CIRRELT
1971 - 2021

CIRRELT-2022-08

A Data-Driven Simulation of Business Model Design with the Value Management Platform: A Case of Aircraft End of Life Business

Marzieh Ghiyasinasab
Samira Keivanpour
Henk de Man

March 2022

Bureau de Montréal
Université de Montréal
C.P. 6128, succ. Centre-Ville
Montréal (Québec) H3C 3J7
Tél : 1-514-343-7575
Télécopie : 1-514-343-7121

Bureau de Québec
Université Laval,
2325, rue de la Terrasse
Pavillon Palasis-Prince, local 2415
Québec (Québec) G1V 0A6
Tél : 1-418-656-2073
Télécopie : 1-418-656-2624

A Data-Driven Simulation of Business Model Design with the Value Management Platform: A Case of Aircraft End of Life Business

Marzieh Ghiyasinasab[1, *], Samira Keivanpour[1], Henk de Man[2]

1. Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT), and Department of Mathematics and Industrial Engineering, Polytechnique Montréal
2. VDMbee, Veenendaal, Netherlands

Abstract. This paper presents a case-study of modeling aircraft End of Life (EoL) in Value Delivery Modeling Language (VDML). VDML is a standard value-based business modeling language for developing conceptual models that can be applied in an interface named Value Modeling Platform (VMP). In VMP the business can be represented as an ecosystem of all partners, players, and customers. It is also designed to cover the concept of continuous business model planning to track and plan changes in the business. The purpose of this paper is to present the EoL case model as an educational simulation/game for interactive learning of the business ecosystem and value chains. First, the main elements of modeling with VMP and four business models for aircraft EoL services are presented. Then, steps of modeling a case of EoL in VMP are elaborated and suggestions to apply this model as an educational tool are discussed. This study provides an online accessible educational and business simulation that integrates value-based modeling for both strategic and operational levels with the possibility of playing with various scenarios. Besides the educational purposes, the presented model contributes to business modeling research as an example of data-driven continuous modeling and its application in EoL business.

Keywords: Conceptual modeling, enterprise modeling, value modeling, VDML, business model planning, simulation game, EoL

Acknowledgements. The authors of this article would like to thank the department of mathematics and industrial engineering of Polytechnique Montreal for the pedagogical project fund (FSE).

---

* Corresponding author: marzieh.ghiyasinasab@polymtl.ca

Dépôt légal – Bibliothèque et Archives nationales du Québec
Bibliothèque et Archives Canada, 2022

1- Introduction

Value chain connects all components of a business. Therefore, understanding the entire value chain is critical to sustaining strategic goals (Rafati et al. 2018). Value models can fill the gap between strategic modeling and operational concept which is related to process modeling (Poels et al. 2018). Value modeling that takes into account values inside an organization, as well as exchange of value with the external network, is getting increasing attention (Langhe 2017). However, there is a lack of platforms that could implement flexible and integrated value-driven modeling (Poels et al. 2018).

To fill this gap, the Object Management Group (OMG) developed the Value Delivery Modeling Language (VDML) which is a standard modeling language for analysis and design of the operation of an enterprise with particular focus on the creation and exchange of value (Object Management Group 2015). Their model aims to integrate many concepts of other value modeling and business modeling approaches. To apply VDML in an interactive and user-friendly way, a software tool named Value Management Platform (VMP) is accessible (Poels et al. 2019). In VMP, it is possible to take the point of view of each stakeholder in the network and follow their role and values while keeping the link between them and the main business. VMP provides a managerial dashboard that supports strategic to operational level of value chain and business decision-making (Poels et al. 2019).

VMP is rather new and there are not many studies about its application, potential benefits, and limitations. Besides the functions of using VMP for business development, the ability to simulate the entire network and develop improvement scenarios makes it an appropriate tool to be applied for learning and educational purposes. Business simulation games are imitations of real enterprises that allow learners to understand various aspects of business and practice decision-making roles in a risk-free environment (Buil et al. 2018). These simulation platforms provide important motivational and learning tools that enable instructors to make a bridge between theory and practice via active engagement (Loon et al. 2015).

The motivation of this article is to provide a use-case of applying VMP for educational purposes. We introduce aircraft End of Life business which has been investigated in previous studies (Keivanpour et al. 2017) and then model it in VMP to utilize the abilities provides by this platform.

Since EoL is a complicated business with various stakeholders, it provides an opportunity to make a simplified learning case that has potential for future investigations and expansion for interested learners. Moreover, this use-case is chosen as an example of a sustainable supply chain and opportunities for environment-friendly decision-making. The case is available on the website of VDMbee (www.vdmbee.com) and there is open access to be used for educational purposes.

The contribution of the paper is to present an interactive environment for business modeling that can be evaluated in an educational setting. Moreover, it provides an instructive approach to demonstrate the necessity of business modeling for aircraft EoL process. Meanwhile, the online accessibility of the platform will provide an educational subject for learners.

In the remaining parts of this paper, brief literature about the application of simulation and games for teaching operations management is presented in section 2, followed by an introduction to VMP in section 3. In section 4, the EoL case and the steps of its modeling in VMP are described. Discussion is presented in section 5, which is followed by conclusions in section 6.

2- Simulation and games for teaching operation management

Business games have a long and varied history, tracing back to war games that were used in ancient China (Faria et al. 2009). Faria et al. (2009) presented the review of development of business gaming of the past forty years. According to their report, modern business simulation games can be dated back to 1932 in Europe and 1955 in North America. Wolfe (1993) divided business games into top management games, functional games and concept simulations, which can respectively be corresponded to strategic, tactical and operational planning. With the increasing general recognition of games and simulation models as tools for imitating real systems, they started to be applied as a teaching tool for acquiring management experience in management and industrial engineering courses (Lewis and Maylor 2007). Early applied simulations were simplistic regarding the number of decision variables such as participants, products, markets, and the amount of feedback available to the participants. By advancements in technology and management studies, business simulations got more popular and nowadays business simulation/games can be applied on personal computers or online platforms.

In the past forty years, several simulation games have been developed and applied for operation management education purpose. One of the most famous examples is named “Beer Distribution

Game” which was developed and used at Massachusetts Institute of Technology (Sterman 1989). The Beer Game is developed based on works of Forrester (1961) on the concept of system dynamics and simulates the environment of supply chain stakeholders and collaboration between different involved parties. Other examples of games provided by Bringelson et al. (1995) and Chang et al. (2009) to practice supply chain, operation management and marketing activities. Some simulation games with pedagogical purposes were developed with the use of discrete event simulation (Battini et al. 2010, Haapasalo and Hyvönen 2001, Chwif and Barretto 2003, and Costantino et al. (2012)). In order to get a complete and holistic review and analysis of operation management games, we refer the readers to Lewis and Maylor (2018).

According to Geithner and Menzel (2016), the use of business games is beneficial for both learners and educators to reach the purpose of active learning. Using business simulation to teach operations management can be described as “learning by doing”, and improves the students’ learning experience (Matute and Melero 2016, Buil et al. 2018). This learning method can improve skills such as decision-making, teamwork, analysing information, and system thinking (Loon et al. 2015, Buil et al. 2018). Therefore, learners would learn educational concepts as well as getting prepared for the real business world (Borrajo et al. 2010, Doyle and Brown 2000). Some studies investigated the impact of simulation games from the point of view of operations management course students (Pasin and Giroux 2011, Fitó-Bertran et al. 2014). Students reported their experienced simulation games as an effective learning tool that helped them with personal control and self-esteem, teamwork, and understanding the fundamentals of business administration and developing strategies.

