NES	RECOMMENDATION	R 03
NORDIC ELECTRIC POWER COOPERATION	FROM THE NES GROUP	PAGES: 26 ENCLOSURES: 0 DATE: 11.03.2002

CONSIDERATIONS CONCERNING PRINCIPLES AND SYSTEMS FOR SIMULATION OF ENERGY CONSUMPTION.

SYNOPSIS:

The aim of this report is to present the results from the investigation of which principles and systems are available to simulate energy consumption within railway traffic in Europe. And to define which requirements are essential for choosing a suitable simulation program for the Nordic region.

Based on a total evaluation of all the information revealed and the comparisons carried out by the work group none of the found programs is recommended for further use. The main reason being the fact that the programs did not fit the work group's chosen specification. They were all considered too complicated and requiring too much effort to use frequently.

The work group's recommendation is hence to look into the aspects of developing a dedicated simulation program for the Nordic region's needs for railway energy settlements.

DISTRIBUTION LIST

The Nordic Technical Directors
JBV, BV, RHK and BS

Summary

NES, Nordic Electric Power Co-operation started, in February 1999, a project to consider methods of energy settlements for railways. The project was divided into three parts. This report represents the results from work group 3 whose aim was to investigate which principles and systems are available to simulate energy consumption within railway traffic in Europe and to define which requirements are essential for choosing a suitable simulation program for the Nordic region.

The work group chose the following formulation as their guideline for the work undertaken:
"Our aim is to have satisfied customers and to receive the appropriate amount of money to cover the expenses of providing energy for the train traffic.
The accuracy of the calculations should therefore be acceptable for the traffic operators. As long as our aim can be achieved, accuracy has limited value in itself. Calculations of very high accuracy are likely to entail higher expenses that must also be added to the cost of the energy. Thus a compromise must be made between accuracy and the efforts/ cost involved in simulating the energy consumption."

Based on this guideline a specification for a suitable simulation program was developed. The specification has a "black box" approach, and define a limited number of input and outputs.

A field-research was carried out among European railways to investigate whether a simulation program to fit the chosen specification, was already readily available. Six programs were found.

Based on a total evaluation of all the information revealed and the comparisons carried out by the work group none of these is recommended for further use. The main reason for this being the fact that the programs did not fit our chosen specification. They were all considered too complicated and requiring too much effort to use frequently.

The work group's recommendation is hence to develop a simulation program that is dedicated to the Nordic region's needs for railway energy settlements. Note that this task should be approached with some caution. Among the most important issues to consider are:

- The expected life span of the simulation program should be viewed in accordance to the Nordic countries' view on energy meters in the trains.
- A common strategy on how to divide the cost among the traffic operators would be a great advantage if agreed on in advance.
- The possibilities of seeking advise and help from countries who have gone through similar processes should be explored in advance

NES – INFORMATION NO. 03

Considerations concerning principles and systems for simulation of energy consumption.

Contents:

1. Introduction

1.1 Background

The background for this report is that NES, Nordic Electric Power Co-operation, in February 1999 started a project to consider methods of energy settlements for railways. The project was divided into three parts. A work group made up of members from the four Nordic countries handles each subproject. This report presents the work carried out by work group 3.

1.2 Aim

The aim of the total project is to establish a set of common rules to applying to energy settlements within the Nordic countries. The rules are to apply to all traffic operators whose electric power are supplied from respectively Norwegian National Rail Administration's (JBV), Finnish Rail Administration's (RHK), Swedish National Rail Administration's (BV) and Danish National Railway Agency's (BS) areas. The set of rules should also be drawn up with special consideration to border-crossing railway traffic. Inquiries and comparisons necessary to fulfil the project's aims are completed as a Nordic collaboration.

Work group 3's aim is to investigate which principles and systems are available to simulate energy consumption within railway traffic in Europe. In addition to doing research, the work group aims to define which requirements are essential for choosing a suitable simulation program for the Nordic region. These requirements will be collected in a specification.

