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IMPROVING ECO-DESIGN PROJECTS THROUGH BETTER UNDERSTANDING OF THE COMPANY CHARACTERISTICS AND BUSINESS CONTEXT

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ABSTRACT

This paper examines the role of the supported pilot project in introducing and embedding eco-design practices. This is achieved through the documentation of a pilot project that failed to achieve a desired level of embedded change.
A comprehensive review of this project identifies the often overlooked impact the company's characteristics and business context, had on the project outcomes achieved. The level of impact observed within this review suggests that more successful outcomes would be have been achieved if the pilot project had been more closely aligned to the company's specific situation.
With this in mind the paper develops a Company Characterisation Process and identifies key company features that should be documented and addressed within eco-design pilot project briefs.
This research encourages a more customised approach to eco-design pilot projects with the aim of supporting environmental design change from within an organisation rather than imposing it externally.The goal is to help future eco-design pilot projects achieve more embedded outcomes that lead to lasting change within industry.

Keywords: eco design, design management, design practice, knowledge-action gap

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1 INTRODUCTION

Eco-design is defined as the "integration of environmental aspects into product design and development" (ISO 2002). Within the literature eco-design has been described both at the product level, focusing on tools and processes (Ghorabi *et al.* 2006; Navarro *et al.* 2005) and at the organisational level, discussing topics such as management support and cross departmental co-operation (Ammenberg and Sundin 2005). However while this discussion seems to have produced many academic case studies that detail eco-design at the product level (Bovea and Vidal 2004; De Langhe *et al.* 1998; Pamminger *et al.* 2007), few acknowledge the business context within which they take place. In parallel many authors document a knowledge-action gap between eco-design academia and industry (Lofthouse 2006; Boks 2006; Karlsson and Luttropp 2006), suggesting that the projects that are taking place are failing to embed long term design changes.

Interestingly those case studies that do document embedded change tend to come from large multinationals, who have undertaken eco-design activities independently of research bodies or academia (Quella and Ieee Computer 2001; Cramer and Stevels 1997). What is striking about these case studies is the degree to which they focus on the development of business systems, whilst documenting environmentally improved products as a natural outcome of their implementation. This is a top down approach that contrasts dramatically with the tool application bottom up approach more commonly observed in academic literature.

1.1 The Pilot Project and its Role in Introducing Eco-design

This paper documents the first stage in a larger research project that aims to determine how the externally supported pilot project can be more effectively used to introduce and embed eco-design practices. Within this research the term 'pilot project' describes any introductory design project used to trial environmental design thinking or approaches and is characterised by an external contribution of expertise and/or manpower. The pilot project is seen as an important focus due to the natural bridge it offers between eco-design knowledge and practice. This is particularly important as many current examples fail to empower companies with the tools required to embed eco-design change, preventing continued progress once the project concludes (Hermandez Pardo et al. 2011). While this may result from the use of the pilot project to prove eco-tool applicability rather than changing design practices, it is seen as a missed opportunity for beneficial knowledge transfer.

1.2 Focus of this Paper and its Contribution to the Wider Research Project

In this paper we examine this role of the pilot project in more detail, through the documentation of a two year eco-design project that failed to achieve the desired level of embedded change. By describing the project, the participating company and the outcomes, we identify the impact of the company situation (viewed as a combination of long term company characteristics and short term business features) had on the work undertaken and the embedded change achieved. This paper argues that failure to adequately appreciate and address the company situation resulted in a project that failed to support lasting change. In order to achieve better alignment between the goals and structure of the project, and the company characteristics and business context, this paper introduces a Company Characterisation Process. This has been developed to support future eco-design pilot projects and improve the level of embedded change they achieve.

This paper documents the first of multiple case studies that will examine the relationship between the company, the pilot project and its outcomes in varied commercial contexts.

1.3 Methodological Approach for this Case Study Analysis

The information contained in this paper is drawn from observations made by the first author during a two year Knowledge Transfer Partnership (KTP). The Knowledge Transfer Partnership scheme brings together a research partner (typically a university) and a small to medium sized enterprise (SME) to conduct a commercially beneficial research and development (R&D) project. As the name suggests the goal is to transfer knowledge from the research partner to the SME.