Among the previously applied simulations, few of them are value-based models. Also, value models usually present a qualitative approach and do not integrate quantitative aspects. The simulation presented in this paper contributed to the existing simulations by providing value-based modeling that has the potential of qualitative analysis and integrates strategic and operational decisions.

3- Description of Value Management Platform

In 2016 a Dutch company named VDMbee presented a software tool to apply VDML in an interactive and user-friendly way (Poels et al. 2019). The approach to value modeling adopted in the VMP is called continuous business model planning (CBMP). The word “Continuous” comes from the idea of iterative approaches, in each phase of modeling. After design of the first phase, analysis and monitoring of the current situation would lead the decision-makers toward potential improvements to be defined in the next phase. The closed-loop of Deming plan-do-study-act (PDCA) cycle is considered to develop and execute strategy in a continuous way. VMP contains three main stages naming (1) discover, (2) prototype and (3) adopt (figure 1). In the discover stage, the user gets an opportunity to identify the core elements of their business in a coherent set of graphical maps (diagrams). The prototype stage, the linkage between elements of the ecosystem is considered to make an integrated multi-perspective environment. And in the prototype stage, managerial dashboards will be created to analyse the business ecosystem and test scenarios.

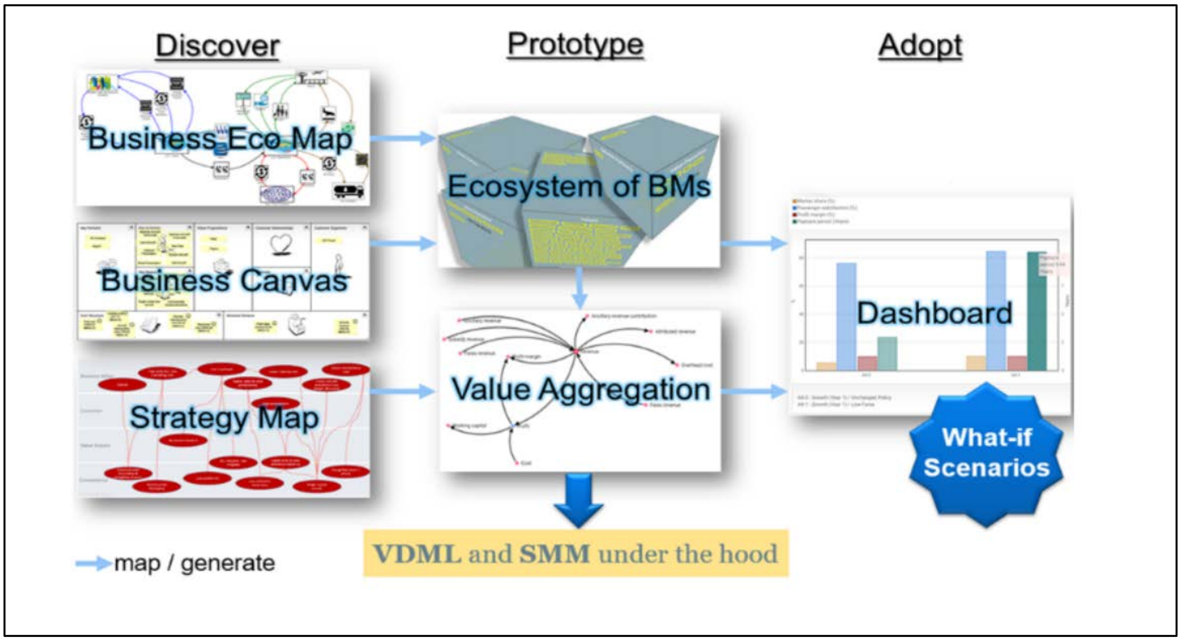


Figure 1. Three main stages of VMP source (Poels et al. 2018 page 3)

3.1 Discover Stage

Ecosystem map: To begin with, in the “discover stage” there is a business ecosystem map to be created. Ecosystem map is an implementation and variation of the VDML-defined value proposition diagram. In this map, one or more businesses (enterprises), their partners, and markets (or customers) are being created. Also, the value that will be exchanged between every two participants that have interaction should be identified (by value propositions). For example, if there is a product to be sold, important values such as volume, and price can be identified and modeled. This map will be linked to other parts of the total model in succeeding steps.

Business model: Each business that is defined in the ecosystem can have a business model to identify main elements such as partners, customers, cost, and other elements of the business model canvas. As Osterwalder and Peigneur (2010) business model canvas is the most used and best-known canvas, it's template is available in VMP. However, VMP supports other known variations of business model canvas as well. The business model canvas template is ready to be chosen by the user and will be linked to the ecosystem in the next steps.

Value stream map: In value stream map, for each identified provided value proposition, related activities, together with the competencies that they require, can be defined and then be linked to the value proposition that is exchanged in the ecosystem. This map is consistent with the Value Stream map as promoted by the BizBoK guide of the Business Architecture Guild (2018).

Strategy map: Strategy map is an important map that would be a guideline to understand the relationships between various partners and various levels including business value (e.g., profits), customer, value stream (e.g., components of profit) and competencies. Each business that has a business model can have its strategy map to have an overview of how value is created for itself and its customers, based on its value streams, that involve its partners and competencies. Strategy maps are used to depict the value creation story from the perspective of each business model-owning participant in the ecosystem. The layout of strategy map in VMP is adopted from the Kaplan and Norton (2004) strategy map, whereby nomenclature is tailored to value delivery modeling needs, and the layout of the map can easily be customized to the modeler's needs.

3.2 Prototype Stage

In the prototype stage, the purpose is to create a multi-perspective business model that covers all internal and external relations in the ecosystem. This business model is inspired by business model cube suggested by Lindgren (2013). This representation provides a tool to ensure the balance of all participants in the business model regarding the customer and partner relationships and exchanges of value between all participants in all directions (Poels et al. 2018).

3.3 Adopt Stage

This stage is designed for creating dashboards and using analytical tools to support the decision-making process. Besides the ability to overview the current models, it is possible to create what-if scenarios and alternatives. In the next section, the EoL business of aircraft is described whereby VMP is applied for modeling the EoL case-study.

4- Case of Aircraft end of life

4.1 Management aircraft at EoL

The management of aircraft at their EoL is a new research theme in the circular economy context. With the increasing number of EoL aircraft, more enterprises will join this business. Hence, developing industrial and managerial solutions is essential. The number of retired aircraft is increasing three times in 2020 due to pandemic in comparison to 2019 (Lambert 2020). The airlines require to cut their costs considering the collapse in the aviation industry. The demand for reusable parts is increasing and more airlines consider dismantling and disassembling aircraft as viable options instead of keeping grounded planes in parking. Different key players are contributed to the EoL aircraft problem including aircraft manufacturers, owners/operators, MRO (Maintenance, repair, and overhaul), and parting out companies. Disassembly and dismantling companies play an essential role in this ecosystem. These players are actively collaborated to develop new strategies for optimizing and sustainability of parts recovery. According to the International Air Transport Association report (IATA 2018), three business sectors are involved in aircraft decommissioning processes: Aerospace business, non-aerospace business, and waste sector. After cleaning and draining the liquids, the first process is disassembling of aircraft for recovery of the valuable parts. The recovered parts will be entered to repair shops for required maintenance, re-certification, and airworthiness. These parts can be interred into the second-hand part markets and will be used or traded by airlines MRO or brokers. Valuation and dismantling could be performed without recertification and airworthiness regulation Concerns. The recovered parts or material from this step will be entered into non-aerospace businesses. Downcycling and upcycling or using the parts for other purposes such as decoration are viable options. The rest of the aircraft will be entered into the waste stream including Recyclable and non-recyclable waste for material valorization or disposal.

