UNIVERSITY OF BERGEN / EUROPEAN MASTER PROGRAMME IN SYSTEM DYNAMICS

Master Thesis

Business Strategy Deltares' Delft3D

How to adjust business strategy of the company according to the changes in the organizational policies

University of Bergen

European Master Programme in System Dynamics

Radboud University Nijmegen

Deltares

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1. Introduction

This thesis work will be devoted to the construction of the model in order to improve Deltares' business strategy and help to the organization to find effective levers for the main goal – spread the modelling software product Delft3D. System dynamics is used by organizations for developing, correcting and adjusting business strategy. It is very useful to have a model that shows possible scenarios of the company's future development. System dynamics is a modelling tool to help the organizational development.

1.1. Background Information

Deltares is an institute for applied research in the field of water, subsurface and infrastructure. The main focus of the company is on deltas, coastal regions, and river basins. Managing these densely populated and vulnerable areas all over the world is complex, which is why Deltares works closely with governments, businesses, other research institutes and universities in the Netherlands and abroad. Their motto is Enabling Delta Life (O. W. Deltares). As an applied research institute, the success of Deltares can be measured in the extent to which their expert knowledge can be used in and for society. For Deltares the quality of its expertise and advice is foremost. Knowledge is core of Deltares' business.

All contracts and projects, whether financed privately or from government research budgets, contribute to the consolidation of Deltares knowledge base. Furthermore, Deltares believes in openness and transparency, as is evident from the free availability of Deltares' software and models. Open source works – is the firm's conviction.

In 2011 Deltares started to spread Delft3D software programme as an open source after 13 years of licensing. With open source strategy Deltares shows that they "dare to share" and believe in switching from a "commercial" perspective, in which licensing is the basis for the revenue stream, to a "value delivering" perspective, where creating value for a client results in a sustainable revenue stream. Deltares wants to strengthen its "strategic positioning as a research institute" (Bruggers, November 13, 2013). Software need to be up-to-date (highest possible standard that will help to contribute the software). The aim is to achieve the bigger market share (the amount of users among the potential clients) in the area of water security software. Deltares is at the stage of transition from "commercial view" to "add value" view.

Here it is very important to understand the difference between "open-source code" software and "free" software. With the "free" one user will get working programme, which he/she can open and immediately start working. "Open-source code" means that user will get the code of the programme

and user does not have to pay for a license. There is also a possibility to ask for the graphical user interface (GUI). But the user still need to compile it together and to do so he/she need to buy the special compiling programme or can buy one of the final version of the programme from the Deltares. It is a scenario for the non-programmers users. If user has a time and programming skills the compiling stage is not difficult.

According to the new policy, the license is absolutely free for any amount of users, but the support and maintenance are costs that depend on the package. In the end, the user will get the working programme, will receive all updates for the programme and agreed amount of time for the support and maintenance if there are any problems during the work with the programme. Because of the same reason (no license payment) it is obvious that the product costs less. It attracted many new companies as clients (see *Figure 1*). The number of users inside the company is varying from 1 till 20 in average. For example, a university is able to have more than 50 users: students simply have classes with Delft3D.

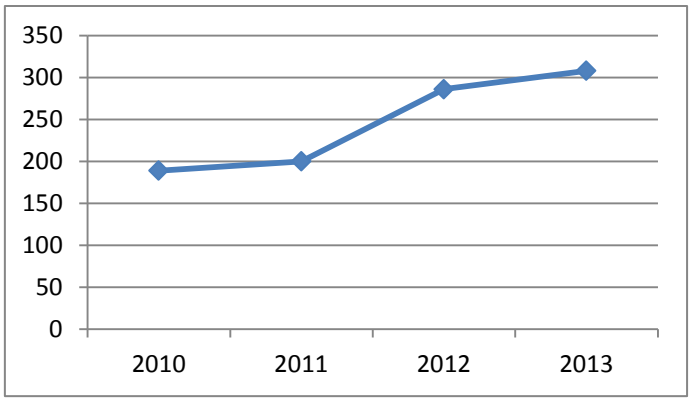


Figure 1. Companies (Delft3D clients)

The main goal for the company: enlarging usage of the product (Delft3D) in order to achieve bigger market share. Deltares wants to see more Research Institutes in the list of clients. Because institutes not just use it, but may help to improve and support the product.

Deltares is a semi-public organization. There are two main sources of the revenue: the 46 % are supported (subsidies) by government (see *Figure 2*), and the last 54 % comes from the sale to public and private sector (Deltares, 2013). The main objective of the company is that software should be widely spread to contribute to the developments in terms of research projects. Profitability in terms of money is a secondary (soft) goal regarding to the software itself. The primary goal is continuing acknowledgement of issues relevant to water security which shows up with new clients.

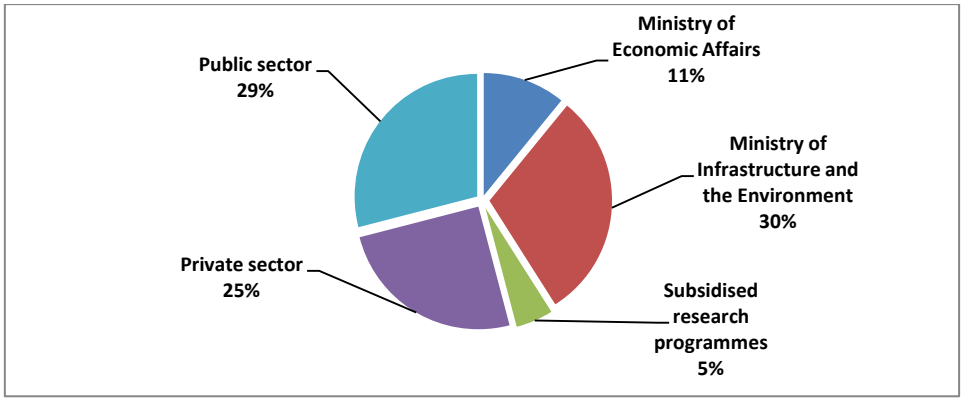


Figure 2. Structure of the Deltares Revenue

As it was mentioned before company policy allows spreading the software among unlimited amount of users inside a company that has bought the support and maintenance package. That is why number of companies/clients in the *Figure 1* does not show the full picture of the users. The number of end users can be approximately assessed through the people that joined Open Source Community of Delft3D. There are more than 6000 participants, among them also employees of Deltares (around 800 people). Employees are one of the most effective promoters of the product and extracting them from the model would be a mistake.

After changing to the open-source strategy, the company obviously started to lose the revenue based on the previous sales policy. But in the overall structure of the revenue has not changed not so dramatically because it took and still takes very small fraction out of the overall turnover. This demonstrates that Deltares did not lose a significant amount of the revenue. Deltares sacrificed it in order to get more clients that will have more research and development projects with the company. The "revenue" will come with those projects.

1.2. Research Objective

The research project will use system dynamics modelling in order to identify the main levers in the business structure for achieving the goal of a bigger market share of Deltares (increasing of users among the potential clients). Modelling is used in order to decrease uncertainty of the future and trying to identify possible scenarios. There are a lot of connections and interrelations inside of any system, in our case in the organizational business strategy of Delft3D product. In order to reach the objective of the project: adjust the business strategy, I will:

- Construct an **explanatory model** for Deltares (particularly consider Delft3D product, impact of others products use as exogenous variables) – how the company has been getting new users (starting from the time with open-source policy);

- Create a **policy model** for adjusting Deltares business strategy in order to identify options for improving company's performance – where the company should put more efforts in order to get more clients.

Explanatory model represents the original system structure (Bossel, 2007). Of course, it does not include *all* relevant parameters to the system. But it has to consist of the most essential, which actually have impact on the behaviour of the system. Explanatory model ideally has to generate the same behaviour of a system, i.e. *reference mode* (will be explored in the part of theoretical framework).

Policy design (model) "includes the creation of entirely new strategies, structures, and decision rules. Since the feedback structure of a system determines its dynamics, most of the time high leverage policies will involve changing the dominant feedback loops by redesigning the stock and flow structure, eliminating time delays, changing the flow and quality of information available at key decision points, or fundamentally reinventing the decision processes of the actors in the system" (Sterman, 2000, p. 104).

The first stage is to model structure of the Delft3D business case close to the real one, use the most relevant parts of the structure. The purpose of the first stage is to recreate the reference mode. And the last stage is to model the policy structure that will change current behaviour of the model on the desirable: when the numbers of users increase more than currently.

The main purpose of constructing model for Deltares is to have an overview of the all system surrounding Delft3D business case in order to find out what kind of marketing efforts are the most effective. To have a possibility to play with parameters to create better understanding how the processes are interacted with each other. Therefore, contribution of this project work is very practical and useful for the company.

Lane (1997) described the case when modeling process helped managers understand the dynamic processes. "The visual and interactive aspects of System Dynamics modelling provide information processing advantages to users. The visual representation of variables and relationships using causal loop diagrams, subsystem overviews and computer models with iconic interfaces all allowed the participants to deal with more information than unaided working memory normally allows." Morecroft (2007) stated that "causal loop diagrams offer a special overview of business and society, showing what is connected to what and how changes in one part of the system might propagate to others and return". This research will be also devoted to the point of learning during the modelling

process in order to give the understanding how dynamics are going on in the system of Delft3D business case.

1.3. Research Questions

Warren (2008) suggested three questions which are helpful to analyze the issue how organisations are perform over time. According to this approach there were formulated research questions to answer in order to reach described objectives and understand how the business situation around Delft3D is functioning now:

- Why is this dynamic behaviour happening?
- What is the most likely forecast of new clients of Delft3D?
- What is possible to do to increase number of users even more?

Answers on these questions will help to identify main parts of the system and links for the modelling purposes. Presentation of all interconnections and interdependencies inside the system will provide better understanding of how is system working and what kind of performance it will create.

1.4. Explanation of the Core Concepts

Several main core concepts are mentioned during this report and will be discussed later:

Delft3D (Software programme) – 1D-2D-3D modeling suite to investigate hydrodynamics, sediment transport and morphology and water quality for fluvial, estuarine and coastal environments. (p.6)

Open Source Code – the programming code, which is distributed without any licensing, can be transformed and used according to user's goal. Researchers view open source as a specific case of the greater pattern of Open Collaboration (a pattern of collaboration, innovation, and production). (p. 6)

Free Software – is a computer software that is distributed along with its source code, and is released under a software license that guarantee users the freedom to run the software for any purpose as well as to study, adapt/modify, and distribute the original software and the adapted/changed versions. (p. 6)

Business Case – is the system that surrounds the Delft3D software product including users, potential clients, effectiveness of marketing efforts, budgets, research-and-development projects are using Delft3D. (p. 9)

Marketing Efforts – activities made by company in order to attract new clients: direct mailing, conferences, presentations, web-pages, social-media marketing, product society, forum. According

to Kotler (2002) marketing tasks include an action helps simulating demand for the product, as well as demand management. The American Marketing Association offers this managerial definition: Marketing (management) is the process of planning and executing the conception, pricing, promotion, and distribution of ideas, goods, and services to create exchanges that satisfy individual and organizational goals (George, Freeling, & Court, 1994). (p. 9)

Bass Diffusion Model – the diffusion model developed by Bass (1969) of the adoption a new product on the market. There are two main structures of a model, which creates S-shaped behaviour: market saturation and word-of-mouth effect. (p. 17)

Word-of-Mouth effect – is the passing of information from person to person by oral communication, which could be as simple as telling someone the time of day. It is actively influenced or encouraged by organisations in order to spread information about the product as much as possible. (p. 17)

1.5. Thesis Outline

Introduction chapter includes background information about the company and explanation of the current situation. Research objectives and research questions are defined and explained the main purpose of the research. Introduced core concepts, which are used in the work and brief outline is provided.

Methodology part consists of description of research design, defining research strategy sources of primary and secondary data collection and data analysis procedures.

Theoretical framework chapter define the research hypothesis, explained relevance of bass diffusion model and its concept and also provide explanation of the marketing efforts.

Case study chapter describe model development stages, main parts of the model and existing loops. There will be discussed interconnections between parameters and explained concepts of the links between the main connections. There are also provided validation procedures such as unit consistency test, reference mode comparison test, parameter sensitivity analysis, structure behaviour test (switching off the loops) and extreme condition test. Policy scenario implications are going to show possible ways for the improvement company's performance.

The last chapter of conclusion is going to provide summary of the work that have been done, main findings and options for the further research.

2. Methodology

The focus of this research is on the construction of an explanatory model and creation a policy options for the business case of Delft3D software product. In order to do that there will be used certain approaches for the research design, research strategy, data collection and data analysis.

2.1. Research Design

This research will be conducted using induction approach. According to the definition by Saunders and Lewis (2012) induction is "a research approach which involves the development of theory as a result of analysing data already collected". This research suggests that at first data will be collected through the interviews and data-bases (see chapter 2.3) and afterwards there will be build a model. For doing that System Dynamics (SD) was chosen as a methodological approach. In order to understand better what kind of procedures will be done during the research lets explain some basics of SD methodology.

System Dynamics is used for studying dynamics problems and systems, i.e. which we can observe over time. These systems are very useful to improving managerial decisions. A lot of problems that arises in the company mostly are "feedback" problems (Barlas, 2009).

Barlas (2009) also provided with the glossary that we are going to use in order to explain chapter model development:

"*Dynamic behavior*: dynamic performance patterns of the variables created by the operation of the structure of the system over time.

Dynamic problems: problems characterized by variables that undergo significant changes in time. Being chronic in nature, they necessitate continuous managerial monitoring, control, and action.

Endogenous: the dynamics are essentially caused by the internal feedback structure of the system.

Feedback: a succession of cause and effect relations that starts and ends with the same variable. Also called "loop" or "circular" causality (see *Figure 3*: Loop 1).

Flows: They directly flow in and out of the stocks, thus changing their values. They represent the "rate of change" of stocks (see *Figure 3*).

Model: a representation of selected aspects of a real system with respect to some specific problem(s) (see *Figure 3*).

Negative (balancing) loop: a feedback loop that balances, counteracts an initial change in any of its variables. It produces a goalseeking behavior.

Non-linearity: any relationship where the output is not purely proportional to the input; any relationship that is not linear.

Positive (reinforcing) loop: a feedback loop that reinforces, compounds an initial change in any of its variables. It produces an exponentially growing or collapsing behavior.

Simulation: a step-by-step operation of the model structure over compressed time; imitation of the operation of the real system.

Stocks: They represent the important accumulations over time. They are also called "states" as they collectively represent the state of the system at time t (see *Figure 3*).

Structure: the totality of the relationships that exist between system variables.

Systemic: resulting from the complicated interactions between many variables in the system.

Time delay: a time duration that intervenes before a cause can reach its effect. Delay can exist in physical flows or in informational cause-effect relations."

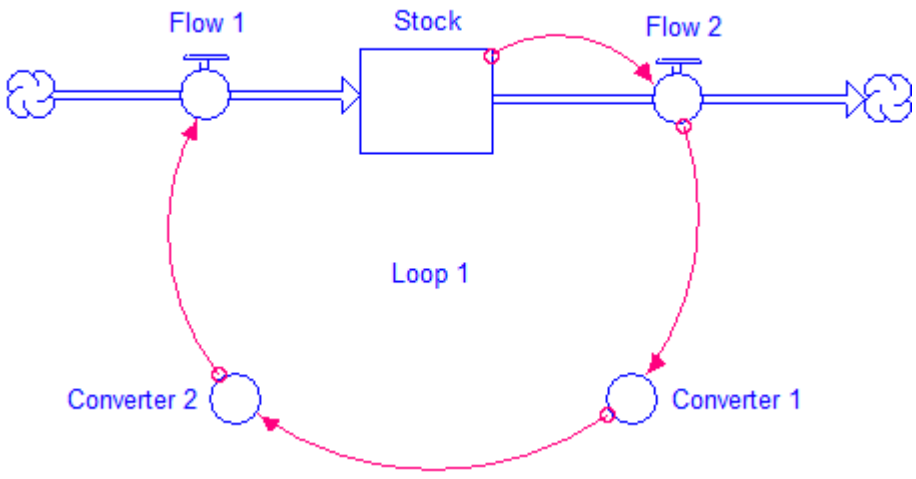


Figure 3. Representation of the model's units

In order to constrict system for further investigation there are used: stocks, flows and parameters (see *Figure 3*: converters). All of them together should produce and close the loops which should explain produced behaviour. Explanatory study will help to look for causality inside the system. In order to do that there will be used the following research strategies

2.2. Research Strategy

In order to achieve the first objective of the research (constructing an explanatory model) will be used case study strategy. According to Saunders and Lewis (2012) "case studies are particularly good at enabling the researcher to get a detailed understanding of the context of the research and the activity taking place within that context". Using a system dynamics as an approach there will be conducted an experiment strategy. It means that there will be made experimental model with the real data base about the company in order to identify and study causal links between variables. This strategy is suitable for the other objective (creation a policy model) because the purpose of an experiment is to establish whether a change in one independent variable produces a change in another dependent variable (Saunders & Lewis, 2012).

2.3. Data Collection

2.3.1. Primary data collection

In order to get theoretical information about the research objectives we will use publications from the system dynamics' conferences, relevant books and journals (open-source from the internet): research in the field of marketing connected with the system dynamics (Allsop, Bassett, and Hoskins (2007); Metawie (2012); Morecroft (2007); Warren (2008); Sterman (2000); Bass (1969)). Because of the chosen approach – system dynamics – main source of information for the modelling is a knowledge of the people, who is working with the observable issue, i.e. mental data base (see *Figure 4*).

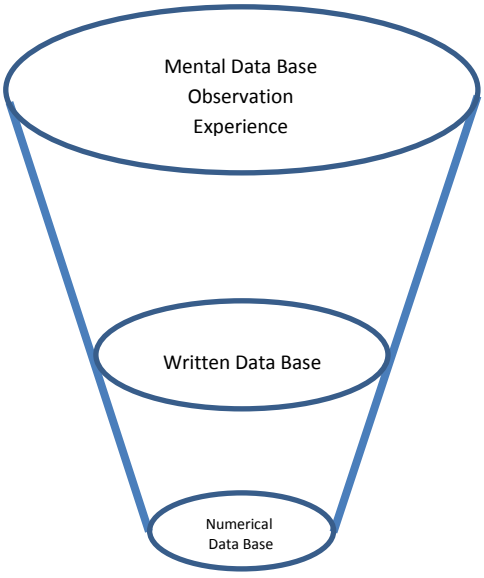


Figure 4. Mental data base and decreasing content of written. (Forrester, 1992)

In order to receive information about the product, we conducted several open interviews with employees of Deltares: product marketing managers, sales managers, maintenance and support team and programmers. The interviewers were selected from the list of people who are connected with the Delft3D product. All numerical data were mined from the internal data-base of the company: presentations, statements.

2.3.2. Secondary data collection

Collecting information about competitors and other products available on the market will gathered from the main internet web-sites of those companies:

Product name	Description	Supplier	Website
ADCIRC	Coastal Circulation & Storm Surge Model	University of North Carolina (UNC)	http://adcirc.org
Delft3D Flexible Mesh	1D-2D-3D modeling suite to investigate hydrodynamics, sediment transport and morphology and water quality for fluvial, estuarine and coastal environments. Together with the familiar curvilinear meshes from Delft3D 4, the unstructured grid can consist of **triangles, pentagons** (etc.) **and 1D channel networks, all in one single mesh**. It combines proven technology from the hydrodynamic engines of Delft3D 4 and SOBEK 2 and adds flexible administration.	Deltares	http://oss.delft3d.nl
MIKE 3 Flexible Mesh	3D modelling package for estuaries, coastal areas, and seas. It covers a wide range of hydrodynamic, environmental and sediment transport processes.	MIKE By DHI	http://www.mikebydhi.com
ROMS	Regional Ocean Modelling System	Rutgers University	https://www.myroms.org
TELEMAC-MASCARET	Free surface hydraulic, Sediment, Waves, in 1D, 2D or 3D	Electricite de France (EDF)	http://www.opentelemac.org

2.4. Data Analysis

All gathered data (primary and secondary) will be an input for the system dynamics model: building the structure, identification connections between parameters, defining values for parameters, initializing stocks. Defining the main links of the structure as well as possible interrelation and interconnections has been collected during the interviews in order to validate the structure.

