EFORWOOD
Tools for Sustainability Impact Assessment

A method of integrating SIA-results of different partial models in the context of Module 3 and first tests in the framework of the single chain

Diana Vötter

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Preface

This report is a deliverable from the EU FP6 Integrated Project EFORWOOD – Tools for Sustainability Impact Assessment of the Forestry-Wood Chain. The main objective of EFORWOOD was to develop a tool for Sustainability Impact Assessment (SIA) of Forestry-Wood Chains (FWC) at various scales of geographic area and time perspective. A FWC is determined by economic, ecological, technical, political and social factors, and consists of a number of interconnected processes, from forest regeneration to the end-of-life scenarios of wood-based products. EFORWOOD produced, as an output, a tool, which allows for analysis of sustainability impacts of existing and future FWCs.

The European Forest Institute (EFI) kindly offered the EFORWOOD project consortium to publish relevant deliverables from the project in EFI Technical Reports. The reports published here are project deliverables/results produced over time during the fifty-two months (2005–2010) project period. The reports have not always been subject to a thorough review process and many of them are in the process of, or will be reworked into journal articles, etc. for publication elsewhere. Some of them are just published as a “front-page”, the reason being that they might contain restricted information. In case you are interested in one of these reports you may contact the corresponding organisation highlighted on the cover page.

Uppsala in November 2010

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EFORWOOD

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Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	X
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Project Deliverable D3.4.3

A method of integrating SIA-results of different partial models in the context of module 3 is developed and first tests are carried out in the framework of the single chain

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Date: 16 January 2008 (first draft)

Summary/Purpose of the report:

This deliverable gives a description of M3-specific modelling routines, as well as basic background knowledge on modelling and EFORWOOD case studies, and perspectives for future work within M3 scenarios.

Table of contents:

1. Introduction

1.1 Short description of ToSIA, and its scope

The EFORWOOD project will strive to develop an overall Tool for this Sustainability Impact Assessment, called ToSIA, for the forestry-wood chain from the forest to the end-of-life of final products. This tool helps to assess the impact of the activities along the forestry-wood chain from economic, environmental and social perspectives. This will be done along the lines of exemplary material flows and processes (chains), representing 60-80% of forest resources, industrial production or consumption within the borders of a defined regional entities (f. e. case study regions, regional of national markets, EU25. This overall tool will be the most important product of EFORWOOD. It does not claim to include a detailed description of all processes involved as it works on a fairly aggregate level. It will however, be able to compare similar chains and their sustainability at a national level.

In deliverable D1.4.3 "Description of the modelling framework" (Lindner et al., 2007) it is stated that the "following question types can be addressed by ToSIA[1]:

- analysing the sustainability of a single FWC by presenting detailed indicator values and general aggregated results
- focusing analysis on a certain subset of indicator values, e.g. only the ecological values
- comparing two chains for differences in sustainability
- comparing sustainability of the same chain at two different time steps (time steps predefined to 2005, 2015, 2025)
- comparing the sustainability impacts of similar processes taking place in different geographical areas
- assessing the sustainability impacts of a policy compared to a base line (the actual policies to be assessed will be defined later).
- analysing the sustainability impacts of partial chains, or comparing two segments of chains for differences in sustainability impacts"

However, at the same time it "is not within the scope of EFORWOOD to evaluate specific plants, firms or identifiable groups of enterprises" (Lindner et al., 2007). Nor does ToSIA compare the sustainability of different machines, details in the applied harvesting or transport systems, or similar questions referring to a much lower aggregation in terms of working processes, instances or geographic areas.

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[1] not all of these question types will be addressed in the EFORWOOD project. For example, the project will not focus on comparative sustainability assessments in different geographical areas. Also, analysis of sustainability impacts of partial chains is not planned with ToSIA.

1.2 Why partial modelling at module level

ToSIA gives the overview of the sustainability of the FWC for every European country. It does so on a highly aggregated national level.

If a user, however, is interested in the comparison of different alternatives within one country in the forestry and wood transport sector – instead of an average for whole countries – he or she can get this answer from the partial modelling. It is much more precise and detailed than ToSIA (eg instead of the process "harvesting" different harvesting methods, including felling and cross-cutting to various assortments are assessed). Thus optimisation possibilities can be detected sooner and easier. At the same time dispensable interfaces, unnecessary or frail activities, become visible, which helps to test sustainability of regional particularities and variations of the European FWC.

The following figures shall give an impression about the differences in terms of aggregation possibilities between ARIS modelling and ToSIA.

Fig 2 (next page) shows aggregation level I and level III within the ARIS modelling (left hand side), in comparison to the one-level-perspective of ToSIA, which is here shown at the right hand side of Fig 2 in the Client view. Furthermore, ARIS can also go even one level deeper in detail, and show the activities at a higher resolution which makes possible optimization of processes easier (compare ARIS level IV; Fig 1). All those levels in ARIS are interlinked.

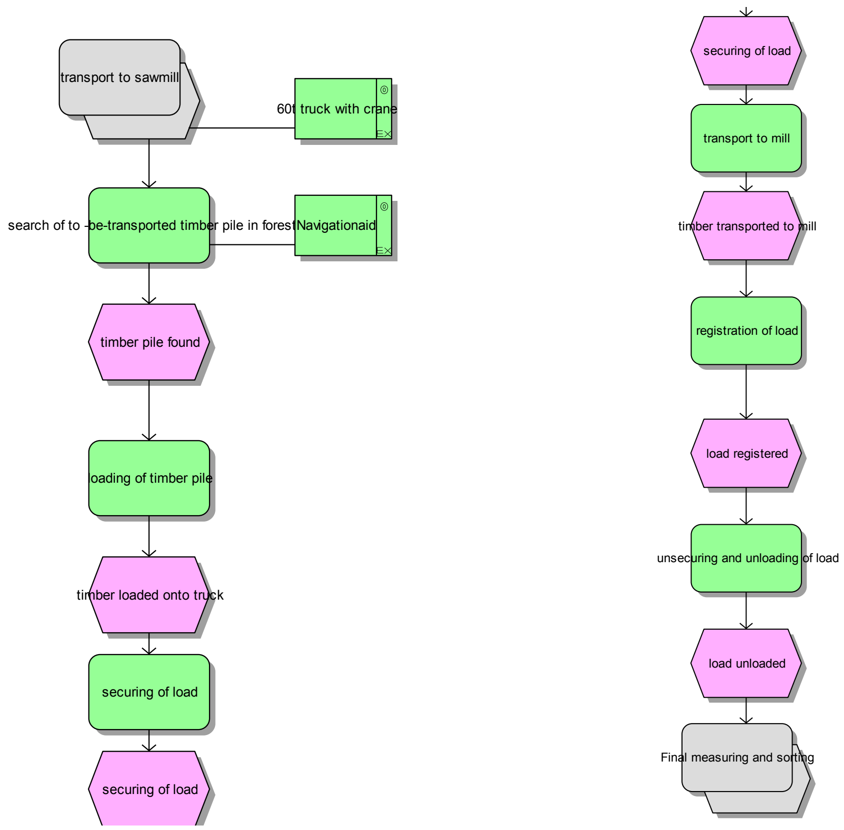


Fig 1: Level IV of ARIS modelling (here split for better readability)

