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>> *Interior design proposal for the **Hulme F1 supercar***

Kenneth Young © 2008

A written component completed in partial fulfilment of the requirements for the degree of Masters of Design at Massey University, College of Creative Arts, Wellington, New Zealand.

Approximate word count: 19,650

Abstract

This research project focused on the development of an appropriate interior design proposal for the Hulme F1 supercar. The Hulme F1 supercar, originally designed by Hulme Supercars Ltd, draws exterior design references from contemporary Formula One Grand Prix race cars. In addition, the Hulme F1 supercar integrated visual design cues expressing luxury, high-performance and exoticness. The existing design established the package, window openings, basic controls and door architecture for this study.

Based on this material, the interior study focused on an overall aesthetic and its integration with ergonomic, technical and functional requirements. The conceptual nature of this project allowed for the inclusion of speculative and experimental design proposals that were not constrained by local contemporary manufacturing and economic issues. Consequently, the project based itself on a technological forecast of five to ten years.

Research first explored and defined several key design motifs central to the Hulme F1 supercar. This involved studies into supercars, luxury, high-performance, exoticness, contemporary Formula One Grand Prix racing and the existing exterior form language. The results from this research established initial themes for development of the interior design proposal.

A review of contemporary theory in visual product communication and experience was undertaken to identify an appropriate framework for this investigation. The research of Monö (1997), Norman (2004a) and Warell (2007) was reviewed. Review

focused on two areas; a structure appropriate for defining design criteria and a comprehensive framework for visual analysis of exemplars to identify visual design trends. The Visual Product Experience (VPE) framework by Warell offered the most appropriate visual framework for this investigation.

Using the VPE framework, a visual analysis of contemporary luxury motorcars, professional race cars and supercars was undertaken. Analysis focused on interior and interior/exterior related design trends. Findings illustrated that luxury motorcars have simple aesthetic compositions with frequent interior/exterior form element repetition. Conversely, professional race cars have complex aesthetic compositions with minimal interior/exterior form element repetition. Meanwhile, supercar interior aesthetics and appear to vary between these two spectrums depending on their overall aesthetic expression. To this end, the analysis illustrated the opposing visual qualities between luxury and high-performance.

This suggested the interior design proposal required a delicate balance between complex and simple aesthetic elements to obtain an appropriate overall visual expression. Consequently, the interior design proposal used a combination of flowing soft surfaces and complex detailing to express luxury and high-performance.

Research also established criteria for the design of interior functional systems required within the interior design proposal. Interior functional systems included control, body-support, display, storage and safety systems.

The development process for the interior design proposal consisted of iterative

design methods. This included concept generation, concept development and three-dimensional form studies. Throughout the development process, concepts were screened against design criteria in order to further direct the iterative process.

Contemporary Formula One race car illustrated an abundance of visual inspiration for the interior design proposal during the development process. Elements such as exhaust and aerodynamic wing details were referenced within the interior design proposal. The intent of this was to create visual harmony between interior and exterior aesthetics.

Research into ingress and egress found a conventionally fixed steering unit impeded participants. As a result, the final design proposed a steering unit that swung towards the centre of the interior for greater entry/exit space.

The interior design proposal was assessed by internal and external ‘design evaluation’ methods. Testing indicated that the interior design proposal had fulfilled most of the experience and performance design criteria and achieved the aim of this research.

Overall, this investigation designed an interior design proposal to compliment the exterior design of the Hulme F1 supercar. The interior design proposal was supported by visual framework developed from this research investigation. In addition, the investigation proposed functional and ergonomic solutions to support the interior design proposal.

Keywords: Supercar, aesthetics, interior, visual product experience, expression, design.

Acknowledgements

I hereby acknowledge the following for their contribution to this research investigation;

- Siu Lan Young
- Wayne Young
- Joy Yang
- Professor Tony Parker
- Associate Professor Dr Anders Warell
- Jock Freemantle
- Fellow Postgraduate students
- Hulme Supercars Ltd.
- Total Experience Inc.
- Formula Challenge Events Ltd.
- The Industrial Design department at Massey University, College of Creative Arts, Wellington

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Reading guide

The overall purpose of this written component is to compliment, document and present creative design work undertaken during this study. Research data is analysed and discussed to inform the design process of issues relating to perception, functionality and ergonomics. Ultimately, this written component provides background support and context for the decisions made during design work.

This written component is structured into 13 main sections. For an overview of this written component, the content of each section is also outlined within Figure 001.

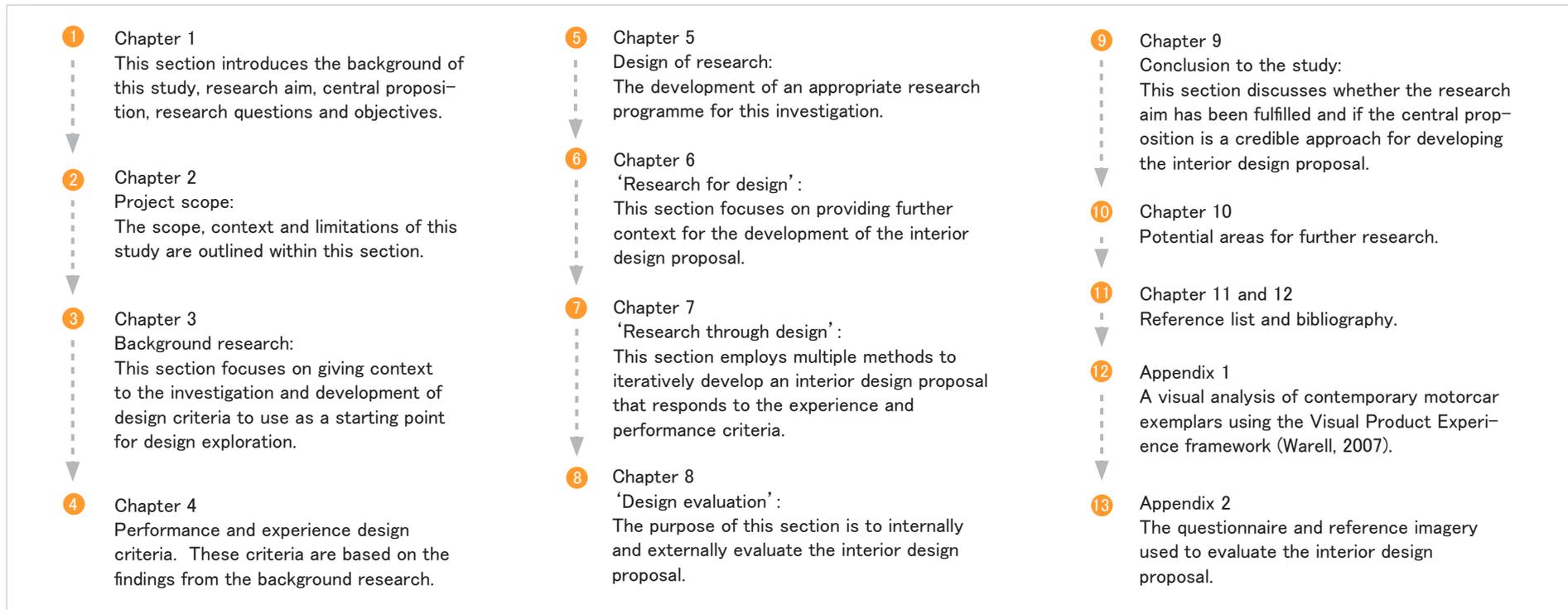


Figure 001. Reading guide.



Figure 002. (Above) Hulme F1 supercar exterior body – (Below) Hulme F1 supercar package. (Supercarsnz, 2006).

1.0 Background to the study

The Hulme F1 supercar (Figure 002) is designed to be an exotic, luxurious and high-performance supercar with the aesthetic expression of a contemporary Formula One race car. Thus far, design development has focused on the exterior aesthetic and overall package. Consequently, greater design focus is now required for the interior occupant cabin. This represents a considerable opportunity for further development, especially since motorcar interiors are becoming an increasing point of difference in the design of contemporary motorcars (Lewin, 2003, p.56).

1.1 Research aim

The aim of this investigation is to develop an appropriate conceptual interior design proposal for the Hulme F1 supercar with emphasis on visual styling.

1.2 Central proposition

This investigation intends to develop an interior design proposal based on experience and performance criteria. The experience criteria are to focus on appropriate visual expressions for the interior design proposal. To give these experience criteria context, research will explore the existing Hulme F1 supercar exterior aesthetic and discuss its implications towards the interior design proposal. Meanwhile, the performance criteria are to focus on basic functional and ergonomic issues required to support the interior design proposal. The interior

design proposal is to be developed and presented by means of iterative design work.

1.3 Research questions

The following research questions are the focus of this investigation:

- What visual aesthetic is appropriate (and inappropriate) for the interior design proposal?
 - What does the exterior aesthetic communicate or express?
 - How should the interior relate aesthetically to the exterior?
 - How have other exemplars addressed this issue?
- What functional and ergonomic solutions are required to support the interior proposal?

1.4 Research objectives

The following research objectives are the focus of this investigation:

- Develop design criteria describing the desired experience and performance requirements for the interior design proposal.
- Produce a three-dimensional aesthetic model of the interior design proposal (1:2 scale) in response to the design criteria.

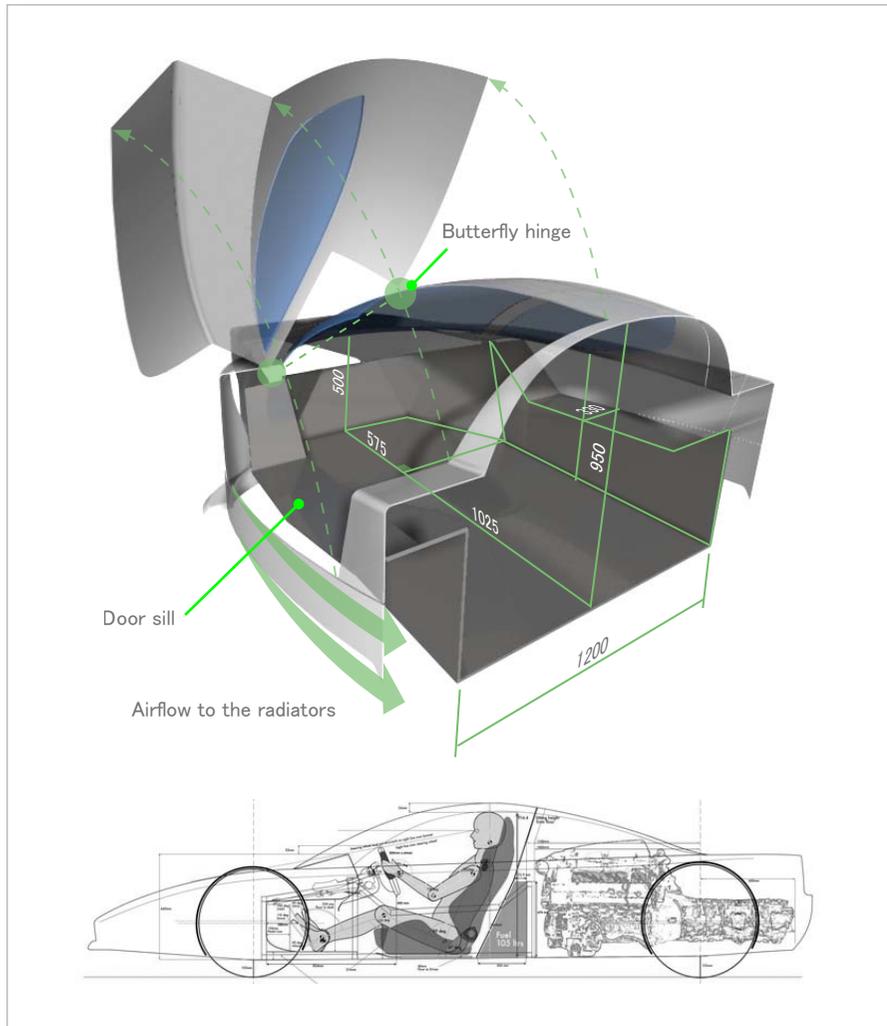


Figure 003. (Above) Interior cabin dimensions – (Below) Hulme F1 supercar package.

2.0 Project scope

This section defines key physical, sociocultural and marketing parameters surrounding the investigation, namely (in sequential order):

- Hulme F1 supercar package
- Hulme F1 supercar interior cabin dimensions
- Overall door architecture
- Interior functional systems
- Technology and material forecasting
- The Hulme F1 supercar brand
- Hulme F1 supercar intended target market

Hulme F1 supercar package

The Hulme F1 supercar package is similar in configuration to many contemporary supercars; with a mid-mounted engine, long wheel-base and forward cabin designed to accommodate two occupants ranging from a 95th percentile stature male to a 5th percentile stature female (Figure 003).

One distinct characteristic of the Hulme F1 supercar package is the high (and wide) door sills. High door sills provide enhanced chassis rigidity, torsion resistance and airflow to the radiators. In the interest of superior vehicle dynamic performance the door sills remained unaltered in design.

Hulme F1 interior cabin dimensions

Figure 003 illustrates the overall interior dimensions of the Hulme F1 supercar interior cabin. The following are the overall major dimensions of the interior:

- Overall cabin length: 1600mm
- Overall cabin height: 950mm
- Overall cabin width: 1860mm (including the width of both door sills)

Overall door architecture

The Hulme F1 supercar design incorporates butterfly hinged doors (refer to Figure 003). In addition, the door structure makes it necessary for the side windows to lower using a front mounted pivoting mechanism (Figure 004).

Interior functional systems

The interior design proposal must also incorporate the following interior functional systems within the interior cabin (Figure 005):

- Control systems (Primary control systems, secondary control systems, information display systems, direct and indirect vision systems)
- Body support systems
- Ingress/egress systems

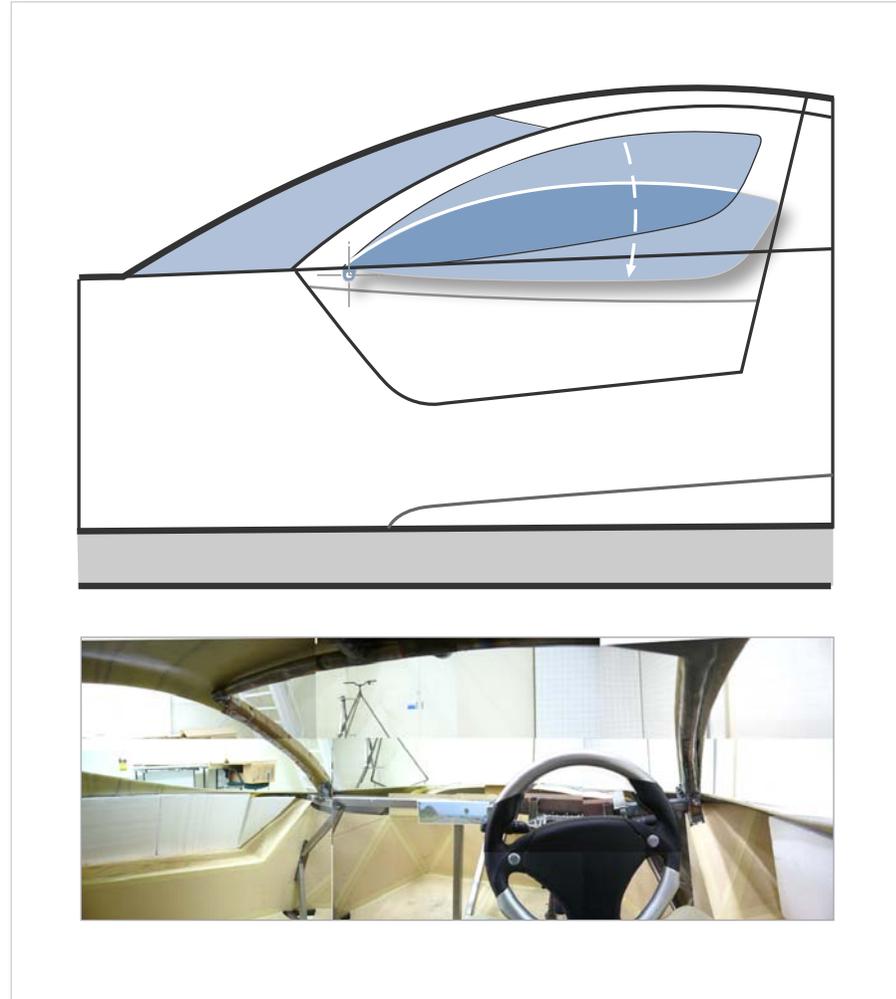


Figure 004. *Hulme F1 supercar window openings.*



Figure 005. Interior mockups of the Hulme F1 interior cabin.



Figure 006. (Left) Denny Hulme – (Right top) McLaren M6A (1967) – (Right bottom) McLaren M14A (1970).

- In-car storage systems
- Occupant safety systems (passive and active)

Technology and material forecasting

Technologies, materials, processes and design for manufacture issues are considered at the level of technical feasibility. The investigation focuses on the use of current or foreseeable (five to ten years) state-of-the-art technologies and/or materials.

The Hulme F1 supercar brand

The Hulme F1 supercar concept is designed and produced by Hulme Supercars Ltd. Hulme Supercars Ltd is a relatively young company with little brand heritage (established in 2003).

The Hulme F1 supercar (and brand) is dedicated to the late Denny Hulme (1936–1992) who is to date New Zealand's only Formula One World Champion (1967). Internationally, Denny Hulme is a well known and reputable motorsport personality. His personality and achievements provide an immediate level of recognition and authority to an otherwise little known manufacturer.

Hulme F1 supercar target end user

The Hulme F1 supercar has been designed for a specific niche market and end user group who may frequently indulge in premium or exotic products such as those illustrated in Figure 007. The following are typical characteristics of the target end user:

- Typically male
- Very high disposable income
- High cost threshold for purchasing goods
- Risk-taker and thrill-seeker
- Appreciates and can afford luxurious and exclusive products
- Constantly seeking an expression of exclusiveness, prestige and recognition through the ownership of luxurious and exotic goods
- Exotic motorcar collector
- Motor racing enthusiast
- Appreciation for high-design and exotic engineering

Access to a significant sample of potential end users who fulfil this profile was not possible. Few people in the world are affluent enough to afford supercars and most are situated outside of New Zealand. As a consequence, end user observations, feedback and testing are not a central focus of this investigation. Instead, the frame of reference to design for this market is based on relative benchmarking of products with similar or desirable characteristics.

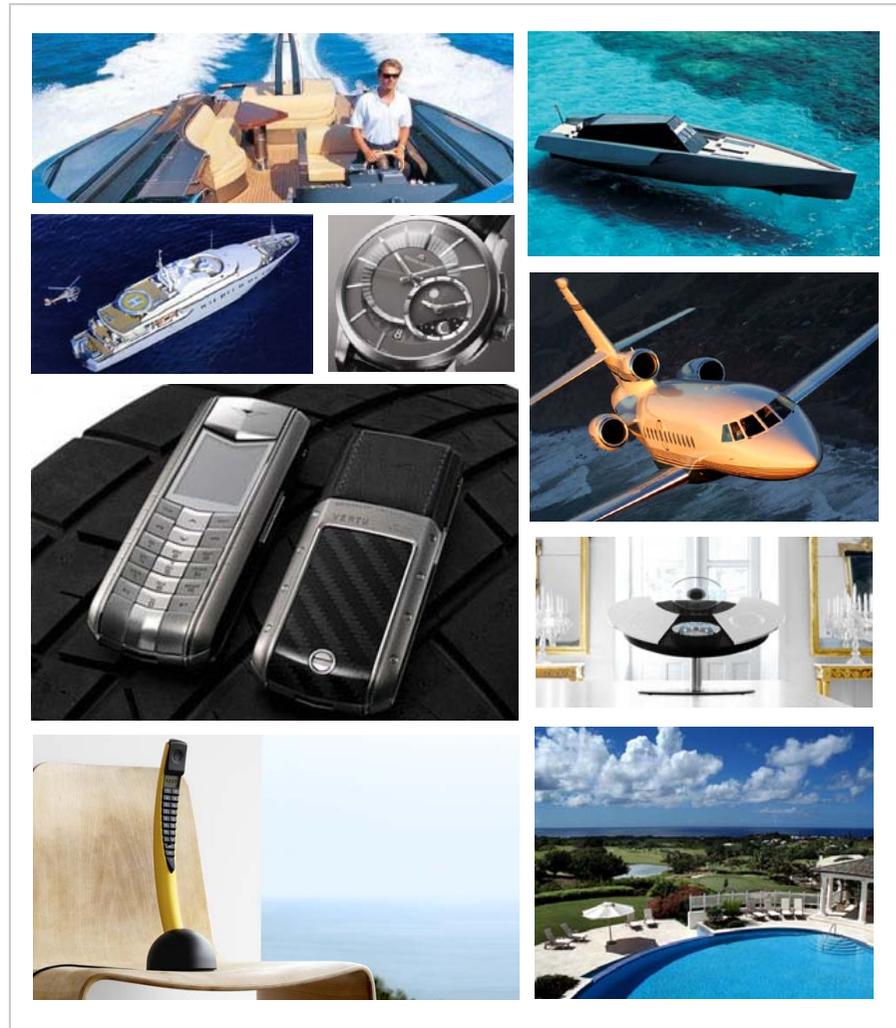


Figure 007. *Luxury and exotic goods the target end user would use or purchase.*

2.1 Initial design criteria

The following is the initial design criteria for the interior design proposal:

- The interior must accommodate two occupants ranging from a 95th percentile stature male to a 5th percentile stature female.
- The interior design proposal must base itself on the proposed Hulme F1 supercar package, door architecture and functional systems (as mentioned previously).

The initial design criteria for the interior design proposal focused on basic packaging issues, with no emphasis on desired visual characteristics or styling. Therefore, as outlined within the central proposition, a focus of this investigation is to develop additional experience and performance design criteria for the interior design proposal.

3.0 Background research

This section aims to provide background context for further research and to formulate design criteria for the interior design proposal. The following areas of research are explored (in sequential order);

- A general understanding of the Hulme F1 supercar motifs¹
- Contemporary theory on visual product communication and experience
- Visual analysis of motorcar aesthetic exemplars relevant to this study
- Contemporary theory on the design of interior functional systems

Figure 008 further describes the stages undertaken during the background research.

1. The term “motif” is defined as “A distinctive, significant or dominant theme or idea ... in a composition or design...” (Oxford, 2002, p.1840). Consequently, the term motif is used to umbrella central themes, ideas or concepts behind the Hulme F1 supercar.

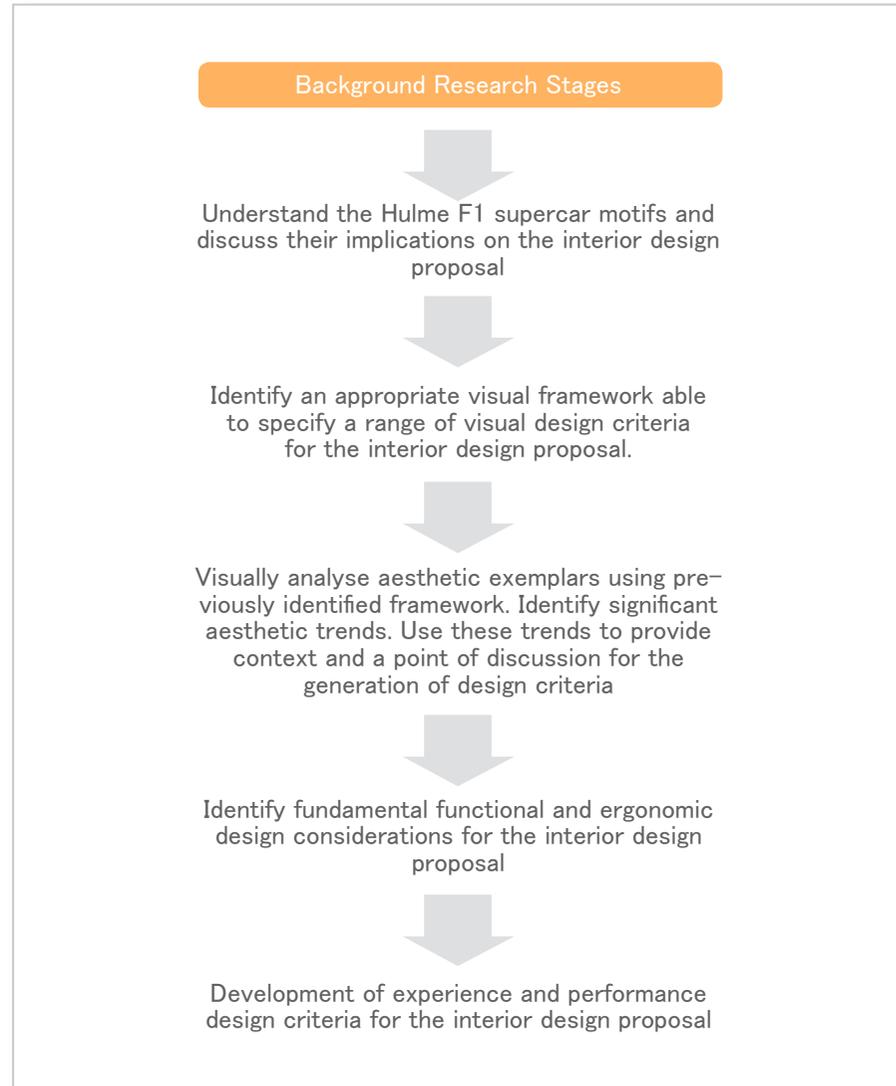


Figure 008. *Background research stages.*

3.1.0 Hulme F1 supercar motifs

The Hulme F1 supercar is designed to be an exotic, luxurious and high-performance supercar with strong visual references to contemporary Formula One race cars. These central qualities of the Hulme F1 supercar are expressed as design motifs.

This section aims to establish a general understanding of each design motif, establish their significance to the Hulme F1 supercar exterior design and discuss their implication of use in context to the interior design proposal. The following design motifs are the focus of this analysis:

- The “Supercar” marque
- Exoticness
- Luxury
- High-performance
- Contemporary Formula One Grand Prix racing
- Hulme F1 supercar exterior form language

3.1.1 The marque of motorcar; the “Supercar”

Since the Hulme F1 is designed as a supercar, understanding the supercar motif is central to this investigation. This investigation examines a range of contemporary supercar definitions from a variety of academic and automotive sources to gain insight into the supercar marque. Examples of these definitions are as follows:

- “... a high-performance sports car ...”
(Oxford, 2002, p.3111).
- Supercars reside at life’s uppermost edge, the stratosphere in a rarified world of passion, measured by beauty, power, performance and wealth... just beyond everyone’s reach. Supercars are sexy and powerful. Supercars are generally uncomfortable, loud, fast, and violent...
(Schewartz, 2004).
- ... A supercar has to be visually arresting, needs to attract attention when standing still, in a parking lot or at the side of the road... a true supercar will also catch the eye of those who have little interest in great feats of motor engineering... Finally, it should be fast – very fast...”
(Dragonmotorcars, 2005).
- ... exceptional performance, very high price, less than four seats, and a genuinely exotic design aesthetic... This exotic aesthetic not only



Ferrari Enzo (2002)



Pagani Zonda F (2005)



Bugatti Veyron (2006)



Audi R8 (2006)

Figure 009. Contemporary examples of ‘supercars’.

contributes to the definition of the genre, but the central value that any supercar delivers to its owner, driver and audience... dynamic proportions, expressive forms, and exuberant detailing... extremely low height, great width and a far forward cabin.

(Livingstone, 2006).

Each definition (above) offers a different interpretation of supercars. Visual research into contemporary supercars illustrates a diverse range of interior and exterior visual aesthetics (refer to Figure 009). For example, the interior aesthetic of the Ferrari Enzo (Figure 009) appears spartan or utilitarian, with large areas of unadorned carbon fibre composite and a steering wheel embellished with various controls. Conversely, the Bugatti Veyron 16:4 (Figure 009) interior appears more luxurious in expression, with a lavish use of leather and rich metal accents.

This analysis suggests that contemporary supercars have various expressions and do not have a 'generic' visual aesthetic (aside from overall proportions). Despite this, several recurring characteristics were identified. These characteristics are as follows:

- An exotic design aesthetic with dynamic proportions (low height, great width and far forward cabin).
- High dynamic performance.
- Use of expensive, rare and exclusive materials.

Consequently, using these characteristics, this investigation defined the term supercar as;

“a motorcar with an exotic aesthetic, dynamic proportions, high dynamic performance, is rare in the market and very expensive”.

Using the definition above as reference, an initial analysis of the Hulme F1 supercar exterior (Figure 010) illustrated genuine supercar characteristics (an exotic Formula One style aesthetic and dynamic proportions). This was significant for two reasons. Firstly, the supercar definition formulated above affirms the exterior aesthetic of the Hulme F1 supercar. Secondly, with the Hulme F1 supercar exterior design reflecting the characteristics of a contemporary supercar, it indicated that the interior design proposal should adopt similar supercar characteristics to maintain a common overall product archetype.

The proposed supercar definition does not explicitly describe aesthetic qualities associated with this class of vehicle. The most notable aesthetic criteria is ‘exoticness’. This raised two issues for the interior design proposal. Firstly, what visual level of exoticness is appropriate for the interior design proposal? And secondly, how should the exotic interior aesthetic compliment the existing exterior aesthetic? These issues require further investigation and exploration beginning with an introduction to the term ‘exotic’.



Figure 010. *Hulme F1 supercar*. (Supercarsnz, 2006).



Figure 011. *Exploration into the term 'exoticness'.*

3.1.2 The definition of 'Exotic'

Exoticness is a central quality for supercars and consequently the interior design proposal. The following definition was used to establish a general meaning for exotic;

- "... strikingly different, attractively unusual; glamorous... now rare..."
(Oxford, 2002, p.891).

Figure 011 (top) illustrates various designs which imbue exotic qualities (with reference to the definition above). These designs demonstrate distinct use of materials and 'unusually attractive' aesthetics in context to their environment and/or design type. As a result, the term exotic is defined as:

"unusual, attractive and rare, but comprehensible within its surrounding environment and/or design type"

This definition supports the exotic quality of the Hulme F1 supercar exterior (when compared to other supercars) with its unusually strong reference to contemporary Formula One race cars (bottom, Figure 011).

The definition of exoticness does address one issue raised earlier: what 'level' of exoticness is appropriate for the interior design proposal? As stated above, the archetype of an exotic design must remain comprehensible despite having unusual

qualities. For example, the exterior design of the Hulme F1 supercar is ‘unusual’ but still can be recognised as a motorcar. This indicates that the interior design proposal also requires a similar level of recognition. In other words, the interior design proposal should integrate unusual qualities, but still needs to be recognised as a motorcar interior.

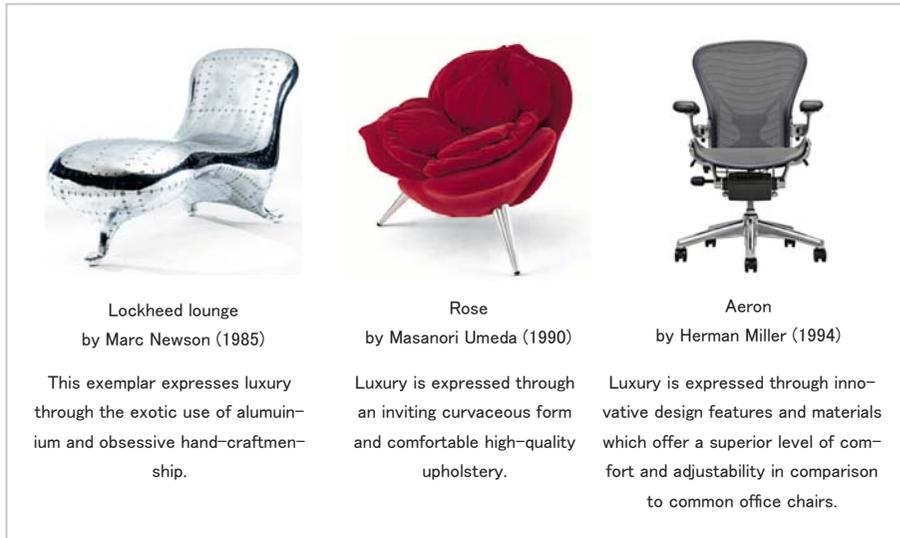
3.1.3 The definition of ‘Luxury’

The following are various definitions and interpretations of luxury:

- “... something desirable for comfort or enjoyment ... expensive ...” (Oxford, 2002, p.1655).
- “It’s now related more to well-being and is not simply an ornamental factor. We need contemporary alternatives or substitutes for materials such as wood or leather, for example aluminium and carbon fibre.”
Roberto Piatti, managing director of Stile Bertone’s. (as cited in Adcock, 2005, pp.16–17)
- “The new luxury is simplicity, but that won’t work if the tactility is poor because of junky material.”
Imre Molnar, dean of the College for Creative Studies (as cited in Adcock, 2005, p.17).

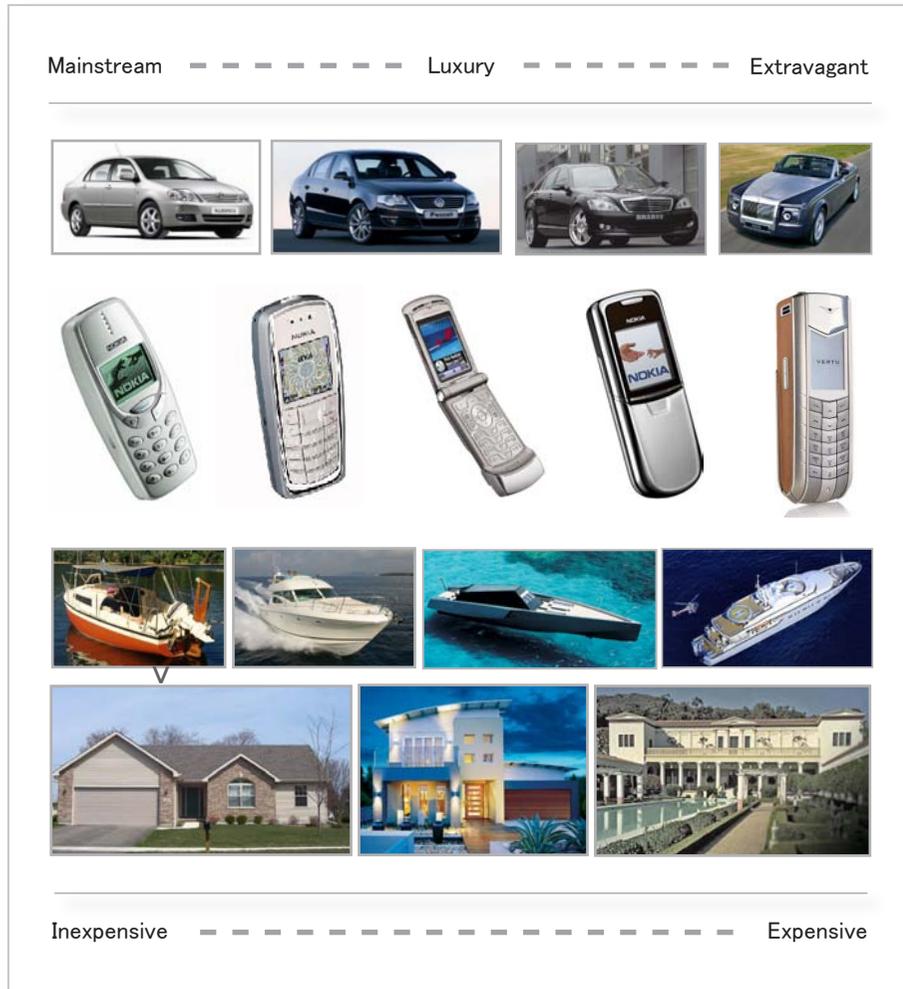


Figure 012. Exploration into the term ‘luxury’.



<p>Lockheed lounge by Marc Newson (1985)</p> <p>This exemplar expresses luxury through the exotic use of aluminium and obsessive hand-craftmanship.</p>	<p>Rose by Masanori Umeda (1990)</p> <p>Luxury is expressed through an inviting curvaceous form and comfortable high-quality upholstery.</p>	<p>Aeron by Herman Miller (1994)</p> <p>Luxury is expressed through innovative design features and materials which offer a superior level of comfort and adjustability in comparison to common office chairs.</p>
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Figure 013. Examples of chairs which express luxury in different ways.

Figure 014. *Continuum of 'Luxury'*.

Each definition illustrates a slightly different interpretation of luxury. To enrich the definition of luxury, Figure 013 illustrates three chairs. Each is visually distinct but all express 'luxury' in their own manner. The initial research found no distinct or singular concept for luxury (in a contemporary context). Therefore, further research was required to understand its meaning in context to the Hulme F1 supercar and this investigation.

Further visual research focused on the perceived value (in terms of luxury) of products within their product groups as illustrated in Figure 014. Although generalised, this research did illustrate several key factors for luxury products. Firstly, unsurprisingly, high price commonly appears to be a factor. Secondly, the quality and presentation of materials also plays a role in perception of luxury. This is best seen in the mobile phone category. The most extravagant models (gauged by price) integrate high quality materials such as stainless steel and leather. Thirdly, size, scale or weight is often (but not always) a factor in determining the luxurious value of a product. Examples such as super yachts or mansions clearly demonstrate this. Lastly, high levels of hedonic value contribute towards luxurious products affording characteristics such as desirability and pleasure.

As noted earlier, comfort is an associated quality of luxury. For an individual to feel comfortable they generally must also feel safe or secure. To further emphasise the issue of comfort, studies into user-product behaviour show that users tend to favour familiar designs over unfamiliar designs, for concern of safety and the unknown (Hekkert, 2006). This indicates that luxurious products require a level of

intended familiarity to imbue a degree of comfort and thus, luxury (in context to the user's associated experiences and preferences to that product and/or brand).

It is important to illustrate the importance of interpretation and meaning in relation to familiarity. To emphasize this, this researcher draws on a previous conversation with his parents. In this conversation, the researcher's parents were reflecting on an experience in the late 1960's. At this time, they had just left the Chinese province of Canton to live in Hong Kong. After arriving in Hong Kong they distinctly remembered seeing a motorcar with a strange metallic fixture on its bonnet. Confused by this object they approached the motorcar for a closer inspection. This confused them further as the fixture appeared much like an analog clock, but without the functionality.

They later discovered this fixture was a Mercedes-Benz hood ornament. With no meaningful reference to what the Mercedes-Benz logo is 'intended' to represent (a prestigious and luxurious motorcar brand), the researcher's parents simply interpreted the fixture with what they were familiar with; a strange misplaced clock on the bonnet of a motorcar (as illustrated in Figure 015). To compound this, their 'un-intended' interpretation was considered unappealing and thus, undesirable.

This discussion further emphasised the subjective nature of luxury. None the less, in context to this investigation luxury can be defined as:



Figure 015. *Unintended interpretation of a the Mercedes-Benz hood ornament logo.*

Qualities associated with ‘Luxury’

- Ease of use
 - Comfort
 - Opulent
 - Extravagant
 - High-quality materials
 - Expensive
 - Desirable
 - Meaningful familiarity
-
- Highly appropriate term to express within the interior design proposal
 - Moderately appropriate term to express within the interior design proposal
 - Inappropriate term to express within the interior design proposal
 - Term not applicable to the development of the interior design proposal

Figure 016. *The desired qualities of ‘luxury’ in context to this investigation.*

‘something expensive, desirable, comfortable, uses expensive or desirable materials and has a degree of meaningful familiarity (or association) with the user’.