The analysis of the constructed model will be made using validation tests, described by Barlas (1996): structure validity (structure of the model in terms of reliability with the real system) and behaviour validity (research behaviour and check it whether it does not produce the contradicting one).

3. Theoretical Framework

3.1. Hypothesis

Sterman (2000) states that there are two main initial characterizations in the modelling process: *reference modes* and *time horizon*. Reference mode is a graph over time characterized problem dynamically. The main purpose for the modeler is to represent with the model's structure the same pattern of the system's behaviour. Time horizon should define how far back modeler starts represent

behaviour through its structure: in our case it begins on 2011. That is why it is important to define reference mode in the beginning: number of users Delft3D software programme.

Because of the simplicity of downloading source-code form the web-site of Deltares it became very difficult to evaluate amount of users of Delft3D software product. One of the options to do that is to look on all groups of participants, interested in Delft3D. One of the main source is "Deltares Open Source Community" (Deltares, 2014). That is why there are only rough data for the reference mode, it does not suggest much about the structure of the system. But research suggests using the Bass Diffusion Model as a starting point for developing the structure. The dynamics of product adoption by word-of-mouth effect – growth from diffusion – are well explained by Sterman (2000) and Morecroft (2007). The archetype of the model suggests that there are going to be at least two stocks which will create diffusion process: adopters and non-adopters. Produced behaviour will be S-shaped. Warren (2008) says that Bass Diffusion model is a "useful framework" to show results of word-of-mouth communication between potential and current users.

According to the internal data-base of users subscribed for exactly Delft3D in the open-source community by 31st of December 2013 we got *Figure 5*. These numbers do not show the all picture. A lot of users are missed. But in general trend are considered to be right which means that this graph over time is suitable to be a reference mode for our case.

According to the Figure 5, growth of the clients in the period between 2010 and 2011 can be represented by structure of reinforcing loop. The period from 2011 and 2013 is a result of behaviour by both reinforcing and balancing loops.

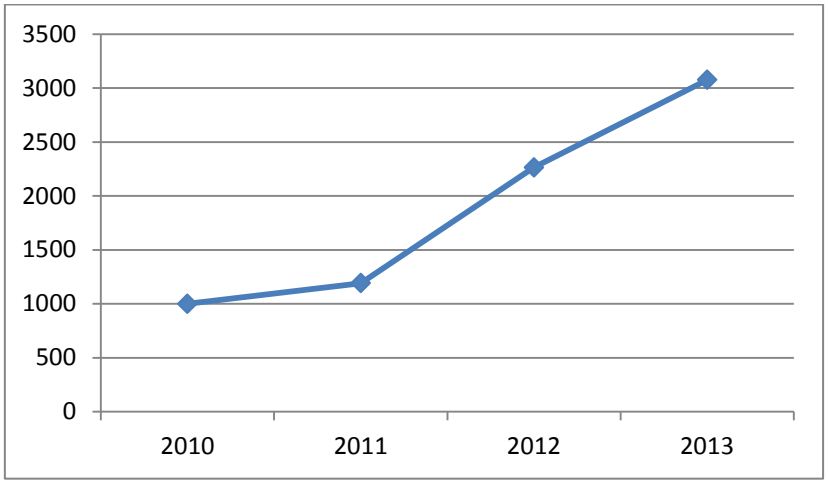


Figure 5. Approximate amount of users of Delft3D since 2010 till 2013

3.2. Bass Diffusion model

In 1969 Frank M. Bass published an article "A New Product Growth for Model Consumer Durables" in Management Science journal. The main idea was that new coming buyers are depend on amount of current buyers of the product, so more current clients lead to increase of the flow of new current buyers (Bass, 1969). Research also concluded that first part of the growth is exponential and after its peak, there is an exponential decay. In terms of system dynamics structure for this kind of behaviour looks the following:

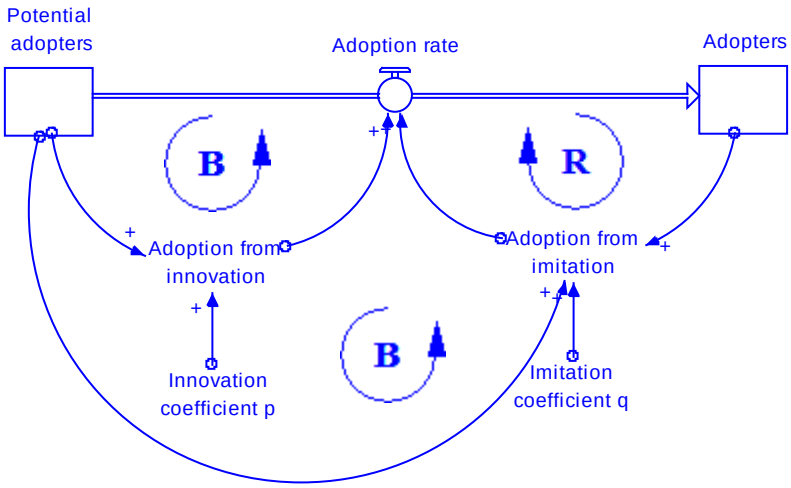


Figure 6. Representation of initial Bass diffusion model in terms of system dynamics. Adapted from (Sterman, 2000)

Sterman (2000) compared the spread of rumors and new ideas, the adoption of new technologies, and the growth of new product with epidemics spreading by positive feedback as those who have adopted the innovation "infect" those who have not. New coming users' decisions to become a user include so-called word of mouth effect from those who already use and positive experiences the product. For the company's case it means that more users have an experience with the product, more potential users start know about it, which leads to more people becoming users – self-reinforcing effect.

4. Case Study

4.1. Model Development

As it was said before the beginning of the model starts with the Bass Diffusion model structure. However, it will not be bounded with only two stocks of non-adopters and adopters. The structure starts with the stock of Potential clients – all amount of people who potentially could be interested in

the product. Going through the flow some of these people are becoming aware of the Delft3D software product. And from here there are two ways: to be adopted or person also can decide that this product does not suit his requirements and go to the stock of Unsuccessful clients. Most of the people have the probability to change their mind and come back to the stock of People aware of Delft3D. Adoption rate is the next flow in the link to the stock of Delft3D users. Here is we have two stocks of users: regulate users (stock of Delft3D users itself) and stock of Latent users, who stopped to use the software for some time, but most of them will become the regulate users again. Described structure is on the *Figure 7*.

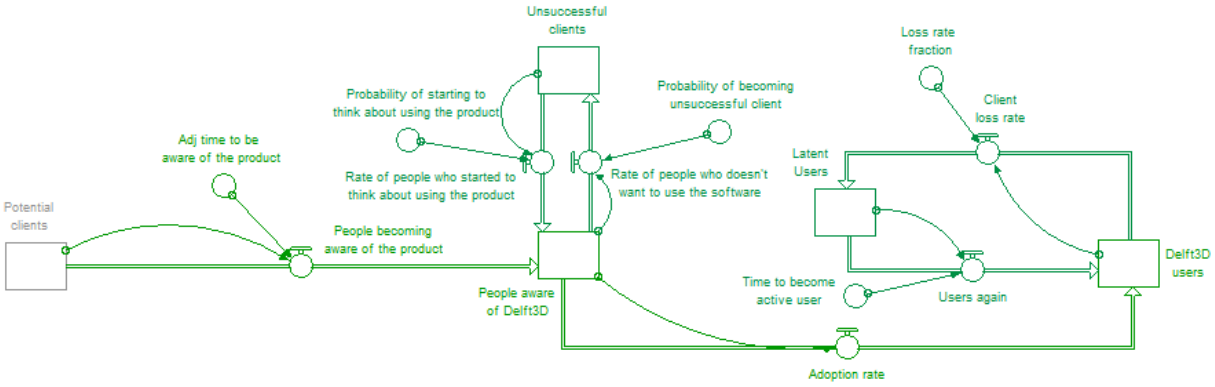


Figure 7. Model Development. Part 1

Flows of people becoming aware of the product and adoption rate are regulated with extra parameters which will be described later. Loss rate fraction was defined by the expert's view of programme manager in Deltares as 10 % out of all users. Similarly, time to become active user was defined as 2.5 years and adjustment time to be aware of the product – 2 years.

Connection between stock of People aware of Delft3D and Delft3D users through the adoption rate explicitly shows diffusion concept when users are flowing from one stock to another. Stock of Delft3D users are influencing back to the adoption rate through the effects you will find below.

Next big part include in it stock of Image, which is defining was the experience with the product good or not. And to do so there was calculated relationship between number of users in the previous year and current amount of users (trend) – to define the rate of users' growth. If the fraction is less than 1 it means that more people went to the stock of latent users than we got through the adoption rate this year (see *Figure 8*). The logic behind constructing Image stock is that when there are more users than is was one year before product become more popular, people got a good experience and shared it with others (word-of-mouth effect). And when there are lees people than it was in the previous year, people were unsatisfied with something and also shared their opinion with others.

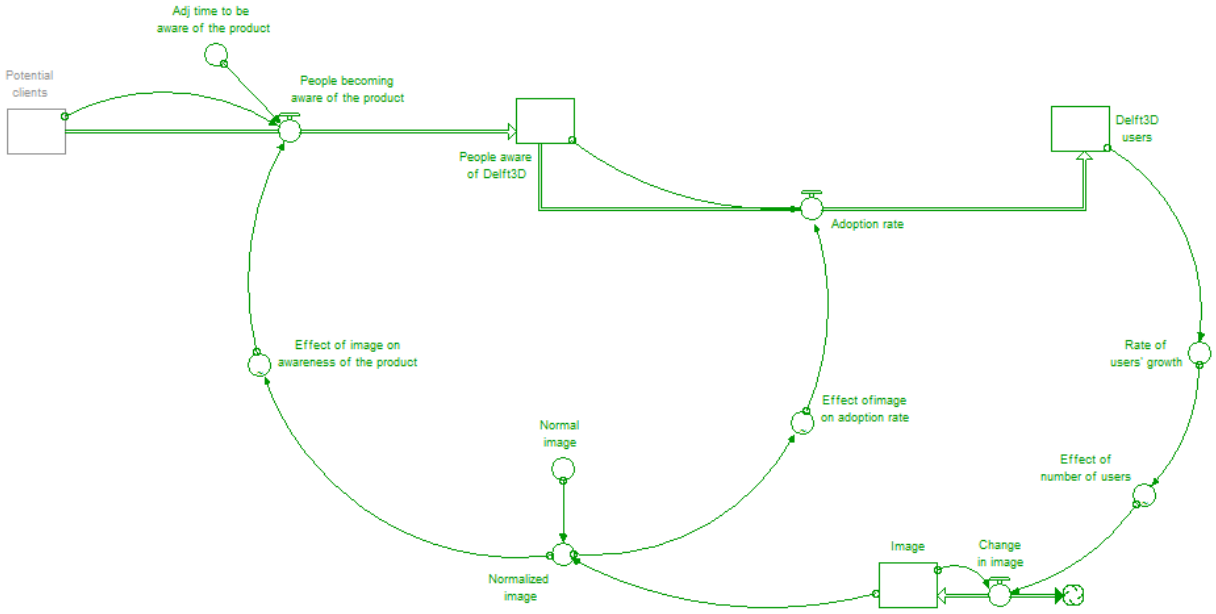


Figure 8. Model Development. Part 2

To get the effects of experience on the flows of people becoming aware of the product and adoption rate there was conducted normalizing procedure. For the normal image there was chosen number 0.5 – it is an estimated assumption. The logic is the following: if there would be number 1 it means that image is perfect which suggests that all users should belong to Deltares. But we know that it is not a truth. We also know that number of users is not a small amount. And we also understand that number which is going to be used later on in the system is normalized, so it does not affect the end result directly. The first effect of number of users that changes the image looks as following (see *Figure 9*):

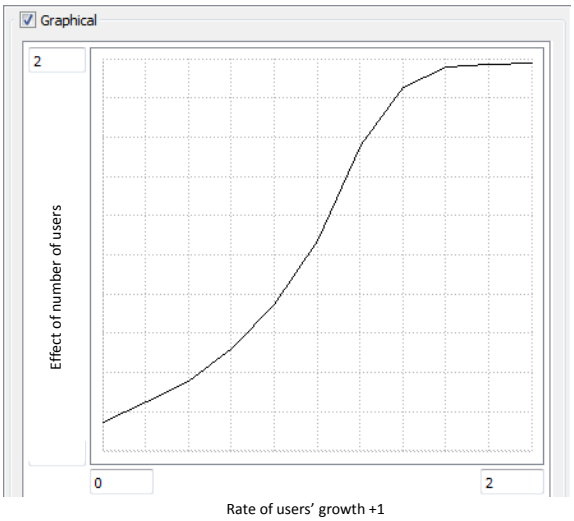


Figure 9. Effect of number of users

Effect of image on awareness of the product was defined by expert's view is on the *Figure 10*:

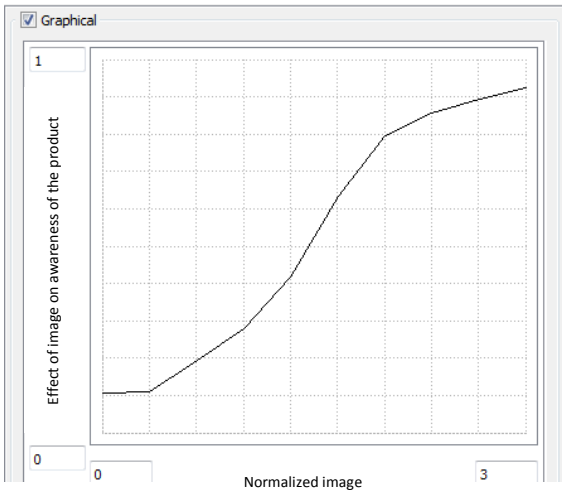


Figure 10. Effect of image on awareness of the product

S-shaped growth means that better become image, bigger effect there will be on potential clients. But at some point effectiveness of the effect is getting lower and stabilizing.

Effect of image on adoption rate was defined as on the *Figure 11*.

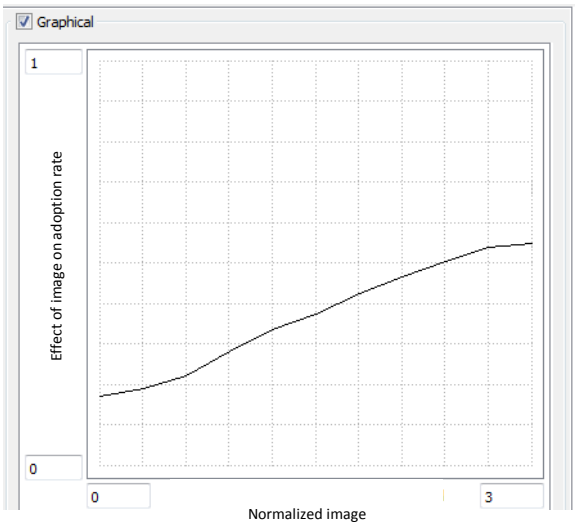


Figure 11. Effect of image on adoption rate

The shape is close to the effect of image on awareness, but the effect itself much less. Because it is not only about recognition and knowing about the product, but about real users, who started to use Delft3D.

These two effects are the main in order to describe word of word-of-mouth effect: the more people use the product leads to more people know about the product, and again more people started to use Delft3D brings more users through the image effect – loops are closed. Therefore, described parts create two big reinforcing loops (see *Figure 12* and *Figure 13*).

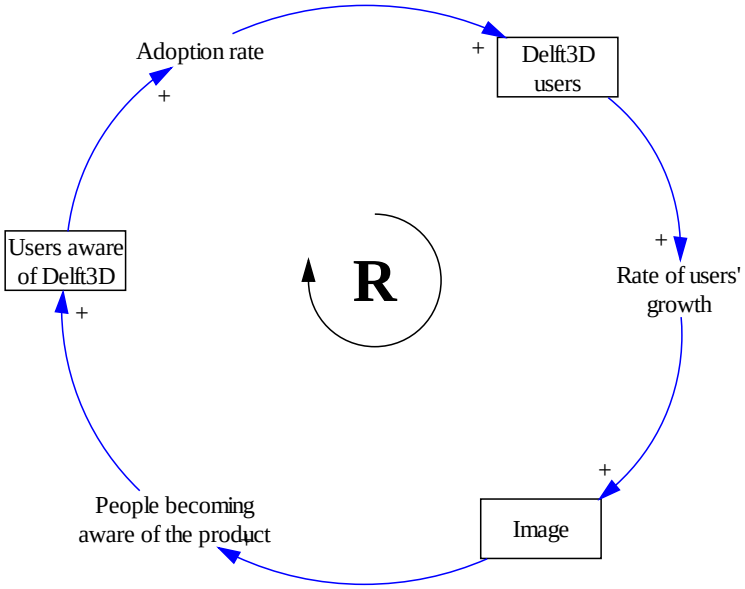


Figure 12. Loop 1: Influence of image on the awareness of the product

Users create certain Image (experience received using the product) which changes number of users aware of the product and next step is increasing of users.

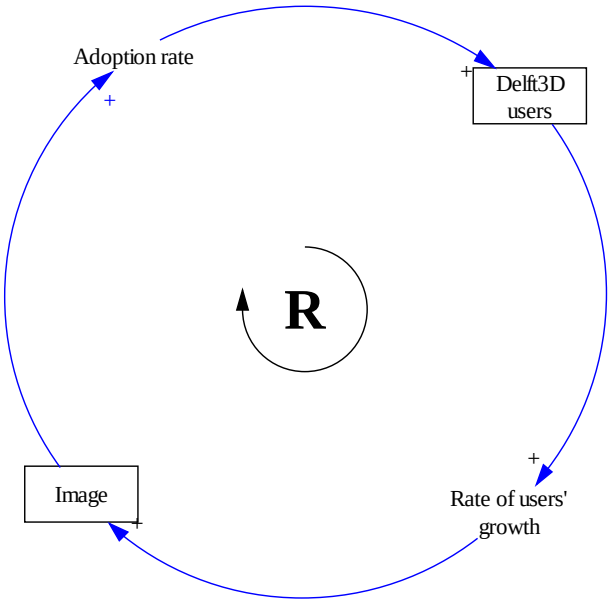


Figure 13. Loop 2: Influence of image on the adoption rate

The next part of model development is about marketing budget and its influence on the people becoming aware of the product. This part mostly constructed in order to create policy structure in the future and make test simulations to check the possible influence of the changing in the marketing budget on the awareness of the product (see *Figure 15*). The spending out of the bank account

affects the flow of people becoming aware of the product through the effect of direct marketing cold contacts. The story behind this connection is that specialists from the marketing department are making new contacts though the e-mails and phone-calls. Every day they contact with the new people as well with old contacts, which are still not users of the product, but were thinking about it. The interesting thing is that budget for the marketing purposes does not change a lot during last years since going open-source (our case). And the real influence cannot be proved and evaluated even by expert view. That is why the following guess is just guess for the simulation and testing purposes (see *Figure 14*).

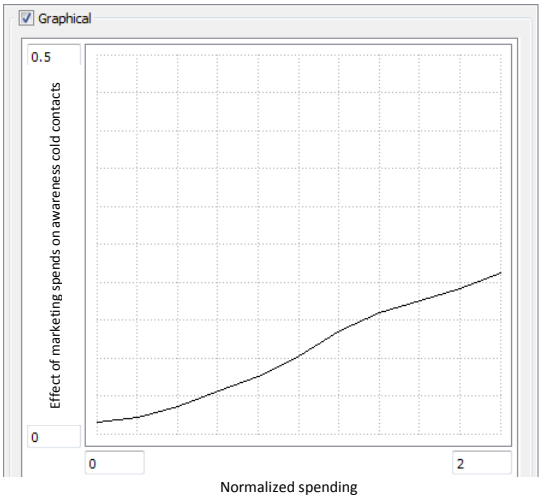


Figure 14. Effect of marketing spends on awareness cold contacts

Marketing budget as we can see is depending on either discrete change in budget or growth fraction for the marketing budget, or both. Usually changes in the company can be made through these two options: it depends on the internal rules of the company. In case of Deltares discrete changes can arise when it is going to be new activities in order to promote company's products.