In this KTP the University employed an environmental designer (known as "the Associate" – the first author of this paper) to work full time at the company, alongside their existing design team. The Associate also had close contact with the companies managing director, technical director and production staff, providing a thorough insight into the perspectives and priorities used in the company's decision making process.

2 THE ECO-DESIGN PILOT PROJECT APPLIED IN THIS CASE STUDY

The project plan for this KTP stated that the company were keen to address the *"challenges presented by environmental issues"* (Best 2009). They had no previous experience of eco-design, but were aware that they operated within a societal and legislative environment that was increasingly focused on environmental issues. As such they wanted to *"respond, and be seen to respond, to the environmental agenda"*, whilst also growing "*their market share by providing [the product] of choice for the 'green' customer"* (Best 2009). To meet these goals the project aimed to develop a new 'eco' product that addressed these impact areas, as well as eco-design features that could be rolled out across their ranges. They were also keen for this product to achieve cost savings for both the company and its customers. These were adventurous goals but they were supported by a two year product development plan that mapped out the tasks necessary to meet requirements. This plan presented typical product design and develop tasks (Pugh 1991), such as market research, concept design and prototyping, with the addition of a Life Cycle Assessment (LCA) to identify the significant environmental impacts related to their existing products (Simon *et al.* 1998; Gertsakis *et al.* 1997; Institute for Engineering Design 2003).

The project was managed and performed by the Associate, removing it from the day-to-day activities of the existing design team to allow for research and development. Communication between the Associate and the management team was achieved through monthly meetings attended by the design manager and the technical and managing directors.

3 THE SIMPLIFIED LCA AND DESIGN FOCUS

The LCA methodology maps the environmental impacts of a product from material extraction through to product disposal and is used to provide a holistic overview of the impacts caused by any product or service. To achieve this overview a full LCA requires large amounts of data and is both time and resource demanding (Guinée *et al.* 2002). In this project it was agreed to simplify the LCA process in three ways to ensure beneficial output with the time and resource available. The first simplification was to limit the impact categories considered to energy consumption (MJ) and carbon dioxide equivalent omissions ($kgCO_2E$). This prevents the possibility of monitoring the transfer of impacts from one category to another (a material may have a lower embodied energy but higher aquatic emissions), but limits data collection to that which is relatively commonplace and familiar, making sources of information more readily available and improving the communication of results to the company and their customers. The second simplification was to perform no interpretation (normalisation, grouping or weighting) of the results, and to instead drive the design focus from the raw data. Finally it was decided to omit the end-of-life phase. This decision was taken because common end-of-life scenarios could not be established, preventing accurate modelling. Due to the innocuous material make-up, it was agreed that the contribution from this phase was likely to be minimal, making this omission acceptable.

3.1 Life Cycle Data Collection

The company's activities consist of the design and manufacture of a product towed by another vehicle. The company produces three ranges characterised by their high-, mid-, or low-level specification and each range contains between 4 and 5 models which vary in size and layout. The focus of this study was a mid-range, mid-sized product, chosen for its representative qualities. To complete the simplified LCA the following data was collected.

Materials: The material and weight of each component was obtained from suppliers for 92% of the total product weight. Publically available databases were then used to assign embodied energy and CO_2 values to each (Hammond and Jones 2008). This product contained over 7,500 components, many of which had complex supply chains. This made data collection both difficult and time consuming as the first point of contact did not always have the information readily available. Others were unable to provide it at all (material data could not be collected for 8% of the product by weight).

Manufacturing: All energy, gas and electricity bills were recorded for a year's production and a relative proportion was attributed to each product manufactured. As the impact of this life cycle phase was predicted to be low, wastage was omitted at this stage.

Transport: Delivery distances and transportation methods were collected from supplier factories to the manufacturing site and from the manufacturing site to retailers. This data collection suffered from the same complexities as that of the materials phase. Delivery from the retailer to end user was omitted due to its variability.
In-use: In use energy consumption was calculated through the completion of customer questionnaires, user observations and product testing. Low, medium and high use models were generated to represent the varied use patterns.

3.2 The Simplified LCA Results

The results of the simplified LCA identified that on average of 80% of the energy and CO_2E figures were attributed to the in-use phase, and a further 19% to the materials phase. This contribution far outweighed that of the manufacturing and transport phases, as shown in Figure 1, providing adequately clear areas of focus for design development and enabling data collection to be stopped.