This definition suggests that the Hulme F1 supercar has a number of luxurious qualities. For example, it exceeds utility and would be purchased for the purposes of pleasure, enjoyment and collection. To this end, it fulfils hedonic requirements more than practical utility. From the perspective of a motor sport enthusiast who appreciates Formula One Grand Prix racing (such as the target end user); the exterior aesthetic is likely to imbue a high level of meaningful familiarity, thereby, evoking a level of desirability. Although this assessment is somewhat subjective, it is by no means more subjective than the concept of luxury.

However, the Hulme F1 supercar does not appear to express high levels of extravagance, opulence, ornateness or ease of use when compared to luxury four door saloons or super yachts. To this end, the Hulme F1 supercar is considered to express a ‘moderate’ level of luxury.

The issue of meaningful familiarity, in context to luxury, is of particular significance to the interior design proposal. As mentioned above, the exterior aesthetic imbues a level of luxury through its Formula One expression. To this end, research deduced that the interior design proposal should share a similar reference to Formula One race cars. The intent of this is to create a coherent overall expression that maximises the user’s relationship with the Hulme F1 supercar and Formula One racing.

To conclude, the qualities associated with luxury that are considered appropriate for the interior design proposal are listed in Figure 016. Integration of these qualities also addresses an earlier issue relating to exoticness; namely whether the interior design proposal should compliment the existing ‘exotic’ exterior aesthetic? Since there is a desire for meaningful familiarity between the exterior and interior, the interior and exterior should compliment each other in a visual manner.

3.1.4 The concept of ‘High-performance’

‘High-performance’ is a commonly used term. This section examines this term in context to the Hulme F1 supercar. In particular, it considers the visual and experienced based qualities of high-performance.

High-performance sporting products (as illustrated in Figure 017) are seen as having the most relevance to this investigation, since the high-performance qualities of a supercar are sports orientated. The following are typical high-performance sport product characteristics:

- Integration of state-of-the-art materials, technologies and design to achieve maximum performance. For example, the use of materials with superior mechanical properties such as carbon fibre composites, titanium or aircraft grade aluminium.
- The design of high-performance sporting products generally focus on



Figure 017. Imageboard of ‘high-performance’ sporting products.

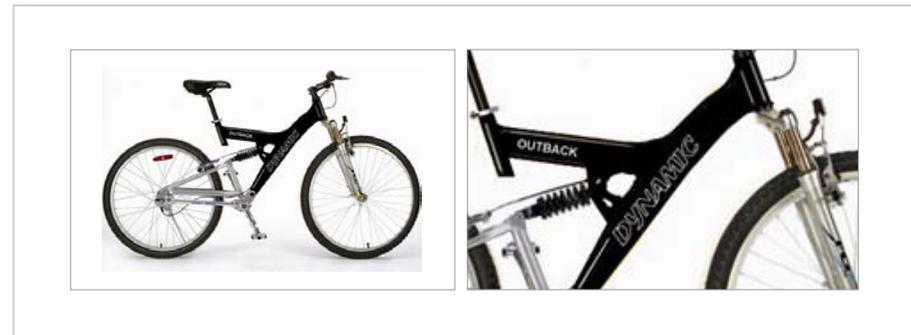


Figure 018. Outback Chainless Mountain bike. (Uncrate, 2007).

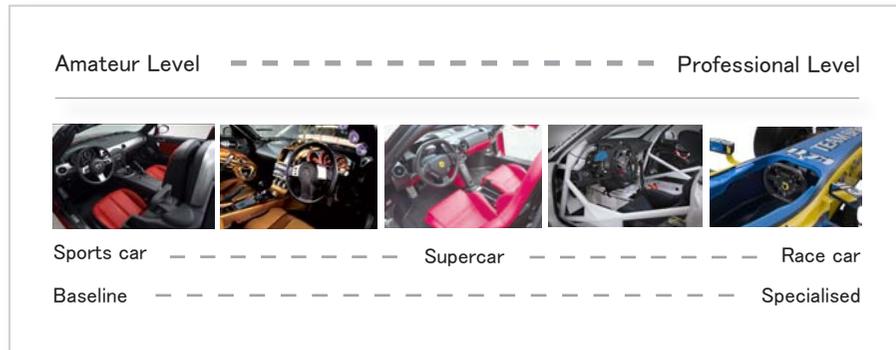


Figure 019. Differing levels of 'high-performance'.

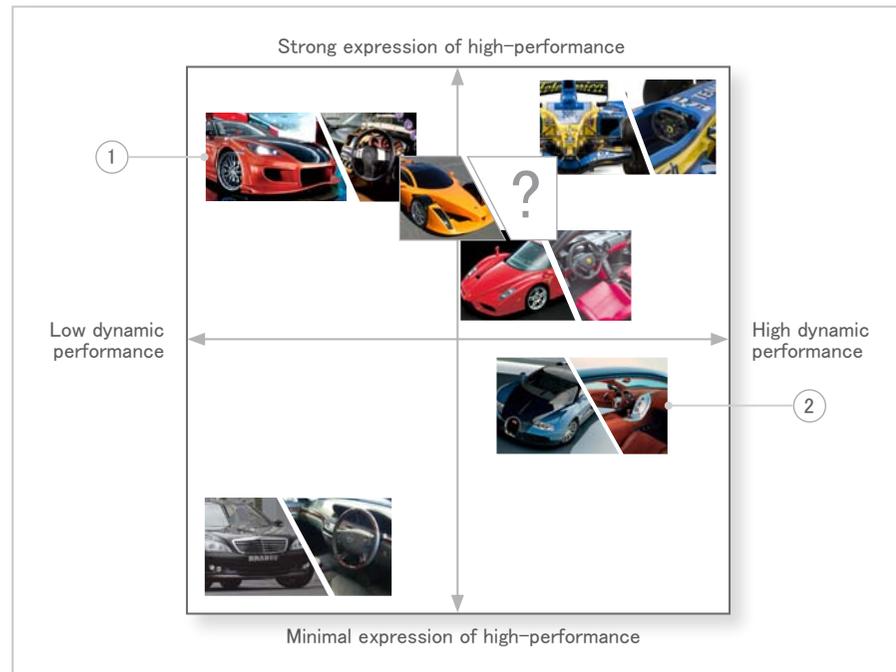


Figure 020. Visual expression against vehicle dynamic performance.

utility and functionality, aesthetic qualities develop from an engineering, ergonomic or technical orientation. For example, the mountain bike (Figure 018) appears utilitarian in design. With design features such as an exposed body frame, suspension units, no mud guard and no reference to comfort or ornamentation.

- High-performance sporting products are often designed for athletes. Expert users at their optimum fitness have a high level of mental focus and have specialised training with the use of the product.

Consequently, high-performance is defined in the context to this investigation as;

“a machine with great or above average capabilities, designed with an emphasis on utility and functionality for professional users”

The general analysis of high-performance sporting products illustrated several design issues for this investigation. Firstly, the Hulme F1 supercar is not designed for 'professional users' (as illustrated in Figure 019). Therefore the interior design proposal should not be designed to the extent that it becomes an actual high-performance race car interior.

Secondly, visual research into high-performance sporting products noted a contrast between the perceived 'suggested' level of performance and the 'actual' dynamic level of performance in some products. To illustrate this, Figure 020

positions various motorcars on a bi-polar chart comparing their visual expression against actual vehicle dynamic performance. The bi-polar chart serves as a general qualitative description, not a quantitative measure. This chart illustrates how some motorcars (i.e. the motorcar modified with after market parts, labelled 1, also seen in Figure 021) are styled to have a strong high-performance expression, but does not necessarily have the corresponding level of ‘sport orientated’ performance. Conversely, some motorcars (i.e. the motorcar labelled 2, also seen in Figure 022) has a very high level of ‘sport orientated’ performance, but is styled in a more sophisticated, understated and/or conservative manner.

To put this into context, the Hulme F1 supercar is also positioned on the chart. Its actual level of performance is based on initial technical specifications and its high-performance expression is inherently strong through the referencing of F1 race cars. The chart illustrates that the high-performance styling of the Hulme F1 supercar roughly compliments its intended level of sports orientated performance.

This raises the next issue for the interior design proposal. What level of high-performance styling is appropriate for the interior design proposal? As mentioned earlier, the Hulme F1 supercar is not designed for professional users and therefore should not be a specialised racing high-performance interior. This does not necessarily determine whether the interior design proposal should be styled to have a low, moderate or high level of high-performance expression (or anywhere in between). To address this issue, previous research into luxury and meaningful familiarity can be used to provide insight. As stated earlier, meaningful familiarity is



Figure 021. *Example of a motorcar modified with aftermarket parts.* (Autosalon, 2006).



Figure 022. *Bugatti Veyron 16:4.* (Seriouswheels, 2006a).



Figure 023. *The opposing qualities of “luxury” and “high-performance”.*

a desired quality between the exterior and interior. It was deemed appropriate for the interior design proposal to share a similar level of visual high-performance. To this end, the interior design proposal should be styled with strong high-performance expressions, descriptions and associations.

As noted earlier, high-performance sporting products require high mental focus, physical focus and specialised training. Conversely, luxury products generally afford comfort, ease of use and familiarity. To this end, the terms high-performance and luxury share certain opposing qualities. It is apparent that the interior design proposal requires an appropriate balance between luxury and high-performance. To address this balance, Figure 023 illustrates the terms associated with luxury and high-performance, and their desired level of use within the interior design proposal. Figure 023 also illustrates a balance between the opposing qualities. For example, ‘comfort’ and ‘ease of use’ have high desirability, consequently ‘demanding to use’ (an opposing term) has low desirability.

This research has illustrated a wide range of issues associated with high-performance and its appropriateness for the interior design proposal. The issues clearly illustrate the need for careful styling of high-performance visual qualities within the interior design proposal. These issues are addressed during the development of the interior design proposal.

3.1.5 Contemporary Formula One motor racing

Formula One (F1) racing (also known as Grand Prix racing) is classified as the highest class of professional motor racing by the world governing body for motor sport, the Federation Internationale de l'Automobile (FIA). F1 is arguably the most dominant visual motif behind the Hulme F1 supercar. Therefore, it is important to understand the aesthetic influence of this motif and its implications for the interior design proposal (in context to the desired quality of meaningful familiarity). The analysis focuses on the following F1 elements;

- The contemporary F1 race car
- The contemporary racing experience (from the perspective of racing)

The elements above were identified as having the greatest relevance to this investigation since they address visual aesthetics and overall experience.

The race car

The contemporary F1 race car is a state-of-the-art high-performance machine. In terms of overall package, the F1 race car is a mid-engined, opened cockpit, open wheeled, single seater professional race car (Figure 024). Critical design factors for F1 race cars include extraordinary dynamic handling, low weight, high performance tyre compounds, aerodynamic performance (straight-line and cornering), suspension setup and driver safety.

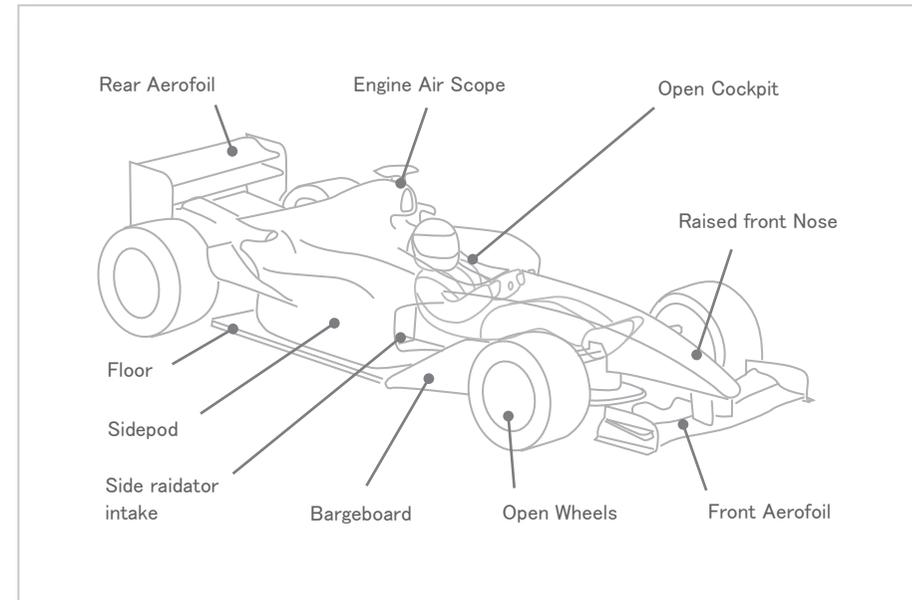


Figure 024. Key design elements which distinguish F1 race cars from road cars.

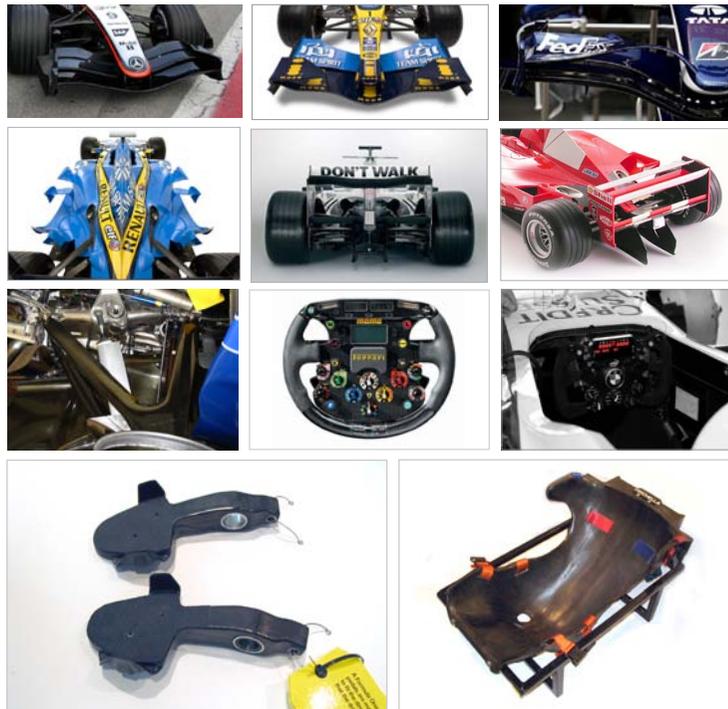


Figure 025. *Inspirational design features from contemporary Formula One race cars.*

The following F1 race car design features were identified as visual inspiration for the interior design proposal:

- The ‘snap-on’ steering wheel. The F1 steering wheel has a unique visual appearance in comparison to typical motorcar steering wheels. The overall rectangular silhouette and integration of various controls contribute toward this. Notably, F1 steering wheels are smaller in diameter compared to typical motorcar steering wheels. The restricted entry/exit space of the driver cockpit also makes it necessary for the steering wheel to be removable.
- ‘Change-up’ lights which tell the driver the optimum time to change gear.
- ‘Multi-link’ (double wishbone) carbon fibre composite suspension arms.
- Carbon fibre bucket seat moulded specifically to the posture of the driver.
- Carbon fibre composite foot pedals.
- Large head bolster forms.
- The aerodynamic wing forms.

Refer to Figure 025 for visual references to these design features.

Many design features identified above were selected for their relationship to the interior cockpit of F1 race cars (for example the F1 steering wheel or foot pedals). The integration of these features within the interior design proposal is considered a significant issue; since visual coherency between the interior design proposal and exterior is desired. Subsequently, the appropriate integration and styling of these

design features is explored during the development of the interior design proposal.

The racing experience

The contemporary F1 world championship season consists of seventeen races held at various venues across the globe. Figure 026 is a generalised visual storyboard illustrating the experience F1 race teams endure. F1 race teams are engaged in a constant cycle of race car tuning/modification, pre-race strategy, driver preparation and the racing event itself.

Two areas associated with the F1 experience were identified as appropriate concepts for further exploration in context to the interior design proposal. These areas are as follows:

- The rigorous and ritualistic process of ingress and egress. To enter into a contemporary F1 race car, the snap-on steering wheel is first removed to create a larger entry/exit space. The driver climbs into the driver cockpit, team members fasten the drivers six-point race harness and the steering wheel is mounted back into position.
- The cocoon-like quality of the carbon fibre cockpit of an F1 race car. These cockpits, also known as a safety cells, are designed with safety and functionality in mind and are unique to racing cars of this nature.

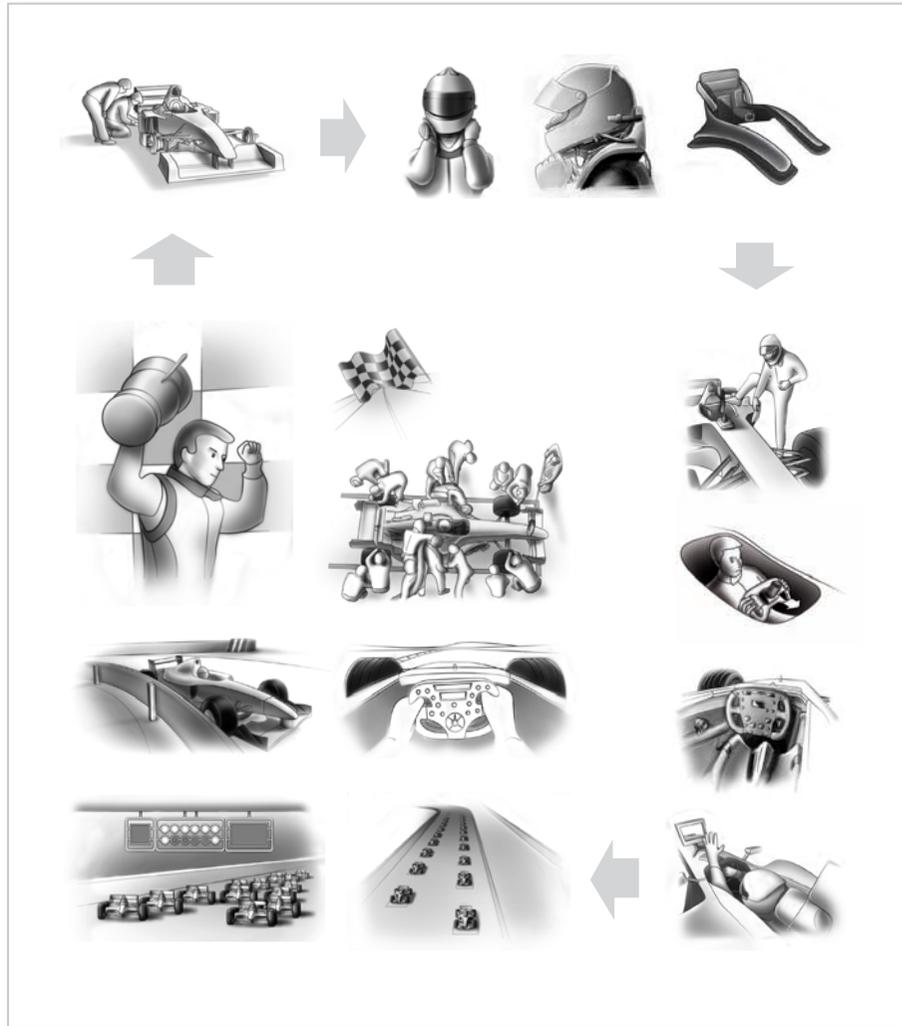


Figure 026. A generalised F1 racing storyboard.

The appropriate integration and referencing of these F1 features requires further

exploration and development. For example, if the interior design proposal were to integrate a cocoon-like cockpit, issues such as occupant confinement and comfort require consideration since the interior design proposal, is intended as a ‘road car interior’.

The research has illustrated the unique qualities associated with F1 race cars and the racing experience. These unique qualities suggest F1 has a degree of ‘exoticness’ as well as ‘high-performance’. This implies that F1 references can be used within the interior design proposal to express both ‘high-performance’ and ‘exoticness’. Further exploration into this notion is discussed during the development of the interior design proposal.

3.1.6 Hulme F1 supercar exterior form language

The following section focuses on the final design motif, the exterior form language of the Hulme F1 supercar. This visual analysis is referenced from informal communication with the design director of the Hulme F1 supercar and the researcher's own observations. The following design features are significant to the exterior aesthetic:

- The proportions of the Hulme F1 supercar are typical of contemporary supercars; extremely low height, great width and a far forward cabin. (Livingstone, 2006)
- Gentle convex surfaces and tightly controlled surface transitions create a muscular or athletic aesthetic.
- Open front and rear wheels with carbon-fibre mud guards create a visual sense of lightness and athleticism.
- Strong repetition of form language creates coherency between aesthetic design features (refer to Figure 027).
- The uninterrupted shoulder line reinforces the sense of continuity by visually connecting the front and rear together.
- The raised front nose, full width front aerofoil, rear aerofoil, open wheels, exposed front suspension linkages and rear diffuser reference contemporary F1 race cars. This in effect creates a silhouette similar to contemporary F1 race cars (Figure 027).



Figure 027. Hulme F1 supercar exterior form language makes strong reference to contemporary F1 race cars and is predominantly composed of a coherent family of curves (highlighted in green).

- The Day Light Opening (DLO) references the head bolsters of contemporary F1 race cars.

The visual analysis illustrated three issues significant to this investigation. These issues are as follows:

- As expected, the analysis affirms that the exterior aesthetic is styled to reference contemporary F1 race cars.
- The use of repeating form language creates a strong level of coherency or familiarity between the various aesthetic features. As mentioned earlier, familiarity is considered as a quality of luxury through safety and security (3.1.3). Consequently, this coherent design language expresses luxury in its own manner.
- The vehicle's low cabin height is likely to make occupants sit in a low position; the implications of this are to be discussed in section 3.4.4 with reference to the user's 'body support' system.

Reflecting upon this finding, research concluded that the interior design proposal should reference the exteriors coherent form language in order to maintain a strong level of interior/exterior familiarity. However, the following design issues arose; should the interior design proposal only reference the 'family of curves' and F1 influences illustrated in Figure 027? Or can it incorporate alternative references or design elements? This design issue is further explored later within the background research.

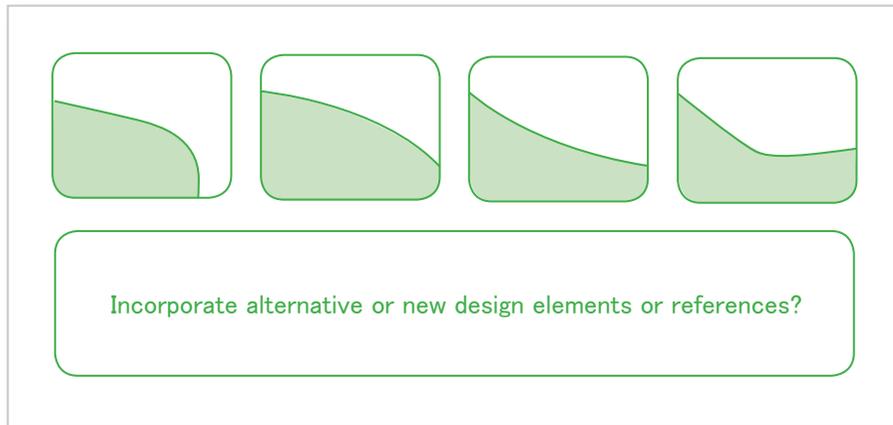


Figure 029. *Repeated Hulme F1 supercar exterior form language.*

- Exterior form language:
 Appropriately integrate existing form language into interior design proposal.

Figure 028 illustrates the terms associated with each motif, their relationship to each other and their desirability of use in context to the interior design proposal.

Research into F1 race cars and racing illustrated many sources of appropriate inspiration for the interior design proposal. The appropriate integration of these sources of inspiration is explored during the development of the interior design proposal. For example, the integration of an ingress/egress design solution which references F1 race car ‘snap-on’ steering wheels.

Another important design issue is the integration of exterior form language into the interior design proposal (Figure 029). As already noted, research concluded that the interior design proposal should reference this form language to maximise familiarity between the interior and exterior. Questions arose over the best way to achieve this; should the interior design proposal only reference this form language or can the interior design proposal incorporate alternative design elements or references? These issues are addressed during the design development of the interior design proposal.

3.2.0 Contemporary theory on visual product communication and experience

Thus far, research has established the desired ingredients for the interior design proposal. Many of these ingredients are abstract terms and therefore do not describe specific design characteristics for the interior design proposal. The aim of this section is two fold;

- To identify an appropriate and existing theoretical framework which can specify experience criteria for the interior design proposal.
- To give the experience design criteria background context, the identified theoretical framework is used to analyse contemporary motorcars for visual trends with respect to luxury, high-performance and exoticness. These trends will then be used as a point of discussion for the development of more refined criteria.

Monö (1997), Norman (2004a) and Warell (2007) have written extensively on visual product communication and experience. Their work is examined and discussed during this section.

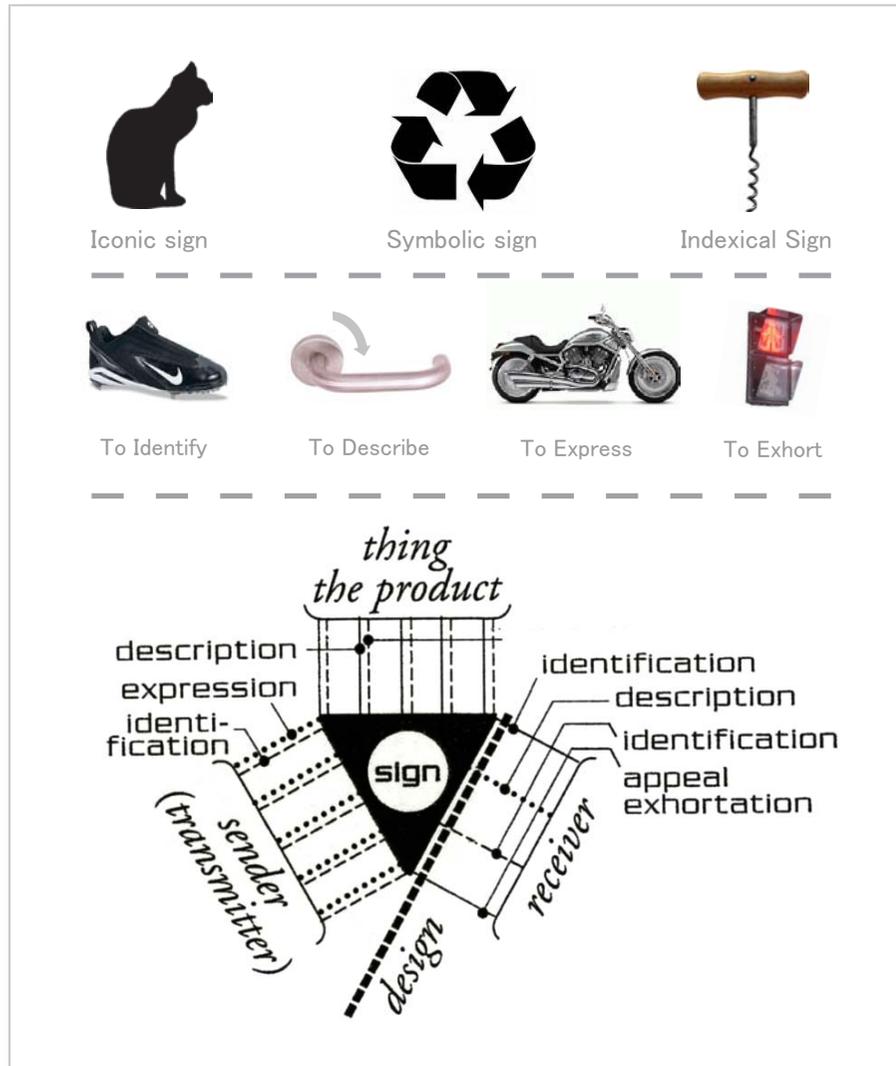


Figure 030. *Understanding product communication through semiotics.* (Monö, 1997).

3.2.1 Product Communication (Monö, 1997)

The research of Rune Monö (1997) focuses on semantic interpretation from a semiotic perspective. Monö's research states that a user interprets a product and its corresponding properties through semiotic signs. These signs are embodied within the visual form. In addition, Monö claims that there are three types of product signs. These signs are as follows:

- Icon; a sign which shares a direct visual resemblance to what it signifies.
- Symbol; a sign that has no direct visual correlation to what it signifies. The interpretation of symbolic signs are completely dependent on the socio-cultural background of the user.
- Index; a sign which has a causal relation or physical connection to what it signifies. For example, the spiral form of a cork screw (top right, Figure 030) signifies its rotational movement of operation.

Monö also states that products communicate their practical qualities using the following four semantic functions:

- To Identify: Communicate origin, location, category or brand
- To Describe: Communicate purpose or mode of operation
- To Express: Communicate properties
- To Exhort: Communicate desired reactions

Figure 030 illustrates visual representation of the types of signs, semantic functions and the overall product communication process.

It is also noted that visual form elements often have more than one semantic function. In example, the grille of a motorcar may ‘express’ the visual theme of the motorcar (eg. aggressive, subdued, confident), ‘describe’ the function of the front radiator and ‘identify’ the brand of the motorcar. There is no easy way to distinguish the limits of each semantic function. However, semantic functions can serve as a guide for designating the visual meaning of a design feature.

This framework convincingly defines how products visually express qualities through semantic functions and establishes a well structured approach for explaining how visual design features communicate qualities through signs and semantic functions. Semantic functions could be used to specify more refined design criteria for the interior design proposal.

There is no substantial structure for the analysis or comparison of aesthetic features. For example, how are these features composed? What makes them distinct from others? And are these features commonly used to express, identify, describe or exhort? This is seen as an important issue where specifying design criteria requires support, justification and context. This framework creates a starting point for specifying visual design criteria. However, a more comprehensive framework is desired for this investigation to give criteria with more context and support.

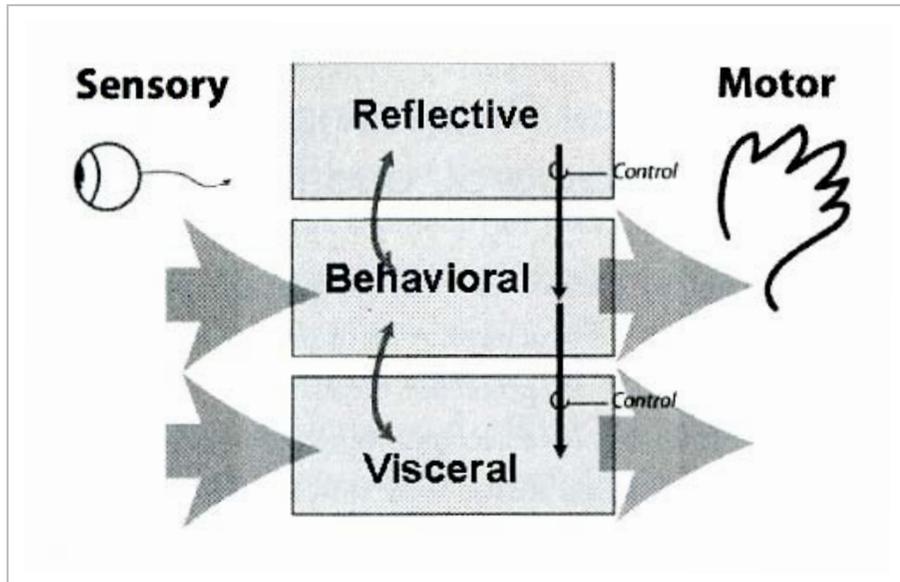


Figure 031. *Three Levels of Emotional Design*. (Norman, 2004a, p.22).

3.2.2 Emotional Design (Norman, 2004a)

The research of Donald Norman (2004a) adapts affective and cognitive information processing systems to describe how users experience a product. Norman's research states that a user's cognitive information process interprets the product, while the affective or emotional information process evaluates a product. In addition, each information system influences each other in an affective process.

Norman's research used information processing systems to generate a framework which described how a product affects the user's experience. This framework is summarised through the following three levels of design:

- Reflective level of design:

Considered the “highest” level of design (as illustrated in Figure 031), the reflective design level refers to user's long term association or relationship with a product. Norman argued that this level of design can be so powerful, a user can overlook other levels of design due to their emotional attachment to the product.
- Behavioral level of design:

This level of design refers to the functional performance of a product. Functional performance can be perceived through both actual performance and visual or aesthetic appearance.
- Visceral level of design:

This level of design accounts for the initial reaction of users when they

encounter a product, with emphasis on appearance. Often the issue of “X-factor” is referenced under this level of design in Norman’s research.

This framework is primarily supported through the evaluation of examples. Although these arguments are generally convincing, the framework has no objective means of measuring the visceral, behavioral and reflective qualities in a product. Norman states that the 1961 Jaguar E-type (Figure 032) is “viscerally exciting” through its sleek and elegant form (Norman, 2004a, p.68). Viscerally exciting to who, by what measure and how does a sleek and elegant form make it viscerally exciting? It is at this point that the highly subjective nature of this framework becomes apparent.

Although it is inherently difficult to ‘measure’ the visceral, behavioral and reflective qualities a product has due to the subjective nature of aesthetics, a basic analytical framework to justify why a product has strong (or weak) visceral or reflective qualities is desirable. This framework is not able to evaluate a number of motorcars to identify aesthetic trends. The evaluation of each product is more or less a stand alone study.

Consequently, the framework presented by Norman is not considered appropriate for this investigation.



Figure 032. 1961 Jaguar E-type. (4Car, 2005).

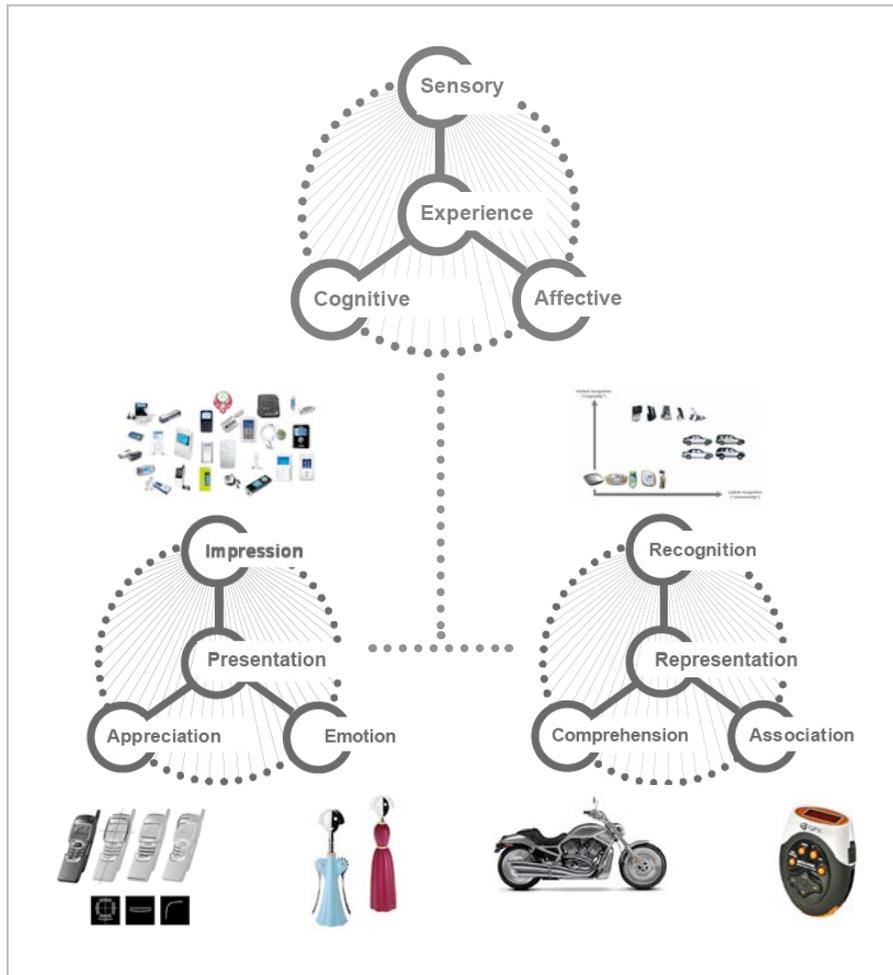


Figure 033. *Visual Product Experience framework.* (Warell, 2007).

3.2.3 Visual Product Experience framework (Warell, 2007)

Warell's (2007) framework of Visual Product Experience (VPE) model describes the affect of products on an individual using two supplementary dimensions (see Figure 033). The dimension of presentation accounts for the affect and perception of traceable design elements, while the dimension of representation accounts for the affect and interpretation of product representation or meaning.

The following is a general breakdown of each model and their corresponding modes of operation:

Dimension of Presentation:

- **Impression mode:**
 This mode refers to a product's visual 'point of difference' amongst its product range and its visual impression on the user. This mode uses the design format analysis matrix (Figure 034) to deconstruct the aesthetic composition of a product or product range. This tool is used to identify visual differences between individual products and identify visual trends amongst a range of products.
- **Appreciation mode:**
 This mode considers aesthetic composition and repetition of visual form elements, with particular emphasis on geometry, unity and harmony. Form elements are categorised into the following four groups:

Superior gestalt

Brand specific form elements (signifiers)

Higher order form elements

Lower order form elements

For a visual breakdown of these groups, refer to Figure 035.

- Emotional mode:

The emotional mode accounts for the emotional affect a products has on users. The type and level of emotion experienced by a user can depend on the type of user, preferences/experience, state of mind and product type. The research of Desmet (2002) contributes towards this mode with the ‘Product Emotion Measurement Instrument’. This research method relies on user questionnaires or surveys.

Dimension of Representation:

- Recognition mode:

This mode addresses a users ability to recognise a product archetype through basic visual features. Archetypes may relate to brand recognition, product type, use or something familiar to the user.

- Comprehension mode:

The comprehension mode addresses the interpretation of a products characteristics through visual references such as properties, performance and mode-of-use. The research by Monö (1997) contributes towards this mode (to express, exhort, describe and identify).

