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# PRODUCT LIFE CYCLE ANALYSIS IN THE AIRLINE INDUSTRY

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## Introduction

The paper focuses attention on life cycle analysis and how this product-orientated approach reflects an understanding of the embedding of products in a chain of relationships extending both backwards and forwards. Moreover, it illustrates how life cycle techniques might be applied in practice in an airline industry context and, equally significantly, identifies the types of difficulties that might be encountered in identifying and treating relationships.

At the outset it is reasonable to acknowledge the appeal of adopting a product focus as it is potentially the appropriate level of disaggregation at which to assess, measure and manage sustainability impacts. Moreover, it is quite reasonable to suggest that a product perspective is the most valid means by which there can be capture of sustainability orientated competitive advantage. Reporting that focuses on the economic, environmental and social impacts of each product is nonetheless not considered as an alternative to triple bottom line reporting at the entity level. Rather, product reporting can serve as a supplement to entity level reporting. Additionally, it can form the basis for reporting, relevant to different users and product-related decision contexts, such as monitoring of eco-efficiency [1] by management, and also for stakeholders who are users of end products.

## What is meant by life cycle and life cycle analysis?

In this discussion the life cycle of a product refers to all steps from the transformation of raw materials, to product use and subsequent waste disposal. [2] The concept of life cycle

[1] For a discussion of eco-efficiency measurement, refer to Schaltegger and Burritt (2000), pp. 238-246 and Schaltegger *et al.* (2003, pp. 62-93).

[2] The meaning of product life cycle should be clearly distinguished from the use of that term to refer to the stages of a product's life over the

assessment[3] has developed since the 1960s and 1970s and is now understood as referring to approaches to product-orientated ecological accounting that incorporate all environmental interventions during the whole life cycle of products, services or infrastructure; while the term, life cycle analysis, is used more broadly to refer to a range of methods incorporating economic, social, political and ecological tasks (Schaltegger and Burritt 2000, p. 243). Within that broad range, Pflieger *et al.* (2005) develop a model capturing sustainability measures, integrating economic, social and environmental aspects of activities, disaggregated at the product level.

Life cycle analysis (LCA) is based on a dichotomy between inventory data, such as emissions, which can be directly measured and thus accumulated, and impact data which are the consequences, such as ozone depletion, of that which is included within the inventory parameter. While environmental inventory parameters can be translated to environmental impacts, "it is currently not possible to quantify the contribution of social inventory parameters such as child labour … in view of social impacts caused" (Pflieger *et al.* 2005, p. 173). Accordingly, the illustration below is confined to inventory parameters. The analysis of performance on inventory parameters and translation to "core indicators" of sustainable development is beyond the scope of this study.

*The Global Reporting Initiative (GRI) Sustainability Reporting Guidelines* (2002) provide a framework of *core* and *additional* economic, social and environmental performance indicators. A core indicator is one that the GRI considers, based on extensive consultative processes, to be relevant to most entities and useful to most stakeholders. Accordingly, the social and environmental effects reflected in the GRI core social and environmental performance indicators are selected for the purposes of this illustration.

Schaltegger and Burritt (2000, p. 237) identify alternative boundaries of the system considered within a product perspective, ranging from a single production step to LCA, incorporating product transformation outside the boundaries of the company. In their discussion of LCA, Pflieger *et al.* (2005, p. 170) refer to all operations occurring at the production site and "therefore" under the control of the entity as direct activities; and operations occurring beyond the site, as indirect activities.[4] In other words, production steps within the boundary of the entity are direct activities, while upstream and downstream production steps in the supply chain are indirect activities. In essence, Pflieger *et al.* argue that both direct and indirect economic, environmental and social effects are relevant

time from its introduction to the market, its growth, maturity and eventual decline, after which it is replaced by alternative products – a tool commonly applied to the examination of marketing and pricing strategies.

[3] This paper provides a brief introduction to life cycle analysis. For a more detailed discussion refer to Schaltegger and Burritt (2000) and Pflieger *et al.* (2005).

[4] The use of direct and indirect terms differs from their application in management accounting. Thus some activities are considered direct because they are controlled (e.g., power consumed to provide lighting in the factory, and administrative functions supporting the production and sale of the product) but their costs would be treated as an indirect product cost or and indirect cost allocated under activity-based costing.

(at least to some users and decision contexts).

