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Modular route bus design – A method of meeting transport operation and vehicle manufacturing requirements

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ABSTRACT

This research examines the problem of route bus specification and vehicle manufacturability. In order for bus operators to provide transport services, a range of vehicle configurations must be available from bus manufacturers, generating variety which has a negative impact on the manufacturing process. Larger part inventories, uncontrolled labour tasks and more troublesome maintenance are known impacts of this variety. This research identifies the functional necessities in route bus interior design and reduces the problems in bus manufacture and operation caused by specification diversity by proposing a modularised system of bus design. In particular, it makes recommendations as to how bus configuration should be carried out, ensuring an optimum mix of operational and manufacturing needs:

1. Determine user needs *before* the bus specification process.
2. Designs to be developed by the *manufacturer* in response to user needs.
3. This design should be *standardised* where possible, as suggested by the user needs.
4. Where user needs dictate product variations, apply a *mass customisation* approach to accommodate these needs.

The recommendations are communicated in design proposals for a modular bus interior, demonstrated by four cases designed to meet the present status quo of bus interior design and predictions for the future of the field.

1. Introduction

Route buses are an integral part of transportation systems. The ubiquity of roads means buses can offer an inexpensive and versatile means of public transport (Griffin et al., 2005). Bus vehicles are capital goods, machinery used to produce a commodity (Acha et al., 2004). Manufacturers make buses – operators provide transport. The nature of bus operators varies from government organisations to small family businesses; they are typically responsible for the operation of buses in a defined geographical area to create transport service. Operators must work within the constraints of their locale and business strategy; reflected in varied methods of operation and marked physical variations in bus vehicles.

This research investigates *body-on-chassis* or *bus bodywork* manufacture, characterised by the fabrication of a bus body on a supplied chassis. This manufacturing methodology is typical in countries where markets cannot support widespread investment into chassis manufacturing capabilities. In the Australian context, the majority of chassis are manufactured in Europe and shipped to the bodywork manufacturer. European chassis are considered market leaders in this area (Vuchic,

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1981). The Australian bus market is dominated by bus bodywork manufacturers, although alternatives are available in the form of locally made complete buses.

The research problem is that specification diversity in route bus bodywork increases the costs of product development, erodes economies of scale, and increases lead times and overall production times in bus manufacture. The result is a more expensive and troublesome vehicle to purchase and maintain. This research sets out to determine a bus interior design providing appropriate vehicles for operational purposes, while ensuring that the vehicles are also capable of efficient manufacture.

Bus variation is manifested in several ways. Vehicle length varies as a result of road-form constraints and desired passenger capacity. Changing components such as doors and air conditioners allows bus operators to meet different functional requirements, the result being vast variation across the product range. In addition to explicit functional needs, bus operators may also have a company history or culture dictating a particular specification, such as floor materials and livery. These variations continue to create unique vehicles.

To the layperson and passenger, bus variation may well be invisible. Their perception is of a vehicle providing the transport commodity; and of being moved from origin to destination. The present aim of bus design is to facilitate manifestation of this service. The commodity-centric view of transport, and in particular bus transport is however changing by becoming attuned to the qualitative requirements of transport, particularly with reference to competition from the private car (Beirão and Sarsfield Cabral, 2007) and light rail (Hensher, 1999).

Variation in bus design is necessary at present to mitigate the discrepancy between bus vehicles and operator needs; ultimately enabling the operator to offer the passenger consistent service. In addition, by specifying the exact nature of its capital goods, the bus operator can integrate the bus into their operational strategy. For example, a bus operator might instigate a particular material specification allowing it to schedule vehicle cleaning around evening shifts, or the design of a driver's area may be more in keeping with union requirements for driver safety – a factor that affects the passenger indirectly rather than directly. Specification is often driven by historical precedent in operator companies, which may be functionally justified as in the case of wanting to use the same chassis marque (brand) to rationalise maintenance programmes, or culturally justified by means of family company history. One example of this – the bus interior – shows significant variation in configuration, and in the part inventory used to accommodate this variation.

In present form, bus bodywork manufacture is highly labour intensive, requiring many skilled tradespeople in various capacities. This is coupled with a considerable amount of engineering, sales and administrative work prior to commencement of build. Bus specification requires extensive negotiation between sales, engineering and the operator, supported by preparation of contracts for delivery and payment; conditions repeated across a variety of orders from bus operators. These conditions have precipitated a bespoke system of manufacturing, distinguished by variety in procedures, parts and the finished product, despite the processes having similarities and the end product being functionally identical to the next – a bus.

At present, operators' specifications are communicated to the manufacturer by means of the sales process and given form in the engineering department before production. While this may appear simple in its linearity, the information passed through this process changes at every stage. Thus, by seeking to intervene in bus design this paper also aims to address the process of bus specification, as shown in Fig. 1. Although the bus may appear somewhat reactionary to specifications,

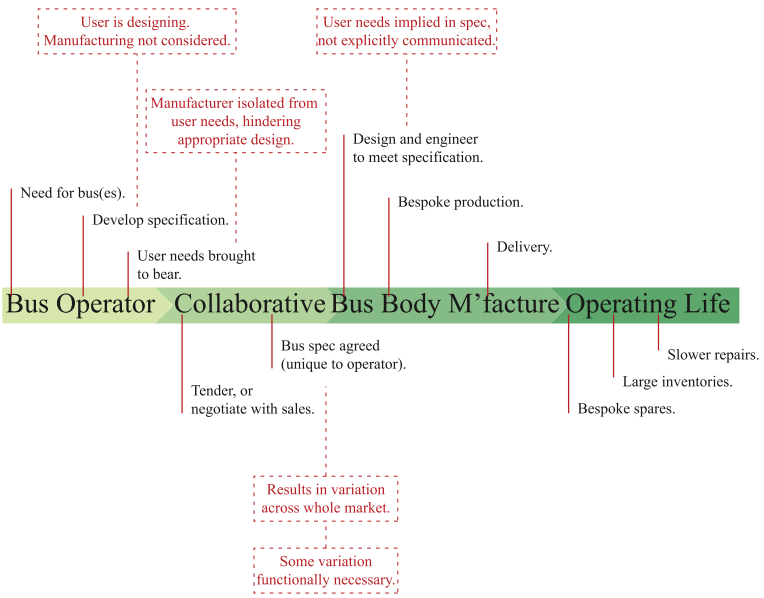

Fig. 1. The typical Australian bus bodywork specification, design, and manufacture process.