitheon

4.3 Copy.ai

4.4 Airfocus

4.5 Moveworks

4.6 Rozes

Conclusions

References

1. Sitography
2. Figures



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*per aspera ad astra,*

*Paola*



## **Abstract**

This thesis aims to provide a comprehensive analysis of the intersection of project portfolio management with artificial intelligence and machine learning.

The document is divided into four chapters, each focusing on a different aspect of the topic. The first chapter provides an introduction to the company for which the document is intended, including a brief overview of its services and mission. The second chapter presents project management basics and outlines the steps for effective project portfolio management. In the third chapter, the basics of artificial intelligence and machine learning are explored, with a focus on their applications for project portfolio management. The final chapter analyzes the startups that utilize AI for project portfolio management, examining the benefits and limitations of these emerging technologies.

The document aims to offer valuable insights and guidance for anyone seeking to enhance their project portfolio management practices.

# 1. BTO Research

## 1.1. An overview

BTO Research S.p.A. is an Italian research company with headquarters in Milan. The acronym stands for Business, Technology and Organization, and the company specializes in providing consulting and research services in a variety of industries, including technology, business, telecommunications, consumer goods, market analysis, and many more.



Figure 1: BTO Research logo

The company focuses mainly on assisting Italian organizations in locating and seizing new technological opportunities, but it also serves clients from other countries in Europe, including Austria, Germany, and Luxemburg. They offer expertise and insights to help clients make informed decisions and improve their performance in their particular markets. The organization's beginnings can be found some years ago, when a group of seasoned researchers and analysts came together with the intention of creating a business that would promote organizational growth.

The founding group recognized the demand for excellent research and analytical services that would provide clients with reliable and practical information to aid in business decisions. They set out to create a company that would meet this demand using their extensive experience and in-depth knowledge of many different enterprises and industries.

With time and development, BTO Research has become known as a reliable and trustworthy partner in research and analysis. The company has a history of offering clients in numerous industries high-quality services that facilitate goal formulation, project management, and decision-making. As new experts join the company and add their expertise and knowledge, the organization's team of specialists continues to grow. The business is still dedicated to giving customers excellent services as well as the information and support they need to succeed in their industries.

Today, BTO Research S.p.A. is a recognized and well-established research and analysis organization that provides clients in various industries with a range of services; the company is committed to helping clients achieve their goals while continuing to aim for excellence.

## **1.2. Company methods**

The methodology employed by BTO Research includes the following steps: defining the issue or opportunity, obtaining and analyzing data, creating solutions, and finally implementing the solution and evaluating the results.

One method used by BTO for research and strategy development is market research. This requires gathering and analyzing information on technological trends, market developments, and competitor activities in order to identify new technology potential. The business also engages in technology research, which comprises assessing the potential commercial impacts and capabilities of various technologies. BTO Research uses this data to help clients understand the potential effects of new technologies on their businesses and to help them develop plans to seize these opportunities. The company uses a range of research methods, including primary and secondary research, to gather data and insights. Reports that are comprehensive, accurate, and easy to understand are produced as a consequence of the analysis and synthesis of this data. BTO Research produces studies that are useful to clients and equips them with the information they need to keep one step ahead of the competition and make informed decisions.

BTO Research often begins by evaluating the client's present IT management practices and procedures when providing IT management and governance consultancy. This assessment may involve data analysis, process mapping, and interviews with significant stakeholders to identify areas for improvement. Based on the results of the evaluation, BTO Research develops an improvement strategy for IT management and governance. This plan might entail changing the organizational structure, improving the processes, or implementing IT management frameworks like COBIT or ITIL. Particularly the ITIL framework, which offers a number of best practices like incident management, problem management, change management, and service level management, is widely used in IT service management. The company helps clients increase the effectiveness and quality of their IT services by identifying areas where ITIL best practices can be applied and developing plans to put those best practices into action.

BTO Research frequently starts by identifying the client's business goals and objectives when offering consulting services for digital transformation before looking for potential applications of digital technology to aid in achieving those goals. After identifying these areas, BTO Research collaborates with clients to develop a digital transformation strategy that specifies a timetable for implementing new methods and technologies. This could involve establishing the project's parameters, figuring out the resources needed, and developing a change management plan. BTO Research also helps clients identify and minimize any risks connected to the digital shift.

Finally, the methodology used by BTO Research is mainly based on data gathering, analysis, and research. They use a variety of research techniques, such as surveys, interviews, case studies, and literature reviews, to gather data and insights. They also employ a variety of analytical techniques, including process mapping, data visualization, and statistical analysis, to assess data and produce recommendations. This tactic enables the business to provide clients with thoroughly researched, useful solutions that are backed by statistics and industry best practices.

### 1.3. Provided services

A variety of services are offered by the company, including assistance with product creation, competition analysis, market research, and market intelligence. These services will help clients make better decisions and perform better in their particular sectors. In addition to business, telecommunications, consumer goods, and technology, they also support other sectors. BTO Research's expert consultants and researchers work closely with clients to understand their individual needs and provide solutions that are tailored to help them succeed. These services include:

- *Market Intelligence:* to help clients understand their target market, including market trends, consumer behaviors, and the competitive landscape, the company offers market intelligence services. This data is used to guide company strategies in order to gain a competitive edge.
- *Competitor Analysis:* in order to help customers better understand their competitors, including their benefits and drawbacks, market share, and business methods, BTO Research offers competition analysis services. Both making data-driven decisions and guiding business strategies make use of this knowledge.
- *Customer Insights:* with the help of BTO Research's consumer insights services, clients may acquire a full understanding of the needs, actions, and preferences of their customers. This data is used to develop new products, improve customer satisfaction, and boost sales.
- *Data Analysis:* the company offers data analysis services to help clients make sense of complex data and use it to inform their business decisions. This includes statistical analysis, data interpretation, and data visualization.
- *Strategic Planning:* in order to develop and carry out strategic plans that are in line with clients' research goals, BTO Research works with them in a collaborative manner. This includes formulating plans for new product development, market entry, and business expansion.
- *Training and Consultation:* the organization provides training and advisory services to help clients understand and use the study's findings to inform their

business decisions. This covers lectures, courses, and individual consultations with competent counselors.

Research and strategy creation are some of BTO Research's main offerings. This service aids businesses in locating new technological opportunities and formulating plans to take advantage of them. In order to help businesses comprehend the possible effects of new technologies on their operations, the firm undertakes research on a wide range of technology areas, including artificial intelligence, blockchain technology, and the internet of things. Additionally, they assist businesses in creating technological roadmaps and strategies to direct their acquisition and use of new technologies. Likewise, consulting for IT management and governance helps firms make their IT management processes more effective. The company's professionals help firms assess their current IT management practices, spot areas for improvement, and build and carry out plans to improve IT management and governance. This solution may prove to be quite beneficial for businesses who have trouble effectively managing and overseeing their IT operations.

Consulting for digital transformation is yet another crucial service offered by the company. This service helps companies develop and implement digital transformation strategies. Before helping them develop and implement adoption plans, the company's experts engage with organizations to identify areas where digital technologies could enhance productivity and competitiveness. This service will be especially useful for businesses looking to take advantage of the many opportunities provided by digital technologies.



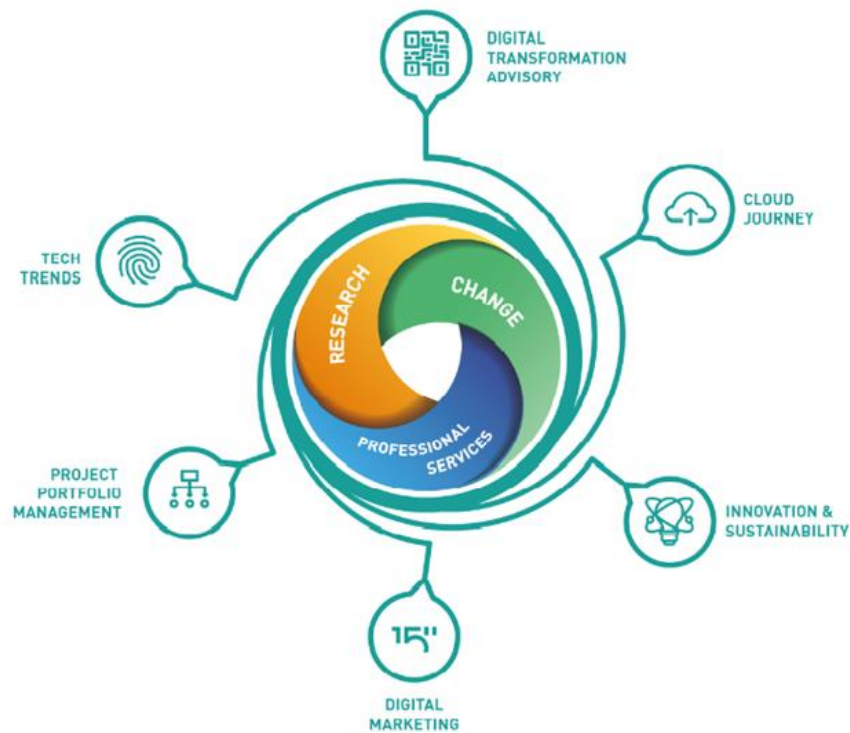


Figure 2: BTO services

BTO Research S.p.A. stands apart from other research and analysis organizations due to the extensive range of services they provide. The company has a history of offering top-notch research and analytical services to clients in a range of industries, helping them to make decisions, manage research projects, and accomplish their goals. The company's team of experts is highly knowledgeable and skilled, and they have a solid grasp of a variety of fields and sectors. By applying the most modern tools and techniques, they provide clients with accurate, reliable, and helpful information. The business' commitment to offering excellent services has helped them build a reputation as a reliable and trustworthy partner for research and analysis. Clients appreciate their attention to detail, ability to provide outcomes on time, and dedication to meeting client goals. These services support clients' decision-making, research project management, and goal setting in addition to project management services. BTO Research S.p.A. is dedicated to providing customers with the information and support they need to be successful in their industries.

