

Exploring Possibilities to Increase Ease of Use of IT Portfolio Management

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ABSTRACT

Portfolio management has always been difficult, especially in the IT sector[1]. Many studies have put forward suggestions to increase reliability of such management systems. However, modeling IT-architectures is hard and time-consuming. Furthermore, giving weights to dependencies in the system is often subject to politics and personal opinions. Additionally, estimating parameters is nearly impossible without big-data to support a valid estimation. This paper focuses on methods to increase usability of IT portfolio management and assessing whether this would be desired. One such suggestion is to make use of system dynamics to enable simulation over time. This is possible when cost and revenue over time is known. When flat cost and revenue is known, assumptions have to be made. Furthermore, a tool is developed to increase ease of use and solve the high complexity problem for modeling dependencies and calculating their estimated outcome.

Keywords

IT-Portfolio, Dynamic systems, IT-Investments, Usability

1. INTRODUCTION

Assessing whether to invest in an IT project is a difficult task [1]. Politics frequently play a part in the decision-making process with negative effect on organizational performance[1]. Therefore, more rational methods are required for determining whether an investment is valuable. However, doing so is difficult, due to a number of factors including:

- Measuring business return after implementation is difficult. [2]
- Calculating the expected costs is difficult. [3]
- Assessing whether an IT investment is profitable or desired is time-consuming. [4]
- Politics or decisions made by management. [5]

Many studies have searched for answers on how to improve these factors. One area of research is the so-called

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IT-Portfolio management, meaning that project dependencies are mapped, potential risks are assessed including their risk on other projects, and decisions whether to invest more or to stop investing depending on risk factors and potential reward. One suggested methodology to model such decisions is described by Ghapanchi et al.[6]. This suggests four steps:

1. Modeling the problem;
2. Selecting candidate projects;
3. Portfolio generation and establishing maximal portfolios;
4. Evaluation of maximal portfolios.

Many ways have been adopted to maximize the models' outcome, like Fuzzy data envelopment analysis (FDEA)[7], focusing on the financial calculations on risk and profit by assessing Decision making units (DMU's) having multiple in- and outputs. One other method of managing projects is system dynamics. System dynamics focus on the impact of individual project components enabling simulations of performance over time. Furthermore, it allows us to improve our intuition and mental simulation capacity, which allows us to improve the rate of decision making by learning the system. This tackles the problem of having to make fast Go/Kill decisions, as well as prioritizing models against each other [8]. This is a problem in traditional portfolio management strategies, because the calculations are very complex and hard to automatically calculate. Furthermore, many ways to handle portfolio management are based on quantitative measurement, while defining these parameters is complex. This paper will focus on the method using system dynamics to assess whether the intuitional choices are easier to make, and better to understand the outcome of an assessment, without the need of hard quantitative measurements. Furthermore, it focuses on exploring whether a more intuitive tool can be created for IT portfolio management.

2. QUANTITATIVE PORTFOLIO MANAGEMENT

Portfolio management makes use of soft- (enhancing) and hard (required) dependencies.

Assume an initial cycle K with projects $k = 1, 2, \dots$. To estimate the profit of project k , one should also consider profit from project in cycle N with projects $n = 1, 2, \dots$ when there is a dependency between the projects. Obviously, when a project has more cycles, all cycles should be considered. Project k in the first cycle is denoted by $P_{1,k}$ and project n in the N^{th} cycle is denoted by $P_{N,n}$

Notation	Definition
NPV	Net present value
$ENPV$	Expected net present value
$ENPV'$	Calculated (project specific) Expected net present value
$NPV_{1,k}$	NPV of project k in first iteration
$NPV_{2,n}$	NPV of project n in second iteration
$OVA_{2,j,k}$	Option value attribute with hard dependency from project k to project j in the following iteration of project k
$OVA'_{2,j,k}$	Option value attribute with soft positive dependency of project j in the second iteration when k is implemented
$OVA''_{2,j,k}$	Option value attribute with soft negative dependency of project j in the second iteration when k is implemented
RR	Weight factor of dependencies. Can be positive or negative