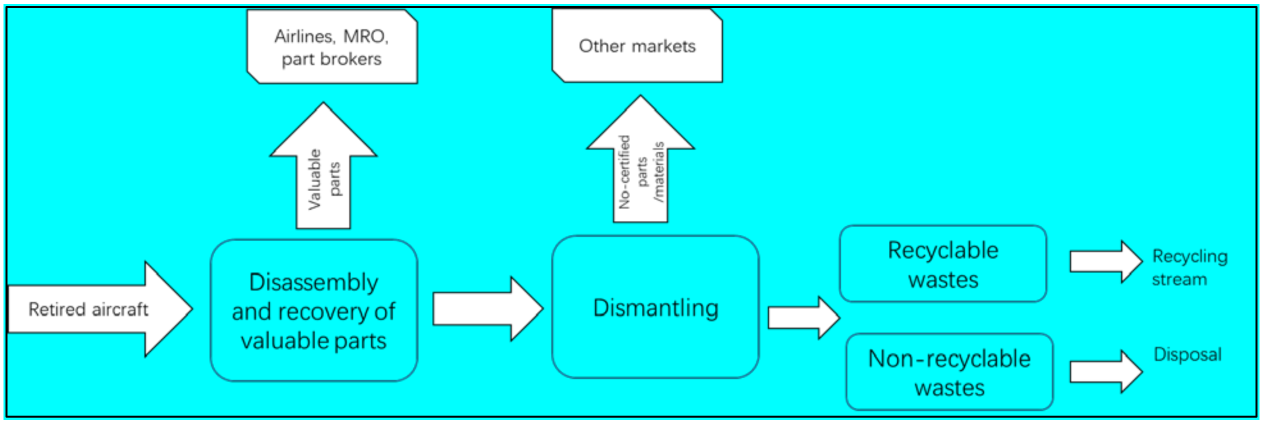


Figure 2. EoL main processes (adapted from IATA (2018))

Based on factors related to the strategy and facilities of the owner of aircraft and EoL stakeholders, different business models can be defined for EoL service. Siles (2011), explained that based on the strategic objectives. The core business concentration point is defined in three ways. In the first type, concentration is on part and equipment management. In these companies, activities related to disassembly, recertification and trading of reusable parts is the priority and treatment of the rest of the aircraft body will be outsourced to another party. In the second type, the main focus is on the remaining parts and carcase after removing the reusable parts of the aircraft. The third type concentrates on environment-friendly activities and recycling. In this case, the green image of the aircraft owner is more important than net profit from EoL. According to Keivanpour (2015), four business models can be assumed for the aircraft EoL process.

Model 1- The owner asks an enterprise to provide all EOL services. Parking and storage, preparation and cleaning, disassembling, part recovery, recertification of the parts and trading. In this model, the waste treatment service will be outsourced and recovered materials will be sent to the appropriate channels.

Model 2- In this model, parking and storage and trading of the parts and materials are assumed to be outsourced. Other subprocesses including a level of waste treatment will be performed by EoL service. In this model, material recovery is not a priority.

Model 3- EoL enterprise performs the storage, cleaning, part removing, trading the parts and components as well as chopping up the skeleton. Then the crushed parts are sent to the dismantling site to extract tradable material and metal from it and landfill the rest. The aluminium alloys will also be sent to smelting facility for recovery.

Model 4- In this model, EoL enterprise provides all of the subprocesses and the only outsourced subprocess is waste treatment service. EoL enterprise is responsible for dismantling and sorting of the material and the stream of the material will be sent to recycling facility.

4.2 Discovery stage for EoL case-study

4.2.1 Ecosystem map

In order to model aircraft EoL in VMP, we make some assumptions to make a simpler business model. Although VMP supports complicated models in real businesses, the simpler model is considered for the educational goal of this paper. The purpose is to demonstrate how we can model a business that has a certain number of partners, internal customers and markets using the VMP. Then we can expand the created model and test other scenarios, other business models and additional types of values, as well as evolutions of business during successive stages of business transformation (EoL innovation). As mentioned in the previous section, a large contribution to profit comes from selling valuable parts such as landing gears, and engines that can be re-used in other aircraft. We choose a variation of business model 3 (presented in section 4.1) where EoL enterprise is responsible for parking and storage, disassembly service and trading reusable parts and the rest of aircraft body is sent to the dismantler. We consider the dismantler (dismantling site) as the main business partner and focus on the costs and profits of this business. In this case, dismantler buys the aircraft body from the owner, outsources the smelting and waste treatment and trades the material to the market, and finally landfills the rest. Main participants of the model are the following (see figure 3):

- Enterprises:
    - Owner
    - Disassembly site
    - Dismantling site (main business in the current model)
    - Smelting site (“Smelter”)
    - Waste treatment site
    - Landfill facility
- Markets:

- Re-usable parts market (traders, MRO companies, aircraft manufacturers, …)
- Scrap Market
- Material Market (traders, material suppliers, components suppliers, ..)

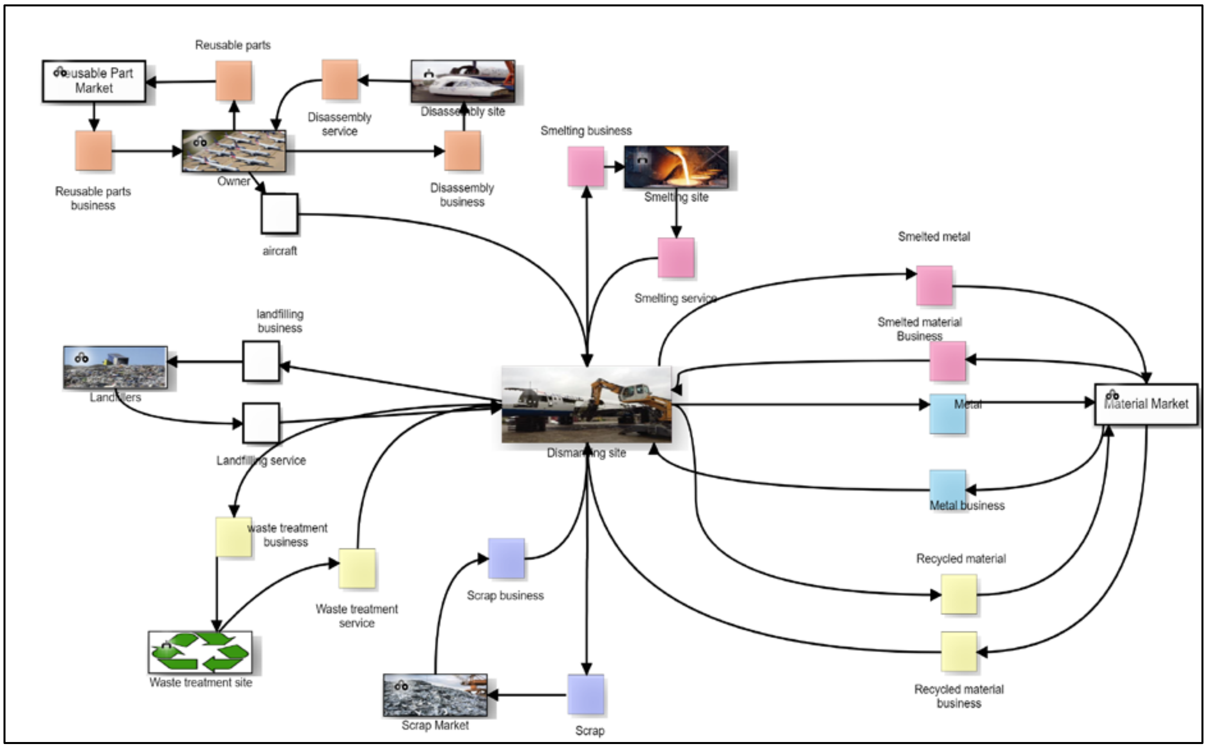


Figure3. Ecosystem map for aircraft EoL example created in VMP (Source of pictures for logos: courtesy of Aircraft End-of-Life Solutions (AELS) Company).