1.3 Work group 3

The work group has consisted of the following members:

Johnny Brevik (chairman)	Norwegian National Rail Administration (Jernbaneverket)
Marianne Nyebak	Norwegian National Rail Administration (Jernbaneverket)
Freddy W. Scheie	Norwegian National Rail Administration (Jernbaneverket)
Jens Bjørn Nielsen	Danish National Railway Agency (Banestyrelsen)
Nils Rohlsson	Swedish National Rail Administration (Banverket)
Erkki Tiippana	VR-Track Ltd

1.4 Guideline for the group's work

The members of this group have chosen the following point of view as a guideline for our work:

"Our aim is to have satisfied customers and to receive the appropriate amount of money to cover the expenses of providing energy for the train traffic.

The accuracy of the calculations should therefore be acceptable for the traffic operators. As long as our aim can be achieved, accuracy has limited value in itself. Calculations of very high accuracy are likely to entail higher expenses that must also be added to the cost of the energy. Thus a compromise must be made between accuracy and the efforts/ cost involved in simulating the energy consumption."

Calculations of lesser accuracy mean that inaccurate invoicing is a more likely scenario. A yearly balance, where the total energy bought is compared to the energy consumption charged to the train traffic and auxiliary consumption, will solve this problem. Any shortcomings in the energy settlements or unfair division of the cost among the traffic operators can then be corrected.

1.5 Issues which are not considered.

The suggestions made in this report do not take into consideration the energy used for heating of stationary trains. This issue is left out because the methods used for taking care of such heating, varies much among the Nordic countries. It is also not considered a natural part of the group's objective.

By adding models to cater for the different methods for heating of stationary trains the energy consumption simulation would be too complex. The opinion of this work group is that suitable schemes for including this aspect must therefore be made in each country. When a simulation program has been established and successfully utilised for a period of time, discussions about incorporating heating of stationary trains may be taken up.

2. First attempt to draw up a specification

As a first attempt the work group has through brainstorming and discussions developed a specification for a suitable simulation program as seen fit to meet the requirements for train traffic energy consumption in our region. It was chosen to use a black box approach where only inputs and outputs are specified. The details of this specification are listed in this chapter. However, this specification was abandoned before total completion. (There are some comments in *Italics* showing issues, which would need more discussion if the specification had been adopted.) The reasons why this specification was abandoned can be found in chapter 2.3.

2.1 Input to the simulation program:

The input to the simulation program is divided into 5 categories. All the aspects in the first 4 categories were at first considered essential for achieving a good simulation model. The aspects in the last category is additional, and viewed as a bonus if possible to include.

2.1.1 Locomotive model

- Traction graph (theoretical)
- Adhesion utilisation
  – must be able to specify an adhesion coefficient.
- Desired acceleration/retardation
  – must be able to calculate an acceleration resistance based on desired acceleration.
- Electrical model for the locomotive:
  – engine type
  – efficiency
  – cos φ as a function of OHL (overhead line) voltage (asynchronous - locomotive)
  – rectifier control as a function of velocity (thyristor - locomotive)
  – auxiliary consumption → power and cos φ must be possible to specify
  – voltage drop in OHL considerations.

2.1.2 Train energy consumption model:

- Rolling resistance (friction, inertia, air resistance)
  – adjusted automatically for driving in tunnels
- Gradient resistance
- Curve resistance
- Train weight
  – dynamic weight
  – adhesion weight
- Maximum train velocity
- Train schedule (including distance. Trains outside passenger- and freight traffic i.e. to/ from workshops, testing for maintenance, repairs etc. also included)
- Braking (including method and consequences)
- Delays in traffic

2.1.3 Infrastructure influence

- Track curvature, horizontal and vertical
- Possibilities to specify different values of track dependent adhesion
- Models for OHL
  – including systems incorporating booster transformers and/or autotransformers
- Models for feeder stations
  – including rotating and or static converters
- Models for configuration of power supply from converter/transformer stations to train.
- Define current, voltage and frequency input
- Losses (converters, transmission lines, catenary) → *very difficult to carry out. Might be impossible. Easy for one train. Losses may be divided between several trains running on the line simultaneously, by a percentage according to their energy consumption.*

2.1.4 Accuracy

- Methods to verify accuracy
  – meters in selected trains
  – other methods may be considered

2.1.5 Additional elements

- Possibilities to enter signalling systems into the simulation program
- Thermal models for locomotives
- "Artificial engine driver" for acceleration / retardation

2.2 Output

Simulation results must show energy consumption; specified for single trains, for a given period of time and for a given section of track.