Table 1. Definitions

To calculate the value of portfolios, both static (passive) revenue and future profit should be taken into account. The following model is presented by Angelou [9]:

The ENPV (Expected Net Present Value) is given by the formula

$$ENVP = \text{Static NPV} + \text{value of future options} \quad (1)$$

In case of a second project $P_{2,n}$ which is hard dependent on the $P_{1,k}$, then the Expected Net Profit Value is denoted by

$$ENPV = NPV_{1,k} + \max(V_{2,n} - C_{2,n}, 0) \quad (2)$$

where $\max(V_{2,n} - C_{2,n}, 0)$ is the Option Value (Attribute) (OVA). In case of soft dependencies, it is required to calculate the contribution to the project in the previous iteration. The contribution is calculated as the value when $P_{1,k}$ is implemented minus when $P_{1,k}$ was not implemented:

$$OVA'_{2,j,k} = OV'_{2,n,k} - OV'_{2,n} \quad (3)$$

where

$$OV'_{2,n,k} = \max(V'_{2,n} - C_{2,n}, 0) \quad (4)$$

$$OV'_{2,n} = \max(RR * V'_{2,n} - C_{2,n}, 0) \quad (5)$$

where RR is the reduction of revenues when $P_{2,n}$ is not preceded by $P_{1,k}$. In case of soft negative dependencies the contribution is calculated with

$$OVA''_{2,j,k} = OV''_{2,n} - OV''_{2,n,k} \quad (6)$$

where

$$OV''_{2,n,k} = \max(RR * V''_{2,n} - C_{2,n}, 0) \quad (7)$$

$$OV''_{2,n} = \max(V''_{2,n} - C_{2,n}, 0) \quad (8)$$

These formulae become very complex in large systems and results are hard to read. This paper focuses on exploring two ways of increasing ease of use when using system dynamics.

- Applying system dynamics to enable use of simulation.

- Exploring ways to find a more intuitive tool for portfolio management.

The next section will elaborate more on system dynamics, before the methodology is explained.

3. SYSTEM DYNAMICS

System dynamics allow simulations of systems, thus allowing the exploration of interactions between subsystems. This is done by defining what parts of system influence each other in what way. Lyneis and Ford[10] conclude that dynamics have positive influence on the following, but not limited to, challenges of decision making:

- Project estimating and risk assessment
- Change management, risk management and project controls: What parts of the system are at the base of organization, and thus have big influence when decisions are made.

One example of applying system dynamics on project management, would look as follows:

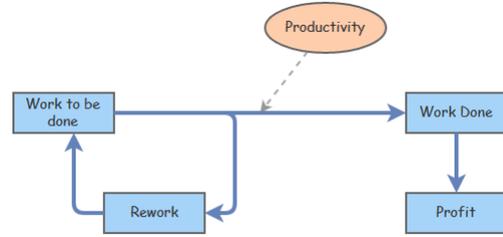


Figure 1. Using the correlations between variables from Leon [11] one can build a decent example

In the example above, some parameters were chosen for demonstration purposes and do not reflect the truth whatsoever. When the simulation of the graph above is ran, the following results are presented:

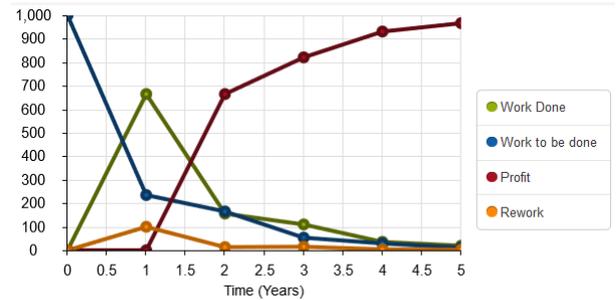


Figure 2. An example of results of a simulation ran using the model described above

The fundamentals of system dynamics, defining interactions between systems and simulating and exploring possible outcomes, could be used on portfolio management as well. The benefit of using system dynamics, is that the output generated is more easy to understand than when using formulae.