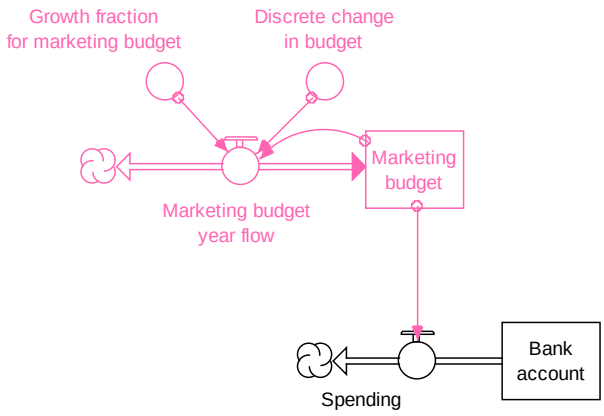


Figure 15. Model Development. Part 3

The next part of the model is connected to the financial section (see *Figure 16*). The number of users creates demand for the research and development projects with Deltares. According to the expert's view of programme manager there around 60 % of all research and development projects (i.e. turnover of the company) are connected with the Delft3D software programme. Therefore increase of users supports income increase, which allows spending money for the marketing budget.

The flow of spending gets signal of amount of money to spend from the marketing budget stock as you can see it at the *Figure 16*.

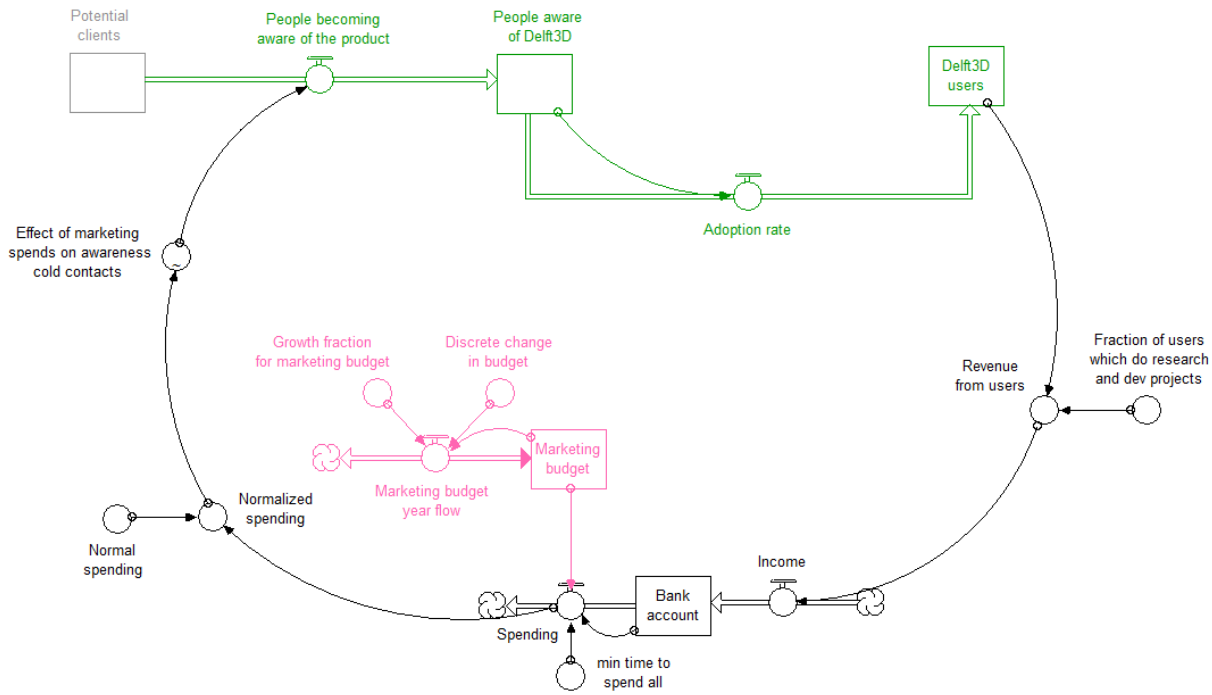


Figure 16. Model Development. Part 4, connection to the part 3

The next part shows how number of the conferences influence on the Image, which in its turn has an impact on average revenue for research and development projects (see *Figure 20*). The mentioned affect are looking as following (see *Figure 17*):

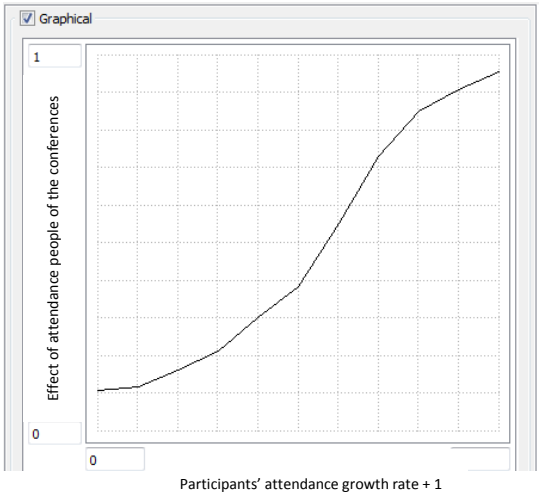


Figure 17. Effect of attendance people of the conferences

The loop for described part will look as following (see *Figure 18*):

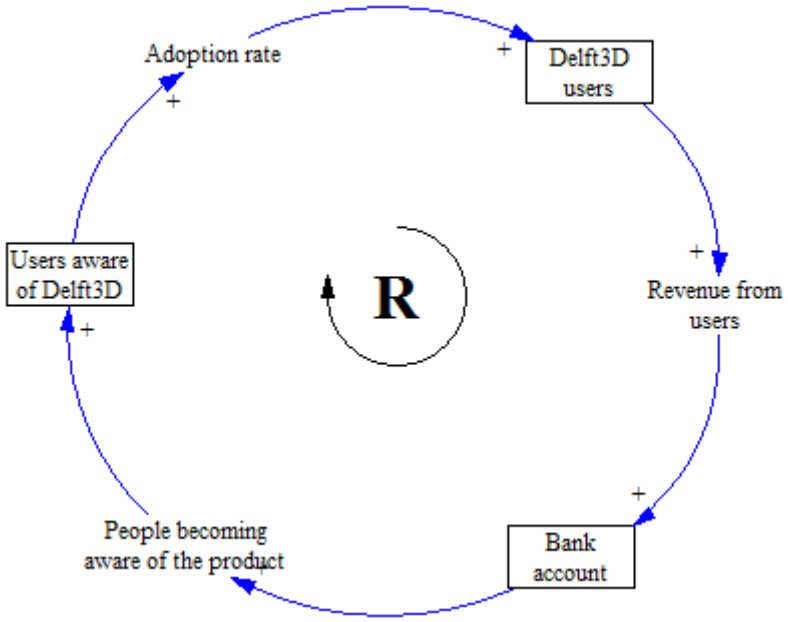


Figure 18. Loop 3: Influence of the marketing spends on awareness cold contacts

More Delft3D users we have more revenue for research and development projects we get. It increases our money resources which company can spend on the marketing activities that will enlarge amount of people becoming aware of the product. And out of this stock Delft3D users stock will also increase.

The number of the conferences attended by the Deltares' employees has influence on the image. The image in its turn has an impact on the average revenue for research and development project per user (see *Figure 19*): higher image – more revenue per user.

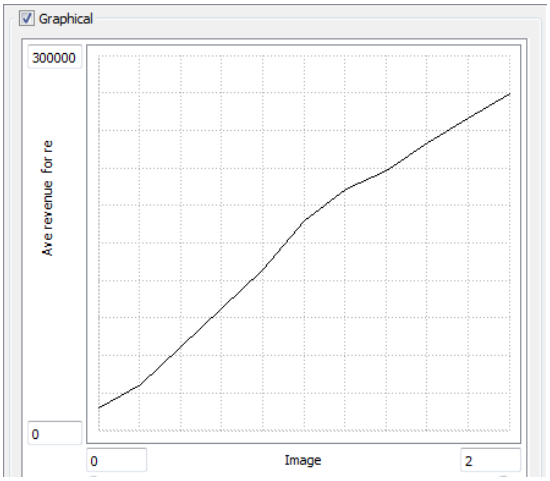


Figure 19. Average revenue for research and development project per user

The curve and approximate data for average revenue for research and development project per user was defined by the expert view: higher image – greater revenue per user.

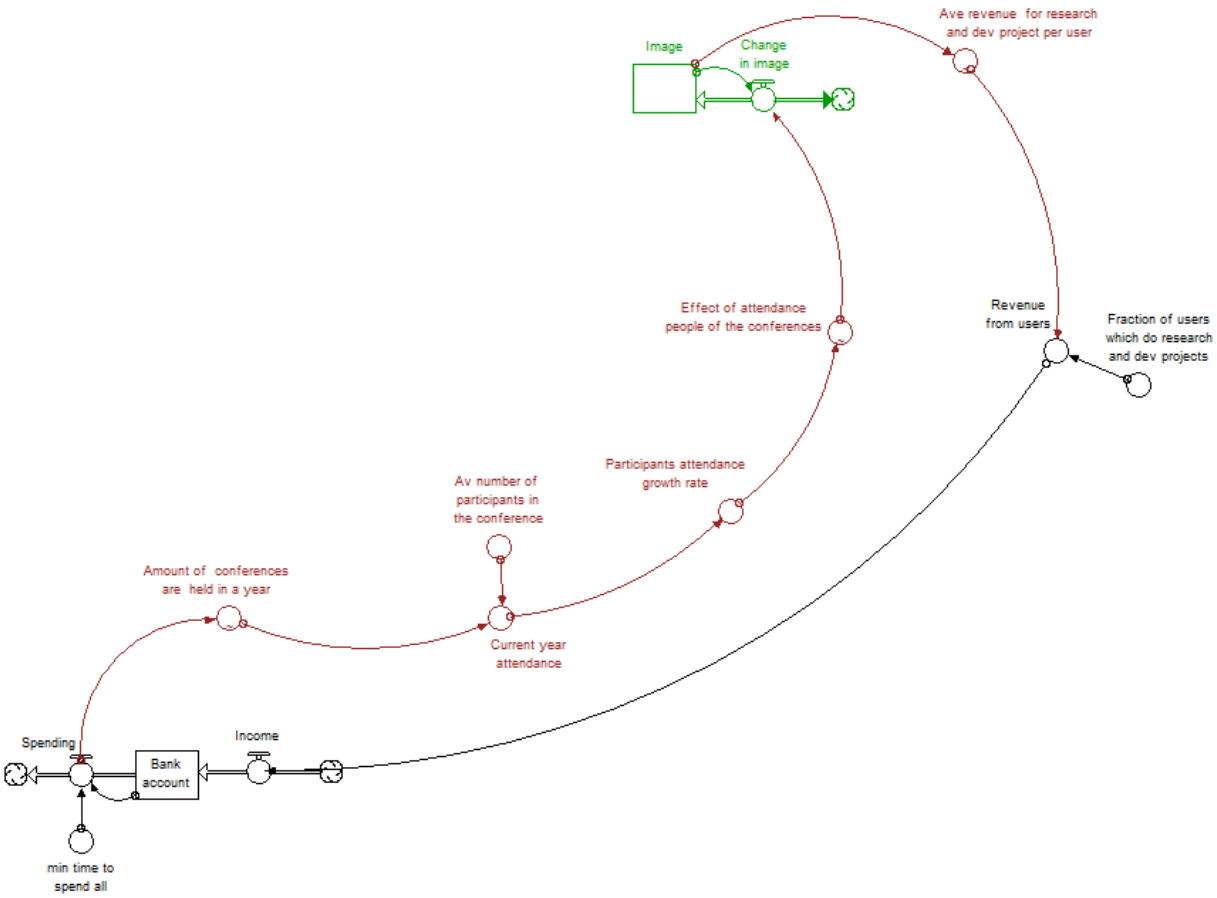


Figure 20. Model Development. Part 5

This stock and flow diagram can be presented as following causal-loop diagram (see *Figure 21*):

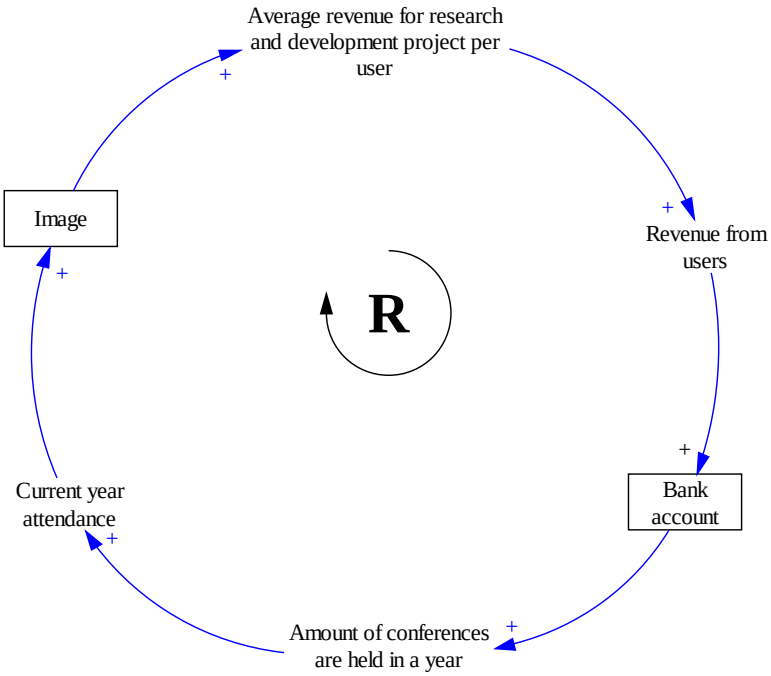


Figure 21. Loop 4: Influence of conference attendance on the revenue through the image

The last, but not least part of the model consists of stock of Universities and Institutes as a development partners. These partners help in promoting and spreading product among the researchers. And its impact is very significant in general. By now, changing of partners' number is exogenous factor (see *Figure 22*).

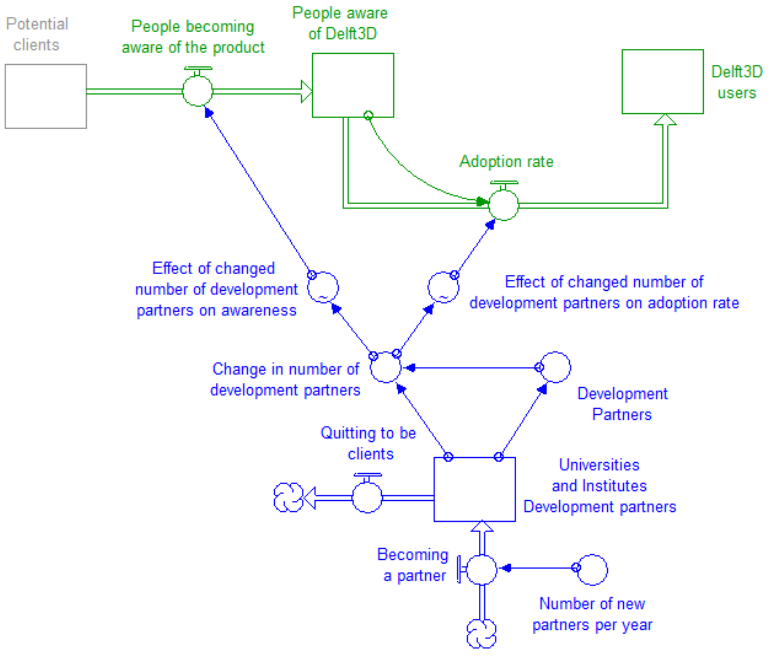


Figure 22. Model Development. Part 6

Therefore after combining all parts of the model we got *Figure 23*. We can see 4 main loops defined before:

- Loop 1: Influence of image on the awareness of the product;
- Loop 2: Influence of image on the adoption rate;
- Loop 3: Influence of the marketing spends on awareness cold contacts;
- Loop 4: Influence of conference attendance on the revenue through the image.

All of them will be tested in the validation part.

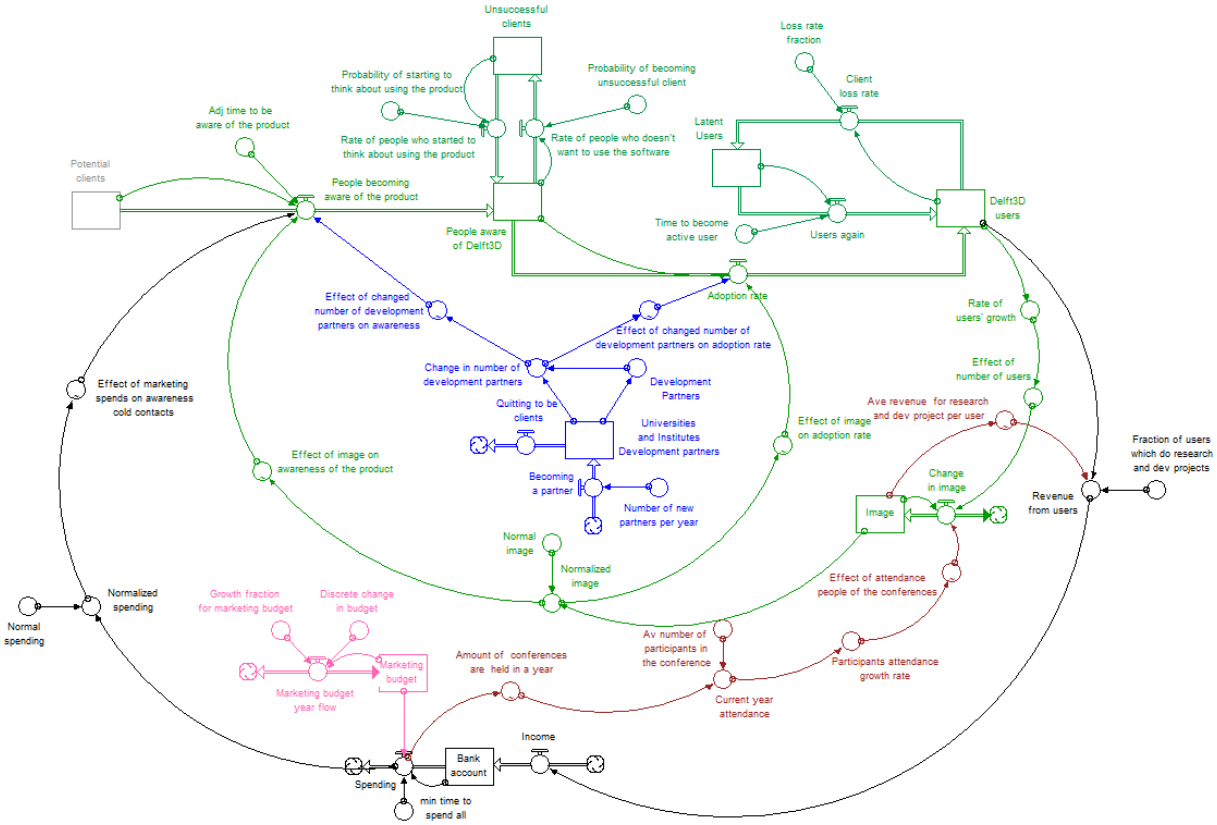


Figure 23. Full model in iThink (for bigger version see Appendix 3)

4.2. Model Validation

In order to verify model there will be conducted several validation procedures. Barlas (1996) stated several formal procedures for the checking model's validity in system dynamics. But he also noticed that procedures cannot be entirely formal and there is room for subjective components. As it was noticed in the paper by Barlas and Carpenter (1990) "A valid model is assumed to be only one of many possible ways of describing a real situation. No particular representation is superior to all others in any absolute sense, although one could prove to be more effective. No model can claim absolute objectivity, for every model carries in it the modeler's world view. Models are not true or false but lie on a continuum of usefulness".

