Market Model Design and Systems Thinking As Decision Support –

Public Wireless LAN Market Dynamics As A Case Study

This paper is an excerpt from a master thesis, which can be found at http://www.pixell.net/doppler/ (chapters 7, 8, 9 and 10). The text contains references to other parts in the main document and has not been tailored specifically in order to constitute a stand-alone article. For example, this paper does not contain conclusions from the study. However, some minor adjustments have been made in order to make it comprehensible.

1 Model Synthesis

Most people believe it is difficult to find an alternative to analysis if they are asked about how to approach a problem. One basic feature of a system is that it cannot be understood as a whole by just analysis – a synthetic perspective is needed for the modelling. While the previous chapter (6, Analysis) yielded knowledge by *describing* the components of the system, the synthesis chapter leads to understanding by *explaining* their relation. It is only by visualising a system as a whole that we can acquire an understanding of its components.

The purpose of this thesis can be recapitulated as "*to explore visualisations of decision making by the design of a dynamic model for the development of a public WLAN infrastructure on the Swedish market*". This chapter accounts for the documentation of how the purpose was filled.

The results and conclusions from the study are discussed in the chapter 2, 'Results From the Study and Conclusions'. This chapter must be treated as a compliment or handbook for the Powersim file. *The aim of this chapter is not to educate the reader in the Powersim application and its various functions, but to walk through the modelling steps.*

For reasons of convenience, some graphical visualisations – i.e. results/conclusions – are shown just next to their respective originating models in this chapter; instead of splitting the graphs and the models over different chapters, a more comprehensible layout was chosen. In this case, the value for the reader was considered more significant than the consistency of the contents.

1.1 The Role of The Performance Measure

Since part of the purpose for the thesis involved the *testing* of different action plans, the actual model synthesis needs a *measure* for the estimation of the outcome form the simulation runs. Depending on what needs to be visualised, different performance measures need to be chosen. In the actual case, a visualisation of the implications of cash flow was required. The WISP market model has evolved from a traditional cash flow model, where incoming and outgoing cash flows are replaced with incomes and costs. This approximation is considered as acceptable among venture capitalists, since it is considered to give a fairly true and justifying view of the aggregated cash flows when considering several – in the actual case five – periods. In addition, this approximation is said to render a valid picture, since no extraordinary activities occur in the model – only customary WISP activities are taken into account. The time span for the simulation model is 5 years (2002-2006), corresponding to what is believed to be a reasonable horizon for new ventures from an investor's viewpoint[1].

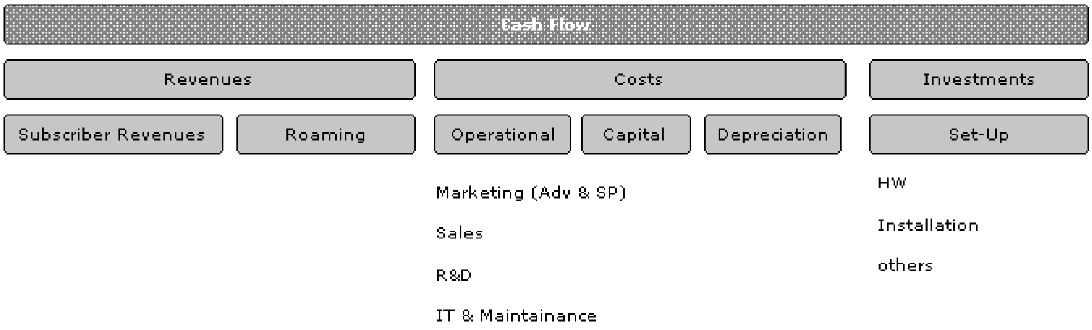


Figure 1:1 The simplified cash flow structure used in the model. The gray fields on the third level correspond to sub-models in the executable Powersim file. The only exception is the Depreciation rectangle,which does not have any corresponding sub-model, since the hardware is written of directly. Look back to this picture when reviewing the sub-models further in this chapter.

1.2 The Powersim Application

The models and screen shots in this chapter are all taken from the executable Powersim file designed for the research project. "Tabs" refer to the Excel-like "sheets" metaphor in Powersim.

Please note: The Powersim and Excel appendices are in fact a part of this chapter, but cannot be included in the formal document, since they require special software to run. For the public version of the Thesis, only the Excel calculations are published. A copy of the Excel document can be obtained at http://www.pixell.net/doppler/.

For readers with no previous knowledge of the program specific similes in Powersim, the following information can be useful:

- Arrays signify that a certain variable consists of a matrix with several entries. For example, the market share variable is an array, since it deals with the market shares of several competing enterprises. An array can be recognised by the *outline* of the variable symbol.

- Imports denote that the data originates from an external file, in the actual case an Excel file. Sometimes large data tables for arrays are more convenient to import from a standard format like Excel. In the case of the model in this study, the Excel file represents for the *deductive* layer,

[1] First paragraph in the introduction section of http://www.hiperlan2.com/WhyHiperlan2.asp

whilst the Powersim file handles the *inductive* side of the research. An import is symbolised by a diagonal arrow attached to the actual symbol.

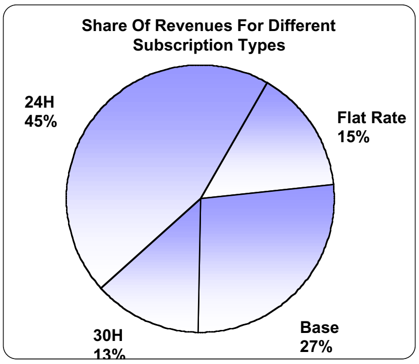
- Ghost symbols are mere mirror images of other symbols, sometimes hidden out of sight, for example behind another tab. A ghost does always have an origin, i.e. a genuine variable. Ghosts are signified by four small "corners" around the symbol. (In Microsoft Windows and Apples Mac OS *shortcuts* and *aliases* have a similar function.)

The model includes assumptions for all market players, which is useful if the reader wants to follow the development of a competitor. It is easy to graph an array so that the market players can be compared.

1.3 Assumptions

Since the model deals with an emerging, virtually non-existent market, the import sheet makes assumptions about the market situation and its outlook in 2003, even though it is difficult to verify. This is thoroughly documented in the main model data file (WLAN.sip) and the data import spreadsheet document (WLAN_2003_PUBLIC.xls). Nevertheless, it is necessary to list the following assumptions as very important for the model.

1. The model only takes into account the WLAN users in public networks. The market for *fixed wireless* broadband access is driven by other user needs and is not included in the calculus, as it is priced differently.
2. New investments are written off directly, due to the low cost and low expected life span of equipment.
3. A market for roaming brokerage is a central component in the model. (Even though the actual figure for the market price of surplus time might fluctuate, it is set to 8 SEK/h in the base run.)
4. The free networks (anarchists) are only representing a market driver; they have no current business models and are not included as network extensions for WISPs.
5. The revenue model from the subscriber revenues resembles HR's price list, with the exception of a fourth, 30H subscription alternative. This alternative has a 495 SEK entrance fee and is valid for 30 non-consecutive hours. The acccount is activated on first log-on and allows the user to "freeze" the counter on every log-out.



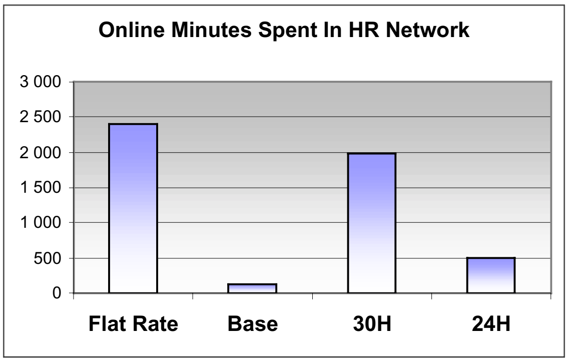


Figure 1:2 The four different subscription types for Telia HomeRun in figures.

6. The average user is expected to spend circa $^1/_2$ hour in the network every day. This is the result of a weighted average for the four subscription types (arbitrary distribution). On average, every customer spends about 10 minutes in customer support every month. For simplification, competitors are assumed to have users with the same needs. Unrealistically, the values have been assumed to stay the same over time.
7. The market share figures are fictious, since there is no way to look into the future.
8. The development of active sites is not based on any reliable input, but is rather tailored to surpass the needs of the market, given the terminal penetration.
9. Since the terminals can be used for many other purposes than just WLAN applications, WISPs are not expected to subsidise handhelds and laptops.
10. The learning effect is assumed slightly higher than what it was proved to be in an early study on NMT telephony – 25% cost reduction for each doubling of volume instead of 0,21.
11. For convenience, AC&P is exchanged for M&S, and sales are exchanged for subscription rate in the Lodish approximation.
12. According to Thorngren, there will be a continued pressure on WISPs to pay rental costs for the ether they dispose in order to provide wireless services. Thorngren proposes sharing revenues with the land owners in order to make it a common commitment marketing the wireless services[2]. Since the market for ether rental has not been stabilised yet, it is difficult to pronounce an ultimate model for ether rental. In the base run, 3,5% of the revenues (not considering costs) is assumed to be costs for "renting" the ether. This value can be altered between different time periods/ run steps, i.e. years. On an imaginary mature WLAN market in 2005-2007, this corresponds to ca 25% of the costs of the WISP.

