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Strategic data acquisition addressed to support implementation of Design for Environment

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Contents

1 Introduction

This project “Addressed data acquisition to support implementation of DfE in the CPM companies” is a continuation project of the IMPRESS sub-project 7 “Measurement and communication of environmental performance of products”[1]. It started in April 2006 and was finalized in September 2006.

1.1 Background

In the IMPRESS project, the RAVEL methodology (see 1.1.2) was applied for a pump manufacturer (ITT Flygt) and a furniture manufacturer (IKEA of Sweden). One of the key components of the RAVEL methodology is a database with environmental properties of different materials. As this database was built up for the train industry it was obvious that material property data was missing if the RAVEL methodology should be able to be used in the other industries. The data gap was especially large for materials used in the furniture industry. Therefore this project was started, to broaden the scope of the material property database with an adressed data acquisition.

1.1.1 Goal and scope

The overall objectives of this project was to ensure that the tools for Design for Environment (DfE) developed and used within CPM should be able to be used in every day work, able to be demonstrated and also be relevant both within and outside of CPM.

More specifically, the aim was to perform a database build up so that the RAVEL methodology and the DfE tool CPM Inventory Tool could be used by the companies also after CPM is ended. In the scope of the project was therefore included both a data collection based on the needs of the companies participating in the project, but also a strategy development for continuous data inflow to the database, maintenance and update of the database.

1.1.2 The RAVEL methodology

The work in the sub project has been based on the RAVEL Design for Environment (DfE) methodology. The RAVEL methodology was developed within the Brite-Euram III (EU) project RAVEL (Rail Vehicle Eco-Efficient Design) project running 1998-2001, and implemented within the railway industry in the REPID (Rail sector framework and tools for standardizing and improving usability of Environmental Performance Indicators and Data formats) project running 2002-2004. The research group IMI – Industrial Environmental Informatics at Chalmers University of Technology participated in both RAVEL and REPID projects. Originally developed for the railway industry, the RAVEL methodology is however designed to be generally applicable to any other business where products are developed.

1.1.2.1 Measurement of environmental performance

As Figure 1 shows, the measurement of environmental performance is based on:

- *Environmental Performance Indicators (EPIs)*
  The indicator set represents the environmental impact of the product.
- *The material list*
  The material list enables consistent calculation of EPI results by removing the

[1] Erlandsson M., Flemström K., Häggström S., Carlson R., “Measurement and communication of environmental performance of products”; CPM Report 2006:2

possibility of double occurrences of a material and thus documenting different material property data for the same material.

- *The component structure*
  The component structure specifies name and weight of all materials in the product.
- *Material property data*
  The values of a specific material property are summed on weight basis for all included materials in the product to form the EPI result.
- *Calculation rules*
  The calculation rules for each EPI specifies the algorithm with which the EPI result is calculated.

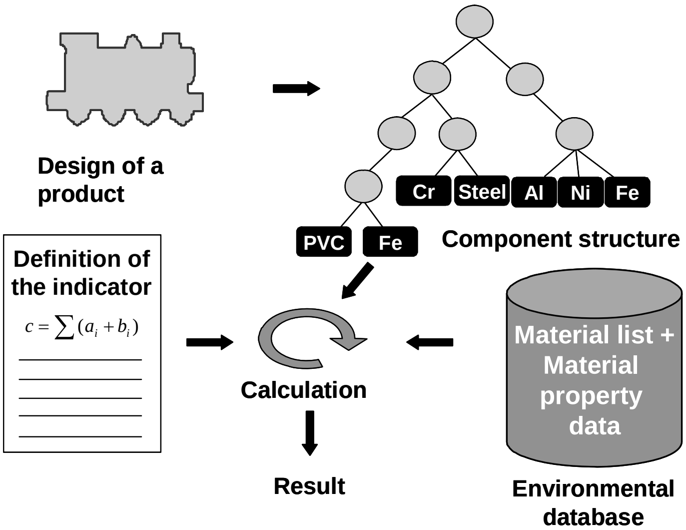

Figure 1: Calculation of environmental performance indicators. Picture describing the RAVEL methodology[2], copyright © Raul Carlson, Chalmers University of Technology.