4.2.1. Unit consistency test

Unit consistency test is very helpful in order to understand if the system is constructed in a right way: parameters are connected correctly, so equations will lead to the same units in the end. Unfortunately there are some limitations in the iThink programme software: if the equation is too complicated (i.e. long, includes structure "if then else") it will not be able to check whether right or nor it was constructed. After making this test in iThink, there were several parameters that had to be checked manually. Test was completed and results say that units are right and consistent.

4.2.2. Reference mode comparison test

This test relates to the behaviour pattern test and it should show how close the reproduced behaviour is to the real one. The reference mode is fitted quite well. Of course, the exact numbers are not the same, but the overall behaviour is right (see *Figure 24*).

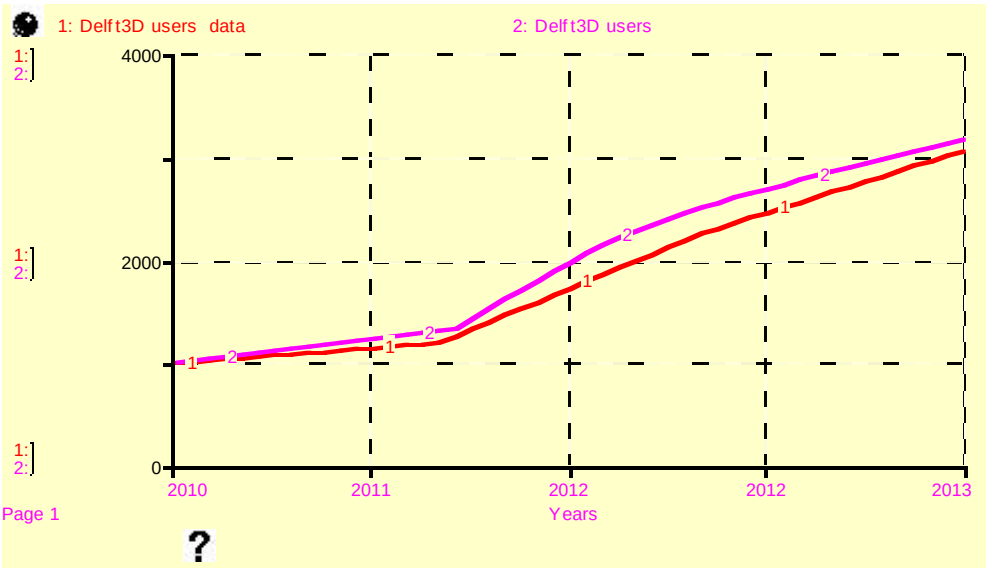


Figure 24. Delft3D users' data vs. Delft3D

4.2.3. Parameter sensitivity analysis

The next important test is a sensitivity test. According to the structure on *Figure 24* we can notice that loops are consist itself effects, which are very important for the structure. And we also know "The behavior of a system arises from its structure" (Sterman, 2000, p. 107). As it was mentioned above, effects were estimated by the expert view and that is why important to see how much system is sensitive to the parameters, will be behaviour changed dramatically or reasonably?

The process of testing was the following: there was a standard (which is used in the model) curve that was changed. Each of these curves was put in the model and the results of running are combined in one graph for each of the effects. The numbers that were used for new graphs of effects are in the Appendix 4.

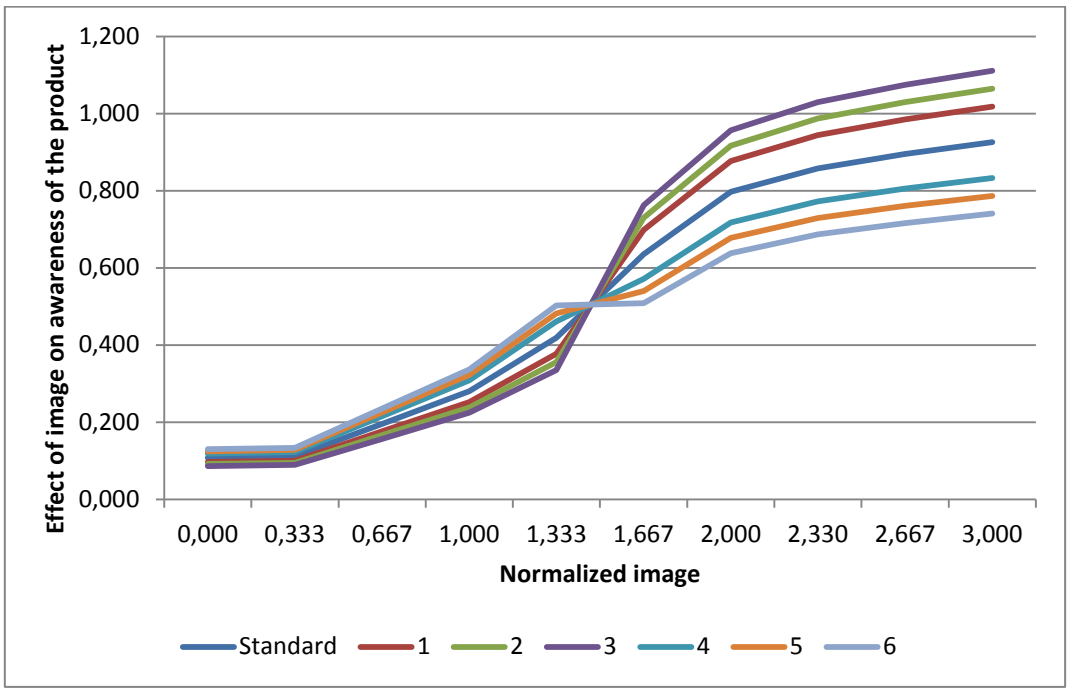


Figure 25. Effect of image on awareness of the product. Graphical functions for sensitivity analysis

On the *Figure 25* there are 6 extra options besides standard effect which influence is tested in the model. The results of testing are on the *Figure 26*. According to the results we can see that model is not sensitive to the changes in the effect of image on awareness of the product. This conclusion is promising because if the standard's curve in the reality looks a bit differently it will not mislead the behaviour of the system. So we can say that in case of sensitivity test for effect of image on awareness of the product the results are good.

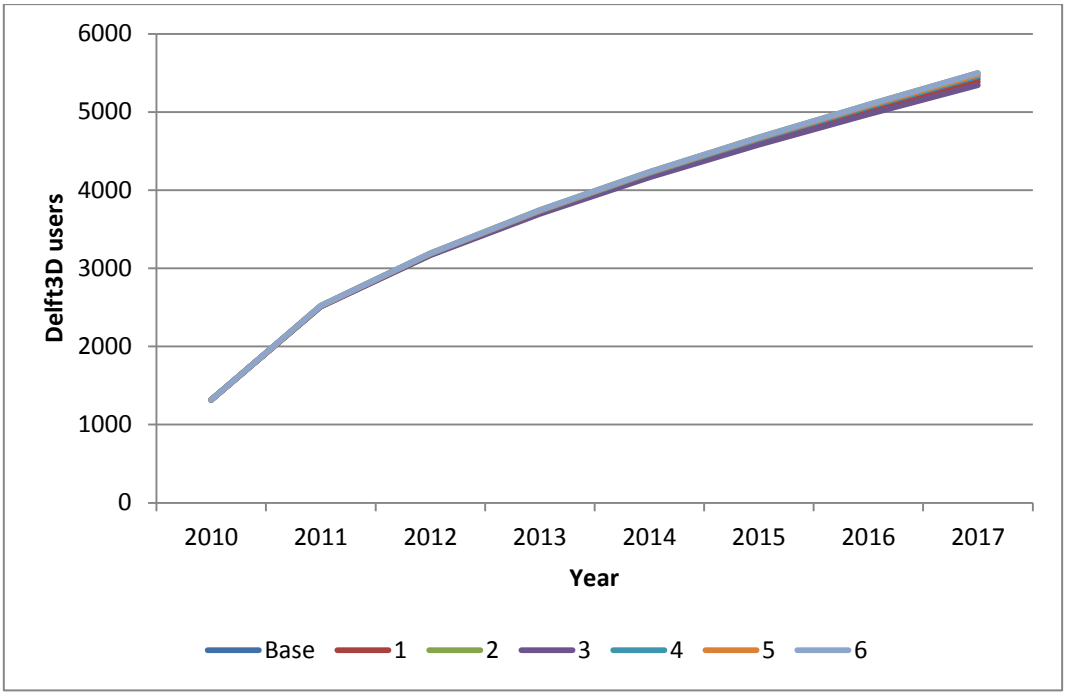


Figure 26. Results for sensitivity analysis for effect of image on awareness of the product

The same procedures were done for effect of image on adoption rate (see *Figure 27*). The results for sensitivity test are shown on the *Figure 28*. According to the results there is a certain degree of sensitivity of the system to the changes, but not so dramatic.

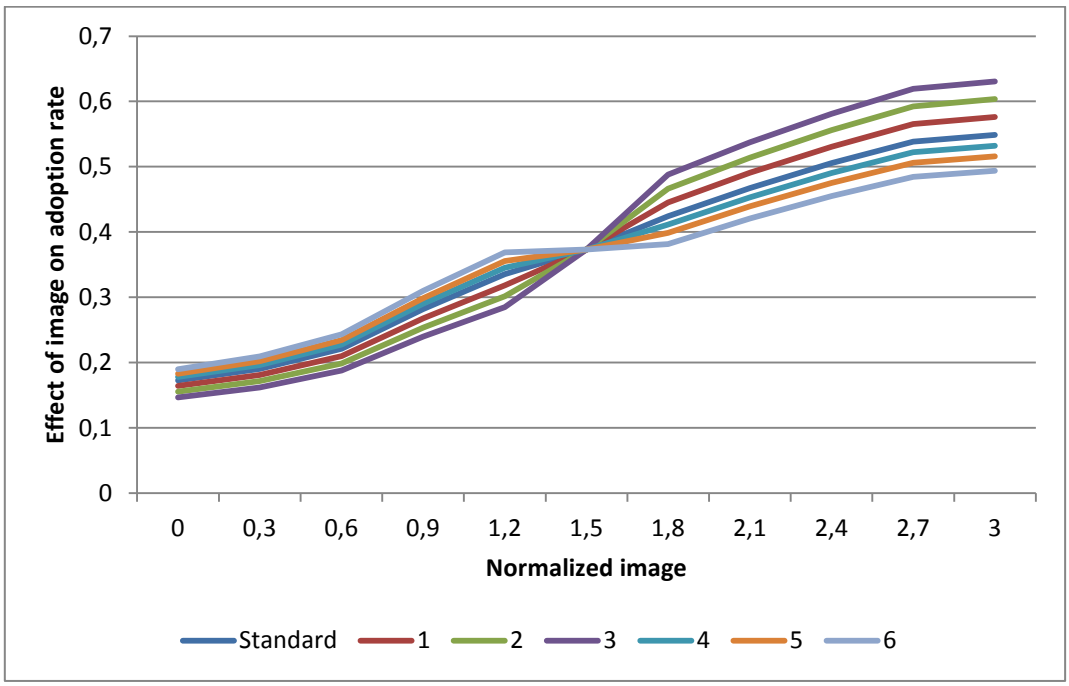


Figure 27. Effect of image on adoption rate. Graphical functions for sensitivity analysis

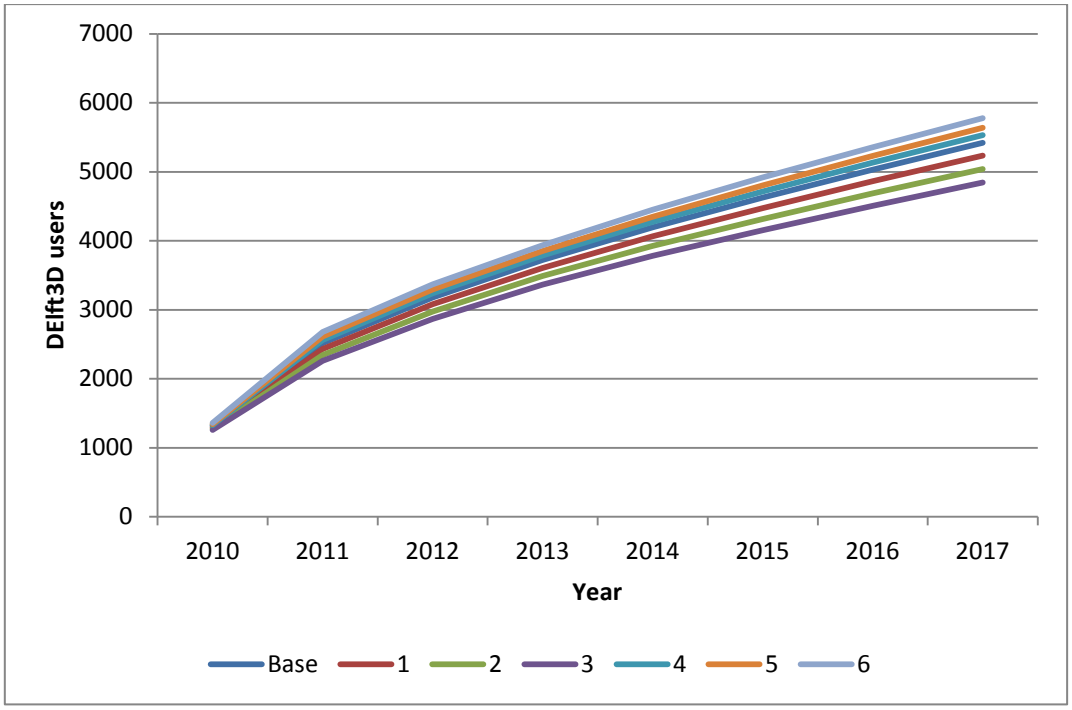


Figure 28. Results for sensitivity analysis for effect of image on adoption rate

The range for the effect of marketing spends on awareness cold contacts is shown on the *Figure 29*. On the *Figure 30* we see that the difference of Delft3D users does not change at all. The model is not sensitive to this effect.

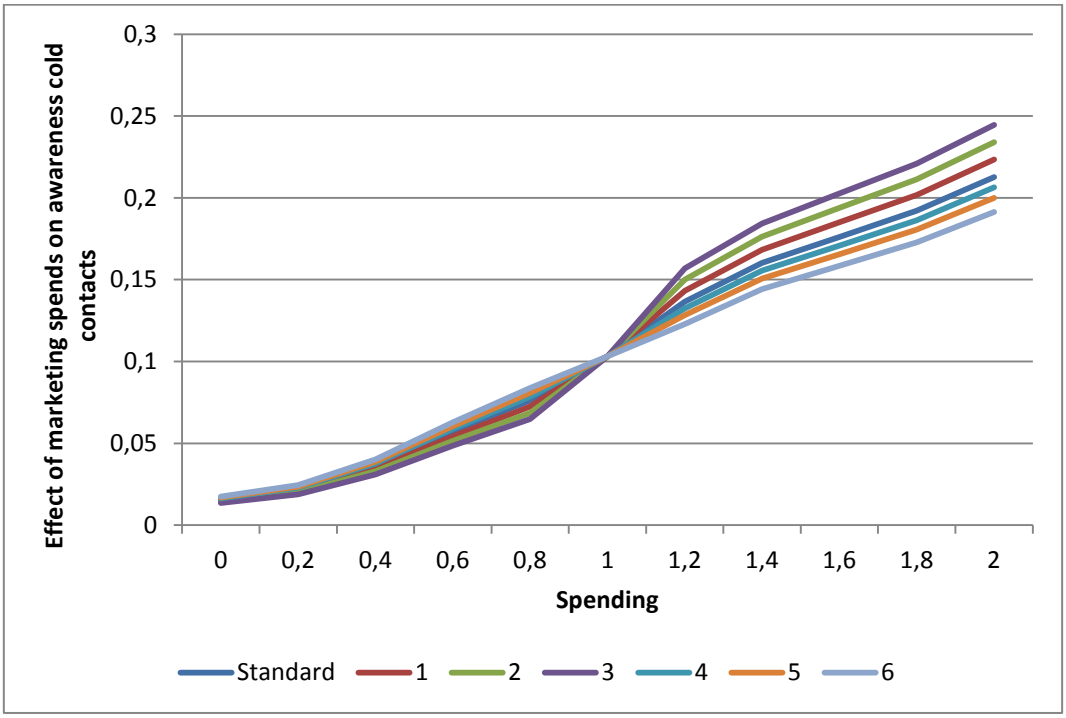


Figure 29. Effect of marketing spends on awareness cold contacts. Graphical functions for sensitivity analysis

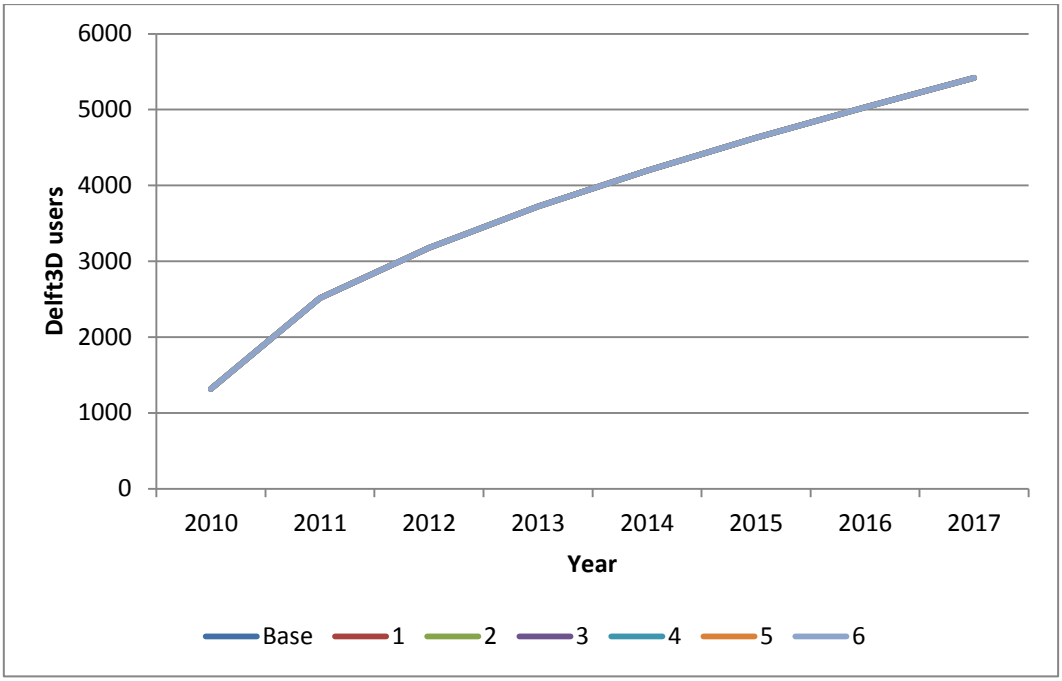


Figure 30. Results for sensitivity analysis for effect of marketing spends on awareness cold contacts

There are different curves on the *Figure 31* for the testing influence of the effect of attendance people of the conferences on the model. There are results of testing on the *Figure 32.* According to the results system is not sensitive to the changes.