1.4 Model Components – Submodels

All submodels, or "constructor diagrams", as they are called in the Powersim terminology, presented in this chapter, are grounded in the simplified cash flow structure shown in *Figure 1:1* on page 2. Each of the components in the cash flow visualisation has a corresponding sub-model in this chapter. Each *ghost* follows the same colour scheme as the corresponding originator variable. The first sub-model, *'Subscriber Revenues'* is explained more thoroughly, in order to help the understanding of the remaining sub-models. For clarification, most of the explanations can also be found in the *Documentation* tab in each variable's properties inspector box. The properties box can be activated by double-clicking the variable in the Powersim file.

1.4.1 Subscriber Revenues

The most comprehensible sub-model is the 'Subscriber Revenues', which can be found behind the *Revenues* tab in *Diagrams* view. Subscriber revenues describe the revenue flow generated from incoming customer payments. The product of 'Total number of subscribers', 'Market Share' and 'ARPU', sum to the total subscriber revenues. The number of subscribers in the different networks is weighted by the overlap variable. Overlap rates are used to signify that users with several different WLAN terminals are, as in the case with GSM, unlikely to have separate WISP subscriptions for each device. (The subscription rates for the device types are based on guesstimations.)

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[2] Master Thesis 'Public W-LAN – The Interaction Between Venues and WISPs by Björn Thorngren; Lund School of Economics and Management, Department of Business Administration; February 2002.

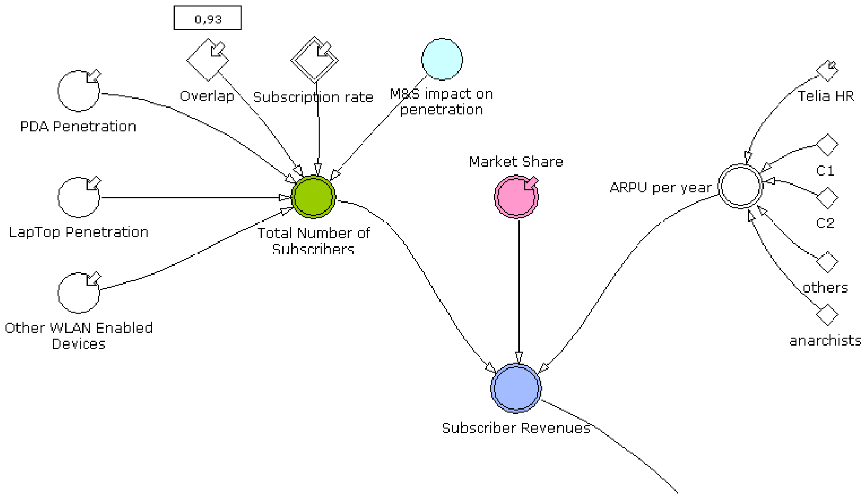

Figure 1:3 Subscriber Revenues sub-model; Powersim constructor diagram.

Certainly, the marketing and sales expenditures will affect the total number of subscribers, which is also defined in the model. In order to estimate the possible impact of shifts in the Marketing and Sales (M&S) budget, Lodish's 5Q Procedure has been tailored for the use in this model. (Complete modelling and documentation found under the tab *'Behind the Scenes'*.)

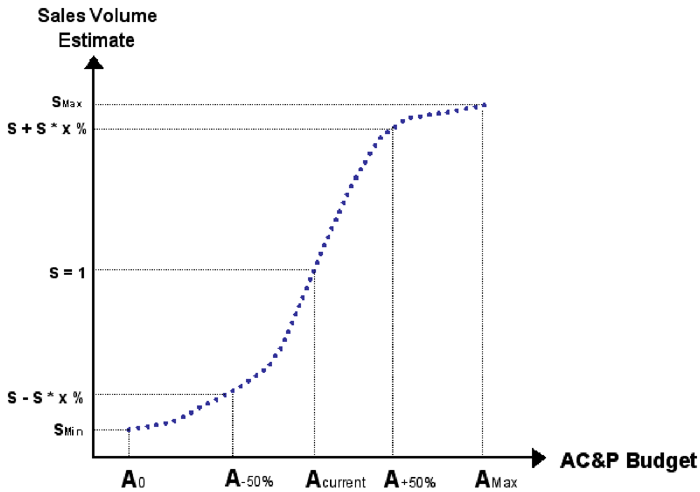

Figure 1:4 Len Lodish's 5Q Procedure, illustrates how the AC&P Budget (Advertising Communications and Promotion Budget - denoted 'A' on the x-axis) influences the sales volume (S). If the advertising budged is increased by +50 %, the sales volume would increase by +x %. X is chosen to match the historical development in the actual business.

Three assumptions were made in order to use Lodish's procedure on the case:

1. The sales volume is substituted with the 'Total number of subscribers' on the y-axis. This is assumed an appropriate equivalent because S is a derivative of 'Total number of subscribers'.

2. The model aggregates the cost of advertising, the cost of other market activities and the cost of the sales force in one activity denoted 'Marketing and Sales'. Lodish proposes the use of just advertising (A) on the x-axis, but the whole post 'Marketing and Sales' (M&S) is used on the x-

axis. This simplification will lead to a more biased model, but the approximation in this case is assumed to be within limits of reasonability.

3. A +50% increase in M&S budget will lead to +30% increase in the 'Total number of subscribers'.

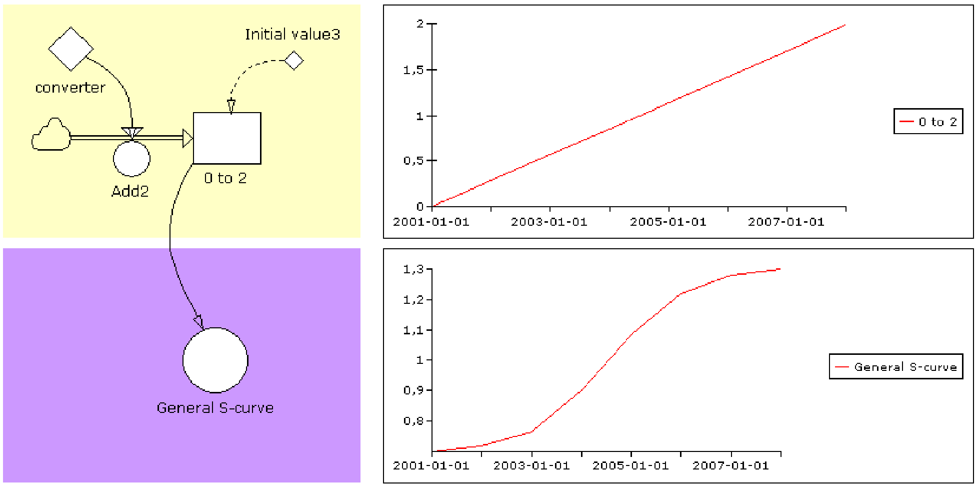

Figure 1:5 The yellow box is just a test model for the S-curve and does not contain any real data. The model is used to simulate linear growth from 0 to 2. As can be seen in the graph to the right, the figure in the purple box renders a perfect S-curve for x=0..2, and the output on the y-axis is 0,7 for x=0 and 1,3 for x=2. (A mathematical definition of the S-curve is used for this purpose: $f(x)=e^{0.5*x}/(1+e^{0.5*x})$ *[3]). This is precisely the result that was sought for, if related to the third assumption above. (A +50% shift in M&S gives +30% shift in subscribers.) The 'General S-Curve' for 0..2 in the purple box uses the GRAPH-function included in the standard functions library of Powersim.*

Lodish's 5Q procedure is adapted to the assumptions above, in order to check how shifts in the marketing budget can affect the subscriber base.

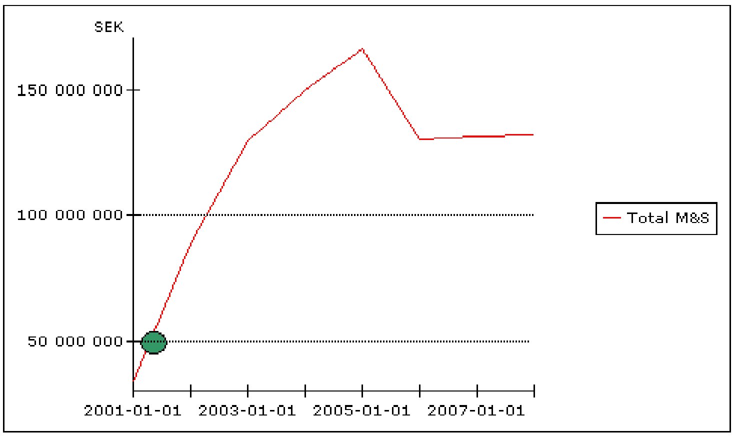

Figure 1:6 The figure is an aggregated graph from all market player's M&S budgets. As can be seen in this "base run" figure, the initial value of 50 000 000 SEK will grow and eventually stay at levels of 100 000 000 to 150 000 000 SEK.