4. METHODOLOGY

This paper aims to explore possibilities to increase ease of use of IT portfolio management. In order to do so, two promising methods have been selected to explore in this paper.

- Applying system dynamics on a case and reviewing the usability of such an implementation.
- Creation of a more intuitive and easier to use tool and compare it to existing software.

In order to explore possibilities of system dynamics, a case study is used to apply system dynamics on, and how to apply the model. From here, options for applying system dynamics are brought up to assess whether system dynamics could be used to increase usability.

In order to create or come up with a new tool to aid in portfolio management, existing tools are compared and reviewed. The ideas from how to apply the model for system dynamics are used to generated requirements for the tool. A new tool is created to suggest an alternative to existing programs, which then will be compared with the existing tools to assess whether exploration of the option is valid for future research.

The criteria used are based upon the case study of Angelou taking the rules of dependencies, project cycles, and intuitively designing the structure in mind. Criteria used are:

- Visually intuitive overview.
- Ability to create hard and soft dependencies.
- Ability to visually see the connections between projects.
- Ability to see the cycles or periods the projects are planned in.
- Ability to create a model of an architecture quickly.
- Ability to simulate what-if scenario's.

The next part will elaborate on the case, in order to try to apply system dynamics.

5. CASE STUDY

This paper uses the case described in Angelou[9]. This case describes the project as described in Table2, where the first digit is the project phase or iteration, and the second digit the project number in that iteration.

Project	Dependency
Project 1.1	-
Project 1.2	Positive soft dependency for P2.1 (25%)
Project 1.3	Negative soft dependency for P2.2 (-15%)
Project 1.4	-
Project 2.1	Hard dependent on P1.1
Project 2.2	Hard dependent on P1.2
Project 2.3	Hard dependent on P1.3
Project 2.4	Hard dependent on P1.4

Table 2. Projects and their dependencies

The content of the projects is omitted, since it does not add value for this paper.

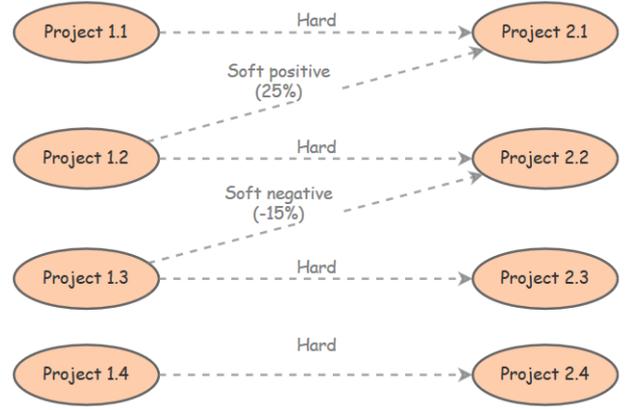


Figure 3. Dependencies in the case study

Drawing the projects as dependencies of each other yields Figure 3:

Applying the theory from chapter 2, Quantitative portfolio management, yields the following formulae:

$$ENPV'_{1,1} = NPV_{1,1} + OVA_{2,1,1} \quad (9)$$

$$ENPV'_{1,2} = NPV_{1,2} + OVA_{2,2,2} + OVA'_{2,1,2} \quad (10)$$

$$ENPV'_{1,3} = NPV_{1,3} + OVA_{2,3,3} - OVA''_{2,3,3} \quad (11)$$

$$ENPV'_{1,4} = NPV_{1,4} + OVA_{2,4,4} \quad (12)$$

Where

(9) is the expected profit based on the Net Present Value of P1.1 combined with the Option Value Attribute of P2.1 given a hard dependency,

(10) is the expected profit based on the Net Present Value of P1.2 combined with the Option Value Attribute of P2.2 given a hard dependency, and project P2.1 with a positive soft dependency,

(11) is the expected profit based on the Net Present Value of P1.3 combined with the Option Value Attribute of P2.3 given a hard dependency, and project P2.2 with a negative soft dependency,

(12) is the expected profit based on the Net Present Value of P1.4 combined with the Option Value Attribute of P2.4 given a hard dependency

Clear is that the fomulae now resemble Figure 3.