- Energy consumption used for traction
- Total losses
- Peak-power in the system → *over what period of time it should be presented must be discussed. Each country may have different requirements.*

2.3 Comments

The first attempt to draw up a specification for a suitable simulation program has been described above. It resulted in numerous inputs and fewer outputs. Not all the listed inputs are considered practical or they are perhaps even close to impossible to achieve. The overall picture gives thus an accurate but highly complicated model for simulation.

In response to this the members of the work group had to reconsider the objective for the work. The first specification appeared to be too complicated for frequent use. The following point of view was developed and agreed upon:

Our aim must be to have satisfied customers and to receive the appropriate amount of money to cover the expenses of providing energy for the train traffic.

The accuracy of the calculations should therefore be acceptable for the operators. As long as our aim can be achieved, accuracy has limited value in itself. Calculations of very high accuracy are likely to entail higher expenses that must also be added to the cost of the energy. Thus a compromise must be made between accuracy and the efforts/ cost involved in simulating the energy consumption.

With this in mind, the second attempt to develop a specification was started.

3. Second attempt to draw up a specification

The first attempt to write a specification was aborted without reaching a unanimous agreement as to which parameters were strictly necessary and which were auxiliary.

The second attempt started in a slightly different direction. The classification of inputs as essential in chapter 2 does therefore not apply for the specification in this chapter.

In order to be able to draw up a satisfactory specification the purpose and frequency of usage for the simulation program had to be considered. There were 3 apparent possibilities:

1. A program to be used rarely, but for the entire network in order to determine different rates of power consumption according to track gradient, season etc.
2. A program used frequently, for instance weekly or monthly, in order to find the power consumption.
3. A program used to estimate power consumption in advance.

The difference between these solutions would be reflected both in respect to accuracy and perhaps also in user-friendliness. The first type of program is in accordance with the first attempt to draw up a specification and will therefore not be considered further in this chapter.

The following two types of programs would have to use a simpler model than the first attempt offered. The required simulation inputs would have to be simple to enter into the program and the simulation must take a short time to run. Thus the accuracy in the result will have to be lowered. The specification in this chapter will be suitable for simulation programs type 2 or 3.

3.1 Specification

The black-box approach is retained for this attempt to develop a specification. Hence the main building blocks for this specification is input and output.

It will be an advantage to have a simulation program that not only calculates the energy consumption but also one that takes care of the invoicing. Meaning that losses and other expenses will be calculated and added to the actual energy cost for each operator. The amount payable for each client will consequently be calculated in one operation.

3.1.1 Inputs

The minimum required input is train weight and train schedule, specifying distance, number of starts and stops and the time of day. Further necessary input is the price of energy. This price may be taken from an elaborate model based on price variation according to feeding points into the network (Source Company) and day/night price variation or as a calculated average price. The more differentiated the price is, the more complicated model for the simulation program.

The next step to consider is the differences between the individual trains in traffic on the lines. The trains themselves will be assembled from different types and numbers of coaches and/ or wagons. They may use single or multiple locomotives or motor coaches. Energy consumption may also vary with the different types of locomotives and motor coaches. Establishing a simulation model that differentiates between all these possibilities is hard to do and will result in a very complicated model. Such a model is not according to the guidelines for this specification.

The train traffic must therefore be divided into categories, for instance local, regional, long-distance and freight traffic. Each train-configuration must be allocated to a category. This division must reflect the difference in energy consumption but should not introduce so many categories that the model becomes overly complicated. The categories may have to be more elaborate than the suggestions made here.