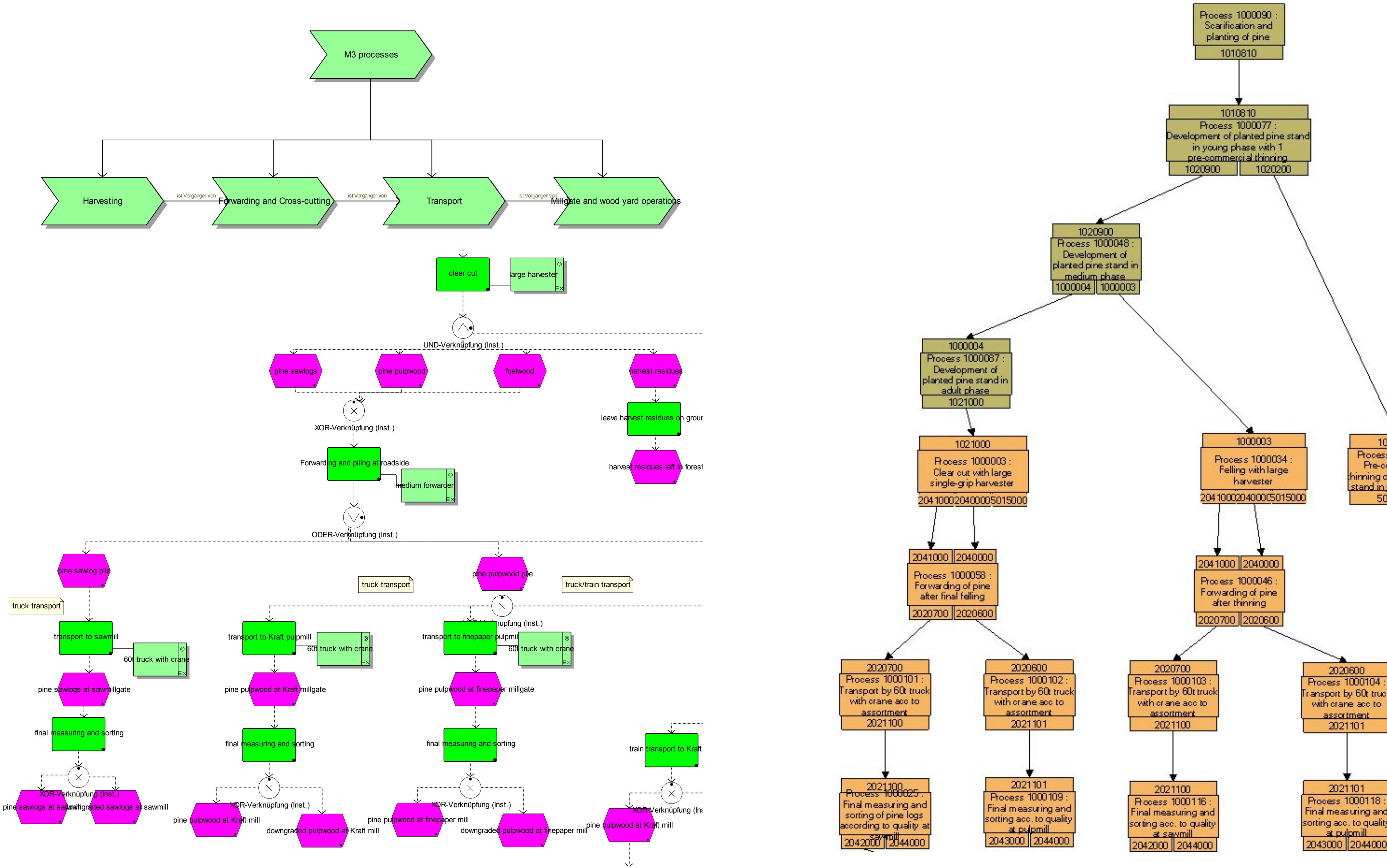


Fig 2: ARIS level I and level III (excerpt) on the left hand side, and ToSIA Client on the right hand side

1.3 Use of already existing partial models in Eforwood Module 3

Different partial models are already available at M3's partner institutes. Those are e.g. Procoul from AFOCEL (France), Forest Research (UK), Holzernte from FVA (Germany), STFI-Packforsk (Sweden), SimaPro from Skogforsk (Sweden), and many different models. The listing of all those models would exceed the scope ogf this deliverable, and is therefore being collected separately.

1.4 Model synopsis via a professional modelling tool

Firstly, today's present situation, the aim as well as the corresponding processes are determined. A suitable means of doing so is the so-called "value-added chain" model (see Fig 3), which depicts the involved main processes and bodies of the supply chain.

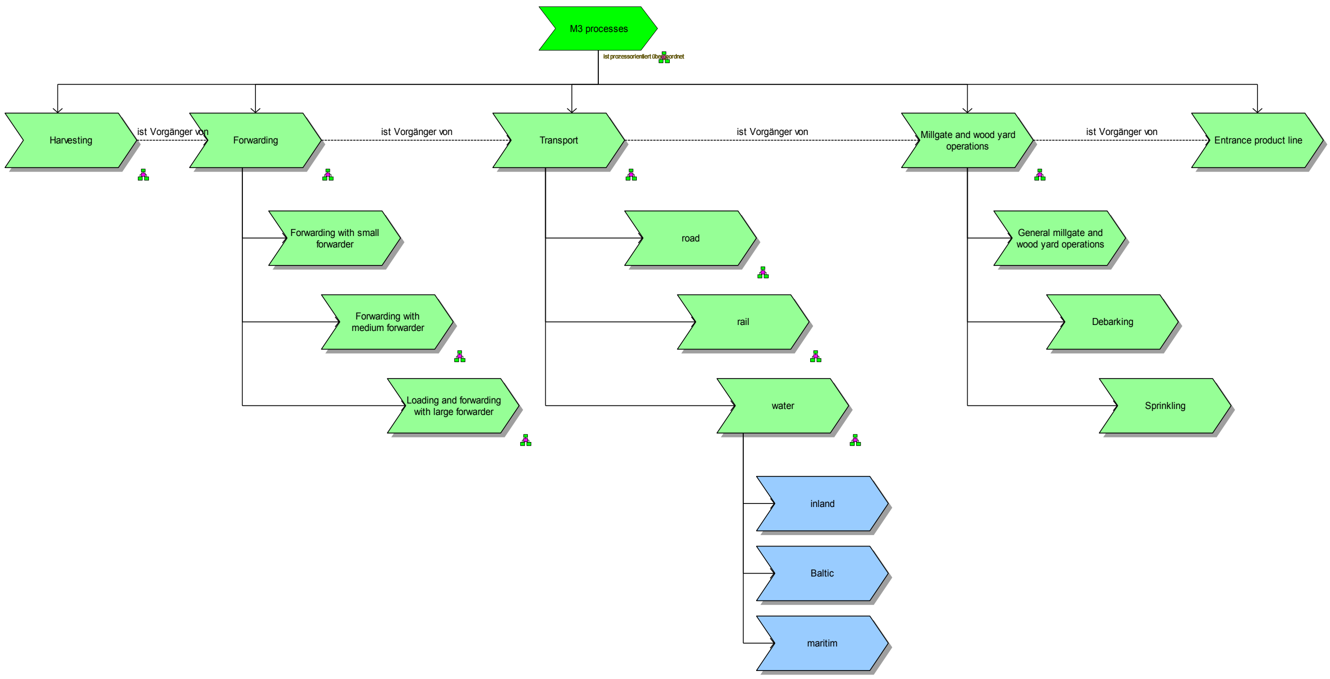


Fig 3: Value-added product chain as a means of modelling M3 processes and their relations

Secondly the individual processes are described as value-added process chains and event-driven process chains (EPCs) (see Fig 4). Loops, decision points and variants are described as they exist in reality. For a later point in time, modelling of scenarios is planned, following the same approach.

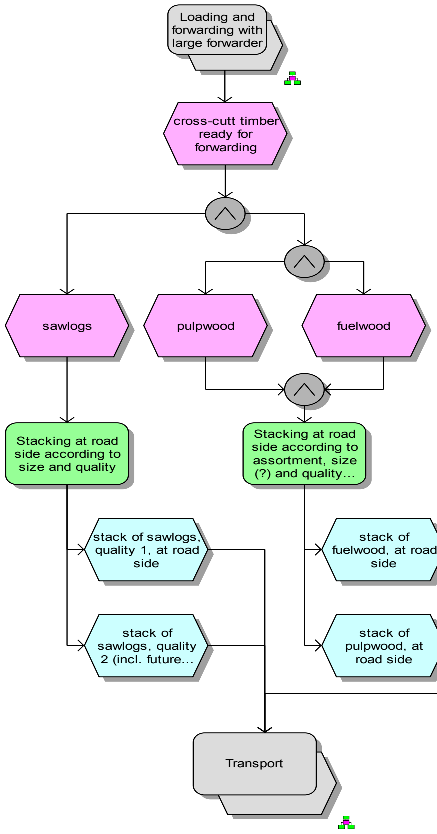


Fig 4: Event-driven process chain as a means of modelling activities within the process of forwarding

1.4.1. **Linkage of data from different sources**

Within the EPCs it is possible to link the individual activities (sometimes also called "functions") to economic, environmental and social indicators, such as production cost, energy consumption, employment, GHG, … . Values for these individual indicators are either calculated within this M3 model itself, or adapted from already existing partial models for allocation, wood quality, transport and harvesting.

In the consequence, all processes and activities are linked with numeric values (eg m^3 sub, tkm, €/m^3, …) for each indicator, which assess the process's sustainability. Those can be summed up per chain alternative, thus comparing the sustainability of different alternatives on the basis of hard quantitative values for all three levels of sustainability.

1.4.2. Comparability of alternatives

It is possible to rearrange those chains due to their modular structure with their specific data. Therefore, alternative chains can be created and also compared with each other.

2. Main part – data material?

The following chapter deals with the thematic and topographic outline on the one hand, and with the theoretical background on system analysis and modelling on the other hand. It also describes the used system approach and the modelling software ARIS Business Optimizer, as well as the specific classification and set-up for work on M3 partial modelling.

2.1. Research area

The area of research within this work is defined by its thematic components as described in subchapter 2.1.1. "Thematic" and its topographic components as described in 2.1.2. "Topographic".

2.1.1. Thematic

From a thematic point of view, the following description of partial modelling within EFORWOOD M3 applies to the field of harvest to pre-product line processes for Solid wood, Pulp and paper, as well as Bio-energy products with respect to economic, environmental and social sustainability.

2.1.1.1. Harvest to pre-product line

Whereas EFORWOOD, and thus also ToSIA, deal with the modelling of the entire forest wood chain (FWC), M3's focus is restricted to the area of Forestry to Industry Interactions (marked green in Fig 3).

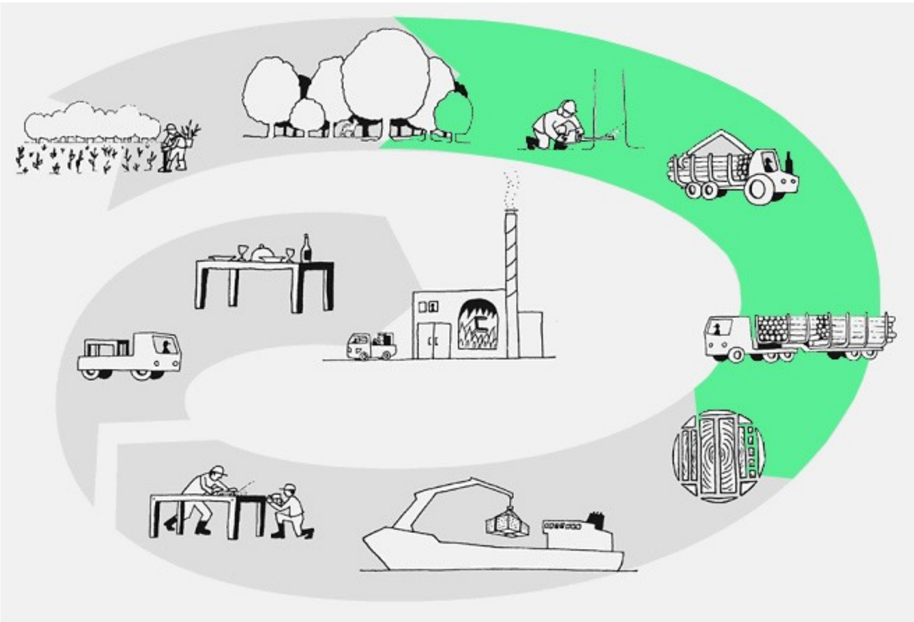


Fig 5: Forestry to Industry Interaction within the framework of the European FWC

It starts with the selected trees ready for harvesting, and includes all harvesting, cross-cutting, forwarding, stacking and transport operations from the forest to the mill. It ends with millyard operations (deloading, weighing, and sorting) and ends before the timber is processed.