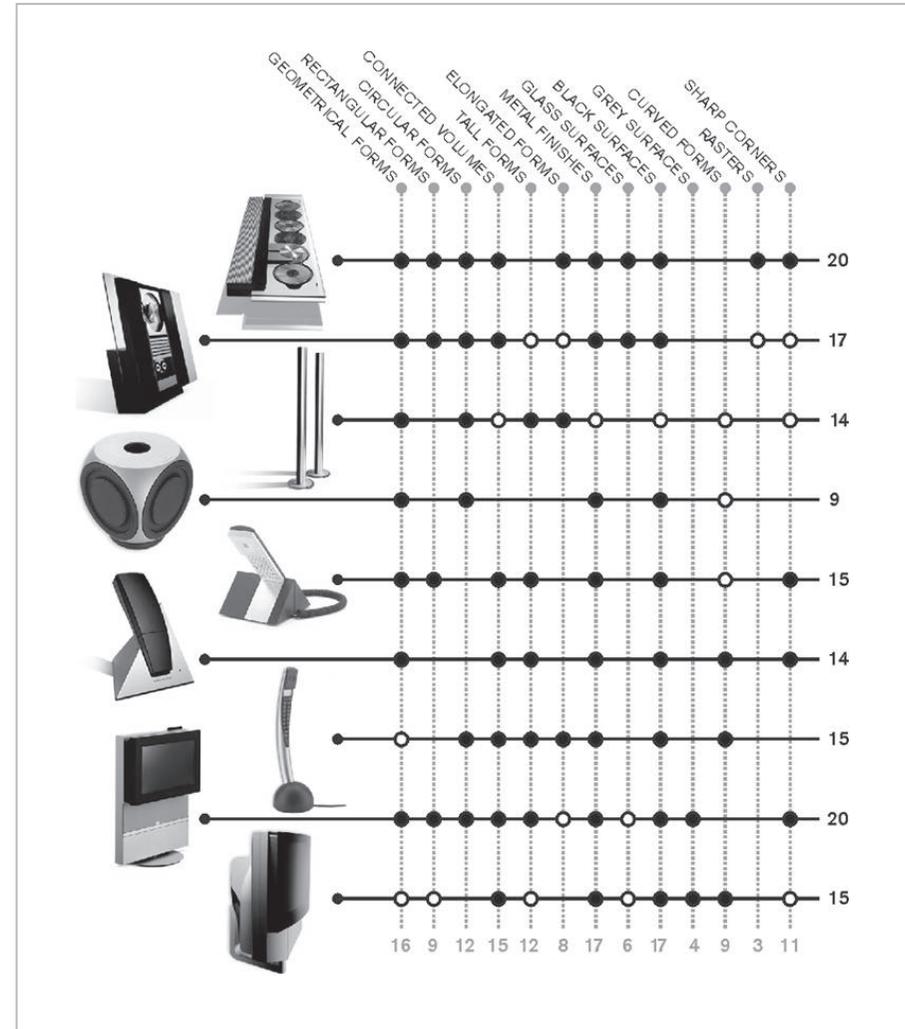


Figure 034. Design Format Matrix. (Warell, 2001, p.125).

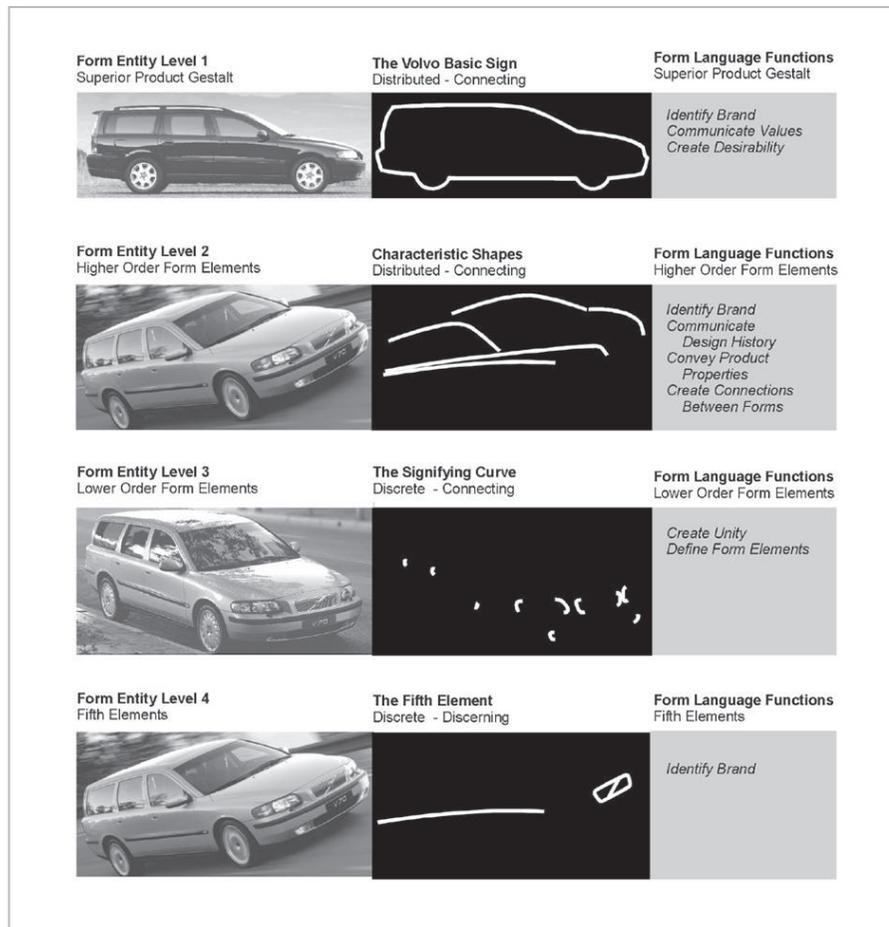


Figure 035. *Levels of visual form structure.* (Warell, 2001, p.129).

- **Association:**

This mode references a product's ability to connote its origin, brand and/or heritage. Furthermore this mode is dependent on the users own socio-cultural background. As a consequence, this mode operates solely through the interpretation of symbolic signs.

Each mode of operation does not operate independently. Instead, each mode is inter-connected and interdependent of each other (in similar fashion to semantic functions presented earlier). Take for example, the front grille, as shown in Figure 035.

Warell presents a comprehensive visual framework which addresses product aesthetics, communication and their corresponding relationship to each other. In terms of product semantics, the framework builds on the research of Monö (i.e to express, describe, exhort and identify). Product aesthetics are evaluated through the identification of form elements and the design format analysis matrix.

The previous frameworks by Monö and Norman demonstrated a lack of consideration for the evaluation of aesthetic qualities in context to form elements. In context to this investigation, Warell's VPE framework offers a significant advantage over the previous frameworks analysed within this review. The Dimension of Presentation is able to assess the visual attributes of a product and its visual context to other products. This allows for the identification of aesthetic trends amongst a group or range of products. Meanwhile, the Dimension of Representa-

tion allows for the assessment of what a product represents, thereby allowing for the identification of aesthetic trends in expression and description.

To this end, this framework allows for the evaluation of aesthetic design trends in luxury, high-performance and exoticness. These trends can then be used as a point of discussion and context for the specification of design criteria for the interior design proposal. Also, higher, lower and brand specific form elements can be used to specify more refined design criteria for the interior design proposal.

One mode of operation considered inappropriate for this investigation is 'emotion', due to the subject nature of emotions. In addition, to evaluate or test this mode requires user surveys or questionnaires. As stated previously in this investigation, the niche market for the Hulme F1 supercar is so small, that access to a significant sample of potential end users is at best, impractical. As a consequence of this, any survey or questionnaire testing emotional response would most likely be insignificant.

Overall the visual framework by Warell appropriately addresses the aims of this section: to identify a visual framework which can specify more refined design criteria and analyse motorcars for aesthetic trends. This visual framework is integrated into the next part of the background research: the analysis of contemporary motorcars exemplars to identify contemporary aesthetic trends.

3.2.4 Summary : contemporary theory on visual product communication and experience

This review focused on the identification of an appropriate visual framework, drawing reference from the research of Monö, Norman and Warell. The VPE framework presented by Warell was identified as the most comprehensive and appropriate visual framework for this investigation.

To further understand the implications of the VPE framework, this framework was used to analyse the Hulme F1 supercar (Figure 036). The analysis illustrated several affirming areas of significance for the investigation. For example, the ‘Dimension of Representation’ illustrates the importance of F1 race cars, where the F1 race car is a dominant element in the modes of recognition and association. This further emphasises the need for the interior design proposal to reference F1 in order to gain a level of meaningful familiarity with the exterior.

More significantly, the framework identified areas which require resolution in context to the interior design proposal. Such as its aesthetic impression in comparison to other supercar interiors, perceived mode-of-use, descriptive and or expressive visual properties. To this end, these analyses further emphasise the appropriateness of this framework.

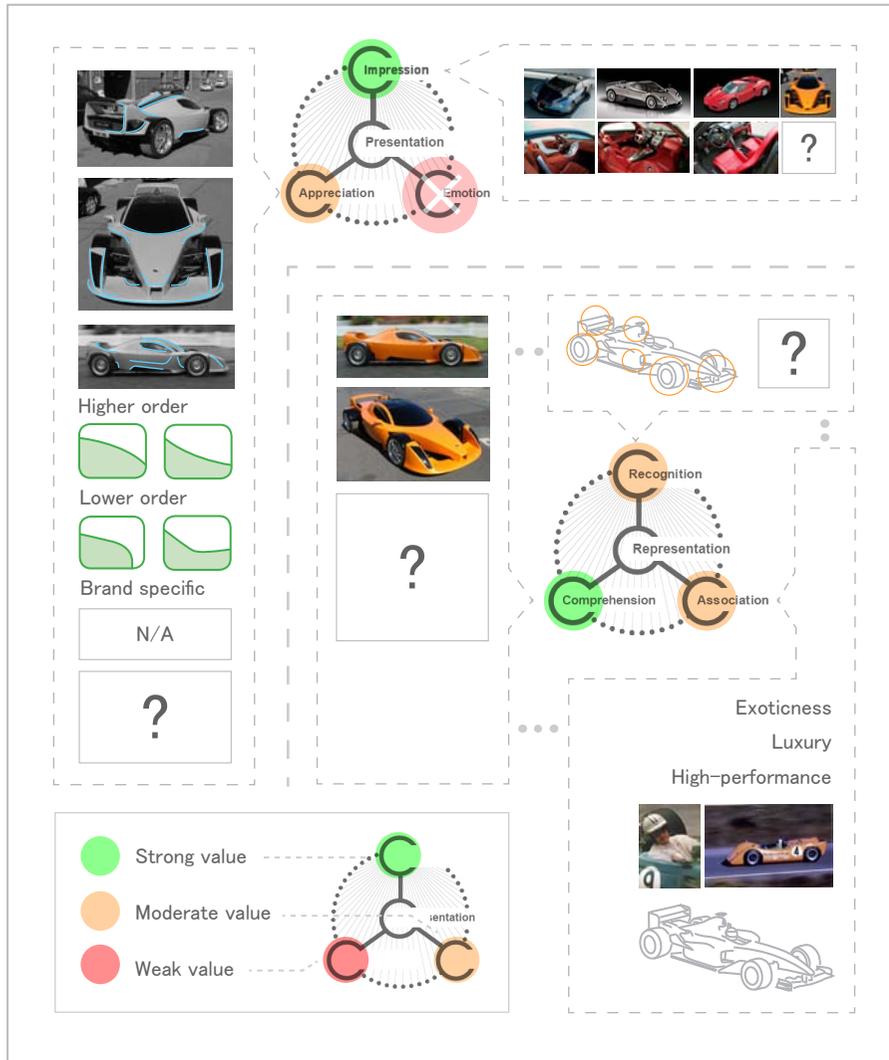


Figure 036. VPE framework applied to the Hulme F1 supercar.

3.3.0 VPE analysis of contemporary motorcar exemplars

This section focuses on contemporary aesthetic motorcar trends and their relevance to the interior design proposal. Work concentrated on the analysis of contemporary motor car exemplars using the VPE framework. Analysis focuses on the identification of interior and interior/exterior related aesthetic design trends. These trends are used as a point of discussion and context for the generation of experience design criteria.

Each exemplar group was selected for their aesthetic relevance to luxury, high-performance and exoticness. These exemplar groups are as follows:

- Luxury four door saloons
- High-performance professional race cars
- Exotic supercars



Figure 037. *Mercedes-Benz S-Class (2006)*. (Seriouswheels, 2006b).



Figure 038. *Bentley Flying Spur (2005)*. (Seriouswheels, 2005a).



Figure 039. *Audi RS4 Quattro (2005)*. (Seriouswheels, 2005b).

3.3.1 Luxurious motorcar exemplars

This investigation now focuses on the analysis of luxury four door saloons using the VPE framework. Four door saloons are generally recognised for their ride comfort and spacious interior, making them an excellent package for expressing luxury. Many premium motorcar manufacturers promote the four door saloon as their flagship product. As a result, they are an ideal motorcar type for identifying interior and interior/exterior related contemporary luxury aesthetic design trends.

The following exemplars are the focus of this VPE analysis:

- Mercedes-Benz S-Class (2006) – Figure 037
 Generally recognised as the benchmark among luxury four door saloons
- Bentley Flying Spur (2005) – Figure 038
 A contemporary luxury four door saloon with distinctly traditional brand values
- Audi RS4 Quattro (2005) – Figure 039
 A contemporary luxury four door saloon with a high-performance sports orientated package

These exemplars are generally accepted as luxury motorcars and represent a breadth of commonly recognised, well established premium motorcar manufacturers. The exemplars were considered an appropriate starting point for understanding the concept of ‘luxury’ in context to contemporary motorcars.

A detailed description of each VPE ‘luxury’ exemplar analysis can be found in Appendix 1. Also, as part of the VPE analysis, a design format analysis was conducted comparing the exemplars against various visual ingredients (as illustrated in Figure 040).

The analysis of luxury motorcar exemplars illustrated the following contemporary aesthetic trends:

- Higher and lower order form elements visually reference brand specific elements, for example the front grille and/or brand logo
- Frequent repetition of common higher and lower order form elements in both the exterior and interior (illustrated in Figure 040).
- Simple aesthetic compositions, achieved through the use of repeating form elements with a coherent form language.
- Frequent use of ‘wrap around’ design features which creates strong visual unity across the composition (demonstrated in Figure 040).
- Interior and exterior are aesthetically different, but still imbue similar qualities and expressions through the use of repeating form elements.
- Each exemplar interior is saturated with high-quality leather trim.
- Wood accents are used to express more traditional or ornate values associated with luxury.
- Interior cabins are spacious, imbuing qualities of comfort.
- Control fixtures are typically embellished with chrome detailing.

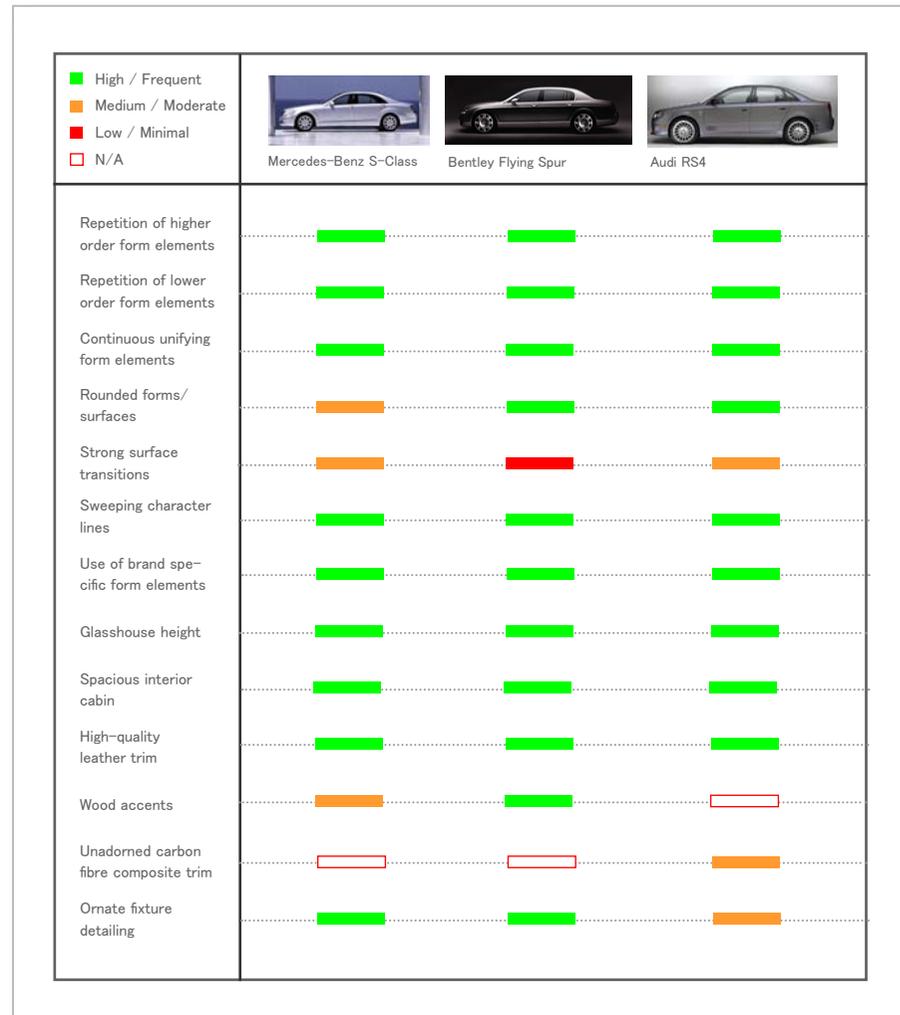


Figure 040. Design format analysis of ‘luxury’ exemplars.

These trends indicate the following in context to the interior design proposal:

- The trends support earlier research claiming a coherent expression is required between the interior and exterior to imbue luxury (3.1.3).
- Luxury design elements can be expressed with simple visual compositions.
- Wood accents are an inappropriate reference to express luxury within the interior design proposal. They express strong ornate qualities, an expression not found within the exterior of the Hulme F1 supercar.
- High-performance materials (such as carbon fibre) should be treated in an ornate or decorative manner in order to maintain a degree of 'luxury'.

3.3.2 High-Performance professional race car exemplars

F1 race cars are one type of 'professional' high-performance race car. However, there are many types and classes of professional race cars. To broaden the understanding of visual high-performance in motorcars this analysis will focus on another class of high-performance motor racing. The 24 Hours of Le Mans series This is a prestigious motor racing series known for its 24 hour endurance races; testing not only speed and driver skill but reliability.

The 24 hour of Le Mans series has a number of race car classes. This analysis will focus on aesthetic exemplars from the Le Mans prototype (LMP) class. The LMP race cars are analysed due to their similarity with the Hulme F1 supercar. Both are designed to accommodate two occupants resulting in a similar overall

package (mid-mounted engine, long wheelbase and far-forward cabin).

To this end, the following contemporary purpose-built LMP race cars are reviewed using the VPE framework;

- Bentley Speed 8 (2003) – Figure 41
- Porsche RS Spyder (2007) – Figure 42

A complete description of each VPE ‘high-performance’ exemplar analysis can be found in Appendix 1. As part of the analysis, a design format analysis was also undertaken. This compared the ‘high-performance’ exemplars against various visual ingredients and the results from the previous ‘luxury’ exemplars (as illustrated in Figure 043).

After the analysis of LMP race car exemplars using the VPE framework, the following ‘high-performance’ interior and interior/exterior inter-related aesthetic trends were identified:

- Professional high-performance motorcars are complex in aesthetic composition and have minimal form element repetition (refer to Figure 043).
- Interior and exterior aesthetics have little in common
- Minimal reference to brand specific design cues (refer to Figure 043)
- Interior cockpits are confined and/or cluttered, this appears to afford a claustrophobic or even hostile expression.



Figure 041. *Bentley Speed 8 (2003)*. (7extrememotorsports, 2003).



Figure 042. *Porsche RS Spyder (2007)*. (Autocult, 2007).

			
	Bentley Speed 8 Porsche RS Spyder		
<ul style="list-style-type: none"> ■ High / Frequent ■ Medium / Moderate ■ Low / Minimal N/A 			
Repetition of higher order form elements	■	■	■
Repetition of lower order form elements	■	■	■
Continuous unifying form elements	■	■	■
Rounded forms/surfaces	■	■	■
Strong surface transitions	■	■	■
Sweeping character lines	■	■	■
Use of brand specific form elements	■	■	■
Glasshouse height	■	■	■
Spacious interior cabin	■	■	■
High-quality leather trim	■	■	
Wood accents	■	■	
Unadorned carbon fibre composite trim			■
Ornamental fixture detailing	■	■	■

Figure 043. Design format analysis of 'luxurious' and 'high-performance' exemplars.

- Secondary controls are visually cluttered and confusing. These elements appear (at a visual level) to require specialised training.
- Interiors are typically void of luxuries or amenities, emphasising necessity.
- Dominant use of unadorned carbon fibre trim with the interiors
- Structural elements are commonly exposed

The design format analysis matrix (Figure 043) also illustrated contrast between a number of visual ingredients for the 'high-performance' and 'luxury' exemplars. Most notably, contrast in the areas of:

- Higher and lower order form element repetition: 'luxury' exemplars demonstrated frequent form element repetition, resulting in a simple visual composition. Meanwhile, 'high-performance' exemplars illustrated minimal form element repetition, creating a complex visual composition.
- Referencing of brand specific design cues: 'luxury' exemplar form elements appeared to reference the front grille and brand logo. This creates strong association and recognition between the exemplars and their brands. In contrast, the 'high-performance' exemplars form elements visually focus on utility and functionality. If the 'high-performance' exemplars did not have exterior signage, it would be difficult to recognise their brand, manufacturer and/or team.

This suggests as a motorcar visual composition becomes more simple and coherent in appearance, the greater its expression of luxury. Conversely, the less

coherent a motorcar visual composition appears, the greater its expression of high-performance. A relationship of this nature was expected, as earlier research in section 3.1.4 outlined the opposing qualities between ‘luxury’ and ‘high-performance’.

These results suggest the following for the interior design proposal:

- High-performance elements within the interior design proposal should appear complex in visual composition. Conversely, luxurious elements should appear simple in visual composition.
- Explore the possibility of exposing structural elements within the interior design proposal to express ‘high-performance’.
- The analysis further supports the use of carbon fibre trim as an expression of ‘high-performance’.
- The interior cabin should not be confining for the occupant, in order to avoid a claustrophobic driving experience.

3.3.3 ‘Exotic’ supercar exemplars

Review now focuses on the analysis of contemporary supercars. As stated earlier, supercars are exotic in nature (3.1.2). Therefore, they are ideal for identifying exotic aesthetic trends in motorcars. The following supercar exemplars are the focus of this review:

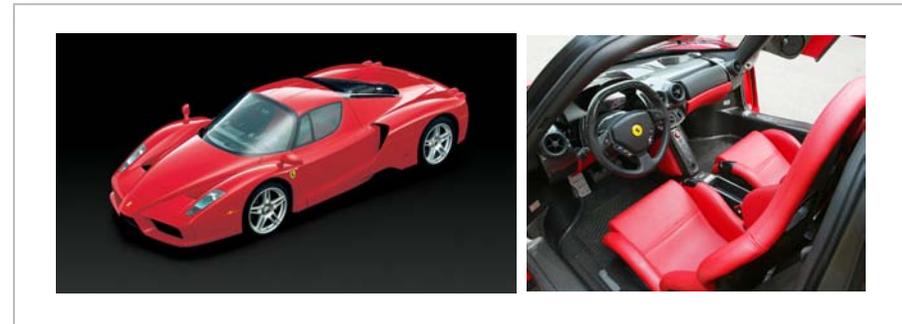


Figure 044. *Ferrari Enzo (2002)*. (Seriouswheels, 2002).



Figure 045. *Pagani Zonda F (2005)*. (Seriouswheels, 2005c).

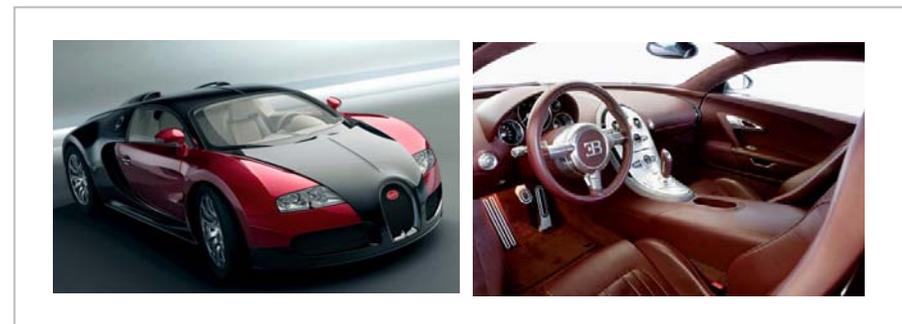


Figure 046. *Bugatti Veyron 16:4 (2006)*. (Seriouswheels, 2006a).



Figure 047. Design format analysis of 'luxurious', 'high-performance' and 'exotic' exemplars.

- Ferrari Enzo (2002) – Figure 044
- Pagani Zonda F (2005) – Figure 045
- Bugatti Veyron 16/4 (2006) – Figure 046

These exemplars represent a range of established, well recognised and emerging contemporary supercar manufacturers. To this end, they are considered a valid starting point for understanding the concept of 'exoticness' within motorcars.

A complete overview of each VPE 'exotic' exemplar analysis can be found in Appendix 1. A design format analysis was also carried out to compare the 'luxury', 'high-performance' and 'exotic' exemplars against various visual ingredients and each other (illustrated in Figure 047).

The VPE analysis identified the following 'exotic' design trends:

- All exemplars illustrated different solutions with regard to their exterior/interior aesthetic relationship.
- Frequent use of strong surface transitions, which can include directional surface change, contrasting surface textures, materials and/or colours.
- Functional control fixtures are often highlighted through contrasting high-performance materials (for example; metallic and/or unadorned carbon fibre composite trim).
- Frequent interior/exterior repetition of lower order form elements.
- All seating features are treated with high-quality leather trim.

The design format analysis (Figure 047) also illustrated an unexpected relationship between the exemplar categories, whereby, many of the ‘exotic’ aesthetic qualities appeared to fall ‘in-between’ the contrasting categories of ‘luxury’ and ‘high-performance’. This indicates that the visual quality of exoticness in contemporary supercars is not only about ‘unusualness’ but also involves facilitating a desired balance between luxury and high-performance.

Another significant finding was with regard to the secondary controls of the Ferrari Enzo. The interior cabin of the Ferrari Enzo appeared to have a high-performance expression similar to that of the Le-Mans race car cockpits. However, a distinct point of difference with the Ferrari Enzo’s interior cabin is easily comprehensible secondary controls. The secondary controls within the Le Mans race car cockpits appear more cluttered and confusing, requiring specialised knowledge to operate. This suggests that the secondary controls of the interior design proposal should appear easily comprehensible in order to maintain a desired expression of high-performance (as outlined in 3.1.4).

The results from this VPE analysis also indicate the following:

- The interior design proposal should reference strong colour, trim and texture contrasts to distinguish and express functional elements.
- Although the overall expression of the interior design proposal should remain similar to the exterior, its visual structure and content can be dissimilar.

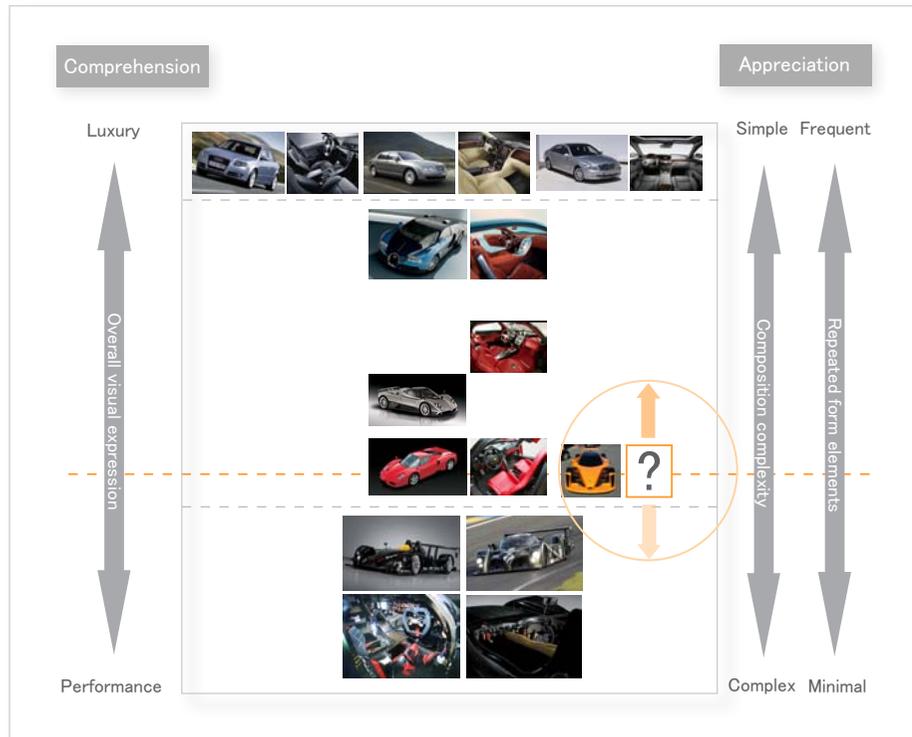


Figure 048. Above illustrates each exemplar positioned relatively according to their expression, visual composition and form element repetition.

3.3.4 Summary : VPE trend analysis

The following trends were identified for their relevance to previous research regarding desired visual qualities and the development of appropriate experience design criteria:

- Figure 048 compares visual expression against composition complexity and interior/exterior form element repetition. Each exemplar has been positioned relatively accordingly on the chart. As discussed previously, the exotic exemplars exhibit a visual balance between the expressions of luxury and high-performance. One can observe this relationship in Figure 048 whereby; as the expression of an exotic exemplar becomes more orientated towards luxury, its composition becomes simpler and has more frequent form element repetition. Conversely, as an exotic exemplar becomes more high-performance focused, its composition becomes more complex and less form element repetition. The Hulme F1 supercar has also been positioned on Figure 048, with a high-performance expression similar to that of the Ferrari Enzo. The location of the Hulme F1 supercar indicates that the interior design proposal should have a moderate to high level of visual complexity and form element repetition, in order to maintain an overall coherent expression between the interior and exterior.
- Control fixtures in exotic exemplars are often treated with contrasting colours and/or high-performance materials, such as unadorned carbon fibre composites and metallic trim. This trend is considered appropriate

for use within the interior design proposal as it allows for the possibility of highly expressive, distinctive and unusual control fixtures.

- High-performance secondary controls are visually cluttered and confusing. At a visual level, these elements appear to require expert knowledge to operate. This is not a desired high-performance quality for the interior design proposal. The interior design proposal should have secondary controls which are easy to comprehend, with the use of commonly recognised motorcar controls and/or icons.
- There is frequent use of unadorned carbon fibre composite trim in high-performance exemplars. Therefore, this material trim can be used to create high-performance associations.
- Frequent exposure of structural elements within high-performance interiors. Exploration and consideration of this trend in context to the interior design proposal will require further investigation.

Figure 049 illustrates the aesthetic design trends (mentioned above) in correlation with the previously identified desired qualities for the interior design proposal. Overall this analysis has identified numerous trends appropriate as visual design criteria for the interior design proposal.

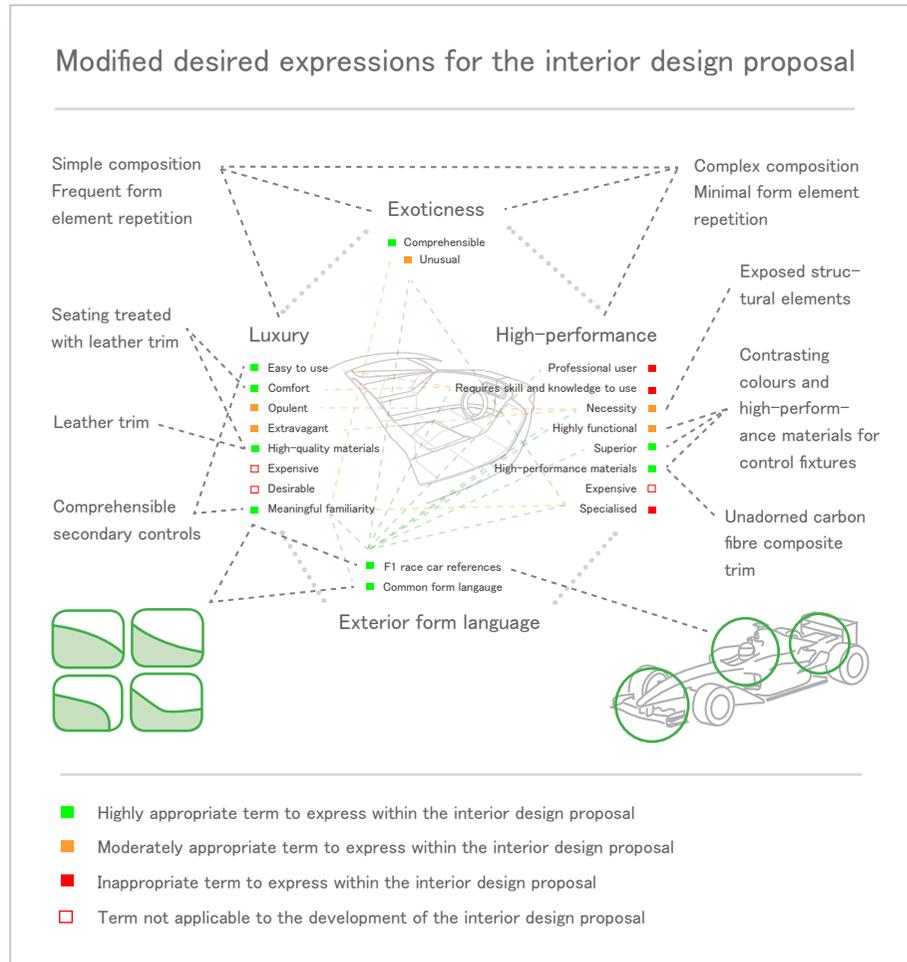


Figure 049. *The implications of this analysis on the desired qualities and expressions within the interior design proposal.*

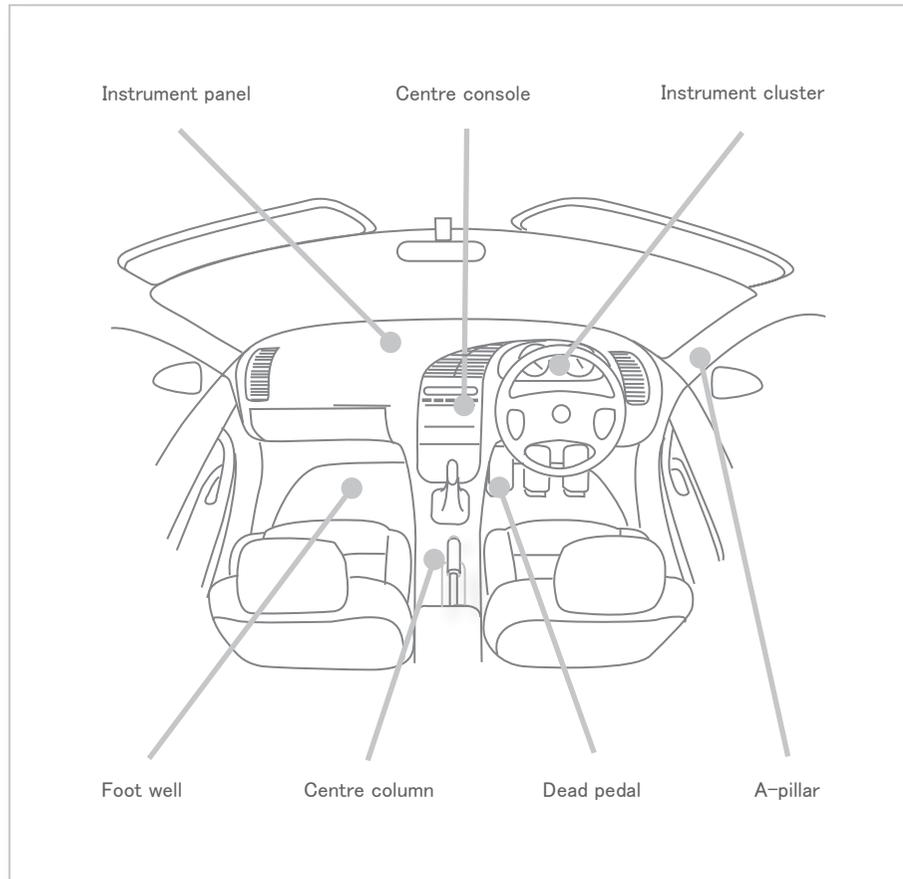


Figure 050. *Term specific features for motorcar interiors.*

3.4.0 Motorcar functional systems

This section focuses on the fundamental functional systems required to support the interior aesthetic proposal;

- Control systems (primary and secondary controls systems, vision systems and information display systems)
- Body support systems
- Ingress-egress systems
- In-car storage systems
- Safety systems (passive and active)

Analysis focuses on theoretical design considerations for each functional system and their associated design features in context to the interior design proposal. In addition, applicable state-of-the-art technologies, materials and designs are also reviewed.

Figure 050 illustrates a typical motorcar interior and terminology used to describe interior features.

All anthropometric measurements in this following section are referenced from *The measure of man and woman: Human factors in design* (Dreyfuss, 2002).

3.4.1 Control systems

The control systems within an interior are divided into the following sub-systems (from most to least important);

- Primary control systems (longitudinal and latitudinal controls)
- Secondary control systems
- In-car information display systems
- Direct and indirect vision systems

Primary control systems (longitudinal and latitudinal controls)

Primary control systems are responsible for the direction and velocity of a motorcar. Typical design features include a steering wheel and foot pedals (break, accelerator and clutch if the motorcar has a manual gearbox). The following are theoretical ergonomic considerations for the design of primary control features within the interior design proposal:

Steering wheel:

- An adjustable steering wheel that caters for a range of users (in/out, up/down and tilt) (Loughborough, 2001).
- Steering wheel should be centrally positioned in relation to the driver and



Figure 051. Audi RS4 Primary control systems (Steering wheel and foot pedals). (Diseno-art, 2005).



Figure 052. *Left foot brake pedal.* (Skene, n.d).

not ‘off-set’ to prevent rotation of the spine (Loughborough, 2001).

- The steering wheel should not obstruct in-car display systems or the driver’s field of vision (FOV).
- The grasping diameter of the steering wheel should be 20mm in diameter (Dreyfuss, 2002, p.66).
- The overall diameter of the steering wheel should be between 254–356mm (Dreyfuss, 2002, p.66).

Footpedals:

- The driver should be able to reach the foot pedal without fully extending their leg.
- Foot pedals should be centrally positioned with adequate space and not ‘off-set’ as this can create torsion in the spine (Loughborough, 2001).
- Maximum travel angle of pedal should not exceed 20° – 72° at rest and 52° for full acceleration (Dreyfuss, 2002, p.67).
- Longitudinally adjustable footpedals (120mm of adjustability) caters for a wide range of users with regard to stature (Codamotion, 2006).
- The elimination of the clutch pedal (with the use of a semi-automatic gearbox) allows for left foot braking. Left foot braking offers enhanced driving performance and control. Many professional race cars including F1 race cars and high-performance road cars are designed for left foot braking (refer to Figure 052) (Stroes, 2004).

Applicable state-of-the-art technology/materials/design

Drive-by-wire technology eliminates the need for primary control features to have direct mechanical linkages to their associated functional components. This is achieved through the use of advanced mechatronics. The elimination of mechanical linkages offers several advantages for the design of the interior design proposal;

- Firstly, drive-by-wire technology allows for greater design freedom without any functional disadvantages.
- Secondly, this technology allows for greater control position adjustability with respect to a range of users (5th percentile female to 95th percentile male).
- Thirdly, this technology allows for the reconfiguration of primary control features. For example, the General Motors Hy-Wire concept car (2002) does not incorporate foot pedals. Instead, the steering wheel grips (Figure 053) function as longitudinal controls (squeeze to accelerate and twist to decelerate). Although the appropriateness of this particular example is unclear for the interior design proposal, it does demonstrate the potential benefits and innovations drive-by-wire technology offers the interior design proposal.



Figure 053. *General Motors Hy-Wire Concept Car primary control system.*
(Howstuffworks, 2002).



Figure 054. *Secondary control systems.* (Bkkautos, 2006).