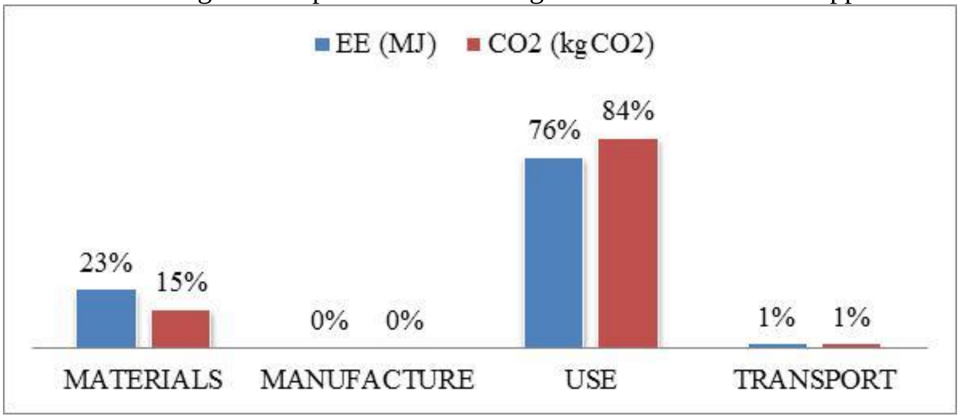

Figure 1: Results of Simplified Life Cycle Assessment

To help clarify the design focuses further, a breakdown of the in-use and material figures was performed (shown in Figure 2). This revealed that 98% of the total in-use figure resulted from the fuel required to tow the product, far outweighing the 2% contribution made by using it. The material breakdown did not provide the same clear focus, as the percentage embodied energy figures tended to be proportional to the corresponding percentage weight. However it was agreed that the substantial use of aluminium should be reviewed.

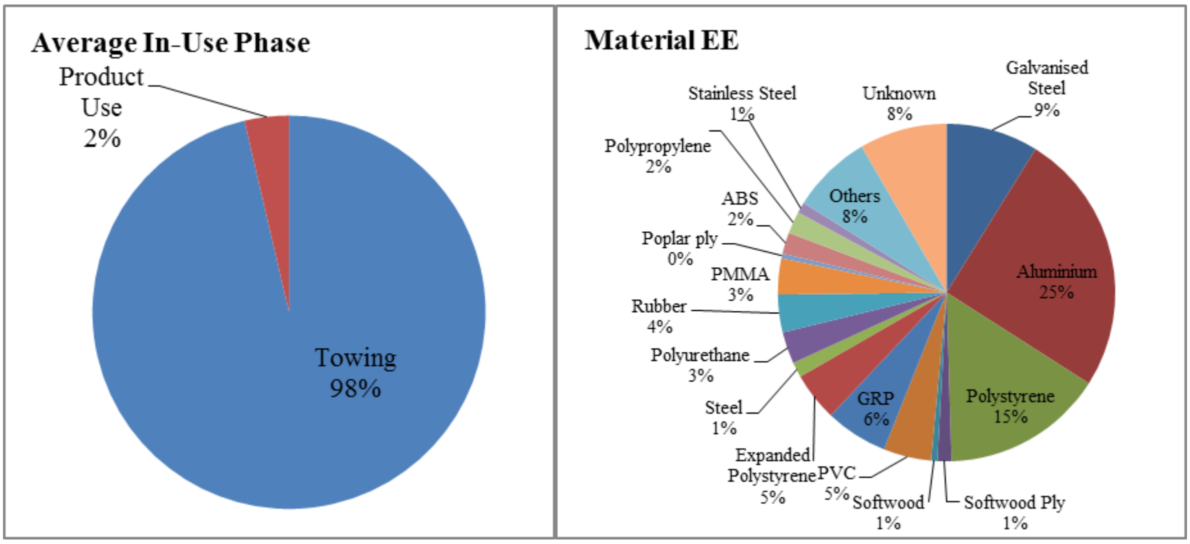

Figure 2: Relative Energy Contributions to the In-use and Material Phases (MJ)

3.3 Design Focus for Redesign as Identified by the Simplified LCA

The in-use towing figures were assigned to three design features; aerodynamic drag, weight and tyre rolling resistance, allowing the following four design development focuses to be identified:

1. Reduce aerodynamic drag
2. Reduce weight

3. Reduce rolling resistance
4. Minimise use of high embodied energy materials (particularly aluminium)

The process and results of this LCA were shared and discussed with the company and academic team throughout.