2.1.1.2. Solid wood, Pulp and paper, Bio-energy

In terms of produced wood products different assortments of sawlogs for construction wood, pulpwood for pulp and paper production, as well as forest wood chips, harvest residues and others for bio-energy purposes are produced.

2.1.1.3. Economic, Environmental and Social Sustainability

Sustainability on an economic, environmental and social level is measured within EFORWOOD by means of a defined set of indicators. Those indicators have been chosen throughout an iterative process, and are still being further defined and refined. The set used within this work is the following set number 5 of General FWC indicators, as stated in the draft document PD0.0.12 "Report on Indicator Working Groups on data collection for Single FWC", dated 25th May, 2007. As a working directive the following explanation of the colour code had been stated: "Indicators in black are operative for immediate data collection for the Single FWC (due until the end of May). Red ones (Nr 4, 7, 16, 19) need further definition. Indicator 18 has been deleted. Blue ones Nr. (17, 20, 21, 28, 30, 31) have not been dealt with by the indicator groups."
Moreover, as those are indicators for the entire FWC, and not only for M3, some of them have default values or are not applicable for forestry to industry interactions. Wherever that is the case it had been stated in the third column. That third column also includes information on how the individual indicators were linked to the applied modelling system. This is further explained in subparagraph 2.2.4. The reason why it is already stated here is for quick look-up and reference purposes.

	ECONOMIC INDICATORS	Data link to model structure Applicability and default values
Name	**LI1 Gross value added and gross domestic product**	Per chain
Sub- Indicators	2 Gross value added (at factor cost) in Euro (million) per reference unit	
Name	**LI2 Production costs**	process
Sub- Indicators	2.1. Average production cost of raw materials from FWC	
	2.2. Raw materials from outside FWC	0,00 €
	2.3. Labour costs	
	2.4. Energy costs (e.g. fuel costs in case of transportation)	
	2.5. Other productive costs (maintenance, general industrial costs, administrative costs, etc)	
	2.6. Non-productive costs (corporate taxes, capital charges, VAT and any other taxes or charges) in Euro (million) per reference unit	
Name	**LI3 Trade balance**	Per chain

Sub- Indicators	3.1. Imports of wood in a) Volume, b) value, c) % of total volume consumed 3.2.Imports of products derived from wood in total FWC and by sub-sector classified by a) Volume, b) value, c) % of total volume consumed 3.3. Exports of wood in a) Volume, b) value, c) % of total volume consumed 3.4. Exports of products derived from wood in a) Volume, b) value, c) % of total volume consumed 3.1.a and 3.2.a and 3.3a and 3.4a) ktonnes, kg, m³, etc. 3.1.b and 3.2.b and 3.3b and 3.4b) Euro (million) (aggregated) 3.1.c and 3.2.c and 3.3c and 3.4c) % of total volume consumed	0 0 evtl. 0
Name **Sub- Indicators**	**LI4 Resource/ material use** 4.1.) volume of material from inside the FWC of virgin origin 4.2.) volume of material from inside the FWC of recovered origin 4.3.) volume of material from outside the FWC of virgin origin 4.4.) volume of material from outside the FWC of recovered origin In ktonnes, m³, kg, etc. (depends on the unit) per reference unit.	process 100% 0% 0% 0%
Name **Sub- Indicators**	**LI5 Enterprise structure** 5.1.1 size of enterprises: micro and small enterprise (0-49 employees), small and medium sized (50-249 employees), large enterprises (>250 employees) 5.1.2 size of forest holdings (<500 ha), (> 500 ha) 5.2 ownership categories for forest and other wooded land (public, private, other ownership)	organisation chart
Name **Sub- Indicators**	**LI 6 Investment and Research & Development** 6.1. Investment (gross fixed capital formation) total value of fixed assets (machinery and equipment, vehicles &, the value of land improvements, and buildings) 6.2. Research & Development expenditure In Euro (million) per reference unit	organisation chart
Name **Sub- Indicators**	**LI7 Innovation** 7.1.1. New goods 7.1.2. New services 7.2. New technological processes In total number per reference unit in % of turnover per reference unit.	organisation chart
Name **Sub- Indicators**	**LI8 Total production** 8.1.1. volume of marketed goods 8.1.2. value of marketed goods 8.2.1. volume of marketed services 8.2.2. value of marketed services Volume in tonnes, kg, m³, etc. Value in Euro (in million)	interface
	SOCIAL INDICATORS	
Name **Sub- Indicators**	**LI9 Employment** 9. 1. male persons employed 9.2. female persons employed Number of employees per year (in full-time equivalents)	organisation chart
Name **Sub- Indicators**	**LI10 Wages and salaries** 10.1. Wages and salaries of male employees 10.2. Wages and salaries of female employees .in €/hour	Organisation chart / process
Name **Sub- Indicators**	**LI11 Occupational safety and health** 11. 1.1. Occupational non-fatal accidents	Organisation chart / process

	11. 1.2. Occupational fatal accidents	
	In absolute numbers and in % per 1000 employees	
	11.2. Occupational diseases	
	In frequency of cases per number of persons exposed multiplied by number of years of exposure and in % per 1000 employees	
Name	**LI12 Education and training**	Organisation chart / process
Sub- Indicators	12. 1. Education time	
	In working time per person-year	
	12.2. Training expenditure	
	In Euro per person-year working time	
	ENVIRONMENTAL AND ENERGY INDICATORS	
Name	**LI13 Energy generation**	process
Sub- Indicators	13.1.1. On-site energy generation from residues from process-inputs	0 %
	13.1.2. On-site energy generation from other wood biomass	0 %
	13.1.3. On-site energy generation from non-wood based renewable energy	0 %
	13.2.1. Energy use of renewable energy	
	13.2.2. Energy use of non-renewable energy	
	13.2.3. Energy use of electricity from the grid	
	In absolute numbers in energy terms (MWh) per reference unit.	0 %
Name	**Greenhouse gas balance**	process
Sub- Indicators	14.1. Greenhouse gas	
	14.2.1. Carbon sequestration in living woody above-ground biomass	
	14.2.2. Carbon sequestration in living woody below -ground biomass	
	14.2.3. Carbon sequestration in dead	
	14.2.4. Carbon sequestration in forest soils	
	14.2.5. Carbon sequestration in harvested wood products	
	all converted in kg of CO_2-equivalents, 14.2 averaged over a period of 5 year	
Name	**LI15 Distance and load indictor**	process
Sub- Indicators	15.1. Transport distance (loaded and backhaulage for road mode)	
	In km	
	15.2. Volume of freight (loaded and backhaulage for road mode)	
	In t km	
Name	**LI16 Water use**	
Sub- Indicators	16 Water use	0 %
	In kg per reference unit, whereas 1kg = 1 dm^3 of water	
Name	**LI17 Forest resources**	?
Sub- Indicators		
Name	**LI19 Emisions to soil, water and air**	process
Sub- Indicators	19.1.1 Soil pollution with pesticides	0 %
	19.1.2 Soil pollution with oil	
	19.1.3 Soil pollution with hydrocarbons	0 %
	19.2.1 Water pollution with organic substances	0 %
	19.2.2 Water pollution with nutrients	0 %
	19.2.3 Water pollution with hazardous substances	0 %
	In gram or kilogram	
Name	**LI20 Tree species composition**	Not applicable
Sub- Indicators	**- not treated**	
Name	**LI21 Corporate responsibility**	?
Sub- Indicators		
Name	**LI22 Generation of waste**	
Sub- Indicators	22.1 Generation of waste	0 %
	22.2 Hazardous waste (part of 22.1)	0 %
	22.3 Waste to material recycling (part of 22.1)	0 %
	22.4 Waste to landfill (part of 22.1)	0 %
	In kg	
	QUALITATIVE INDICATORS	
Name	**LI23 Compliance costs**	?
Sub- Indicators	Low – medium – high	

Name	**LI24 Quality of work**	Organisation chart / process
Sub- Indicators	24.1.1. Persons employed - low skilled workers 24.1.2. Persons employed - high skilled workers 24.2.1. Persons employed - direct employment 24.2.2. Persons employed - indirect employment 24.3. Persons employed - equality of treatment In absolute number (in full-time equivalents)	
Name	**LI25 Other services to the public including the recreational use of forests (social indicator)**	?
Sub- Indicators		
Name	**LI26 Community participation and communication (social indicator)**	?
Sub- Indicators		
Name	**LI27 Consumer attitudes on forest management, forestry and forest products (social indicator)**	?
Sub- Indicators	% of certified products Or: Qualitative assessment? – Good – bad?	
	INDICATORS UNDER CONSTRUCTION/CONSIDERATION	
Number	**(29)**	
Name	**Revenue**	
Sub- Indicators	29.1. goods and services In Euro (million)	
Name	**LI30 Noise and smell**	
Sub- Indicators	**- not treated**	
Name	**LI31 Aesthetics**	
Sub- Indicators	**- not treated**	

2.1.2 Topographic

Topographic reference area of the case studies is Baden-Württemberg for Central Europe, Västerbottens län for Scandinavia, and the Iberian Peninsula for Southern Europe.