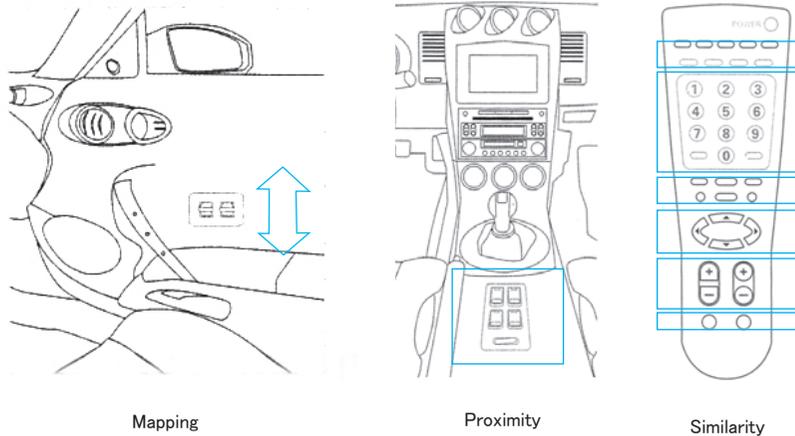


Figure 055. *Secondary control systems.* (Lidwell et al. 2003)

Secondary control systems

Secondary control systems refer to any controls that do not directly relate to the movement of the motorcar. The majority of secondary controls are found on the instrument panel (generally referred to as the ‘dashboard’) and centre console (refer to Figure 054). Other areas where secondary controls are typically found include the steering wheel, doors, seats and the cabin ceiling.

The following are general design considerations to enhance the usability and functionality of secondary controls within the interior design proposal:

- **Colour:**

Colour can be used to group elements, indicate meaning and attract attention (Lidwell et al, 2003, p.38).
- **Accessibility:**

Control design, layout and position should be easily accessible to a wide range of users, easy to interpret and easy to operate. (Lidwell et al, 2003, p.14)
- **Mapping:**

“A relationship between the controls and their movements or effects. Good mapping between controls and their effects result in greater ease of use.” (Lidwell et al, 2003, p.128). For example, in Figure 055 (left), the vertical movement of the window control buttons express to the raising and lowering of the door window.

- The research discussed earlier by Monö (1997) also references Gestalt theory. The following Gestalt principles are considered appropriate for the design of secondary controls:

Proximity:

Elements positioned close together are perceived to be more related than elements positioned further apart. For example, Figure 055 (centre) illustrates how window controls are positioned on the centre column. The window controls do not express or describe their functional purpose well due to their distance from the door window.

Similarity:

Elements with similar properties are perceived to be more related than elements with dissimilar properties. An example of this is illustrated in Figure 055 (right), the similar visual characteristics of different controls group them visually.

- Figure 056 illustrates commonly used automotive control symbols (ISO standard 2575). These symbols are generally recognised by all users who are familiar with driving a motorcar.

With regard to the usability of secondary controls, Norman (2004b) argues that the design, layout and positioning of secondary controls in contemporary motorcars is complex, not user-friendly and thus dangerous. In addition, Norman put emphasis on the design layout of the centre console controls. For example, Norman highlights the difficulty of operating the in-car radio whilst driving at high speeds. This is due to the controls being small in size and clustered close together (Figure 057).

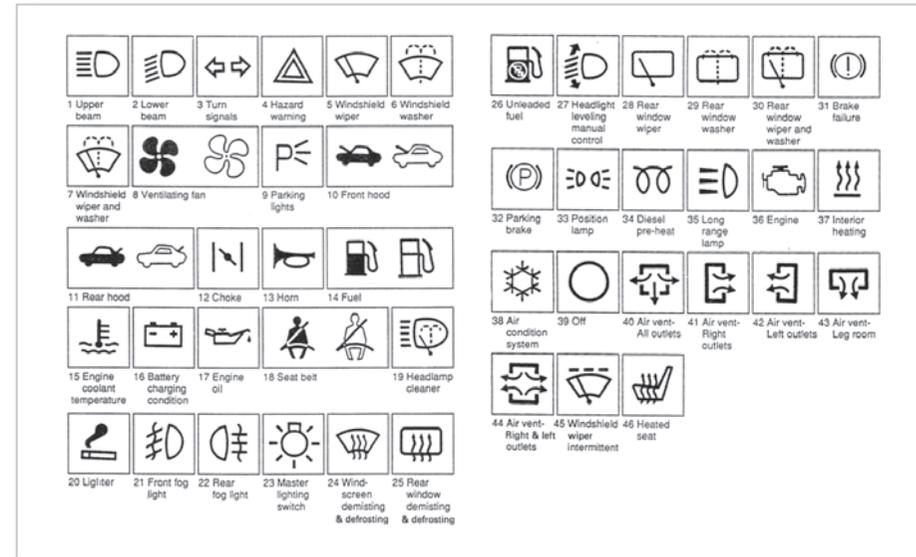


Figure 056. *Symbols in ISO Standard 2575.* (Peacock and Karwoski. 1993, pp.240–241).



Figure 057. “Try hitting the button for station 6, while driving at high speeds in this sports car”. (Norman, 2004c).



F1 race car secondary controls positioned on the steering wheel. This enhances general accessibility of these controls. Safety is also improved by allowing the driver to keep his/her hands on the steering wheel at all times.



Citroen C4 steering wheel (2005). In similar design fashion to the F1 steering wheels, some secondary controls were positioned on the steering wheel.



The General Motors Hy-wire (2002) eliminated many secondary controls for improved usability and visibility.



In similar fashion to the Hy-wire, the Renault Altica (2006) eliminated many secondary controls.

Figure 058. *Various state-of-the-art configurations for secondary controls.*

Norman's emphasis on simple, easy to use controls has clear implications on the interior design proposal. The design of uncluttered, simple and easy to use controls is also a design consideration for the interior design proposal. The appropriate positioning of secondary controls within the interior design proposal requires further investigation. This will require investigation into the static and dynamic reach envelopes of a range of users from a seated position.

Applicable state-of-the-art technology/materials/design

Research identified the following as innovative design solutions for the configuration, layout and placement of secondary controls:

- Moving secondary controls to the steering wheel;

The placement of secondary controls on the steering wheel is becoming increasingly common (particularly in luxury motorcars). Placement of secondary controls on the steering wheel provides easier accessibility.
- Reduction in the number of secondary controls;

The overall intent of this is to reduce visual clutter and put emphasis on the task of driving.

For visual reference to the concepts mentioned above, refer to Figure 058. The integration of these secondary control design solutions is explored during the development of the interior design proposal.

3.4.2 In-car information display systems

In-car information display systems have various functions within a motorcar. One common design feature associated with the in-car information display systems is the instrument cluster situated behind the steering wheel. The instrument cluster displays vital motorcar information to the driver (i.e. speed, engine temperature, fuel). Both analog and/or digital display technology is commonly used in the design of contemporary instrument clusters.

Recent years has seen the introduction of additional in-car display features in contemporary motorcars. These additional display features are often found in the centre console, cabin ceiling and rear compartment (assuming the motorcar has a second row of seats). Generally, these displays present entertainment information, GPS navigation information and multi-level menu interfaces associated with secondary control features. Figure 059 illustrates various examples of in-car display features used in both contemporary road going motorcars and race cars.

The following are general in-car display design considerations for the interior design proposal:

- In-car displays should be positioned high and as far back as possible from the driver (without obstructing the drivers FOV). The overall intent is to reduce glance time and increase the likely-hood of detecting danger within their peripheral FOV.

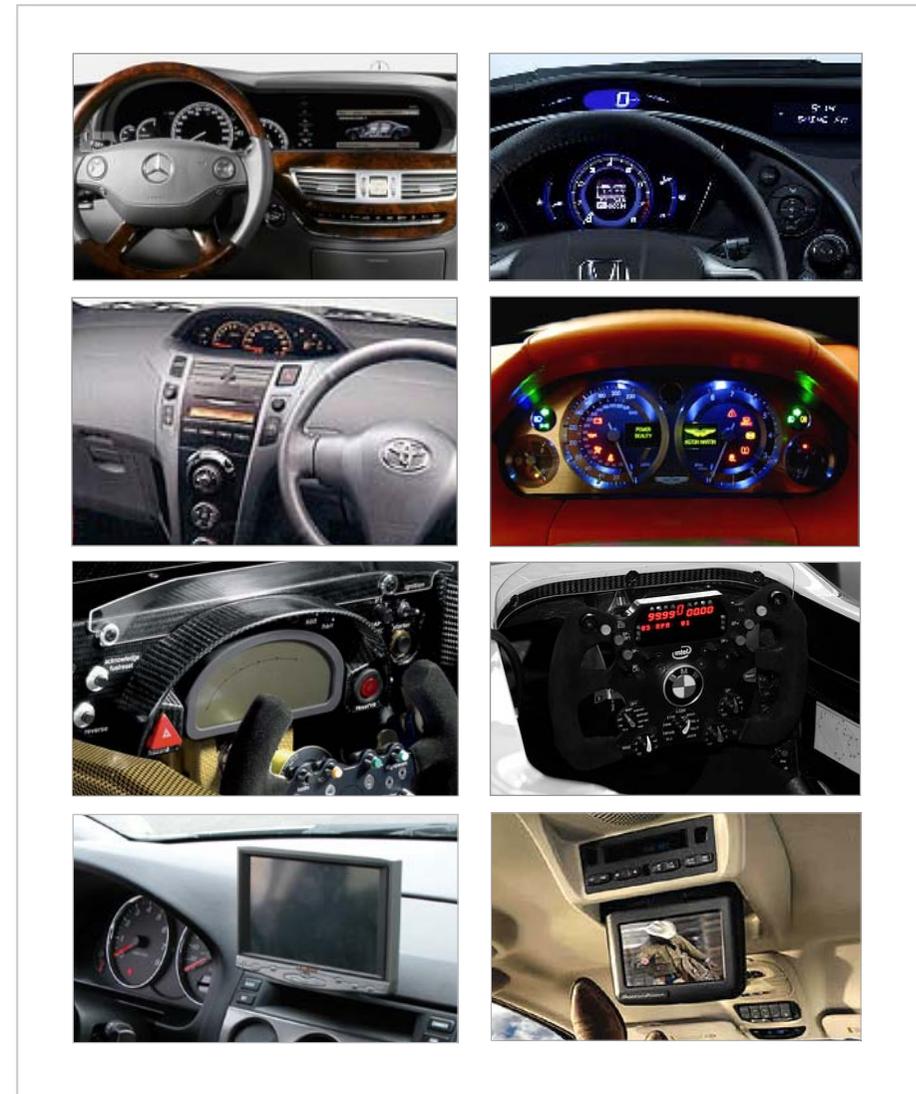


Figure 059. Various contemporary road car and racing car display features.



Toyota Endo LCD dashboard – 2004



Saab Aero X instrument cluster – 2006



Honda FCX heads up display – 2005

Figure 060. Various innovations in in-car display design.

- Labels/text should possess adequate size and contrast ratio.
- Visual layout should be designed to minimise visual clutter and confusion. In-car displays should be easily viewed by the driver.
- Ideally, information displayed should be red or orange, as these colours appear at a greater distance to all other colours. This reduces focusing time between the display and road (Dreyfuss, 2002, p.85).

Applicable state-of-the-art technology/materials/design

The following are state-of-the-art technologies applicable to the interior design proposal:

- Large touch sensitive LCD or OLED display screens; These displays allow for the reduction of secondary controls, allowing for greater use of smooth surfaces (Cardesignonline, n.d.).
- Intelligent displays; Displays which only display necessary information to the driver. This has the advantage of reducing visual clutter and improving readability.
- Heads up displays (HUD); Information is projected onto the front windscreen. This reduces glance time and keeps the drivers peripheral FOV forward. This increases the likely-hood of detecting danger. However, projecting information onto the windscreen may become distracting and also obstruct the driver's direct FOV.

3.4.3 Direct and indirect vision systems

Direct and indirect vision systems allow an occupant to view their surrounding external environment. Typically, the direct vision system features the interior cabin window openings (i.e. front windscreen and side windows). Indirect vision system typically feature side and rear vision mirror displays for rear vision (Figure 061). Reverse camera displays are also becoming more common in contemporary motorcars. It is important to note that the window openings for the interior design proposal are already well defined as illustrated in Figure 062. Also, the exterior side mirrors have also been designed and are outside the scope of this investigation.

The following are general considerations for the design of direct and indirect vision systems within the interior design proposal:

- Design should minimise obstruction of the driver's direct FOV where possible. This is of particular significance due to the low cabin height of the Hulme F1 supercar. Because the low cabin inherently reduces the driver's FOV, any further obstructs would have driver safety implications.
- Minimise use of reflective surfaces within the interior to reduce glare.
- Indirect vision displays should be positioned so that the combined head and eye movement of the driver does not exceed 60 degrees (SAE, 1967). However, there are possible advantages to positioning these displays closer to the drivers forward line of sight. If the angle between the rear-



Figure 061. *Toyota Corolla indirect vision system design feature.* (Bkkautos, 2006).

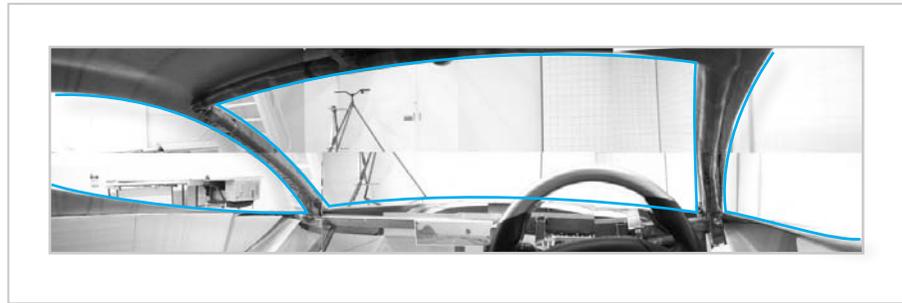


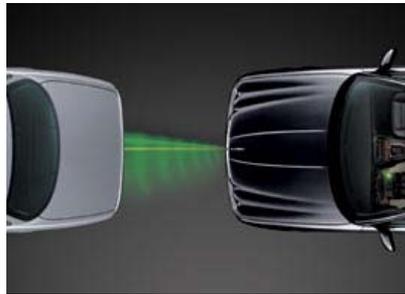
Figure 062. *Hulme F1 supercar window openings.*



Ferrari Enzo steering wheel has a bevelled top edge to not impede driver FOV (Grabianowski, 2004).



Many motorcars now incorporate reverse cameras displays. This design features give the driver additional information about their surrounding environment.



External sensors detect the proximity of near objects, and warn the driver of impending collisions



Infra-red night vision cameras improve night time driving visibility.

Figure 063. *State-of-the-art design features and technologies which aid direct and indirect vision.*

view display and the driver's forward line of sight is small enough, drivers will be able to view rear events without removing their gaze from the forward environment (Peacock and Karwowski, 1993, p.211).

- Rear view displays should not be positioned on the same elevation as the most critical forward images. (Peacock and Karwowski, 1993, p.212).

The drivers FOV is directly related to their driving posture. Issues relating to driver FOV are covered under body support systems (3.4.4).

Applicable state-of-the-art technology/materials/design

There has been little change in the design of direct vision systems in recent years, perhaps this is due to the technical constraints and demands of existing materials and cabin safety cell design requirements. There has been however many innovations in the design of indirect vision systems. Some of these innovations are as follows:

- Infra-red night vision camera displays
- External sensors using radar or sonar technology
- Reverse camera displays

The application of these technologies is not a primary concern of this investigation. However, the integration of a reverse camera display is important since the interior cabin is not designed with a rear window opening.

3.4.4 Body support system

In-car body support systems are designed to support the driver and passenger/s in an appropriate driving posture. Generally, the occupant seating posture is defined by the interior cabin dimensions.

Preliminary research into occupant seating posture for the Hulme F1 supercar has already been conducted (top, Figure 064). To affirm the quality of this research, the ergonomic data was cross analysed with ergonomic literature regarding ideal driving posture (Dreyfuss, 2002). The ergonomic data for the Hulme F1 supercar showed similar information to the recommended literature (bottom, Figure 064). However, there are variations with leg and arm posture. These variations are unavoidable due to the packaging constraints.

This investigation will now focus on the design of body support system features. Typically, a body support system features one of the following types of seats (also see Figure 065):

- Passenger car seat; the traditional motorcar seat.
- Sports seat; similar in design to passenger seats but with increased bolster support.
- Bespoke ‘bucket’ seat; a custom racing seat tailored to the dimensions of the driver. These seats are designed with minimal adjustability.

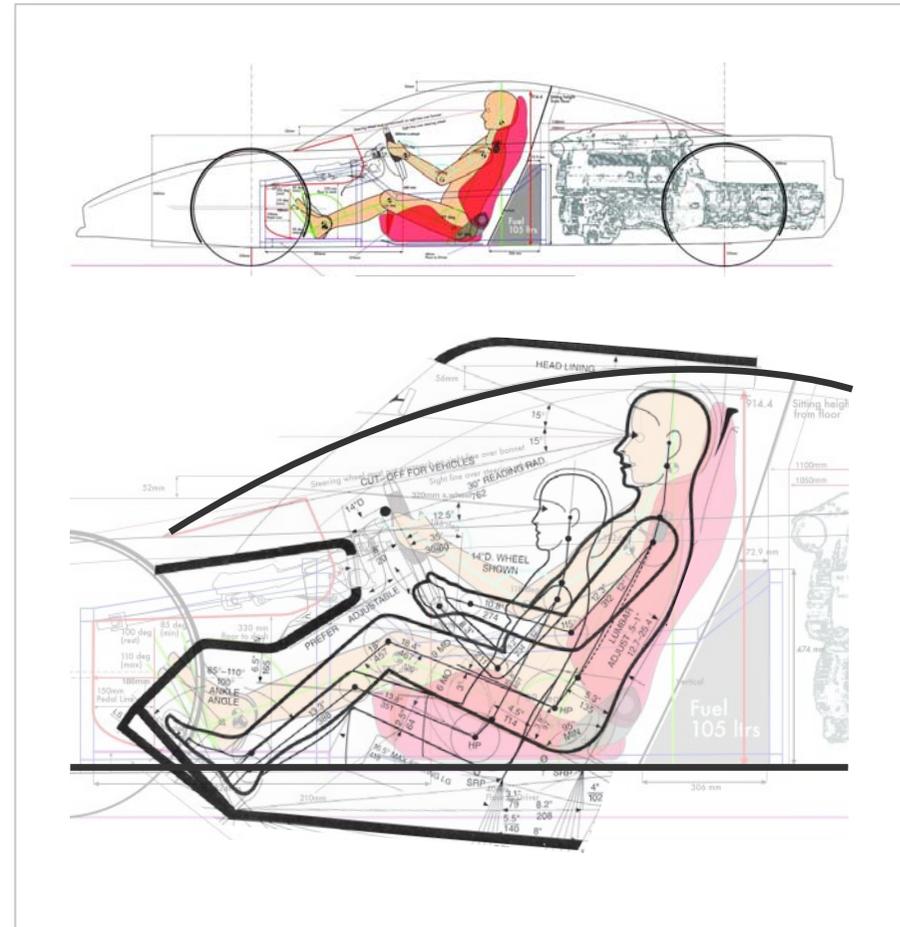


Figure 064. Comparison of earlier ergonomic research on the Hulme F1 supercar against ergonomic literature from Dreyfuss (2002).

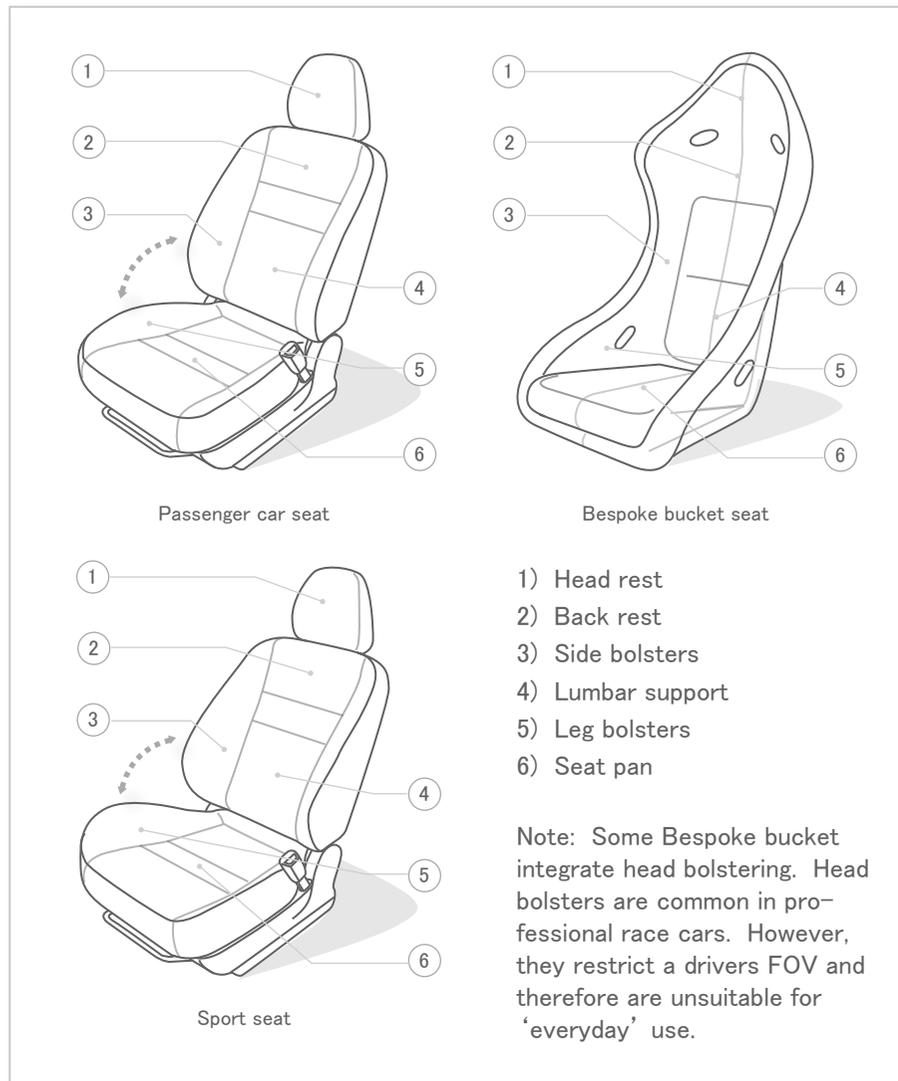


Figure 065. Common types of body support systems.

Each seat type offers the occupant a different level of functional performance in the areas of contour adjustability, manoeuvrability, support from dynamic driving forces, overall weight, motorcar-road haptic feedback and safety (see Figure 066).

Despite the differing types of seating and functional performance, several key design factors remain in common for sound motorcar seat design. The following are general design considerations for seating within the interior design proposal:

- **Head rest:**
The top of the head-rest should be at least as high as the occupants eye-level (NRMA, 2006).
- **Seat Pan:**
Inclined angle to provide support from the 'submarine effect' (longitudinal forces experienced under extreme braking).
Seat Pan width should reference the hip breadth of a 95th percentile female (432mm).
Seat pan must be no more than 419mm in length (Dreyfuss, 2002).
- **Backrest:**
Height of backrest should reference the sitting shoulder height of a 95th percentile male (646mm) (Loughborough, 2001).
Backrest width should reference the shoulder breadth of a 95th percentile male (535mm) (Loughborough, 2001).
- **Lumbar support:**
The lumbar support should provide continuous support along the length

and contour of an occupants back.

- Side and leg bolsters:

Bolsters should provide adequate support from dynamic driving forces.

Supercars are designed to have greater dynamic performance in comparison to most road going motorcars. This results in the need for high-performance seats. The Hulme F1 supercar requires a seat package characteristic of a sports seat, which offers adequate support from dynamic driving forces, but also allowing for the accommodation of a wide range of users.

The importance of visual comfort features

Research by Helander (2003) shows that once basic ergonomic and anthropometric needs are met in an automotive seat, a user’s sensory feedback from their ligaments, joints and spine are unable to distinguish between minor functional or ergonomic design differences. Furthermore, visual design features associated with comfort were easier to perceive and differentiate over minor ergonomic differences. This research provides support to the approach of this investigation; where once basic ergonomic and anthropometric requirements are met, emphasis focuses on the visual aspects of the interior design proposal.

H-Point (HP) and driver field of vision (FOV)

The HP is a theoretical point that references the pivot centre of the occupants

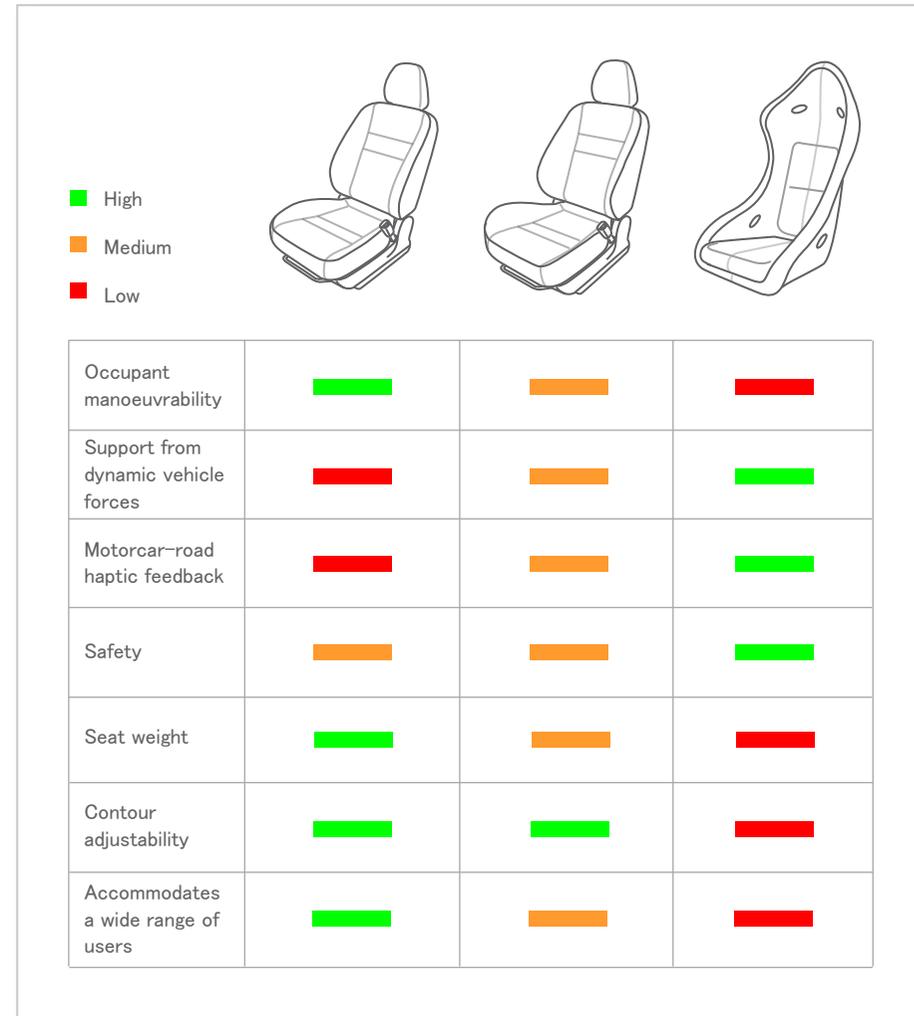


Figure 066. Evaluation of the common types of body support systems.

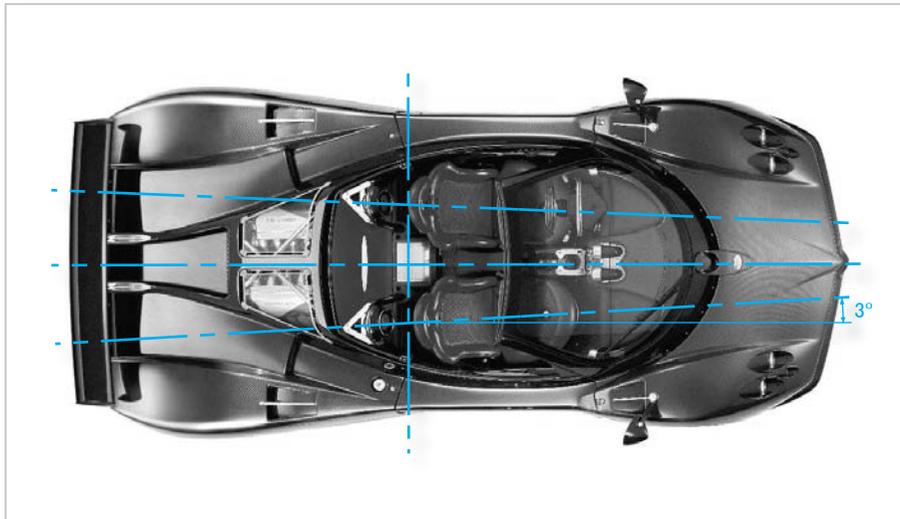


Figure 067. *Pagani Zonda F Roadster offset driving position.* (Autodrome, n.d.).

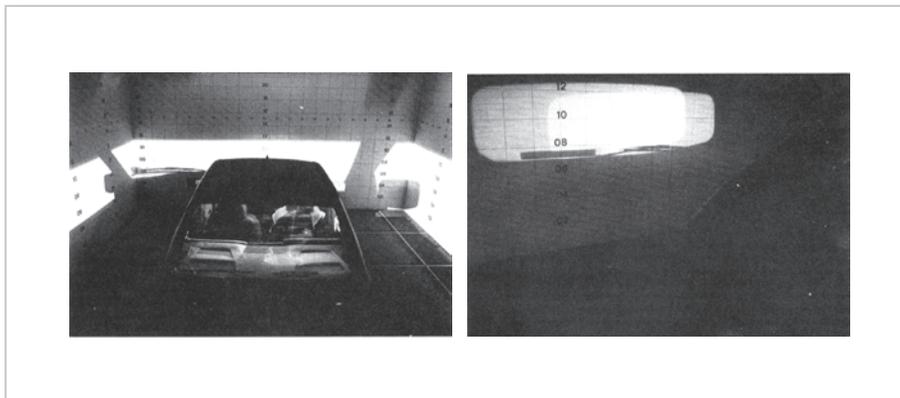


Figure 068. *Two light method.* (Peacock and Karwowski, 1993. p.91).

torso and thigh centre lines (Peacock and Karwowski, 1993, p.32). Functional task orientated anthropometric measurements are referenced from the HP. Typically, the HP is measured using a H-point manikin or 2D occupant templates. This investigation does not have access to an H-point manikin. Therefore, referencing the HP is only possible using 2D manikins. Previous ergonomic research into the Hulme F1 supercar only demonstrates the HP of a 95th percentile male (Figure 064). There is no data illustrating the HP for a range of users (i.e. 5th percentile female to 95th percentile male). As a result, all control and driving posture data illustrated in Figure 064 is only appropriate for a 95th percentile male. This issue is considered significant, since the Hulme F1 supercar is intended for a range of users. This issue is further explored during this investigation.

A driver's FOV is largely determined by their eye position; driver eye position is determined by the design of the body support system and package. As a result, a driver's FOV is typically referenced from their HP. Previous ergonomic research on the Hulme F1 supercar does not discuss the implications of different HP locations on a driver's FOV. This issue is also further explored during investigation.

Off-set driving position and foot wells

An off-set driving position occurs when the motorcar seat is positioned at an off set angle from the central motorcar axis. To demonstrate this, Figure 067 illustrates the seats of the Zonda F Roadster at a 3° off set. Off set driving positions are common in contemporary supercars (Nye, et al, 1999). This is due to their

package configuration, where the mid-mounted engine pushes the interior cabin forward. The front wheel wells are typically wider than conventional road cars and therefore reduces foot well size. This forces the occupant to be positioned at a slight off set to the central axis. There is currently no existing data on whether the Hulme F1 supercar interior has an off set driving position, although this is likely to be the case. If this occurs, altering the package to eliminate an off set driving position is outside of the scope of this investigation.

Longitudinally fixed seat position

As stated earlier, the use of drive-by-wire technology allows highly adjustable controls. The use of this technology eliminates the need for longitudinally adjustable seating, as the occupants do not need to adjust their seated position to reach controls. As a result, the interior design proposal focuses on longitudinally fixed seating. A fixed seat position was also considered more reflective of the F1 cockpit and driving experience.

Adjustable seat height

Height adjustable seats are becoming increasingly common in contemporary motorocars. The purpose of this is to provide improved FOV; particularly with drivers who are small in stature (Loughborough, 2001). The implications of height adjustable seats within the interior design proposal are explored during its development.

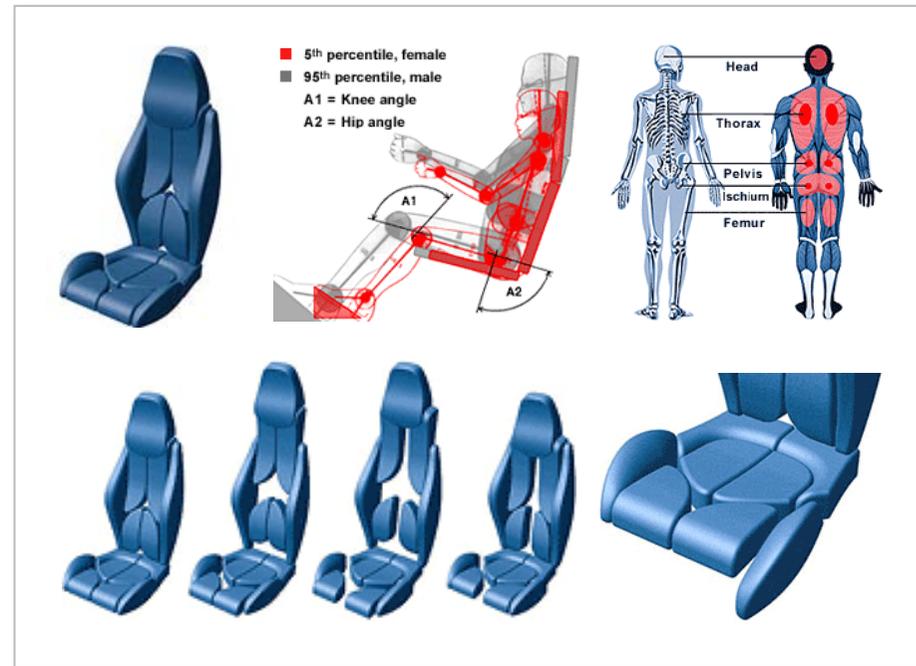


Figure 069. *RealFlex concept seat.* (IAV, 2004b).

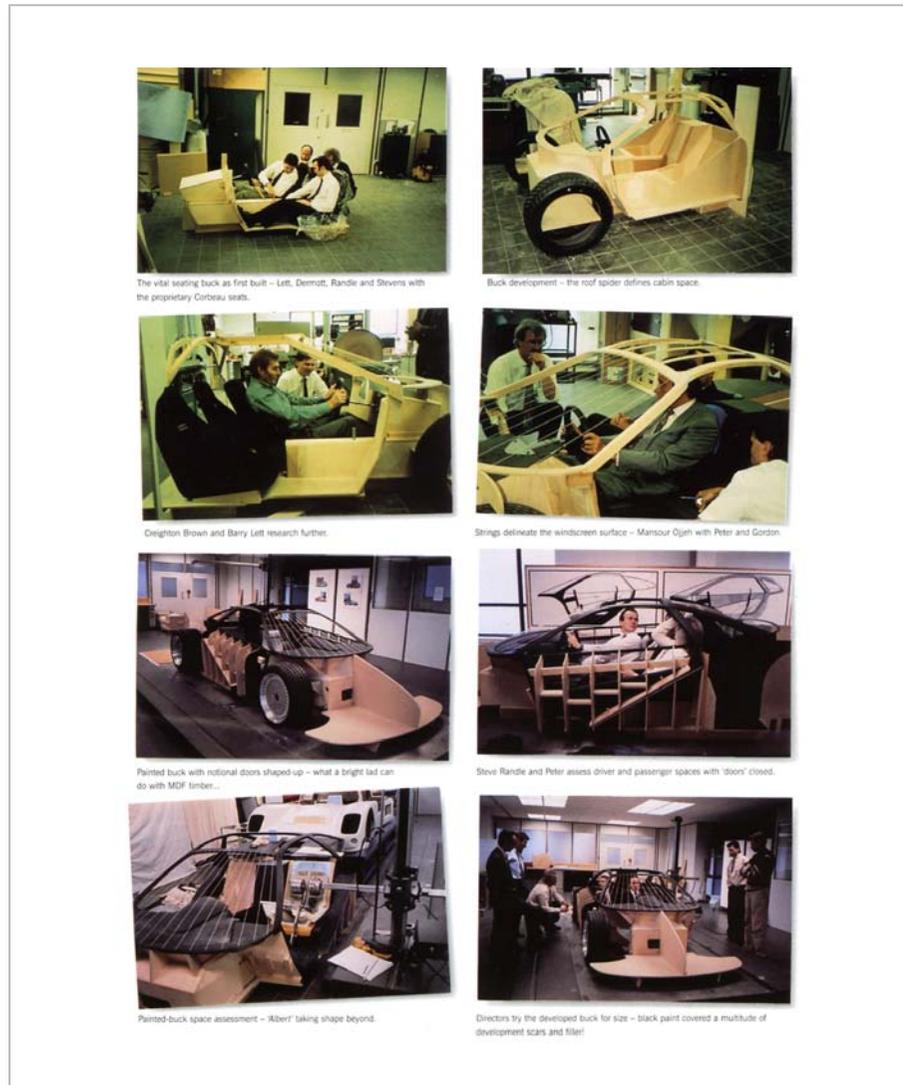


Figure 070. *Interior buck ergonomic testing* (Nye, et al, 1999, p.87).

Applicable state-of-the-art technology/materials/design

Figure 069 illustrates the RealFlex seat concept (IAV, 2004a), a state-of-the-art motorcar seat design. This design offers superior functional performance through the use of adjustable multi-contour support surfaces. The design also caters for a wide range of users through its adjustable seat pan, back rest and bolsters.

Since functional innovation is not the primary concern of this investigation, there is no intention to integrate this seating concept into the interior design proposal. However, the integration of adjustable bolstering within the interior design proposal is desirable, as this allows for the accommodation of a wide range of users whilst offering the required level of support for supercars.

Gaps in knowledge requiring further research

Several areas of research require further investigation with regard to body support system for this interior design proposal. Firstly, there is no existing data on the occupant seating posture from plan view or the front elevation. These alternative perspective planes allow for a more comprehensive assessment of appropriate seating postures and occupant spatial requirements. Secondly, current data only accounts for the seating posture of a 95th percentile male. With the intended end-user having no specific anthropometric description, a wider range of occupants must be tested. To gather additional anthropometric and ergonomic data, testing similar to that illustrated in Figure 070 is required. Testing of this nature with the use of a 1:1 interior buck is common practice.

3.4.5 Vehicle ingress/egress systems

The ingress-egress system facilitates occupant entry and exit. Typical features include the motorcar doors, seats, entry/exit space and support surfaces (typically handles). The entry/exit space is also a distinct feature of the ingress/egress system.

The following are general considerations for the design of an ingress/egress system for the interior design proposal:

- Design features should not obstruct the existing entry/exit space. An unobstructed entry/exit space allows for easy entry and exit. Typically, the steering wheel and door shutline are the main obstruction for occupants.
- Support surfaces should be designed and appropriately positioned to assist the occupant when entering and exiting the motorcar.