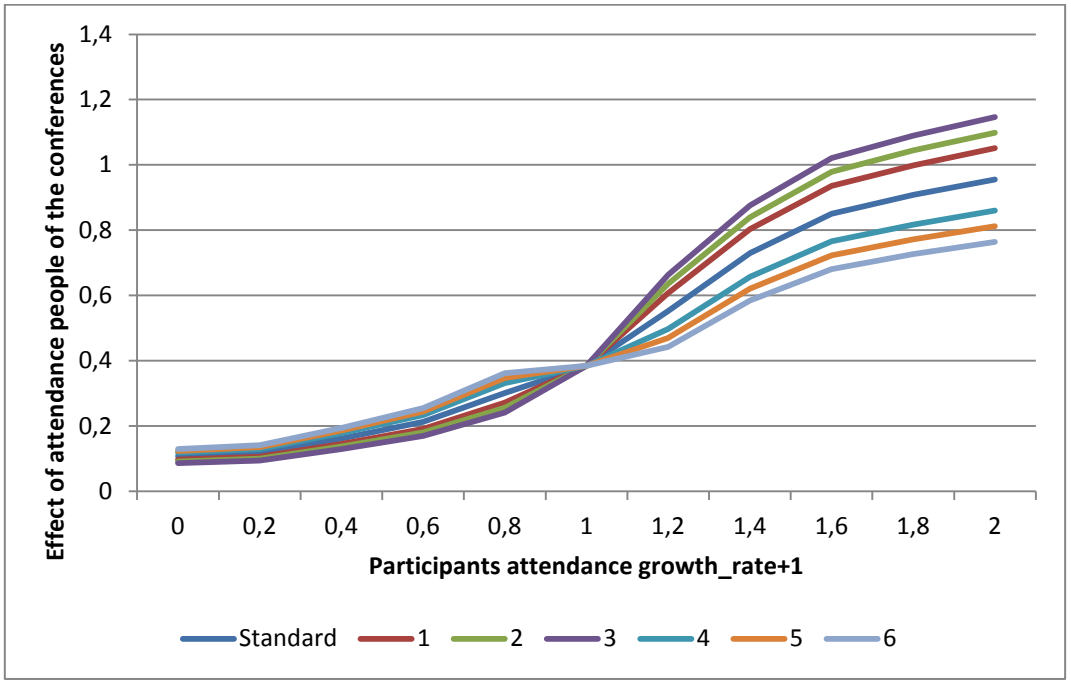


Figure 31. Effect of attendance people of the conferences. Graphical functions for sensitivity analysis

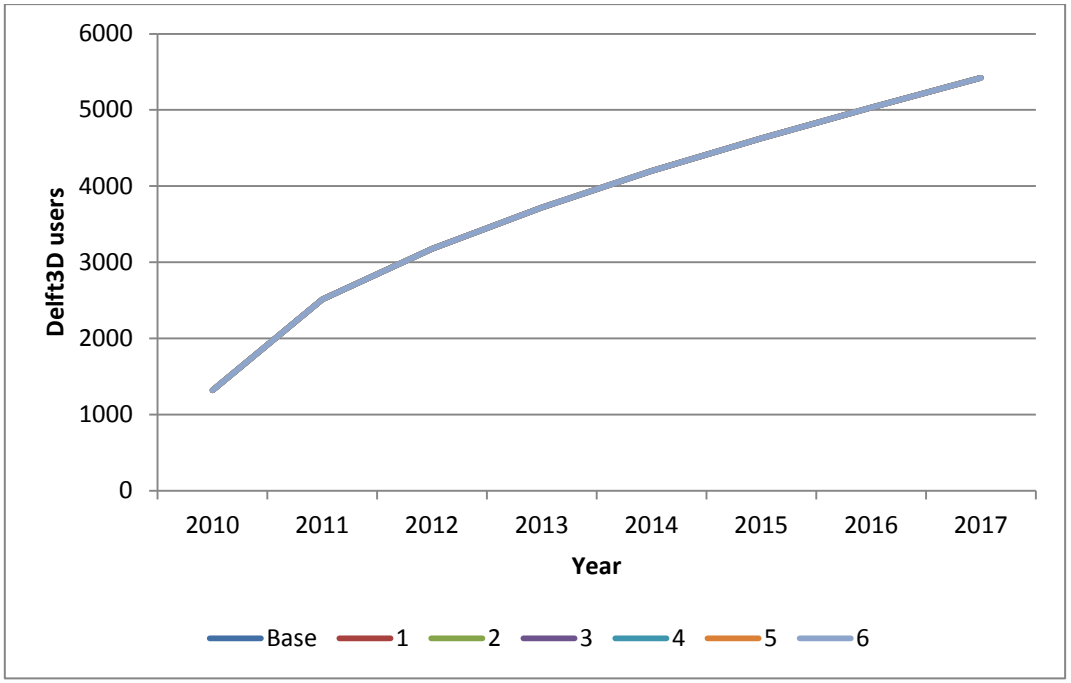


Figure 32. Results for sensitivity analysis for effect of attendance people of the conferences

On the *Figure 33* there are graphical functions for the testing effect of changed number of development partners on awareness. The results on the *Figure 34* show very low changes in the system, it means that system is not sensitive to this parameter.

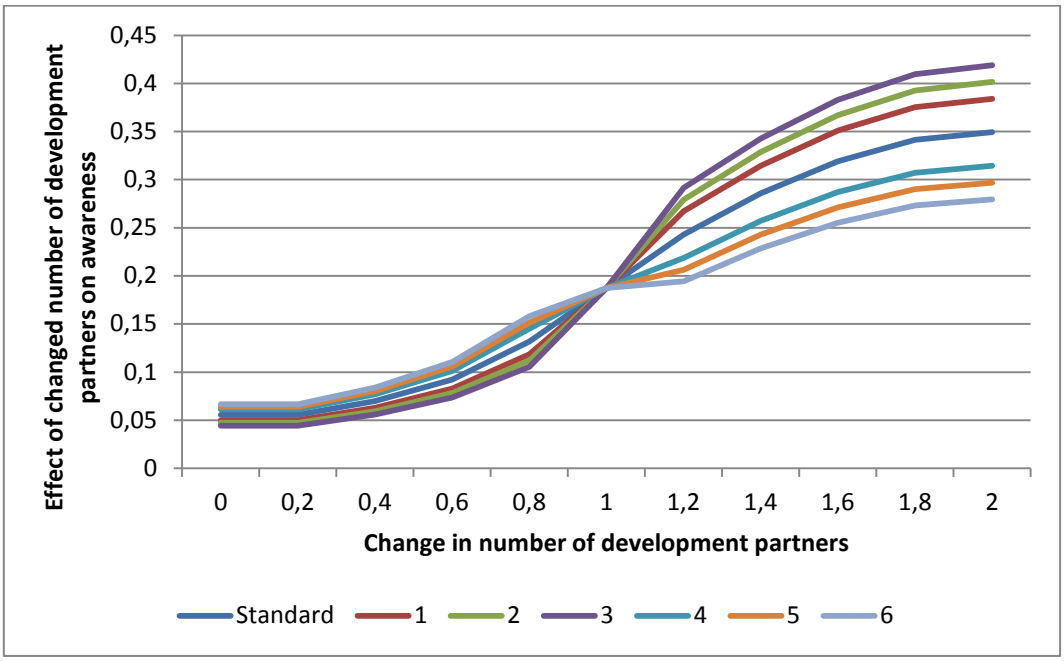


Figure 33. Effect of changed number of development partners on awareness. Graphical functions for sensitivity analysis

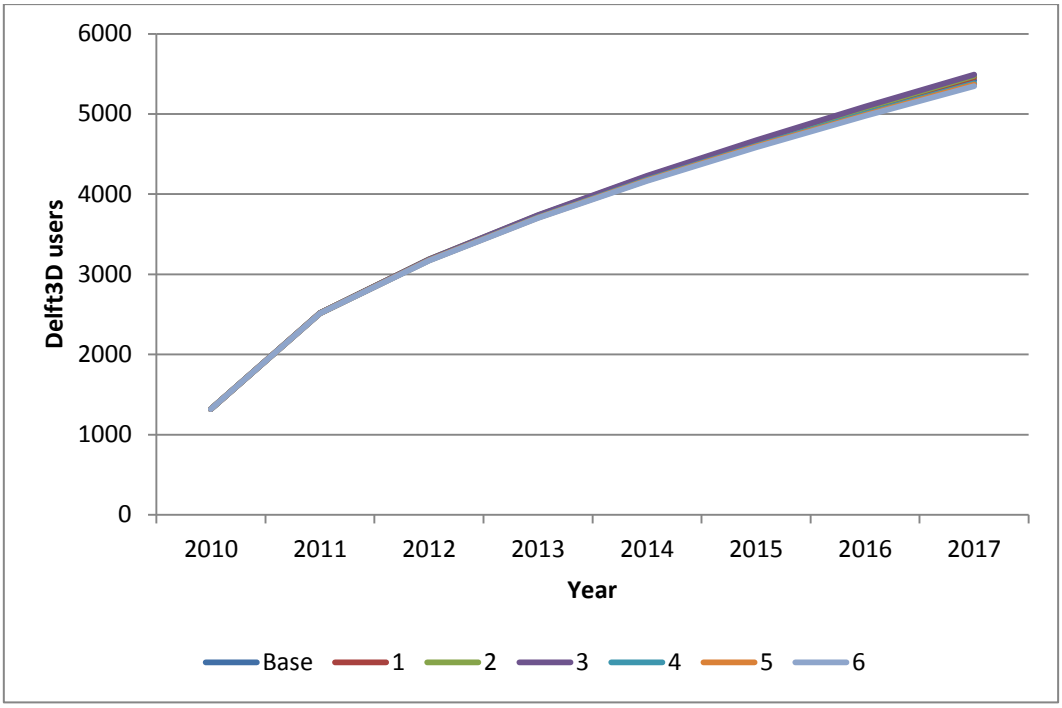


Figure 34. Results for sensitivity analysis for effect of changed number of development partners on awareness

The last test was made for effect of changed number of development partners on adoption rate (see *Figure 36*). As well as it was with the effect of attendance people of the conferences there is a certain degree of sensitivity of the system to the changes, but not so dramatic.

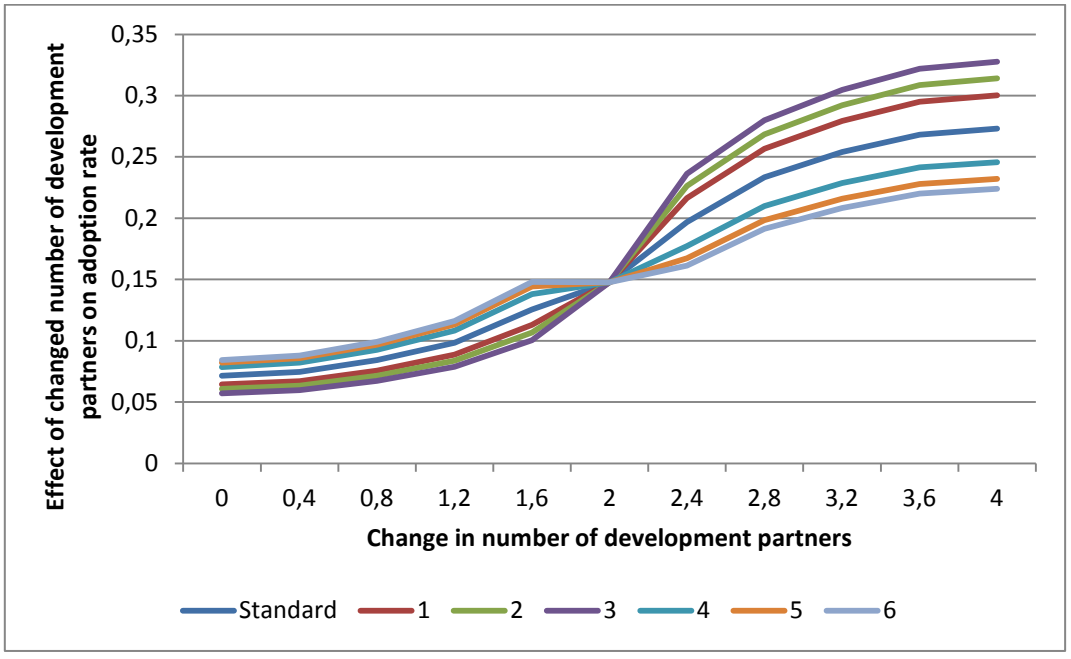


Figure 35. Effect of changed number of development partners on adoption rate. Graphical functions for sensitivity analysis

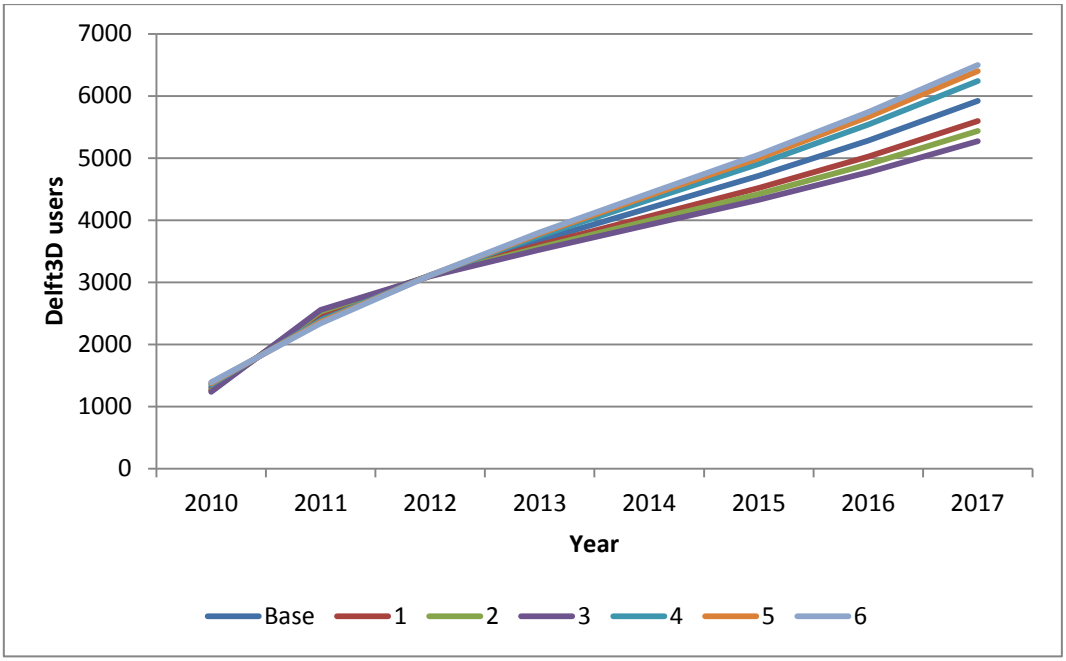


Figure 36. Results for sensitivity analysis for effect of changed number of development partners on adoption rate

According to all results of the testing, we can see that the model is stable for the changes of effect parameters. As it was explained above, it was important to see how system will behave according to the changes in the effects, because they are important for the structure. And we got good results.

4.2.4. Structure behaviour test

Let start with the switching off loop 1 (see *Figure 12*). There will be the following graph (see *Figure 37*):

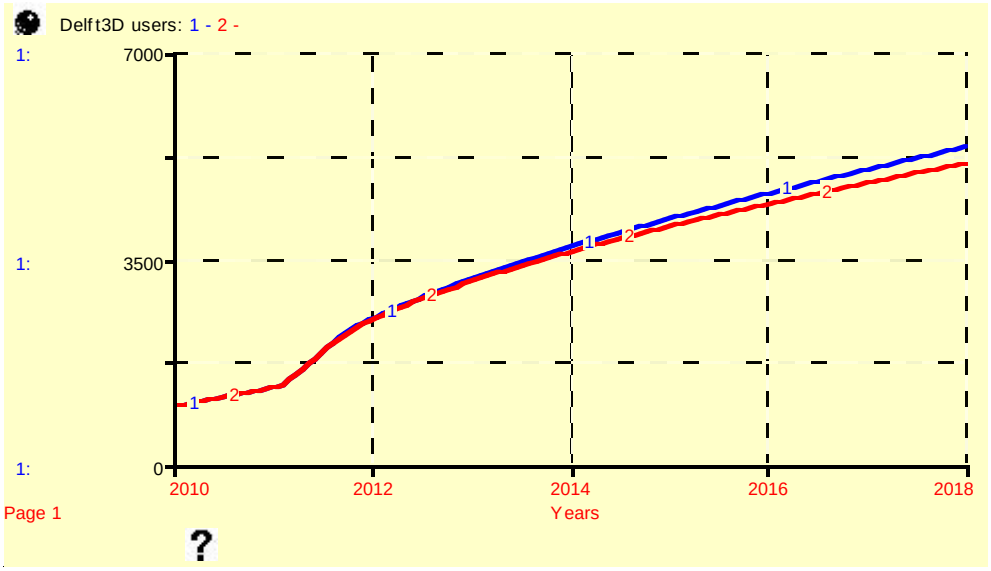


Figure 37. Switch off effect of the image on the awareness of the product

Blue line is the basic run, red – switch off the loop. We can see that without the effect of the image on the awareness of the product there is going to be 280 (5420 - 5140) users less by 2018.

Continue with the loop 2 (see *Figure 13*) we will get the next graph (see *Figure 38*):

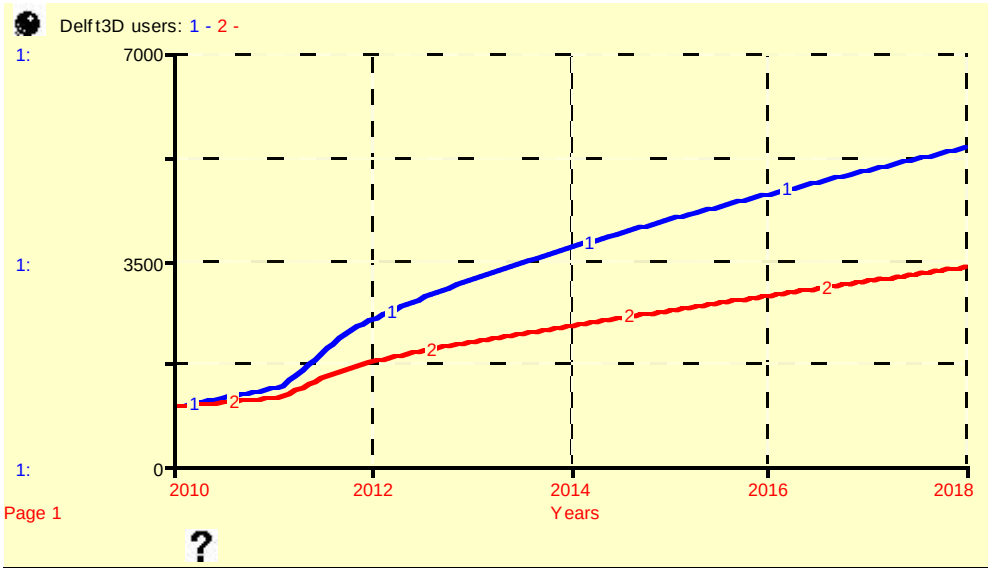


Figure 38. Switch off effect of the image on adoption rate

Blue line is the basic run, red – switch off the loop. There is similar situation, but the result even more impressive: without the effect of the image on adoption rate there is going to be 2033 (5420 - 3387) users less by 2018.

If to discard 3rd loop (see *Figure 18*) we will get this graph (see *Figure 39*):

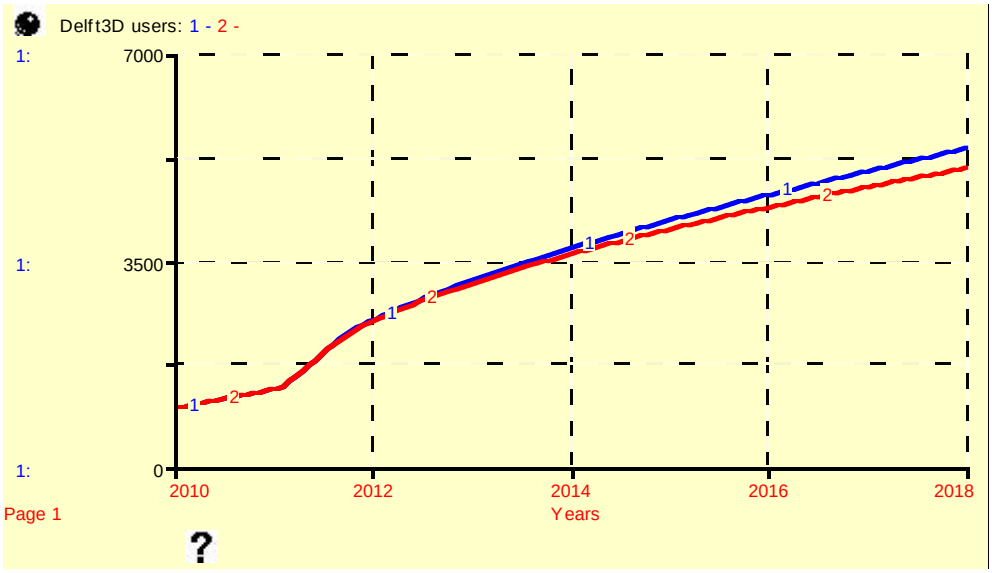


Figure 39. Switch off effect of marketing spends on awareness cold contacts

Blue line is the basic run, red – switch off the loop. Number of users will be decreased on 335 (5420-5085) users if effect of marketing spends on awareness cold contacts will not work.