2.1.2.1 Central Europe (BW)

Baden-Württemberg (short: BW) is situated in the South-West of Germany. With a population of 10.736 Mio inhabitants (urban population: 65%, rural poulation: 35%), equalling 300 people/km², and an area of 35 751.65 km³ (approximately 3.6 mio ha) BW is the third largest of Germany's federal states. It has common borders with the German federal states Bavaria, Rhineland-Palatinate and Hesse, as well as with France in the West and Switzerland in the South; furthermore, BW is connected to Austria via Lake Constance.

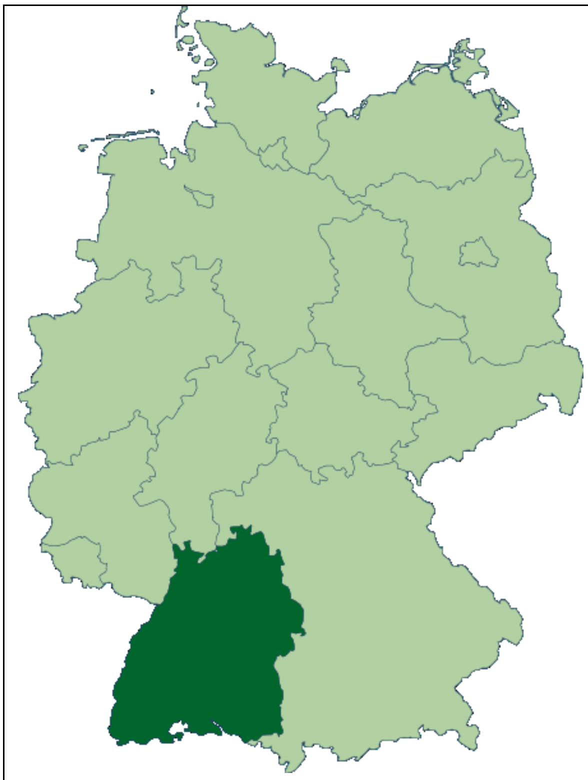


Fig 6: Germany with its 16 states and (dark green) the position of BW[2]

Average annual temperature and annual precipitation vary largely, depending on the area. On the one hand, at the lower altitudes and river valleys to the West as well as the Lake Constance region, the average temperature is 9°C with up to 200 frost-free days and thus is among the mildest regions of Germany, with a precipitation of 600-700 mm per year. On the other hand, the higher altitudes like e.g. the Black Forest are among the coldest regions of Germany with 4°C annual average temperature and ca. 120 frost-free days (the average for BW is 170 days), and an annual precipitation of more than 1000 mm (in the Southern Black Forest even over 2000 mm).

The forest cover of BW is 38.1%, equalling a forest area of 1.4 mio ha. The ownership is split between state-owned forest 24 % and one owner, the national forest service "Landesforstverwaltung BW", communal forest 39 % of the forest shared by 1073 owners as well as privately-owned forest summing up to 37 % and ca. 220.000 owners. In 2005 the annual turnover of forestry and wood based industry was 23 bio €, representing a share of 7 % in GDP of BW.

Baden-Württemberg represents the typical structure and variety of Central-European forestry-wood chains.

[2] source: DeStatis, 2006 ; downloaded : 2007-11-15

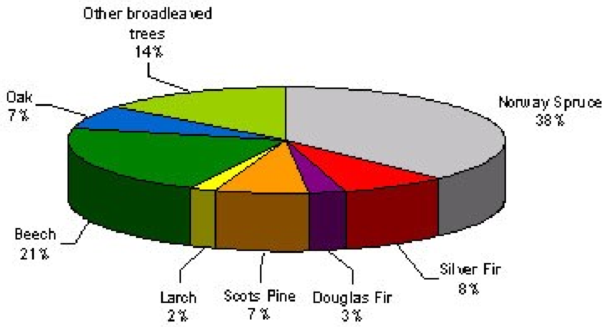


Fig 7: Tree species distribution in BW

The mean annual increment is 13.7 m3/year/ha, economically most important are Norway Spruce with 38 %, Beech with 21%, Silver Fir with 8 %, Scots Pine with 7 % and Oak with 7 %, as well as other broadleaved species with 14 %.

2.1.2.2 Northern Europe (Västerbotten/Sweden)

Of Sweden's 21 counties, Västerbotten, "Västerbotten län" in Swedish, is its next most northern county and is also the next biggest in terms of land area. Its surface area of approximately 55 000 km² takes up about an eighth of Sweden's total landmass.

The county borders both Finland and Norway and extends from the Gulf of Bothnia in the East to the Scandinavian mountain chain in the West. To the North of Västerbotten lays the county of Norrbotten, and to the South Västerbotten borders the counties of Västernorrland and Jämtland. In the cities lives the majority of Västerbotten's 250 000 inhabitants, which gives a population density of 4.6 inhabitants per km².

Fig 8: Sweden with its 21 counties[3]

Of Västerbottens län's areal 22 886 000 ha are forest land, which is approximately 42 %. Its main tree species are Scots pine (Pinus sylvestris (L.)), Norway spruce (Picea abies (L.) Karst.), Weeping birch (Betula pendula Roth.), and Lodgepole pine (Pinus contorta Dougl. ex Loud.), covering more than 70 % of the basal area.

The reference year for the Scandinavian case study is not 2005 as agreed for EFORWOOD modelling of status quo, but the mean values for the years 2001-2005 instead. All figures refer to the forest area in Västerbotten, i.e. the area that is suitable for forest production and where the annual production is higher than 1 m3/ha, year. As already stated, all figures represent the situation within the period 2001-2005. The year 2005 has not been chosen because it was an exceptional year regarding cutting also in Northern Sweden, not just following the storm Gudrun (storm event in Januar 2005 mainly in Southern Sweden felling approximately 70 mio cubicmeter of forest (Bromann et al. 2006)) in Southern Sweden. That year 33% more wood were cut.

The total forested area of Västerbotten comprise 1 861 000 ha (inland), and 1 318 000 ha (coastal), equalling a total of 3 179 000 ha (in these areas forest area without trees are included). The proportion of Scots pine, Norway spruce and Birch dominated forests is approximately 70% of the total area.

As described by Valinger et al (2007) the Scandinavian case study is a production-defined case study and based on the whole County of Västerbotten. That means that single chains should

[3] source: Statistika centralbyrån Sverige, Stockholm, downloaded: 2007-11-15

cover 60-80% of wood harvested in the region. Besides the three main species pine, spruce and beech, also all other species produced in that region should be included in the case study.

For the eight chains (pine, spruce, mixed and birch with variations for even-aged and uneven-aged stands) the following forest operations were defined:

2.1.2.3 Southern Europe (Iberian Pen-Insula)

The Iberian Peninsula, or Iberia, is located in the extreme southwest of Europe, and includes modern day Spain, Portugal, Andorra and Gibraltar. It is the western- and southernmost of the three Southern European peninsulas (the Iberian, Italian, and Balkan peninsulas). It is bordered on the South and East by the Mediterranean Sea, and on the North and West by the Atlantic Ocean. The Pyrenees form the North-East edge of the peninsula, connecting it to the rest of Europe. In the South, it approaches the Northern coast of Africa. It is the second largest peninsula in Europe, with an area of 582 860 km².

Further info is to be provided by task force of Iberian consumption case.

2.2 Process Modelling

Process modelling in this paper follows the concept of systems theory. A short introduction into the topic as well as the developed structure is explained in the following subchapter.

2.2.1 Systems analyses and process modelling

A popular saying claims that it is better to never touch a running system[4] – so why do systems analyses and what gain does it yield? In short, the advantage of systems analyses and the consequent modelling of its processes, can be found in its ability to give an overview over

- Processes and activities
- Involved resources (f. e. machine and manpower time)
- Interruption time
- Weak spot analysis
- Redundancies
- Dead-ends
- Information handling
- Breaks within the system
- Test compatibility of new systems prior to introduction
- Links data values to activities, etc => e.g. sustainability assessment