The ingress/egress system for the interior design proposal is already well defined (Figure 071). The design and treatment of support surfaces to assist occupant entry and exit still requires further investigation. In addition, the design of the entry/exit space has yet to be completely resolved and therefore also requires further investigation.

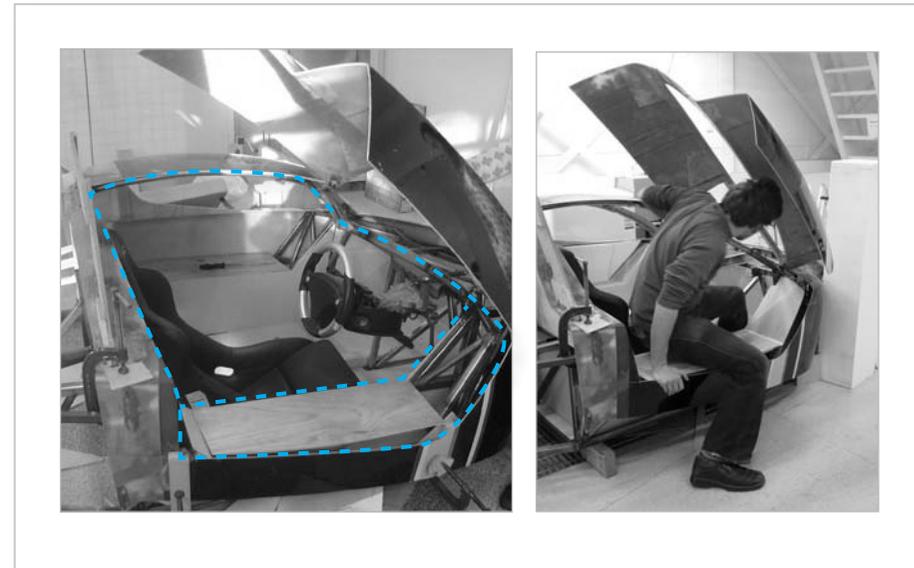
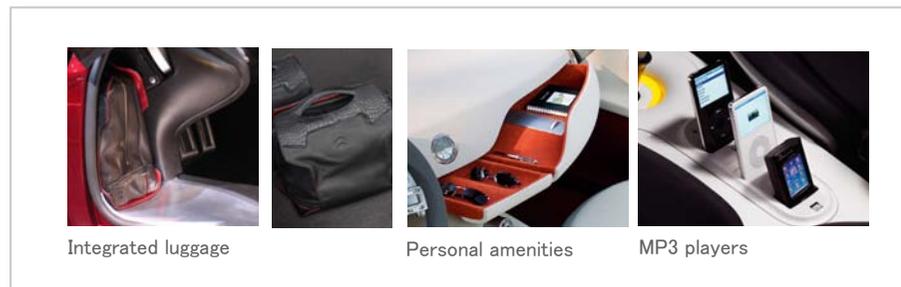


Figure 071. *Interior buck entry/exit space.*

Figure 072. *Common in-car storage features.*Figure 073. *Innovative in-car storage features.*

3.4.5 In-car storage systems

This research defines in-car storage systems as systems designed to package and/or support occupant goods. The following are typical in-car storage system features (also illustrated in Figure 072):

- Centre console storage compartments.
- Glove box (generally found in the instrument panel on the passenger side).
- Door storage compartments.
- Armrest storage compartment (found between occupant seats).
- In-car cup holders (found in various positions within the interior).

To date, there is a lack of literature regarding design considerations for in-car storage systems. To this end, this research proposed the following as basic design considerations for in-car storage system design:

- Features should be easy to use and easily accessible.
- Features should adequately package and support the occupants goods.
- These features should not impede on the operation of other design features (eg. driver controls).

There are many innovative ways to design in-car storage system features (Figure 073). Due to the scope of this investigation, the interior design proposal focuses on the design of basic storage features.

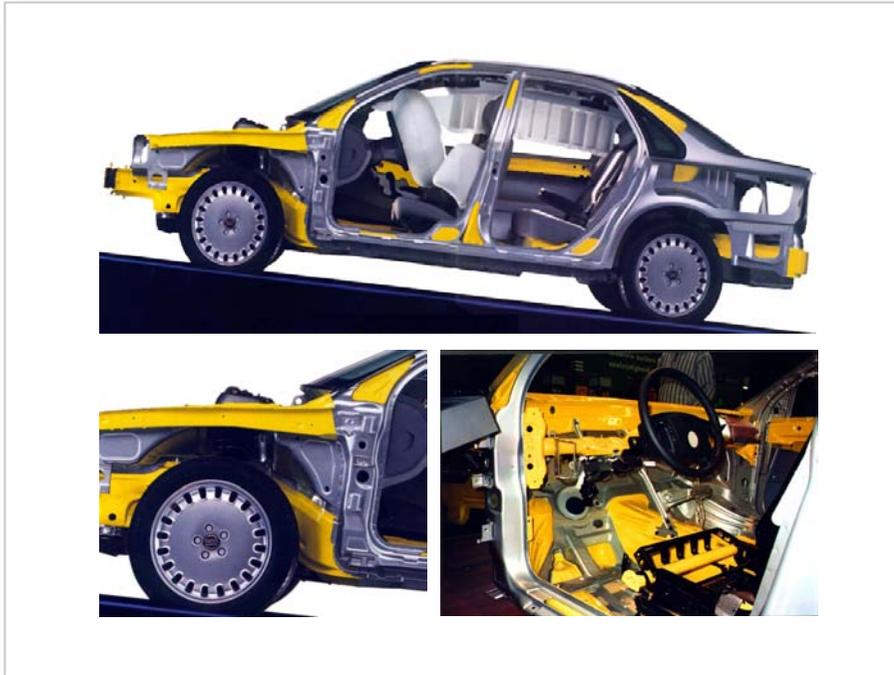


Figure 076. *Common deflection features highlighted in yellow.* (Automobiles, 2005).

found in contemporary motor cars:

- Airbags: contemporary airbag units are compact enough to fit into the most confined spaces. As a result, multiple airbag units commonly surround occupants to cater for a variety of collisions (as illustrated in Figure 075).
- Occupant safety harness (seat belt): there are generally two types of safety harnesses; a three point safety harness (diagonal lap belt) generally designed for road cars and a four to six point racing harnesses orientated towards race cars.
- Energy absorbing deflection features: these are designed to absorb and deflect the energy of an impact in order to maintain the structural integrity of the interior safety cell and protect the occupant/s from harm. Figure 076 illustrates these safety features in yellow. Typically, these features are constructed from materials such as high-tensile strength steel.

There are many theoretical design considerations associated with occupant safety system design. Due to the scope of this investigation, a thorough analysis, design and testing of safety systems for the interior design proposal is not possible. Therefore, the design of the interior design proposal will only focus on the general integration of common interior safety system design features (mentioned above).

3.4.7 Summary : Interior functional systems

The aim of this section was to identify fundamental functional and ergonomic design considerations to support the interior design proposal. Review focused on each functional system of the interior design proposal, establishing the general ergonomic and functional requirements of each system and their associated features.

The following gaps in knowledge were identified in context to the interior design proposal:

- Potential locations for in-car storage systems.
- Positioning and design of support surfaces to assist ingress and egress.
- Static and dynamic reach envelopes for a range of users. These envelopes are required for the appropriate placement of controls.
- Appropriate positioning of a rear vision display feature.
- Changes in direct FOV with a range of users.
- Occupant driving posture with regard to a range of users.
- Plan and front-end elevation ergonomic diagrams with an appropriate range of users.

These issues are addressed during the development of the interior design proposal.

3.5 Background research conclusion

The aim of this research investigation is to develop an appropriate conceptual interior proposal for the Hulme F1 supercar. To facilitate this, the investigation required a thorough understanding of the Hulme F1 supercar's context. Background research focused on the following areas of research:

- The Hulme F1 supercar motifs.
- Contemporary theory on visual product communication and experience.
- Visual trend analysis of contemporary motorcar exemplars.
- Contemporary theory on the design of interior functional systems.

The findings of each section outlined above illustrate significant implications for the interior design proposal. For example, research into the Hulme F1 supercar motifs began to outline appropriate expressions for the interior design proposal (Figure 028). The contrasting qualities associated with high-performance and luxury was a recurring issue during the background research, indicating that the interior design proposal requires an appropriate balance between the expressions of high-performance and luxury. Research also concluded that F1 references can be used to express both 'exoticness' and 'high-performance' within the interior design proposal.

The VPE framework by Warell (2007) offered a systematic approach for developing more refined design criteria for the interior design proposal. To give the design

criteria context and support, the framework was used to analyse aesthetic trends in luxury, high-performance and exoticness in contemporary motorcar interiors and interior/exterior relationships. The identified trends illustrated many implications for the development of design criteria. For example, many exotic exemplars use contrasting high-performance materials such as unadorned carbon fibre composite and metallic trim to highlight functional control features. This was seen as an appropriate trend to reference in the interior design proposal as it allows for highly distinctive and expressive control features.

A summary of the desired qualities and expressions for the interior design proposal is illustrated in Figure 077.

The following gaps in knowledge were identified in context to the interior design proposal, which required further investigation:

- Appropriate integration of an ingress/egress system similar to a F1 race car ‘snap on’ steering wheel
- The appropriateness of a cocoon like driver cockpit
- Potential locations for in-car storage systems
- Positioning and design of support surfaces to assist ingress and egress.
- Static and dynamic reach envelopes for a range of users, to establish appropriate areas for the placement of controls.
- Appropriate positioning of a rear vision display feature
- Changes in direct FOV with a range of users

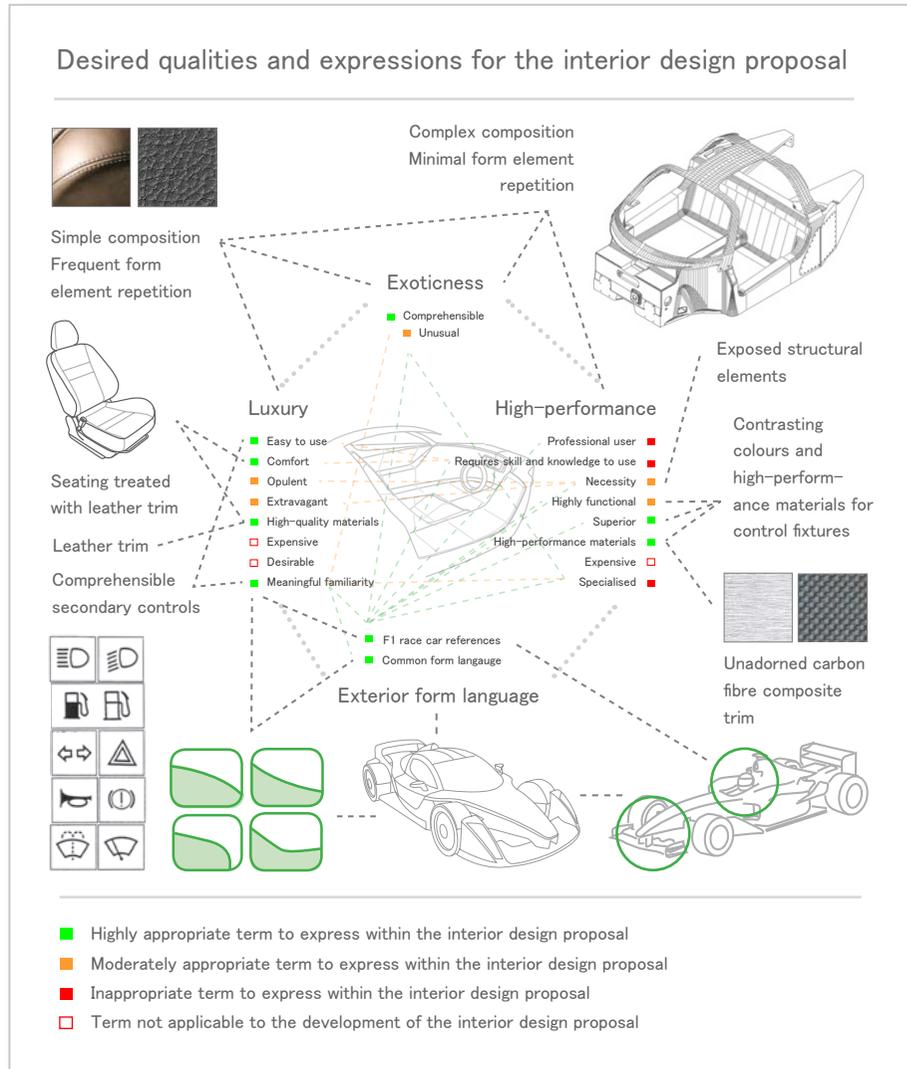


Figure 077. The desired qualities and expressions within the interior design proposal.

- Occupant driving posture with regard to a range of users
- Plan and front end elevation ergonomic diagrams with a range of users.

The integration and significance of the background research findings can be seen within the design criteria in chapter 4. As proposed within the central proposition (1.2), the design criteria are divided into two categories; performance and experience design criteria. Experience design criteria outlines the desired visual requirements of the interior design proposal, while performance criteria outlines the functional and ergonomic requirements and considerations for the interior design proposal. These criteria are used as a starting point for the development of an interior design proposal that fulfils the aim of the research.

4.0 Experience design criteria

Table 001. *Experience design criteria – part 1.*

Experience criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)
Repetition of higher order form elements 		<input type="radio"/>		
Repetition of lower order form elements 		<input type="radio"/>		
High-performance design elements should be styled to appear complex in composition and use minimal form element repetition		<input type="radio"/>		
Luxury design elements should be styled to appear simple in composition and use frequent form element repetition		<input type="radio"/>		
High-performance design elements should reference contemporary F1 race cars		<input type="radio"/>		
Interior design proposal expression should compliment the existing exterior aesthetic expression			<input type="radio"/>	
Secondary control features should be easy to comprehend.		<input type="radio"/>		

Experience design criteria

Table 002. *Experience design criteria – part 2.*

Experience criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)
Interior aesthetic should reference structural elements				○
Overall aesthetic composition should not be overly simple or complex. Complex Simple 		○		
Integrate unadorned carbon fibre and leather trim.		○		
Control features should be treated with contrasting colours and/or high-performance materials.		○		
Visual features associated with seat comfort should be expressed.			○	
Body support system should integrate high-quality leather trim.			○	
The aesthetic composition should utilise negative space		○		

Performance design criteria

Table 003. *Performance design criteria – part 1.*

Performance criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)
Interior must accommodate two occupants	<input type="radio"/>			
The interior design proposal must fit within the existing package	<input type="radio"/>			
Forward visibility should be free of visual obstructions.		<input type="radio"/>		
In-car display systems should be positioned as far from the driver as possible (while still legible) and high as possible (without obstructing the drivers direct FOV)		<input type="radio"/>		
Adjustable headrest (laterally and longitudinally)			<input type="radio"/>	
Body support design feature considerations (refer to 3.4.4)	<input type="radio"/>			
The interior must have occupant safety harnesses	<input type="radio"/>			
The interior should have occupant airbags units		<input type="radio"/>		
The interior design meets general requirements implied by deflection features.				<input type="radio"/>

Performance design criteria

Table 003. *Performance design criteria – part 2.*

Performance criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)
Primary controls integrate drive-by-wire technology		<input type="radio"/>		
Foot pedals designed to allow for left-foot breaking.		<input type="radio"/>		
Primary controls should be longitudinally adjustable		<input type="radio"/>		
Body support system should be fixed in position		<input type="radio"/>		
Entry/exit space should remain as large and unobstructed as possible		<input type="radio"/>		
In-car storage features are to be easily to used and accessible.			<input type="radio"/>	
Dynamic contouring seat bolsters		<input type="radio"/>		
Easy access to secondary control features for a wide range of users		<input type="radio"/>		

5.0 Design research

The background research has established the context, identified existing gaps in knowledge and developed a comprehensive list of experience and performance design criteria for this study. The purpose of this section is to develop a research programme which focuses on the development and testing of an appropriate interior design proposal for the Hulme F1 supercar. The following subjects are examined in this section:

- Research Approach
- Research Methods

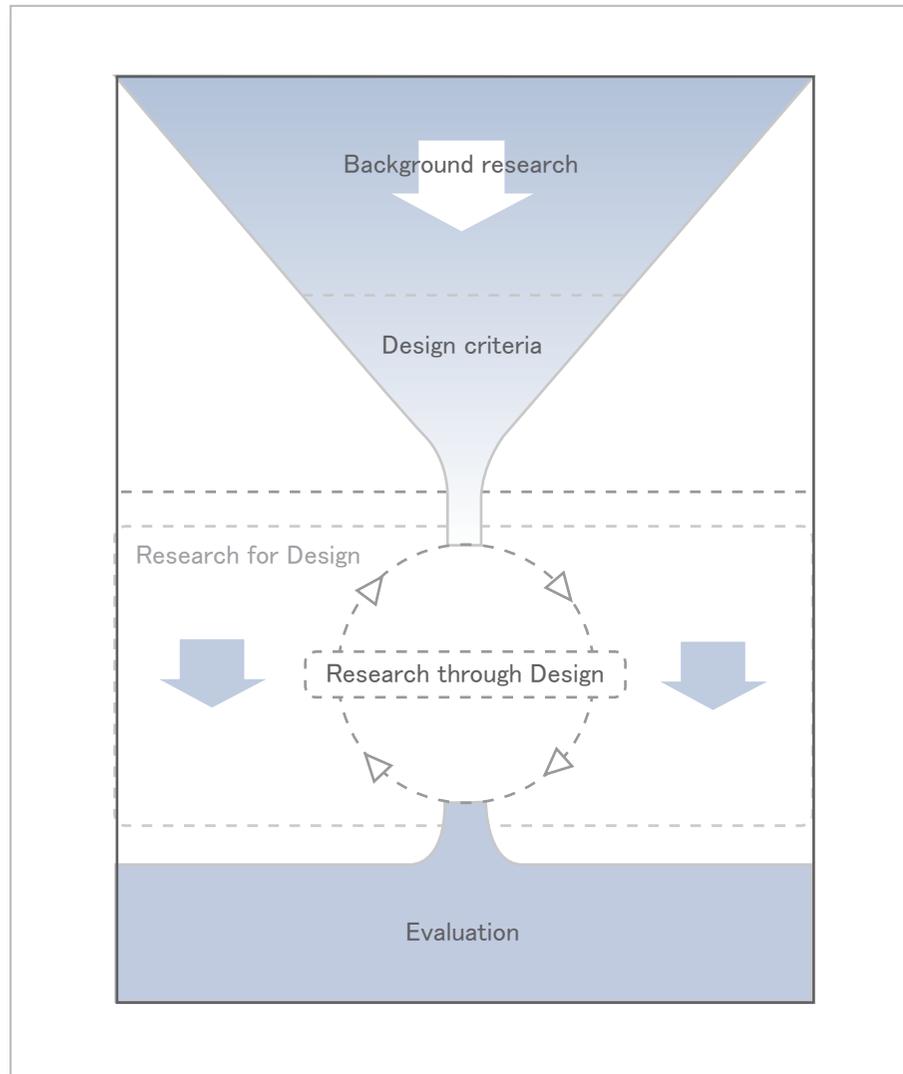


Figure 078. Overall research approach.

5.1 Research approach

As stated in Chapter 1.1, the aim of this research is to ‘develop an appropriate interior design proposal for the Hulme F1 supercar’. This by nature implies creative practice is required to fulfil or address the research aim. However, it is difficult to design without supporting context. Therefore, there are two primary modes of research for this investigation; ‘research through design’ and ‘research for design’.

‘Research through design’ places emphasis on design practice as a means of inquiry and producing knowledge (Downton, 2003). Design practice is used to develop the interior design proposal within the context the design criteria outlined in chapter 4. The interior design proposal is in turn used to test the credibility of the design criteria and evaluate whether it has fulfilled the aim of this investigation.

‘Research for design’ is used as a means of supporting the research through design process (Downton, 2003). The research for design focused on unresolved user issues identified within the background research and development of supporting material required for the interior design proposal.

Figure 078 illustrates how the two primary modes of research compliment each other during the development of the interior design proposal.

5.2 Research methods

This section discusses the selection and design of research methods employed in this study. When considering development and testing of an appropriate interior design proposal for the Hulme F1 supercar, the need to use multiple research methods becomes evident. For example, the development of the interior design proposal requires a range of qualitative, quantitative and iterative research through design methods. Meanwhile, testing of the interior design proposal requires different research methods altogether.

Figure 080 illustrates the range of research methods selected for this investigation. Many of these research methods are qualitative, reflecting the ‘research through design’ stance of this investigation. A number of quantitative research methods will also be used to ensure the functional and ergonomic requirements are fulfilled.

The research methods selected for this investigation can be categorised as follows:

- ‘Research for design’ methods
- ‘Research through design’ methods
- ‘Design evaluation’ methods

For a full description of each research method refer to Tables 005, 006 and 007.

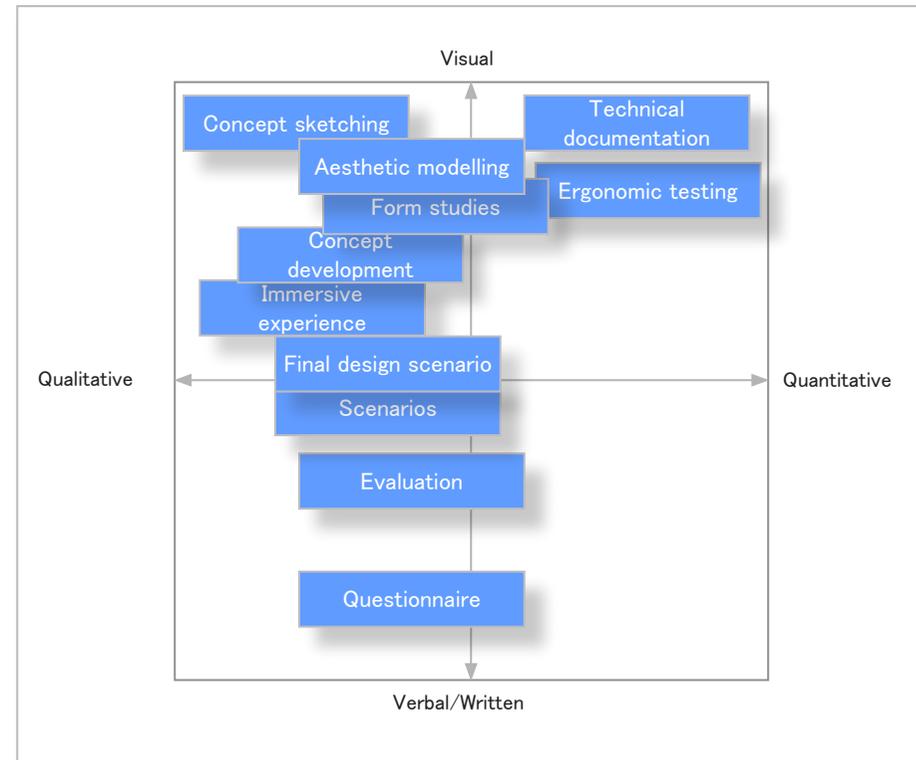


Figure 079. Types of research methods used in this investigation.

‘Research for design’ methods

Table 005. Description of each ‘research for design’ methods used in this investigation.

Method	Method Aim	Method Objectives	Appropriateness of use	Disadvantages or issues of use	Minimisation of potential issues	Method Description and Process
Immersive experience (Moore and Conn, 1985)	Investigate additional sources of inspiration and/or design issues in context to the interior design proposal.	Additional design criteria. Unforeseen design issues for further consideration.	Creative and constructive means of gaining new insight into possible rituals and/or design issues.	Findings can be highly subjective	The researcher remained as objective as possible while participating in the activities under study. Events were recorded for post-examination.	This method required the researcher to be an objective observer or participant in the following activities under study; Driving a Formula Challenge race car Passenger within the Saker GT
Ergonomic testing	Address the gaps in knowledge outlined within the background research with regard to ergonomic and functional issues. (refer to 3.5).	Additional performance design criteria for the interior design proposal.	Data generated from basic ergonomic testing with human participants is fast and easy to interpret.	An in-depth ergonomic investigation is outside the scope of this study. It requires lengthy testing with numerous participants.	Focus testing on existing gaps in knowledge.	Test a range of participants and a 1:1 scale interior buck with exterior bodywork. Ergonomic and anthropometric data was recorded. The descriptions of each test are discussed in section 6.2.
Scenarios (Black, 2007)	Illustrate and/or propose intended user rituals for the interior design proposal.	Outline ‘typical’ user rituals and potential solutions for embodying experience criteria.	An effective and simple means for expressing a product in use. Allows for the identification of specific design issues.	Without access to the target end user, accurate scenarios are not possible.	Scenarios were developed covering a range of ‘typical’ user tasks.	Illustrated storyboards were developed depicting a series of sequential tasks relating to the use of the interior design proposal. Storyboard material was based upon the researchers observations and findings from the ‘immersive experience’ method.

‘Research through design’ methods

Table 006. Description of each ‘research through design’ methods used in this investigation.

Method	Method Aim	Method Objectives	Appropriateness of use	Disadvantages or issues of use	Minimisation of potential issues	Method Description and Process
Concept sketching	Generate concepts which respond to the design criteria (4.0).	Develop range of potential concepts for evaluation.	Fast means for for the exploration of a range of concepts.	2D drawings have limitations when resolving 3D formal qualities.	Used in combination with form studies and aesthetic modelling.	The researcher used a range of media to iteratively generate a range of concepts.
Form studies	Generate 3D concepts.	Form studies demonstrating surface and spatial qualities.	Easy to evaluate surface and spatial qualities.	Lack of resolution due to the type of media used.	Used in combination with concept sketching.	Fast modelling materials such as polystyrene were used to sculpt concepts in 3D.
Concept development	Develop a concept to the stage where it fulfils most of the design criteria (4.0).	A refined concept that is ready to be developed as an aesthetic model.	Allows for a more focused iterative process.	Design development may take an inappropriate design direction.	Referencing of design criteria to guide design direction.	Iterative design techniques were used to develop a concept. Emphasis was placed on fulfilling experience and performance criteria
Aesthetic modelling	Produce a model that embodies the assumptions of the design criteria.	1:2 scale looks like model of the interior design proposal.	Effective means of fully resolving the visual aesthetic in 3D.	Will not have the same resolution as a 1:1 model.	A high level of visual resolution was imbued within the model.	Model making techniques were used to develop an aesthetic model based on concept renderings and form studies.
Final design scenario	Describe interior design proposal in context to the end user.	Illustrated storyboards.	Effective means for expressing user related design features.	No way to ensure users will interact in the ‘intended’ manner.	Storyboards focused on common user tasks within motorcar interiors.	Illustrated storyboards expressing the intended mode of use and rituals for the interior design proposal.
Technical documentation of the final design	Illustrate that the design fits within the package and accommodates a range of users.	Plan and elevation cross-section drawings.	Plan and elevation drawings of the interior design proposal are measurable.	A range of drawings are required to communicate dimensional properties of the design.	3D scan the model or generate a CAD model of the interior design proposal.	Referencing dimensions from the 1:1 interior buck and ergonomic data, cross-sectional plan and elevation drawings of the interior design proposal were developed.

‘Design evaluation’ methods

Table 007. Description of each ‘design evaluation’ methods used in this investigation.

Method	Method Aim	Method Objectives	Appropriateness of use	Disadvantages or issues of use	Minimisation of potential issues	Method Description and Process
Evaluation	Evaluate whether the interior design proposal fulfils the design criteria outlined in chapter 4.0.	Assess how many design criteria are fulfilled by the interior design proposal.	Provides the ‘research through design’ process a general framework to follow.	If the design criteria are invalid, then design work is likely to proceed in an inappropriate direction.	Constantly reflect on the design criteria and if necessary make changes to it.	Design criteria was referenced during the ‘research through’ design process. Also, the interior design proposal was evaluated against the experience and performance design criteria.
Qualitative questionnaire For a complete copy of the questionnaire and reference imagery used in this study, refer to Appendix 2.	Evaluate whether the interior design proposal compliments the existing exterior, thus fulfilling the aim of this research. Assess whether the design criteria and is of a credible nature. This will in turn assess the credibility of the central proposition.	Establish general trends in participant responses with regard to the visual impression of the interior design proposal. Establish to what degree participants believe the interior design proposal compliments the exterior.	Simple means for gathering a number of qualitative responses	Difficult to know whether participants will respond in a fashion that is constructive for this investigation. Time consuming for participants. Limited number of potential participants due to the size of New Zealand.	Question ambiguity was minimised by phrasing them correctly. Short questionnaire The researcher visited as many appropriate dealerships as possible to obtain an adequately sized sample group. The literature of Brace (2004) on the design of questionnaires was referenced.	Target participants: 10–15 luxury and/or exotic motorcar sales people. Participants were selected from Ferrari, Porsche, Lamborghini, Mercedes-Benz, Audi and Bentley dealerships. They were selected for their expert knowledge of luxury and exotic motorcars, and association with potential end users. Questionnaire design and format: Questions were answered in response to imagery of the interior design proposal. Questions 1–3 assessed the visual impression of the interior design proposal in relation to keywords the design based itself on. Visual Analogue Scales (Gould et al, 2002, p.706) were used to allow participants to answer. A detailed description of Visual Analogue Scales is discussed in 8.2. Participants were also given the opportunity to explain their response through open-ended qualitative questions. Question 4 assessed how well participants believe the interior design proposal compliments the exterior. Answers were given through a rating based multi-choice question and open-ended qualitative response explaining their response if applicable.

6.0 ‘Research for design’ results and discussion

The following ‘research for design’ method results are discussed in this section:

- Immersive Experience (Moore and Conn, 1985)
- Ergonomic Testing
- Scenarios (Black, 2007)

The results from these methods contributed to the development of the interior design proposal.

6.1 Immersive experience results

The following two immersive experience studies were the focus of this study;

- Travelling in a Saker GT
- Driving a Formula Challenge race car

These activities involved the researcher as an active participant or objective observer. The two experiences were planned to develop further insight into possible design issues relating to the interior design proposal.

Figure 080. *The Saker GT.*Figure 081. *Ingress and egress was made easier with a steering wheel which horizontally shifted towards the centre of the cabin.*

6.1.1 Saker GT experience

The Saker GT (1992) is a New Zealand built kit-car, assembled by the owner from a set of prefabricated parts. To reduce engineering development time, cost and to give the Hulme F1 supercar an immediate level of proven performance, the chassis and suspension setup from the Saker GT was modified for use on the Hulme F1 supercar prototype. The interior cabin of the Saker GT offers an ideal environment for the researcher to experience dynamic driving forces and spatial issues that relate closely to the Hulme F1 supercar.

In this experience, the researcher was a passenger within the Saker GT. The following observations were made during this experience:

- The steering wheel was designed to shift horizontally towards the centre of the interior cabin (Figure 081). This, in effect, made ingress and egress easier by creating a larger entry/exit space.
- The interior cabin was slightly claustrophobic with restricted vision compared with a conventional road saloon. A far forward dashboard and narrow foot wells also contributed towards this claustrophobic experience. This issue was compounded by the fact that the researcher is small in stature.
- The existing seats lacked adequate side bolster support, particularly while cornering.

From these observations, the following design issues arose;

- The steering wheel of the Saker GT had strong implications for the steering wheel design of the interior design proposal. As mentioned in section 3.4.5, a conventionally positioned steering wheel obstructs the entry/exit space. A horizontally shifting steering wheel as observed in the Saker GT could be referenced within the interior design proposal to address this issue. The concept of an articulating steering wheel also makes reference to F1 steering wheels where the restricted entry/exit space makes it necessary for a removable steering wheel (3.1.5).
- The interior cabin should be as spacious as possible, as a claustrophobic experience is not desirable. This could be achieved by minimising the size of the dashboard to open up the interior space.
- This experience affirmed the need for adequate side bolstering within the interior design proposal, as outlined in section 3.4.4.



Figure 082. *Formula Challenge racing experience.*

6.1.2 Formula Challenge race car experience

The Formula Challenge race car experience offers participants the opportunity to emulate their Formula One racing heroes in an open wheeled, open cockpit race car. This racing experience was ideal for gaining insight into of F1 aesthetics and rituals. With the sponsorship of Total Experience Inc, the researcher was given the opportunity to experience first hand driving an open wheel race car on a professional race circuit.

Firstly, the researcher was given a brief introduction to the race circuit and track driving techniques. Racing overalls, gloves and a helmet were supplied to the researcher to wear. He was then invited to enter the Formula Challenge race car and drive five laps around the race circuit (Figure 082). The following observations were made from this Formula Challenge experience:

- The lack of a glasshouse provided unrestricted vision. Having unrestricted vision was a very liberating experience for the researcher, since most conventional road going motorcars have an enclosed cabin with limited exterior vision. This experience was surprising, since the narrow cockpit was expected to create a claustrophobic experience.
- There was a lack of luxuries within the cockpit compared to conventional road saloons. This was not surprising, as previous background research illustrated the lack of luxuries within high-performance race cars (3.3.2). This insight did illustrate how a lack of luxuries minimises driver

distraction and maximises driver focus on the racing circuit and driving. For example, when braking to turn into a corner, there were no distractions such as in-car entertainment or fiddly climate control buttons to disturb the researchers concentration. The controls and display were also positioned directly in front of the driver. This further facilitated the researchers focus on the race circuit and driving issues.

- Driving the race car was a unique and rich sensorial experience. For example, the deafening rumble of the engine mounted directly behind the seat created a raw driving experience unlike any conventional road saloon. The firm racing suspension further emphasised this ‘rawness’ by allowing the researcher to feel every imperfection on the track surface and unrestricted vision created a visually liberating driving experience.

Overall, this driving experience was unique when compared to that experienced in a conventional road going motorcar. This uniqueness demonstrated ‘exotic’ qualities. As already stated, exoticness is a desired expression within the interior design proposal. This experience provided additional support for the F1 cockpit as an appropriate reference for the interior design proposal. Qualities such as unrestricted vision and a driving focused user interface reinforced this experience. It is important to note that providing complete unrestricted vision for the interior design proposal is not possible, as the window openings have already been established. The implications of these references within the interior design proposal are explored and discussed during the ‘research through design’ process (7.0).



Figure 083. 1:1 Scale interior buck, bucket seat and steering unit used for ergonomic testing.

6.2 Ergonomic testing results and discussion

The aim of ergonomic testing was to evaluate the existing interior space in relation to driver and passenger tasks and activities. This information provided basic specifications for further design exploration and development. Ergonomic testing focused on the following areas:

- Driving posture and spacial requirements
- Driver reach envelopes
- Driver field of vision (FOV)
- Positioning of a rear vision display
- Potential areas for in-car storage
- Positioning of ingress/egress support surfaces

Front, side and plan ergonomic diagrams were generated as part of this section. The term 'range of users' used throughout this research refers to a breadth of users ranging from a 5th percentile stature female to a 95th percentile stature male. Designing for this range of users is common practice (Peacock and Karwowski, 1993, p.20). To represent this breadth of users during testing, a 5th percentile stature female (participant one) and 95th percentile stature male (participant two) were selected. These participants were selected to evaluate ergonomic and anthropometric issues within a 1:1 scale interior buck (Figure 083). This buck utilised a Recaro Pole Position (FIA) bucket seat and steering wheel unit with a steering wheel diameter of 320mm in order to resemble a typical supercar interior.

6.2.1 Driving posture and spatial requirements

This test aimed to verify previous ergonomic research which claimed the interior cabin could accommodate a 95th percentile male (Figure 064). It also aimed to develop new insight into driver posture and spatial issues with regard to a range of users. Another focus of this test was to gather anthropometric data for use in ergonomic diagrams. These diagrams can be seen in section 6.2.7.

Before testing with participants commenced, the bucket seat was positioned within the interior buck. Seat placement was referenced from earlier ergonomic research on the Hulme F1 supercar package (Figure 064). This involved a back rest incline of 67° and positioning of the headrest 100mm from the rear wall. As stated earlier, use of ‘drive-by-wire’ technology allows for longitudinally adjustable primary controls, eliminating the need for longitudinally adjustable seating (3.4.4). As a result, testing focused on a fixed seat position, not a longitudinally adjustable seat.

Participants were invited to sit within the interior buck. The steering wheel was positioned at a comfortable reaching distance from each participant. To ensure reaching distances were acceptable, participant elbow angles were referenced against recommended comfort angles by Dreyfuss (2002, p.66). Anthropometric data was recorded using basic measuring instruments. Visual observations were also made with regard to the participant’s driving posture and spatial issues. Following this, participants were invited to make verbal comments in regard to issues associated with testing. Results from testing are illustrated in Figures 084 and 085.