4.2.2 Strategy map

strategy map is a very important tool that is a base for further decisions and maps. To create strategy map, we should first identify the fundamental aspects of the business, including revenue and costs, and their components. The top-level of strategy map is named business value. Let us recall that the maps presented in this paper are from the point of view of the dismantling business model. We define our business values as profit, recoverability ratio and landfill ratio. Landfill ratio simply implies the volume of the material that is landfilled at the end. Respectively, recoverability ratio is defined as the total volume of material that is sold as scrap, metal and other material, relative to aircraft mass as received from the owner. Profit is consisting of total revenue that is reachable by selling products to the market and total cost that comes from paying for services, activities and buying the aircraft from the owner. Detailed components of total cost and revenue, which also typically occur in the business model canvas as “revenue streams” and “cost structure”, are as follows:

- Total revenue = dismantled metal revenue + recycled metal revenue + smelted metal revenue + scrap revenue
- Total cost = aircraft (buying) cost + smelting cost + waste treatment cost + landfill cost

The second layer of strategy map concerns the customers (customer value) and their effect on business value. We have four markets that should be linked to four sources of revenue. Here we add values that matter to the customer, and that affect each revenue and provide us with the formulation for calculation of revenue in the next steps.

- Dismantled metal revenue = dismantled metal volume * dismantled metal price
- Recycled metal revenue = recycled metal volume * recycled metal price
- Smelted metal revenue = smelted metal volume * smelted metal price
- Scrap revenue = scrap volume * scrap price

The third level in the strategy map is about value stream and definition of costs and volumes, that occur at value stream level. The main question is how we define the volume of each component of the model. We assume when the dismantling site buys an aircraft, the unit of purchase is "tons" of aircraft mass. Units can be easily modified in VMP. Other volumes, including the amount that will be sent for smelting, the amount of metal extracted directly from dismantling, the scrap and the amount that will be sent to waste treatment volume, are expressed as a percentage of aircraft volume. Dismantled metal and scrap will be directly sold to the market and we assume that the market is willing to buy all of the offered material. From the material sent for smelting, it is aimed to extract the maximum possible amount of smelted metal. However, a percentage of it will not be useful and will be landfilled at the end. Similarly, from the waste treatment volume, there will be a percentage of extracted recycled material and the rest will be landfilled. Formulas and percentages that are applied to this case are listed in table 1.

Table 1- Variables and formulas applied for EoL model (unit of volumes is tons per year)

VA	Aircraft volume		-
PS	Percentage of *VS* extracted from *VA*		-
VS	Smelting volume		*VS = PS * VA*
	PSm	Percentage of metal extracted from *VS*	-
	VSm	Smelted metal volume	*VSm = PSm * VS*
	VSl	Landfill from smelting	*VSl = VS - VSm*
PD	Percentage of *VD* extracted from *VA*		-
VD	Dismantled metal volume		*VD = PD * VA*
PSc	Percentage of *VSc* extracted from *VA*		-

VSc	Scrap volume		$VSc = PSc * VA$
VW	Waste treatment volume		$VW = VA - VS - VD - VSc$
	PR	Percentage of Recycled material extracted from VW	-
	VR	Recycled material volume	$VR = PR * VW$
	VWl	Landfill from waste treatment	$VWl = VW - VR$
VL	Total landfill volume		$VL = VSl + VWl$

Parameters and formulas described in table 1, can be filled by real numbers from a company or hypothetically for a learning objective. To continue the example of this case, we applied hypothetical numbers and percentage in the model and achieved the results of calculations performed in the model. The example is illustrated in table 2.

Table 2- hypothetical input data and results of formulas for EoL example

VA	300 ton/year	
PS	30%	
VS	30% * 300 = 90 ton/year	
	PSm	70%
	VSm	70% * 90 = 63 ton/year
	VSl	90- 63 = 27 ton/year
PD	30%	
VD	30% * 300 = 90 ton/year	
PSc	10 %	
VSc	10% * 300 = 30	
VW	300 – 90 – 90 – 30 = 90 ton/year	
	PR	60%
	VR	60% * 90 = 54 ton/year
	VWl	90 – 54 = 36 ton/year
VL	27 + 36 = 63 ton/year	

Now we can identify cost components in a way similar to how we identified revenue components, namely by multiplying volumes and service costs (prices paid for services). The only different formula is for dismantling cost which regards to the costs of activities inside the dismantling business instead of asking services from outside. The formula of dismantling cost is calculated by summation of the costs of operational activities such as chopping, cleaning and sorting of aircraft. We simplified dismantling operation costs in three main groups. Cleaning & sorting cost (metal) implies the activities to extract metal from the aircraft body. It is linked to dismantled metal volume as the better quality of cleaning and sorting can increase the amount of metal extracted. Chopping cost (smelting) implies the chopping activity to create input for smelting. Cleaning & sorting cost (scrap) implies the activities to separate scrap from the other parts of aircraft.

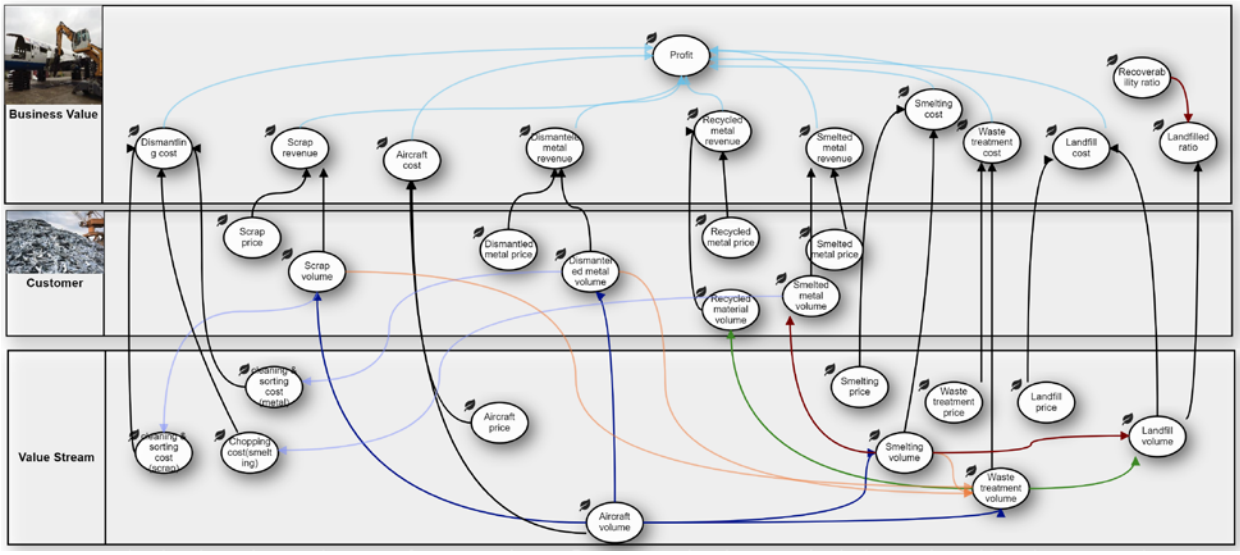


Figure 4. Strategy map for aircraft EoL model

By creating the ecosystem map, business map and strategy map, we had identified the whole story of our business and therefore the discovery stage is completed. In the next section, we will describe the business model cube which is created by mapping (transforming) all components and values of the system into an integrated structured model, based on the VDML meta-model.