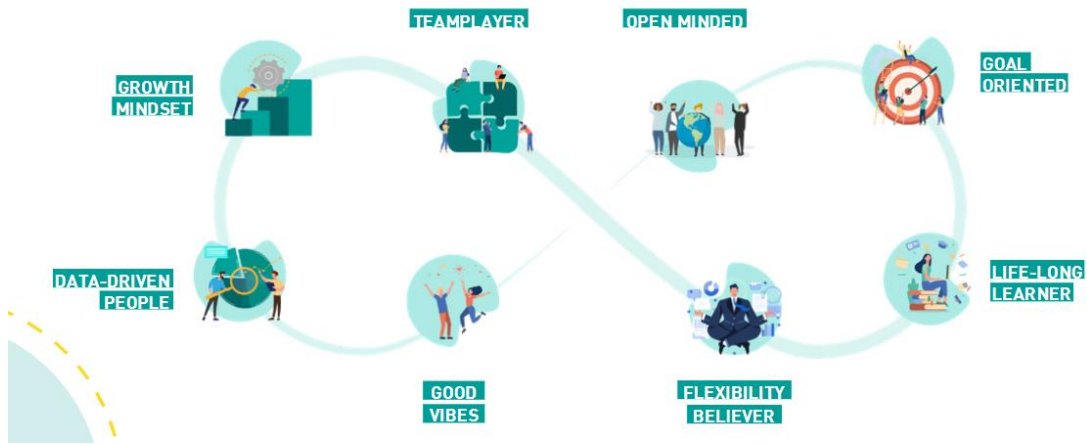


Figure 3: BTO manifesto

In conclusion, BTO Research S.p.A. is an expert research and analysis firm that provides a range of services to help clients succeed in their particular industries. The organization distinguishes itself as a reliable and trustworthy partner because to their commitment to provide top-notch services and their team of specialists.

## 2. Literature review

### 2.1. Project Management

*"First, have a definite, clear practical ideal; a goal, an objective. Second, have the necessary means to achieve your ends; wisdom, money, materials, and methods. Third, adjust all your means to that end."*

Aristotle

#### 2.1.1. What is Project Management?

Project management is the practice of initiating, planning, executing, controlling, and closing the work of a team to achieve specific goals and meet specific success criteria within a specified time. The primary challenge of project management is to achieve all of the project goals within the given constraints, including scope, time, quality, and budget. Project management is often associated with fields such as engineering, construction, and information technology, but it can be used in any field where complex projects need to be completed.

The main steps involved in project management are:

- Project Initiation
- Project Planning
- Project Execution
- Project Monitoring and Control
- Project Closure

These steps are often referred to as the project management life cycle, and they provide a structured approach to managing projects, ensuring that they are completed successfully within the given constraints. All the phases will be analyzed in further detail in the following section.

## 2.1.2. Main Project Management steps

**Project initiation** is the first stage of project management and involves the following formal steps:

- *Define the Project:* In this step, the project is defined, and the goals and objectives are identified. The project manager works with stakeholders to determine what needs to be achieved and why it is important.
- *Conduct a Feasibility Study:* Once the project has been defined, a feasibility study is conducted to determine whether the project is viable. This includes looking at factors such as the cost, available resources, and timeline for completion.
- *Establish the Project Team:* Once the project has been deemed viable, a project team is assembled. The team may include project managers, subject matter experts, and other key stakeholders.
- *Develop the Project Charter:* The project charter is a formal document that outlines the scope, objectives, and stakeholders of the project. It is an essential part of project initiation and provides a clear understanding of the project's goals and objectives.
- *Identify Risks and Constraints:* Risks and constraints are identified and documented in this step. This includes looking at potential obstacles that could affect the project's success and identifying potential solutions.
- *Obtain Approval:* Once all of the above steps have been completed, the project manager presents the project proposal to the stakeholders for approval. This includes presenting the project charter, feasibility study, and risk assessment.

The project initiation phase is critical to the success of the project as it sets the foundation for the project and ensures that everyone is on the same page before moving forward. By formally defining the project, assessing its feasibility, and establishing a project team, the project manager can ensure that the project has a strong start and is well-positioned to move on to the planning phase.

**Project planning** is the second stage of project management and involves the following formal steps:

- *Define the Scope:* The first step of project planning is to define the project scope. This involves identifying the specific tasks and deliverables that need to be completed, as well as any constraints that may impact the project.
- *Develop the Project Plan:* The project plan outlines the approach, timeline, budget, and resources required to complete the project successfully. The plan includes a project schedule that breaks down the work into specific tasks and identifies the dependencies between them. It also includes a budget that outlines the costs associated with each task, as well as the resources required to complete the work.
- *Develop a Risk Management Plan:* A risk management plan identifies potential risks to the project and outlines a plan for addressing them. The plan includes risk assessment, risk mitigation, and risk monitoring strategies to ensure that the project stays on track.
- *Identify Project Stakeholders:* Stakeholders are individuals or groups that have an interest in the project or can be impacted by its outcome. In this step, the project manager identifies all stakeholders and determines their level of involvement in the project.
- *Establish Communication Plan:* A communication plan outlines how project information will be shared with stakeholders. This includes the frequency, format, and type of information to be communicated.
- *Obtain Approval:* Once the project plan has been developed, it is presented to stakeholders for approval. This includes the project scope, timeline, budget, risk management plan, and communication plan.

The project planning phase is critical to the success of the project as it provides a roadmap for the project team to follow. By formally defining the project plan, the project manager can ensure that everyone understands what needs to be done, when it needs to be done, and how it will be accomplished. This helps to reduce confusion, minimize misunderstandings, and prevent delays or budget overruns.

**Project execution** is the third stage of project management and involves the following formal steps:

- *Assign Tasks*: In this step, the project manager assigns specific tasks to team members based on the project plan. Each task is accompanied by a set of instructions and a timeline for completion.
- *Monitor Progress*: The project manager monitors the progress of each task to ensure that it is being completed on time and to the required quality standards. This involves regular check-ins with team members to assess their progress and identify any issues.
- *Manage Risks*: The project manager is responsible for managing any risks that arise during the project execution phase. This includes implementing the risk management plan developed in the planning phase and taking appropriate action to address any new risks that arise.
- *Communicate Progress*: The project manager communicates project progress to stakeholders, including updates on task completion, budget spending, and any issues that arise. This helps to keep stakeholders informed and engaged in the project.
- *Manage Changes*: If changes to the project plan are required, the project manager must manage these changes carefully to minimize their impact on the project. This includes identifying the impact of the changes on the project timeline and budget, and obtaining approval from stakeholders.
- *Manage Quality*: The project manager is responsible for ensuring that the project is completed to the required quality standards. This involves monitoring the quality of each deliverable and taking appropriate action to address any issues that arise.

The project execution phase is where the majority of the work is done, and it is vital to the success of the project. By assigning tasks, monitoring progress, managing risks, communicating progress, managing changes, and managing quality, the project manager

can ensure that the project is completed on time, within budget, and to the required quality standards.

**Project monitoring and control** is the fourth stage of project management and involves the following formal steps:

- *Monitor Project Progress*: The project manager continues to monitor project progress during this phase. This involves tracking task completion, budget spending, and the quality of deliverables to ensure that the project remains on track.
- *Compare Actual Performance to Planned Performance*: The project manager compares the actual progress and budget spending to the planned progress and budget spending. This helps to identify any variances between the actual and planned performance, which can be used to adjust the project plan as needed.
- *Analyze Performance Data*: The project manager analyzes the performance data to identify the root causes of any variances that arise. This helps to identify any issues that need to be addressed to ensure that the project stays on track.
- *Take Corrective Action*: The project manager takes corrective action to address any variances that arise. This may involve adjusting the project plan, reassigning tasks, or implementing new risk management strategies to address new risks.
- *Report Project Progress*: The project manager reports project progress to stakeholders, including updates on progress, budget spending, and any issues that arise. This helps to keep stakeholders informed and engaged in the project.
- *Manage Changes*: The project manager manages any changes to the project plan carefully to minimize their impact on the project. This involves obtaining approval from stakeholders and adjusting the project plan as needed.

The project monitoring and control phase is essential to the success of the project as it helps to ensure that the project stays on track. By monitoring project progress, comparing actual performance to planned performance, analyzing performance data, taking corrective action, reporting project progress, and managing changes, the project manager

can ensure that the project is completed on time, within budget, and to the required quality standards.

**Project closure** is the fifth and final stage of project management and involves the following formal steps:

- *Deliver the Final Product or Service:* In this step, the project manager delivers the final product or service to the customer or end-user. This includes ensuring that the product or service meets the required quality standards and is delivered on time.
- *Conduct a Post-Project Review:* The project manager conducts a post-project review to evaluate the success of the project. This involves reviewing the project plan, performance data, and stakeholder feedback to identify areas for improvement and best practices that can be applied to future projects.
- *Close Out Contracts:* The project manager closes out any contracts that were entered into during the project. This includes ensuring that all payments have been made and that all contractual obligations have been fulfilled.
- *Document Lessons Learned:* The project manager documents lessons learned from the project. This includes capturing best practices, identifying areas for improvement, and documenting any issues that arose and how they were addressed.
- *Archive Project Documentation:* The project manager archives all project documentation, including the project plan, performance data, and stakeholder feedback. This ensures that the information is available for future reference and can be used to inform future projects.
- *Celebrate Success:* Finally, the project manager celebrates the success of the project with the team and stakeholders. This includes recognizing individual contributions, reflecting on the achievements of the project, and celebrating the successful delivery of the final product or service.

The project closure phase is crucial to the long-term success of the project and the organization. By delivering the final product or service, conducting a post-project review, closing out contracts, documenting lessons learned, archiving project documentation, and



celebrating success, the project manager can ensure that the project is successfully completed and that the organization can learn from the project to improve future project performance.