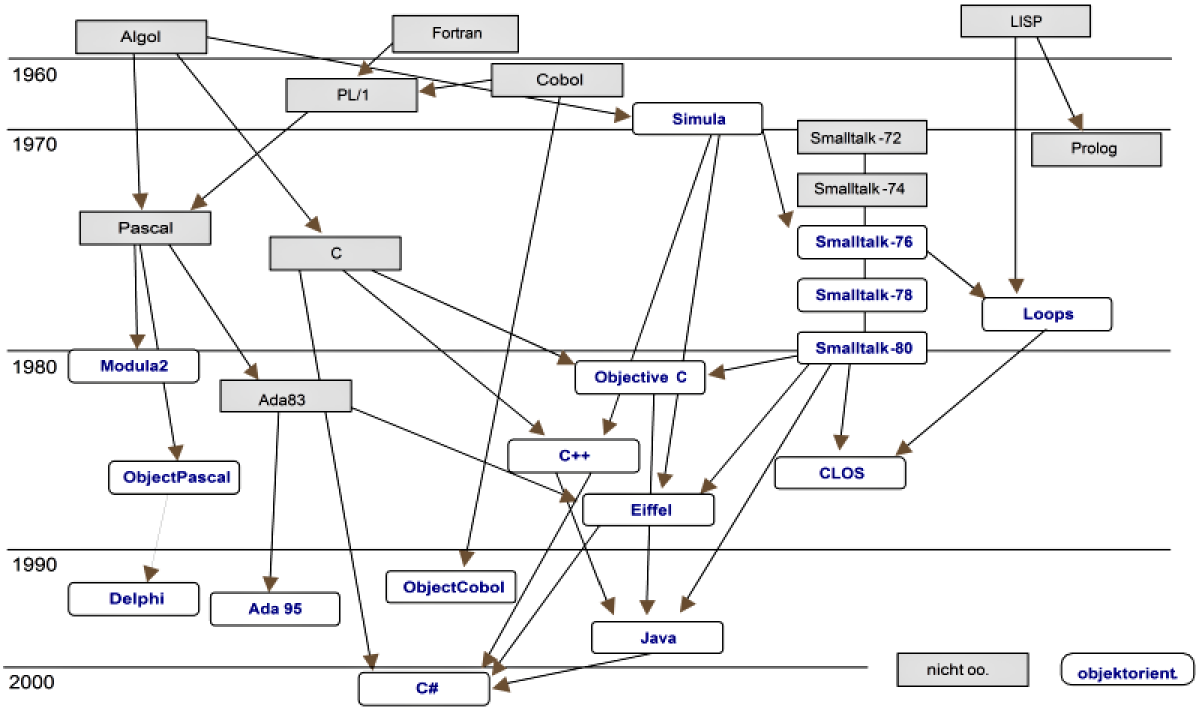
Process modelling is a more detailed description of the system involved. Possible methods and approaches are explained in the following.

2.2.2 Modelling Approaches and Languages (OOP)

For modelling two different concepts exist: object-oriented modelling, short OOP, and procedural modelling. For this work the approach of object-oriented modelling was chosen for its higher flexibility and re-usability, which is one of its main characteristics. Main idea of this concept is to group objects into classes and to closely link data and functions to objects, i.e. to "encapsulate" them. In short, OOP is a programming paradigm that uses "objects" and their interactions to design applications and computer programs. It is based on several techniques,

[4] WIKIPEDIA: "System (from Latin 'systēma', in turn from Greek 'σύστημα') is a set of interacting or interdependent entities, real or abstract, forming an integrated whole. There are natural and man-made (designed) systems. Man-made systems normally have a certain purpose, objectives. They are "designed to work as a coherent entity". Natural systems may not have an apparent objective.
A system is a fundamental concept of systems theory, a way of thinking about the world, a model. We determine a system by choosing the relevant interactions we want to consider, plus choosing the system boundary —– or, equivalently, providing membership criteria to determine which entities are part of the system, and which entities are outside of the system and are therefore part of the environment of the system.
An open system usually interacts with some entities in their environment. A closed system is isolated from its environment. A subsystem is a set of elements, which is a system itself, and a part of a larger system. "

including inheritance, modularity, polymorphism, and encapsulation. It was not commonly used in mainstream software application development until the early 1990s, even though first programming languages were developed according to this concept as early as in 1960ies, as the following figure illustrates.



Historical development of OOP[5]

Nowadays, many modern programming languages support OOP, and its concepts can also be found in more user-friendly applications like Microsoft Visio, UML (unified modelling language), and ARIS.

2.2.2.1 Microsoft Visio

First draft processes for the modelling of the Forestry Wood Chain (FWC) have been made with Microsoft Visio, as it is a ready available software. However, soon its boundaries were reached due to its tendency to become increasingly convoluted. Further, it is just a means of depiction of simple relations, not of actually linking data values and arithmetic functions to the objects in question. Therefore, further work with Microsoft Visio was discarded for this project.

2.2.2.2 UML

Unified Modelling Language (UML) is a notation for analysing and developing software system. It is also applicable for analysing and developing any other system.

[5] source: http://de.wikipedia.org/wiki/Bild:Historie.png, downloaded : 2007-11-16

According to Rupp et al. (2005) serves the UML as a means of modelling, documentation, specification and visualisation of complex software systems, independent from any field of application. It provides notation elements for static and dynamic analysis, design and architecture models, and – in particular – supports object-oriented procedures.

Means of UML notation are 13 diagram types. Six of them are structure diagrams, which are suitable for the modelling of static systems: class diagram, package diagram, object diagram, composition structure diagram, component diagram and distribution diagram. The remaining seven diagrams are performance diagrams (use-case- diagram, activity diagram, finite automaton), of which four are interaction diagrams: sequence diagram, communication diagram, timing diagram, and interaction overview diagram.

structure diagrams	**performance diagrams**	
		interaction diagrams
class diagram	use-case- diagram	sequence diagram
package diagram	activity diagram	communication diagram
object diagram	finite automaton	timing diagram
composition structure diagram		interaction overview diagram
component diagram		
distribution diagram		

Tab 1: Overview over the 13 diagram types of UML

For working with UML it is not necessary to use all types of diagrams, but to use the best suitable for the problem in question, which may result in different models depending on the level of aggregation and dynamic or static state of a system.

2.2.3 Databases and their practical application (in ARIS)

Modelling is only one side of the coin, as all information gathered also has to be stored somewhere, and should then also be easily retrievable. When it comes to large amounts of data, these data is usually stored in databases. "A DATABASE is a collection of information organized in such a way that a computer program can quickly select desired pieces of data."[6] And those databases can be organized in different models, the two most common groups are hierarchical data bases and relational databases.

2.2.3.1 Hierarchical Databases vs Relational Databases

Those two different types of databases shall be explained in the following:

Hierarchical databases represent the older type of database. Hereby data stored is organised as a long list with a binary tree-like structure, implying a single upward link in each record to describe

[6] http://www.library.uq.edu.au/training/skills/what_dbase.html; downloaded: 2008-01-11

the nesting, and a sort field to keep the records in a particular order in each same-level list. This means that for a query all information available which is linked to the searched item appears. In contrast however, linked data only have a one-way reference, which leads to update-/ insert-/and delete-anomalies. This means that when an item is altered, the connected data is not, which leads to unconnected or wrongly connected, und thus useless, data fragments. All this makes the maintenance of this type of databases inconvenient to impossible.

Relational databases are based in their design on the theory of sets. Thus they are built up from "relations", "attributes", and "domains". "A relation is a table with columns and rows. The named columns of the relation are called attributes, and the domain is the set of values the attributes are allowed to take."[7] This structure allows the relation of an entity (a singular item, e.g. harvester) between different tables and its connected attributes by means of a primary key, a unique identification number of the table. By this, information can be handled more easily and specifically. Du to its clearly defined relations, updating, inserting and deleting can be done without redundancy and without leaving scrap-fragments of data. Furthermore, it also creates modular structure which is handy to impose on object-oriented modelling.

2.2.3.2 Short Introduction into ARIS

In short, ARIS combines object-oriented modelling with a relational database. The database is created while the processes are designed and filled with data. These may be environmental indicator data (greenhouse gas emission, energy consumption, etc) or economic indicator data (production cost, productivity, time duration. etc) or other sort of data (product-IDs; organisational data, etc).

ARIS, short for "Architecture of Integrated Information Systems" – and also the Latin version of the name of the Greek God of War – is a method for analyzing processes and taking a holistic view of process design, management, workflow, and application processes. It integrates "various modeling methods and frameworks, such as, EPC, UML, BPEL, BPMN, ITIL, TOGAF, DoDAF, TEAF/FEAF, ArchiMate, and Zachman, [and] supports the deployment of ARIS in many different business areas"8. This is done by enterprise modelling9, featuring the four different aspects of applications:

- The ARIS concept is the architecture for describing business processes.

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[7] http://en.wikipedia.org/wiki/Database#_note-0; "Relational model"downloaded: 2008-01-11
[8] www.aris.com/en/ARIS_Software_Software/3730.html; downloaded: 2007-11-19
[9]http://en.wikipedia.org/wiki/Enterprise_Modeling:
"**Enterprise modelling** is the process of improving the enterprise performance through the creation of enterprise models. This includes the modelling of both business processes and IT."; downloaded: 2007-11-19

- The ARIS concept provides modelling methods. Its meta-structures are comprised in information models10.
- The ARIS concept is the foundation for the various ARIS platforms' software systems (e.g. ARIS Architect or ARIS Business Optimizer) for the support of modelling.
- The ARIS "House of Business Engineering" represents a concept for comprehensive computer-aided Business Process Management.

For short background information, (Business Process) Modelling presents the current and future processes of an enterprise, so that the current process may be analysed and improved.