More expansion of the formulae yields:

$$ENPV'_{1,1} = Rev_{1,1} - Cost_{1,1} + Rev_{2,1} - Cost_{2,1} \quad (13)$$

$$ENPV'_{1,2} = Rev_{1,2} - Cost_{1,2} + Rev_{2,2} - Cost_{2,2} + \max(Rev_{2,1} - Cost_{2,1}, 0) - \max(RR * Rev_{2,1} - Cost_{2,1}, 0) \quad (14)$$

$$\begin{aligned}
ENPV'_{1,3} = & Rev_{1,3} - Cost_{1,3} + Rev_{2,3} - Cost_{2,3} \\
& + \max(Rev_{2,2} - Cost_{2,2}, 0) \\
& - \max(RR * Rev_{2,2} - Cost_{2,2}, 0)
\end{aligned} \tag{15}$$

$$ENPV'_{1,4} = Rev_{1,4} - Cost_{1,4} + Rev_{2,4} - Cost_{2,4} \tag{16}$$

Angelou continues by applying ROAHP model to the estimations, taking other factors in account which influence prioritization like customer satisfaction and competitor advantages. These will not be applied in this study since this research focuses on increasing the ease of use by comparing to existing products. None of these products implement the model, and therefore has no additional value in this research. Furthermore, for simplicity, the log transform binomial in 50 steps is not applied to the ENPV, since this enhances the correctness of the calculation, but does not influence ease of use. The log transformation can easily be built in later and does not influence ease of use.

As the model used by Angelou is now described, we will now focus on implementing the model in insightmaker, in order to see whether system dynamics create ease of use.

6. APPLYING THE MODEL

Describing the case in insightmaker yields Appendix A, which is derived from formulae (13 - 16). In this model, the soft and hard dependency weights are described in the variables RR, and the formulae are defined in the variables.

This system looks quite complex, even though it has only a few parameters:

- The revenue of each project.
- The cost of each project.
- The weight of the dependencies.

The case does not describe other parameters, and therefore the model is fairly easy to implement in a program. This yields the following rules:

- The NVP is solely dependent on the cost and revenue parameters.
- Hard dependencies are simply addition of other projects,
- Soft positive dependencies are modeled as an additive project, where the project itself is an addition of the cost and value when implemented, and cost and value multiplied by the weight factor when not implemented.
- Hard positive dependencies are modeled as an subtracting project, where the project itself is an addition of the cost and value when not implemented, and cost and value multiplied by the weight factor when implemented.

Figure 3 feels like a more intuitive and simplistic way of modeling entire systems, where formulae are embedded in the existing links. One can see that cost and value can be parameters of a project, and the weight can be parameters of soft dependencies, omitting the need of complex calculations.

Clear is that the system could be optimized, increasing the usability and readability of such models. The further aim

of this paper is to produce such a system with increases usability and readability.

For such a system, one needs to be able to define projects with costs and revenues, and dependencies with weights and types (hard, soft positive, soft negative). Furthermore, to apply intangible factors.

In order to apply system dynamics to the model, parameters need to be defined. Since Angelou did not describe any such parameters, some were made up and added to the case. These include:

- The duration of a project is randomly chosen.
- The start of a project with a hard dependency cannot start before the preceding project has finished.
- All projects in the first iteration start at the same time.
- Profit declines over time for all projects.
- Cost is spread over the duration of the project.
- Some random events have been included to simulate interaction.
- Since actual costs and values do not matter, those are randomly chosen.