While the more holistic approach of LCA potentially provides more relevant information, the extension of the system considered beyond the boundaries of the control of the entity may detract from the quality of information collected and analysed. The GRI Boundary Protocol recommends the determination of report boundaries based on control, significant influence and significant impact. A three-tiered reporting approach is recommended, reflecting the practical difficulties of accessing information from entities over which the reporting entity does not exercise control.

At a minimum, the scope of operating performance indicators should include entities over which the reporting entity has control. The scope of management performance indicators should include entities over which it has significant influence, while narrative disclosures should capture entities over which the reporting entity does not exercise control or significant influence but which pose key challenges for the entity because of their significant impacts (GRI 2006, p. 10).

While at a conceptual level LCA should proceed with a holistic approach, its practical application in the context of existing information technologies, efficiencies and inter-entity data flows may be constrained to the narrower boundary over which the entity has control. Towards that end, the illustration contained herein focuses on direct activities with some reference to indirect activities to facilitate discussion of reporting issues.

## Illustration of LCA in the Airline Industry

This illustration is not intended to represent any particular airline, nor is it intended to be comprehensive with respect to the operations and significant environmental and social effects of airlines. Rather, it examines the identification of social and environmental effects of selected activities, intra-period and inter-period allocation of effects pertaining to activities that are not feasibly traceable to specific products, and the implications of outsourcing for the monitoring of social and environmental effects.

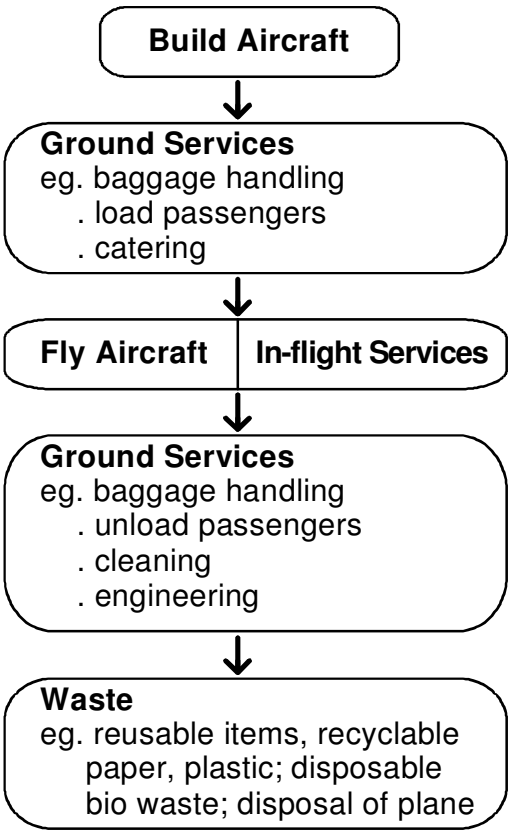
### Flight Services

The airlines' major products are flight services; each scheduled flight may be considered as a separate product. The numerous activities that contribute to the airline's provision of flight services for passengers include: flying the aircraft; in-flight services, which refer to services provided to passengers during the flight; ground services, such as baggage handling, passenger handling, waste disposal and engineering and maintenance; finance; marketing; and human resource management. The classification of the effects of each activity as direct or indirect in the context of LCA is based on the presence of control over the activity by the airline. For example, the operation of the flight is usually controlled by the airline and the economic, social and environmental effects of the flight are classified as direct, while the economic, social and environmental effects of waste disposal undertaken by other entities are classified as indirect.

A selection of direct and indirect activities involved in the delivery of flights is illustrated in Figure 1. The selected activities are readily identifiable with typical organisational structures adopted in the

industry. Ground services appear twice in the diagram because they occur both before and after the flight. Pre-flight ground services include loading passengers and baggage onto the flight, safety checks by maintenance and engineering, and the preparation of food and beverages. Post-flight ground services include unloading passengers and baggage, cleaning and maintenance of the aircraft.

**Figure 1: Selected activities in the life cycle of flight services**




Some of the inputs to in-flight services are outputs of other activities that form part of the product life cycle of the flight service. For example, the outputs of catering activities are inputs to in-flight services. Inputs that represent outputs of another direct activity are not considered so as to avoid double counting.

*Environmental effects*

The application of LCA involves the collection of information about economic, social and environment effects of all production steps and tracing or allocating the effects to specific products. Table 1 shows examples of environmental effects for ground services, drawing from performance indicators used in the GRI (2002).