To be able to analyze a specific design, a component structure consisting of all the components and materials in the component is needed for the design. The calculation rules define how the material property data, for the materials found in the component structure, shall be aggregated to reach a result for each EPI.

[2] Ander, A, Duflou, J., Dewulf, W., et al, Integrating Eco-efficiency in Rail Vehicle Design, Leuven University Press, 2001

1.1.3 Project participants

IKEA of Sweden (IoS):
Gunilla Clancy
Magdalena Wejss
Paul Adam
Carina Andersson

Industrial Environmental Informatics (IMI):
Sandra Häggström
Staffan Skön
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Bombardier Transportation:
Ylva Bergkvist

ITT Flygt:
Christian Wiklund

1.1.4 Project runtime and budget

This project has been a very limited project with runtime between April 2006 and September 2006.

The budget has been 255 000 SEK.

2 Results from the project

In this section, the work performed and the results achieved in the project is described.

2.1 Definition of scope of data collection

A meeting was held where the scope of the project was decided, in terms of which indicators, material properties and which materials that data were going to be collected for. The indicators that were chosen for the project were:

- Fraction recycled material
- Fraction renewable material
- Can be material recycled
- Can be incinerated with energy recovery
- Materials inventory degree
- Product weight

Two more indicators were discussed but were decided not to include in the project

- Can be composted
- Amount of restricted materials

2.1.1 Decision on the material list

It was decided in the project that the material list (see 1.1.2.1) should consist of the REPID material list and add to this the materials in the IKEA Materialregistret that could not be found in the REPID material list. A mapping was therefore made of the IKEA Materialregistret to the REPID material list (see 2.3.2). All companies were invited to propose further inclusions in the list but the REPID material list already fulfilled the need for both Bombardier Transportation and ITT Flygt.

2.1.2 Changes in the indicator definitions

Some minor changes in the indicator and material property definitions were made to better suit the new range of products.

The specification of the material property value was changed for three material properties; “renewable”, “material recycling” and “Can be incinerated”. The specification for the material property value was changed from yes/no to % renewable, recyclable (in EOL) or incinerable. This means that the formulas for calculating the indicator values also needed to be changed. The material property values in the database was further needed to be collected anew for those materials where it was not obvious that the value was 0% or 100%, and the meta data did not provide information about the real percentage. The indicators affected by this change were:

- Fraction renewable material
- Can be material recycled
- Can be incinerated with energy recovery

2.1.3 Separability in the end of life phase

The issue of separability of the materials in a product or component in the end of life phase was discussed. In the CPM Inventory Tool, the material property is documented using a tick box named “Possible to separate”, and ticking this box means that all the material in the product or component are regarded as separable. The material property ”Can be separated” will influence the indicator “Can be material recycled”. If the materials are not ticked as separable it means that all materials will get the value zero for material recycling.

The concept of “separability” was defined as follows: “If in the design phase of the product or component it is known and can be shown that all the different parts can be separated with minimal energy, then the product or component is defined as separable”.

If the designer or the environmental specialist knows that the product or component is separable according to this definition, the box “Possible to separate” will then be ticked on the relevant product or component level. This definition is thus encouraging for the designer, the box is ticked if it is possible to separate the materials (with minimal energy).

2.2 Improvements of prototype tools

In the project the prototype tools CPM Inventory Tool[3] and DfE MaterialData Administration[4], both developed by IMI, were improved in order to fulfil the requirements put on them with the enlargement of the applicability to new industry sectors.