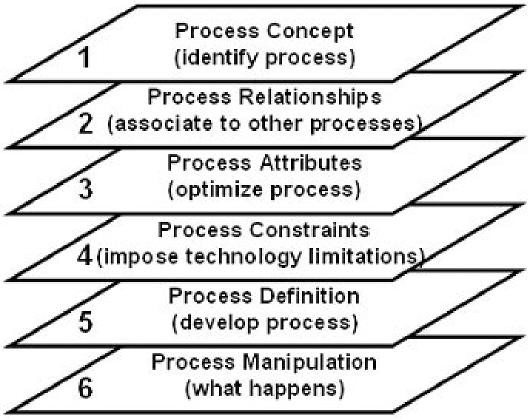


Fig 9: Stages of (Business Process) Modelling - Zachman Framework Perspectives of Process Focus[11]

Its approach is accurately described in Zachman's Framework perspective of process focus, which illustrates the individual successive steps of business process modelling. First, the process concept is identified. This describes the topic which should be examined more closely and presets its boundaries. Secondly, the process relationships are described, i.e. in which dependencies and relations, or associations the individual processes are related with each other, or are not. Thirdly, after the definition of the status quo, possible optimizations of those processes can be considered. This is influenced largely by the process attributes. Fourthly, Process constraints are taken into consideration. This includes technological limitations. Fifthly, In the (new) process definition, the processes are developed under consideration of technical restraints and optimised

[10] http://en.wikipedia.org/wiki/Information_models :
"**Information model**: An information model is, within the field of data modeling, an abstract but formal representation of entities including their properties, relationships and the operations that can be performed on them. The entities being modeled may be real-world, such as devices on a network, or they may themselves be abstract, such as the entities used in a billing system. Typically, though, they are used to model a constrained domain that can be completely described by a closed set of entities, properties, relationships and operations.
The main driving force behind the definition of an information model is to provide formalism to the description of a problem domain without constraining how that description is mapped to an actual implementation in software. There may be many mappings of the information model. Such mappings are called Data Models irrespective of whether they are Object Models (e.g. using UML), Entity Relationship Models or XML schemas."; downloaded: 2007-11-19

[11] source: Grant Czerepak, 2007-08-07, http://en.wikipedia.org/wiki/Image:Zfprocess.jpg, downloaded : 2007-08-16

procedures. Sixths and last, the so-called process manipulation takes place. This is the testing of possible alternatives and scenarios of what-happens-if.

More specified, and also slightly more complex, is this issue described in Zachman's enterprise modelling framework[12].

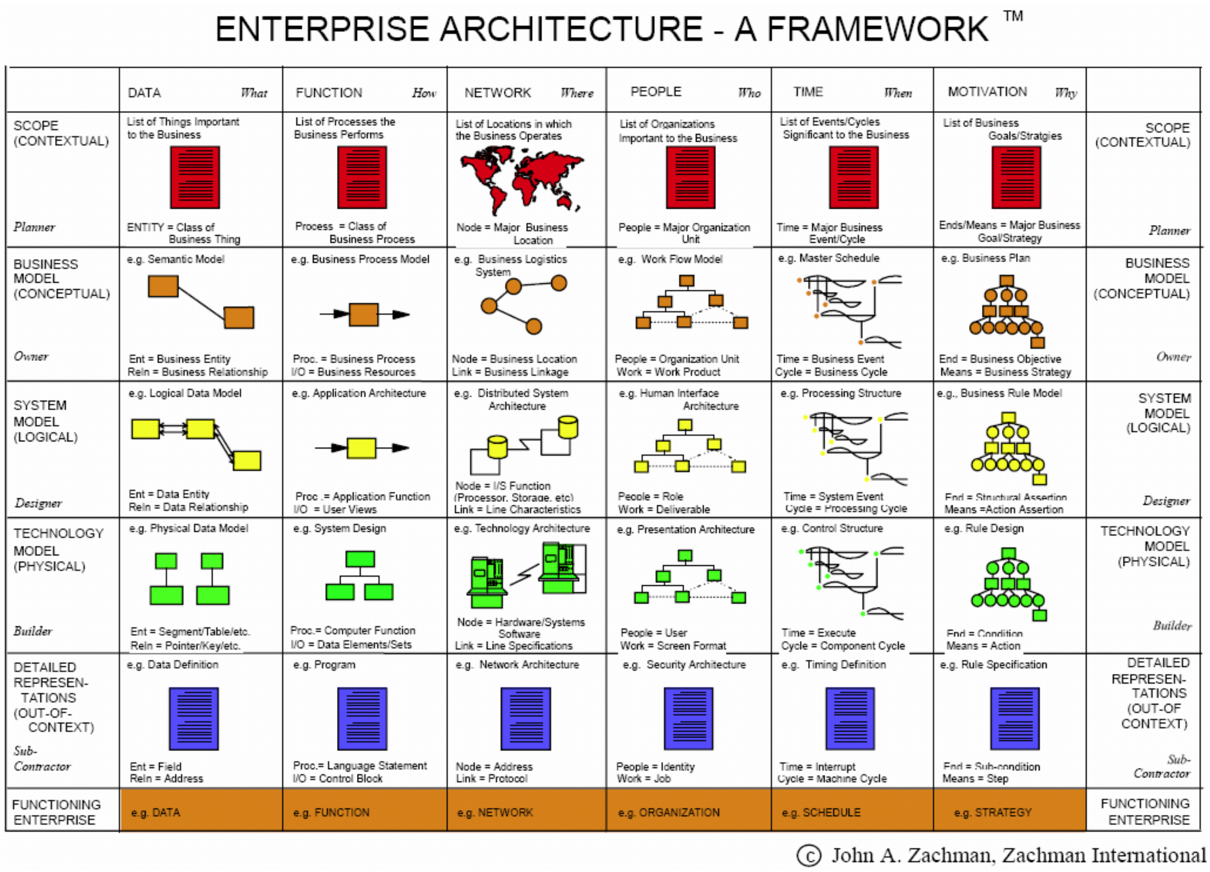


Fig 10: Zachman's enterprise modelling framework

It describes the same steps as the framework perspectives of process focus, but adds another dimension which is hidden in the preceding model. It uses a two dimensional classification model based around the six basic communication interrogatives (what, how, where, who, when, and why), intersecting six distinct model types which relate to stakeholder groups (visionary, owner, designer, builder, implementer, and worker) in order to give an holistic view of the modelled enterprise(, or industry section) and its processes.

All those concepts are integrated in the ARIS business modelling approach, and can be found in the various sections of the ARIS process architecture as well as in the concept of the ARIS "House of Business Engineering".

[12] source: http://zachmaninternational.com/2/ZachmanFramework.asp; Copyright ® 2002-2007 John A. Zachman; downloaded : 2007-08-19

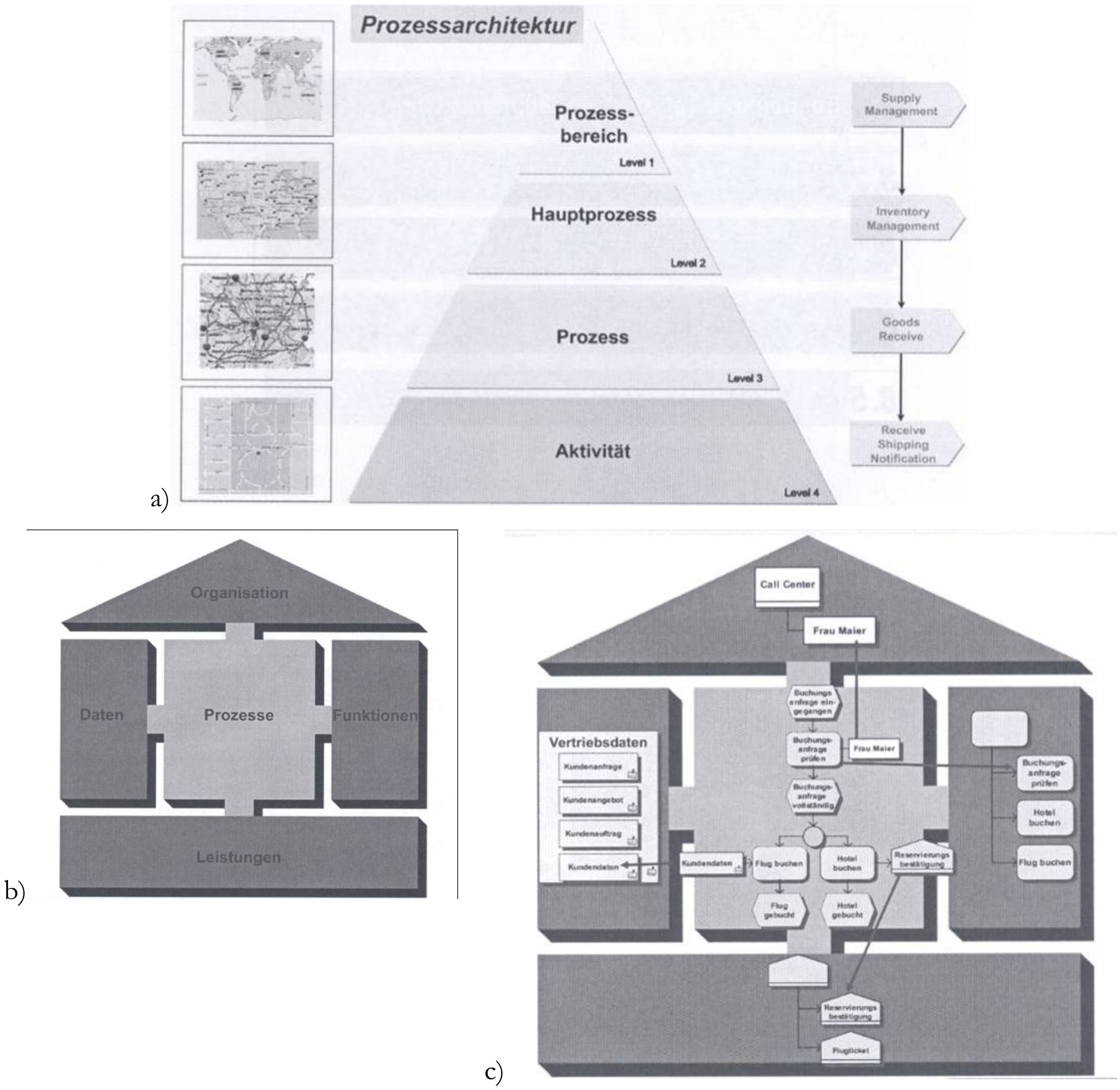


Fig 11: **a)** ARIS process architecture **b)** concept of ARIS "House of Business Engineering" **c)** detailed examples for ARIS "House of Business Engineering"

The ARIS process architecture follows a top-down approach, splitting the complex processes of e.g. a supply chain (in our case: the M3 part of the FWCs of the individual case studies), down into its main processes, subordinate processes and finally into its individual activities.