Some environmental effects, such as electricity used by the ground power unit for lighting, cleaning, door operations and avionic systems, may be readily traced to each flight service, while other environmental effects, such as the consumption of water at the terminal, are not feasibly traceable to particular flight services. Drinking fountains, bathrooms and lavatories at the terminal are used by passengers and visitors associated with the many flights scheduled to arrive at, or depart from, the airport. In the application of LCA social and environmental effects should be allocated to each product using an appropriate driver in a similar manner as economic overhead costs are allocated to products using an appropriate cost driver. For instance, the consumption of water at the terminal may be allocated to flights on the basis of the number of passenger hours[5] spent at the terminal. Similarly, the environmental effects of inspection,

[5] Passenger hours at the terminal may be a more appropriate allocation base than the number of passengers if there are significant differences in check in requirements prior to departure for flights operated by the airline. This occurs, for instance, if the airline operates both domestic and international flights from the same airports.

maintenance, repair, modification and testing of the components of the aircraft can be allocated to flight services, in a manner similar to the allocation of economic effects, such as the allocation of maintenance costs using techniques applied in activity-based-costing.

**Table 1: Selected environmental effects of ground services**

| Environmental effect (inventory) | Description |
|---|---|
| **Materials** | |
| Inputs of food and beverage | Preparation of meals by catering |
| Inputs of spare parts, grease, oil, fuels, aluminium in sheet, bar and rod forms, composite materials, various plastics, wires, bolts, etc. | Materials used in the maintenance, repair and overhaul of components of the aircraft |
| **Energy** | |
| Electricity consumed | Ground power unit used while aircraft is on the ground for lighting, cleaning, door operations, avionic systems; at the terminal for baggage handling, air conditioning, cleaning, heating, automatic doors, lighting, conveyer belts, escalators, elevators; in catering for food preparation, cooking, refrigeration and freezing; and for lighting and operation used in engineering and maintenance |
| **Water** | |
| Water consumed | Washing the aircraft and other vehicles; used by ground power units and other vehicles; cleaning and cooling processes in engineering; used as drinking water and to flush toilets at the terminals; used to remove ice and snow from the plane, if applicable; and used in food preparation |
| **Emissions, effluents and waste** | |
| Greenhouse gas emissions | Jet engine testing; $CO_2$ emissions from ground power unit, pneumatic ground cart, emergency diesel generators, baggage handling, push-back tractor and other vehicles |
| Discharge to water | Washing parts, aircraft and other vehicles; hand washing, laundry (uniforms/overalls) |
| **Biodiversity** | |
| Impermeable surface % of entity's land | Concrete area at engineering workshops, terminals and related sites |

The allocation of social and environmental effects of engineering and maintenance activities in the application of LCA poses additional complexities where operations performed in one period, such as the overhaul of an engine, pertain to the production of flight services over multiple periods. When accumulating social and environmental effects of engineering and maintenance activities it is often necessary to consider a longer horizon than one year.[6]

For example, the overhaul of an aircraft engine is scheduled after each cycle of a specified number of engine hours [7], irrespective of whether the engine hours are spent on the ground or in flight. The social and environmental effects of the labour, materials, energy and waste associated with the overhaul can then be allocated to flight services based on the actual or expected number of engine hours consumed by each flight service.

*Social effects*

Table 2 lists selected social effects of ground services including engineering and maintenance.

Some social effects, such as certain labour practices, may be more readily traceable to specific flight services than others. For example, hours lost due to injuries resulting from a baggage handling accident may be easily associated with a flight service, while hours lost due to repetitive strain injury are unlikely to be specific to an individual flight service, and thus need to be allocated on a reasonable basis. In applying LCA the social effects of activities with a high labour component can be allocated based on a measure of labour hours used in the production of each product or service.

In measuring the social effects of human rights policies on the freedom of association, it is necessary to determine weighting applicable to different labour input, to the extent that labour resources used in the production of the flight service are not covered by the same policies. For example, due to differences in labour laws between countries, ground crew employed offshore, either directly by the airline or as part of an indirect activity performed at the destination airport, might not have the freedom of association enjoyed by domestic ground crew. Thus in measuring the social effect for the freedom of association parameter for the flight service it is necessary to identify the portion of labour contributed by workers who have freedom of association. This could be achieved by measuring the actual or expected labour hours of the relevant categories of workers per flight service.