Overall, project management helps businesses to improve their project performance, achieve better results, and drive success. By applying project management principles and practices, businesses can improve their ability to plan, execute, and complete projects efficiently and effectively, leading to improved outcomes and increased competitiveness.

## **2.2. Project Portfolio Management**

### **2.2.1. What is a portfolio?**

The definition of a portfolio given by the Project Management Institute reads, "A portfolio is a collection of projects or programs and other work, which are grouped together to facilitate effective management of the work and to achieve strategic business objectives."

An organization may have more than one portfolio at the same time, each related to a business area or strategic objective. The components of a portfolio (projects, programs, other work) have some common characteristics:

- They represent investments made or planned by the organization,
- They are aligned with the organization's strategic goals,
- They usually have distinctive characteristics that allow them to be grouped together for effective management,
- They are quantifiable and consequently can be measured, ranked and prioritized.

Such projects and programs need not be interdependent or directly related.

### **2.2.2. What is Project Portfolio Management?**

Project Portfolio Management (PPM) is defined as, "Coordinated management of a portfolio of components to achieve specific objectives of the organization."

PPM includes the processes of identifying the organization's priorities, of making investment decisions and allocating resources to the different components of the portfolio. The PPM also ensures that the interrelationships between projects and programs and that resources are allocated in a manner concordant with the organization's priorities.

The purpose of the PPM is to ensure that the organization does "the right job" rather than doing "the job correctly."

The PPM aims to translate the organization's strategy into a portfolio of strategic and operational initiatives and to ensure their implementation through the deployment of organizational resources.

For PPM to be effective, it is critical that it be aligned with the organization's strategy; only in this way it is possible to correctly balance the use of resources, maximizing the value generated in strategy execution and operational activity.

The impact of PPM on strategy can be assessed by considering 5 aspects:

1. Maintaining portfolio alignment: each component of the portfolio must be associated with one or more strategic objectives.
2. Allocation of financial resources: the priority of each component guides the allocation of financial resources.
3. Allocation of human resources: the priority of the components guides the human resource planning, recruitment, and allocation of the resources in terms of time and skills.
4. Measurement of component contributions: since each component is associated with at least one objective it is necessary to measure quantitatively the contribution it makes to the realization of that objective.
5. Strategic risk management: for each component it is necessary to assess the risks and how they may impact the strategic objectives.

PPM requires the use of dedicated methods and techniques, such as:

- Project selection methods,
- Decision support tools and models (ROI, IRR, NPV, Etc.),
- Simulation techniques,
- Prioritization algorithms,
- Auditing techniques for projects and programs,
- Risk management techniques at the organizational and portfolio level.

These methods and techniques require to be adapted to the organization of reference, given the complexity of the projects and objectives the methods will be different from those commonly used by private companies.

Monitoring the PPM also requires establishing a set of metrics to assess the achievement of strategic objectives, financial contribution, stakeholder satisfaction, the profile of risk and use of resources. The metrics selected must agree with the organization's strategic objectives and aligned with other metrics used to assess performance within the organization.

These metrics measure quantitative or qualitative information by considering the different components of the portfolio in aggregate. Some examples of quantitative metrics outlined in the "Standard for Portfolio Management" are:

- Development of new markets and increase in customers,
- Increases in revenues,
- Cost reductions,
- Change in the Net Present Value (NPV) of the portfolio,
- Return On Investment (ROI) from the portfolio,
- Internal Rate of Return (IRR) from the portfolio,
- Degree of portfolio and business risk reduction,
- Availability of resources,
- Percentage of Cycle times reduction,
- Quality improvement.

Some qualitative metrics, on the other hand, are:

- Degree of alignment with strategic objectives,
- Compliance with laws and regulations.

### **2.2.3. Project Portfolio Management Processes**

PPM is a process that supports executive management in the achieving the goals that the organization has set for itself. The strategy of the organization and its goals therefore represent the main inputs of the process. Should the organization's strategy change, the portfolio will need to be adjusted immediately to reflect that change, in order to maintain alignment between portfolio and objectives.

This implies that the PPM process and the strategic planning process are closely related and therefore need constant coordination and information sharing.

Parallel to the strategy, representing an input to the PPM, are the criteria and performance evaluation metrics employed by the organization for the monitoring of objectives.

Another key input to the process is the availability of the resources (human, financial, assets). In fact, the balance of the portfolio must be achieved while always respecting resource availability constraints.

The final input necessary for the implementation of the PPM process is the organizational structure that makes it possible to define the division of authority and responsibilities over the different components of the portfolio. The PPM process is itself composed of a series of sub-processes related to each other. These processes are not the same for every organization, but depend on a number of factors: the industry they belong to, the strategy of the organization, availability of resources, skills held, etc.

The figure below shows the processes commonly carried out by organizations and the correlations between them.

These processes are divided into 2 macro-groups:

- Aligning process group, which are processes to establish the alignment of the portfolio components with the organization's strategy.
- Monitoring and controlling process group, processes designed to ensure that the portfolio is maintaining forecasts and is achieving the goals set.

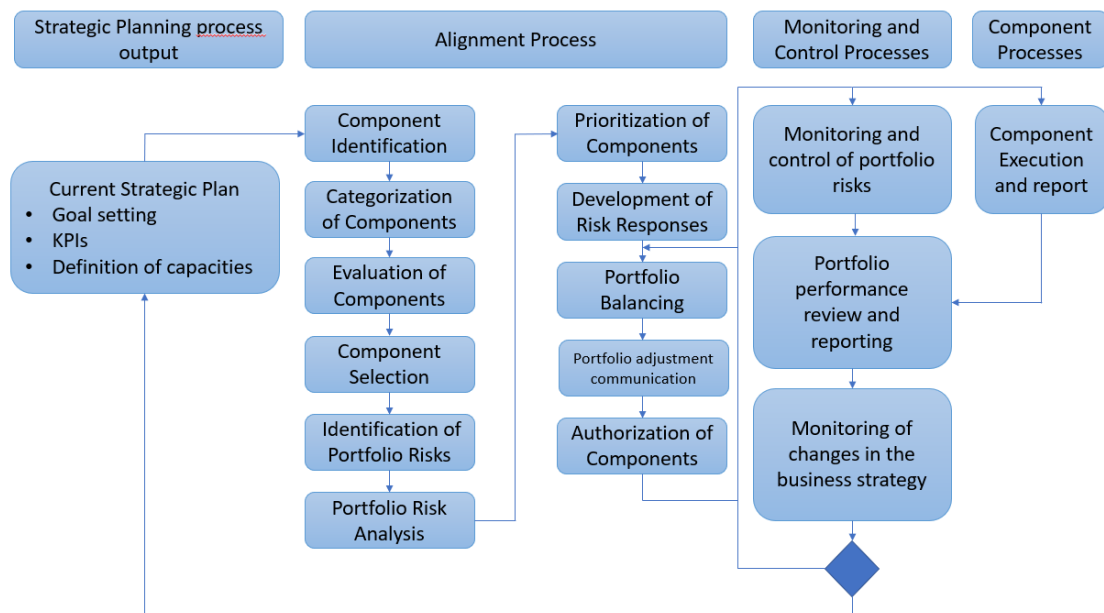


Figure 4: PPM processes

The following is a description of the 14 processes that make up the PPM:

1. *Component identification*: is the first step in project portfolio management, in which an organization identifies and defines the key components of its project portfolio. This step involves breaking down the portfolio into smaller, more manageable components, such as business units, project types, or market segments, in order to gain a better understanding of its structure and composition. The purpose of component identification is to assess the strengths and weaknesses of each component and to develop targeted strategies to improve overall portfolio

performance. By breaking the portfolio down into smaller components, the organization can more easily evaluate the performance of each component, identify any issues or challenges, and develop specific strategies to address them. In addition, component identification can help the organization to more effectively allocate resources and manage risk. By understanding the composition of the portfolio, the organization can better assess its resource needs and ensure that resources are allocated appropriately to support the most critical projects. It can also identify any potential areas of risk, such as overreliance on a single business unit or product line and take steps to mitigate those risks.

2. *Component categorization*: is the second step in project portfolio management, which involves categorizing the components identified in the first step based on specific criteria. This step is essential for prioritizing the components and making informed decisions on how to allocate resources and manage risks across the portfolio.

In component categorization, the organization defines a set of criteria for categorizing the components, such as revenue potential, strategic alignment, risk level, and resource requirements. The organization then evaluates each component against these criteria and places it into a category based on the results of the evaluation.

For example, a company may categorize its components into three categories: high-priority, medium-priority, and low-priority. The high-priority components are those that have the greatest potential to contribute to the organization's goals and strategy, require the most resources, and have the highest risk. Medium-priority components have lower potential impact, require fewer resources, and have moderate risk. Low-priority components have the least potential impact, require minimal resources, and have low risk.

By categorizing the components, the organization can more easily prioritize and manage its project portfolio. It can make informed decisions about how to allocate resources, such as budget and personnel, across the components based on their importance and risk level. It can also manage risk more effectively by focusing

on the high-priority components and developing contingency plans for those with higher risk levels.

Overall, component categorization is a crucial step in project portfolio management, providing a structured approach to prioritizing and managing the components of the portfolio. By categorizing the components based on specific criteria, the organization can make informed decisions about resource allocation and risk management, which can ultimately lead to more successful project outcomes and better overall portfolio performance.

3. *Component assessment*: is the third step in project portfolio management, which involves a more detailed evaluation of the components in the portfolio. This step is critical for identifying the strengths and weaknesses of each component, as well as the opportunities and threats that may impact the overall performance of the portfolio.