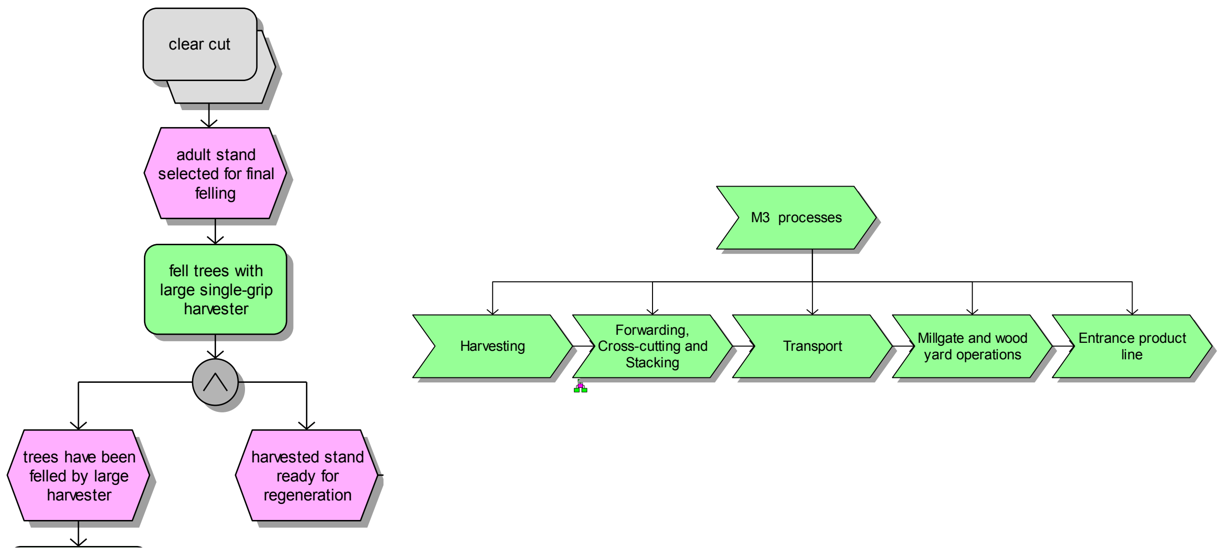
The ARIS "House of Business Engineering" is oriented at this approach, combining business and enterprise modelling, by not only reflecting the processes at their different levels, but by also liking it with connected organisations, carried out functions and services and, most important, with the connected data.

2.2.4 Definition of Processes, Products and Edges

The toolset of modelling (business) processes consists primarily out of processes, activities, products, edges, interfaces and loops. Attached to those are attributes, which are grouped into attribute group types for classification and better handling purposes. All those terms are explained in the following sub-paragraph:

Process:

Process, from Latin "processus" – movement, is a sequence of operations or events, possibly taking up time, space, expertise or other resources, in order to produce an outcome. Each process has a starting point as well as an end point; it contains classes with e.g. objects, attributes and methods. Processes are modelled in a formal structure, so that they can be computerized. At this point it is important to mention that processes can be described at different levels of resolution, which results in a process, possibly consisting out of several other processes, which again can be split into more detailed sub-processes. In practice this means that M3's processes are defined as harvesting, forwarding, transport, and millgate operations. E.g. Harvesting consists of processes of motormanual harvesting and fully mechanised harvesting, which again can be described more detailed as selecting and approaching a tree – clearing off hindering brushes – felling it – de-branching and delimbing – measuring – cross-cutting according to assortment – loop: start process chain again with next tree. Further, each process (as it is also true for products and activities) has its own unique identification by name and identification number (ID). The IDs of ToSIA's processes are the same as for the equivalents within M3 ARIS modelling. As there are, however, more processes modelled in ARIS than there are in ToSIA, there are also more process IDs in the former. That means that each ToSIA process has an ARIS counterpart with the same ID, but not every ARIS process ID (usually at even-driven process chain level) can be found in ToSIA.



a. Process chain as a EPC model (=event-driven process chain)

b. Process chain as a VAC model (=value added chain)

Fig 12: Different depictions of processes, alias process chains

Activity

The smallest unit of a process is an activity and thus also sometimes described as an "atomic process". When working within a process chain of a process chain model, the terms activity and process are often used simultaneously.

Processes, as they are named also in the ToSIA nomenclature, are named "function" in the ARIS modelling environment and symbolised by a green rectangle with rounded edges.

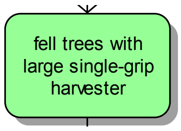
e.g.: 

Fig 13: ARIS symbol for a function, alias an activity, alias a process

Product

A Product, or "object" in object-oriented programming (OOP) modelling language, "event" as named within ARIS, is the output of each process or activity, describing a point in time linking the result of an activity/process to the new status as a result. In ToSIA, a product is formed when there is a change in place or properties; in general, however, also a decision or planning, i.e. immaterial products, are products.

In ARIS it is symbolised by a pink hexagon.

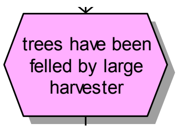
e.g.: 

Fig 14: ARIS symbol for an event, alias an object, alias a product

Interface

An interface is a linkage between models, processes or process chains. In ToSIA there is no counterpart of that, as everything is linked directly without any choice of levels of aggregation or increased detail. In ARIS it is symbolised by a grey rectangle with rounded edges over a grey hexagon.

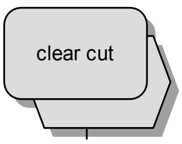
e.g.: 

Fig 15: ARIS symbol for an interface. There is no counterpart in ToSIA.

Resource ("Betriebsmittel")

The model item "resource" (in German: "Betriebsmittel") is also an ARIS-specific feature. Meant to give a better overview over employed resources, it also provides the possibility to be further described by a specific set of indicators or parameters. This is very valuable fo the M3 modelling point of view, as specific tree characteristics or log characteristics can be calculated and gathered here, and used for allocation purposes.

In ARIS it is symbolised by a blue rectangle.

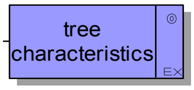


Fig 16: ARIS symbol for a resource. There is no counterpart in ToSIA.

Edge

The direct linking device between processes, products, interfaces, resources, etc. are edges. They also link decision points, e.g. between process and several products, alternative process chains, e.g. transport by 40t truck in one case and transport by 60t truck in an other case. At the same time an edge can also be a loop, repeating an activity a fixed number of times or until 100% have been reached. Each edge can be linked with a value. The default value is 1, alias 100%. It is, however, possible to set fixed product shares (e.g. 60% pulpwood and 40% sawlogs), and that can be done by assigning a specific value to certain edges.

Attributes and attribute groups

A convenient way of handling indicator and parameter, which are essential for indicator calculation, is to define them as attributes and link them to the respective model structure. Those attributes can be classified and organised as attribute groups. ARIS offers the possibility to create individual attributes. This is done in the Administration of ARIS Business Architect in Configuration -> Conventions. There are already numerous so-called "free attribute types" (and also "attribute type groups") available, which are, for instance text (for further descriptions), integer or float (for calculation of figures), Boolean (yes/no, true/false) values. Depending on the desired indicator or parameter and their treatment, the corresponding attribute type has to be chosen, renamed and classified. After that preparation the respective attributes and attribute groups can be linked in the ARIS designer to the model and its objects, where they are individually filled with data.

2.2.5 Data and Model Structure

In order to link the graphical models with the respective indicators, the following classification and organisation is being used:

Colour	ToSIA	ARIS	Attribute group	Attribute

Green	Process	Function	Identifier	Process-ID
			Indicators – economic and environmental	LI2.1 Average production cost of raw materials from FWC LI2.3 Labour costs LI2.4 Energy costs LI2.5 Other productive costs LI2.6 Non-productive costs LI13.2.1. Energy use of renewable energy LI13.2.2. Energy use of non-renewable energy LI14.1. Greenhouse gas LI 14.2.1. Carbon sequestration in living woody above-ground biomass LI 14.2.2. Carbon sequestration in living woody below -ground biomass LI 14.2.3. Carbon sequestration in dead LI 14.2.4. Carbon sequestration in forest soils LI 14.2.5. Carbon sequestration in harvested wood products LI15.1. Transport distance (loaded and backhaulage for road mode) LI 15.2. Volume of freight (loaded and backhaulage for road mode) LI 19.1.2 Soil pollution with oil
			Link with organisation chart: Social indicators	LI 10.1. Wages and salaries of male employees LI 10.2. Wages and salaries of female employees LI 11. 1.1. Occupational non-fatal accidents LI 11. 1.2. Occupational fatal accidents LI 11.2. Occupational diseases LI 12. 1. Education time LI 12.2. Training expenditure LI 24.1.1. Persons employed - low skilled workers LI 24.1.2. Persons employed - high skilled workers LI 24.2.1. Persons employed - direct employment LI 24.2.2. Persons employed - indirect employment LI 24.3. Persons employed - equality of treatment
Pink	Product	Event	Identifier	Product-ID