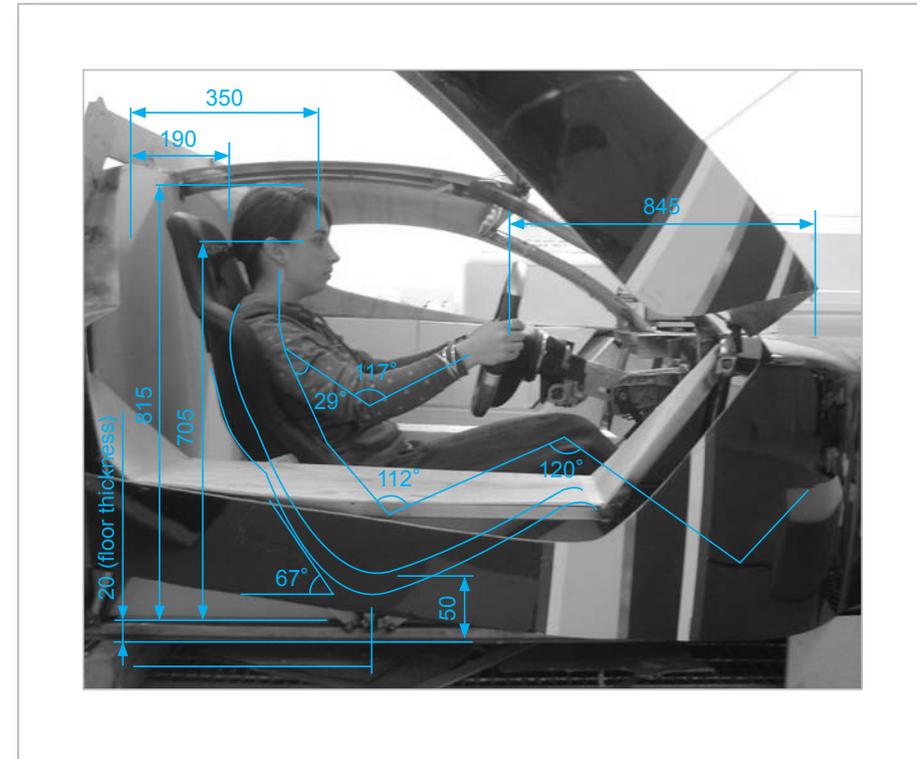


Figure 084. *Ergonomic test for posture and spatial requirements: participant one.*

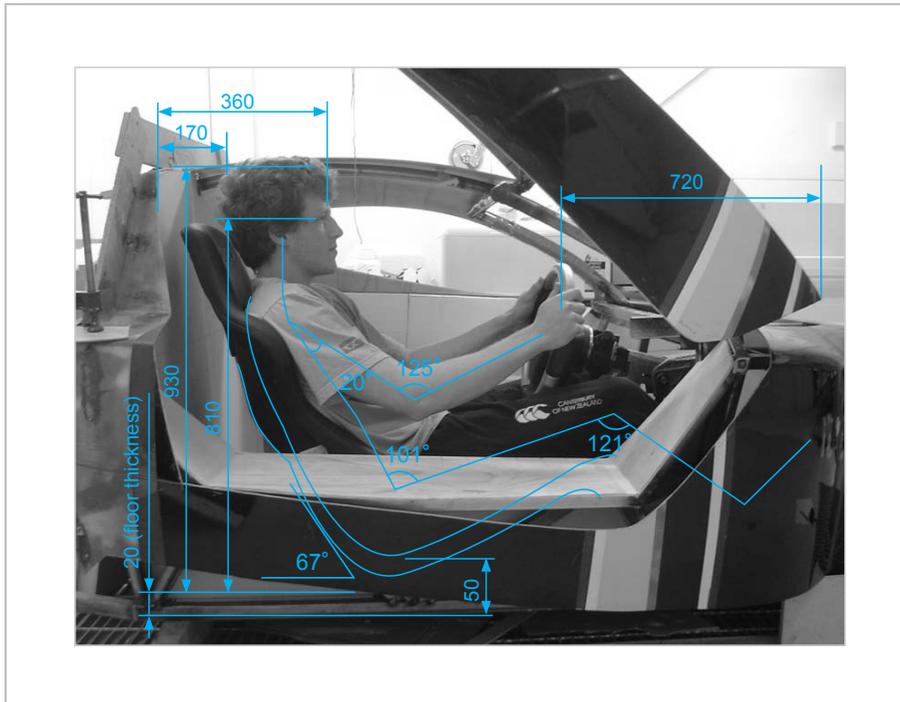


Figure 085. *Ergonomic test for posture and spatial requirements: participant two.*

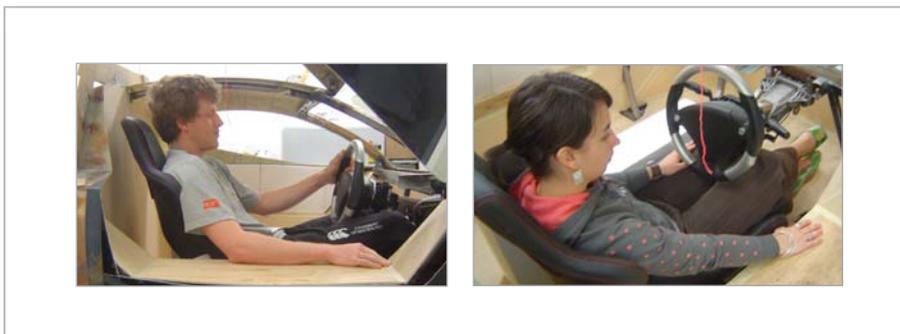


Figure 086. *Door sill could potentially be used as an arm rest.*

The following observations, insights and design recommendations for the interior design proposal were made during testing:

- Testing verified previous ergonomic research illustrating that the interior accommodates a 95th percentile male occupant in the proposed posture.
- As expected, the interior buck accommodated participant 1 and 2. This demonstrates that the interior design proposal is capable of accommodating a range of users.
- Testing confirmed that offset foot wells forced occupants to sit at an offset angle. This offset driving angle was measured at 3.5° . As mentioned earlier (3.4.4), alternating the foot well is outside the scope of this study.
- There was minimal clearance between the steering wheel and the thighs of participant two. This indicated that the interior design proposal should ideally have a steering wheel with a diameter less than 320mm.
- After taking into account the cabin ceiling thickness, there is minimal head clearance for participant two (20mm). Whilst increasing cabin height is outside the scope of this investigation, it was noted that the low cabin height (950mm) was likely to compromise comfort for occupants larger than a 95th percentile stature male.
- Participants found the high door sill useful as an arm rest (Figure 086). The implications of this findings were further explored during the ‘research through design’ process (7.0).
- The steering wheel requires 125mm of longitudinal adjustability to cater for a range of users.

6.2.2 Driver reach envelopes

This test aimed to establish reach envelopes within the interior cabin for the placement of secondary controls. To achieve this, testing focused on the static and dynamic reach distances of a range of users. For the purposes of this test, reach distances were referenced from the head rest in the vertical plain.

Testing began with participants seated within the interior buck using seating positions referenced from the previous test (6.2.1). Participants were invited to reach forward with their shoulders rested against the back rest (Figure 087, tests 1 and 2). This demonstrated the static reach of each participant. They were then asked to lean forward and reach as far as possible (Figure 087, tests 3 and 4), demonstrating the maximum dynamic reach of each participant.

The results of tests 1 and 2 illustrated static reach distances of 715mm and 775mm between the participants. Tests 3 and 4 illustrated dynamic reach distances of 840mm and 975mm between the participants. From these tests, the following conclusions were drawn;

- Non-critical secondary controls should not be placed beyond 840mm forward of the headrest in the vertical plain. If controls are positioned beyond this distance, their accessibility to a range of users decreases.
- Critical secondary controls should be positioned between 715 – 775mm forward of the headrest in the vertical plain. Placing controls within this

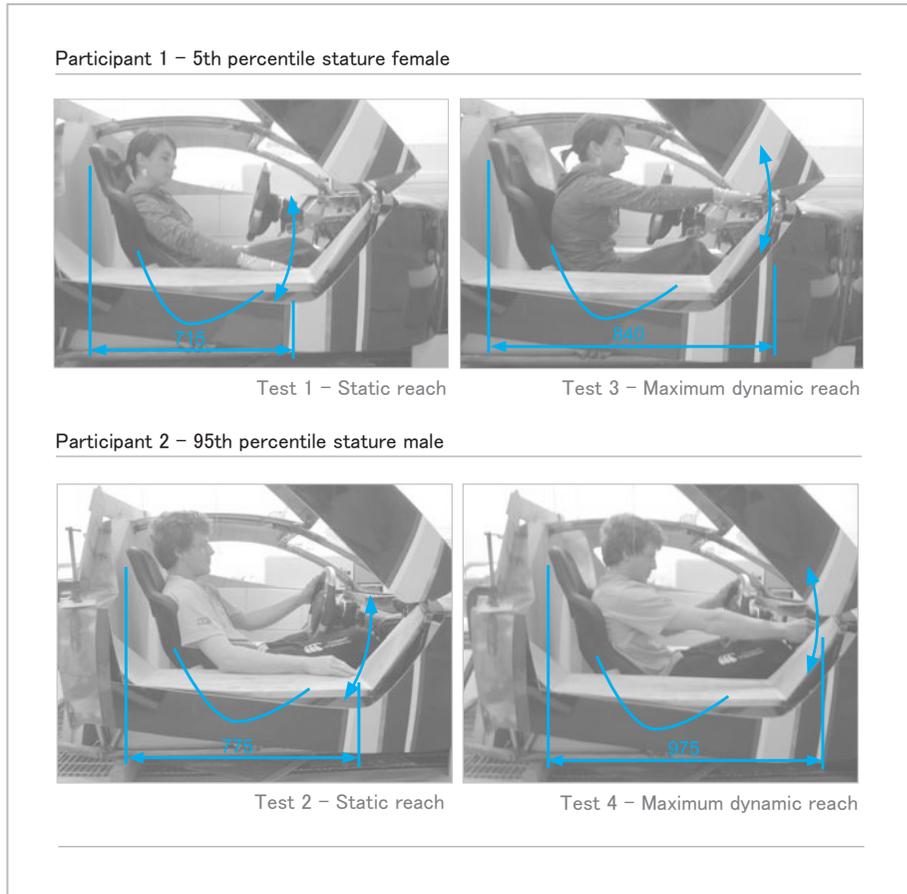


Figure 087. *Static and dynamic reach for a range of users.*



Figure 088. *Driver vision boundaries cast by 'two light' method.*

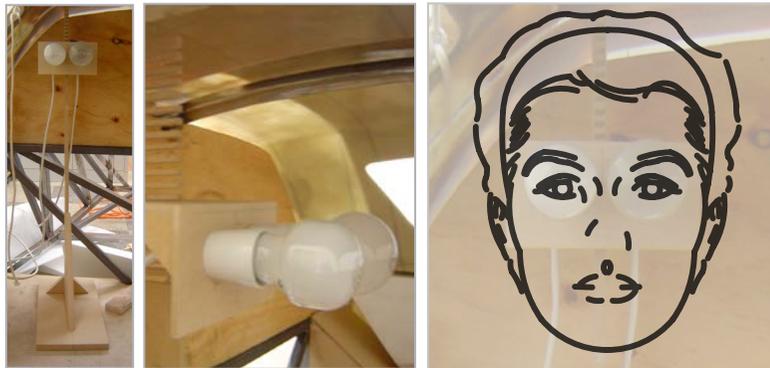


Figure 089. *'Two light' instrument developed to investigate trends in driver FOV.*

area will make them accessible to a range of users without the need for longitudinal adjustability.

The data collected from this test was also used in combination with 2D manikins to establish horizontal and vertical plane reach envelopes. These reach envelopes outline the appropriate placement of controls and are illustrated in section 6.2.7.

6.2.3 Driver field of vision (FOV)

This test aimed to establish general trends in driver FOV across a range of users. Testing also focused on the effects of visual obstructions within a drivers FOV.

Testing used the 'two light' method (Peacock and Karwowski, 1993, p.92) for direct measurement of a driver's FOV. This method involved the use of two lights to represent the driver's eyes. Any objects within the FOV (i.e. windscreen surround or pillars) obscured the projection of light and cast shadows (Figure 088). These shadows defined driver vision boundaries. Moving the two lights within the interior buck simulated different driver eye positions, allowing for the analysis of FOV trends.

To conduct the test, a 'two light' instrument was developed (Figure 089). The instrument employed two filament light bulbs, which were adjustable in height from 700mm to 810mm off the cabin floor (adjustments could be made in increments of 10mm). Maximum and minimum height ranges were referenced from the sitting eye heights of participants one and two (6.2.1), representing a range of user sitting eye

heights. The two light bulbs were spaced 61mm apart to represent the eye breadth of a 50th percentile male (Dreyfuss, 2002, p.27) as an average value for the participant range.

To begin with, the instrument was placed within the interior buck and the lights were adjusted to the sitting eye height of a 5th percentile female (700mm high, 350mm forward of the rear cabin wall and centrally aligned with the seat position with an offset angle of 3.5°). The light bulbs were then turned on with no other active light source in the testing lab. This generated a cast shadow vision boundary, its outline was traced using 2mm masking tape. This process was repeated with the instrument moved 100mm forward and backward. The results of this initial test are illustrated in Figure 090.

The process described above was repeated using different light bulb heights. These heights were 760mm and 810mm, representing the sitting eye heights of a 50th and 95th percentile stature males. This established the vision boundaries for a range of users in a variety of eye positions (Figure 091).

As background research indicated, the Ferrari Enzo steering wheel was designed with a bevelled top edge to not obstruct a drivers FOV (Figure 063). This suggests that the steering wheel of the interior design proposal may also obstruct a drivers FOV. To test this, the steering wheel was placed in its proposed positioned according to previous ergonomic research (Figure 064). The two light method was used to assess the effect of the steering wheel on vision boundaries (Figure 092).

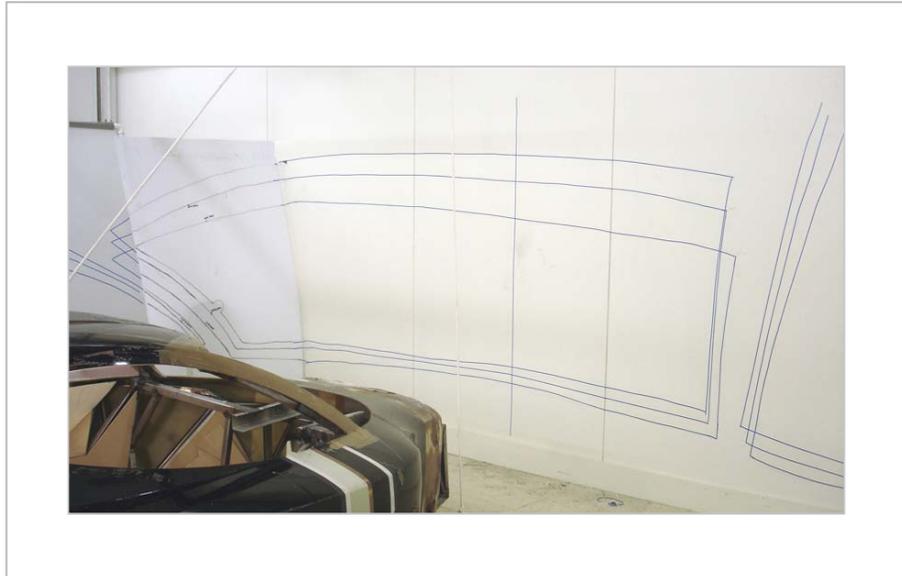


Figure 090. *Initial vision boundary tape line results from testing.*

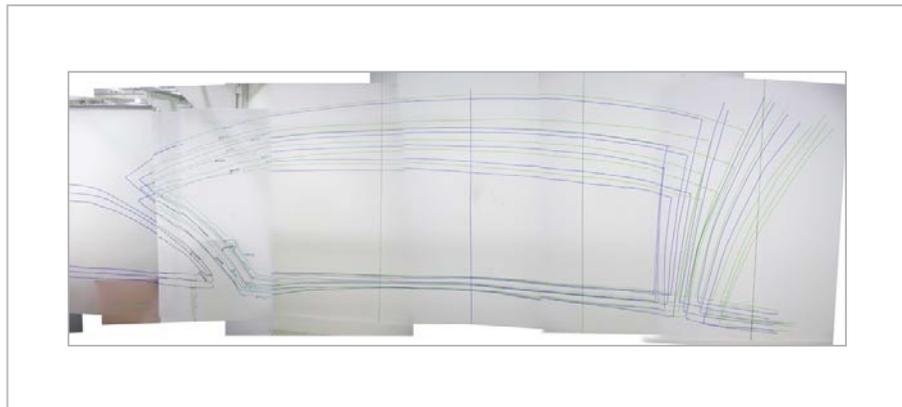


Figure 091. *Final vision boundary tape line results from testing.*

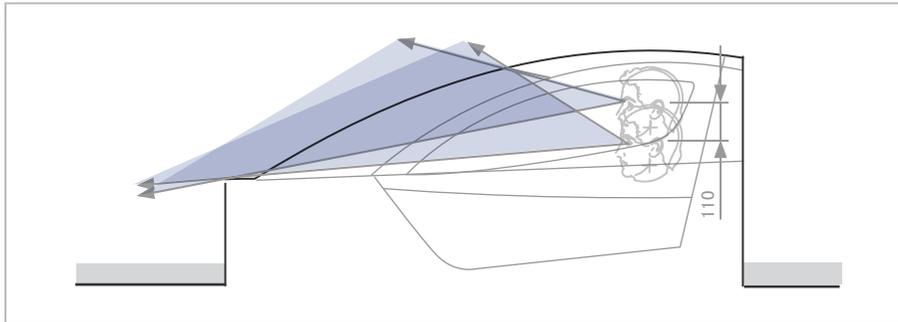


Figure 092. *Trend in driver FOV with different eye heights.*

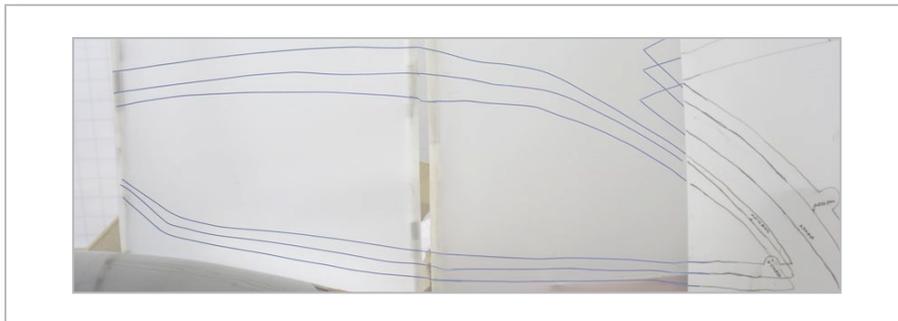


Figure 093. *Testing of visual obstructions within the drivers FOV.*

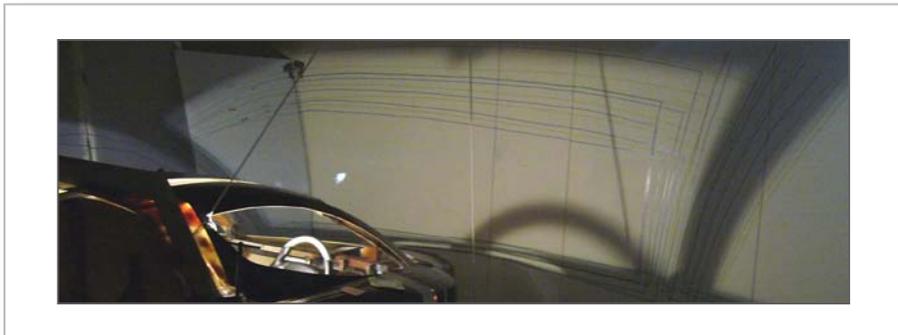


Figure 094. *Testing of visual obstructions within the drivers FOV.*

The following findings were identified and discussed:

- As a drivers eye position moves forward, their external FOV increases. Although this is beneficial, there is a limit to how far forward a driver should move. This is because moving a driver forward will most likely increase their offset posture angle due to the offset foot wells.
- As a drivers eye height is increased their upward angle of forward visibility decreases and downward angle of forward visibility increases and vice versa. This trend, illustrated in Figure 092, indicates that a change in eye height is a relative compromise between upward and downward visibility, as both upward and downward visibility have their advantages. This is in contrast to earlier research claiming that adjustable seat height allows for improved driver FOV (3.4.4). The spatial constraints of the cabin only allow drivers of a lower percentile range to have a discernable amount of seat height adjustability. Consequently, adjustable seat height for improved FOV appears to have diminishing returns in context to the interior design proposal.
- User side visibility (left and right) remain relatively constant through a range of different positions (Figure 093). In light of this, the drivers eye position should not fall behind the side window opening.
- As illustrated in Figure 094, the steering wheel is a major obstruction to driver FOV. This implies that the steering wheel requires a bevelled top edge in similar fashion to the Ferrari Enzo to keep forward driver FOV free from visual obstruction.

6.2.4 Positioning of a rear vision display

The interior cabin has no rear window openings. Therefore a digital rear vision display screen will be utilised to give the driver rear visibility. The aim of this test was to identify an appropriate position for the rear vision display.

A rear vision display mockup was created to test different display positions (top, Figure 095). The size of this mockup was based on a standard rear vision mirror (200mmx70mm). A road landscape was printed onto the mockup to simulate rear visibility. Five positions were tested within the interior buck. Each position was selected for its proximity within the drivers forward FOV and spacial requirements of the display screen. Observations were made identifying advantages and disadvantages for each position.

The following five positions within the interior were investigated:

- Position 1: Conventional rear view mirror position (Figure 095):

Advantages: Convention creates the expectation for a rear vision display to be positioned here. As a result, this position is familiar to most drivers and should minimise glance times. As mentioned in 3.4.3, minimising glance times increases the likely-hood of a driver detecting danger.

Disadvantages: Display obstructs drivers forward FOV. This is an impediment to driving and a potential safety hazard.

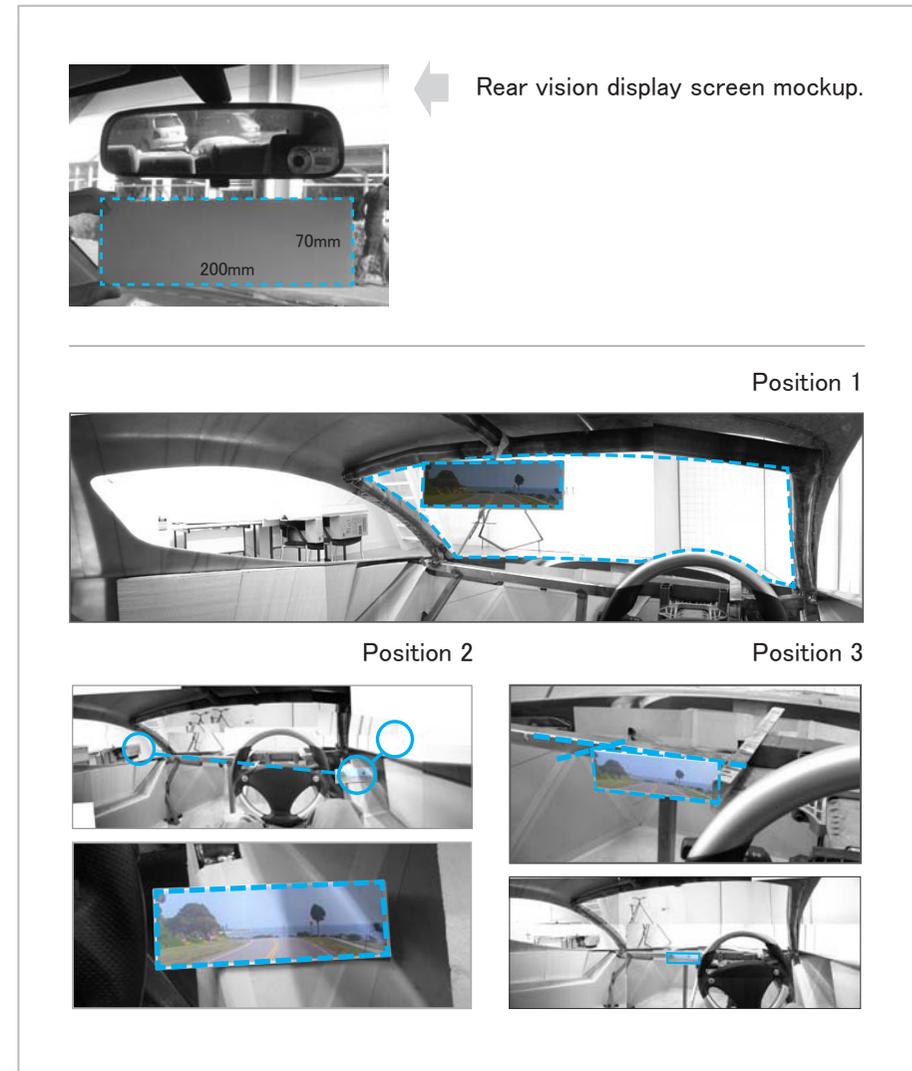


Figure 095. Rear vision display mockup in position 1,2 and 3.

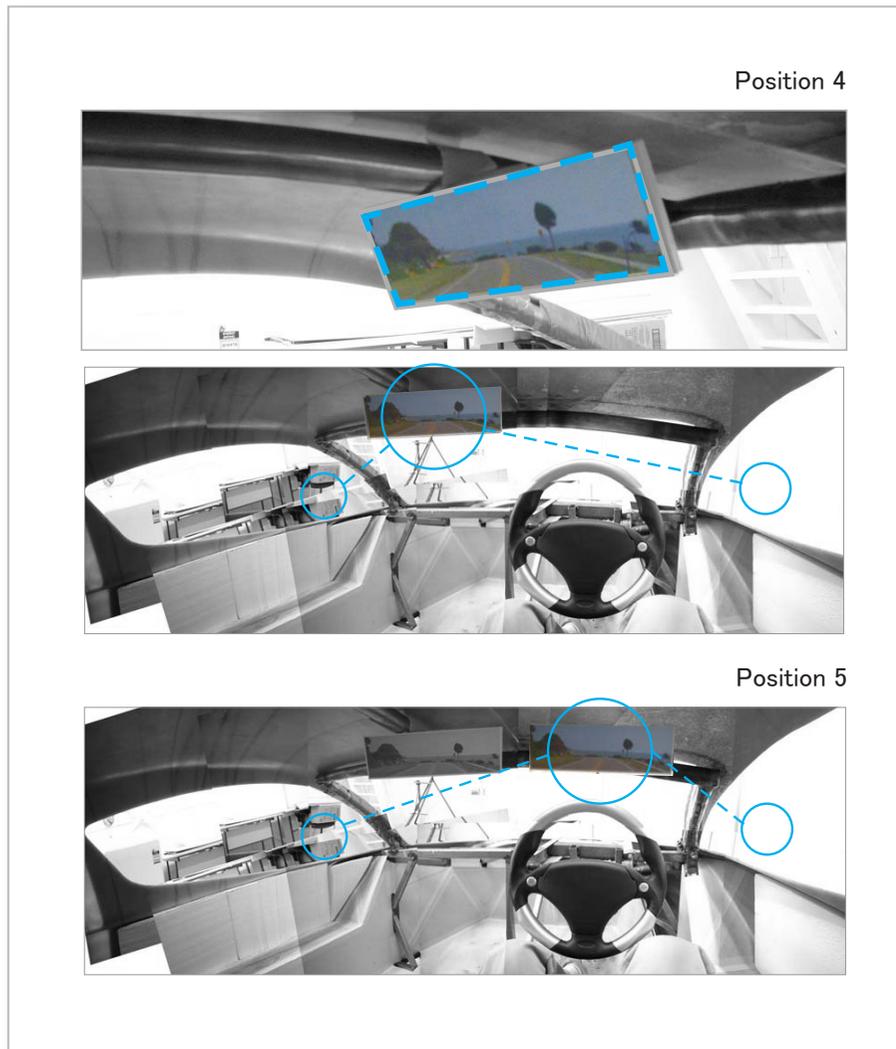


Figure 096. *Rear vision display mockup in position 4 and 5.*

- Position 2: Door sill (Figure 095):

Advantages: Positioning the display here will not obstruct forward visibility.

Disadvantages: Firstly, driver peripheral vision is moved away from the forward scene. This reduces the chance of detecting danger as stated in section 3.4.3. Secondly, the close proximity between the display and driver side wing mirror may result in visual clutter and confusion, thereby becoming a potential safety hazard. Thirdly, position 2 is unconventional, requiring the driver to re-train driving habits. This also may become an impediment to driving and/or a safety hazard.
- Position 3: Centre stack (Figure 095):

Advantages: This position will not obstruct forward visibility.

Disadvantages: Rear vision displays are becoming increasingly common in this position (3.4.3). However, they are typically used to detect objects at a close proximity and are not the primary means for rear visibility. The use of this position still requires training. This will potentially lead to increased glance times and increase the likelihood of not detecting danger.
- Position 4: Inset into cabin ceiling – centred (Figure 096):

Advantages: The curvature of the cabin ceiling allows the display to not obstruct forward visibility. Additionally, this position

is similar to the conventional placement for rear vision mirrors (position 1) and therefore does not require additional training to use.

Disadvantages: The displays height can not exceed 70mm without becoming an obstruction to forward visibility.

- Position 5: Inset into cabin ceiling – aligned with driver (Figure 096):

Advantages: This position has similar advantages to position 4. Additionally, this position may further emphasize the notion of a ‘cockpit-like’ F1 driving experience, since most driver related controls and displays are positioned directly in front of the driver, as observed in the Formula Challenge race car experience (6.1.2).

Disadvantages: Similar disadvantages to position 4.

From this test, position 5 was considered the most appropriate location for a rear vision display. This is because it requires little in the way of additional training for the user, does not obstruct forward visibility and references the F1 driving experience.

6.2.5 Potential areas for in-car storage systems

The focus of this test was to identify potential storage areas within the interior buck. This was conducted by visually inspecting the 1:1 interior buck (with the bucket seat and steering wheel appropriately positioned) for potential storage areas. Inspection focused on identifying accessible areas with adequate volume for storing personal items typically found in motorcars, such as sunglasses, clothes and bags.

The investigation identified the following six potential areas for storage within the interior buck (Figure 097):

- 1 – Behind the seats
- 2 – Between the door sill and side bolster
- 3 – Front dash area
- 4 – Beneath the seat pan
- 5 – Lower door compartment
- 6 – Between the two seats

Each proposed area for storage had visual and functional implications (i.e. reach during driving) on the interior design proposal. The integration and resolution of these areas are considered during the ‘research through design’ process (7.0).

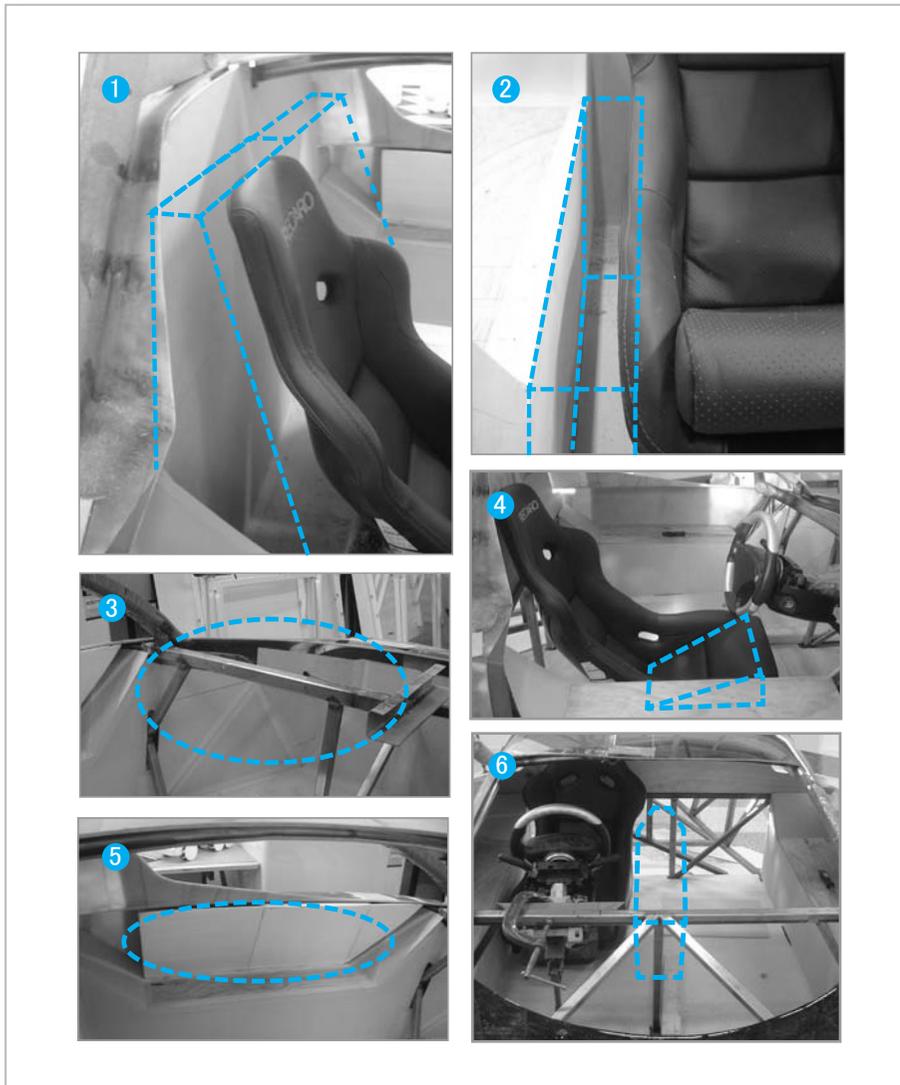


Figure 097. Areas identified as appropriate for storage design features.

6.2.6 Positioning of ingress/egress support surfaces

There was an expectation that the height and width of the door sills would compromise ease of ingress and egress. Altering the door sills is outside the scope of this study. As a result, this test focused on establishing support surface positions to assist with entry, exit, opening and closing of the door.

Testing began with the door in an open position and seat placed similarly to previous tests. Participants were invited to enter and exit the interior buck. Their activities were noted through observation and recorded using still photography.

As shown in Figure 098, the following observations were made during entry/exit testing:

- As expected, the size of the door sill made entry and exit an awkward process for the participants in comparison to a conventional motorcar.
- 1. Participant 1 used the top surface of the door sill to support herself while entering the interior buck.
- 2. Participant 2 found grasping the front windscreen frame assisted ingress and egress by providing leverage directly above the seat.
- 3. Participant 2 sat on the top surface of the door sill, this allowed him to place his legs into the foot wells without needing to support his weight.

Testing then focused on potential door handle positions. Two handle positions were explored, located centrally above and below the door window as illustrated

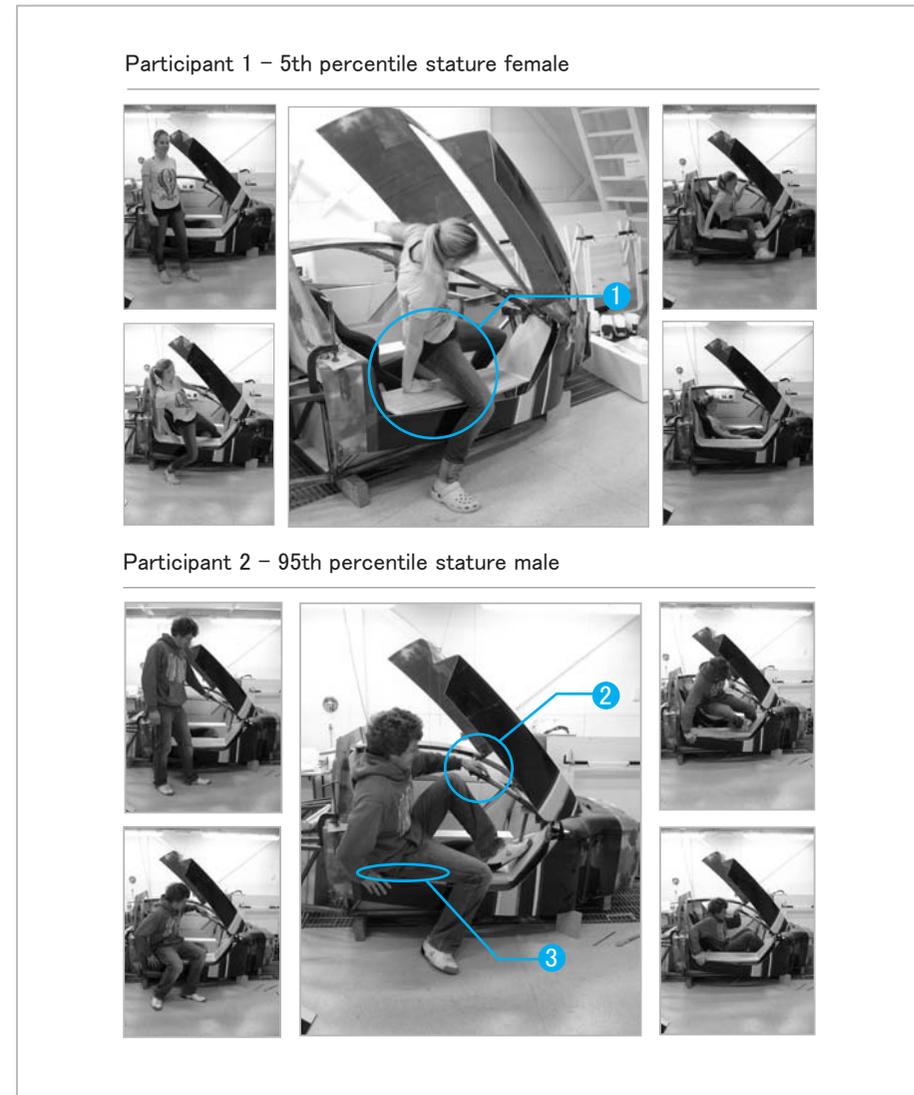


Figure 098. *Investigation into ingress and egress.*

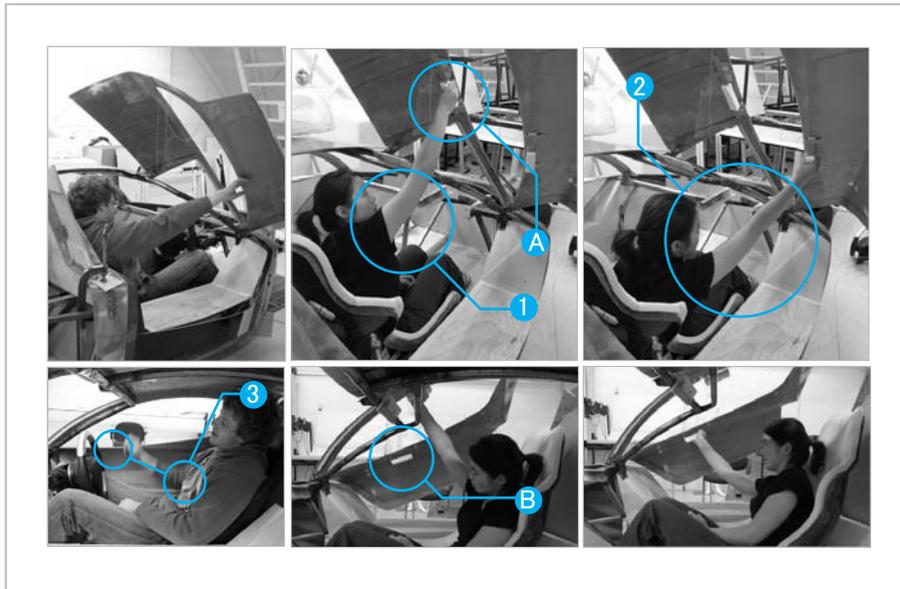


Figure 099. *Investigation into door handle positions.*

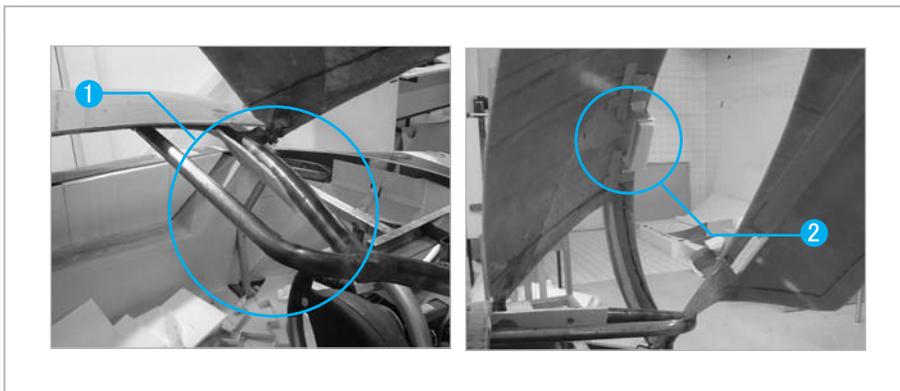


Figure 100. *Potential areas for entry/exit support surfaces and door handles.*

in Figure 099 (labelled A and B). These positions were proposed for their close proximity to the occupant and centralised position for a balanced weight distribution when in use. Mock door handles were fixed to positions A and B. Participants were invited to open and close the door using these handles.

As shown in Figure 099, the following observations were made during testing of the two door handle positions:

- 1. Position A required a relatively vertical arm action to open or close the door. This vertical action placed minimal load bearing on the participants shoulders.
- 2. Position B required the participants to reach horizontally outward to open or close the door. This created additional load on the participants shoulders when opening and closing the door.
- 3. The height of the door sill was an obstruction to participant 2 while reaching for position B to open the door.
- Participant 1 was able to reach both handle positions A and B.

From these observations, the following conclusions were deduced; firstly, the top surface of the door sills should be relatively flat and free of obstruction to allow occupants to use it as a ingress/egress support surface. Secondly, a support handle should be located near the top end of the A-pillar (Figure 100, labelled 1). Lastly, position A was the most appropriate location for a door handle (Figure 100, labelled 2).