2.2.1 DfE MaterialData Administration

The data documentation tool DfE MaterialData Administration has been improved with features for grouping of materials to different groups and work with different nomenclatures. This was made to enable for IKEA to use the nomenclature in IKEA Materialregistret which is the nomenclature the IKEA personnel is used to. It is now possible to change between the REPID nomenclature (which is more or less used by Bombardier Transportation) and the IKEA nomenclature. Other features to facilitate the data documentation were also added such as the possibility to search for material groups in the “Edit all materials” mode in the tool.

2.2.2 CPM Inventory Tool

The DfE tool CPM Inventory Tool was also improved. After the material list was decided (see 2.1.1) there should not be any additions to the list according to the methodology and the possibility for adding new materials to the material list was therefore removed.

2.3 Data collection

The data collection was the main activity performed in this project. A database was built up, currently named IMI material database. The DfE method demands that the database does not contain any gaps. The methodology for data gap manangement developed in the REPID project (see 3.3.2) was therefore used.

2.3.1 Results from the data collection

The data collection was performed with the tool DfE MaterialData Administration. Data could be collected for all the materials in the IKEA Materialregistret due to the fact that the material properties varied very little inside material groups.

In the data collection, European average values have been acquired in first hand, Swedish average values in second hand, and world average in third hand.

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[3] http://project.imi.chalmers.se/IMPRESS_SP7/, login and password is needed.

[4] http://project.imi.chalmers.se/DfE_MaterialData_Administration, login and password is needed.

2.3.2 Mapping of IKEA Materialregistret to the REPID material list

The IKEA Materialregistret was mapped to the REPID material list. This was not trivial as the nomenclatures were quite different in their structures. The materials in the REPID material list are grouped more or less after material properties, while the materials in the IKEA Materialregistret are grouped after in which application they are used (filling material, surface material etc.). This means for e.g. that a material can occur several times if it is used in different applications. Some of the REPID materials have therefore been mapped to several of the IKEA Materialregistret materials. The REPID nomenclature was used when collection material property data.

2.3.3 Learnings from the data collection

The availability of material property data was very varied depending on material. Metals are very well described[5] while polymeric materials are hard to find satisfying data for. There are further often large differences between countries in recycling statistics of polymers. Wood and paper is also very dependent on the country as it is mainly a question of wood resources and waste management. Glass recycling is very commonly described, however, data sources treats seldom any other type of glass than bottles. Construction glass etc. is very hard to find data for.

The conclusion is that great consideration must be made when collecting material property data in order to get fair values with a reasonable collection effort. The data is often also very dependent on the material property definition. E.g. recycling in the end of life phase is in the project defined as the *probable* recycling rate. If there are no recycling facilities for a certain material, e.g. glass fibre wool, then data about how much of glass fibre wool that is possible to recycle (e.g. from the manufacturer) is irrelevant. To encourage companies to make their products recyclable, data about the *possible* recycling rate could be used. The principal thing is that the same definition must be used throughout the entire database to make the figures fair.

2.4 Strategy development

The strategy development contained two major steps; development and documentation of strategy for continuous data acquisition and maintenance of databases and education of the company participants.

One learning from previous work with database build-up at IMI is that databases are never “finished”, they need continuous updating if the documented data is going to reflect the changes in the physical world[6]. The data acquisition should therefore be performed to facilitate for future updates. This means also that the companies will have to be prepared to maintain the database that they will use. An education in strategic data acquisition and maintenance based on the knowledge developed in CPM and in the REPID project was performed at the workshop in Älmhult in May 2006 to give this support to the CPM companies.

The strategy for continuous data acquisition and maintenance of databases is described in detail in chapter 3 in this report.

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[5] http://minerals.usgs.gov/minerals/pubs/commodity/recycle/

[6] Erixon M., Carlson R., Pålsson A-C.; "Measuring the environmental impact of products" CPM report 2003:1, Swedish Environmental Protection Agency Report 5349, 2003

2.5 Preparations for maintenance of data

To ensure that the data collected in this project will be kept available to the CPM companies, preparations were made for maintenance of the database, to keep the cost and effort needed to attain the data at a later occasion or with different tools than them used in the project.