In order to accommodate for effects of varying track gradient there are three main possibilities:

- Set energy consumption according to geographical area of the network.
- Set the energy consumption according to gradient intervals and define which interval each section of the track belongs to. Suitable sections will be between two stations.
- Find an average energy consumption factor and apply it to all areas of the network.

Of these solutions number 2 will give the most accurate result. Solution number 3 is the simplest to implement in a simulation.

A code to identify to which traffic operator each train belongs will simplify invoicing and should therefore be included.

Preparing the interface for input information to be able to receive automatic transfer from other sources and not to depend on having all input keyed in manually, will reduce personnel requirements. The possibility to manually add information must be available to allow for corrections or for entering traffic additional to normal schedules.

3.1.2 Outputs

The output from the simulation must be energy consumption in terms of Wh/gross-tonne-km and/or kWh/km, multiplied by travelled kilometres. If possible the losses in transmission and converter stations should be specified and divided among the trains and/or train operators. The division of losses may have different specific features for each country, but the cost of losses will have to be covered by the payment from the operators. Invoicing will be made simpler if the simulation program do this division of the cost among the operators.

The output from the simulation must be able to give the energy cost for a specified train and the accumulated cost for all trains belonging to an operator for a given period.

Output results must be presented in a format that can be processed by other programs for further use.

4. A overview of available simulation programs

Field-research carried out by the participating countries has revealed a few simulation programs. These are listed in the following chapters. For a more detailed description and an overview of advantages and disadvantages please refer to chapter 5.

4.1 Austria

ÖBB uses a simulation program for energy calculation. This program is an additional module to their load-flow calculation program. The information about this did not arrive in time for the work group to discuss in their meetings.

4.2 Belgium

The Belgian railway has no simulation program for train energy consumption calculation in use.

4.3 Bosnia- Herzegovina

The Bosnian railway has no simulation program for train energy consumption calculation in use.

4.4 Czech Republic

There has been no response from the Czech railway to our queries.

4.5 Denmark

Banestyrelsen uses a simulation program called "KTID". This program is not regarded suitable for further use according to the criteria in this report.

4.6 Estonia

The Estonian railway has no simulation program for train energy consumption calculation in use.

4.7 Finland

The Swedish simulation program SIMON is used in Finland.

4.8 France

There has been no response from SNCF to our queries.

4.9 Germany

There are found three programs in use in Germany. SimONe and SIDYZUG belong to Siemens. They are meant for AC and DC lines respectively. These programs have been under development since 1990. It is unlikely that the programs will be sold. Probably Siemens will, if simulations are required, only carry out these on order. The third program, Energie- und verbrauchsrechnungen, is owned by Deutsche Bahn AG.

4.10 Hungary

There has been no response from the Hungarian railway to our queries.

4.11 Italy

There has been no response from the Italian railway to our queries.

4.12 Latvia

The Latvian railway has no simulation program for train energy consumption calculation in use.

4.13 Lithuania

There has been no response from the Lithuanian railway to our queries.

4.14 Luxembourg

The railway in Luxembourg has no simulation program for train energy consumption calculation in use.

4.15 Netherlands

The Dutch railway has no simulation program for train energy consumption calculation in use.

4.16 Norway

Norway has two possible simulation programs, Togkjør, which apparently does not work properly for this usage, and SIMTRAC. SIMTRAC is the simulation program for energy consumption currently in use.

4.17 Poland

The Polish railway has no simulation program for train energy consumption calculation in use.

4.18 Portugal

There has been no response from the Portuguese Infrastructure owner to our to our queries.

4.19 Romania

There has been no response from the Romanian railway to our queries.

4.20 Russia

Despite our efforts there has been no response from Russia. The group does not consider it likely that there will be any simulation program in use and thus have terminated our efforts to contact the Russian railway.

4.21 Slovakia

Despite our efforts there has been no response from Slovakia. The group does not consider it likely that there will be any simulation program in use and thus have terminated our efforts to contact the Slovakian railway.