4.3 Prototype stage for EoL case-study

In the prototype stage, we can see that, based on mapping of ecosystem map, value stream maps and strategy map, the business model cube is created (illustrated in figure 5).

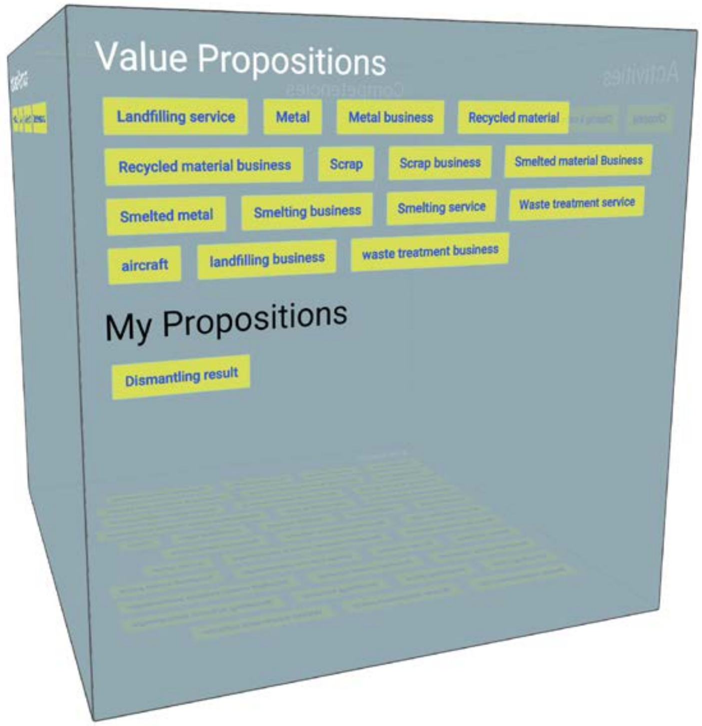


Figure 5. Business model cube for EoL case-study

In this stage, all details of values and calculation formulas should be added, in order to make the model computationally complete. Starting from the top level of strategy map, which contains elements of profit, recoverability ratio and landfill ratio, which occur in the business model cube as values of “my proposition”. The reason for this labelling is that these three elements comprise the business value that the owner of the business model gains from it. Each element of profit should be computationally completed by filling the information of formula and links to where it is aggregated from and will be aggregated to. For example, formula for calculating the cost of waste treatment service is defined as multiplying waste treatment price and its volume. Therefore, the waste treatment cost is aggregated from these two values and is aggregated to profit as it is part of the calculation of profit. Figure 6 illustrates this, based on the user interface on the business model cube in VMP. It should be mentioned that the numeric values for volume and cost rate, are hypothetical at this point, though based on common sense. In case of applying this platform to real-world businesses, the values will be the real values, while, for teaching purpose, the values can be assumed by the players. Other “dimensions” of the business model cube are participants, value propositions, activities, values, and competencies, each represented by a specific tab in the user interface. The information related to the business model cube has been added in previous mappings and can be edited or completed in this step.

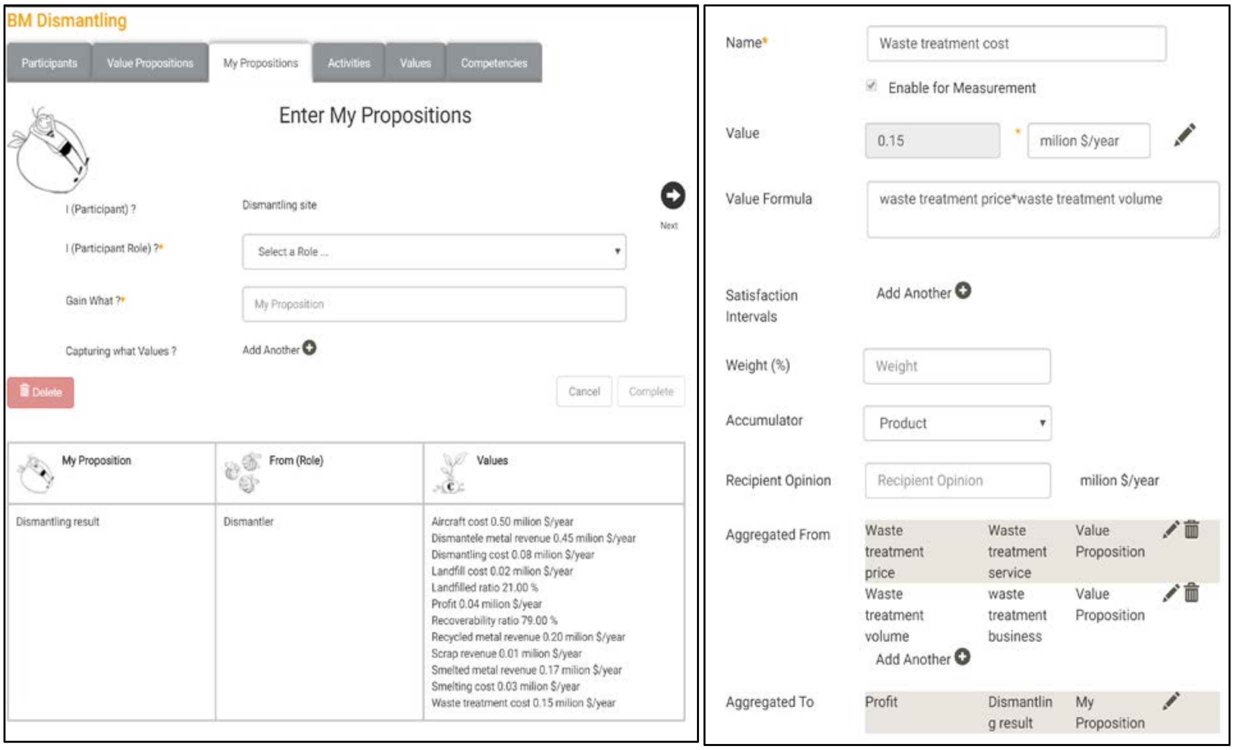


Figure 6. Adapting stage for top-level values

In the tab named participants, the main business (dismantling), and the customers and partners including their roles are created. They can be reviewed, managed and modified here. In the value proposition tab, each value proposition is listed as well as its components (values), its provider and receiver. For example, aircraft is a value proposition that comes from the owner to the dismantling business. Components of this value proposition are aircraft volume and aircraft price. The first tabs for participant and value proposition tabs are represented in figure 7.