The result of switching off the last 4th loop (see *Figure 21*) will look as following (see *Figure 40*):

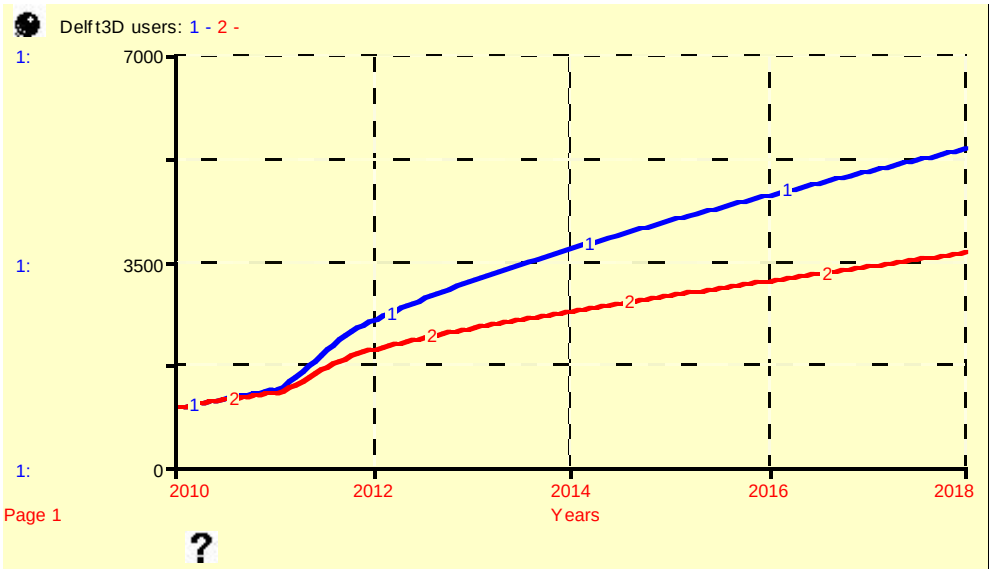


Figure 40. Switch off effect of attendance people of the conferences

Blue line is the basic run, red – switch off the effect. By 2018 there is going to be 1771 (5420-3649) users less.

When effect of changed number of development partners on awareness will not play role there is going to be the following situation (see *Figure 41*):

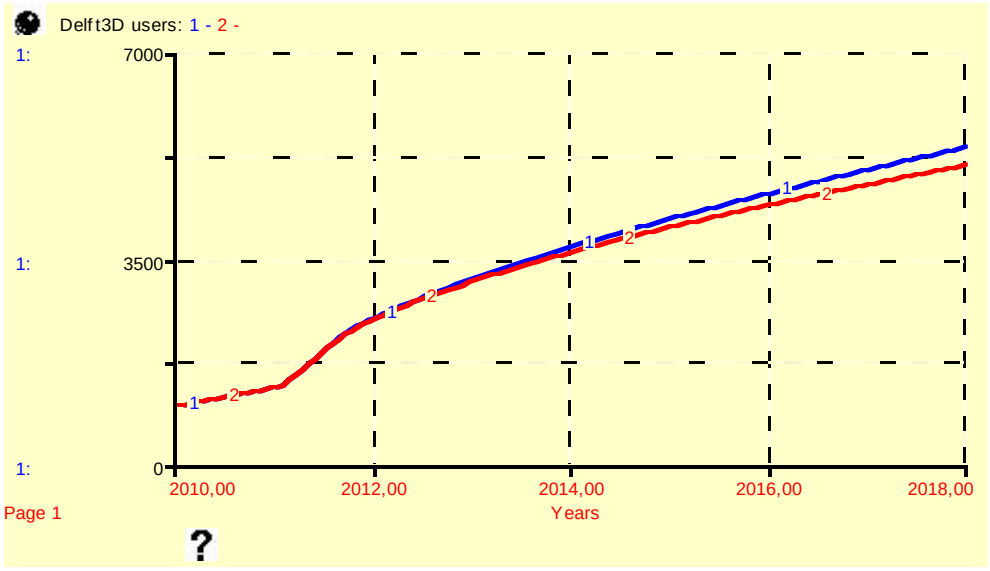


Figure 41. Switch off effect of changed number of development partners on awareness

Blue line is the basic run, red – switch off the effect. By 2018 there is going to be only 308 (5420-5112) users less.

And if we will switch off the effect of development partners on adoption rate (see *Figure 42*):

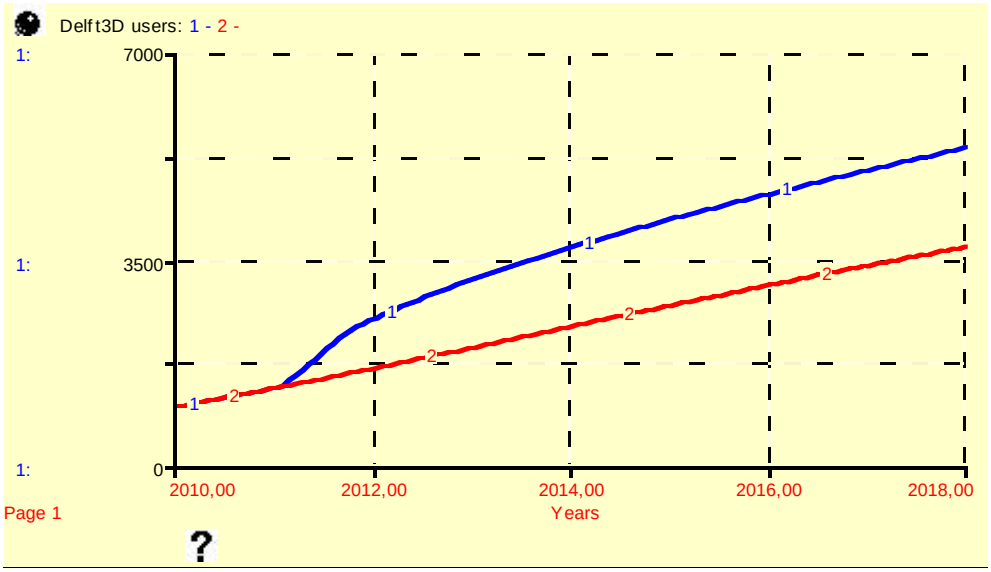


Figure 42. Switch off effect of changed number of development partners on adoption rate

Blue line is the basic run, red – switch off the effect. By 2018 there is going to be 1688 (5420-3732) users less. We can see that this effect has one of the biggest influences on the behaviour of the system.

Therefore we can see that all of effects play a role in the system. To have a better overview which one has the most impact we construct the following table (see *Table 1*):

Table 1. Impacts by the effects

№	Name of the switched off effect	Impact
1	Effect of the image on the awareness of the product	280 users less
2	Effect of the image on adoption rate	2033 users less
3	Effect of direct marketing cold contacts	335 users less
4	Effect of attendance people of the conferences	1771 users less
5	Effect of changed number of development partners on awareness	308 users less
6	Effect of changed number of development partners on adoption rate	1688 users less

As we can out of this table one of the highest influences create image on adoption rate. It means company should put more efforts on increasing its image.

4.2.5. Extreme condition test

Taking into the account structure of the model, there are conducted three ways of checking the behaviour of the model in extreme conditions.

The first one is devoted for seeing what will happen with the stock of Potential clients, because in the current model there is no inflow (Policy 1 will provide an experiment when it exists). Let's run the model till 2050. And the graph you can see on the *Figure 43*:

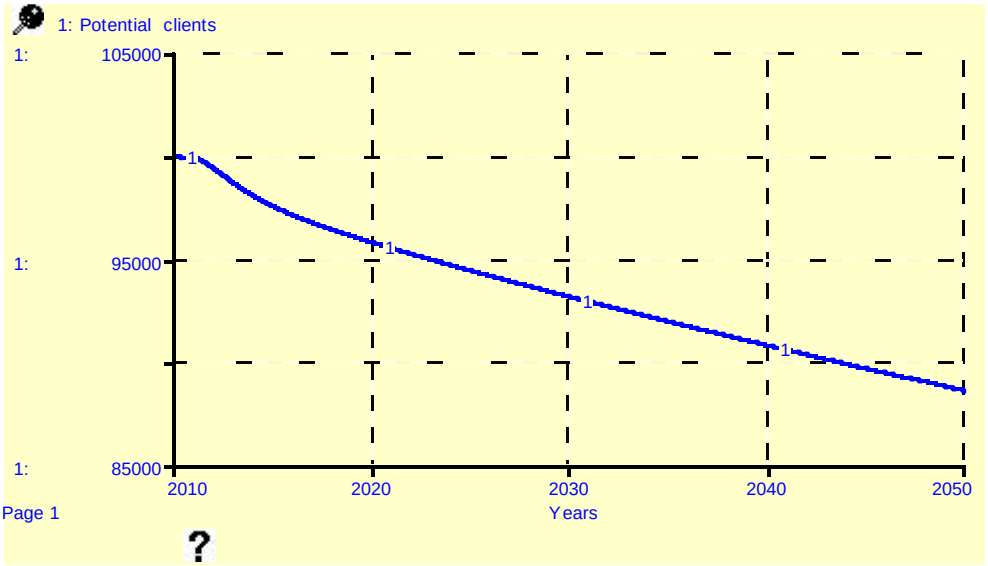


Figure 43. Stock of Potential clients

We can see that stock is still quite full. That is why we can say that in long term situation there still will be enough people to move from the stock.

The second option is to see how system will behave when we remove restriction from all stocks to be "Non-negative". The results are shown on the *Figure 44*. None of any chosen for the check stocks are going under zero. So, we can make a conclusion that system is working correctly.

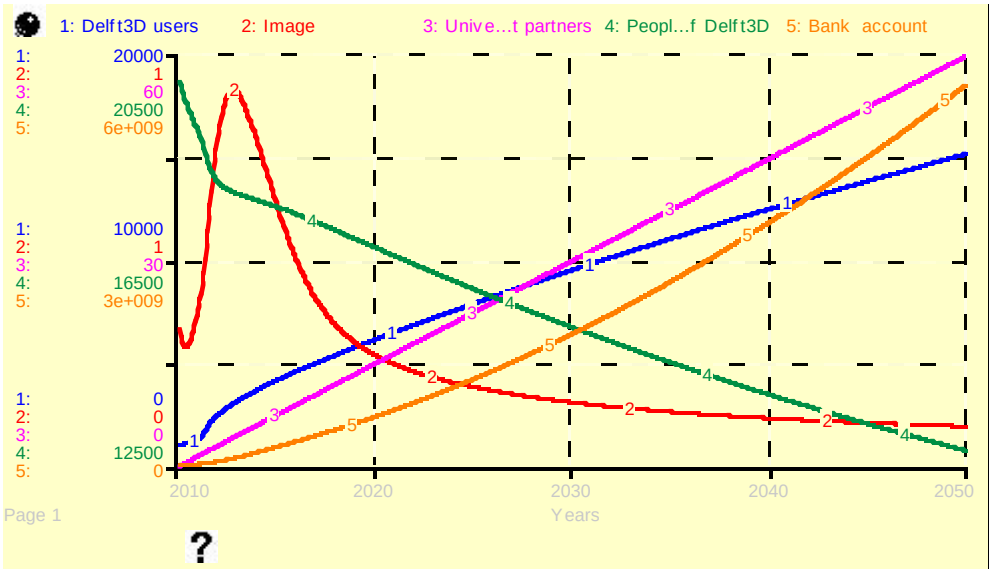


Figure 44. Run: Non-negative restriction removed

(1: Delft3D users; 2: Image; 3: Universities and institutes Development partners; 4: People aware of Delft3D; 5: Bank Account)

The third option is to conduct extreme condition test is to see what will happen with the system if we will change the inputs. This option was tested in the part of policy scenario implications: Policy 2. Stock of marketing budget.

4.3. Policy scenario implications

This research provides three possible policy scenario implications. There are:

– increasing stock of Potential clients;

– changes in the marketing budget.

4.3.1. Policy 1. Stock of potential clients

The main idea of this policy is that right now in the model there is a stock of Potential clients which is not changing over time, but has given as an exogenous parameter with initial value. The point is that current amount of people who could be interested in the Delft3D software can be increased by making new features in the application. That is how we can increase the stock which in its turn will increase the further flows.

In order to test this suggestion and to see the dynamics of the system there was made a slider in the interface of the model where Deltares can test how exact amount of extra potential clients can change the stock of Delft3D users: from 10 000 till 100 000. There are results of this policy test from 0 to 100 000 with the step of 10 000 extra potential clients on the *Figure 45*:

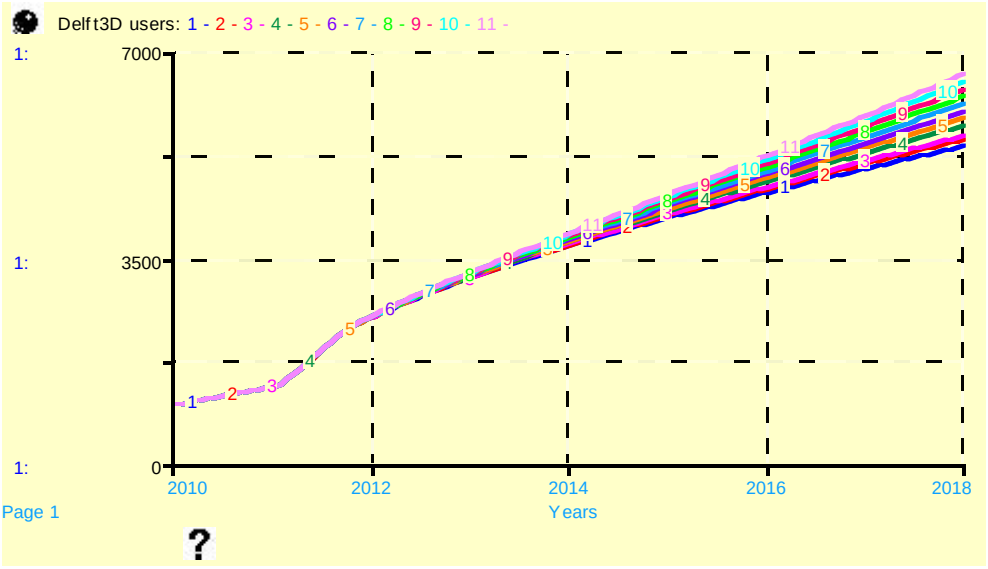


Figure 45. Results for testing "Policy 1. Stock of potential clients"

4.3.2. Policy 2. Stock of marketing budget

In order to check policy options connected to the changes in marketing budget there will be made simulations with parameters of growth fraction of marketing budget and discrete change in budget (see *Figure 15*). The parameter of growth fraction of marketing budget was changed from 0 to 1 with the step of 0.1 and the results are shown on the *Figure 46*.

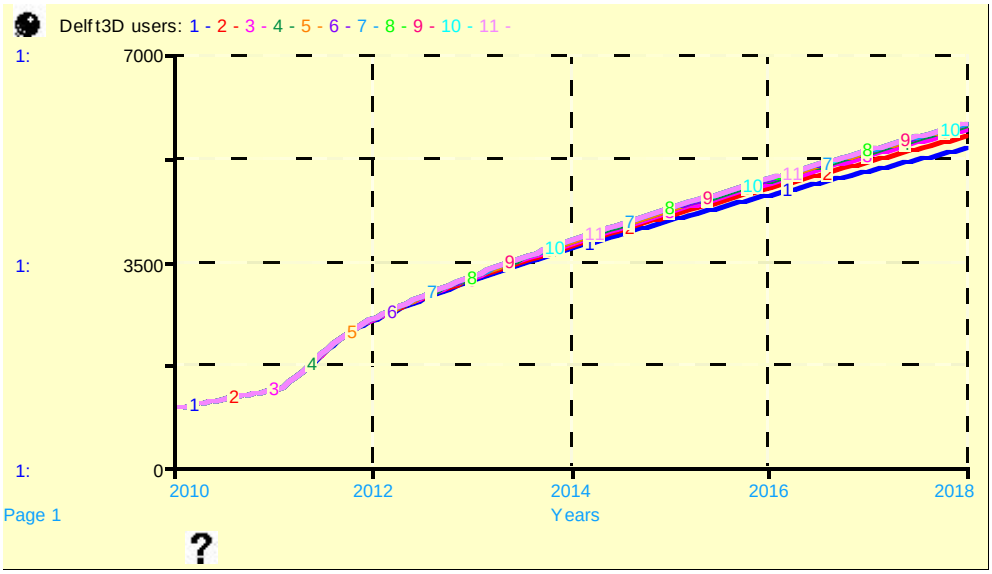


Figure 46. Results for testing "Policy 2. Stock of marketing budget: parameter of growth fraction of marketing budget"

The parameter of discrete change in budget was changed from 0 to 50 000 with the step of 10 000 euro per month. There are results of testing this policy option on the *Figure 47*.

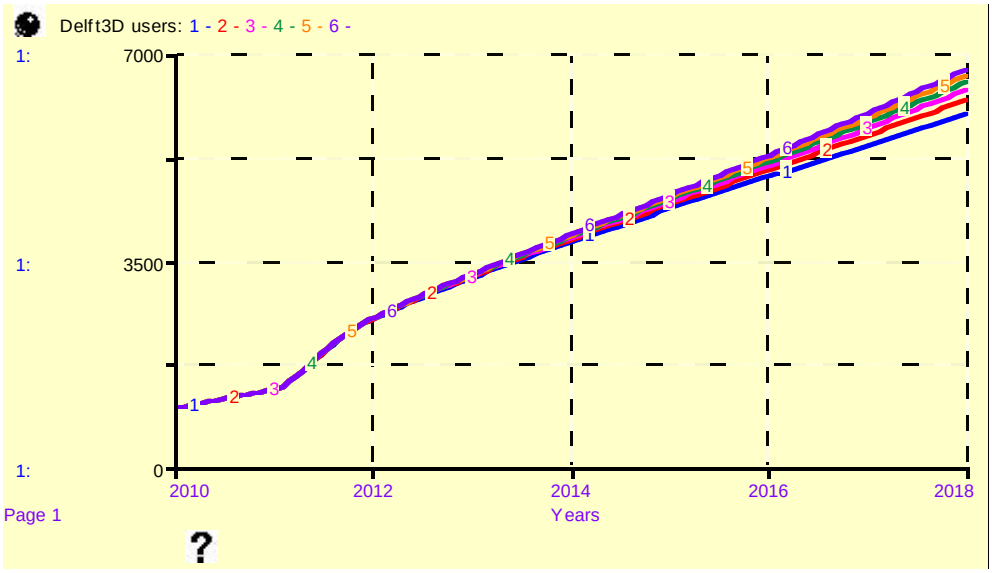


Figure 47. Results for testing "Policy 2. Stock of marketing budget: parameter of discrete change in budget"

According to the results of testing policy options make sense to improve the software programme with the new features in order to increase stock of Potential clients.

5. Conclusion

5.1. Summary

There were constructed explanatory model of Delft3D software product business case. Plus, there were suggested two policy options in order to improve company's performance. Therefore, research objectives were reached. To do that research questions were answered. The construction part of model helped to understand why the behaviour of the system is happening how it is. Through the different simulations and checking behavioral test we know and can see on the graphs what kind of behaviour of the system is going to be in the nearest future. And the same graphs can help company to understand where it is better to put more efforts in order to increase number of Users of Delft3D.

The validations tests showed that model is valid for its purpose which is to have an overview of the all system surrounding Delft3D business case. Specialists from marketing department requested to make a model which can show what kind of marketing efforts bring more clients: and it was shown in the part of testing behavioral structure when we switch off the loops and effects. To minimize difficulties in understanding, there was created interface, so specialists can easily "play" with parameters and switching off the loops.

5.2. Further research options

In order to develop the policy option about intending new features inside the software, it would make sense to include the budget inside the model. To develop several scenarios of what kind of features it could be, how much it will approximately cost for Deltares and how many potential clients it can bring. This research will help to conduct cost-benefit analysis.