A decision was therefore taken to store the data in three different ways to give the most possibilities:

- SQL database
  Possible to use in the CPM Inventory Tool
- Excel sheets
  Possible to use in many other softwares that are used in CPM companies
- Printed copies
  Possible to retreive the data if the electronic alternatives do not suit the purpose

The electronic alternatives are available on CD-rom or via the web.

3 Strategy for continuous data acquisition and maintenance of databases for DfE work

The strategy for continuous data acquisition and maintenance of databases for Design for Environment (DfE) work has been developed to ensure that databases are used and maintained on long-term basis in the CPM companies. It is also developed to ensure that the data collected in this project will be available also after the project is ended.

The strategy for data collection consists roughly of three steps:

- Thorough defining the data needed for the database.
- Define a list of information sources e.g. reports, other databases, experts etc.
- Comprehend, interpret and transfer data from the source to the database.
- Data maintenance

Each step is describe in further detail below.

This section is based on the reports *"Measurement and communication of environmental performance of products"*[7] and *"Manual on data management for REPID information system"*[8].

3.1 Definition of data need

Data acquisition can be very time consuming and when building the database both the data quality and quantity have to be considered, one thing depending on the other. The cost issue also has to be included in a practical database build up strategy[9]. If the aim is to include a lot of data with good quality, the cost will be higher than if the quality requirements or amount of data is decreased.

In the RAVEL DfE methodology, a database containing a common material list and acquired material property data or environmental data is required for calculation of the defined EPIs.

3.1.1 The material list

A common material list is one of the main concepts in the RAVEL method and an important part to enable consistent calculation of EPI results (see 1.1.2.1). By removing the possibility of material mix-up by agreeing on a common material list, the EPI results for different products can be compared and analysed with confidence in that it is based on the same basic data.

In this project a material list was created by merging the REPID material list and the IKEA Materialregistret. The list was then closed and the possibility to add materials was removed from the CPM Inventory tool.

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[7] Erlandsson M., Flemström K., Häggström S., Carlson R., "Measurement and communication of environmental performance of products"; CPM Report 2006:2

[8] Flemström K., "Manual on data management for REPID information system", Technical report from REPID project, 2003

[9] Erixon M., Carlson R. (2000), Practical Strategies for Environmental Data Acquisition, paper presented at The fourth International Conference on EcoBalance October 31-November 2, Tsukuba, Japan

3.1.1.1 Nomenclature management

The nomenclature in the database effects the data collection. With a nomenclature created after material properties it is rather easy to fill in group values as materials with similar properties will then be grouped to the same material group. With a nomenclature based on the application of the materials it is not trivial to use the opportunity to fill in material group values when data for a specific material is missing.

It is also important when collecting data that all multiple occurrences of a material are known so that different material property data will not be documented for a material just because it occurs at several places in the nomenclature. An easy way to reassure this is to create the nomenclature as an ontology, i.e. an inclusive list where all materials only occur once.

A third nomenclature issue impacting the data collection is whether trade names, chemical formulas, abbreviations etc. are used. The material names must be unambiguous to the data collector so that true data can be collected and understandable to the user of the database so that the user can find the material data needed.

3.1.1.2 Extensions of the material list

Extensions of the material list means that the agreement on a common material list is no longer valid. Old result calculated with the old material list might no longer be comparable to results calculated with the new material list.

If a company specific extension of the material list is going to be made, the administration tool DfE MaterialData Administration Tool[10] can be used. The tool supports different alternatives:

1. New materials are added to an unstructured company specific nomenclature. Material property data need to be defined for all new materials.

2. New materials are added to the existing nomenclature. Material property data can be estimated with the data for the material group.

3.1.2 Material property data

Calculation of the set of EPIs is based on material list, material property data of each material in the list and also the algorithm for each EPI as shown in Figure 1. All data used was acquired and stored in the IMI material database to enable calculations of the EPIs. The material property data required by each EPI is specified in the detailed definitions of the EPIs.