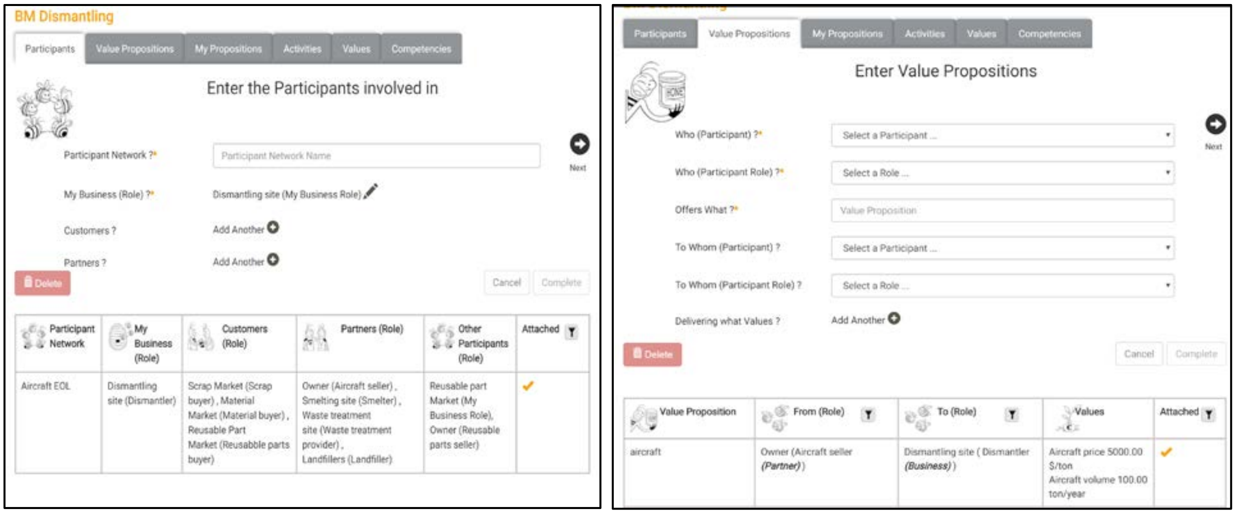


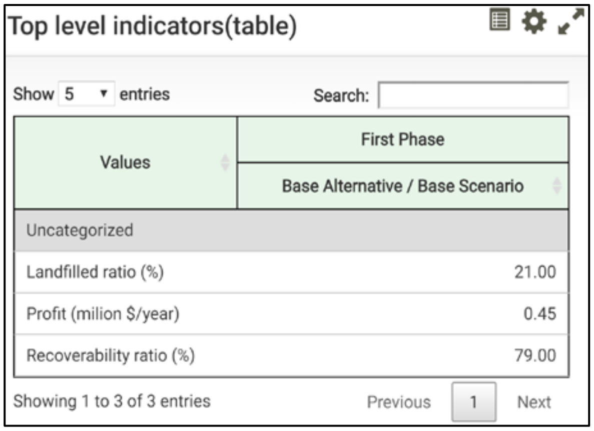
Figure 7. Participants tab(left) and value proposition tab(right) in the business model cube

4.4 Adopt stage for EoL case-study

After completion of prototyping, so that the model is now computationally complete, whereby calculation formulas are now also demonstrably correct, we can go the adopt stage. The adopt stage provides two main decision-support tools. One is an integrated framework to configure interactive dashboards, with a variety of tables and charts to analyse the value chain and key performance ("value") factors of the business. The second is about creating what-if scenarios and compare them. In this section, the adopt stage for the EoL case is presented.

4.4.1 Managerial dashboard

Here we can create dashboards to observe the performance of the system and create scenarios based on them, to change variables (input values) and see and compare the results. The learning audience would have access to this part without requiring to be able to make or adapt the structure of the total model. For the EoL case, we create a top-level indicators table and can monitor these indicators in table format while other formats such as bar chart or pie chart can be chosen as well. As illustrated in figure 8 (table of top-level indicators), given selected input values, the landfilled ratio is 21 %, comparing the 79 % recovery ratio and total profit is 0.45 million dollars. Another presentation (or gadget) that we can create is the chart of profit and revenues that shows every element of revenue. As it is illustrated in figure 8 (right), selling dismantled metal is the larger component of profit.


Top level indicators(table)

Show 5 entries Search:

Values	First Phase
	Base Alternative / Base Scenario
Uncategorized	
Landfilled ratio (%)	21.00
Profit (milion $/year)	0.45
Recoverability ratio (%)	79.00

Showing 1 to 3 of 3 entries Previous 1 Next

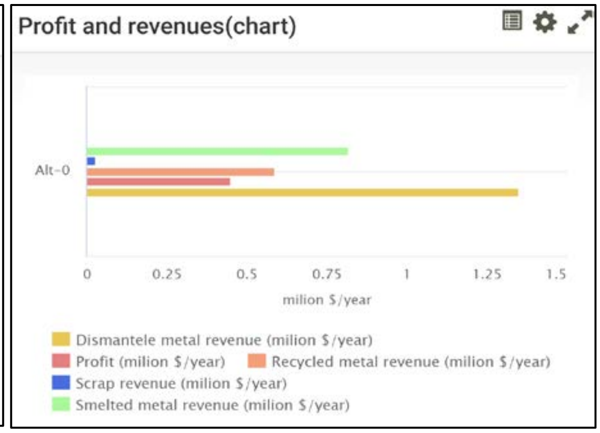


Figure 8- Dashboard of top-level indicators (left) and profit and revenues (right)

It is possible to create a rich variation of charts at this stage, supporting analysis from multiple viewpoints. Another example is breakdowns of revenue and costs. Revenue breakdown shows components of revenue and cost breakdown shows components of cost elements for the cost. As it is illustrated in figure 9 (right) the main component of cost breakdown is aircraft price. In short, charts and tables in this stage provide an analytics dashboard and a holistic overview of the business and its components.

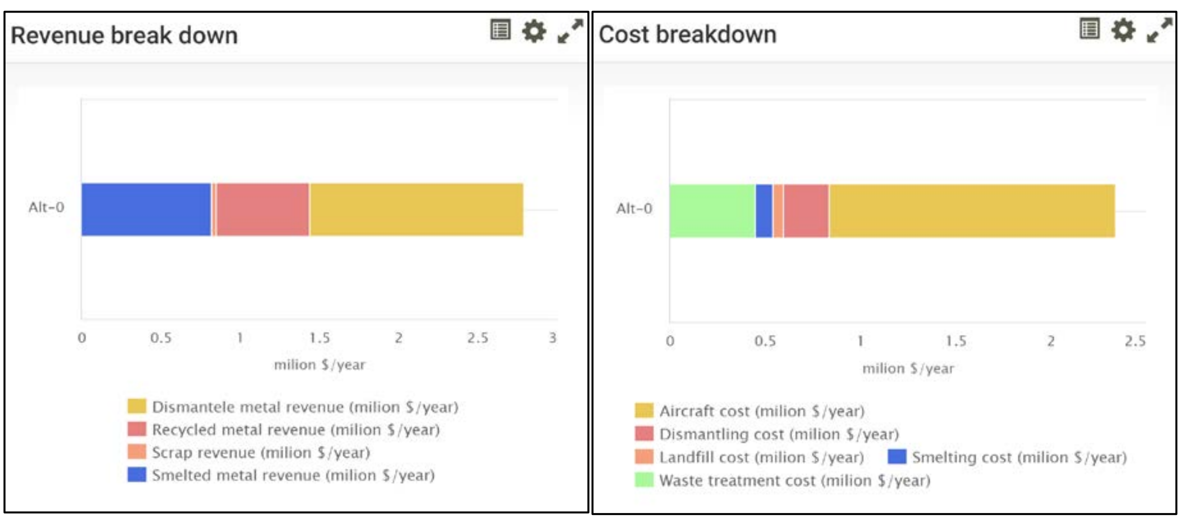


Figure 9 – Revenue break down (left) and cost break down (right) for EoL case-study

Before introducing the scenarios, it is worth to mention another useful facility is that by clicking on each value in the dashboard, the user can see a dynamically built value aggregation view that shows how each value is aggregated from which source value and how it influences (i.e., is aggregated to) which other values. For example, for the landfilled ratio (figure 10) the value aggregation view shows each component of the value chain. This chart can be expanded, on-demand, interactively.