4.22 Spain

There has been no response from the Spanish railway to our queries.

4.23 Sweden

There are two possible simulation programs. They are called SIMON and POET (new name for SIMTRAC).

4.24 Switzerland

The SBB uses a self-developed simulation program called I-Prix. It is based on train weight and distance travelled by the trains. The program takes input data from the timetable system called SYFA. The weight are taken from REBE Reisezugbewirtschaftung (for passenger traffic) and by CIS Cargo Information System (for freighttraffic).

The system makes a real-time calculation of all trains running on SBB's infrastructure. It is not a simulation system for future calculations. It is possible to calculate a train from A to B based on train schedule (stops) and environment but there is not any possibilities to put different locomotive and car specifications into I-Prix. It is, however, possible to put any weight of train to calculate a train in I-Prix. The system was built to make offers to the railway undertakings and for the invoicing of all the trains. The invoicing include all costs which an operator is required to pay to travel on the network, not merely energy costs.

4.25 Ukraine

There has been no response from the Ukrainian Infrastructure owner to our queries.

4.26 United Kingdom

Railtrack does not use any simulation program for their energy settlements.
An English simulation program called "Vision" has previously been used by Jernbaneverket to simulate the power supply in their network. It had to be adapted as it is based on double track railway network (most of the Norwegian network is only single track). It was chosen to use SIMTRAC for future simulation as this program was better suited to their needs. Hence further investigation of Vision has not been considered necessary.

4.27 Yugoslavia

The Yugoslavian railway has no simulation program for train energy consumption calculation in use.

5. General information about each program

Some additional, and more detailed, information about the simulation programs discovered is presented in this chapter.

5.1 SIMON

5.1.1 Advantages

- SIMON/TTS has a usergroup within Banverket, The Finnish Rail Administration (RHK) and ÅF-Industriteknik AB for traffic simulations and running time calculations.
- SIMON Powerlog has been used within Banverket for power supply – traffic simulation since 1997.
- Banverket has research co-operation with Royal Institute of Technology for studying energy calculations since 1992.
- Banverket and ÅF-Industriteknik AB has good experience in traffic simulation development and usage.

5.1.2 Disadvantages

- The latest research results from Royal Institute of Technology Stockholm in energy calculations are not implemented in SIMON/TTS.
- The verification of the SIMON powerlog shows that the accuracy is about + 20% for the simulated power. This implies that the simulated power is 20% higher than the real power.

5.1.3 Experience

SIMON/TTS has been in use in traffic simulation projects by Banverket and ÅF-Industriteknik since 1992 and by RHK since 1998. For more information, see reference [1].

SIMON Powerlog has been in use by Banverket since 1997. For more information, see reference [1].

SIMON/TTS has been used in research at Royal Institute of Technology Stockholm in energy calculation. For more information, see reference [2].

5.1.4 References

Table 5.1 References SIMON

Program name:	SIMON/TTS
Year of development:	1992
Producer / supplier:	ÅF-Industriteknik AB
Person to contact (supplier):	Per Lindström (Per.Lindström@ind.af.se)
Used by: (company, country)	Sweden (BV) and Finland (RHK)
Person to contact (user):	Magnus Wahlborg (magnus.wahlborg@banverket.se)
Literature:	[1] TTS Train Traffic Simulation Package, [2] International references SIMON/TTS energy calculations
Field-research carried out by: (name, company)	Nils Rohlsson Banverket Sweden.
Comments:	SIMON/TTS is owned by Banverket. Contact person is Peder Wadman Banverket Infrastructure Management.

5.2 SIMTRAC

5.2.1 Advantages

- There is experience from usage of this program in Norway.
- To a large extent the required input for locomotives and infrastructure does not vary much. This means time saved once the first simulation for a given length of track has been carried out.
- SIMTRAC may be used for both trains running on AC and DC current.