3.1.3 Data quality

Data quality may be defined as “characteristics on data that bears on their ability to satisfy stated requirements”. About 10 years experiences from work with data quality and establishing data quality criteria in the Swedish national competence center CPM have shown that the quality of a dataset can only be assessed if the characteristics of the data are sufficiently documented. Data quality does therefore in many respects correspond to documentation quality.[11, 12]

[10] http://project.imi.chalmers.se/DfE_MaterialData_Administration, login and password is needed.

[11] Arvidsson, P., Krav på Datakvalitet, CPMs Databas 1997, CPM Report 1997:1, Chalmers University of Technology, Sweden

[12] Pålsson A-C., Introduction and guide to LCA data documentation using the CPM data documentation criteria and the SPINE format, CPM Report 1999:1, Chalmers University of Technology, Sweden

A decision must be made which data quality is needed in the database before starting the data acquisition.

3.2 Define a list of information sources

In the definition of these sources an explanation is needed to satisfy their reliability and to clear what kind of data it could bring.

3.2.1 Data sources

Basic environmental and material data needed in the RAVEL methodology for the calculations of quantitative Environmental Performance Indicators (EPIs) can be acquired in a huge amount of ways, for example through interviews with competent people with knowledge in a specific area, literature, internet, specific companies, environmental-, material- and toxicity- databases etc. One critical aspect of data acquisition is the lack of suitable data and well documented data sources.

3.3 Data acquisition

This also include documentation of the data source, data acquisition process etc. All three steps need to be systematically documented in the different documentation fields in the database to achieve the decided data quality needed (see 3.1.3).

3.3.1 Data documentation

Data documentation for material property data consist of information about the data (the value) e.g. which acquisition method and information sources used, assumptions made, who gathered the data and when, conscious lack of knowledge etc. Data is sufficiently documented if the documentation is understood by the user and correctly used, and so that it can easily be improved or update when better data exists, new knowledge is available or better competence is involved in the work.

3.3.1.1 Documentation format for material property data

To facilitate the data documentation a documentation format called ISO/TS 14048[13] is used in the IMI material database. The fields used to document each data set of material property data are listed in the table below.

[13] International Organization of Standardization, ISO/TS 14048: Environmental management - Life cycle assessment – Data documentation format, 2002

Table 1: Material property data documentation structure of ISO/TS 14048.

Data type	Data field	Description
Depending on the value type	**Value**	This is the value for a specific property for a given material in the database. A material property value can be of three types: numeric value, range of allowed words (nomenclature) to choose from and free text. The definition of numeric values in the web tool; an integer shall be used, units are specified in *material* property specification, therefore no unit should be included in this field. If the class of the value type is nomenclature, the value of the property shall be selected from a pre-defined range. For example the nomenclature Boolean has the range Yes/No. The definition of free text in the web tool; maximum 255 characters can be used.
Nomenclature*	**Data collection**	A short description of the methods used during the data collection e.g. Derived, specified; Derived, legal requirements; Unspecified, expert outspoke; Derived, statistics etc. See below for explanations*
Date interval *YYYYMMDD/YYYYMMDD*	**Collection date**	The time period under which the data were acquired.
Free text	**Data treatment**	A description of the methods, sources and assumption made.
Free text	**Reference**	All references to data source used e.g. literature, other databases, internet sites, communication with well informed persons etc
Free text	**Notes**	For further information needed to specify the data, shall also contain name and organization of the person who inserted the data and data documentation

*** Derived, specified -** Data can be traced to the basic source, from well known sources e.g. reports and articles.
Derived, unspecified - Data is based on information from one or more unspecified sources. For example: Internet information without references etc.
Derived, statistics (unspecified/specified) - The data can be derived to calculations based on statistical methods.
Unspecified, expert outspoke - Data has been acquired through personal communication.
Derived, legal requirements - Data is based on legislations
Derived, estimated – Data is based on estimations. The basis for estimations made is described in the field Data treatment.
Note: This list can be extended based on the data acquisition procedures used.