In component assessment, the organization analyzes each component based on a set of criteria that is relevant to the organization's goals and objectives. This may include factors such as market demand, profitability, strategic alignment, technical feasibility, and risk level. The organization uses this information to develop a more comprehensive understanding of the potential risks and benefits of each component. Once the components have been assessed, the organization can use the results to prioritize and allocate resources, as well as to develop strategies to address any weaknesses or threats. For example, the organization may decide to allocate more resources to components that have the highest potential for success or to develop contingency plans for components with a higher risk level.

Overall, component assessment is a crucial step in project portfolio management, providing a deeper understanding of the components in the portfolio and their potential impact on overall portfolio performance. By evaluating each component against a set of relevant criteria, the organization can make more informed decisions about resource allocation and risk management, which can ultimately lead to better project outcomes and improved overall portfolio performance.

4. *Component selection*: is the fourth step in project portfolio management, which involves choosing which components to include in the portfolio and determining their priority order. This step is critical for ensuring that the portfolio is aligned with the organization's goals and objectives and is feasible in terms of available resources.

In component selection, the organization considers the results of the previous steps, including component identification, categorization, and assessment, as well as any other relevant information, such as market trends, competitor activity, and regulatory changes. Based on this information, the organization decides which components to include in the portfolio and assigns each component a priority level.

The selection process may involve a range of factors, such as revenue potential, strategic alignment, resource requirements, and risk level. For example, the organization may choose to prioritize components that have the highest potential for revenue growth or that are aligned with the organization's long-term strategic goals. It may also consider the availability of resources, such as budget, personnel, and technology, when determining the priority order.

Once the components have been selected and prioritized, the organization can develop a more detailed project plan for each component, including timelines, budgets, and resource allocation. This plan will help ensure that each component is executed effectively and efficiently, with a clear focus on the organization's goals and objectives.

Overall, component selection is a critical step in project portfolio management, as it determines the focus and direction of the portfolio and sets the stage for successful execution. By selecting the right components and prioritizing them appropriately, the organization can ensure that its portfolio is aligned with its goals and objectives and is feasible in terms of available resources, which can lead to better project outcomes and improved overall portfolio performance.

5. *Portfolio risk identification*: is the fifth step in project portfolio management, which involves identifying potential risks and uncertainties that may impact the



portfolio's performance. This step is critical for ensuring that the organization is prepared to address potential risks and can make informed decisions about resource allocation and risk management.

In portfolio risk identification, the organization analyzes the potential risks and uncertainties associated with each component in the portfolio, as well as any risks that may be inherent in the overall portfolio strategy. This may include factors such as market volatility, changes in regulatory requirements, unexpected resource constraints, and shifts in customer demand.

The organization then evaluates each risk based on its potential impact on the portfolio and the likelihood of it occurring. It may use a variety of tools and techniques to assess the risks, such as risk matrices, scenario planning, and statistical analysis.

Once the risks have been identified and evaluated, the organization can develop strategies to address them. This may involve developing contingency plans for high-risk components, increasing the level of monitoring and oversight, or adjusting the portfolio strategy to minimize the potential impact of specific risks. Overall, portfolio risk identification is a critical step in project portfolio management, as it helps the organization identify potential risks and uncertainties that may impact the portfolio's performance. By proactively identifying and addressing these risks, the organization can reduce the likelihood of project failures, minimize the potential impact of unexpected events, and improve overall portfolio performance.

6. *Portfolio risk analysis*: is the sixth step in project portfolio management, which involves assessing the potential impact of identified risks on the portfolio's performance. This step is critical for making informed decisions about resource allocation and risk management and ensuring that the organization is prepared to address potential risks.

In portfolio risk analysis, the organization assesses each identified risk based on its potential impact on the portfolio's objectives and goals, as well as the likelihood of it occurring. This may involve evaluating the potential financial, operational,

and reputational impact of each risk, as well as its likelihood and frequency of occurrence.

The organization may use a variety of tools and techniques to analyze the identified risks, such as scenario planning, sensitivity analysis, and statistical modeling. These techniques can help the organization understand the potential impact of each risk, as well as the potential interdependencies between different risks.

Once the risks have been analyzed, the organization can develop strategies to address them. This may involve developing contingency plans for high-risk components, increasing the level of monitoring and oversight, or adjusting the portfolio strategy to minimize the potential impact of specific risks.

Overall, portfolio risk analysis is a critical step in project portfolio management, as it helps the organization assess the potential impact of identified risks on the portfolio's performance. By proactively analyzing and addressing these risks, the organization can reduce the likelihood of project failures, minimize the potential impact of unexpected events, and improve overall portfolio performance.

7. *Component prioritization*: is the seventh step in project portfolio management, which involves ranking the selected components in order of importance or priority. This step helps organizations focus on the most important projects and allocate resources accordingly.

To prioritize the components, the organization typically uses a set of criteria or evaluation factors, such as strategic alignment, potential benefits, risk levels, resource requirements, and feasibility. These factors are used to assess each component and assign a score or ranking to it.

For example, strategic alignment may be a key criterion for prioritization, as the organization may want to focus on projects that align with its overall business strategy. Similarly, potential benefits, risk levels, and resource requirements may also be important factors to consider when prioritizing components.

Once the components have been prioritized, the organization can allocate resources to the most important projects and ensure that they receive the necessary

support and attention. This may involve reallocating resources from lower-priority projects, adjusting project timelines or budgets, or revising the portfolio strategy to focus on higher-priority projects.

Overall, component prioritization is a critical step in project portfolio management, as it helps organizations focus on the most important projects and allocate resources effectively. By prioritizing the components based on their strategic alignment, potential benefits, risk levels, resource requirements, and feasibility, the organization can ensure that it is investing in the right projects and achieving its overall business goals.

8. *Development of responses to portfolio risks:* after identifying and analyzing the risks associated with the portfolio components, the organization needs to develop a plan to mitigate or manage these risks. The development of responses to portfolio risks involves assessing the potential impact of each risk on the portfolio and identifying strategies to address the risks. The response strategies may include risk avoidance, risk transfer, risk mitigation, or risk acceptance.

For example, if a particular component has a high risk of failure, the organization may choose to avoid the risk by removing the component from the portfolio altogether. Alternatively, the organization may choose to transfer the risk by partnering with a vendor or outsourcing the project to a third party. In some cases, the organization may choose to mitigate the risk by implementing risk management strategies, such as increasing project oversight or implementing contingency plans. The response strategies should be aligned with the organization's risk tolerance and overall business objectives. The organization should also consider the feasibility and cost-effectiveness of each response strategy.

Once the response strategies have been developed, the organization needs to monitor the risks and the effectiveness of the response strategies over time. This involves tracking the progress of each component, identifying any changes or new risks that arise, and making adjustments to the response strategies as needed.

Overall, the development of responses to portfolio risks is a critical step in project portfolio management, as it helps organizations identify and manage risks that could impact the success of the portfolio. By developing response strategies that are aligned with the organization's risk tolerance and overall business objectives, the organization can mitigate the impact of portfolio risks and increase the likelihood of portfolio success.

9. *Portfolio balancing*: after identifying and selecting the components for the portfolio, the organization needs to balance the portfolio in order to ensure that it aligns with the organization's overall strategy, risk tolerance, and resource constraints.

Portfolio balancing involves reviewing the selected components and assessing their impact on the portfolio as a whole. This includes analyzing the components based on their potential benefits, costs, and risks, as well as considering their impact on other components in the portfolio.

The goal of portfolio balancing is to create a portfolio that is diverse, balanced, and aligned with the organization's overall goals and objectives. This may involve adjusting the mix of components in the portfolio, reallocating resources, or identifying new components to add to the portfolio.

For example, if the portfolio is heavily weighted towards high-risk components, the organization may need to rebalance the portfolio by adding lower-risk components to provide a greater level of diversification. Alternatively, if the organization is facing resource constraints, it may need to reallocate resources from lower-priority components to higher-priority components.

Portfolio balancing also involves ongoing monitoring and analysis of the portfolio to ensure that it remains balanced and aligned with the organization's goals and objectives. This may involve periodic reviews of the portfolio, adjustments to the component mix, and continuous evaluation of portfolio performance.

Overall, portfolio balancing is a critical step in project portfolio management, as it helps organizations create a portfolio that is aligned with their overall strategy, risk tolerance, and resource constraints. By balancing the portfolio and monitoring

its performance over time, the organization can ensure that the portfolio remains relevant and provides maximum value to the organization.

10. *Communication of portfolio adjustments*: Once the portfolio has been balanced and the organization has identified the components that will be included in the portfolio, it's important to communicate any adjustments to stakeholders and team members.

Effective communication is essential to ensure that everyone involved in the project portfolio is aware of any changes, understands the reasons for the changes, and is able to adjust their plans and priorities accordingly.

The communication of portfolio adjustments involves keeping stakeholders informed of any changes to the portfolio, including changes to the component mix, resource allocation, timelines, and budget. This includes communicating the reasons for the changes, the expected impact of the changes, and the steps that will be taken to implement the changes.

In addition to communicating changes to stakeholders, it's also important to communicate any changes to team members who will be working on specific components of the portfolio. This may involve adjusting project plans, timelines, and resource allocation to ensure that teams are aligned with the new portfolio priorities.

Effective communication of portfolio adjustments requires a clear and concise communication plan that outlines the key messages, audiences, and channels for communication. This plan should be developed early in the portfolio management process and should be updated as needed to ensure that all stakeholders are informed and engaged throughout the project.

Overall, the communication of portfolio adjustments is a critical step in project portfolio management, as it helps to ensure that everyone involved in the project is informed and aligned with the organization's overall strategy and goals. By effectively communicating portfolio adjustments, organizations can minimize confusion, manage expectations, and ensure that the portfolio delivers maximum value to the organization.

11. *Component authorization*: Once the project components have been prioritized and the risks associated with each component have been analyzed, the next step is to obtain authorization for the selected components.