[3] http://www.maths.lth.se/query/answers/q200012.html

The *normal* M&S budget for the total market is 100 000 000 SEK per year. (The normal M&S budget corresponds to '$A_{Current}$' in *Figure 1:4*.) Any M&S figures above 100 000 000 SEK will result in more customers, and any values below will end in customer loss, according to assumptions 1 - 3.

The theory implementation can be illustrated with an example: If the aggregated M&S budgets on the market constitute a total amount of 50 000 000 SEK (signified with the green marker in the graph above), it can be related to the *normal* ($A_{Current}$) budget of 100 000 000. The relation between the two is 50/100 = 0,5 (that is, the budget is 50% less then the normal $A_{Current}$). This will lead to a drop in the total number of subscribers.

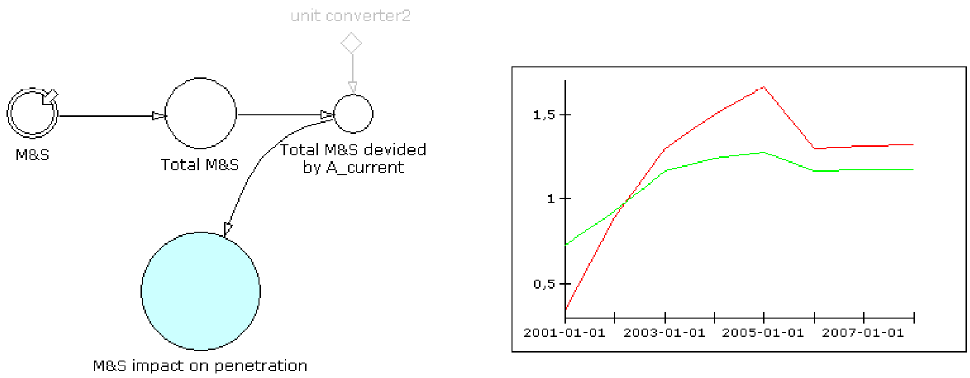

Figure 1:7 This model applies the theory implementation for all values. The red curve in the graph is the same measure as the example above, but this time for all values. The green curve illustrates the same values with consideration of the S-curve designed earlier. The variable 'M&S impact on penetration' is used in the 'Subscriber Revenues' sub-model in the 'Revenues' tab.

Note that the "+50% to +30%" correlation assumption is not verified. It is normally recommended to balance similar assumptions with the IAF juror method (Independent Averaged Forecast) in order to get a less biased picture. What must be considered is that the IAF/5Q methodology is not recommended at all for new product categories. (Normally, the Objective-and-Task Method is considered to be the optimal way to help marketers in dimensioning the M&S budget for a new category, but it is difficult to decide whether WLAN services belong to a new product category or if it is has become an established product category already. Indeed there are no alternative methods to use other than guesswork - the approach presented above at least offers a possibility to reason systematically around the possible M&S variations.)

Having derived the M&S impact on subscriber penetration, it is now possible to return to the subscriber revenues model (*Figure 1:3*) and define the relation between the number of subscribers and the marketing expenditures. *This loop between revenues and costs is difficult to model in a regular spreadsheet.*

The market growth is assumed dependent on the actual number of terminals available to the end user. The last variable, ARPU, is derived from a modified HomeRun product portfolio[4]; the competing WISPs have arbitrary ARPUs, assumed both lower and higher than Telia HomeRun. The free network operators ('Anarchists') do not play an active role in the given model, but are still represented in order to enable further expansion of the model – it would be more difficult to integrate the free networks later.

1.4.2 Roaming Revenues

In order to calculate the revenues related to roaming, we must assume that there is a positive gap between HomeRun supply and total market demand. Note that there is no deficit for online hours, the roaming business is assumed to be enabled because of other reasons, such as patchy coverage for the WLAN infrastructure. WISPs will have to cooperate if they want to offer networks with acceptable coverage[5]. The theoretical roaming volume for HomeRun is visualised by the area between the green, yellow and red graphs in Figure 1:8 below.

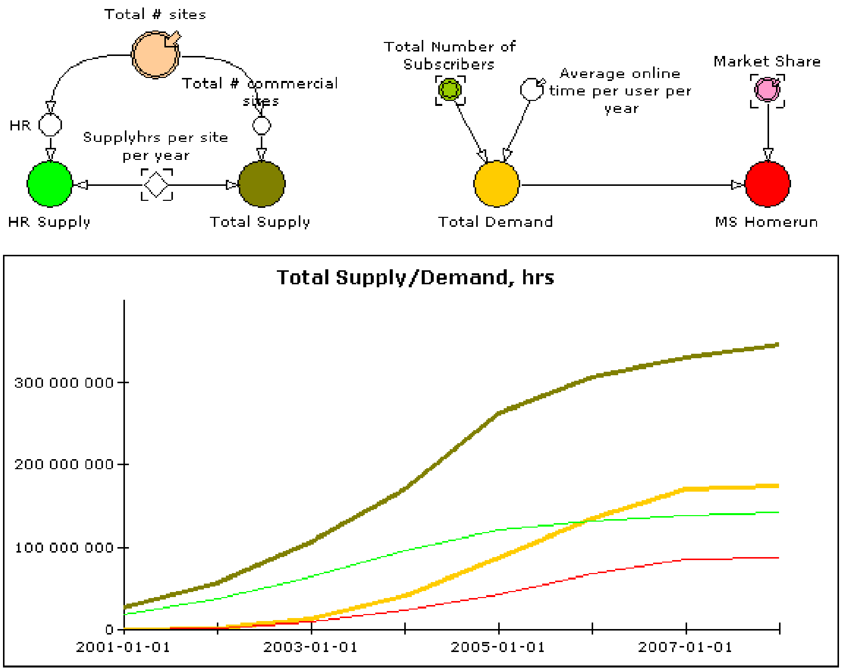

Figure 1:8 Supply and demand of online hours in the WLAN networks; Powersim constructor diagrams and graphs. The graph colours correspond to the mini-model above. The theoretical roaming business opportunity is the difference between Total Demand (yellow), HR Supply (light green), and MS Homerun (red). The market players with the largest and most attractive networks will be able to sell most roaming hours to the competitors.

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[4] HomeRun is assumed to have a fourth subscription option that allows the user to use a member card for 30 non-consecutive hours. This extra subscription alternative is intended to complement the existing offering. See also appendix WLAN.xls

[5] Private communication with Joakim Wiling, ex Telia HomeRun December 14th 2001 and Wiktor Södersten, DefaultCity Network, February 13th 2002.

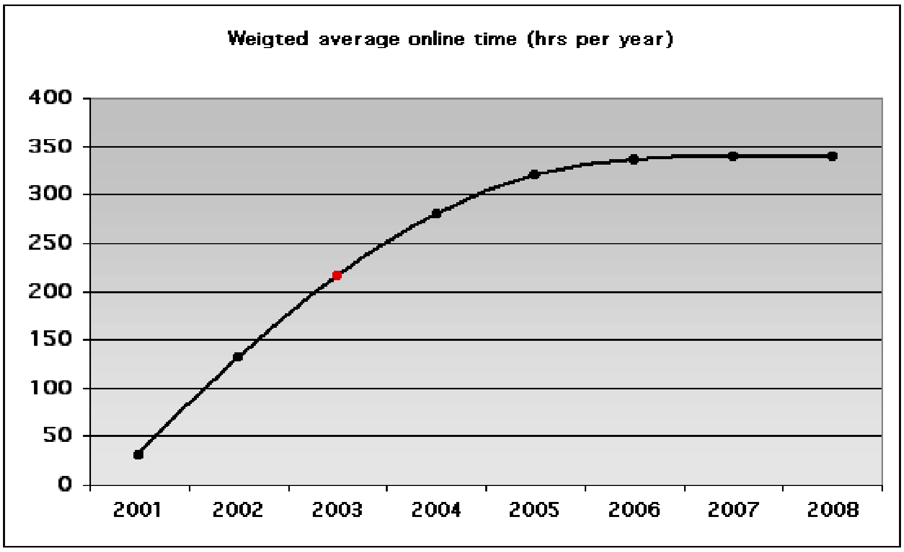

Figure 1:9 Assumed average time spent per year in a public WLAN system by a single user.

If surplus WLAN capacity would be traded on a roaming brokerage "stock market" with an enabler like Excilan[6], the roaming revenues could be calculated from the product of three factors, namely: the WISP stock market price, the theoretical free time for roaming and a roaming distribution, which is different for every player at every time step. The model is not complete; roaming revenues must be controlled to fall within their natural limits of demand.