6.2.7 Ergonomic diagrams

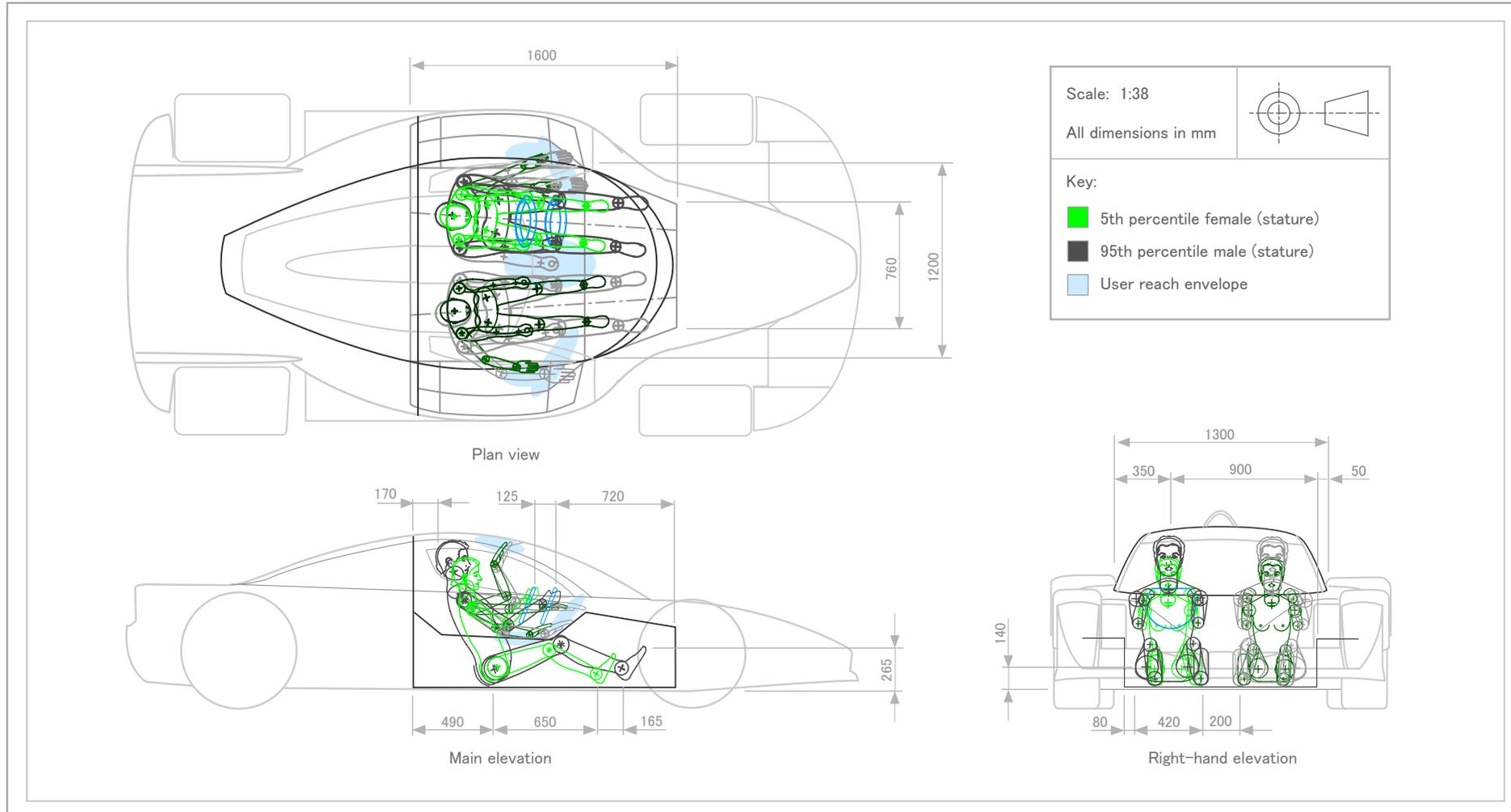


Figure 101. Front, side and plan ergonomic drawings for the interior design proposal.

The ergonomic diagrams provide dimensional references for the development of the interior design proposal (Figure 101). This ensured a range of users could be accommodated within the design.

The diagrams also indicate that the footpedals should have 165mm of longitudinal adjustability to accommodate a range of users. This contradicts earlier background research that stated 120mm of longitudinal adjustability would be adequate (3.4.1). The extra 45mm of adjustability is required due to the low seating posture within the Hulme F1 supercar, where occupants legs are pushed further forward in comparison to the seating posture of a conventional road going saloon.

6.3 Scenario results and discussion

This section focuses on two scenarios;

- A typical user scenario depicting how a driver would normally use the Hulme F1 supercar interior cabin (6.3.1).
- A scenario proposing the integration of F1 design references to enhance the user experience (6.3.2).

These scenarios were based on results from the immersive experience method (6.1), the researcher's own experiences and research into functional systems (3.4). They were depicted in the form of illustrated storyboards.

6.3.1 Hulme F1 supercar storyboard – Typical user experience

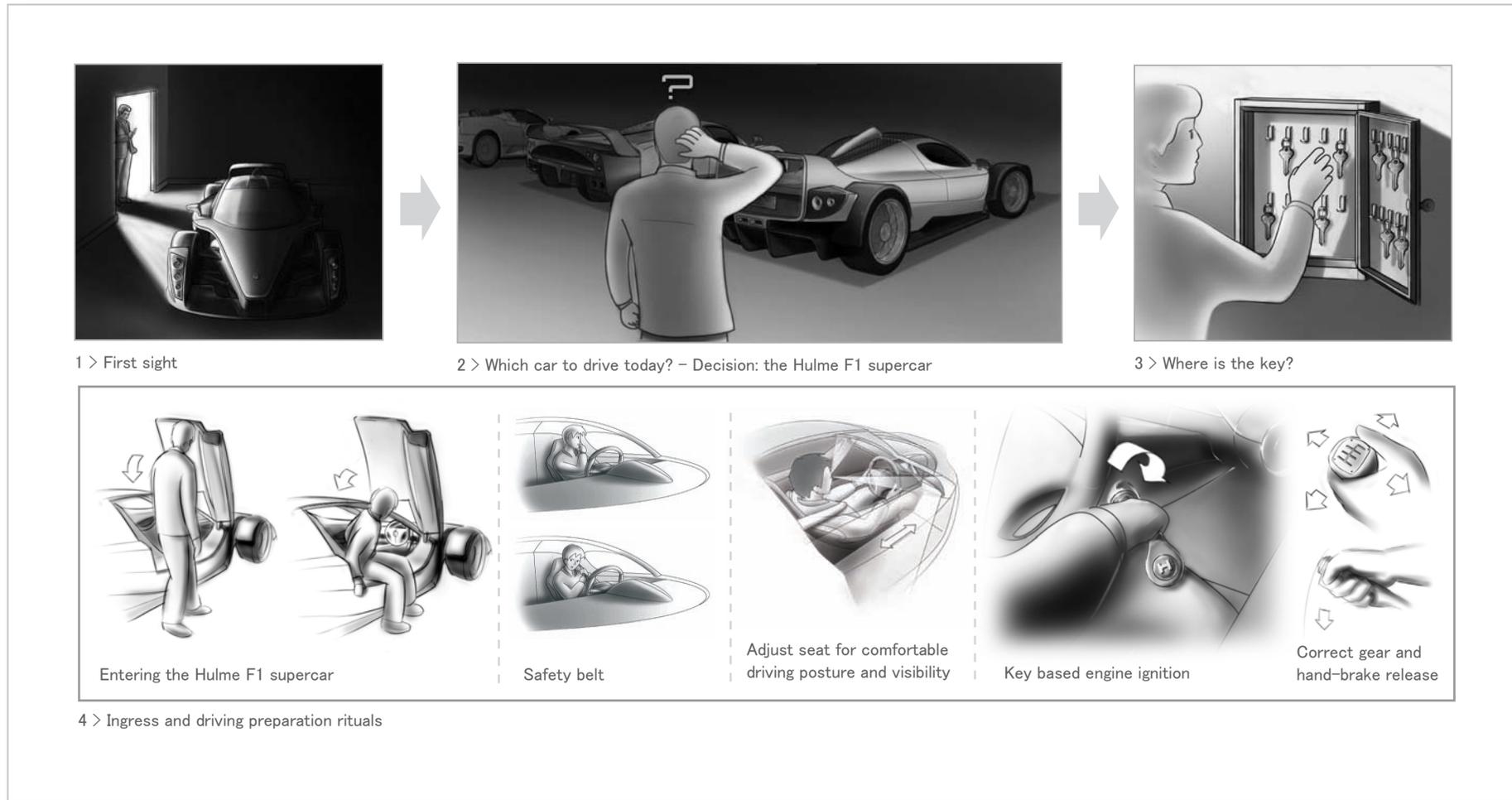


Figure 102. Typical user experience storyboard – part 1.

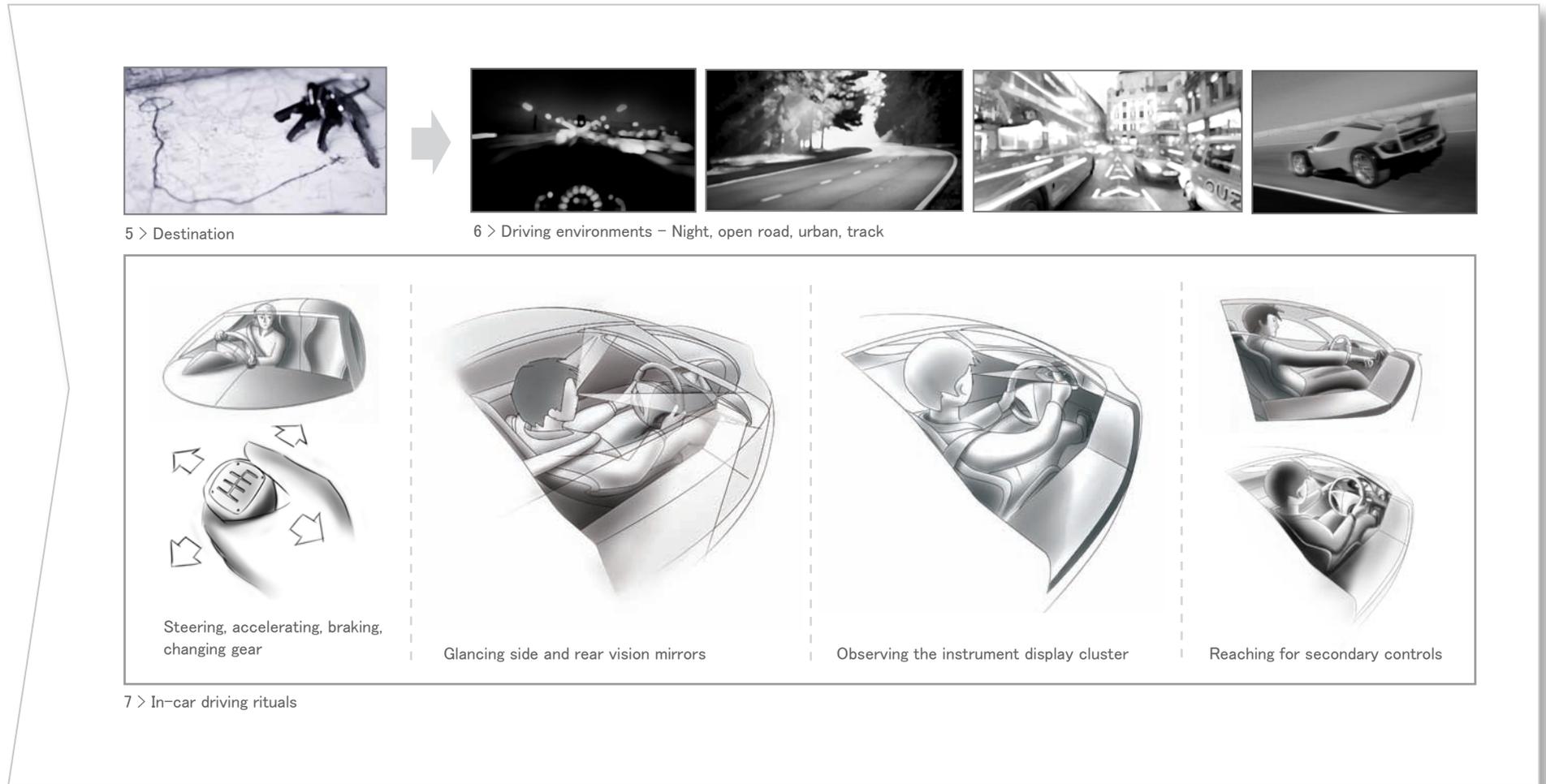


Figure 103. Typical user experience storyboard – part 2.

6.3.2 Hulme F1 supercar storyboard – Proposed user experience integrating F1 references

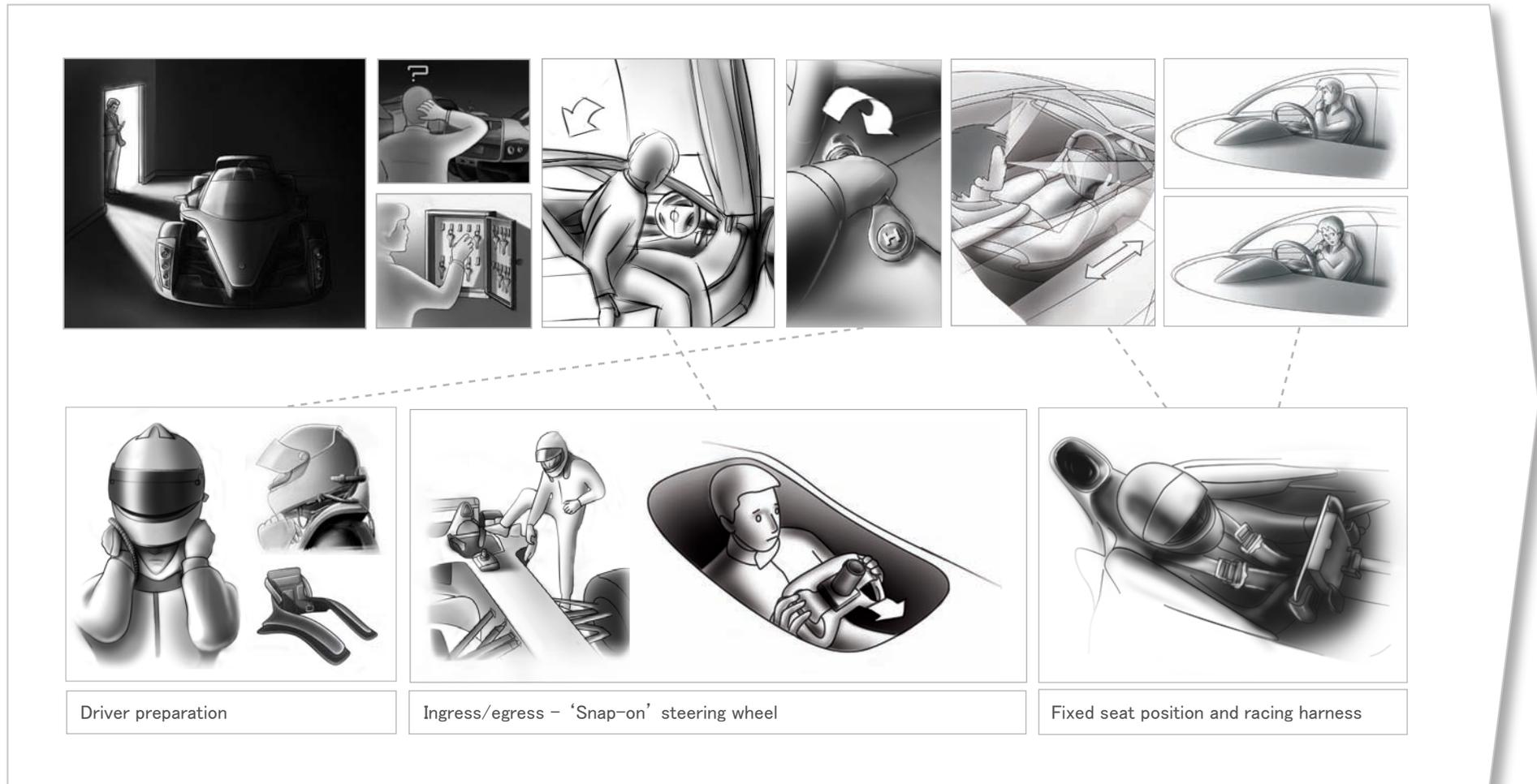


Figure 104. Proposed F1 user experience storyboard – part 1.

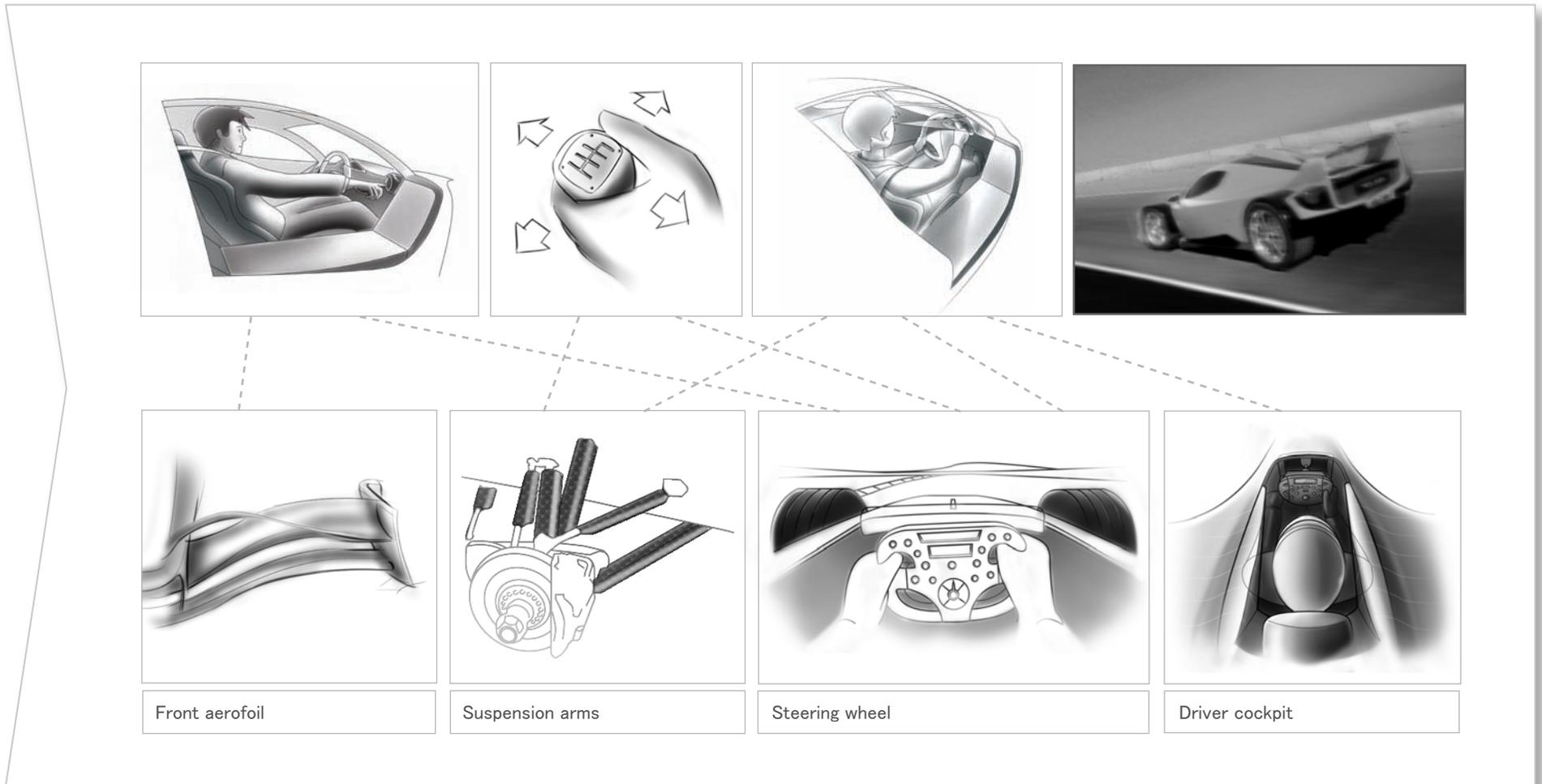


Figure 105. *Proposed F1 user experience storyboard – part 2.*

The storyboards proved useful for demonstrating how the user interacts with functional systems within the interior cabin. They also illustrated how the different functional systems interact with each other within a sequential set of tasks. Prior to this, background research only investigated these systems on an individual basis.

There are some limitations to the storyboards. It is impossible to predict all user behaviours and rituals with an interface as complex as a motorcar interior. Because of this, the storyboards focused on common user rituals.

6.4 ‘Research for design’ conclusion

The ‘research for design’ methods investigated a range of issues in context to the interior design proposal and end user. The results from these methods led to the development of additional performance design criteria (Figure 106). These criteria were integrated into the existing performance criteria outlined in chapter 4.0. Insight from this investigation illustrated the following areas as requiring further exploration during the ‘research through design’ process (7.0):

- An appropriate means of moving the steering wheel for larger entry/exit space.
- Expressing the concept of ‘unrestricted vision’ from F1 cockpits.
- The visual implications of recommended in-car storage compartments (6.2.5).

Performance criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)
Steering wheel should have a bevelled top edge	○			
Rear vision display should be set into cabin ceiling and centrally aligned with the driver.		○		
Secondary controls should be positioned within reach envelopes (6.2.7).		○		
Top surface of door sill should be relatively flat		○		
Door handle should be placed in a central position above the door window.		○		
Ingress/egress handle should be located near the top end of the A-pillar.			○	
Steering wheel diameter must not exceed 320mm.	○			
Steering wheel should slide or rotate towards the cabin centre.		○		

Figure 106. Additional performance design criteria.

7.0 ‘Research through design’ results and discussion

This section reports and discusses the results from a typical iterative design process. The focus of this iterative design process was to develop an interior design proposal that focused on fulfilling experience and performance criteria outlined in chapter 4.0.

Concept sketching



Figure 107. *Initial concept sketching.*

Form studies and concept development

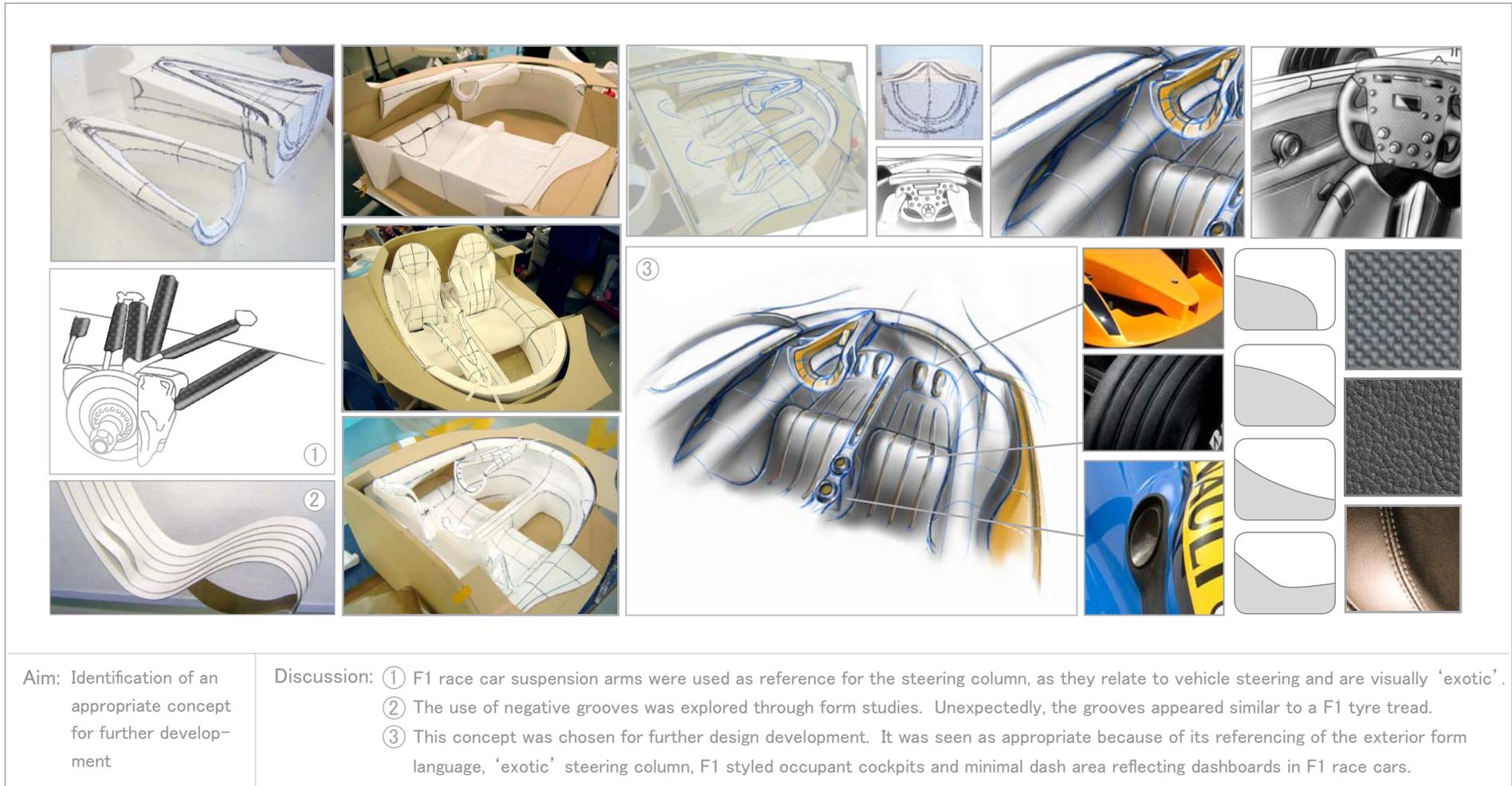


Figure 108. Selection of a concept for further development.

Concept development

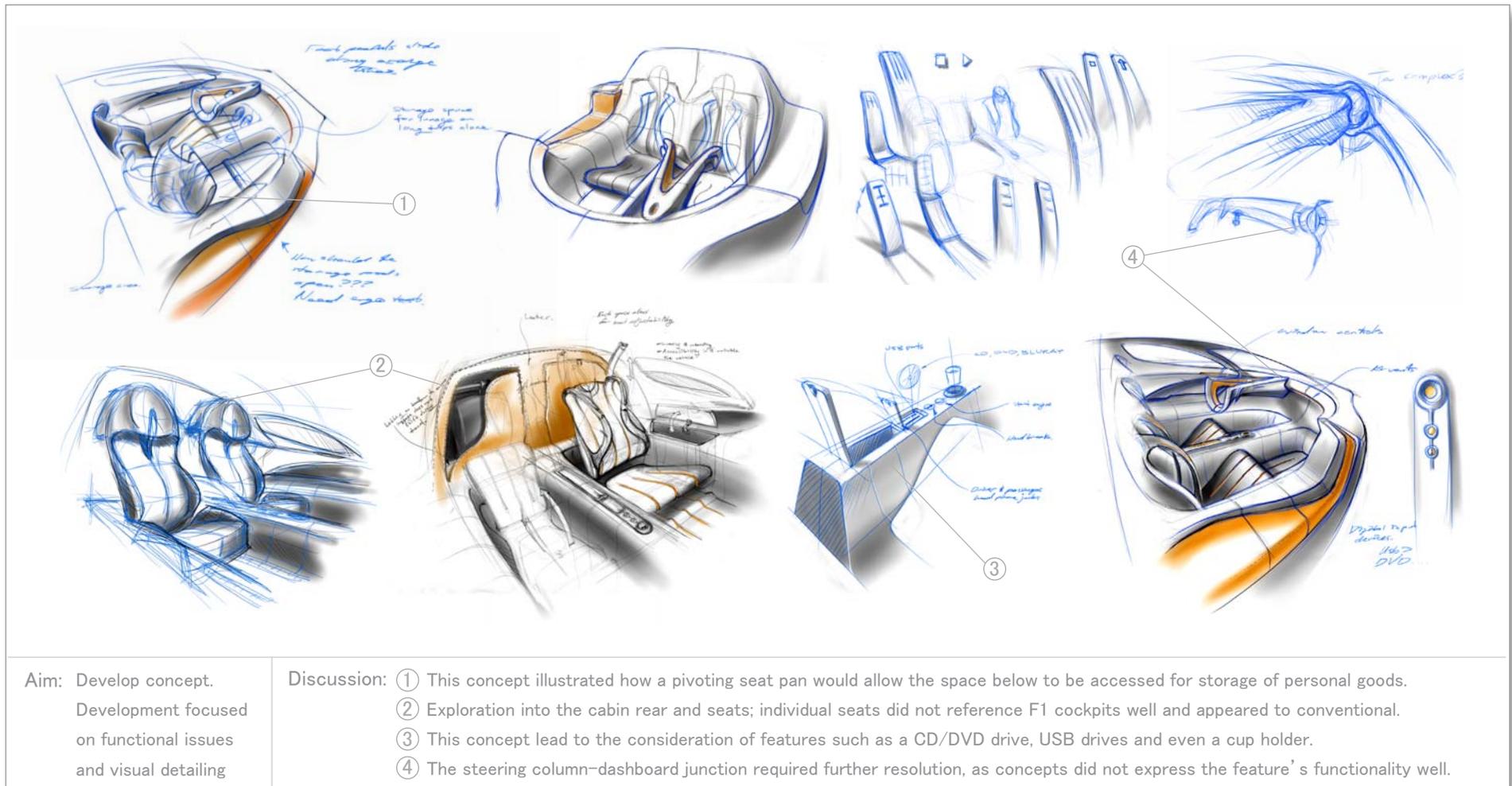


Figure 110. Further resolution of design issues.

Concept development

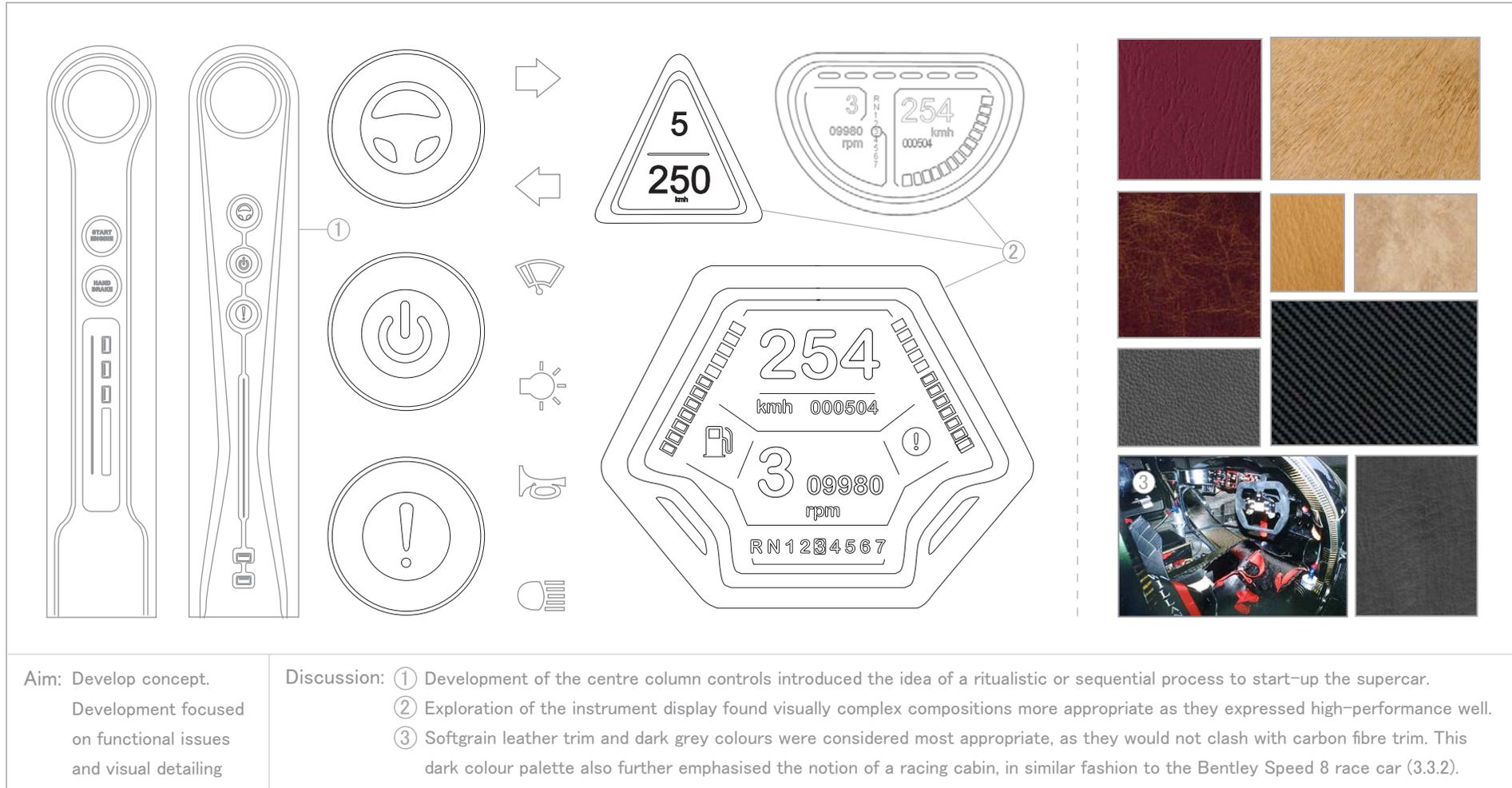
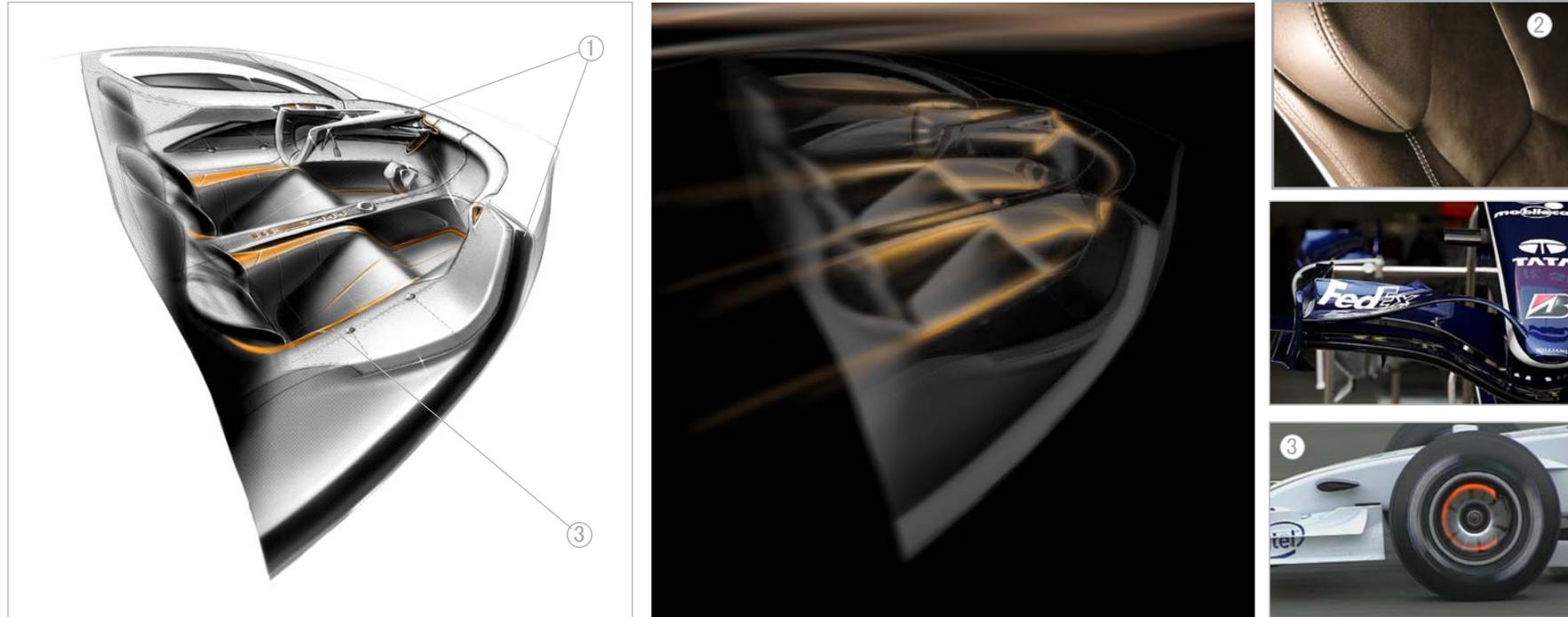


Figure 111. *Development of control interfaces, displays, trim and colour selection.*

Concept development



Aim: Develop concept.
Development focused
on colour and trim,

Discussion: ① This concept illustrated how the exotic properties of carbon fibre could be integrated with more traditional trim.
② Matching twin-needle stitching provided inspiration for imbuing the quality of luxury within the interior design proposal.
③ The use of orange accents was inspired by the high-temperature glow from F1 race car disc brakes. This also expressed high-performance and dynamism through strong colour contrast. Consequently, this colour was used to highlight functional areas.

Figure 112. Further development of the interior design proposal.

Aesthetic modelling within a 1:2 scale buck



Figure 113. *Development through aesthetic modelling.*

Full scale form study



Aim: Explore the concept in full scale. Examine the appropriateness of the steering column concept.

Discussion: ① This form study generated further support for the steering column concept. It appeared to be appropriately proportioned and visually light. In addition, the steering column gave a strong impression of an F1 cockpit.
 ② Testing of the form study indicated that the proposed hubless steering wheel would function as intended.
 ③ Leaving the door sill relatively flat allows it to be used as a arm rest.

Figure 114. Full scale form study of the concept interior design proposal.