Component authorization involves obtaining approval from senior management or other decision-makers to proceed with the selected components. This approval is typically based on a detailed analysis of the component's potential benefits, risks, and costs, as well as an assessment of how the component fits within the organization's overall strategic objectives and goals.

To obtain component authorization, the project team must develop a comprehensive business case that outlines the expected benefits, costs, and risks of the component, as well as a detailed implementation plan that identifies the resources, timelines, and milestones required to successfully deliver the component. The business case should also include a detailed analysis of the potential impact of the component on the organization, including its alignment with the organization's overall strategy and goals.

Once the business case has been developed, it must be presented to senior management or other decision-makers for approval. This may involve preparing a formal presentation, meeting with key stakeholders, or providing a detailed written report that outlines the key findings and recommendations.

Component authorization is a critical step in project portfolio management, as it helps to ensure that the organization is fully committed to the selected components and has the resources and support necessary to successfully deliver them. By obtaining component authorization, the project team can move forward with confidence, knowing that the organization is fully aligned with the project goals and objectives.

12. *Portfolio risk monitoring and control*: This step involves ongoing monitoring and management of portfolio risks to ensure that the portfolio continues to align with the organization's overall strategy and objectives.

Portfolio risk monitoring and control typically involves a range of activities, including regular reviews of portfolio performance, ongoing risk assessments, and

the development and implementation of risk mitigation strategies as needed. The goal of these activities is to identify emerging risks or issues as early as possible and to take proactive measures to address them before they become major problems.

To effectively monitor and control portfolio risks, it is important to establish clear performance metrics and regularly review performance against these metrics. This may involve the use of dashboards or other tools that provide real-time data on portfolio performance, as well as regular meetings with key stakeholders to review progress and identify any emerging issues or concerns.

In addition, it is important to regularly review and update risk management plans to ensure that they continue to reflect the most current information and that they are aligned with the organization's overall strategy and objectives. This may involve updating risk registers, revising risk response strategies, or developing new risk mitigation plans as needed.

Portfolio risk monitoring and control is a crucial step in project portfolio management, as it helps to ensure that the portfolio remains aligned with the organization's strategic objectives and that risks are effectively managed and mitigated to minimize their impact on portfolio performance. By regularly monitoring and managing portfolio risks, organizations can achieve greater success in delivering their strategic initiatives and achieving their long-term goals.

13. *Review and report on portfolio performance*: this step involves the ongoing evaluation of the portfolio's performance against established metrics and goals, and the preparation and distribution of regular performance reports to key stakeholders.

The review and reporting process typically involves the collection and analysis of data related to portfolio performance, such as project completion rates, budget adherence, and other key performance indicators (KPIs). This data is then used to identify trends and areas for improvement, and to evaluate the overall effectiveness of the portfolio management approach.

Performance reports may be prepared on a regular basis, such as monthly or quarterly, and are typically distributed to key stakeholders, such as senior executives, project sponsors, and other relevant parties. These reports may include information on portfolio performance against established targets, progress toward key milestones, risk management activities, and other relevant information.

In addition to regular performance reporting, it is also important to conduct periodic portfolio reviews to evaluate the effectiveness of the portfolio management approach and identify areas for improvement. These reviews may be conducted annually or as needed and may involve a comprehensive assessment of the portfolio's strategic alignment, risk management practices, and overall performance.

Overall, the review and reporting step is a critical component of project portfolio management, as it helps to ensure that the portfolio is delivering on its intended outcomes and that performance is being tracked and evaluated in a meaningful way. By regularly reviewing and reporting on portfolio performance, organizations can make more informed decisions about resource allocation, risk management, and other key factors, and can ensure that their portfolio management approach is aligned with their overall strategic objectives.

14. *Monitoring changes in strategy*: this final step involves ongoing monitoring and assessment of the organization's overall strategic goals and objectives, as well as the portfolio of projects that support those goals.

To effectively monitor changes in strategy, organizations need to have a mechanism in place for regularly reviewing and updating the project portfolio. This may involve a formal review process that includes senior management, project managers, and other stakeholders, as well as ongoing monitoring of key performance indicators and other metrics that help to assess the effectiveness of the portfolio.

By monitoring changes in strategy, organizations can ensure that their project portfolios remain aligned with their overall objectives, and that they are able to



adapt to changing business conditions and market trends. This helps to ensure that the organization remains competitive and able to achieve its strategic objectives. In summary, monitoring changes in strategy is a critical final step in project portfolio management. By continuously assessing and adjusting the portfolio of projects, organizations can ensure that they are investing their resources in the most effective way possible and maximizing their potential for success.

In conclusion, project portfolio management plays a critical role in helping organizations achieve their strategic objectives by enabling them to make informed decisions on which projects to pursue and which to abandon. By applying the disciplined and structured approach seen hereabove to the management of project portfolios, organizations can ensure that the projects they undertake are aligned with their overall strategy. This not only helps to increase the likelihood of project success, but also enables organizations to achieve their long-term goals and remain competitive in a rapidly changing business environment.

## 3. Artificial Intelligence

*"The question of whether machines can think is like the question of whether submarines can swim."*

Alan Turing, 1950

### 3.1. Artificial Intelligence basics

Artificial intelligence (AI) is a field of computer science and engineering that focuses on creating machines and systems that can perform tasks that typically require human intelligence, such as learning, reasoning, problem-solving, and perception.

AI can be defined as the study and design of intelligent agents, where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of achieving its goals. This definition emphasizes the idea that AI is not just about creating systems that are capable of performing tasks, but also about creating systems that can learn from their experiences and adapt to new situations.

Machine learning, natural language processing, computer vision, robotics, and expert systems are just a few of the many subfields of AI. Each of these subfields focuses on a distinct area of AI, employing various methods and algorithms to accomplish its objectives.

There are different ways to categorize artificial intelligence (AI), but one common approach is to divide AI into four main types based on their capabilities and level of human-like behavior. These four types of AI are as follows:

- **Reactive AI:** is a type of artificial intelligence (AI) system that operates solely on the basis of pre-programmed rules or algorithms. Reactive AI systems do not have the ability to form memories or use past experiences to inform their decisions.

Instead, they are designed to react to specific situations in a predetermined way, based on the rules and algorithms that have been programmed into them.

Reactive AI systems are generally very fast and efficient at processing information and making decisions. They can be very useful in situations where quick and precise responses are needed, such as in chess-playing programs or image recognition systems. However, they have limitations when it comes to dealing with complex or unpredictable situations.

One major disadvantage of reactive AI systems is that they are unable to learn from new data or adjust their behavior based on feedback. This means that they can be vulnerable to errors or unexpected outcomes when faced with situations that are not covered by their pre-programmed rules. For example, a reactive AI system that has been programmed to identify cats in images might struggle to recognize a new type of cat that it has not encountered before. Another limitation of reactive AI is that it does not have the ability to plan or make predictions about future events. Reactive AI systems are designed to react to specific situations in the present moment, but they cannot anticipate or plan for future events based on past experiences.

In essence, reactive AI is a useful type of AI for certain applications, particularly those that require fast and precise responses to specific situations. However, it has limitations when it comes to dealing with complex or unpredictable situations, and it does not have the ability to learn from new data or adjust its behavior based on feedback.

- **Limited Memory AI:** is a type of artificial intelligence (AI) system that is designed to use past experiences to inform its decisions, but it does not have the ability to learn from new data. Unlike Reactive AI systems that operate solely on pre-programmed rules, Limited Memory AI can access past data to make predictions or recommendations.

Limited Memory AI systems are often used in applications that require pattern recognition or prediction. For example, a spam filter might use limited memory AI to analyze past email messages to identify patterns of spam behavior. A fraud

detection system might use limited memory AI to analyze past transactions and identify patterns of fraudulent behavior.

Limited Memory AI systems work by storing past data and using it to make predictions or recommendations based on the current input. However, they do not have the ability to learn from new data or adjust their behavior based on feedback. This means that they are limited in their ability to adapt to changing circumstances or to learn from their mistakes.

One advantage of Limited Memory AI is that it can be very efficient at processing large amounts of data and making predictions or recommendations based on that data. It can also be very effective at identifying patterns or trends in the data that might not be immediately obvious to a human observer.

To sum up, Limited Memory AI is a useful type of AI for certain applications, particularly those that require pattern recognition or prediction based on past data. However, it has limitations when it comes to adapting to new circumstances or learning from feedback, and it may not be suitable for applications that require more advanced decision-making capabilities.

- **Theory of Mind AI:** is a type of artificial intelligence (AI) system that is designed to understand the mental states and intentions of other entities, such as humans or other AI systems. It can use this understanding to predict the behavior of others and adjust its own behavior accordingly.

The concept of Theory of Mind refers to the ability of humans to understand and attribute mental states to other individuals. For example, we can infer whether someone is happy, sad, or angry based on their facial expressions and other nonverbal cues. Theory of Mind AI systems are designed to emulate this ability in order to interact more effectively with humans and other AI systems.

Theory of Mind AI systems can be used in a variety of applications, such as personal assistants, social robots, and autonomous vehicles. For example, a personal assistant might use Theory of Mind AI to understand the user's intentions and preferences in order to provide more personalized and effective recommendations. A social robot might use Theory of Mind AI to understand the

emotions and needs of its human users in order to provide more empathetic and engaging interactions.

One of the key challenges in developing Theory of Mind AI is the complexity of human mental states and the difficulty of accurately predicting human behavior. There is also the issue of how to ensure that the AI system respects human privacy and ethical considerations when dealing with sensitive personal information.

Overall, Theory of Mind AI is an exciting area of research with a lot of potential for improving human-AI interactions. However, it is still in the early stages of development, and there are many challenges that need to be overcome in order to create effective and ethical Theory of Mind AI systems.

- **Self-aware AI:** is a type of artificial intelligence (AI) system that has the ability to not only understand its environment and interact with it, but also to understand its own internal state and make decisions based on that understanding.