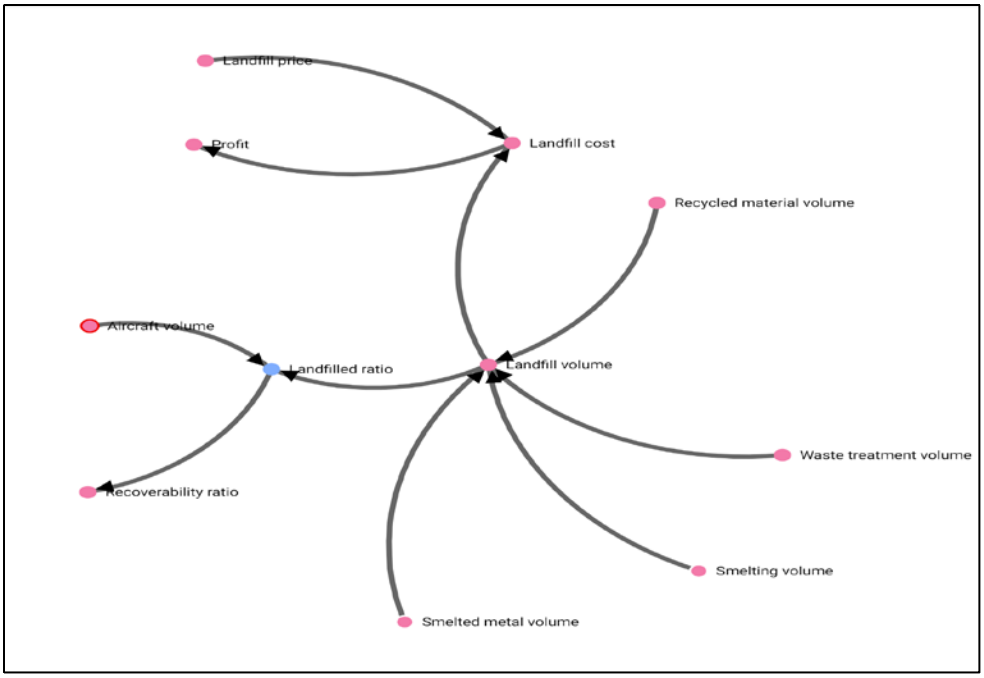


Figure 10 – Value aggregation view

4.4.2 Scenarios and alternatives

The last part of the model description is about creating and testing scenarios. As mentioned before, we can consider changes and alternatives from strategic levels to the operational level. As an example, we consider a scenario of improving the sorting and cleaning activities, assuming that better sorting increases the extracted metal from the dismantling process. Better sorting requires applying enhanced equipment and manpower that is costly. Therefore, we would like to analyse the effect of increasing operational cost on total profit. Figure 11 shows the scenario window and new values for cleaning and sorting rate, and percentage of metal extracted from sorting.

Scenario* Improved sorting for dismantled metal

Search: Show All Phases

Input Values	First Phase
	Base Alternative
Cleaning & sorting rate	4000.00 ($/ton)
Dismantling metal volume percentage	0.40 (%)

Showing 1 to 2 of 2 entries Previous 1 Next

Figure 11- Scenario window and entry of new values

The results as illustrated in figure 12, show that the considered scenario will improve both profit and recoverability rate.

Top level indicators(table, snenarios)

Show 5 entries Search:

Values	First Phase	
	Base Alternative / Base Scenario	Base Alternative / Sorting
1-Top level indicator		
Landfilled ratio (%)	21.00	17.00
Profit (milion $/year)	0.45	0.50
Recoverability ratio (%)	79.00	83.00
2-Input factor		
Cleaning & sorting rate ($/ton)	2000.00	4000.00
Dismantling metal volume percentage (%)	0.30	0.40

Showing 1 to 5 of 5 entries Previous 1 Next

Figure 12- Comparing the indicators for the base plan and scenario of improving sorting

4.4. 3 List of suggested scenarios and changes for future

In the previous section, an example of scenario testing was presented while various scenarios and alternatives can be identified. VMP is designed to support the long-term evolutions and changes in the business. The model, in this case, is created in the first phase and the future changes can be adapted to new phases while keeping the first phase unchanged. Also, for each phase, it is possible to keep add alternatives. Moreover, what-if scenarios can be defined across phases (and their alternatives) to provide a variety of ways to analyse permanent changes or changing scenarios. In this section, some suggestions for scenarios and alternatives to the model are listed regarding the expansion of the model, changing the input variables or changes in the business model strategy.

- The model can be expanded by adding other businesses and partners involved in the EoL that was not considered in the current model to avoid complexity. For example, the logistic partner and energy market can be added.
- Analyze the business model for other key partners in the ecosystem.
- Scenarios based on changing variables can be tested such as change in the volume of aircraft bought per year, or the price of selling products or asking for services.

At the strategic level, the alternative business models that are described in section 4.1 of this article can be considered to make alternatives and scenarios.

- As it is suggested in business model 1, the EoL enterprise can be responsible for activities such as parking and storage, disassembly and dismantling. The model can follow the point of view of the owner or the EoL enterprise. Another strategy is regarding profit sharing. EoL enterprise might ask for a service fee or to be beneficiary from selling the valuable parts. Buying the whole aircraft might not be an option in this case.
- As described in business model 2, the model can be changed as trading of the materials and parts be outsourced. In this model, the percentage of recovery is lower as the owner is not willing to pay much for the waste treatment and recovery services. Comparing the profit and recoverability rate would be interesting in this model.
- Model 3 is adapted for this case while it has changed and simplified. Other alternatives can be considered to be tested. First of all, the role of EoL enterprises and the value of trading reusable parts can be added to the model. The business can be analyzed from the point of the owner or EoL enterprise as well. According to the profit-sharing, dismantling business can claim for a services price while the benefit of selling material goes to the owner.
- Model 4 can be adapted by making a model similar to model 1 while adding sorting activity for EoL that increases the possibility of material recovery.

5- Discussion and lessons learned guidelines for teaching

This paper expects to get attention from three groups of audience. First the readers with an interest in value management modeling. The second group would be the readers interested in EoL business and case studies and analysis in this area. The third group would include the readers interested in educational tools and teaching operations management or related concepts via interactive methods. For educational purposes, this paper can be useful for university courses or business workshops outside the academic context. Therefore, some guides and lessons learned points about managing teaching classes and workshops are presented in the next paragraph.

VMP has been used in classroom training by students at multiple universities, during several years. For instance at the University of Turin, where the first year a case-study from the VDMbee website was chosen and the second year a primary version of EoL case was applied by multiple master classes during a workshop, as part of their design thinking course. VMP and be installed from the VDMbee website and the EoL case-study and model can be downloaded for use. Dependent on the time available for, and strategy of the course, different approaches can be adopted. Lessons learned from experiences during workshops provided some guidelines that helped the authors in writing this case paper and might help to apply the case (or a case like this) for educational purposes:

- For a workshop or a session of a course where there is not much time for the students to understand the modeling phase, it is more efficient to use a prepared model and let the students benefit from analysis, whereby they focus on the dashboard and try pre-defined what-if scenarios. In case more time can be devoted to this subject or when groups of students are engaged in a modeling project, expansion of the model and adding phases and parameters would be a useful practice for the students.
- The current case can be applied by students in teams of three to four and they can design scenarios that would ultimately improve all or most of the KPIs. The evaluation can be based on the benefits and sustainability of decisions. In case the model is expanded, involving multiple businesses (and their business models), it would be interesting if each group of students would associate with “their” business model (and related perspective) in the ecosystem. By this a “business game” setting is achieved, whereby the different groups (as teams), through their respective business models, collaborate, for purpose of achieving best global win-win, beneficial for each of them, as well as for the “environment” (e.g., society and ecology).
- It would be helpful to provide a precise plan for managing the course. This includes the introduction of the model and the course, assigning groups, and asking the groups to analyse the scenarios and make a report based on what they learned and the ideas they had.

- The feedback from the students of design thinking was positive in terms of getting an opportunity to understand and practice many aspects of a business. In particular, the practical and hands-on approach of value delivery analysis around their (often technologically focused) innovations, was an eye-opener to them.