5.2.2 Disadvantages

- It takes a lot of initial effort to be familiar with and to use the program efficiently.
- There is no model for signalling system incorporated in the program. This means that if the train schedules is not exactly correct, more than one train can run on the same track in the simulation. To ensure that trains only pass each other in stations manual control of the trains running in the simulation is required.
- Train schedules must be entered into the program for each new simulation if there has been changes to it.
- A lot of different parameters are required to make a good model. These are tied to locomotives, railway infrastructure and also the national grid which supply the converter stations. Collecting the appropriate information and typing it into SIMTRAC takes a lot of time.

- This program does not take into consideration the "driver-factor", meaning that speed reduction towards stations is abrupt, not gradually, and that different drivers have different driving patterns.

5.2.3 Experience

SIMTRAC has been in use by Jernbaneverket since 1996. Experience from usage shows good results in the field it has been used so far. This is mainly in order to control that there is sufficient power supply for traction. The controls' purpose being to ensure both sufficient amount of power available and acceptable voltage levels. Verification carried out by Jernbaneverket showed that the program calculates voltage and power to an acceptable accuracy. Calculation of energy consumption was less accurate.

5.2.4 References

Table 5.2 References SIMTRAC

Program name:	SIMTRAC
Year of development:	1995
Producer / supplier:	Adtranz
Person to contact (supplier):	Gunnar Strand
Used by: (company, country)	Jernbaneverket
Person to contact (user):	Frode Johannessen (frj@jbv.no)
Literature:	Brukermanual, test 1997
Field-research carried out by: (name, company)	Marianne Nyebak, Jernbaneverket
Comments:	

5.3 I-Prix

5.3.1 Advantages

The program is self-developed and does therefore fit its specification very well. It takes train information (schedule and weight) from connected programs and databases automatically. Automatically transferred data may be edited if necessary.

5.3.2 Disadvantages

This program is custom-made to bill traffic operators according to the Swiss method and therefore includes far more than energy settlements. It is specifically made for interaction with specified programs and databases used in Switzerland. Due to this it will require much adaptation to meet our requirements. It also requires a lot of measurements to establish valid values for energy consumption for each type of train traffic.

5.3.3 Experience

I-Prix has been used by *SBB* since 1999. Experience from usage shows that it fits well with their requirements. However, it is self-developed and has been adapted according to acquired experience from usage. The program is used for all traffic in Switzerland but operated by SBB.

5.3.4 References

Table 5.3 References I-Prix

Program name:	I-Prix
Year of development:	1999
Producer / supplier:	SBB
Person to contact (supplier):	Mr. Roland Jordan
Used by: (company, country)	SBB, Switzerland
Person to contact (user):	Jürg Fankhauser
Literature:	
Field-research carried out by: (name, company)	Marianne Nyebak, Jernbaneverket
Comments:	

5.4 SimONe

5.4.1 Advantages

The group did not acquire sufficient knowledge about this program to assess its advantages.

5.4.2 Disadvantages

The group did not acquire sufficient knowledge about this program to assess its disadvantages.

5.4.3 Experience

Sufficient knowledge about earlier experience with usage of this program was not available. It is, however, claimed to be very similar to its equivalent program for DC lines SIDYZUG.

5.4.4 References

Table 5.4 References SimONe

Program name:	SimONe, Simulation of Power Supply of Main Line Railways
Year of development:	2000 (development started 1990)
Producer / supplier:	Siemens AG, Erlangen, Germany
Person to contact (supplier):	Siemens DK, Jan Lohmann
Used by: (company, country)	
Person to contact (user):	Jens Bjørn Nielsen, BS
Literature:	Sales presentation
Field-research carried out by: (name, company)	Jens Bjørn Nielsen, BS
Comments:	For AC Railways

5.5 SIDYZUG

5.5.1 Advantages

The group did not acquire sufficient knowledge about this program to assess its advantages.

5.5.2 Disadvantages

The group did not acquire sufficient knowledge about this program to assess its disadvantages.

5.5.3 Experience

An earlier version of this program has been used for simulation of the Danish metro (S-bane). Siemens carried out the simulation.