The result of such simulation look like the graph in Figure 4. This figure and Figure A (Appendix) will be used to evaluate system dynamics with the tool InsightMaker

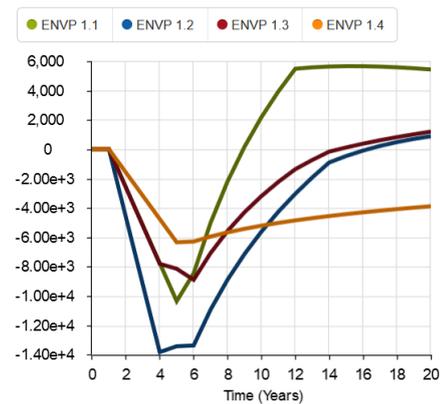


Figure 4. Simulation of SD with project as in the case

7. SIMILAR SOFTWARE

Software exists which allows for estimating system dynamics. The software will be compared based on certain criteria described in the methodology, from where use cases will be defined for the new tool.

There are quite a few software programs which focus on investments, like:

- Planview[12]
- Triskell[13]
- Insightmaker[14]

Other tools were not free of use or had too little documentation public.

The next part will review the tools based on the criteria defined in the Methodology in words. The comparison of the tools based on the criteria can be found in the Appendix B.

7.1 Planview

Planview was contacted for a trail version, but no such solutions were available. Information below in from an available demo and might not cover the entire product.

Planview is a large program with a special solution for portfolio management.

Planview is dashboard program where users can see the status of their projects, their estimated profit and resources allocated to it. It uses a table overview with color schemes to display information like cost per project. Advantages include: Ability to compare project and resource allocation, ability to track changes and act accordingly and the ability to make dependencies between projects. Many dashboards that enable overviewing of the current portfolio's Disadvantages include: Unable to define soft- and hard dependencies, being unable to define weights to assert ENPVs for multi-tier strategies. Capterra score: 3.8/5 stars. [15]

7.2 Triskell

Triskell was contacted for a trail version, but no such solutions were available. Information below in from an available demo and might not cover the entire product.

Triskell has videos online describing how the program works. Triskell uses more charts and diagrams to display information. Its focus is to deliver a fullstack solution for a company from teammembers to CEO. Advantages include: Ability to use what-if scenarios, ability to deliver a full stack solution, ability to define dependencies Disadvantages include: Complex overview, not intended for considering projects but instead the goal is to maintain projects. Capterra score: 4.8/5 stars. [16]

7.3 Insight maker

Insight maker is a tool developed to create dynamic systems. It uses stocks, flows and variables to define connections. It can be programmed to have dependencies where dependencies are defined as variables. It has a button to simulate the model and see what effects events have on the outcome of variables. Users have the ability to run their project with timesteps, allowing them to change variables during the simulation and check their effects. Insight maker is hard to model since it is not designed specifically for IT portfolio management, and therefore takes a lot of time to implement a model in.

8. REQUIREMENTS NEW PROGRAM

To develop a new program with a more intuitive design, requirements are made to ensure user satisfaction. Criteria mentioned in the Methodology are used together with the results of the comparison of tools.

8.1 Use cases

The following use cases are described:

- As user, I want to be able to add a project.
- As user, I want to be able to set the cost and revenue of a project.
- As user, I want to be able to add hard, soft positive and soft negative dependencies.
- As user, I want to be able to connect two project with a dependency, given a source and destination.
- As user, I want to be able to set a weight to a soft dependent project.

- As user, I want to be able to simulate investment in a project.
- As user, I want to easily see what the result of an investment would be.

These requirements enable all functions required to calculate the expected profit, while taking usability in mind.

Since *c#* is the language best known to the authors, the program was developed in this language.