4 ADDRESSING THE IMPACTS

The LCA was completed within the first 6 months of the project, leaving a remaining 18 months to work on redesign options that addressed the areas of impact identified. The LCA had provided conclusive results and the project plan allocated time for design development. Despite this and despite careful adherence to the project plan and timetable, the design development stage of the project failed to achieve the outcomes desired.

A summary of the project can be seen in *Table 1*. This summary includes the short- and long-term outcomes achieved within each area of design focus. Alongside each are the key company characteristics and business context features that were found to impact the outcomes. As previously noted this summary has been taken from observations made during the authors two year employment at the company.

Table 1: The Design Outcomes and Influencing Factors relating to Each Area of Design Development

Eco-Design Focus	**Project Outcomes – Short Term**	**Impacting Company Situation Factors**	**Project Outcomes – Long Term**	**Influencing Company Situation Factors**
Reduce Aerodynamic Drag	- Aerodynamic study - Aerodynamic fuel and tuft testing - Figures for marketing	- High and recent investment in new manufacturing capabilities, project out of sync with company R&D cycle. - No detailed aerodynamic testing capabilities.	- Introduced aerodynamics as a competitive issue within the market. - Inspired aerodynamic developments from competitors. - Informed management.	- Highly competitive industry but no existing eco-design capabilities.
Reduce Weight	- Supply chain informed of weight reduction goals. - Reduced weight, reduced function model launched on to the market.	- Low influence within supply chain. - No material testing and optimisation capabilities. - No capabilities to analyse the products complex weight/impact relationship.	- Further weight reductions achieved by existing design development team.	- Product development team with existing experience in weight optimisation. - Clear market appeal for low weight design.
Reduce Rolling Resistance	- Improved understanding of issue internally and within supply chain.	- Low influence within supply chain. - Pending legislation creating a pause in tyre development.	- Future development potential established. - Informed management team.	- Future legislation due to drive development in the supply chain.
Reduce Use of High Impact Materials	- LCA results. - Aluminium identified for review. - Focus communicated to supply chain.	- No formal material information capabilities within company. - No established sources of environmental information.	- Contribution to marketing message when major aluminium component was replaced with GRP.	- Informed management team.

To complement the information contained in *Table 1* and improve the readers understanding of the issues, the following section details particularly relevant examples.

4.1 Reducing Aerodynamic Drag

In this project reducing the aerodynamic drag of the current design was largely influenced by the company's recent completion of a significant design and development project. This limited resource availability and company motivation for significant design or manufacturing alterations and yet this was only uncovered as design concepts began being rejected by the company. The company also had no high tech aerodynamic testing or life cycle assessment capabilities, making it difficult to prove the aerodynamic benefits of subtle design changes and hindering the ability to gain company support.

4.2 Reducing Weight

Weight reduction has always been a significant feature for this product's development and is an area of constant development and competition within the industry. However when a weight analysis highlighted that it was the 'bought-in' components that made the greatest weight contribution, improvements became dependent upon the company's relationship with their suppliers. Due to the company's small size relative to many of their suppliers (particularly those who supply high weight appliances) and their low order numbers, their level of influence was limited. This was also an issue when addressing tyre rolling resistance due to the global nature of the tyre business.

Despite this the managing director was keen to explore weight reductions due to the belief that the use of a smaller towing vehicle would open up new markets. In pursuit of this goal a reduced function product was developed that achieved an 8% weight reduction and 10% cost reduction compared to the equivalent model. This product was launched a month before the completion of the KTP project, but due to low market demand it was discontinued shortly after launch. The company then conducted another development project that made weight a priority, but retained functionality, and utilised existing expertise within their design and development teams to develop it. This range was launched after the KTP project and achieved weight reductions of between 6 and 8%. It is still on the market today.