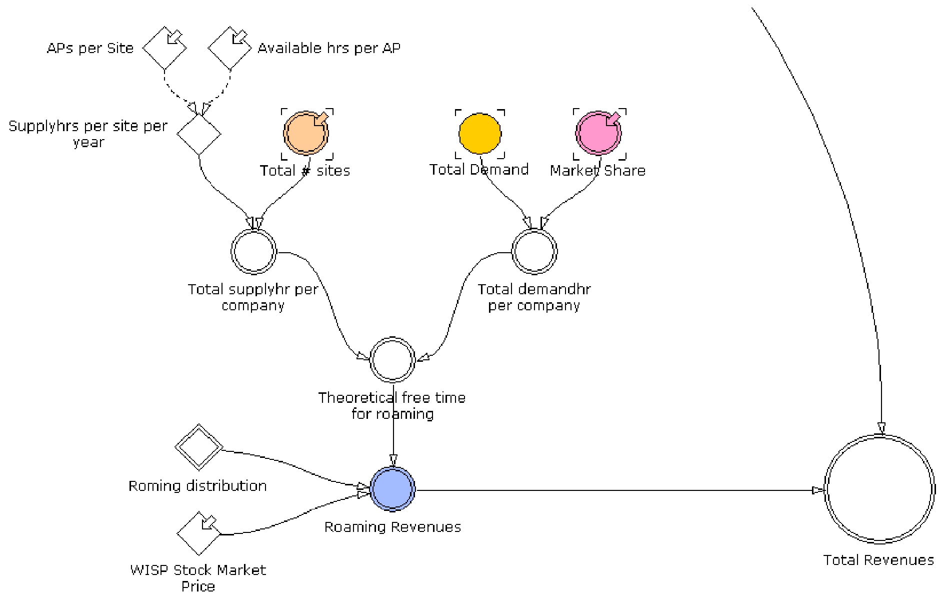

Figure 1:10 Roaming Revenues; Powersim constructor diagram.

As a consequence of this, the roaming revenues constitute barely a small percentage of the total revenues, which by all assessments seems to be an under-estimation; WLAN coverage can be very patchy and roaming is necessary to cover larger areas, such as an entire city centre. To compare, roaming revenues on

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[6] Excilan is a Dutch company within seamless roaming for WLAN; http://www.excilan.com/

average account for 30% of the turnover in the GSM business[7], but this is rapidly starting to change with new PTS[8] regulations. However, during the modelling, the roaming revenues were found to be negligible compared to the subscriber revenues.

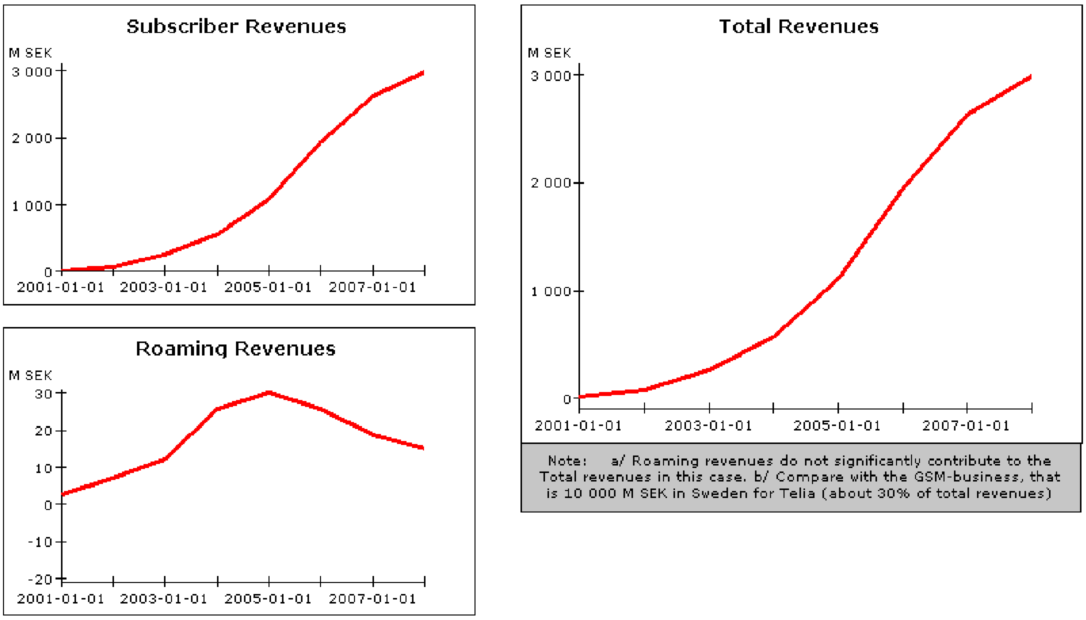

Figure 1:11 Revenue graphs for HomeRun. Notice the difference between the scales on the Y-axis for roaming and subscriber revenues. The roaming revenues in (with the assumptions in the base run) are much less significant compared to the subscriber revenues; compared to the distribution ratio for GSM (1:3 roaming - subscriber), this is a remarkable observation.

1.4.3 Set-Up Costs

The sub-model for set-up costs is very basic, if one does not consider the experience curve. The experience curve is a justified addition to the model, but one must be aware of the weaknesses of the theory. However, experience curve slopes tend to have strong variations - from 0 to 60%, which means it is a quite uncertain method. Moreover, experience demands automation, resulting in a negative impact on the flexibility, that is highly desired on the fast-moving WLAN market.

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[7] 30% is a general industry estimate, no verified sources were found to confirm this figure.

[8] The County administrative Court of the City of Stockholm has settled that Telia has got to abide by the injunction of PTS to lower the costs for roming leases of Telia's GSM network. PTS will also review the pricing of Europolitan Vodafone and Tele2. http://www.pts.se/dokument/getFile.asp?FileID=2699

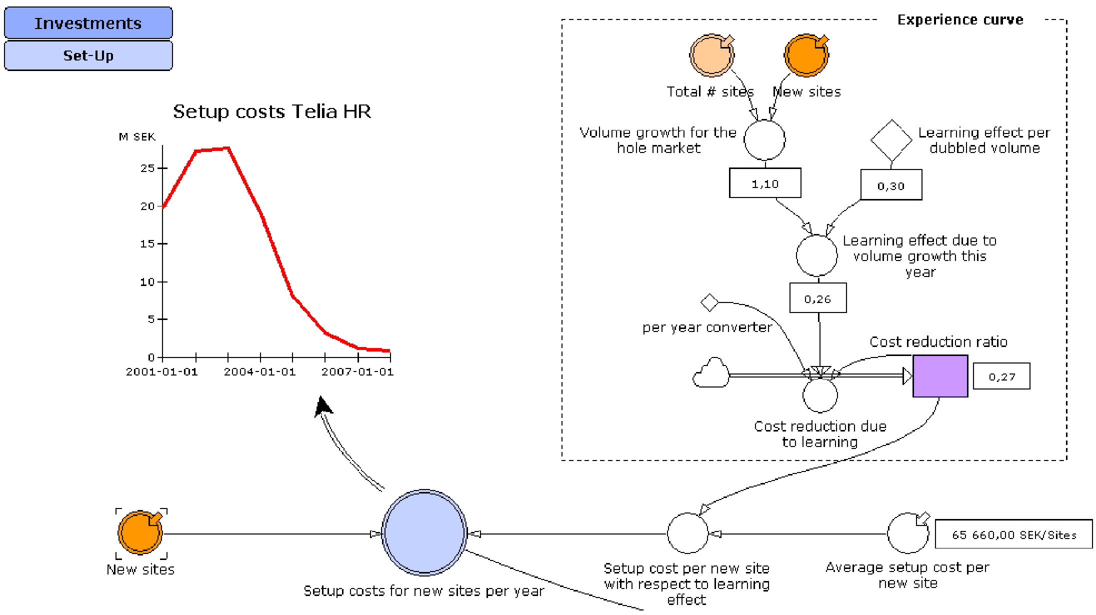

Figure 1:12 Set-up Costs and Experience Curve; Powersim constructor diagram. The learning effect is set to 0,26 in the base run, close to the value of 0,21 found by Helgesson, Hultén and Mölleryd in 1991[9]

The imported values for new sites[10] are multiplied with the set-up cost per site with respect to the learning effect. Note that technology upgrades and maintenance are not within the scope of this sub-model, it is rather included in the *operating costs*.

The cost reduction ratio that influences the set-up cost per site is modelled as follows. The arrays of total number of existing sites and number of new sites are added and divided with the total number of sites for the given year in order to receive a figure with the "Volume growth for the hole market". This variable describes how many times the volume growth has occurred the given year on the entire Swedish market.

In the base run, the price is reduced by 30% for each doubling of the volume, according to the learning assumptions for the experience curve; $0{,}3^{\text{Volume Growth/year}}$. When the model starts, the *cost reduction ratio* equals 1, i.e. no cost reduction is taking place. For each simulation time step (in this case year), the cost reduction ratio will drop with the value of the learning effect, i.e. $(1-(1*0{,}3^{n}))$ for each time the capacity (n) will be doubled.