9. DESIGN NEW TOOL

The tool allows for drag and dropping for projects, with the ability to link them using dependencies. The tool is useful for a small analysis with only a few projects. Maintaining a portfolio is no option due to the way the overview is created. The tool enables overview of potential interesting investments, since the user can change the weights of certain dependencies and thus comparing results with different estimations.

Taking for example the *ENPV* from project 1.2 of the case study (see 5, case study), with its hard dependency to project 2.2 and soft positive dependency to 2.1 yields the following input:

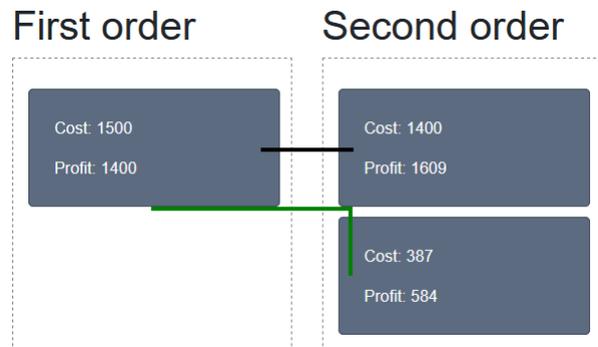


Figure 5. Project 1.2 designed in the tool

The tool consequently calculates that, based in the profit, cost and weights of the dependencies, the *ENPV* of the project P1.2 is €255 (one euro off due to rounding in the paper of Angelou). The model can be created in less than a minute, and is much more intuitive than the formulae in the model.

Furthermore, the tool is able to simulate over time. For this, some assumptions have been made, including:

- Projects with a hard dependency can only start when its predecessor has fully been implemented.
- Projects with a soft dependency can be implemented when no hard dependencies exist.
- Profits do not decline.
- Cost is evenly spread out over the duration of a project.

The result of a simulation defined in Figure 5, yields the following outcome.

The tool has an intuitive design and therefore has potential to increase ease of use. Due to how the initial release is built, no database is connected, which disables the use of saving and loading. Furthermore, the tool is more of a quick checking tool, then a portfolio manager.

The review of the cool can be found in Appendix B.

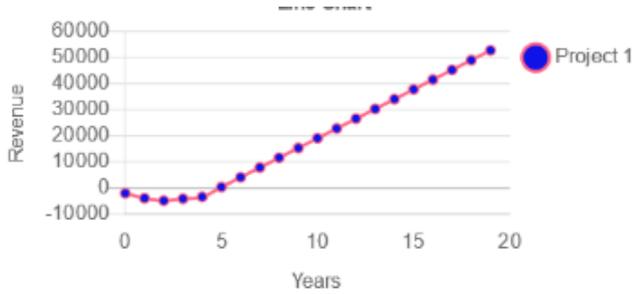


Figure 6. SD simulation of Figure 5

10. RESULT

This section will evaluate on the results of the project.

10.1 System dynamics

During exploration of applying system dynamics on portfolio management, it became clear that no the case has no dynamic parameters. In order to continue with the research, some were made up. With these new parameters, a system dynamic simulation could be made. Parameters that were required include:

- Start and duration of a project.
- Expected time to receive profit and over what period.
- Events happening to simulate dynamics.

Based on this, when having a static, non-reactive estimation, SD would not fit to be applied. When a yearly cost and revenue is known, together with duration of projects, the project is fit to apply SD on.

10.2 Comparison of available tools

Tools focus on the full stack development for the entire backbone of a company. This means tools are complex and must be committed to. Insightmaker is free and more flexible, but is really hard to understand.

The following results come from the comparison:

- Planview and Triskell are more of a waterfall, full company wide management tool with powerful features. Triskell is more intuitive and receives better ratings.
- Insightmaker gives more flexibility, but is hard to implement. Just like the new tool, it is used for calculations before investment, and not during the investment.
- The tool is more intuitive than Insightmaker and easier to use.