4.3 Minimising High Embodied Energy Materials

The introduction of environmental materials was hindered by two wider business factors. The first was the novelty of environmental information both within the company and their supply chain (who had been the primary source of new material information to date). The second was the limited use of material data in general throughout the company.

Addressing the novelty of environmental information to those throughout the product lifecycle required better understanding of the environmental impacts of materials from those within the company and yet the project did not provide the time or resource for this. Addressing the companies use of material data and establishing systems to allow better data use, could also be viewed as an additional project, more focussed on internal capability development and cultural changes than eco-design. Within the goals and focus of this project, environmental information was requested from all suppliers and a new material search was conducted. However due to the set-up of the project this was done separately from the day-to-day operations of the company meaning that there was a 'business as usual' approach to material selection taking place elsewhere. This limited knowledge transfer because it undermined the importance of this work and failed to motivate those in the company and those in the supply chain to take an active part.

4.4 Reviewing the Outcomes and Influencing Factors

From the previous section we can see that this project did achieve outcomes, however if we compare these outcomes with the project goals as shown in *Table 2* we can see that these achievements were limited, and tended to involve little embedded change.

What this analysis shows is the application of a highly adventurous project that failed to appreciate the novelty of environmental considerations, the complexity of the issue and the company capabilities required to make eco-design happen. While the project outcomes included the market launch of an environmentally improved product, this proved to be commercially unsuccessful, and as the project focus was geared more towards product development than knowledge transfer, the company is likely to struggle to build on this progress independently.

Table 2: A Comparison Between the Desired and Actual Project Outcomes

Desired Project Outcomes	Actual Project Outcomes
New low impact prototype.	New reduced function, weight and cost model taken to market. Management team aware of environmental impacts of product.
Reduce impact of manufacturing process.	Management team aware of environmental improvements achieved by existing design changes and options for further improvements.
Reduce impact and cost of product use.	New reduced function, weight and cost model taken to market. Market demand found to be low.
Tackle strategic design issues.	Weight reductions prioritised within new product development.
Design the new product family for 2012.	Environmental issues were raised within industry for the first time. Suppliers, press, competition and customers discussing the environment.
Increase market share.	Environmental activities promoted in marketing material. Company were the first to do this.

5 IMPROVING OUTCOMES BY MAPPING THE COMPANY CHARACTERISTICS AND BUSINESS CONTEXT

5.1 Re-designing the Project to Better Match the Company

Having identified a misalignment between the company situation and the project focus, *Table 3* examines the project goals and structure in more detail. This retrospective exercise shows how the project could have been designed to better represent the company's characteristics and business context. It is believed that these alterations would have resulted in higher impact outcomes that were better embedded in the company.

Table 3: Investigating how the project could have been better mapped to the company characteristics and situation

Company Situation Factors	Projects Impact on Outcomes	Project Alteration
Family run business with a hierarchical management structure with strong management control.	Project outsourced design to Associate, in contrast to normal working procedure.	Simplified LCA results fed into *existing* R&D decision making process. Closer development with existing team.
Cost-, performance- and customer feedback-driven design development process.	LCA results were not weighted against existing business drivers, resulting in a disparity between the project and company goals.	Focus on clear business-environmental win-wins to help improve company support and build a case for environmental improvements.
Low level of influence over many important suppliers.	Project failed to appreciate the importance of supply chain relationship in achieving environmental goals.	Map relationships with key suppliers to help identify potential collaborations and set realistic goals.
High and recent investment in new design and manufacturing.	The company's new product development (NPD) cycle and recent business activity not addressed in project plan.	Map existing design and development process and NPD cycle. Mapping of recent activity to determine current point in this cycle.
Environmental issues new to company.	Project applied a full eco-design product development project on a company with no existing capabilities. Project was separated from the day-to-day operations of the company.	Map current eco-design capabilities and prioritise knowledge transfer to development of these capabilities. Reduced scope to allow greater focus on important areas.

5.2 Company Profiling to Improve Eco-design Pilot Projects

Table 3 identifies a failure to understand and address the long term company characteristics and short term business context within which this project was taking place. This resulted in a project that had unrealistic goals and a structure that tended to impose eco-design rather than support it. This finding implies that better company profiling at that start of the project would have improved its outcomes. In response to this finding a Company Characterisation Process has been developed as shown in Figure 3.