There are limitations of the model: several variables are introduced exogenously and the model cannot be used as it is forever; it needs to be adjusted over time. That is why, it is possible to develop model further and try to make left exogenous parameter as endogenous.

Appendixes

Appendix 1. Model equations

Bank__account(t) = Bank__account(t - dt) + (Income - Spending) * dt

INIT Bank__account = 10000000

INFLOWS:

Income = Revenue__from_users

OUTFLOWS:

Spending = min(Marketing__budget,Bank__account/min_time_to__spend_all)

Delft3D_users(t) = Delft3D_users(t - dt) + (Adoption_rate + Users_again - Ñlient__loss_rate) * dt

INIT Delft3D_users = 1000

INFLOWS:

Adoption_rate = IF (Effect_of_changed_number_of_development_partners_on_adoption_rate=0) THEN (People_aware__of_Delft3D*Effect_of_image__on_adoption_rate) ELSE (IF (Effect_of_image__on_adoption_rate=0) THEN (People_aware__of_Delft3D*Effect_of_changed_number_of_development_partners_on_adoption_rate) ELSE (People_aware__of_Delft3D*Effect_of_changed_number_of_development_partners_on_adoption_rate*Effect_of_image__on_adoption_rate))

Users_again = Latent__Users/Time_to_become__active_user

OUTFLOWS:

Ñlient__loss_rate = Delft3D_users*Loss_rate__fraction

Image(t) = Image(t - dt) + (Change__in_image) * dt

INIT Image = 0.5

INFLOWS:

Change__in_image = Effect_of_attendance_people_of_the_conferences*Effect_of___number_of_users-Image

Latent__Users(t) = Latent__Users(t - dt) + (Ñlient__loss_rate - Users_again) * dt

INIT Latent__Users = 0

INFLOWS:

Ñlient__loss_rate = Delft3D_users*Loss_rate__fraction

OUTFLOWS:

Users_again = Latent__Users/Time_to_become__active_user

Marketing__budget(t) = Marketing__budget(t - dt) + (Marketing_budget__year_flow) * dt

INIT Marketing__budget = 285000

INFLOWS:

Marketing_budget__year_flow =
Marketing__budget*Growth_fraction_for_marketing_budget+Discrete_change__in_budget

People_aware__of_Delft3D(t) = People_aware__of_Delft3D(t - dt) +
(People_becoming_aware_of_the_product +
Rate_of_people_who_started_to_think_about_using_the_product - Adoption_rate -
Rate_of_people_who_doesn't_want_to_use_the_software) * dt

INIT People_aware__of_Delft3D = 20000

INFLOWS:

People_becoming_aware_of_the_product =
Potential__clients*Effect_of_changed__number_of_development__partners_on_awareness*Effect_of_image_on_awareness_of_the_product*Effect_of_marketing__spends_on_awareness__cold_contacts/Adj_time_to_be__aware_of_the_product

Rate_of_people_who_started_to_think_about_using_the_product =
Unsuccessful__clients*Probability_of_starting_to_think_about_using_the_product

OUTFLOWS:

Adoption_rate = IF (Effect_of_changed_number_of_development_partners_on_adoption_rate=0)
THEN (People_aware__of_Delft3D*Effect_of_image__on_adoption_rate) ELSE (IF
(Effect_of_image__on_adoption_rate=0) THEN
(People_aware__of_Delft3D*Effect_of_changed_number_of_development_partners_on_adoption_rate) ELSE
(People_aware__of_Delft3D*Effect_of_changed_number_of_development_partners_on_adoption_rate*Effect_of_image__on_adoption_rate))

Rate_of_people_who_doesn't_want_to_use_the_software = Probability_of_becoming_unsuccessful_client*People_aware__of_Delft3D

Potential__clients(t) = Potential__clients(t - dt) + (Flow_of_new__potential_clients - People_becoming_aware_of_the_product) * dt

INIT Potential__clients = 100000

INFLOWS:

Flow_of_new__potential_clients = New_potential_clients_because__of_new_features_in_Delft3D*Switch_Policy_option_with_new_features

OUTFLOWS:

People_becoming_aware_of_the_product = Potential__clients*Effect_of_changed__number_of_development__partners_on_awareness*Effect_of_image_on_awareness_of_the_product*Effect_of_marketing__spends_on_awareness__cold_contacts/Adj_time_to_be__aware_of_the_product

Universities__and_Institutes__Development_partners(t) = Universities__and_Institutes__Development_partners(t - dt) + (Becoming__a_partner - Quitting_to_be__clients) * dt

INIT Universities__and_Institutes__Development_partners = 0

INFLOWS:

Becoming__a_partner = Number_of_new__partners_per_year

OUTFLOWS:

Quitting_to_be__clients = 1

Unsuccessful__clients(t) = Unsuccessful__clients(t - dt) + (Rate_of_people_who_doesn't_want_to_use_the_software - Rate_of_people_who_started_to_think_about_using_the_product) * dt

INIT Unsuccessful__clients = 0

INFLOWS:

Rate_of_people_who_doesn't_want_to_use_the_software = Probability_of_becoming_unsuccessful_client*People_aware__of_Delft3D

OUTFLOWS:

Rate_of_people_who_started_to_think_about_using_the_product = Unsuccessful__clients*Probability_of_starting_to_think_about_using_the_product

Adj_time_to_be__aware_of_the_product = 2

Amount_of__conferences_are__held_in_a_year = GRAPH(Spending)

(0.00, 3.81), (30000, 15.6), (60000, 26.3), (90000, 39.7), (120000, 49.2), (150000, 60.0), (180000, 69.5), (210000, 81.0), (240000, 90.2), (270000, 96.2), (300000, 100)

Ave_revenue__for_research_and_dev_project_per_user = GRAPH(Image)

(0.00, 18095), (0.2, 37143), (0.4, 67619), (0.6, 99048), (0.8, 128571), (1.00, 168000), (1.20, 193333), (1.40, 208571), (1.60, 230476), (1.80, 250476), (2.00, 269524)

Av_number_of__participants_in__the_conference = 200

Change_in_number_of_development_partners = if Development__Partners=0 then 0 else (Universities__and_Institutes__Development_partners/Development__Partners)

Current_year__attendance = Amount_of__conferences_are__held_in_a_year*Av_number_of__participants_in__the_conference

Delft3D_users__data = GRAPH(TIME)

(2010, 1000), (2011, 1192), (2012, 2264), (2013, 3075), (2014, 3075), (2015, 3075), (2016, 3075), (2017, 3075), (2018, 3075)

Development__Partners = HISTORY(Universities__and_Institutes__Development_partners, time -1)

Discrete_change__in_budget = 0

Effect_of_attendance_people_of_the_conferences = GRAPH((Participants_attendance__growth_rate+1)*Switch_Effect_of__attendance_people_of__the_conferences)

(0.00, 0.108), (0.2, 0.117), (0.4, 0.162), (0.6, 0.213), (0.8, 0.302), (1.00, 0.384), (1.20, 0.552), (1.40, 0.73), (1.60, 0.851), (1.80, 0.908), (2.00, 0.956)

Effect_of_changed_number_of_development_partners_on_adoption_rate = GRAPH(Change_in_number_of_development_partners*Switch_Effect_of_changed_number__of_dev_partners_on_adoption_rate)

(0.00, 0.0714), (0.4, 0.0746), (0.8, 0.0841), (1.20, 0.0984), (1.60, 0.125), (2.00, 0.148), (2.40, 0.197), (2.80, 0.233), (3.20, 0.254), (3.60, 0.268), (4.00, 0.273)

Effect_of_changed__number_of_development__partners_on_awareness = GRAPH(Change_in_number_of_development_partners*Switch_Effect_of_changed_number_of_dev_partners_on_awareness)

(0.00, 0.0556), (0.2, 0.0556), (0.4, 0.0698), (0.6, 0.0921), (0.8, 0.132), (1.00, 0.187), (1.20, 0.243), (1.40, 0.286), (1.60, 0.319), (1.80, 0.341), (2.00, 0.349)

Effect_of_image_on_awareness_of_the_product = GRAPH(Normalized_image*Switch_Effect_of_the_image_on_awareness_of_the_product

{people/year per euros/year})

(0.00, 0.108), (0.333, 0.111), (0.667, 0.196), (1.00, 0.28), (1.33, 0.419), (1.67, 0.635), (2.00, 0.797), (2.33, 0.858), (2.67, 0.895), (3.00, 0.926)

Effect_of_image__on_adoption_rate = GRAPH(Normalized_image*Switch_Effect_of_the_image_on_adoption_rate)

(0.00, 0.173), (0.3, 0.19), (0.6, 0.221), (0.9, 0.282), (1.20, 0.335), (1.50, 0.373), (1.80, 0.424), (2.10, 0.467), (2.40, 0.505), (2.70, 0.538), (3.00, 0.549)

Effect_of_marketing__spends_on_awareness__cold_contacts = GRAPH(Normalized__spending*Switch_Effect_of__marketing_spends__on_awareness_cold_contacts)

(0.00, 0.0159), (0.2, 0.0222), (0.4, 0.0365), (0.6, 0.0571), (0.8, 0.0762), (1.00, 0.103), (1.20, 0.137), (1.40, 0.16), (1.60, 0.176), (1.80, 0.192), (2.00, 0.213)

Effect_of___number_of_users = GRAPH(Rate_of__users'_growth+1)

(0.00, 0.152), (0.2, 0.254), (0.4, 0.356), (0.6, 0.527), (0.8, 0.749), (1.00, 1.07), (1.20, 1.56), (1.40, 1.85), (1.60, 1.96), (1.80, 1.97), (2.00, 1.98)

Fraction_of_users__which_do_research_and_dev_projects = 0.2

Growth_fraction_for_marketing_budget = 0

Loss_rate__fraction = 0.1

min_time_to__spend_all = 0.08

New_potential_clients_because__of_new_features_in_Delft3D = 50000

Normalized_image = Image/Normal__image

Normalized__spending = Spending/Normal__Spending

Normal__image = 0.5

Normal__spending = 285000

Number_of_new__partners_per_year = 2.5

Participants_attendance__growth_rate = TREND(Current_year__attendance,1)

Probability_of_becoming_unsuccessful_client = 0.05

Probability_of_starting_to_think_about_using_the_product = 0.85

Rate_of__users'_growth = TREND(Delft3D_users,1)

Revenue__from_users = Delft3D_users*Ave_revenue__for_research_and_dev_project_per_user*Fraction_of_users__which_do_research_and_dev_projects

Switch_Effect_of_changed_number_of_dev_partners_on_awareness = 1

Switch_Effect_of_changed_number__of_dev_partners_on_adoption_rate = 1

Switch_Effect_of_the_image_on_adoption_rate = 1

Switch_Effect_of_the_image_on_awareness_of_the_product = 1

Switch_Effect_of__attendance_people_of__the_conferences = 1

Switch_Effect_of__marketing_spends__on_awareness_cold_contacts = 1

Switch_Policy_option_with_new_features = 1

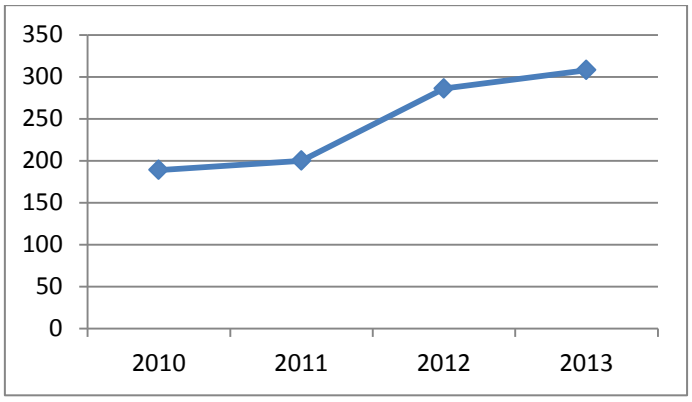
Time_to_become__active_user = 2.5

Appendix 2. Policy Memorandum

Deltares is an institute for applied research in the field of water, subsurface and infrastructure. The main focus of the company is on deltas, coastal regions, and river basins. Managing these densely populated and vulnerable areas all over the world is complex, which is why Deltares works closely with governments, businesses, other research institutes and universities in the Netherlands and abroad.

In 2011 Deltares started to spread Delft3D software programme as an open source after 13 years of licensing. With open source strategy Deltares shows that they "dare to share" and believe in switching from a "commercial" perspective, in which licensing is the basis for the revenue stream, to a "value delivering" perspective, where creating value for a client results in a sustainable revenue stream.

According to the new policy, the license is absolutely free for any amount of users, but the support and maintenance are costs that depend on the package. Because of no license payment it is obvious that the product costs less. It attracted many new companies as clients (see *Companies (Delft3D clients)*). The number of users inside the company is varying from 1 till 20 in average.

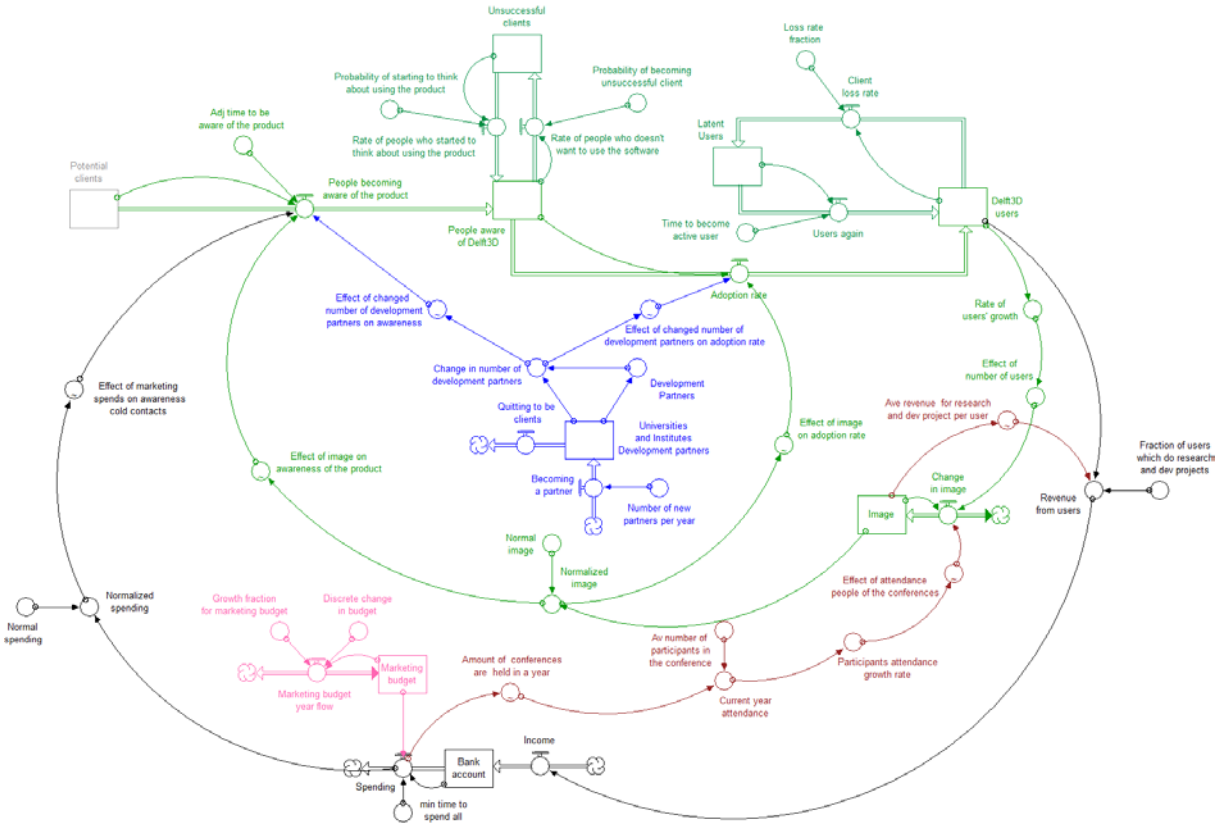


Companies (Delft3D clients)

The main goal for the company: enlarging usage of the product (Delft3D) in order to achieve bigger market share. Deltares wants to see more Research Institutes in the list of clients. Because institutes not just use it, but may help to improve and support the product.

In order to do that Deltares asked to make a practical model which can help to see which of the marketing efforts are more efficient, to be able to change the parameters and to see what happened.

The following model comes out of all interview and databases (see *Full model*):



Full model

Each of loops with effects was tested and there are results in the table (*Impacts by the effects*):

Impacts by the effects

№	Name of the switched off effect	Impact
1	Effect of the image on the awareness of the product	280 users less
2	Effect of the image on adoption rate	2033 users less
3	Effect of direct marketing cold contacts	335 users less
4	Effect of attendance people of the conferences	1771 users less
5	Effect of changed number of development partners on awareness	308 users less
6	Effect of changed number of development partners on adoption rate	1688 users less

As we can out of this table one of the highest influences create image on adoption rate. It means company should put more efforts on increasing its image.

Two policy options were checked:

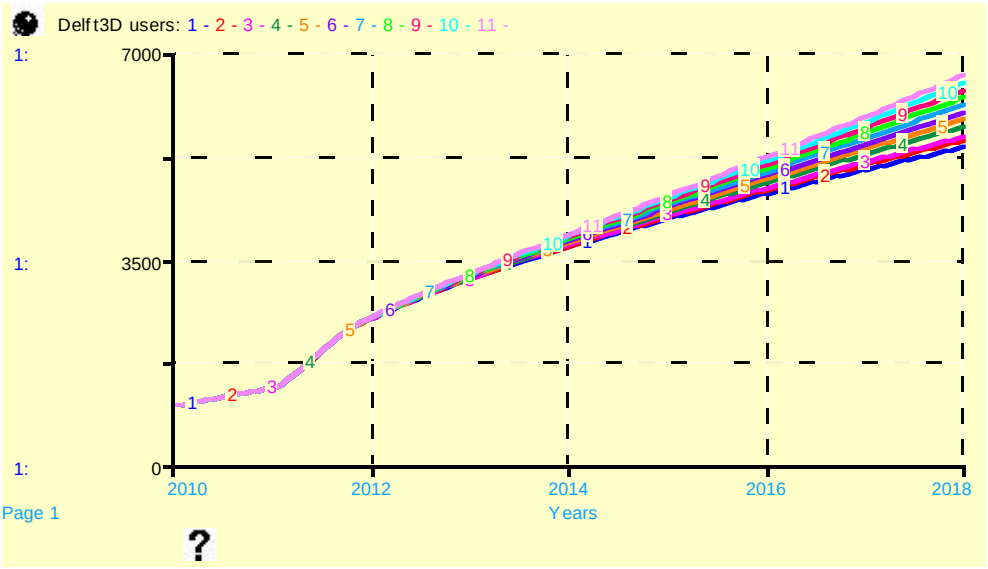
– increasing stock of Potential clients;

– changes in the marketing budget.

Policy 1. Stock of potential clients

The main idea of this policy is that right now in the model there is a stock of Potential clients which is not changing over time, but has given as an exogenous parameter with initial value. The point is that current amount of people who could be interested in the Delft3D software can be increased by making new features in the application. That is how we can increase the stock which in its turn will increase the further flows.