The *cost reduction ratio* (purple stock) is used in several places in the operating costs sub-model.) The reason for this is that several different costs are influenced by some kind of price reduction factor. It might not be a precise picture of reality, but it still gives a hint about the direction. *This loop for cost reduction is difficult to model in a regular spreadsheet.*

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[9] A linear regression of historical values for the NMT system proved that a 21% learning effect could be observed. The relation was used for similar system modelling in the Stella software. EFI working paper 'Simulering av utvecklingen för mobiltelefonnät' by C-F Helgesson, Staffan Hultén and Bengt Mölleryd; Stockholm School of Economics, September 1991.

[10] A 'site' in this thesis refers to what also is called HotSpot. The average site is about six wireless access points for 802.11b, each one with a coverage radius of 30-50m.

1.4.4 Operating Costs

The sub-model for the operating costs is a simplified hands-on visualisation of the costs related to the maintenance of the wireless service. The 'Cost reduction ratio' ghost is applied to customer service, overhead and operational cost per site, whilst the other variables are not affected by the experience curve. M&S and R&D are linked to a cost ratio distribution variable in order to simplify the model. By far the largest cost segment is the customer service, which is important to consider when designing a WLAN system, i.e. using a WLAN must be as simple as using a regular LAN in order to avoid an increase of the customer support costs.

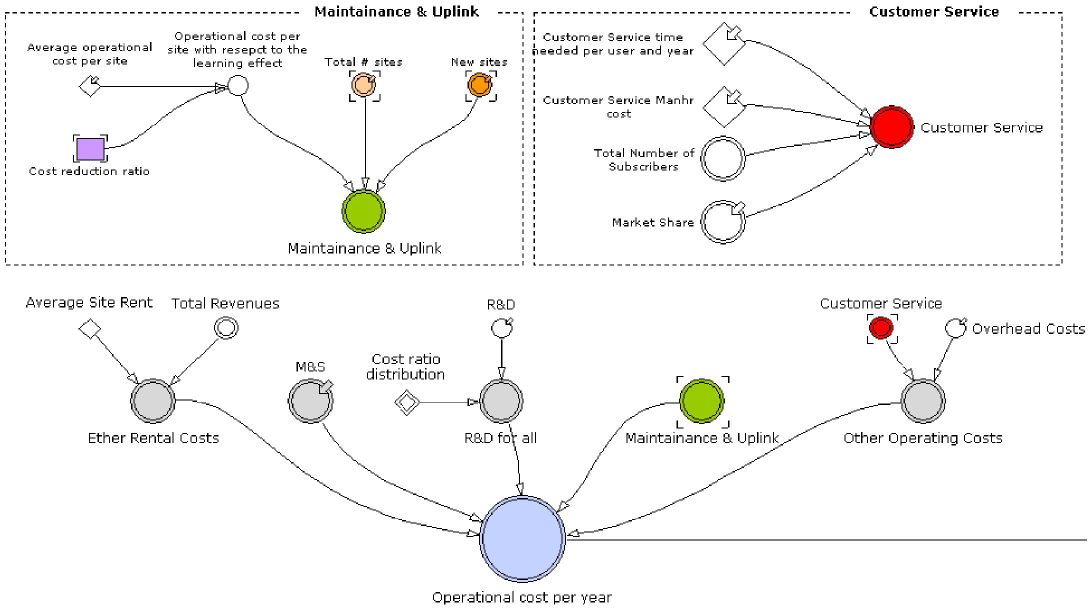


Figure 1:13 Operational costs; Powersim constructor diagram. Note that the variable "Total Number of Subscribers" is copied from the revenues sheet. Due to a bug in the Powersim application, it is not evident that the variable is a 'ghost'. (When variables are copied to other tabs/sheets in Powersim, the ghost marking disappears.) This link signifies that M&S budget will affect the operational costs not only directly, but also as an echo through the "Customer Service" costs.

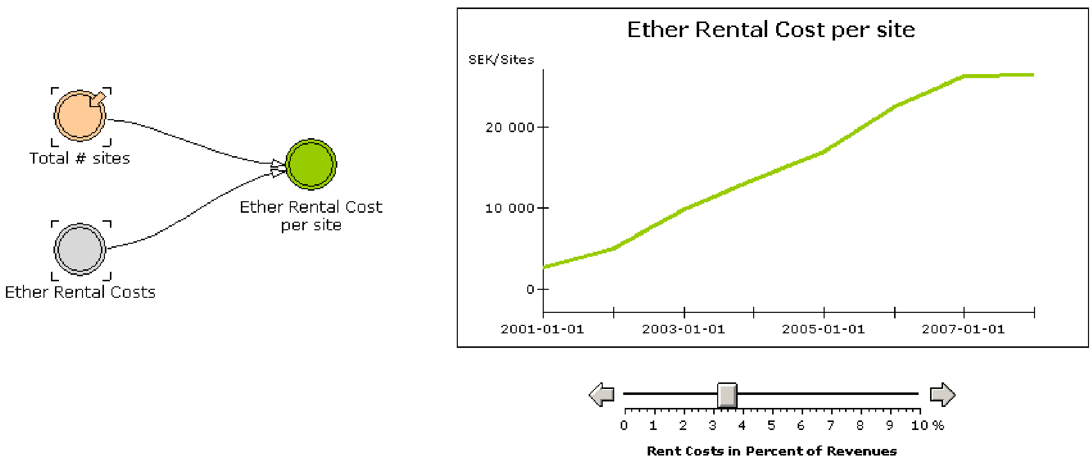
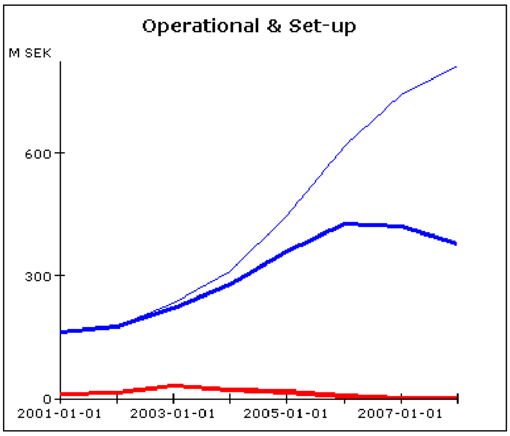


Figure 1:14 The yearly rental cost per site is assumed to be between 3 and 4 percent in the base run. This figure illustrates how the rental costs can be adjusted at will with a "mechanic" slider. Like all other variables that are not defined by a formula or import, it is possible to alter the intrinsic value for each simulation step, in the actual case every year, which

means that it is possible to simulate one period, then change the rental costs to an other value and continue the simulation with the new value.



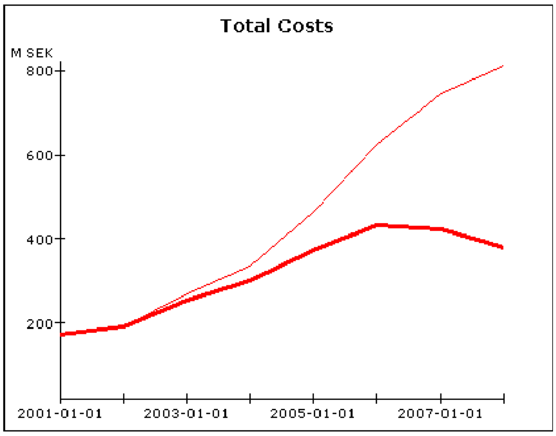


Figure 10, Operational cost graphs. The thin lines represents costs without the experience curve. This scenario suggests that the operator should build capacity fast at a rather low cost to guarantee good coverage. Major cost drivers are the operational costs derived mostly from heavy Customer Service and Overhead costs. It is therefore important to make easy-to-use "Plug & Play" products, rather follow a GBF strategy. Knowing this, it is important to extend the model to work with also with other performance measures, such as customer value, as suggested in the appendix 'Value for Money'.

1.4.5 Discounted Cash Flow

The total revenues (green) and costs (red) sum to the 'Net Cash Flow' (yellow); which discounted for the 'Capital Cost' will equal the 'Aggregated Cash Flow' (blue). This is the actual bottom line discounted cash flow for the venture, i.e. the metric sought after in strategic planning and decision-making. Altogether, this sub-model shows us the impact of the capital cost in a simplistic way. If the 'Net Profit' is negative, a capital cost will occur. Break-even is to occur in 2004 according the base run scenario.