Self-aware AI is still a theoretical concept, and there is no existing AI system that can be considered truly self-aware. However, some researchers believe that it may be possible to create such a system in the future.

A self-aware AI system would be able to monitor and understand its own processing, making it capable of self-diagnosis and self-repair. It would also be able to reason about its own goals and motivations, and to adjust those goals and motivations based on its understanding of its own internal state and the external environment.

Self-aware AI systems could have a wide range of potential applications, from autonomous robots and self-driving cars to medical diagnosis and treatment. For example, a self-aware medical diagnostic system could monitor its own performance and make adjustments to improve its accuracy or efficiency.

One of the challenges of developing self-aware AI is that it requires a deep understanding of human cognition and consciousness, which are still not well understood by scientists. There are also significant ethical considerations involved in creating self-aware AI, as it could potentially lead to new forms of artificial life and raise questions about the nature of consciousness and identity.

To conclude, self-aware AI is a highly speculative concept with a lot of potential for both positive and negative consequences. While we are still far from creating a truly self-aware AI system, research in this area could lead to important insights into the nature of consciousness and the future of artificial intelligence.

Overall, the goal of AI is to create machines and systems that can perform tasks that would normally require human intelligence, with the ultimate goal of creating machines that are more intelligent than humans. While there are still many challenges to be overcome in the field of AI, there is no doubt that it has the potential to revolutionize many aspects of our lives, from healthcare and education to transportation and entertainment.

### **3.2. Artificial Intelligence for Project Portfolio Management**

Artificial Intelligence (AI) and its subset, Machine Learning (ML), have the potential to revolutionize project management. The ability of AI and ML to analyze large volumes of data, identify patterns, and make predictions can help project managers make more informed decisions, improve project planning and execution, and optimize resource allocation. By leveraging these technologies, project managers can gain deeper insights into project performance, identify areas for improvement, and take proactive measures to prevent issues before they arise. This can lead to increased project success rates, improved efficiency, and better overall business outcomes. In this context, it is important to explore the potential benefits of AI and ML in project management and how these technologies can be effectively integrated into project management processes.

In project portfolio management specifically, Artificial Intelligence and Machine Learning can provide a wealth of data-driven insights and analysis that can help organizations make more informed decisions about their project portfolios. However, successful integration of AI and ML into project portfolio management requires careful

planning and consideration of the unique needs and goals of the organization. It also requires a strong data infrastructure and a commitment to ongoing learning and improvement to maximize the benefits of these technologies.

Some of the most useful AI and machine learning processes for project portfolio management are:

- Predictive Analytics;
- Natural Language Processing;
- Intelligent Scheduling;
- Decision Support;
- Sentiment Analysis;

And will be closely analyzed here below:

### **Predictive Analytics:**

Predictive analytics is an AI process that involves using machine learning algorithms to analyze historical data and predict future outcomes. In the context of project portfolio management, predictive analytics can help project managers forecast project performance, including timelines, budgets, and risks. Here are the key steps involved in the predictive analytics process:

1. *Data Collection:* The first step in predictive analytics is to collect historical project data, such as project timelines, budgets, and risk profiles. This data is typically stored in a database or data warehouse, where it can be easily accessed and analyzed.
2. *Data Preprocessing:* Once the data has been collected, it must be cleaned and preprocessed to ensure that it is accurate and consistent. This may involve removing duplicate records, filling in missing data, and converting data to a consistent format.
3. *Feature Selection:* The next step is to select the relevant features, or variables, that will be used to train the predictive model. In project portfolio management, these

features may include project timelines, budgets, resource allocation, and risk profiles.

4. *Model Training:* With the data and features in place, the next step is to train a machine learning model on the historical data. There are many different machine learning algorithms that can be used for predictive analytics, including linear regression, decision trees, and neural networks. The goal is to create a model that can accurately predict project performance based on the selected features.
5. *Model Evaluation:* Once the model has been trained, it must be evaluated to ensure that it is accurate and reliable. This involves testing the model on a validation set of data that was not used during training, and comparing the predicted outcomes to the actual outcomes. If the model is not accurate enough, it may need to be retrained or adjusted.
6. *Prediction:* Finally, with a validated model in place, the predictive analytics process can be used to forecast future project performance. By inputting current project data into the model, project managers can obtain predictions about future timelines, budgets, and risks, allowing them to make informed decisions about how to optimize their project portfolios.

In summary, predictive analytics is an AI process that involves using historical project data to train a machine learning model that can predict future project outcomes. This can help project managers make data-driven decisions about which projects to pursue, how to allocate resources, and how to manage project risks.

### **Natural Language Processing:**

Natural Language Processing (NLP) is an AI process that involves teaching machines to understand and interpret human language. In the context of project portfolio management, NLP can be used to extract valuable insights from unstructured text data, such as project proposals, emails, and meeting notes. Here are the key steps involved in the NLP process for project portfolio management:



1. *Text Collection*: The first step in NLP is to collect text data from various sources, such as project proposals, emails, and meeting notes. This data is typically stored in a database or data warehouse, where it can be easily accessed and analyzed.
2. *Text Preprocessing*: Once the text data has been collected, it must be cleaned and preprocessed to ensure that it is accurate and consistent. This may involve removing stop words (common words that do not carry much meaning), stemming (reducing words to their base form), and converting text to a consistent format.
3. *Text Analysis*: With the text data and preprocessing in place, the next step is to analyze the data using NLP techniques such as sentiment analysis, topic modeling, and named entity recognition. Sentiment analysis involves determining the overall sentiment (positive, negative, or neutral) of the text, while topic modeling involves identifying the main themes or topics in the text. Named entity recognition involves identifying and categorizing specific entities mentioned in the text, such as people, organizations, and locations.
4. *Insight Extraction*: With the text data analyzed, the final step is to extract valuable insights that can inform project portfolio management decisions. For example, sentiment analysis can be used to gauge stakeholder sentiment towards specific projects, while topic modeling can be used to identify emerging trends or areas of opportunity. Named entity recognition can be used to track mentions of key stakeholders or competitors.

In summary, Natural Language Processing is an AI process that involves using machine learning algorithms to analyze and extract insights from unstructured text data. In the context of project portfolio management, NLP can be used to inform decision-making by providing valuable insights into stakeholder sentiment, emerging trends, and key stakeholders or competitors.

### **Intelligent Scheduling:**

Intelligent Scheduling is an AI process that can be used for project portfolio management to optimize project timelines and resources. Here are the key steps involved in the intelligent scheduling process:

1. *Data Collection*: The first step in intelligent scheduling is to collect data on the project portfolio, including project timelines, resource availability, and project dependencies.
2. *Data Preprocessing*: Once the data has been collected, it must be cleaned and preprocessed to ensure that it is accurate and consistent. This may involve removing duplicates, filling in missing data, and converting data to a consistent format.
3. *Machine Learning Model Development*: With the preprocessed data in place, the next step is to develop a machine learning model that can optimize project scheduling. This model can be based on a variety of machine learning algorithms, including decision trees, random forests, and neural networks.
4. *Model Training*: Once the machine learning model has been developed, it must be trained on historical project data to identify patterns and relationships between project variables. This training data can be used to fine-tune the model and improve its accuracy.
5. *Predictive Analytics*: With the machine learning model in place and trained, the next step is to use it to make predictions about future project schedules. This involves inputting data about new projects or changes to existing projects, and using the model to predict the optimal schedule based on available resources and project dependencies.
6. *Decision Making*: Finally, the predictions generated by the machine learning model can be used to inform decision-making about project scheduling. For example, the model may recommend adjusting project timelines or resource allocation to optimize the overall project portfolio.

Basically, intelligent scheduling is an AI process that involves using machine learning algorithms to optimize project schedules and resource allocation. This process can help project portfolio managers make data-driven decisions that maximize efficiency and minimize costs.

## **Decision Support:**

Decision support is an AI process that can be used for project portfolio management to help project managers make informed decisions based on data and analytics. Here are the key steps involved in the decision support process:

1. *Data Collection:* The first step in decision support is to collect data on the project portfolio, including project timelines, resource availability, project costs, and other relevant metrics.
2. *Data Preprocessing:* Once the data has been collected, it must be cleaned and preprocessed to ensure that it is accurate and consistent. This may involve removing duplicates, filling in missing data, and converting data to a consistent format.
3. *Data Analysis:* With the preprocessed data in place, the next step is to analyze the data using a variety of analytics techniques. This may include statistical analysis, trend analysis, and predictive modeling.
4. *Machine Learning Model Development:* Based on the data analysis, a machine learning model can be developed to provide decision support for project portfolio management. This model can be based on a variety of machine learning algorithms, including decision trees, random forests, and neural networks.
5. *Model Training:* Once the machine learning model has been developed, it must be trained on historical project data to identify patterns and relationships between project variables. This training data can be used to fine-tune the model and improve its accuracy.
6. *Predictive Analytics:* With the machine learning model in place and trained, the next step is to use it to make predictions about future project performance. This involves inputting data about new projects or changes to existing projects, and using the model to predict outcomes based on available resources and project dependencies.

7. *Decision Making*: Finally, the predictions generated by the machine learning model can be used to inform decision-making about project portfolio management. For example, the model may recommend adjusting project timelines, resource allocation, or project priorities to optimize the overall project portfolio.

Overall, decision support is an AI process that involves using data analytics and machine learning to inform decision-making about project portfolio management. This process can help project managers make data-driven decisions that maximize efficiency, minimize costs, and optimize project outcomes.