Quantitative social indicators, such as the amount of staff training, present additional complexities when measuring effects at the product level. In allocating the staff training of ground crew to a flight service it is necessary to consider the amount of training undertaken by ground crew within a specified period of time. This will vary between staff and employment category, with more training time experienced by employees engaged in apprenticeships. The accumulated training time may then be allocated to flight services, based on a measure of actual or expected labour hours (or minutes). For example, if baggage handlers undertook 8,000 hours of training during the year, and performed 320,000

[6] This is not to suggest that inter-period allocation of environmental and social effects of activities in the application of LCA is confined to engineering and maintenance activities.

[7] Additional engine overhauls may be scheduled on inspection after incidents such as bird strikes or the use of power in excess of the normal maximum under emergency conditions, causing potential reduction in the expected life of the engine.

hours of service, 0.025 [8] hours of staff training would be allocated to a flight service for every man-hour of baggage handling. This process could then be repeated for other categories of employment.

The effects of outsourcing on reporting and monitoring social and environmental effects can be considered in the context of catering services. The airline may choose to outsource some or all of its catering services. The social and environmental effects of catering services may be included in the entity-focused sustainability report of an airline to the extent that the activity is controlled by the reporting entity, as recommended in the GRI Boundary Protocol. The proposed *G3* suggests that if the activity is neither controlled nor significantly influenced, but the social and environmental impacts are significant, narrative disclosure should be included. Thus, in applying the proposed *G3* to reporting on the social and environmental effects of an airline's catering services, social and environmental performance indicators would be provided to the extent that the catering services are controlled while reporting would be confined to narrative disclosure for outsourced catering services. In contrast, LCA conceptually makes no distinction between controlled and outsourced activities other than to classify them as direct or indirect components of the product's life. However, in practical terms there may be some limitations on access to information about the social and environmental effects of activities beyond the control of the reporting entity.

## Concluding comments

Parallel to the development of economic measures at the product level, such as activity-based costing, is the burgeoning product-focused approach to sustainability reporting. This approach, combined with life cycle analysis, incorporates the economic, social and environmental impacts of the direct and indirect activities that collectively contribute to products delivered to end consumers. The information thus produced, enables product-related decision making by management and stakeholders to reflect sustainability considerations. Ultimately, sustainability information at the product level provides capacity for sustainable operations to be driven by market transactions. Information about social and environmental effects at the product level is also useful for management decisions about the continuation or existing product lines, new product developments or investments. This is achieved by facilitating assessment of the potential impact of product-related decisions on the entity's objectives of satisfying stakeholders' expectations of social and environmental performance.

A difficulty that may be encountered in the practical application of life cycle analysis with respect to indirect activities is limited access to the information comprising the inventory parameters of social and environmental effects. The ability of the entity and other stakeholders, such as consumers, to analyse the sustainability dimension at the product level is subject to the level of transparency of social and environmental effects throughout the supply chain. Similarly, difficulties may arise in the management of social and environmental effects where an activity is predominantly beyond the control of the entity. While the entity, in applying its own sustainability principles, may prefer, for example, a high level of recycling, the decisions made by downstream operators may reflect a greater weighting on economic considerations.

[8] 8,000 hours of training/320,000 hours of service

**Table 2: Selected social effects of ground services**

| Social effect (inventory) | Description |
|---|---|
| **Labour practices and decent work** | |
| Injuries, days lost | Injuries and days lost for ground crew including engineering and maintenance staff from incidents traced or allocated to the flight service |
| Staff training in hours | Apprenticeship programmes in engineering and maintenance, staff training programmes |
| **Human rights** | |
| Policies against discrimination: policy to cater for disabilities, religious beliefs and dietary requirements | Policies to cater for disabled access around the terminal, and religious requirements, such as prayer rooms, EEO policies and procedures |
| Policies for freedom of association | Policies applicable to ground crew including maintenance and engineering departments |
| **Society** | |
| Noise problems | Noise generated in testing jet engines |
| **Product responsibility** | |
| Policy for preserving customer health and safety | Safety procedures for passenger handling; procedures and regulations for safety and monitoring systems (e.g., certified staff on certain tasks, formal and regulated training), aircraft engineers' log books |

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