			Reference units	Mean stem volume [m^3 fub] Mean stem volume [m^3 sub]
			Conversion factors	Factor [m^3 fub] to [m^3 sub] Tons of carbon [tC/m^3 sub]
Yellow	-	Organisation unit type	Machine classification	Size [small, medium, large] Weight total [t] Processing speed [m/min]
Grey	-	interface	Total production	LI8.1.1 Total production – goods' volume [t, kg, m3, etc /m^3 sub] LI8.1.2 Total production – goods' value [€ /m^3 sub] LI8.2.1 Total production – services' volume [t, kg, m3, etc /m^3 sub] LI8.2b Total production – services ' value [€ /m^3 sub]
			Stand classification	Area District Stand ID Ownership Treatment regime Stand size [ha] Tree species Mean stem volume [m^3 fub] Number of stems pre-treatment [stems/ha] Number of stems post-treatment [stems/ha] Cutting volume [m^3 fub/ha] Undergrowth [stems/ha] Number of assortments Terrain factor surface [class] Terrain factor slope [class] Terrain transport distance [km] Road network [km/ha] Distance to industry
Blue	-	Resources ("Betriebsmittel")	Tree characteristics	Tree species Latitude Altitude DBH [cm] Height [m] Height of live crown [m] Age at BH Decay [%] Crookedness [%] Other damages [%]
Orange	-	organisation chart	Indicators – social and environmental	LI5.1.1 size of enterprises [micro - small - medium sized – large] LI 5.1.2 size of forest holdings [<

or > 500 ha]
LI 5.2 ownership categories for forest and other wooded land [public, private, other]
LI 6.1. Investment [€/m3 sub]
LI 6.2. Research & Development expenditure [€/m3 sub]
LI 7.1.1. Innovation - New goods
LI 7.1.2. Innovation - New services
LI 7.2. New technological processes
LI9. 1. male persons employed [FTE/m3sub]
LI 9.2. female persons employed [FTE/m3 sub]
LI 10.1. Wages and salaries of male employees
LI 10.2. Wages and salaries of female employees
LI 11. 1.1. Occupational non-fatal accidents
LI 11. 1.2. Occupational fatal accidents
LI 11.2. Occupational diseases
LI 12. 1. Education time
LI 12.2. Training expenditure
LI 24.1.1. Persons employed - low skilled workers
LI 24.1.2. Persons employed - high skilled workers
LI 24.2.1. Persons employed - direct employment
LI 24.2.2. Persons employed - indirect employment
LI 24.3. Persons employed - equality of treatment

As further parameter the (slightly adapted) Swedish classification system for slope (lutningsklass) and surface structure (ytstrukturklass) were used, as they are described in Forskningsstiftelsen Skogsarbeten, 1992.

Slope is described in a 5-class system with

Class	Percent [%]	Inclination degree [°]
1	0 - 10	0 -6
2	11 - 20	7 – 11
3	21 - 33	12 – 18
4	34 - 50	19 – 27
5	> 50	> 27

Tab 2: Swedish classification system for slope (lutningsklass)

Surface structure is also described in a 5-class system and had been slightly adapted for these purposes, featuring

Class	Surface structure class
1	Very even ground class
2	Even intermediate class
3	Somewhat uneven ground surface
4	Uneven intermediate class
5	Very uneven ground surface

Tab 3: Swedish classification system surface structure (ytstrukturklass)

3. Perspective/further work

3.1. Case studies

The module-specific modelling will be particularly used in the modelling of the case studies. They are an interesting field for its application due to the fact the 60-80% of a region, a country's production or consumption are represented, depending on the definition of the case study. The following three case studies will be treated in Eforwod:

- a production defined case study in Västerbotten, Sweden
- a regional defined case study in Baden-Württemberg, Germany
- a consumption-driven case study of the Iberian peninsula

3.1.1. Status quo

The present status quo of the case studies is described in the following documents:

- for the Scandinavian case study:
- for the Baden-Württemberg case study:
- For the Iberian case study:

Those documents are updated twice a year after each EFORWOOD week. To put those documents into a nutshell, the following gives a minute summary of the respective case study at present date, with special emphasis for M3:

Scandinavia:

"PD2.0.3 Report describing the Forest-based Case Study 'Scandinavian regional case'"

Baden-Württemberg:

PD3.0.3 "Task Force - Case study 'Baden-Württemberg'"

Iberia:

not yet available

3.1.2. Future scenarios

Future scenarios within the framework of EFORWOOD follow two guidelines: The first is the general reference futures A1 and B2 which set the overall frame work for two extremes of possible developments and which are binding for all modules. The second guideline is the general scenario type:

a) Bio-energy policies,
b) strict environmental regulation (due to climate change),
c) Consumption scenario and
d) Technology changes.

Those types are referred to A1 and B2.

Each module defines for this framework conditions first general trends they foresee for their developments towards 2015 and 2025. For M3 they would be the following:

In A1:

Bio-energy policies cause an increase of bio-energy use of 20 %, 20 % of bio fuel used in transport as well as 60t trucks.

Strict environmental regulations due to climate change lead to a 20 %-increased use of harvest residues, but no increase in reserved forests. Wages stay at the same level as in 2005, but there might be a shift in the percentage distribution of modes used for wood transport, namely 75 % road, 10 % rail and 15 % ship transport.

Consumption scenarios yield a 10 %-decrease in solid wood, and an increase in boards of 15 %, in paper of 10 % and wood use in general of 5 %. Wages for forest workers increase, do does their mobility. Distribution of transport modes is 75 % road, 10 % rail and 15 % ship transport.

Technological changes yield for forest machines engines with 20 % lower energy use per m³ than today, and for transport trucks with a 10 % higher energy efficiency per tkm than nowadays in 2005.

In B2:

Bio-energy policies are considered much more important, resulting in an increase of bio-energy use of 50 %, and 40 % of bio fuel is used in transport, but only 44t trucks.

Strict environmental regulations due to climate change lead to a 50 %-increased use of harvest residues, and 50 % more of reserved forests. Wages compared to 2005 experience an increase. The shift in the percentage distribution of modes for wood transport is considerable, namely 60 % road, 20 % rail and 20 % ship transport.

Consumption scenarios yield an increase of 25 % in board consumption; solid wood and paper stay the same. In general, wood use is extensified and rises 20 %. Wages for forest workers increase sky-rockingly, while wages in general also increase. Distribution of transport modes is 60 % road, 20 % rail and 20 % ship transport.

Technological changes yield for forest machines engines with 40 % lower energy use per m³ than today, and for transport trucks with a 20 % higher energy efficiency per tkm than nowadays in 2005.

	General	
	A1	**B2**
Bio energy policies	Har res-> energy 20% 20% bio fuel 60t trucks	Har res-> energy 50% 40% bio fuel 44t trucks
Strict	Har res-> energy 20%	Har res-> energy 50%

environmental regulation (climate change)	No increase in reserved forests 0% Road: 75% Rail:10% Ship: 15% Wages: 0	Reserved forests +50% Road: 60% Rail:20% Ship: 20% Wages: +
Consumption	Solid: -10% Boards: +15% Paper :+10% Wood use +5% Wages (forest) + (higher mobility) Road: 75% Rail:10% Ship: 15% Wages: 0	Solid: 0% Boards: +25% Paper :0% Wood use +20% Wages (forest) +++ Road: 60% Rail:20% Ship: 20% Wages: +
Technology changes	Engines -20% energy use/m3 Engines -10% energy use/tkm	Engines -40% energy use/m3 Engines -20% energy use/tkm

Tab 4: General M3 scenarios and their consequences

More specifically this means for A1 a 30 % information on the resource from the standing tree (via remote sensing) to the millgate (laser scanning of logs), as well as use of plantations where fibre and wood volume are produced at low cost. Sorting is organized centrally. Harvesting and forwarding is experiencing high-tech automatisation to an extent of a 30 % increase compared to 2005, including terrain driving, hybrid engines, 40 % of digital FWC via harvester-forvarder-transponder-interaction. Machine weight will decrease and only 10 % of the FWCs in practice remain "free-tech" (e.g. motormanual systems and similar). Further, better info will also be available at transport level including a better integration of back-haulage, as well as of containerisation including optimised backhaul also here.

For B2 information of the resource is much more important. Ca 70 % of the resource is known from the standing tree (via remote sensing) to the millgate (laser scanning of logs). Plantations where fibre and wood volume are produced at low cost are important; sorting is organized centrally. Harvesting and forwarding is experiencing high-tech automatisation to an extent of a 20 % increase compared to 2005, including terrain driving, hybrid engines, 80 % of digital FWC via harvester-forvarder-transponder-interaction. Machine weight will decrease and 20 % of the FWCs in practice remain "free-tech" (e.g. motormanual systems and similar). Further, better info will also be available at transport level including a better integration of back-haulage, as well as of containerisation including optimised backhaul also here.

	Specific

	A1	B2
Bio energy policies		
Strict environmental regulation (climate change)		Better info on resource, trees, logs (incl. Mill gate) remote sensing: 70% Plantation: Fibre, mass!, low cost. Centralisation of sorting 30%
Consumption	Better info on resource, trees, logs (incl. Mill gate) remote sensing: 30% Plantation: Fibre, mass!, low cost. Centralisation of sorting 70%	
Technology changes	Automatisation 30% (hightech) Terrain driving Hybrid engines Digital FWC (harv.-forw-transp):40% Machine weight Free-tech 10% Better info (back haulage truck) Containerisation (back haulage truck)	Automatisation 20% (hightech) Terrain driving Hybrid engines Digital FWC (harv.-forw-transp):80% Machine weight Free-tech 20% Better info (back haulage truck) Containerisation (back haulage truck)

Tab 5: Additional specific M3 scenarios, and their consequences

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