### **Sentiment Analysis:**

Sentiment analysis is an AI process that can be used for project portfolio management to gain insights into stakeholder opinions and perceptions about projects. Here are the key steps involved in the sentiment analysis process:

1. *Data Collection*: The first step in sentiment analysis is to collect data on stakeholder opinions and perceptions about projects. This may include survey data, social media data, customer feedback, and other sources of stakeholder input.
2. *Data Preprocessing*: Once the data has been collected, it must be cleaned and preprocessed to ensure that it is accurate and consistent. This may involve removing duplicates, filling in missing data, and converting data to a consistent format.
3. *Natural Language Processing*: With the preprocessed data in place, the next step is to use natural language processing (NLP) techniques to analyze the data. NLP involves using machine learning algorithms to understand and interpret human language. This may include identifying sentiment, emotion, and other linguistic features, as explained in the paragraph above.
4. *Sentiment Analysis*: Based on the NLP analysis, sentiment analysis can be performed to gain insights into stakeholder opinions and perceptions about

projects. Sentiment analysis involves using machine learning algorithms to classify text as positive, negative, or neutral. This can be used to identify trends and patterns in stakeholder sentiment over time.

5. *Visualization*: Finally, the insights gained through sentiment analysis can be visualized in a variety of ways to make them more accessible and actionable. This may include using charts, graphs, and other visualizations to display sentiment trends and patterns.

In summary, sentiment analysis is an AI process that involves using natural language processing and machine learning to gain insights into stakeholder opinions and perceptions about projects. This process can help project managers understand stakeholder sentiment, identify areas for improvement, and make data-driven decisions about project portfolio management.

All things considered, the integration of artificial intelligence and machine learning into project portfolio management processes has the potential to significantly enhance the efficiency and effectiveness of project management. With the ability to analyze large amounts of data and provide valuable insights, AI and ML technologies can assist in making informed decisions, reducing risks, and improving project outcomes. As these technologies continue to advance, it is likely that they will become increasingly integrated into project portfolio management, enabling organizations to better manage their project portfolios and ultimately achieve their strategic goals.

## 4. AI powered Startups for Project Portfolio Management

In this chapter will be examined the most recent and viable startups that use artificial intelligence and machine learning mechanisms, seen in the previous chapter, in the service of Project Portfolio Management.

### 4.1. ClickUp

ClickUp is a productivity and project management platform that offers features such as task management, time tracking, calendars, goal setting, and collaboration tools. It was founded in 2017 by Zeb Evans, and has since grown to become a popular tool for teams of all sizes and industries.



*Figure 5: ClickUp logo*

It can be used for personal or team projects and offers integrations with other tools such as Google Calendar, Slack, and more.

They do offer features that utilize machine learning algorithms to assist users, such as the ability to prioritize tasks based on deadlines and progress, automatically generating progress reports, and providing recommendations for next steps. The main AI mechanisms used by ClickUp are the following:

- **Smart Notifications:** ClickUp's smart notification system uses machine learning algorithms to predict which notifications are most important to each user based

on their previous interactions with the platform. This helps users stay on top of the most critical tasks and updates without being overwhelmed by unnecessary notifications.

- **Task Assignments:** ClickUp's task assignment system uses natural language processing (NLP) to interpret and extract information from task descriptions and assign tasks to the appropriate team member. For example, if a task includes the phrase "Design a new logo," ClickUp's NLP system can recognize that it is a design-related task and assign it to a team member with relevant skills and experience.
- **Intelligent Task Sorting:** ClickUp's task list view includes an AI-powered sorting system that automatically organizes tasks by priority based on factors like due date, task dependencies, and estimated time to completion. This helps users focus on the most critical tasks first and ensures that work is completed on time.

Mainly, ClickUp uses AI mechanisms to automate repetitive tasks, help users stay organized and on track, and improve the overall productivity and efficiency of teams using the platform.

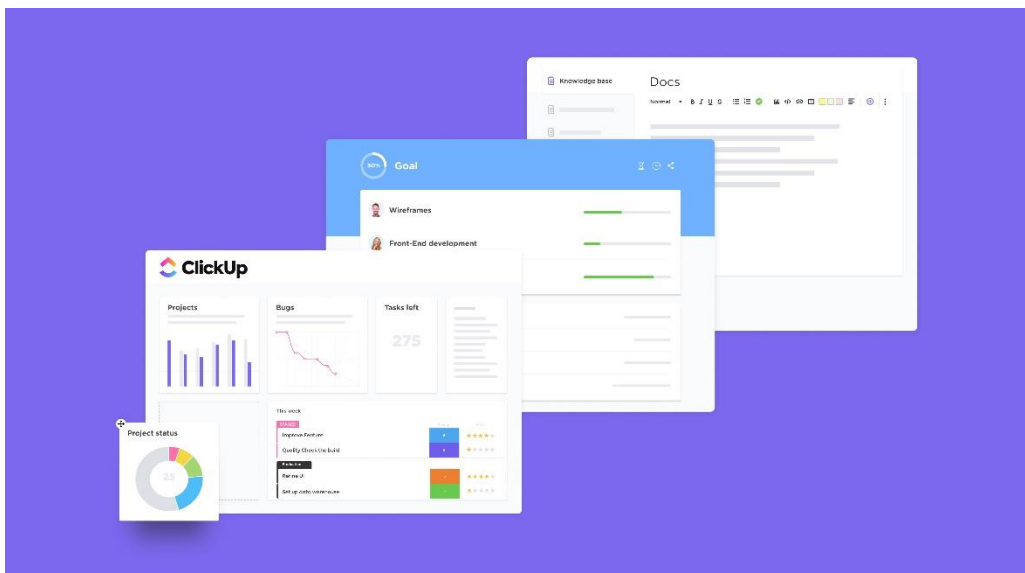


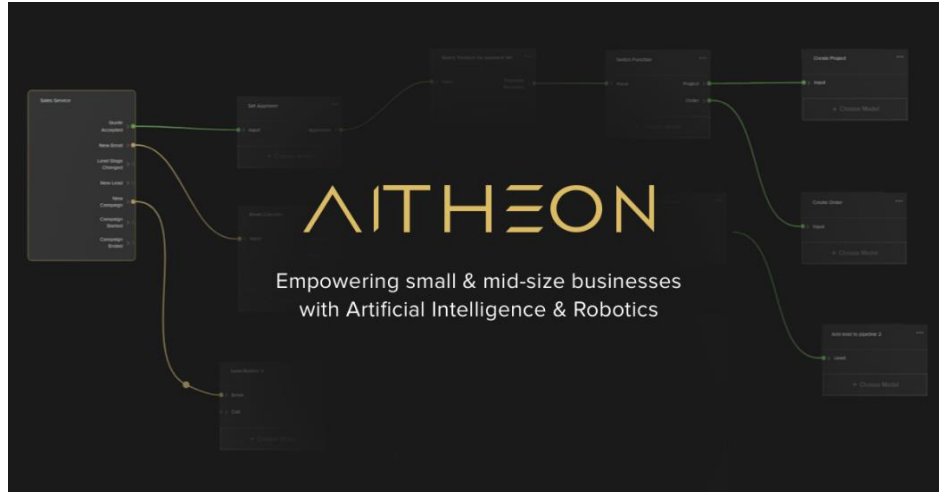
Figure 6: ClickUp overview

## 4.2. Aitheon

Aitheon is a technology company that offers a platform for integrating artificial intelligence (AI) and robotics to automate business processes. The company was founded in 2017 and is based in Tallinn, Estonia.

Aitheon's platform includes a range of tools and technologies for automating tasks and workflows, including computer vision, natural language processing (NLP), machine learning (ML), and robotic process automation (RPA). The platform can be used by businesses in a variety of industries to automate tasks like data entry, customer service, inventory management, and more.

In addition to its platform, Aitheon also offers a range of products and services including autonomous mobile robots (AMRs), humanoid robots, and a blockchain-based marketplace for hiring robots and AI-powered services.



*Figure 7: Aitheon logo and motto*

Aitheon is primarily focused on automating business processes using AI and robotics, it does offer some features that are useful for project portfolio management (PPM) processes. Here are a few examples:



- **Intelligent Automation:** Aitheon's platform includes tools for automating repetitive tasks and workflows using AI and RPA. This could include automating tasks like data entry, report generation, and other administrative tasks that are commonly associated with PPM processes.
- **Natural Language Processing:** Aitheon's platform includes NLP capabilities that can help with tasks like extracting data from unstructured sources (such as project update emails or meeting notes) and analyzing that data to identify patterns or trends.
- **Computer Vision:** Aitheon's platform also includes computer vision capabilities that could be useful for monitoring progress on physical projects, such as construction projects or manufacturing processes. For example, computer vision could be used to monitor the progress of a building project and flag any delays or issues that might impact the overall timeline.

Aitheon has been recognized for its innovative approach to automation and has won several awards and accolades, including the "Best Robotics Company" award at the World AI & Robotics Conference in 2019.

### **4.3. Copy.ai**

Copy.ai is an AI-powered platform that provides copywriting assistance and automation for businesses and individuals. The platform was launched in 2020 and is based in San Francisco, California.

Copy.ai uses natural language processing (NLP) and machine learning (ML) algorithms to generate high-quality copy for a variety of purposes, such as social media posts, product descriptions, email subject lines, and more. Users can input prompts or keywords related to the copy they need, and the platform will generate multiple variations of the copy, which users can then select, edit, and refine as needed.

The platform also includes several features to help users optimize their copy for specific purposes, such as creating headlines that will perform well on social media or generating email subject lines that are more likely to be opened.



Figure 8: Copy.ai features

Copy.ai is primarily designed to assist with copywriting and content creation, so its direct application to project portfolio management (PPM) may be limited. However, there are some ways in which Copy.ai could potentially be useful for PPM processes:

- **Automated Report Generation:** Copy.ai's platform can generate high-quality copy for various purposes, including reports. This could be useful for PPM professionals who need to generate regular reports to track project progress, budget, and other key metrics. By using Copy.ai to generate reports, PPM professionals could save time and ensure that their reports are well-written and effective.
- **Social Media Management:** Many PPM professionals use social media to promote their projects and communicate with stakeholders. Copy.ai's platform includes

features that can generate social media posts and headlines optimized for specific platforms, such as Twitter or Instagram. This could help PPM professionals save time and improve the effectiveness of their social media efforts.