10.3 The new tool

Created is an intuitive and easy to use system for estimating portfolio dynamics before the investment. During the investment, the tool is not suitable for use. It is possible to set costs, revenues, and dependencies with weights. This already allows for basic calculations for portfolio management, as described by Angelou[9].

The tool displays projects and dependencies more as in figure 3, which is a more intuitive way of displaying projects. Furthermore, it is easy to set the cost and profit of a project (select the project and enter the amount) and the dependencies (click on the dependency, select source and

target and weight). The program does all calculating when pressing the button.

Furthermore, the tool allows for simulations over time.

The tool can be found at:

<https://github.com/MartijnWoudstra/PortfolioTool>

11. CONCLUSION

System dynamics is applicable to portfolio management when cost and revenue over time is known. When only one-time values are known, it is required to make estimations of the values over time. System dynamics can help to give more insight in portfolio management by plotting the expected outcome.

Planview and Triskell are the most suitable tools when managing portfolio's during the periods they run. For estimation beforehand, Insightmaker or the new tool can be used to estimate beforehand.

The tool suggest a way of defining in an interactive way how project and dependencies are modeled. It can be experienced as a more intuitive way of defining these dependencies.

12. DISCUSSION

The case used to explore whether system dynamics can be applied did not have dynamic parameters. Therefore, estimations had to be made. Due to this, the result could not have been compared to the output of the case. The research suggests the results are valid, but there might have been more parameters or influences which have not been discovered by discussing this particular case.

Tools reviewed were not available for students. Therefore, there might have been some functionalities or options which have not surfaced. The results might have changed when the programs were available. Therefore, the comparison should be done again with availability of the tool.

Tools were compared by the author of the paper without a control group, and therefore are subject to personal preferences. The comparison should be done by more than one person.

13. FUTURE WORK

Explored is that system dynamics can be applied to portfolio management based on this case. In feature research, other cases with cost and revenue over time should be assessed, to confirm the claim.

The tools reviewed should be reviewed again when a licence is available to give better review of the available tools. Furthermore, more people should assess whether criteria are met.

The tool should be extended with a better layout, to increase ease of use. Furthermore, possibilities to integrate the idea of the new tool into existing software, to increase ease of use when modeling the projects and their dependencies. Furthermore, research should investigate whether more parameters are crucial for applying system dynamics to portfolio management.