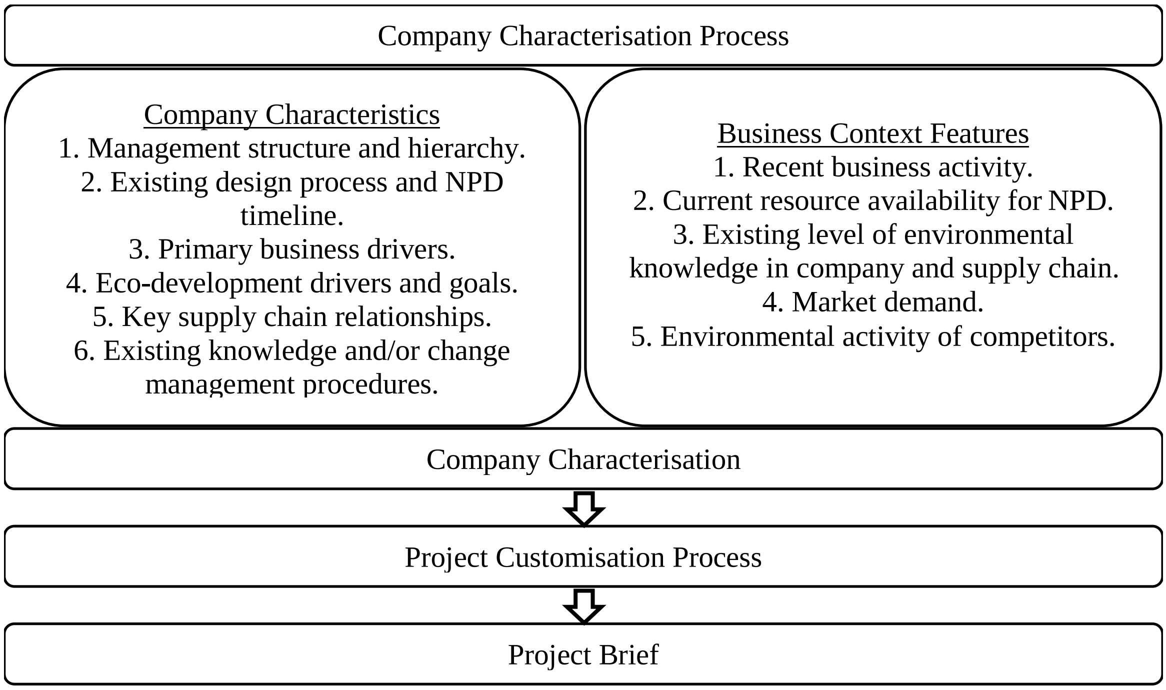

Figure 3: Company Characterisation Process developed from the case study review and its relationship to the start of a pilot project.

This characterisation process provides an overview of prominent the features found, in this study, to impact pilot project outcomes. The company characterisation it produces aims to improve the goals and structure of pilot projects to ensure that they address the current needs of the company within which they are taking place. This process acknowledges the scope of eco-design and the level of change many companies must go through to adequately address environmental development. It also appreciates that a pilot project is a contribution to this development, not the development itself. This research outcome aims to support those working on or developing eco-design pilot projects and improve their ability to introduce and embed eco-design practices.

6 CONCLUSIONS

This case study review has identified the important role of the pilot project in the introduction and embedding of environmental design practices. Through the review of a project that failed to achieve the desired level of embedded change, this paper has shown the importance of understanding the company characteristics and business context within which the project is taking place.

To help future projects in this understanding a Company Characterisation Process has been developed and key company characteristics and business context features have been identified. The aim is to promote understanding of these features, and encourage the development of eco-design pilot projects whose goals and structure support greater embedded change.

This paper documents the first stage of a wider research project and its findings are based on a single case study. Future work will seek to test these findings within varied commercial contexts. Identified areas of future work include:

1. Examination of the relationship between company characteristics and business context to help determine their weighted impact on project outcomes.
2. Examination of the relationship between the goals and structure of the pilot project to help determine their weighted impact on project outcomes.

3. Improvement of the Company Characterisation Process by applying it within introductory pilot projects in multiple commercial contexts.
4. Use data to develop a generally applicable project optimisation tool that maps eco-design projects to specific company profiles.

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