The results from that simulation have not been verified against the current situation. It is also a complex procedure to have simulation done by another company in terms of gathering sufficient and adequate input to the simulation. It can also be difficult to discover all possibilities of presentation of results and receiving the right amount of information.

5.5.4 References

Table 5.5 References SIDYZUG

Program name:	SIDYZUG, Simulation of Dynamic Status of DC Railways
Year of development:	2000 (development started 1990)
Producer / supplier:	Siemens AG, Erlangen, Germany
Person to contact (supplier):	Siemens DK, Jan Lohmann
Used by: (company, country)	Banestyrelsen
Person to contact (user):	Jens Bjørn Nielsen, BS
Literature:	From Copenhagen S-bane simulation. Sales presentation
Field-research carried out by: (name, company)	Jens Bjørn Nielsen, BS
Comments:	For DC Railways

5.6 "Energie- und verbrauchsrechnungen"

5.6.1 Advantages

The group did not acquire enough knowledge about this program to assess its advantages.

5.6.2 Disadvantages

The group did not acquire enough knowledge about this program to assess its disadvantages.

5.6.3 Experience

DB-Gesellschaften, private railway companies and railway consultants use this program alike.

5.6.4 References

Table 5.6 References "Energie- und verbrauchsrechnungen"

Program name:	Energie- und verbrauchsrechnungen
Year of development:	
Producer / supplier:	Forschungs- und Technologiezentrum der Deutschen Bahn
Person to contact (supplier):	Helmut H Lehmann, Deutsche Bahn AG, TPF 2
Used by: (company, country)	DB-Gesellschaften Privatbahnen und Ingenieurbüros u.a.m
Person to contact (user):	Helmut H Lehmann, Deutsche Bahn AG, TPF 2
Literature:	Available
Field-research carried out by: (name, company)	Jens Bjørn Nielsen Banestyrelsen
Comments:	

6. Conclusion

The conclusions drawn in this chapter are based on a total evaluation of each simulation program comparing the program to the specification in chapter 3.

6.1 SIMON

This program requires a lot of inputs. It is mostly in accordance with the first attempt to draw up a specification.

6.2 SIMTRAC

This program requires a lot of inputs. It is mostly in accordance with the first attempt to draw up a specification.

6.3 I-Prix

This program is custom-made for Switzerland and thus it may require a lot of adaptation to adopt in the Nordic region. It has also a wider scope than just energy settlement.

6.4 SimOne

SimOne is very similar to SIDYZUG but used for AC lines. This program is mostly in accordance with the first attempt to draw up a specification.

6.5 SIDYZUG

The program is mostly in accordance with the first attempt to draw up a specification. It requires a lot of inputs. An earlier version has been used in simulation of the S-bane of Copenhagen with good results. The supplier ran the simulations.

6.6 Energie- und verbrauchsrechnungen

Limited information about this simulation program has been available for the work group . It is assumed that the program is mostly in accordance with the first specification attempt.

7. Recommendation

The recommendation is based on a total evaluation of all the information the field-research revealed and the comparisons carried out by the work group. According to these considerations none is recommended for further use. The main reason for this being the fact that the programs did not fit our chosen specification.

Choosing a specification describing a simple simulation program is based on the belief that the advantages of such a program by far outnumber the disadvantages. Also the accuracy from such a calculation does not give an unacceptable response. A simple program is likely to be user-friendlier. Some of the main advantages by using a small and simple program are listed below:

- Large complicated simulation programs require a number of inputs. Any inaccuracy in these are accumulated and added to the simulation model's inherent inaccuracy. Hence the simulation result may not be more accurate than the result from a simpler simulation.
- Large complicated simulation programs tend to require a lot of initial knowledge from the operator. Identifying and locating faults are difficult. The dependency on key personnel is high. Simpler programs are normally more user-friendly and have lower knowledge thresholds.
- Large complicated simulation programs often require more preparation and longer running times. They may be less suitable for frequent simulations.