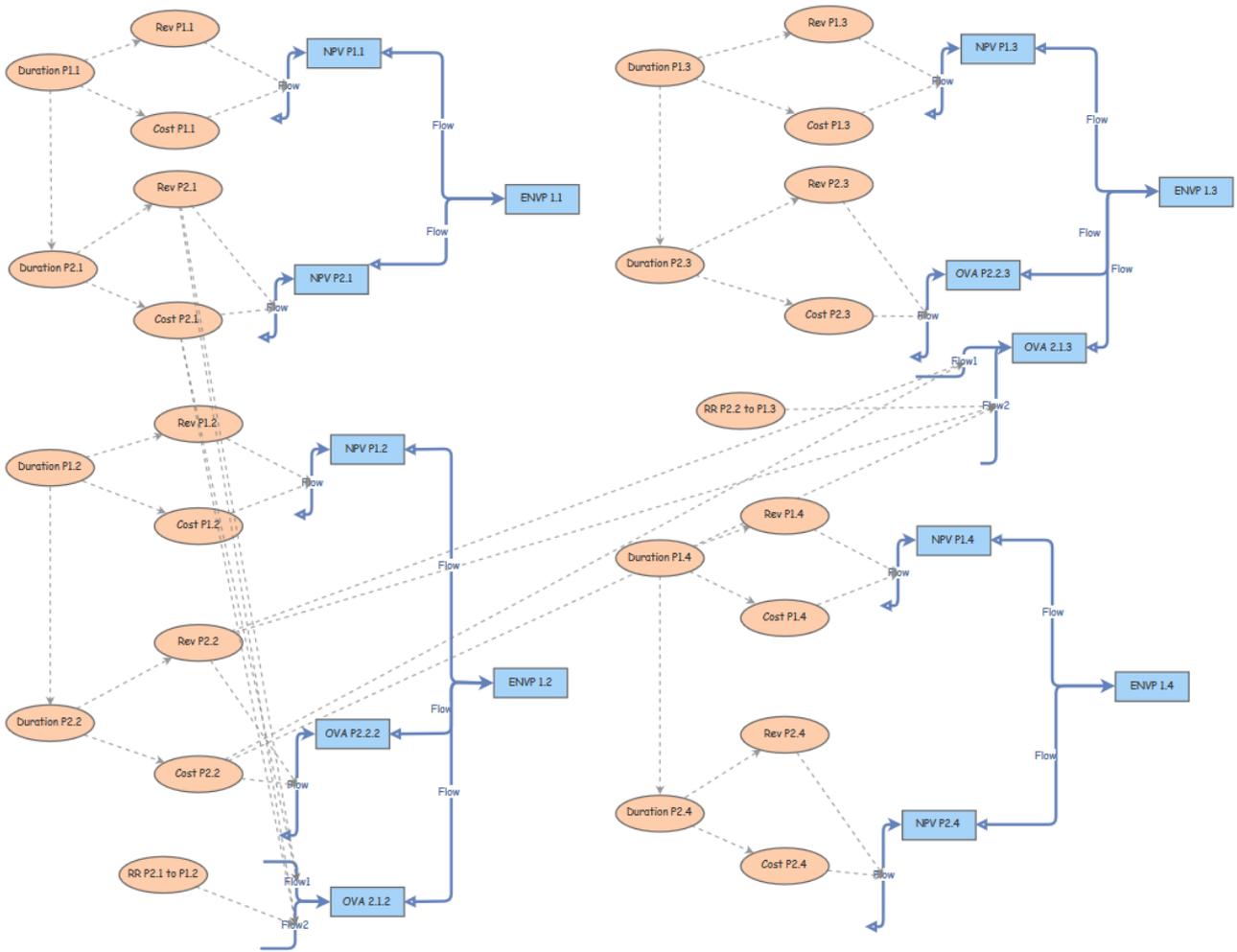
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APPENDIX

A. INSIGHT MODEL OF CASE STUDY



B. COMPARISON OF TOOLS

Criteria of comparisons:

1. Visually intuitive overview
2. Ability to create hard and soft dependencies
3. Ability to visually see the connections between projects
4. Ability to see the cycles or periods the projects are planned in
5. Ability to create a model of an architecture quickly
6. Ability to simulate what-if scenario's

Table with comparisons

Tool	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6
Planview	Somewhat, could be more intuitive	Somewhat, ability to subcategorize, but not to lay dependencies with weights. Different scenario's are possible	No, Only for subprojects, not for dependencies	Yes, Scheduling is part of the tool	Yes, many calculations are done automatically without having to enter data yourself	Yes, one can model scenario's
Trikell	Yes, many overviews offer dashboards, with only tables where necessary	Yes, allowing What-If scenario sketches	Yes, there exist built in dashboards for that	Yes, Scheduling is part of the tool	Yes, many calculations are done automatically without having to enter data yourself	Yes, there is a dedicated option for this
Insight maker	Yes, With easy changable simulations	Yes, by inserting formula's as discussed in the case.	Yes, links can be created	Somewhat, you can drag items to specific places on the canvas or enable parameters in the simulation	No, Insight maker is very time consuming	Yes, by changing values of variables
New tool	Yes, the tool is intuitive	Yes, it is possible to create dependencies	Yes, although not visually pleasing, it is possible	Yes, using different columns	Yes, it can be created in little time	Yes, by running multiple simulations

Table 3. Comparison of different tools