- **Email Communication:** Effective communication is a critical part of PPM processes, and email is often a primary means of communication between team members and stakeholders. Copy.ai's platform includes features that can generate email subject lines and body copy optimized for specific purposes, such as reaching out to potential partners or stakeholders. This could help PPM professionals save time and improve the effectiveness of their email communication.

Overall, Copy.ai's platform aims to help businesses and individuals save time and improve the effectiveness of their marketing and communication efforts by using AI to automate the copywriting process, and while it may not be specifically designed for PPM, its copywriting automation features could be useful for streamlining various communication tasks associated with PPM processes.

#### **4.4. Airfocus**

Airfocus is a web-based software application designed to help businesses prioritize and manage their product roadmaps, project portfolios, and other strategic initiatives. Founded in 2017 in Hamburg, Germany, by Christian Hoffmeister e Malte Scholz. The software is primarily used by product managers, project managers, and other stakeholders involved in product development and strategic planning.

The Airfocus platform includes features such as customizable scoring frameworks, prioritization matrices, and progress tracking tools, which help users make informed decisions about where to focus their efforts and resources. The platform also includes integrations with popular project management tools like Trello, Jira, and Asana, allowing users to easily import and export data.

One of the key features of Airfocus is its ability to visualize and communicate complex information in a way that is easy to understand. Users can create customizable dashboards and reports, which allow them to track progress and communicate updates to stakeholders. This can be especially useful for businesses that have multiple teams or stakeholders involved in their product development or strategic planning processes.

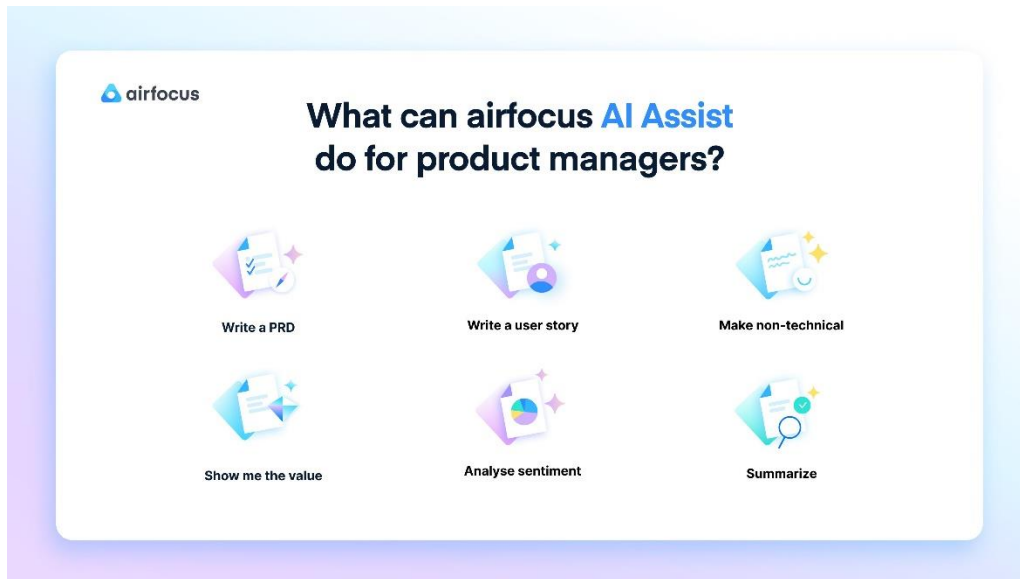


Figure 9: Airfocus' main PM features

Airfocus incorporates artificial intelligence (AI) and machine learning (ML) technologies in several key areas to help users make better data-driven decisions. Here are some of the AI features of Airfocus:

- **Prioritization Algorithm:** Airfocus uses a proprietary algorithm that takes into account various factors such as impact, effort, and risk to prioritize items on a roadmap or project portfolio. The algorithm is designed to learn from user behavior and feedback, improving the accuracy of its recommendations over time.
- **Scoring Framework Customization:** Airfocus allows users to create customized scoring frameworks that reflect their specific needs and goals. The software uses

AI to analyze historical data and user input to suggest the best parameters for the scoring framework.

- **Risk Analysis:** Airfocus uses AI to analyze potential risks associated with a project or initiative, and to suggest mitigation strategies based on historical data and best practices.
- **Predictive Analytics:** Airfocus includes predictive analytics features that use AI and ML to forecast the potential impact of different initiatives or scenarios. This allows users to make informed decisions about which projects or initiatives to prioritize based on their expected outcomes.
- **Integration with Third-Party Tools:** Airfocus integrates with a range of third-party project management and collaboration tools, such as Jira and Asana, to import and analyze data from those sources using AI and ML algorithms. This allows users to get a comprehensive view of their project portfolio and make informed decisions based on the data.

In summary, Airfocus's AI features aim to help users make more informed decisions about their product roadmaps and project portfolios by providing insights and recommendations based on historical data, best practices, and user input and also to improve collaboration and communication among stakeholders involved in those processes.

## **4.5. Moveworks**

Moveworks is an AI-powered platform that helps enterprises automate and resolve employee IT support issues using natural language understanding (NLU), conversational AI, and machine learning. The platform is designed to streamline employee support workflows and provide faster and more accurate resolutions to common IT support issues.



*Figure 10: Moveworks logo*

Moveworks integrates with a range of enterprise software systems, such as HR and IT management tools, to provide employees with personalized support and automate routine tasks. For example, employees can use natural language queries to troubleshoot common IT issues, such as password resets, software access requests, and hardware issues. Moveworks uses NLU to understand the intent of the user's query and provides a relevant response or action.

Moveworks' machine learning capabilities enable it to learn from past interactions and improve its accuracy over time. The platform also includes a range of analytics tools that allow enterprises to monitor and optimize their support workflows, including response times and issue resolution rates.

While Moveworks is primarily focused on providing IT support to employees, it may also have some features that can be useful for project portfolio management. Here are some of the main features that could potentially be helpful:

- **Natural Language Understanding (NLU):** Moveworks' NLU capabilities enable employees to ask questions and get answers in natural language. This could be useful for project managers who want to quickly access information about project statuses, timelines, or resources.
- **Analytics and Reporting:** Moveworks includes analytics tools that can help enterprises monitor and optimize their support workflows, including response times and issue resolution rates. Project managers could potentially use these tools to track progress and identify areas for improvement in their project portfolio management processes.

- **Integrations:** Moveworks integrates with a range of enterprise software systems, such as HR and IT management tools. This could potentially allow project managers to access data from other systems that are relevant to their project portfolio management processes.
- **Personalization:** Moveworks' conversational AI capabilities enable it to provide personalized support to employees. This could potentially be helpful for project managers who need to access specific information or resources related to their projects.

Even though Moveworks is not specifically designed for project portfolio management, its NLU capabilities, analytics tools, integrations, and personalized support features could potentially be useful for project managers who need to access information and resources quickly and efficiently.

Overall, Moveworks aims to improve the employee experience by providing faster and more personalized IT support, while also reducing the workload of IT support teams.

## **4.6. Rozes**

Rozes is a data intelligence service provider startup that offers a predictive service to help businesses assess the risk associated with forming business alliances with potentially unsafe or financially unstable firms, founded in 2017 by Università di Padova.



*Figure 11: Rozes logo*

Some key features of Rozes that can be useful for businesses and project portfolio management:

- **Predictive Analytics:** Rozes uses predictive analytics to forecast the risk associated with forming business alliances with different firms based on a range of quantitative data points. This can help businesses to make data-driven decisions about which partnerships to prioritize and allocate resources to within their project portfolio.
- **Real-Time Risk Assessment:** Rozes provides a quick and streamlined tool for businesses to sift through potential critical issues in real-time, speeding up risk assessment processes on customer and supplier portfolios. This can help businesses to identify potential risks within their project portfolio and take proactive measures to mitigate them.
- **Consistent Criteria:** Rozes ensures a consistent criterion for determining the risk map associated with customer and supplier clusters. This can help businesses to make more consistent and objective decisions based on standardized criteria.
- **Data Analysis:** Rozes' analytical tools use quantitative data to carry out assessment and evaluation activities. This can help businesses to enrich their team and expertise with analytical tools and make data-driven decisions about how to optimize their project portfolio.

Overall, Rozes appears to be a useful tool for businesses that want to assess the risk associated with forming business alliances with potentially unsafe or financially unstable firms. Its machine learning algorithms and predictive analytics can be helpful for businesses managing multiple partnerships and investments as part of their project portfolio, and its real-time risk assessment, consistent criteria, and analytical tools can help businesses to make more informed decisions based on data-driven insights.





## Conclusions

The integration of artificial intelligence in project portfolio management has proven to be a significant paradigm shift for businesses across various industries.

The emergence of AI-powered startups has brought about a transformative shift in project portfolio management by leveraging cutting-edge technologies to provide innovative solutions. By utilizing machine learning algorithms, predictive analytics, natural language processing, and automation, these startups have enabled organizations to make data-driven decisions, optimize resource allocation, and mitigate risks. This has resulted in improved project performance, better risk management, and enhanced organizational efficiency. As the technology continues to evolve, it is expected that AI will play an increasingly vital role in project portfolio management, enabling businesses to stay competitive in today's rapidly changing and challenging marketplace.

The impact of AI-powered startups on project portfolio management is expected to continue to grow, enabling organizations to stay ahead of the curve and achieve long-term success.

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## 2. Figures:

Figure 1: BTO Research logo

Figure 2: BTO services

Figure 3: BTO manifesto

Figure 4: Project Portfolio Management processes

Figure 5: ClickUp logo

Figure 6: ClickUp overview

Figure 7: Aitheon logo and motto

Figure 8: Copy.ai features

Figure 9: Airfocus' main PM features

Figure 10: Moveworks logo

Figure 11: Rozes logo