6- Conclusions

In this paper, we introduced the VMP platform as a business user-oriented tool to apply VDML and presented a case-study that has been developed for educational purpose. A case of simplified modeling for aircraft EoL business was presented to provide a guideline for understanding the stages of ”value delivery management”. This paper has at least three contributions.

The first contribution is to introduce the VMP platform and increase the maturity of value modeling by introducing steps of applying the platform to a tangible case-study. VMP has some unique characteristics that attracted the authors to consider it as an effective interface. It is a user-friendly tool for working with VDML that provides various kinds of business maps and templates such as business canvases, business ecosystem maps, strategy maps, business model cubes, and interactive dashboards, together with providing a consistent view of the integrated structured model, based on VDML. The user can benefit from this platform even without knowing VDML. VDML guides and supports businesses in their strategic planning process while connecting strategy and operations and considering the concept of continuous improvement. Ultimately, VMP does not just support modeling, but analysis is possible as well. The second contribution is to provide educational material for interactive workshops and teaching classes. The novelty of the platform, and simplicity of the introduced case are the motivations for considering this case as a pedagogical simulation platform. The third contribution is to present the process of EoL business with focus on sustainability.

However, that, though this study highlights the unique opportunity to apply VMP (and by that, VDML) in an educational setting, it is also limited. It is not a tutorial to explain how to use all features of VMP. The EoL case, as presented in this paper, represents a simplified view of EoL business, based on assumptions. Further exploration of this case may lead to expanding the EoL model by including more partners and stakeholders as well as future phases of the strategic plan to transform EoL business in the scope of the case.

References

Borrajo F, Bueno Y, de Pablo I, Santos B, Fernández F, García J, Sagredo I (2010) SIMBA: A simulator for business education and research. *Decision Support Systems*, 48, 498–506. https://doi.org/ 10.1016/j.dss.2009.06.009

Battini D, Faccio M, Persona A, Sgarbossa F (2009) Logistic Game™: learning by doing and knowledge-sharing. *Production Planning & Control* 20:724–736.

Buil I, Catalán S, Martínez E (2018) Exploring students' flow experiences in business simulation games. *Journal of Computer Assisted Learning*. 34(2), 183–192. https://doi.org/10.1111/jcal.12237

Bringelson L S, D M Lyth, R L Reck, Landeros R (1995) Training Industrial Engineers with an Interfunctional Computer Simulation Game. *Computer Industrial Engineering*. 29:89-92.

Business Architecture Guild (2018) A Guide to the Business Architecture Body of Knowledge (BIZBOK Guide), Version 7.0 (2018)

Chang Y C, Chen W C, Yang Y N, Chao H C (2009) A Flexible Web-Based Simulation Game for Production and Logistics Management Courses. *Simulation Modelling Practice and Theory* 17:1241–1253.

Chwif L, Barretto M R P (2003) Simulation Models as an Aid for the Teaching and Learning Process in Operations Management. Edited by Chick S, Sánchez PJ, Ferrin D, Morrice DJ. In Proceedings of the *Winter Simulation Conference*. *2003* (Institute of Electrical and Electronics Engineers, Piscataway, New Jersey), 1994-2000.

Costantino F, Di Gravio G, Shaban A, Shaban M (2012) A Simulation Based Game Approach For Teaching Operations Management Topics. Proceedings of the 2012 Winter Simulation Conference. Berlin.

Doyle, D, Brown FW (2000) Using a business simulation to teach applied skills—The benefits and the challenges of using student teams from multiple countries. *Journal of European Industrial Training*. 24, 330–336. https://doi.org/10.1108/03090590010373316

Faria A J, Hutchinson D, Wellington W J, Gold S (2009) Developments in business gaming: A review of the past 40 Years. *Simulation and Gaming*. 40(4), 464–487. https://doi.org/10.1177/1046878108327585

Fitó-Bertran A, Hernández-Lara A, Serradell-López E (2014) Comparing student competences in a face-to-face and online business game. *Computers in Human Behavior*. 30, 452–459. https://doi.org/ 10.1016/j.chb.2013.06.023

Forrester JW(1961) *Industrial Dynamics* (MIT Press, Cam- bridge, MA).

Geithner S, Menzel D (2016) Efectiveness of Learning through Experience and Reflection in a Project Management Simulation. *Simulation&Gaming* doi: 10.1177/1046878115624312.

Haapasalo H, Hyvönen J (2001) Simulating business and operations management - A learning environment for the electronics industry. *International Journal of Production Economics,* 73(3), 261–272. https://doi.org/10.1016/S0925-5273(01)00088-3

IATA (2018) Best Industry Practices for Aircraft Decommissioning (BIPAD). *International Air Transport Association.* Retrieved January 20, 2021, https://www.iata.org/contentassets/ffbed17ac843465aad778867cb23c45c/bipad.pdf

Kaplan R S, Norton D P (2004) *Strategy maps: Converting intangible assets into tangible outcomes* (Harvard Business Press (2004))

Keivanpour S, Ait Kadi D, Mascle C (2017) End-of-life aircraft treatment in the context of sustainable development, lean management, and global business. *International Journal of Sustainable Transportation*. 11(5), 357–380. https://doi.org/10.1080/15568318.2016.1256455

Lambert A (2020) With airline fleets grounded, plane recyclers bet on parts boom Retrieved January 20, 2021, https://www.reuters.com/article/us-health-coronavirus-aviation-focus-idCAKBN26405X.

Langhe D De (2017) the Congruence Between Vdml and Damian a case study: in vehicle signage. Master's dissertation, Ghent University, Ghent, Belgium.

Lewis M A, Maylor H R (2007) Game playing and operations management education. *International Journal of Production Economics,* 105(1), 134–149. https://doi.org/10.1016/j.ijpe.2006.02.009

Lindgren P, Rasmussen O H (2013) The Business Model Cube. *Journal of Multi Business Model Innovation and Technology*. 1(3), 135-182.

Loon M, Evans J, Kerridge C (2015) Reprint: Learning with a strategic management simulation game: A case-study. *International Journal of Management Education*. 13(3), 371–380. https://doi.org/10.1016/j.ijme.2015.10.004

Matute J, Melero I (2016) Aprender jugando: La utilización de simuladores empresariales en el aula universitaria. *Universia Business Review*. 2016(51), 72–111. https://doi.org/10.3232/UBR.2016.V13.N3.03

Object Management Group (2015) Value Delivery Metamodel. Retrieved October 2 2020, from http://www.omg.org/spec/VDML/1.0/

Osterwalder A, Pigneur Y(2010) *Business model generation: A handbook for visionaries, game changers, and challengers* (John Wiley & Sons).

Pasin F, Giroux H (2011) The impact of a simulation game on operations management education. *Computers and Education*. 57(1), 1240–1254. https://doi.org/10.1016/j.compedu.2010.12.006

Poels G, Roelens B, De Man H, Van Donge T (2018) Continuous business model planning with the value management platform. *CEUR Workshop Proceedings*. 2239, 2–19.

Poels G, Roelens B, de Man H, van Donge T (2019) Revisiting continuous business model planning with the value management platform. *CEUR Workshop Proceedings*, 2383(Vdml), 1–7.

Rafati L, Roelens B, Poels G (2018) A Domain-specific Modeling Technique for Value-driven Strategic Sourcing. *Enterprise Modelling and Information Systems Architectures-an International Journal*. 13(SI), 1–29. https://doi.org/10.18417/emisa.13.8

Siles C (2011) Aide à la décision pour la gestion d'un parc d'avions en fin de vie. Master dissertation, École Polytechnique de Montréal.

Sterman J (1989) Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment. *Management Science*. 35 (3), 321-339.