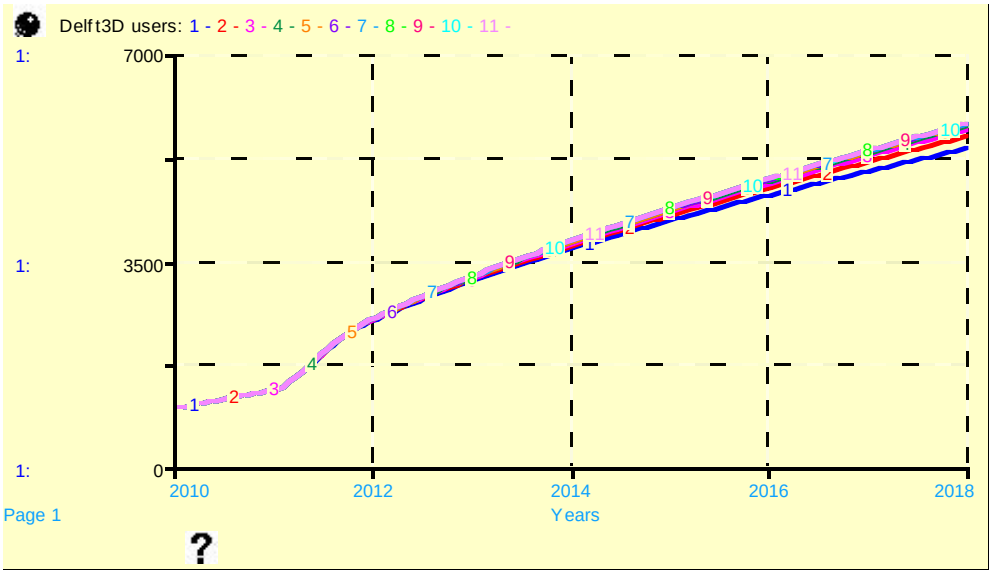
In order to test this suggestion and to see the dynamics of the system there was made a slider in the interface of the model where Deltares can test how exact amount of extra potential clients can change the stock of Delft3D users: from 10 000 till 100 000. There are results of this policy test from 0 to 100 000 with the step of 10 000 extra potential clients on the *Figure Results for testing "Policy 1. Stock of potential clients"*:



Results for testing "Policy 1. Stock of potential clients"

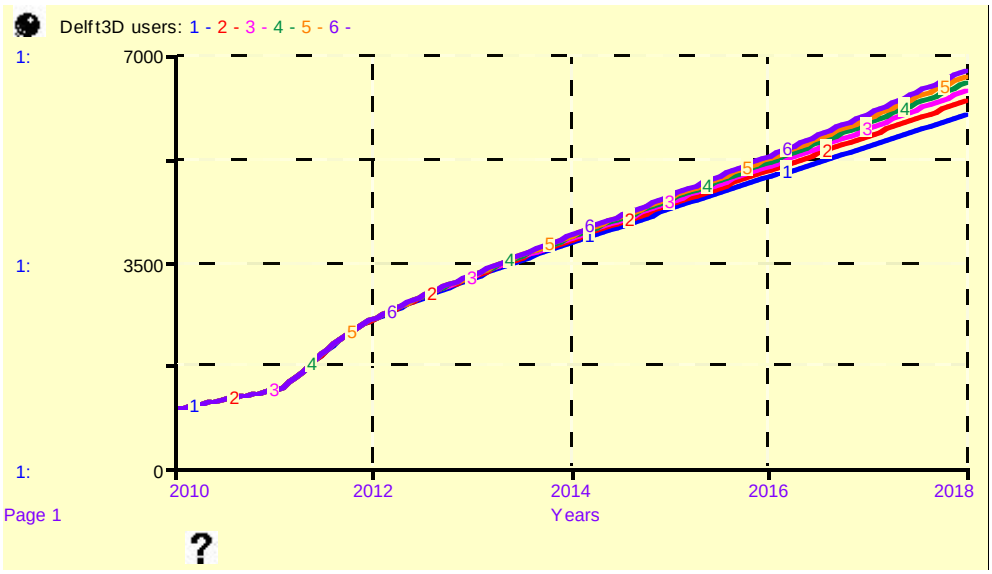
Policy 2. Stock of marketing budget

In order to check policy options connected to the changes in marketing budget there will be made simulations with parameters of growth fraction of marketing budget and discrete change in budget (see *Full model*). The parameter of growth fraction of marketing budget was changed from 0 to 1 with the step of 0.1 and the results are shown on the *Figure Results for testing "Policy 2. Stock of marketing budget: parameter of growth fraction of marketing budget".*



Results for testing "Policy 2. Stock of marketing budget: parameter of growth fraction of marketing budget"

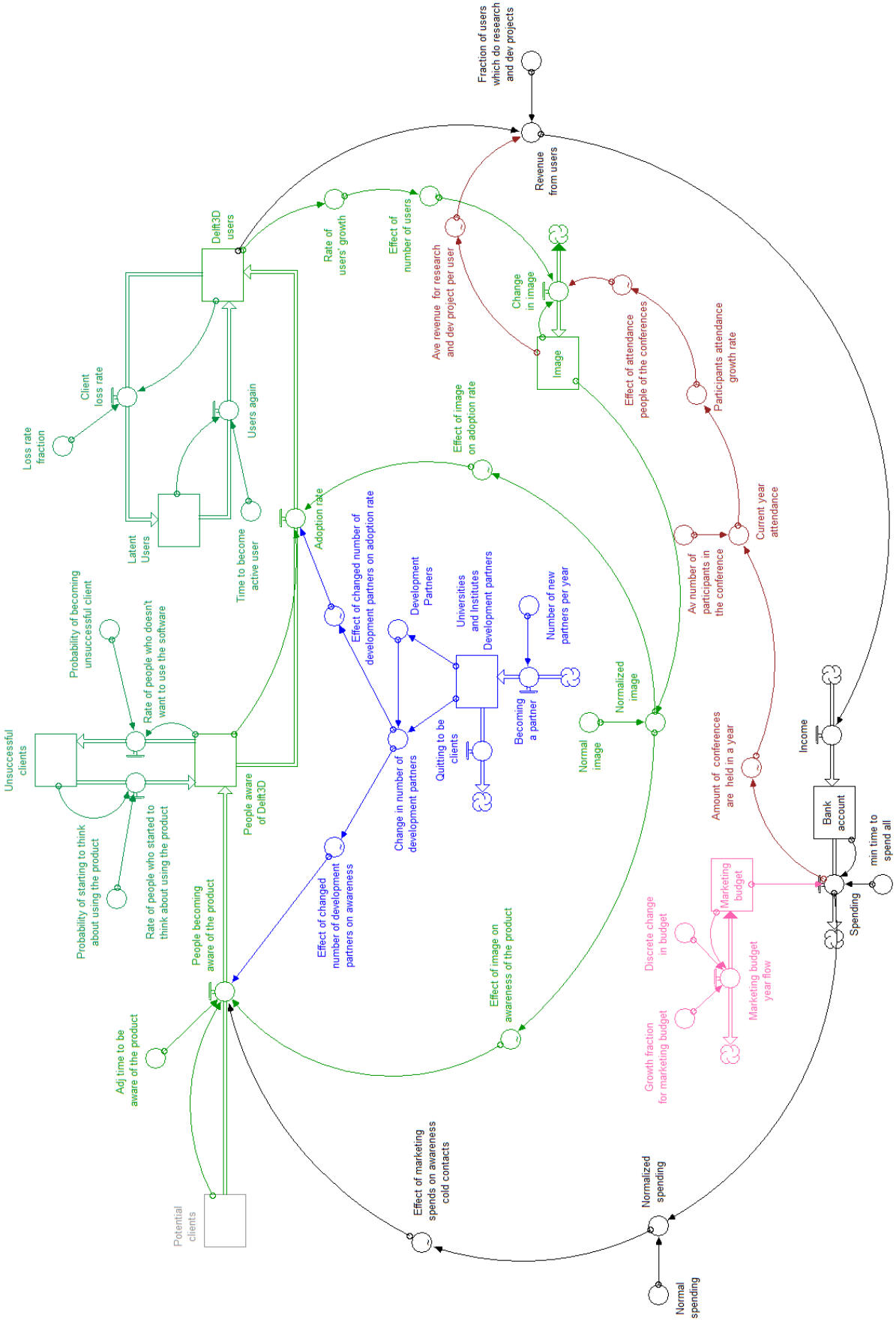
The parameter of discrete change in budget was changed from 0 to 50 000 with the step of 10 000 euro per month. There are results of testing this policy option on the *Figure "Policy 2. Stock of marketing budget: parameter of discrete change in budget"*.



Results for testing "Policy 2. Stock of marketing budget: parameter of discrete change in budget"

According to the results of testing policy options make sense to improve the software programme with the new features in order to increase stock of Potential clients.

Appendix 3. Full model in iThink



Appendix 4. Tables for validation tests of the effects

Effect of image on awareness of the product

		Standard	1	2	3	4	5	6
1	0,000	0,108	0,097297	0,091892	0,086486	0,118919	0,124324	0,12973
2	0,333	0,111	0,100338	0,094764	0,089189	0,122635	0,128209	0,133784
3	0,667	0,196	0,176351	0,166554	0,156757	0,215541	0,225338	0,235135
4	1,000	0,280	0,252365	0,238345	0,224324	0,308446	0,322466	0,336486
5	1,333	0,419	0,377027	0,356081	0,335135	0,460811	0,481757	0,502703
6	1,667	0,635	0,699	0,730405	0,762162	0,571622	0,539865	0,508108
7	2,000	0,797	0,877	0,916892	0,956757	0,717568	0,677703	0,637838
8	2,330	0,858	0,944	0,986824	1,02973	0,772297	0,729392	0,686486
9	2,667	0,895	0,985	1,029561	1,074324	0,805743	0,76098	0,716216
10	3,000	0,926	1,018	1,064527	1,110811	0,833108	0,786824	0,740541

Effect of image on adoption rate

		Standard	1	2	3	4	5	6
1	0	0,172698	0,164063	0,155429	0,146794	0,177879	0,18306	0,189968
2	0,3	0,190476	0,180952	0,171429	0,161905	0,19619	0,201905	0,209524
3	0,6	0,220952	0,209905	0,198857	0,18781	0,227581	0,23421	0,243048
4	0,9	0,281905	0,26781	0,253714	0,239619	0,290362	0,298819	0,310095
5	1,2	0,335238	0,318476	0,301714	0,284952	0,345295	0,355352	0,368762
6	1,5	0,373333	0,373333	0,373333	0,373333	0,373333	0,373333	0,373333
7	1,8	0,424127	0,445333	0,46654	0,487746	0,411403	0,398679	0,381714
8	2,1	0,467302	0,490667	0,514032	0,537397	0,453283	0,439263	0,420571
9	2,4	0,505397	0,530667	0,555937	0,581206	0,490235	0,475073	0,454857
10	2,7	0,538413	0,565333	0,592254	0,619175	0,52226	0,506108	0,484571
11	3	0,548571	0,576	0,603429	0,630857	0,532114	0,515657	0,493714

Effect of marketing spends on awareness cold contacts

		Standard	1	2	3	4	5	6
1	0	0,015873	0,015079	0,014286	0,013492	0,016349	0,016825	0,01746
2	0,2	0,022222	0,021111	0,02	0,018889	0,022889	0,023556	0,024444
3	0,4	0,036508	0,034683	0,032857	0,031032	0,037603	0,038698	0,040159
4	0,6	0,057143	0,054286	0,051429	0,048571	0,058857	0,060571	0,062857
5	0,8	0,07619	0,072381	0,068571	0,064762	0,078476	0,080762	0,08381
6	1	0,103175	0,103175	0,103175	0,103175	0,103175	0,103175	0,103175
7	1,2	0,136508	0,143333	0,150159	0,156984	0,132413	0,128317	0,122857
8	1,4	0,160317	0,168333	0,176349	0,184365	0,155508	0,150698	0,144286
9	1,6	0,17619	0,185	0,19381	0,202619	0,170905	0,165619	0,158571
10	1,8	0,192063	0,201667	0,21127	0,220873	0,186302	0,18054	0,172857
11	2	0,212698	0,223333	0,233968	0,244603	0,206317	0,199937	0,191429

Effect of attendance people of the conferences

		Standard	1	2	3	4	5	6
1	0	0,107937	0,097143	0,091746	0,086349	0,11873	0,124127	0,129524
2	0,2	0,11746	0,105714	0,099841	0,093968	0,129206	0,135079	0,140952
3	0,4	0,161905	0,145714	0,137619	0,129524	0,178095	0,18619	0,194286
4	0,6	0,212698	0,191429	0,180794	0,170159	0,233968	0,244603	0,255238
5	0,8	0,301587	0,271429	0,256349	0,24127	0,331746	0,346825	0,361905
6	1	0,384127	0,384127	0,384127	0,384127	0,384127	0,384127	0,384127
7	1,2	0,552381	0,607619	0,635238	0,662857	0,497143	0,469524	0,441905
8	1,4	0,730159	0,803175	0,839683	0,87619	0,657143	0,620635	0,584127
9	1,6	0,850794	0,935873	0,978413	1,020952	0,765714	0,723175	0,680635
10	1,8	0,907937	0,99873	1,044127	1,089524	0,817143	0,771746	0,726349
11	2	0,955556	1,051111	1,098889	1,146667	0,86	0,812222	0,764444

Effect of changed number of development partners on awareness

		Standard	1	2	3	4	5	6
1	0	0,055556	0,05	0,047222	0,044444	0,061111	0,063889	0,066667
2	0,2	0,055556	0,05	0,047222	0,044444	0,061111	0,063889	0,066667
3	0,4	0,069841	0,062857	0,059365	0,055873	0,076825	0,080317	0,08381
4	0,6	0,092063	0,082857	0,078254	0,073651	0,10127	0,105873	0,110476
5	0,8	0,131746	0,118571	0,111984	0,105397	0,144921	0,151508	0,158095
6	1	0,187302	0,187302	0,187302	0,187302	0,187302	0,187302	0,187302
7	1,2	0,242857	0,267143	0,279286	0,291429	0,218571	0,206429	0,194286
8	1,4	0,285714	0,314286	0,328571	0,342857	0,257143	0,242857	0,228571
9	1,6	0,319048	0,350952	0,366905	0,382857	0,287143	0,27119	0,255238
10	1,8	0,34127	0,375397	0,39246	0,409524	0,307143	0,290079	0,273016
11	2	0,349206	0,384127	0,401587	0,419048	0,314286	0,296825	0,279365

Effect of changed number of development partners on adoption rate

		Standard	1	2	3	4	5	6
1	0	0,071429	0,064286	0,060714	0,057143	0,078571	0,082143	0,084286
2	0,4	0,074603	0,067143	0,063413	0,059683	0,082063	0,085794	0,088032
3	0,8	0,084127	0,075714	0,071508	0,067302	0,09254	0,096746	0,09927
4	1,2	0,098413	0,088571	0,083651	0,07873	0,108254	0,113175	0,116127
5	1,6	0,125397	0,112857	0,106587	0,100317	0,137937	0,144206	0,147968
6	2	0,147619	0,147619	0,147619	0,147619	0,147619	0,147619	0,147619
7	2,4	0,196825	0,216508	0,226349	0,23619	0,177143	0,167302	0,161397
8	2,8	0,233333	0,256667	0,268333	0,28	0,21	0,198333	0,191333
9	3,2	0,253968	0,279365	0,292063	0,304762	0,228571	0,215873	0,208254
10	3,6	0,268254	0,295079	0,308492	0,321905	0,241429	0,228016	0,219968
11	4	0,273016	0,300317	0,313968	0,327619	0,245714	0,232063	0,223873

Effect of image on awareness if the product

Delft3D users	Base	1	2	3	4	5	6
Initial	1000	1000	1000	1000	1000	1000	1000
2010	1318,08	1318,01	1317,97	1317,93	1318,16	1318,2	1318,24
2011	2514,79	2512,6	2511,5	2510,4	2517,02	2518,12	2519,23
2012	3179,79	3173,62	3170,52	3167,41	3186,02	3189,11	3192,21
2013	3720,89	3709,43	3703,67	3697,9	3732,4	3738,13	3743,85
2014	4197,06	4179,41	4170,54	4161,66	4214,76	4223,57	4232,37
2015	4628,4	4604	4591,75	4579,49	4652,85	4665,02	4677,19
2016	5032,16	5000,75	4984,98	4969,2	5063,65	5079,33	5095
2017	5420,48	5381,81	5362,4	5342,97	5459,28	5478,6	5497,9

Effect of image on adoption rate

Delft3D users	Base	1	2	3	4	5	6
Initial	1000	1000	1000	1000	1000	1000	1000
2010	1318,08	1297,62	1277,22	1256,88	1330,39	1342,71	1359,17
2011	2514,79	2430,89	2345,8	2259,86	2564,49	2613,7	2678,17
2012	3179,79	3080,12	2976,63	2869,21	3237,87	3294,73	3368,34
2013	3720,89	3607,7	3489,49	3365,82	3786,65	3850,93	3934,07
2014	4197,06	4064,32	3926,1	3781,78	4274,4	4350,16	4448,48
2015	4628,4	4475,97	4317,92	4153,63	4717,46	4804,89	4918,68
2016	5032,16	4862,17	4686,35	4504,13	5131,67	5229,47	5356,96
2017	5420,48	5234,36	5042,16	4843,33	5529,55	5636,82	5776,8

Effect of marketing spends on awareness cold contacts

Delft3D users	Base	1	2	3	4	5	6
Initial	1000	1000	1000	1000	1000	1000	1000
2010	1318,08	1318,08	1318,08	1318,08	1318,08	1318,08	1318,08
2011	2514,79	2514,79	2514,79	2514,79	2514,79	2514,79	2514,79
2012	3179,79	3179,79	3179,79	3179,79	3179,79	3179,79	3179,79
2013	3720,89	3720,89	3720,89	3720,89	3720,89	3720,89	3720,89
2014	4197,06	4197,06	4197,06	4197,06	4197,06	4197,06	4197,06
2015	4628,4	4628,4	4628,4	4628,4	4628,4	4628,4	4628,4
2016	5032,16	5032,16	5032,16	5032,16	5032,16	5032,16	5032,16
2017	5420,48	5420,48	5420,48	5420,48	5420,48	5420,48	5420,48

Effect of attendance people of the conferences

Delft3D users	Base	1	2	3	4	5	6
Initial	1000	1000	1000	1000	1000	1000	1000
2010	1318,08	1318,08	1318,08	1318,08	1318,08	1318,08	1318,08
2011	2514,79	2514,79	2514,79	2514,79	2514,79	2514,79	2514,79
2012	3179,79	3179,79	3179,79	3179,79	3179,79	3179,79	3179,79
2013	3720,89	3720,89	3720,89	3720,89	3720,89	3720,89	3720,89
2014	4197,06	4197,06	4197,06	4197,06	4197,06	4197,06	4197,06
2015	4628,4	4628,4	4628,4	4628,4	4628,4	4628,4	4628,4
2016	5032,16	5032,16	5032,16	5032,16	5032,16	5032,16	5032,16
2017	5420,48	5420,48	5420,48	5420,48	5420,48	5420,48	5420,48

Effect of changed number of development partners on awareness

Delft3D users	Base	1	2	3	4	5	6
Initial	1000	1000	1000	1000	1000	1000	1000
2010	1318,08	1318,01	1317,97	1317,93	1318,16	1318,2	1318,24
2011	2514,79	2515,71	2516,17	2516,62	2513,87	2513,42	2512,96
2012	3179,79	3184,15	3186,33	3188,51	3175,42	3173,24	3171,05
2013	3720,89	3730,29	3734,99	3739,69	3711,47	3706,76	3702,05
2014	4197,06	4212,45	4220,15	4227,84	4181,65	4173,95	4166,23
2015	4628,4	4650,36	4661,34	4672,32	4606,41	4595,42	4584,42
2016	5032,16	5060,97	5075,38	5089,78	5003,33	4988,91	4974,49
2017	5420,48	5456,3	5474,2	5492,11	5384,65	5366,74	5348,82

Effect of changed number of development partners on adoption rate

Delft3D users	Base	1	2	3	4	5	6
Initial	1000	1000	1000	1000	1000	1000	1000
2010	1318,08	1277,22	1256,88	1236,59	1359,17	1379,79	1392,18
2011	2514,79	2576,06	2606,04	2635,53	2451,45	2418,6	2398,62
2012	3179,79	3181,88	3182,39	3182,42	3175,89	3172,72	3170,52
2013	3720,89	3655,95	3623	3589,6	3784,26	3814,79	3832,83
2014	4197,06	4075,37	4013,99	3952,17	4316,78	4375,32	4410,14
2015	4628,4	4457,09	4370,98	4284,5	4797,85	4881,19	4930,81
2016	5032,16	4817,61	4709,79	4601,56	5244,56	5349,24	5411,63
2017	5420,48	5167,17	5039,73	4911,73	5670,96	5794,4	5867,94

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