The group's conclusion is thus that there seem to be no suitable simulation program readily available. It is possible to adapt existing programs to fit our specification. This may be both costly and require much work. It also introduces dependencies to other companies. It raises among others the question of updates. Whether a new version of the underlying program is developed to cater for our needs too, or will introduce new development costs each time, will be of great importance. **Thus it appears to be more appropriate to develop our own simulation program.**

This, however, must be approached with caution. There are several issues to be considered and work to be done before the decision is made.

7.1 Issues to consider before undertaking program development.

Before the process of developing a new simulation program, its boundaries must be agreed upon. This is absolutely essential in order to achieve a good result using the optimal mix of effort and expenses.

The first issue to consider is the life expectancy of the program. If the program is expected to have long-term usage, it is sensible to invest in features as interfaces for automatic data transfer of input and output. Short-term use does probably not support such features. The program's expected life span should be viewed in accordance to the Nordic countries' view on energy meters in the trains.

The resources needed to develop a simulation program are also essential. Developing an own program may appear to be an extensive task, but measurements and research to determine input data may turn out to be a larger undertaking. Hence which inputs to use must be decided before the work of acquiring them starts. This includes charting the differences between the systems of the Nordic countries and knowing which differences the program must accommodate for.

Determination of the outputs is no less important. This means that a common strategy on how to divide the cost among the traffic operators would be a great advantage if agreed on in advance. Some sort of agreement will have to be reached in order to adapt the simulation program to be usable in all four countries.

The model in the diagram below may be adopted for developing a simulation program according to the work group's chosen specification.

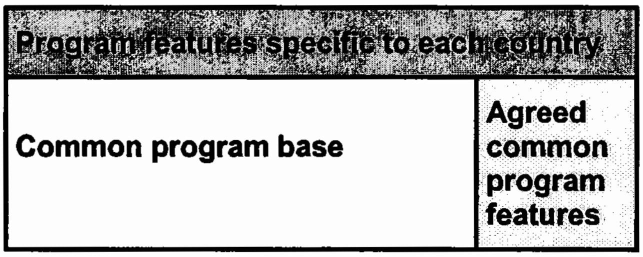

Figure 7.1 Possible simulation program model.

The possibilities of seeking advise and help from countries who have gone through similar processes should be explored in advance. Also the potential for making use of results from earlier work and surveys from our own countries must be explored before the development of the simulation program starts.

Finally, the way in which to organise the program development process should be discussed. Whether to delegate the task to one country, establish a work group or some other form of co-operation must be decided.

8. References

The texts and web-sites listed below have been very useful during the field research and are included to provide further reading and ease supplementary research.

8.1 Text

[1] *"TTS Train Traffic Simulation Package"*

[2] *"International references SIMON/TTS energy calculations",*

[3] "Alternative energiavregningsmetoder", rev. 1, Jernbaneverket Bane Energi, September 1997

8.2 Web-sites

- The European Railway Server: http://mercurio.iet.unipi.it/
- UIC International Union of Railways: http://www.uic.asso.fr/
- Swiss Federal Railways: http://www.sbb.ch/

9. Enclosures

9.1 Contacts

Getting questions through to the appropriate person in a company is difficult unless this person is known in advance. As a result, the contacts the work group has established through the field research are enclosed with the report. For any further contact with these railway companies required in the future, it may be helpful to try to contact one of those persons listed below. If not able to help they may be able to direct the enquiries to the appropriate person.

Name (Position)	Telephone/ email	Country
Nicolas Welsh	nicolas.welsch@cfl.lu	Luxembourg
Helena Vanlangenhove	helena.vanlangenhove.042@b-rail.be	Belgium
Cees Harinck	c.hrinck@railned.nl	Netherlands
Mirjam Kastelic	Mirjam.kastelic@slo-zeleznice.si	Yugoslavia
Roland Jordan	ROLAND.RJ.JORDAN@SBB.CH	Switzerland
Jayne Carrington	carringtonj.railtrack@ems.rail.co.uk	England
Sophie Albenque-Chaurin (Chargée de Communication. Direction de l'Infrastructure)	Tél. 31 02 64 Fax 31 02 57 / sophie.albenque@infra.sncf.fr	France