3.3.2 Methodology for data gap management

In some cases it can be difficult to find all information required. The fact that information is missing is however important information for the receiver of the data, for this reason that should be documented as well. For example, to document the lack of suitable information and explain in what way the data was acquired, nevertheless, can be satisfying. In the IMI material database, the metadata also contains information of the data gaps. When no data has been found, an artificial value has been input, and this is noted in the data field Data collection as “Estimated”. The imputation method is described in the data field Data treatment.

Where no other information has been found, the material properties are estimated with those of similar materials. On first hand, the value of the closest material group has been used. An example is that the recycling rate of glass fibre reinforced epoxy is set to the average value for glass fibre reinforced thermo sets. If the closest material group is too wide, the value of a similar material has been assumed to be more accurate. An example is organic insulation materials, where the recycled content of elastomer insulation is more likely to coincide with the polymer than with the material group. This way of handling the gaps is similar to the “hot deck method”[14], but is done by hand and the method must be described as a combination of mean value imputation and expert estimation. More information about how to handle data gaps is described in the report *Data gaps* written by Sandra Häggström, IMI, Chalmers University of Technology.

3.4 Data maintenance

The recommendations for data maintenance can be summarized as:

- Do not design an information system which requires more data than it is worth to maintain
- Use information in existing information systems
- Coordinate data acquisition with other company functions

These recommendations are described in more details below.

3.4.1.1 Do not design an information system which requires more data than it is worth to maintain

The data collected should be stored in a way that is appropriate for the use both today and in the future. This means e.g. that it must be considered if the currently used technique will continue to be used. If it is not clear how the data will be used in the future it is recommended to store data in a both easily available and cost effective way, e.g. as an Excel sheet or in printed paper copies.

Every information system is designed for a specific context. If the information system does not contain data that fulfil the requirements of this context, the information system is useless even if it is technically working perfectly. The establishment of organisational functions for data quality maintenance of an information system must be part of the design of the information system[15]. This means that if it is not decided how the information system will be kept updated you do not have any information system at all.

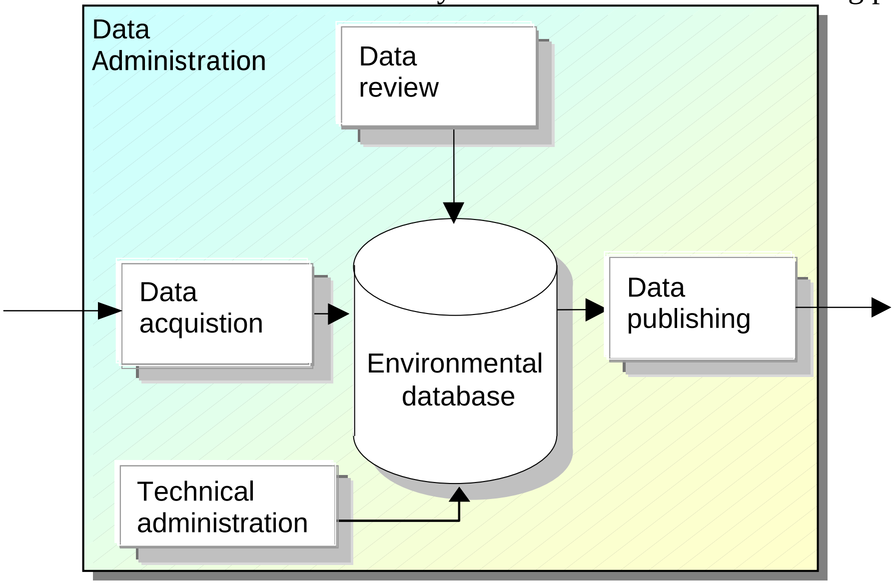
Data sources of a good quality call for organisational functions for maintenance of the data quality. One example is the organisation of the maintenance of the database SPINE@CPM[16]. The picture below illustrates the different organisational functions