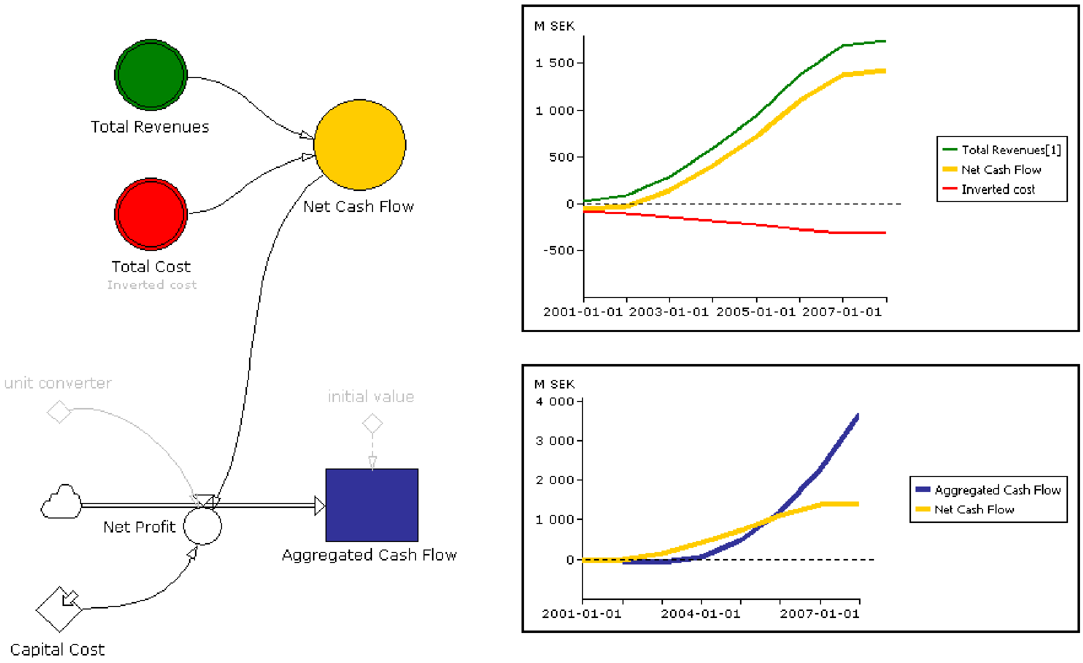


Figure 1:15 Cash Flow and Capital Cost; Powersim constructor diagram. Note: the red and green 'Total costs' and 'Total revenues' variables are not marked as ghosts due to a bug in the Powersim application. (When variables are copied to other tabs/sheets in Powersim, the ghost marking disappears.) The relatively low dip in the cash flow curve is related to the organic rollout for the WLAN infrastructure.

In all, we can conclude that the WISP business will become relatively large and profitable using the input data accounted for in the Assumptions chapter and the appendix v4.xls. With the assumptions made in the base run, the business will be profitable before the final period of the simulation.

1.4.6 Scenarios

One of the objectives for this study was to generate different scenarios from the model. The actual scenarios are not accounted for here, since the Powersim file allows any variable to be adjusted in many ways/steps. If several variables were changed in combination, this would allow an infinite amount of permutations. Any variable or import data can be adjusted to the preferred value for each simulation step and every such run can be saved. For the exemplification of possible tweaks to the base run, four different scenarios are suggested:

1. Laptop and PDA penetration – the penetration pace of mobile terminals for WLAN is slower than in the base run.

2. Overlap rate – the overlap between different WLAN terminal types turns out to be higher than originally planned, which results in fewer subscribers.

3. WISP stock market price – the roaming business takes off later than expected, resulting in lower roaming revenues.

4. Learning effect – the learning effect turns out to be considerably lower than in previous cases within telecom, resulting in a more moderate gain from scale and experience.

2 Results From the Study and Conclusions

One of the objectives for the study is to draw conclusions regarding the visualisation tools, the WISP case and decision-making.

Research conclusions are always a result of a fundamentally subjective enterprise, thus also in this case; nevertheless, it is not the objectivity and truthfulness of a study that makes the research interesting, it is rather the *approach*. The value of the conclusions is not decided by the writer's ability to mirror the empirical reality, but more accurately *other social factors*, like the novelty of the subject of the case study and the writer's ability to generate creative visualisations of the research as explained in chapter **Error! Reference source not found.** *'Error! Reference source not found.'*.

The conclusions below are undeniably affected by the preconditions for the study, and should therefore be considered as such. Please note that for reasons of convenience, some graphical visualisations – i.e. results/conclusions – are shown just next to their respective originating models in the previous chapter; instead of splitting the graphs and the models over different chapters, a more comprehensible layout was chosen. In this case, the value for the reader was considered more significant than the consistency of the contents.

2.1 System Dynamics Modelling and Decision Making

One of the objectives with the study was *"to draw conclusions regarding the benefits of system dynamics as a modelling tool when used in a decision making process for market positioning in a real world telecom context"*. After identification of variables, causality mapping, modelling and simulating, system dynamics tools can be concluded to be very useful and powerful in decision-making contexts. This is particularly the case, if the actual decision makers create the model in a workshop situation. What was not known when the modelling started was that it required dedication from all participants, including the ordering party. Because of this, there were difficulties with acquisition of data, identification of model variables and definition of interdependency between variables. A conclusion from the work with the modelling that can be made is that designing a system replica is a very difficult task. It is much easier to perform a system design with other individuals, using the combined experiences, knowledge, understanding and mindsets. *The transportation trip from mental models to formal models is travelled faster and more comfortable with system dynamics, in particular if there are many interdependent variables involved. What might be the best feature of system dynamics is that there is a slightly higher likeability to arrive to the destination intended.*

2.2 The Choice of Performance Measure

The uncertainty and eventually the late decision of *the most basic performance criteria* (cash flow) for the model can serve as an illustrative example of how the conscious and visual representation of systems modelling can confront decision makers with difficult and critical assumptions. It is probably the best example of how systems thinking puts pressure on the participators of the modelling rounds to define variables and their interdependencies.

2.2.1 The Value of The Modelling Design Process

Modelling can be said to constitute a design issue foremost, which implies that the modelling process can contribute substantially to consensus in a boardroom. A decision that has been made in consensus between the parties involved can have a higher status since it is grounded by peer review. *It is thus as much, if not more the inductive design process methodology than the model in itself that has significance for the decision process.* Ironically, the major drawback of a design approach is the low level of acceptance for design as a way of creating knowledge and understanding. This issue can only be solved with a more active participation in the design process.

One of the most controversial "features" of the system dynamics interface is that it is more difficult to set a fictitious agenda for the action plan, since the modelling stage offers a transparent overview of the situation. This question is controversial, since it is sometimes desirable to keep a certain level of obscurity from a decision-makers viewpoint; on the other hand, it is highly desirable for a controller to visualise the causal map as fair as possible. This is a general conclusion; this is not to say that any instances of such intentions to obscure were found at Telia.

The causality mapping of the system dynamics language provides a more transparent method to of identifying problems, hidden actors and policies. Kingdon identifies it as a major problem for decision makers that attention can be drawn to proportionally unimportant indicators or events, resulting in obscurity for other, more important variables – this can, luckily enough, be avoided in a system dynamics model. Excel spreadsheets and other "linear" tools do not offer the same flexibility and visual overview, besides taking much more time during the scenario planning activities. The more imports from external databases or spreadsheets that will be added, the less transparent will the model be. The transparency offered by systems modelling can reveal bias and unreasonable assumptions easily, thus eliminating sources of conflict and helping the decision-making group to gain consensus.

System thinking is very interesting for making visible assumptions about causality, but it has a high barrier of entry, with requirements such as knowledge of the tools and understanding of the subject. System dynamics modelling entails preparation for the data import, which is extremely time consuming, unless there is access to reliable sources for data. System model design or synthesis is not a substitute for a good portion of effort on the analytical level, but a welcome compliment in order to reveal bias and increase transparency.

The outcome of design also makes it possible to virtually test a system. In an iterative design process, such tests will lead to continuation and further refinement of the model, which will yield more knowledge and finally result in more understanding.

2.2.2 The Value of Models as Artifacts

A model is of highest value to the people who created it by walking through a design process. As a separate artefact, a model has less value if separated from its originator. *Models have small value as black boxes, but can be used successfully to transport ideas and help to benchmark or reflect on other mental or formal models.*

2.2.3 The Value of Model Structures

For war game scenario planning with active participants, the rapid visualisation of causal diagrams, feedback loops and variable dependencies, is a major leap forward compared to traditional tools. *Some of the system components and their interdependencies are not even possible to model in for example Excel* (see for example Lodish's 5Q implementation in chapter 1.4.1 *'Subscriber Revenues'*). The difficulty of comparing alternative action plans earlier discussed in chapter **Error! Reference source not found.** ***'Error! Reference source not found.'***, is solved with a straightforward creation of different scenarios and the ability to save runs.

In comparison to spreadsheets, systems modelling is far superior, spreadsheets do not make clear their assumptions about causality, keeping equations and links hidden behind the cells – every time a cell is exited by the cursor, the equation field is emptied. A printout from Excel is never so mysterious if it makes use of links from other cells or maybe even sheets. In a system dynamics approach, calculus is less powerful as a tool for argumentation, and it is close to impossible to manipulate the system structure without others noticing such manipulation. A causal loop diagram is transparent by its nature, the fact that it is constructed by several individuals representing different interests, makes it an even more justifying description of the authentic system. Awkward assumptions or broken causal links are revealed earlier, resulting in a more precise visualisation of the environment being modelled. For complex environments or processes, this is, of course, a welcome improvement.