[14] Carlos López (1997); Quality of Geographic data, Detection of Outliers and Imputation of Missing Values; Kungliga Tekniska Högskolan; ISSN 1400-3155

[15] Carlson R. Erixon M, Pålsson A-C.; "Establishment of Trade Structures for LCI Data", CPM-rapport 2000:3

[16] Carlson R., Pålsson A-C; "Establishment of CPM's LCA Database"; CPM Report 1998:3

involved in the data administration. The data acquisition function makes it possible to insert data into the system. All data that is inserted into the system is reviewed by a data review function. The review function makes sure that the data quality requirements of the system are fulfilled. The data publication function makes sure that the data in the system is available through a standard communication format. The system does also need technical administration to make sure that the system is available and is working properly.



© R. Carlson, A-C. Pålsson, Chalmers University of Technology, 1998

Figure 2: Illustration of the data administration of CPM LCI database[17].

3.4.1.2 Use information in existing information systems

There exists a vast set of different management tools which may contain design-related information like for example

- ERP (Enterprise Resource Planning)
- SCM (Supply Chain Management)
- CAD (Computer-aided design)
- CAM (Computer-aided manufacturing)
- PDM (Product Data Management)
- PLM (Product Lifecycle Management)

Check what type of information that is available at your company or organisation. Do however not expect to find all the information needed for the environmental assessments in the existing information systems. The resolution of the information you will find in the different information systems depends on the requirements of the usage domain the system is designed for. For example from a design perspective the important thing is that the product complies with the specifications. The exact material content and how products are produced are not in focus, and detailed information on material contents and component structures for products delivered from sub-suppliers is hence generally not available in these kinds of systems. On the other hand, from a risk perspective exact information on content of certain materials is essential.

[17] Carlson R., Pålsson A-C; "Establishment of CPM's LCA Database"; CPM Report 1998:3

3.4.1.3 Coordinate data acquisition with other company functions

Functions such as safety and health often need the same type of detailed information on material content which is needed for environmental issues. Economical gains may be achieved by coordinating inventory systems for different company functions that call for similar information. The persons responsible for providing the information will only have to provide the information once, and a better data quality can hence be required. Furthermore, when the information is updated it only needs to be changed in on place. Integrated systems do however require material nomenclatures and other important concepts to be harmonized. When different material names and material properties are used in different usage domains with different requirements on the resolution etc., it is of vital importance that common agreements are reached on the definition of these names and properties. Common nomenclatures are often costly to achieve but economical gains from a common understanding of the meaning of the data will be achieved in many different areas.

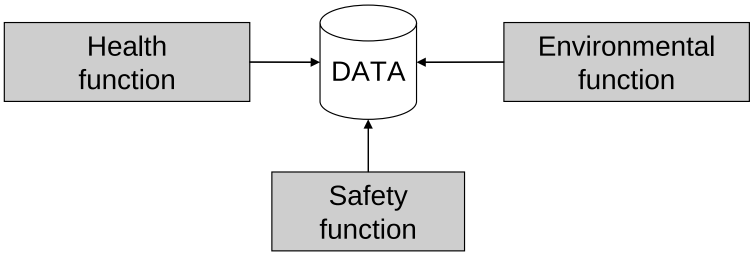


Figure 3: Health, safety and environmental functions at a company often have a common data need.

4 Conclusions

The objectives of this project; to perform a database build up based on the needs of the companies participating in the project, but also a strategy development for continuous data inflow to the database, maintenance and update of the database so that the RAVEL methodology and the DfE tool CPM Inventory Tool could be used by the companies also after CPM is ended, have been achieved.

The material list has been redefined to include also materials used in the furniture industry which is a good complement to the previous material list only containing materials used in the train industry. Collection of material properties for the new materials has also been performed so that indicator results, or EPI values, can be calculated. This means that the RAVEL methodology is now applicable also for other industry than the train industry.