A robust model structure's greatest value is that the potential biases are made transparent. The observation or reflecting upon model structures gives an understanding of the problem at the system level, which is highly desirable for decision makers.

2.2.4 Comparison With BSC and Other Diagnostic Tools

Since no good criterion exists for evaluating the comparative advantages and drawbacks of different methodologies, it is also a different task to select an appropriate methodology for a given problem on rational grounds.[11] It is therefore an impossible task to make a fair and just comparison with (all) other diagnostic tools there are, and only a brief presentation of some of the popular ones will be made here.

A popular diagnostic control system for decision makers during the late 1990's has been the Balanced Scorecard[12], BSC. Whilst the BSC method of analysing critical success factors groups the performance variables into four categories (see appendix 'BSC'), system dynamics does not require such division. Also, BSC is limited by what is normally described as a *single feedback loop*, whilst a system dynamics interface can use multiple feedback loops, thus enabling *interdependent* factors. A system dynamics model could also be scaled to include many more categories than those included in the BSC.

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[11] 'System Dynamics: A Critical Review' by Augusto A. Legasto Jr. and Joseph Maciariello; published in SIMS (Studies in the Management Sciences), Volume 14/1980, pp 23-24.

[12] 'The Balanced Scorecard – Measures That Drive Performance' by Robert S. Kaplan and David P. Norton; Harward Business Review January-February 1992. The four measures that form the BSC bubble are financial, customer, internal business and innovation, each one representing a different perspective.

Another major difference is that BSC lists the goals of a business before the causality is mapped, something that the business dynamics interface effectively avoids. *It is difficult, if not impossible to set up realistic goals without first looking at the dependency/inter-dependency of variables.*

Similar problems also apply to the *regular spreadsheet* and the *root cause* or *fish bone* diagrams. The logic trees of such methods are often difficult to scale and do not visualise well in a simple, comprehensible overview. What is even worse is that associated causality only can be assigned in a single direction, which implies that these control systems tend to work with *independent* variables.[13] Systems thinking effectively avoids these flaws, thanks to its system dynamics interface.

What must not be forgotten, is that the learning costs for system dynamics are high in terms of time and other efforts, which can be considered as a higher entry barrier compared to other diagnostic tools.

2.3 Public WLANs As a Case Study

To recapitulate chapter **Error! Reference source not found.** *'**Error! Reference source not found.**'*, the choice of public WLANs as a case study has caused a shift from the question of *how implications of decisions can be visualised* to a foremost empirical study with heavy market research.

During the last decade, the telecom market – has slowly started to transform from a developing product scene to a mature services arena, but it still satisfies needs rather than desires and emphasises technology features more than benefits. The modelling of the WISP market clearly showed that the operator scope is still very product-focused. ***End user activity, wants and desire** drive the development of a communications network design, rather than a five-year plan behind locked doors in a boardroom – system dynamics or not – no dynamic model in the world can change this fact.*

2.4 WLAN and The WISP Business

As mentioned before, the research questions deal with a general decision making support *methodology*, rather than ensuring the validity of data and correctness of possible scenarios. What has been designed is not a system that can predict the future outcome on the authentic WISP market, but rather a system that allows us to represent and test our knowledge. Regarding the uncertainty of the in-data and the amount of crucial assumptions, the conclusions from the synthesis should not be treated as definite answers to the outcome of HomeRun or any other WISP venture from a shareholders or an operators perspective. Hence, caution is recommended when interpreting the bottom-line cash flow graphs.

The main conclusions related to the modelling can be described as follows:

- The *penetration* of WLAN enabled devices and the *overlap rate* is crucial to subscriber revenues. Expensive terminals in combination with a slow-down in the economy can cause severe delays to the WISP market.
- The operational costs, and in particular the *customer service costs* of the WISP in question are the largest challenges for a new entrant on the market. This demands a thought-through service design, so that end-users will have as little problems as possible setting up and using the service.

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[13] 'An Introduction to Systems Thinking' by Barry Richmond; High Performance Systems Inc 2001.

- A winning strategy seems to roll out the WLAN infrastructures rapidly at a low cost, in order to guarantee good coverage. After 2004, the implications of the experience curve will be higher in proportion to the actual turnover.[14]
- The necessity of a WISP roaming brokerage is of extreme importance for the success of the roaming business. Before there exists a straightforward, standardised way of selling surplus time on a global market, the public WLAN business will have a hard time to take off. The player with the most developed infrastructure will have a sustainable advantage due to the WISP roaming brokerage market.
- It will be difficult, if not impossible for WISPs to finance a WLAN venue with revenues from content. (The content revenue model was removed from the original model.) The whole idea of public wireless WLAN is to offer the same protocols[15] applications that the consumer already uses and pays for.
- HomeRun WISP business is likely to have a break-even sooner than Telia mobiles UMTS. This is partly due to the fact that there are no legal agreements with the governmental authorities concerning the rollout pace. A WLAN infrastructure can grow organically, allowing the WISP to offer coverage at so-called 'hotspots' (i.e. primarily where it is needed). See also *Figure 1:15.*
- The modelling and simulation shows that the resource allocation is difficult – if every part of the model, considered separately would be optimised, the system as a whole would not gain in efficiency. This is particularly evident in the case of resource allocation of surplus time/roaming and marketing/customer support.

If the research conclusions (and the accompanying models for the report) have to be used in a real business case, a careful walk through the assumptions is recommended, so that necessary modifications to the models can be made. The conditions of the WISP environment are constantly changing and as of this writing, public commercial WLAN solutions are just at the beginning of a very long road. See also chapter 4, *'Critique and Openings For Further Synthesis'.*

2.5 Evaluation and Criticism of The Conclusions

Again, it must be said that every conclusion is subjective. Since criticism is nothing but conclusions on conclusions, criticism is also a subject for subjectivity.

2.5.1 System Dynamics

It takes time to master a subject like system dynamics. Even though literature and software was available, it takes a lot of intellectual effort to actually start to think in a systemic way. There is always a risk that the reliability of the study will suffer from insufficient knowledge of the writer.

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[14] This conclusion courtesy Fredrik Halsius, TRAB.

[15] The notion of (computer) "protocol" is taken from the OSI (Open Systems Interconnection) model. An example of a protocol is hyper text transfer protocol, http. Definitions of OSI and protocol: http://www.webopedia.com/TERM/O/OSI.html http://www.webopedia.com/TERM/p/protocol.html

2.5.2 The Modelling Results

As stated earlier, insufficient market data made it necessary to make assumptions. One of the assumptions that could potentially be a source for a validity flaw, is the M&S expenditures. Analyst Andrew Seybold has criticised the emerging WISP business for not marketing the services enough. According to Seybold, a real high speed connection for public WLANs would require at least 300 monthly users per hot spot to become profitable as a stand-alone product.[16] Seen against this background, it can be concluded that the model presented in this thesis has:

- A very moderate estimate of the marketing costs for public WISPs.
- No causal links to other infrastructures, such as the GSM/GPRS/UMTS.

The first point can be easily adjusted, whilst the second requires some re-modelling.

An other validity-decreasing factor is the assumptions taken on the roaming business. Since there are no working roaming agreements to this date, it is impossible to know whether the assumptions have validity at all. (Luckily, it was not the purpose of this thesis to produce a crystal ball!)

2.5.3 Decision Making

Since the writer has little experience from decision-making in a telecom context, there is a risk that important observations have been excluded from the thesis, or even worse – not even made.

[16] http://www.theinquirer.net/a_23040207.htm

3 Recommendations

These recommendations are subjective viewpoints of the author and should be considered as such.

3.1 Recommendations to TRAB/AO Strategy

Please note that the following recommendations might differ from the recommendations of the VAKA project owners and the other VAKA participants. The thesis study is only a part of the VAKA project and the writer is not a TRAB employee.

3.1.1 Next Steps

The proposed follow-up to this study is described in chapter 4 *'Critique and Openings For Further Synthesis'*. The knowledge generated in this project still has unique value within the telecom sector[17], which gives TRAB a certain lead as an analyst and research company. As mentioned in chapter 2.2.4, the system dynamics requires a lot of time and effort in getting started, which is an entry barrier for other analysts.

The first thing to do after the project completion is to run a series of internal workshops in order to get the knowledge to the TRAB analysts outside the VAKA project. It is also important to develop systems thinking further, in order to keep and maintain the knowledge lead over the competitors. Older models can be updated with real market data as time passes by, in order to verify early assumptions.

Secondly, TRAB is recommended to act quickly in order to get as many clients as possible within a short period of time, and to make most use of its current competitive advantage. Other analysts will inevitably follow and soon offer similar modelling methodology for war games and scenario planning within the telecom sector. This can eventually make it more difficult for TRAB to market modelling seminars especially to clients outside the Telia sphere. As the current TRAB strategy is to engage more external clients, this point is especially important. (If the result of good research can benefit the total market and its growth, the Telia concern will also gain from external TRAB clients – there should not be any competition issues.)

3.1.2 Modelling Tool s

The overall judgement concerning Powersim software is that it is a very heavy and difficult implementation of the system dynamics interface, with a steep learning curve, a half-baked feature set and *a lot* of bugs. Especially the awkward data import functions were frustrating and time consuming. The program interface is not consistent and does not follow basic GUI guidelines. Working with Powersim Enterprise Edition 2001 often resulted in frustration - especially when linking external data into the model. The application features were definitely not en par with what you would expect from a $5.000-program; occasionally the software crashes resulted in data loss.

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[17] Judging from the participation list of the System Dynamics Society conference in Atlanta in June 2001, there are few telecom players that monitor the development in the field of System Dynamics.

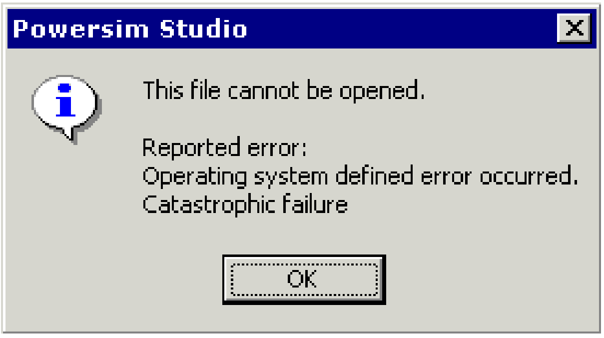

Figure 3:1 One of the numerous cryptic error messages in the Powersim application.

In order to have full use of the modelling, you must master the cash-flow analysis, marketing and technical fields, as well as system dynamics and the Powersim software interface. To gain access to the advanced features, some knowledge of VisualBasic is also useful. For this reason, complimentary competencies in the modelling team are strongly recommended.

Extensive research and preparations were necessary before starting the modelling. For the cash flow model in this study, a set of Excel spreadsheets with in-data was composed, based on both assumptions and real-life data. It is recommended to have the import data files ready and quality assured as soon as possible, preferably before the modelling starts, since this could save time identifying influencing variables.

3.2 Recommendations to TRAB's Clients

The modelling approach of system dynamics offers a fresh perspective to any score-keeping factor for the telecom industry. If your company works with traditional cash flow, I would recommend you involve TRAB AO Strategi after a basic overview and a traditional spreadsheet calculation is made. This will save a lot of time and frustration, making it easier to create data imports for the Powersim file.

Assign complimentary competencies from your company to work with TRAB staffers, calculate with at least 80-120 working hours for preparations and modelling before a war game workshop. Mileage may vary with the extent of the project and amount of import data. It may sound like a lot of resources for preparations, but the result of a system dynamics workshop is, in my opinion, far more rewarding than a regular spreadsheet dissection of the problem.

4 Critique and Openings For Further Synthesis

There are many aspects not covered in this study. Due to the vast amount of work and complexity of the task and general limitations, there is still much to research, expand, clarify and refine. Below, the main issues are explained and possible improvements are suggested.

4.1 Alternative Performance Measures

There are as many viewpoints as there are researchers and there are fashions in all fields – also in the field of capital investments. Taking cash flow as fair measure for the success of a communications infrastructure rollout, is somewhat inaccurate by today's standards, although very traditional. It is clear that cash flow is not the ultimate answer to why a company is profitable, a fact that has been proven recently in the case of Ericsson[18]. An organization's success and level of prosperity is still often defined and measured from a cash flow perspective.

The original research for this thesis was intended to be market oriented and deal with alternative score-keeping factors for the modelling[19]. There is a strong need for such alternative measures and score-keeping factors; 'value for money', 'market share' and 'market dynamics' are just a few examples. (See also the Ajzen-Fishbein derivative in the *Value-For-Money appendix*. The matrixes pictured in the spreadsheet file could serve as data import for a completely different dynamic model.) Also, there are good chances for market modelling from other perspectives, such as the consumer or customer perspective. Today, there is a great deficit on these alternative perspectives within decision-making.

4.2 Alternative Perspectives

The study is performed from an operator or shareholder's viewpoint and does not illustrate the situation as it is perceived from other perspectives, such as a macro perspective or a micro/end user perspective.

Macro

A macro perspective might be experienced as the least important, but one must remember that large-scale investments often require government support and subventions, legislation and monopoly considerations. Hence, it is also important to show the impact on society at large.

Micro

To any marketer, it is evident that neglection of the needs of the end user will inevitably result in a profit decrease.

In this study, no micro aspects have been covered, because it is difficult to discern and predict such things as the current price strategies of the WISPs. Nevertheless, it is very important to match the needs of the customers with the value proposition.

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[18] Articles about Ericsson in Swedish daily Finanstidningen Tuesday January 29th 2002.

[19] Taken from the original project proposition document from May 28th 2001.

4.3 Complex Modelling

The design of the model presented in this thesis lacks in functionality and would need some improvements in order to become useful. As previously stated, the model in itself has little value, since the factual contribution is the design process. Therefore, this chapter may be useful for those who want to implement systems thinking in their respective organisations.

4.3.1 Connection to WLAN Alternatives

The original plan was to research the possible connection between different alternatives for wireless connectivity, such as an interlinked model with both UMTS and WLAN. The most obvious feedback loops between the two different models would concern customers, their disposable income and possible segmentation. There is a strong need for such links – it is clear that the WLAN business will snap a portion of the data transfer of UMTS; as an example, McKinsey consults expect WLAN to cannibalise about 17% of the UMTS revenues within six years, as end users will choose wireless computer networks for larger data transfers.[20]

Due to the overall complexity of the task and time constraints, integration of the WLAN case with a case for an alternative technology was left out, even though the model was prepared for later integration with add-on layers[21]. A good example of this is the use of RAN (Radio Access Network, not included in the public version) calculations[22], which actually include most wireless LAN standards and UMTS. The RAN calculations in the current model are a good example of how the model can be expanded and refined further with new modifications and add-ons.

As stated in chapter **Error! Reference source not found.**, *'Error! Reference source not found.'*, future shifts caused by market convergence urge the addtion of other aspects, such as cannibalisation.

4.3.2 Feedback Loops

The main disadvantage in the model is that it does not give a fair picture of the possibilities in system dynamics, due to the virtual absence of feedback loops. (One of the major differences between designing a market model with a linear tool such as a spreadsheet program, in comparison to system dynamics, is that it is possible to illustrate interdependencies and feedback loops, as stated in chapter **Error! Reference source not found.** *'Error! Reference source not found.'*.) Fact is, that most of the current model can be designed in a spreadsheet application! The only feedback loops included in the model today is the experience curve**Error! Bookmark not defined. Error! Bookmark not defined.** and a simple implementation of the M&S budget's impact on sales. Other interesting applications would be price elasticity[23] and sypply/demand for capacity. What lacks in the supply/demand model is an auto-sensing

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[20] Fredrik Geertman (McKinsey Co); seminar at TRAB Vision Centre, December 13th 2001.

[21] A UMTS model, which is also a part of the VAKA project is under development. Fredrik Halsius, TRAB AO Strategi. The Powersim software allows integration of different projects with shared resources.

[22] See appendix WLAN_2003_PUBLIC.xls, 'RAN' sheet.

[23] The theory of price elasticity deals with customer willingness to pay for different alternatives, so-called substitutions. A good summary of elasticity studies is given in 'Market Response Models – Econometric and Time Series Analysis' by Dominique M. Hanssens, Leonard J, Parsons and Randall L. Schültz; Kluwer Academic Publishers 1990; pp187-91.

feedback loop in order to link the roaming distribution and the theoretical free time for roaming, so that the implication of the roaming distribution will not exceed the demanded volumes. The model could also be extended with implications from network externalities, such as loops connecting the marketing and sales and the market share.

4.3.3 Delay Functions

Normally, reactions in a process take time to play out fully. In '*Industrial Dynamics*', Jay W. Forrester explains the importance of delay functions. Chapter nine, 'Representing Delays', deals with the importance of delays in feedback systems. Delays are important for the aggregation of values in feedback loops, hence important to consider in most models; in principle, all flow channels must include delay functions.[24] Everywhere a level (stock) is involved, there is probably also a delay; knowing this we can conclude that the model contains too many imports and too few levels (stocks).

In the model presented in the Analysis chapter, no delay functions have been presented in order to reduce the complexity of the causal loop diagram. The only two logical places in the model where a delay function can be included as of this writing is the experience curve and the M&S impact on the subscription rate. *An example of a significant delay function would be the marketing expenditures impact on the subscription rate and indirectly shifts in customer support costs.* This should of course be considered as a weakness in the model and could be a subject for further research – a valid mirror of a complex environment should normally be full of delays. If the model would be expanded further to contain other reality-like variables such those discussed in chapter **Error! Reference source not found.** *'Environmental Aspects'.*

Also, even if it is not a delay technically, discarding variables were not taken in account to show haw a leakage in the system can occur. (As it is now, it seems like the system will go on forever.)

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[24] 'Industrial Dynamics' by Jay W. Forrester; MIT 1961. Chapter 9, pp86-92.