Concept Development

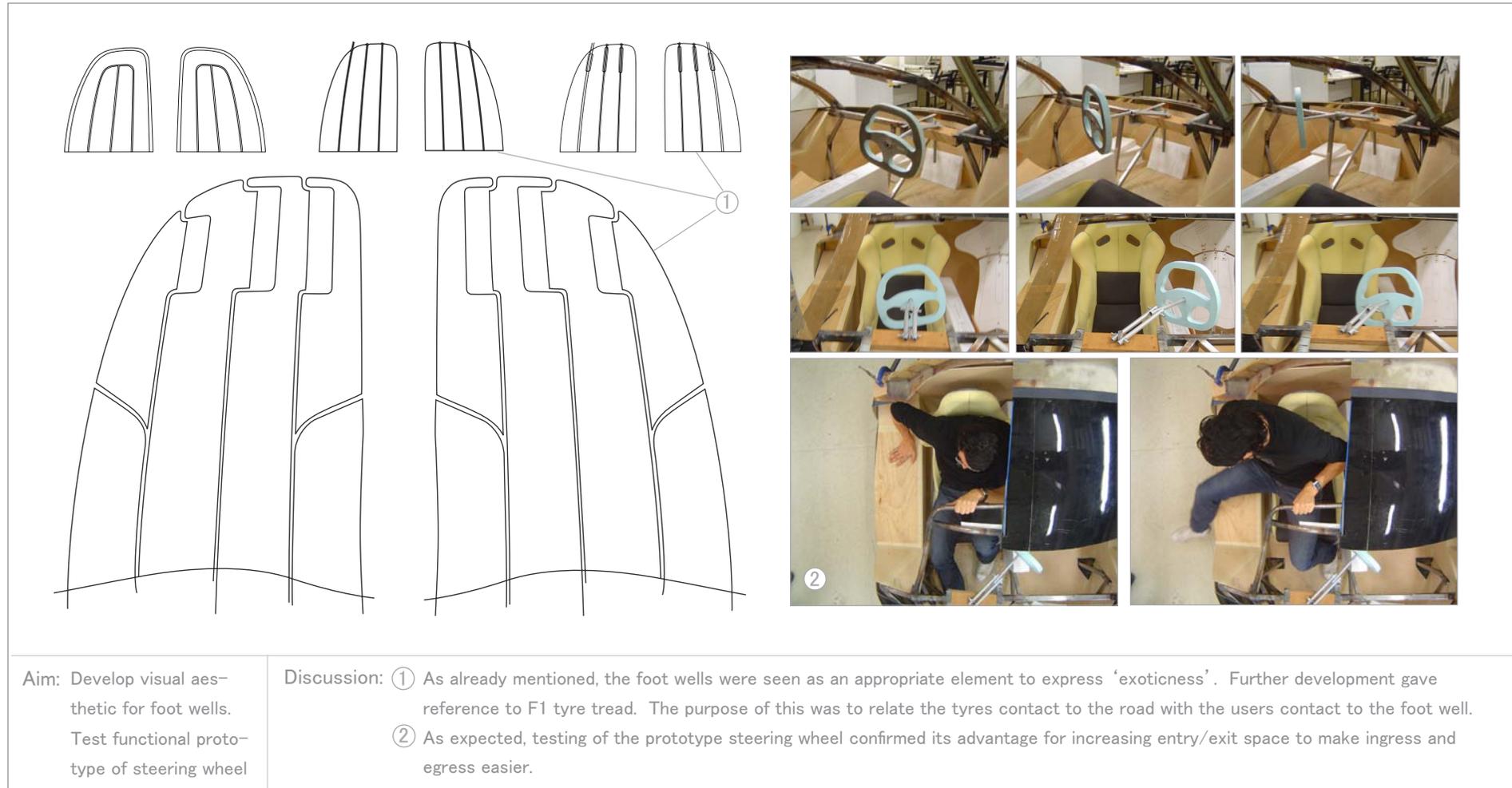


Figure 115. *Development of foot wells and ergonomic testing.*

Concept Development

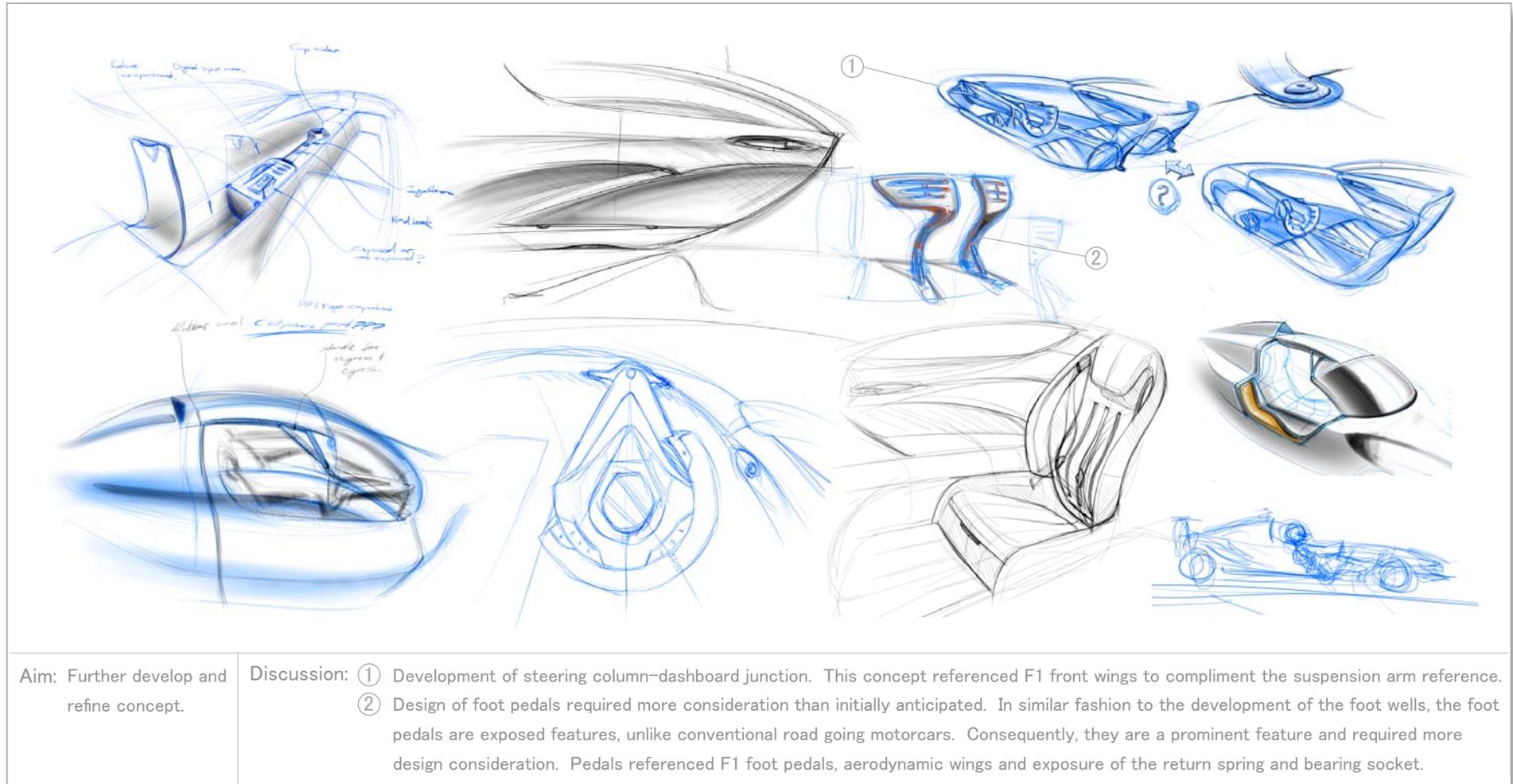


Figure 116. Further development of design details.

7.1 Final Design – Interior cabin

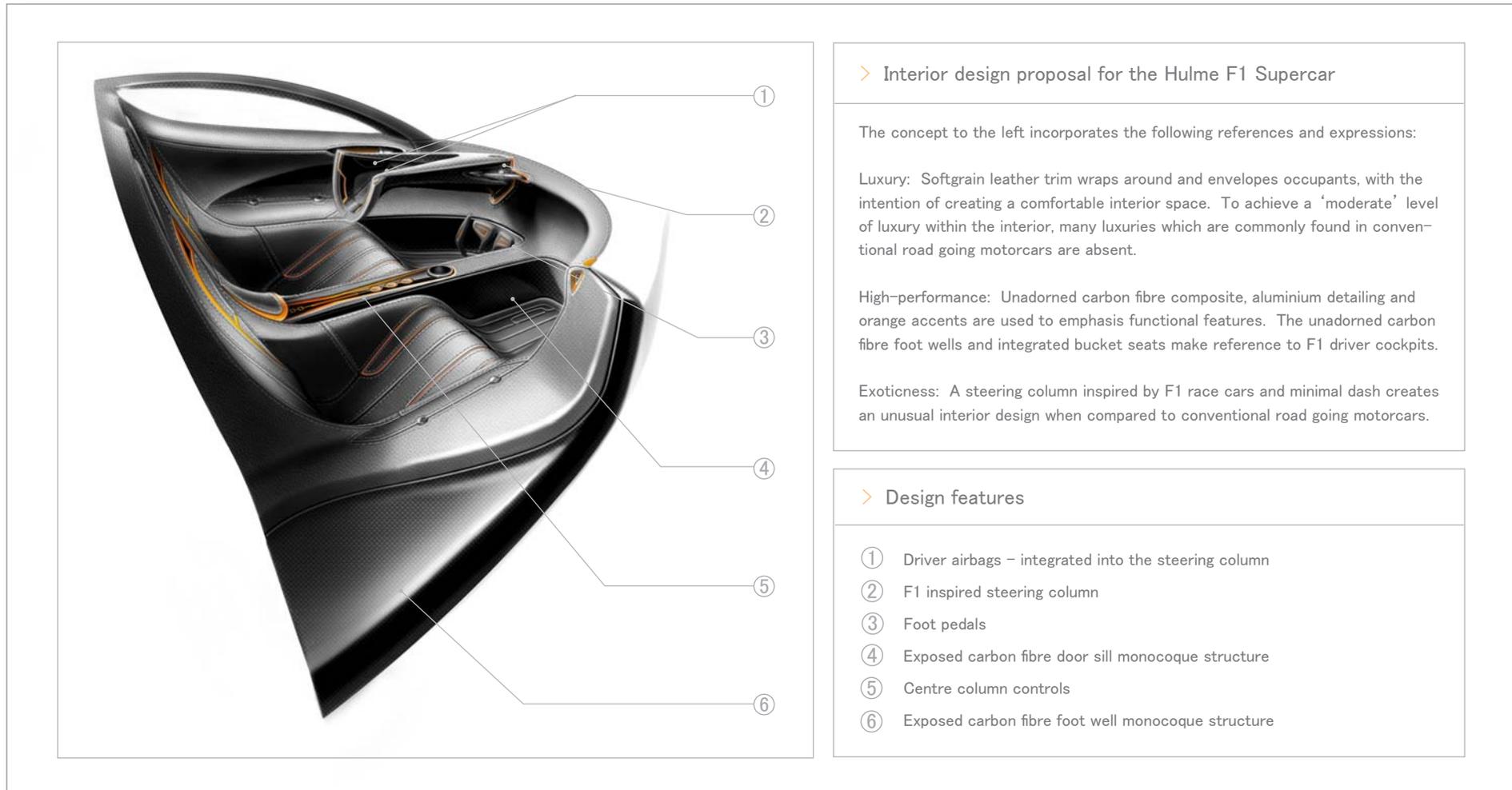


Figure 117. Final design – Interior cabin.

Final Design – Cabin rear and seats

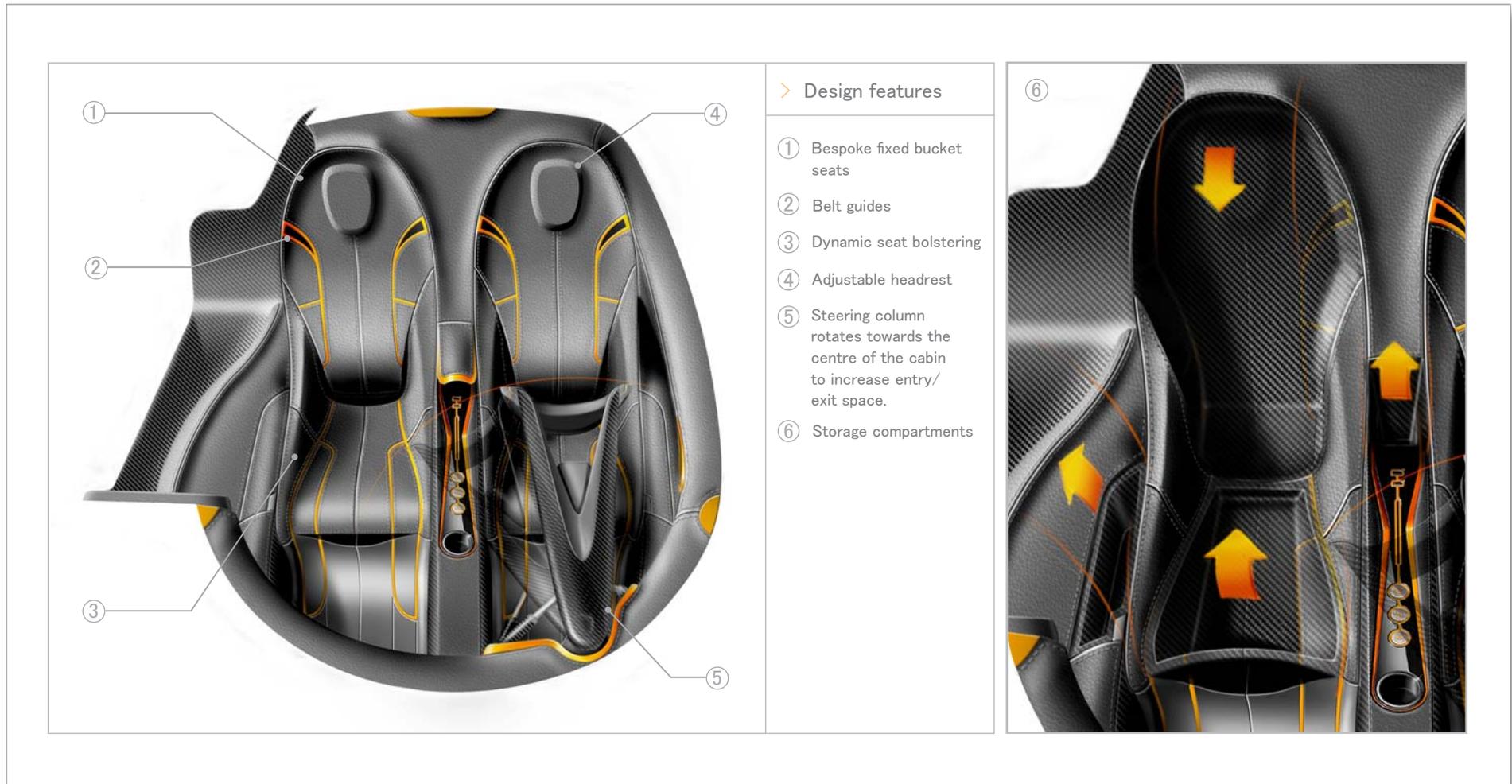


Figure 118. *Final design – Cabin rear and seats.*

Final Design – Steering column

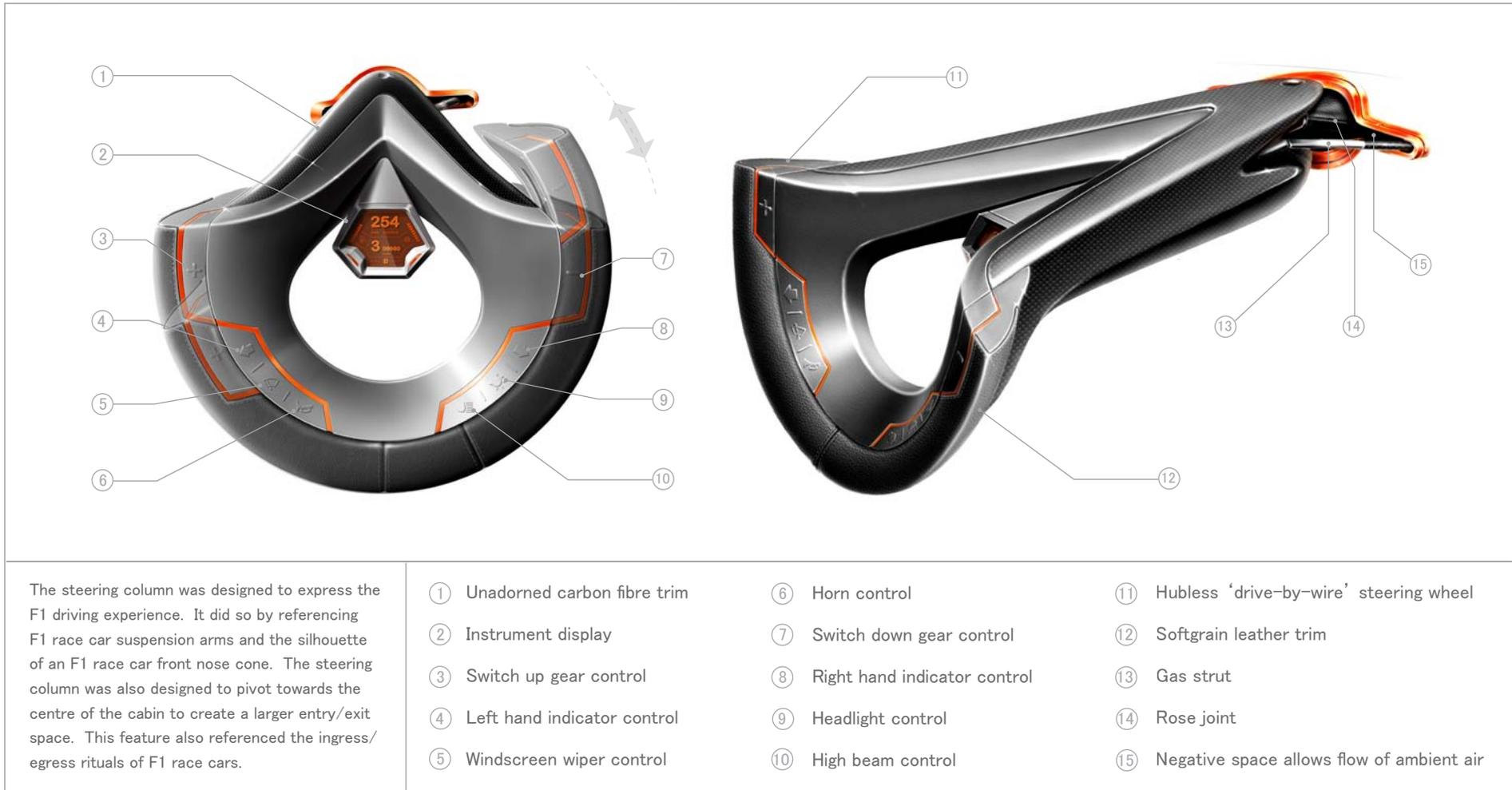


Figure 119. *Final design – steering column.*

Final Design – Display and control systems

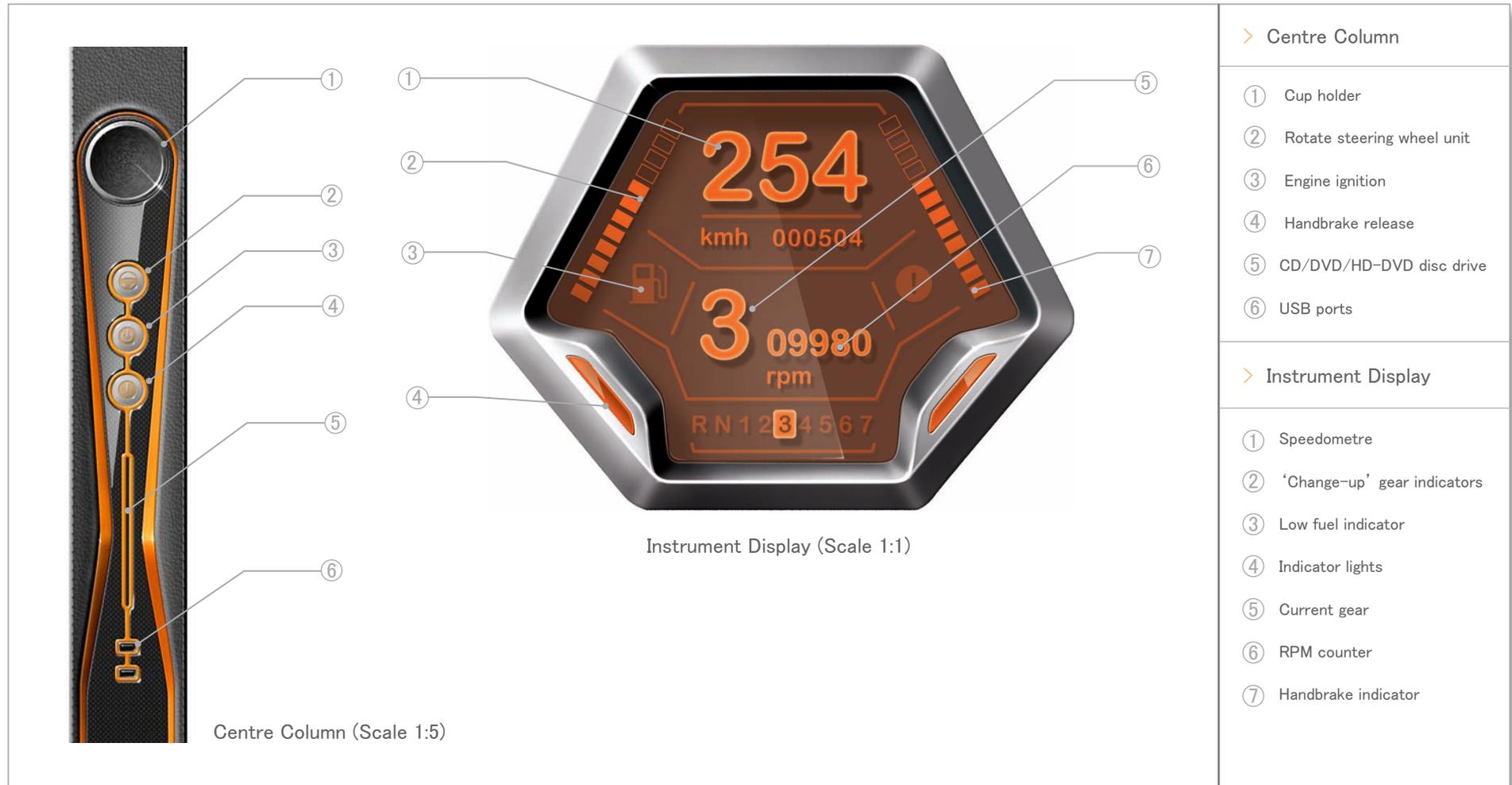


Figure 120. Final design – displays and controls.

7.2 Cross-section drawings

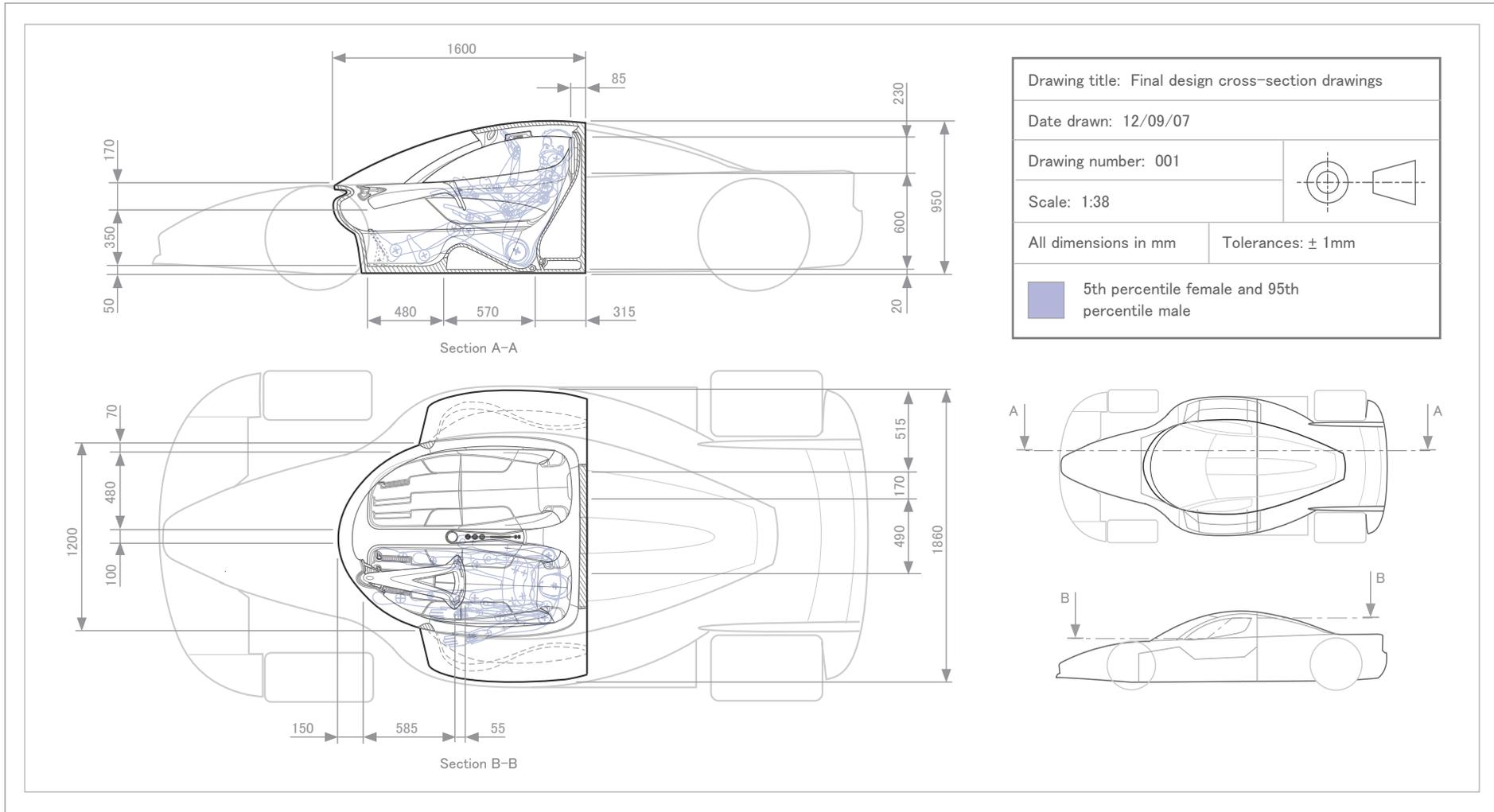


Figure 121. Interior design proposal cross-section drawings.

7.3 Final aesthetic model (1:2 Scale)



Figure 122. *Interior design proposal aesthetic model – view 1.*

Final aesthetic model (1:2 Scale)



Figure 123. *Interior design proposal aesthetic model – view 2.*

Final aesthetic model (1:2 Scale)



Figure 124. *Interior design proposal aesthetic model – view 3.*

Final aesthetic model (1:2 Scale) – Cabin ceiling



Figure 125. *Interior design proposal aesthetic model – view 4.*

Final aesthetic model (1:2 scale) – Steering column adjustability and storage compartments



Figure 126. Interior design proposal steering column adjustability and storage compartments.

Final aesthetic model (1:2 Scale) – Steering column



Figure 127. Interior design proposal aesthetic model – steering column.

Final aesthetic model (1:2 scale) – Foot pedals



Figure 128. Interior design proposal aesthetic model – foot pedals.

Final aesthetic model (1:2 Scale) – Overhead systems



Figure 129. Interior design proposal aesthetic model – overhead systems.

7.4 Interior design proposal user scenario

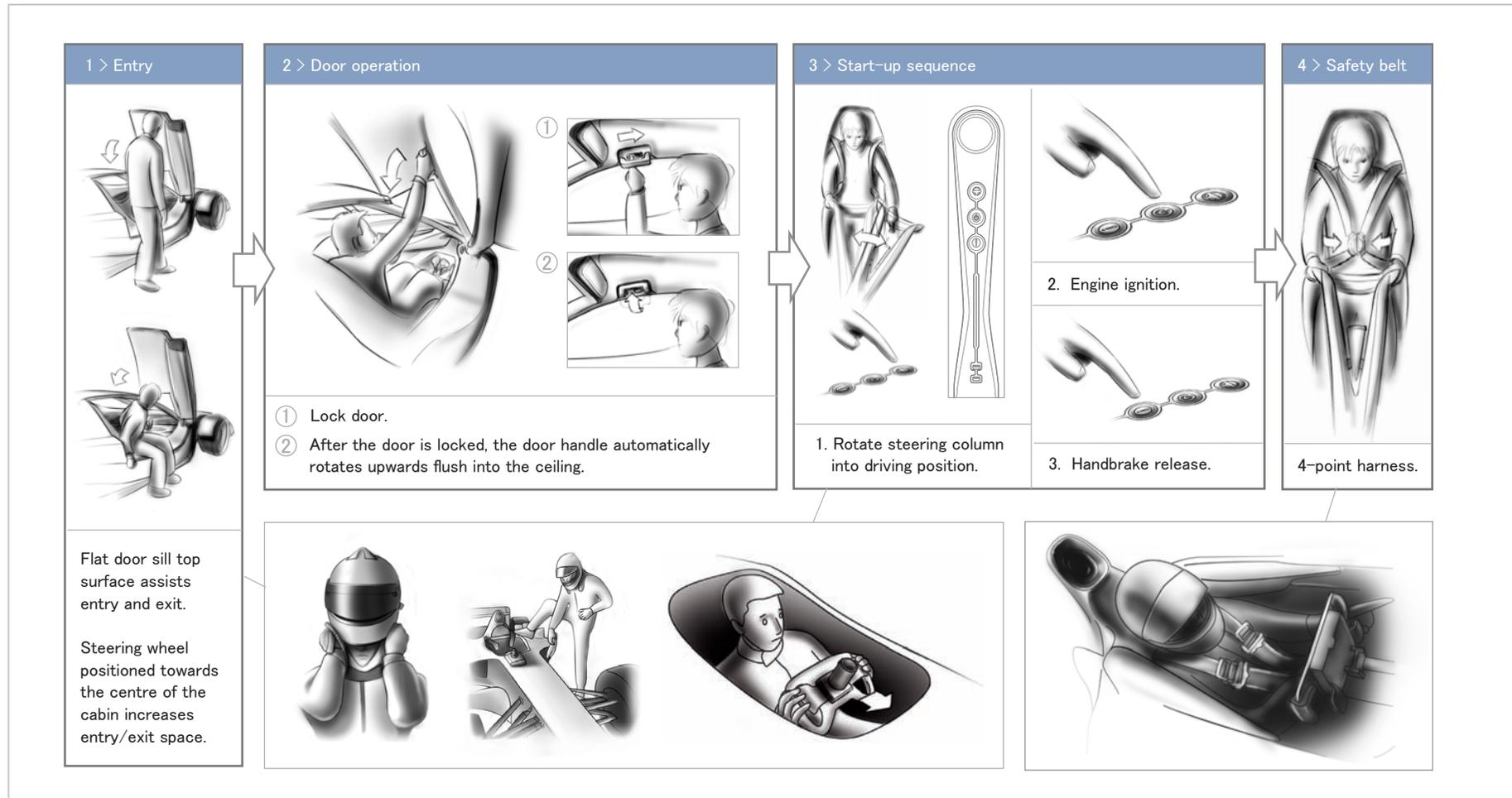


Figure 131. Interior design proposal user storyboard – part 1.

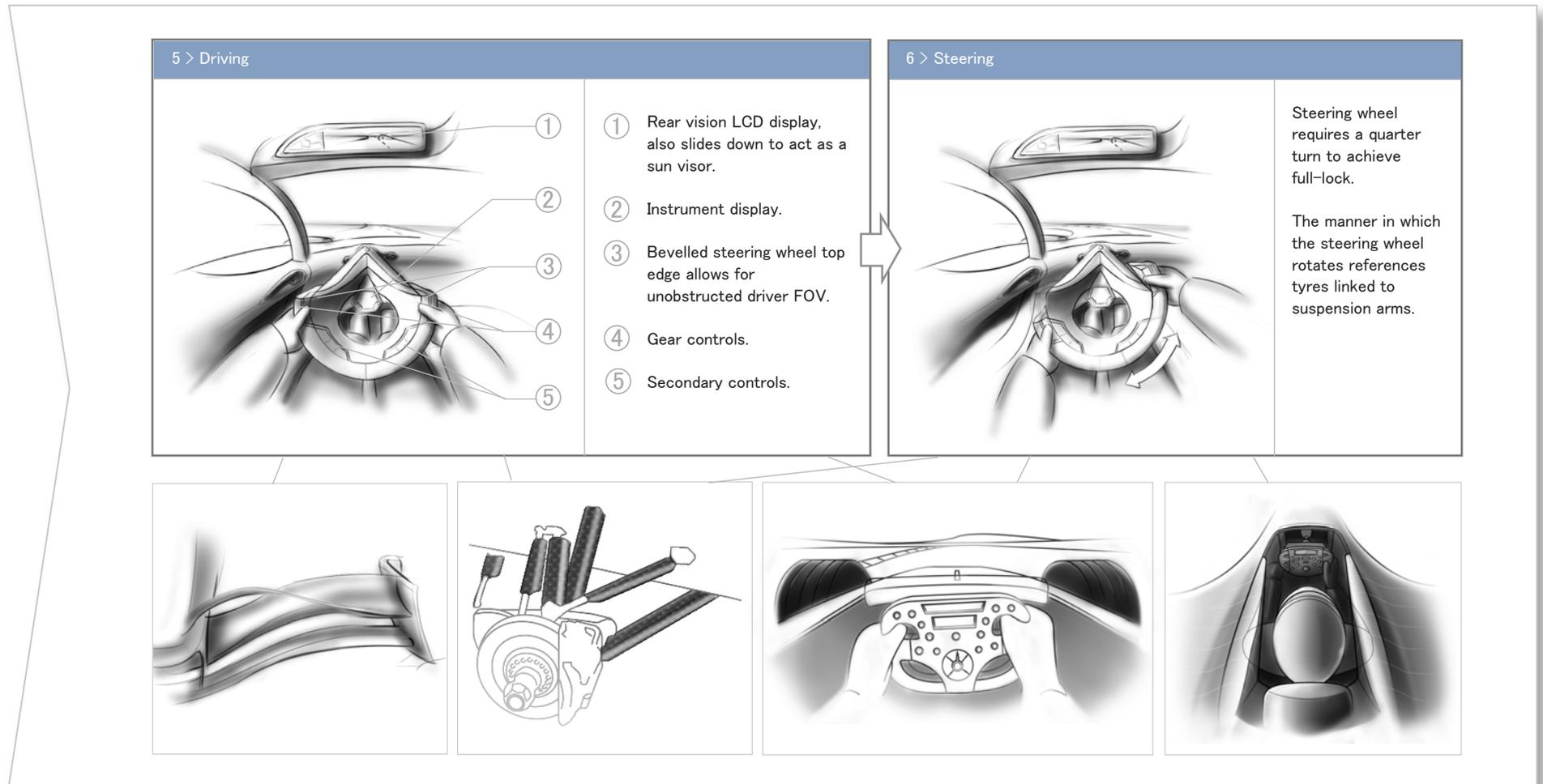


Figure 132. Interior design proposal user storyboard – part 2.

7.5 Reflection on the ‘research through design’ process

This section reflects on a number significant issues not yet discussed or requiring further discussion. Please note, evaluation of the interior design proposal with respect to the design criteria and research aim is discussed in chapter 8.0.

Many unique challenges were undertaken during this iterative design process. One such challenge was achieving an appropriate visual balance between the expressions of ‘luxury’ and ‘high-performance’. Achieving this was a difficult task and not entirely unexpected, as previous research had outlined their opposing qualities (3.1.4). To this end, the Visual Product Experience (VPE) trend analysis results proved insightful; as it reiterated that each element within the interior design proposal did not require the same expression (3.4.4). Design development sought to differentiate high-performance elements with contrasting orange accents, carbon fibre trim, increased visual complexity and references to F1 race cars. Luxurious elements drew strong reference from the existing exterior form language to create visual coherency.

Another significant design challenge was the resolution of the steering wheel. This design feature was deemed significant for the following reasons: firstly, the researcher considered the steering wheel as an appropriate element to express ‘exoticness’ through the referencing of F1. Secondly, the VPE trend analysis identified that luxury motorcar steering wheels reference exterior or brand expressions (3.3.1).

The development of the steering column concept which referenced F1 suspension arms proved significant. Its development was not only significant for the reasons previously outlined, but also served as a point of reference for the resolution of the rest of the interior design proposal.

One design feature not integrated into the final design was the ingress/egress support handle located at the top of the A-pillar. After careful consideration it was decided to not integrate the support handle as the shutline, thin cabin ceiling and rear vision display were all located in the same position. This did not allow for a practical integration of the support handle in this location.

Development of a Computer Aided Design (CAD) model for the interior design proposal would have been beneficial, it would allow for a more accurate modelling of the interior design proposal. Indeed, an initial CAD model of the interior buck and exterior body work was generated. However, as design development progressed, it was found to be more efficient to create fluid surfaces with form studies modelled within a 1:2 scale interior buck, rather than building them in a virtual CAD environment. A 3D surface scan of the aesthetic model would have been desirable, but this was found to be not necessary for resolution of the interior design proposal.

Overall, the ‘research through design’ process developed an interior design proposal that has strong emphasis on the F1 driving experience and is also practical on a functional level.

8.0 ‘Design evaluation’ results and discussion

This section discusses the results of the following ‘design evaluation’ methods:

- Final design evaluated against design criteria.
- Qualitative questionnaire

These methods focused on testing whether the interior design proposal had successfully fulfilled the design criteria and thus fulfilled the aim of this research.

8.1 Final design evaluated against design criteria

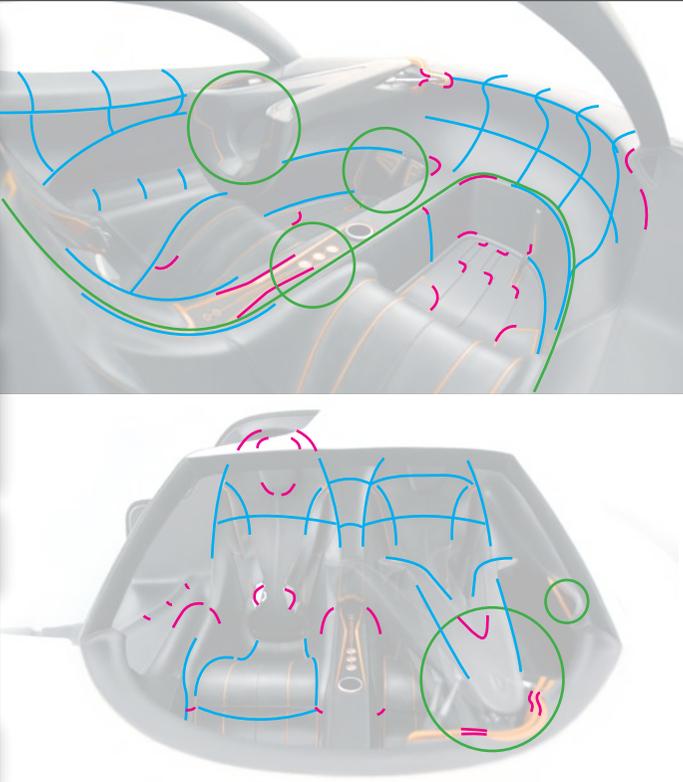
This section focuses on an internal evaluation of the interior design proposal.

Emphasis is placed on whether the interior design proposal fulfilled each individual experience and performance design criterion outlined in chapter 4.0 and section 6.4.

The results from this method are illustrated in tables 008, 009, 010, 011 and 012.

Table 008. Design evaluation testing of interior design proposal – part 1.

Design evaluation – Experience design criteria

Experience criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)	Key:  Criteria fulfilled  Criteria not fulfilled
Repetition of higher order form elements 			Refer to diagrams on the right. 		
Repetition of lower order form elements 			Refer to diagrams on the right. 		
High-performance design elements should be styled to appear complex in composition and use minimal form element repetition			High-performance elements use a variety of trim and colour contrasts. Strong surface transitions are also used.		
Luxury design elements should be styled to appear simple in composition and use frequent form element repetition			Elements intended to express luxury were the forward dash, door shoulder line and seats. Their simplicity was visually expressed through the repetitive use of higher order form elements.		
High-performance design elements should reference contemporary F1 race cars			Refer to diagrams on the right. For further details, refer to 7.1 and 7.3. 		
Interior design proposal expression should compliment the existing exterior aesthetic expression	Use of higher and lower order form elements identified in the exterior, a strong F1 theme and use of negative space gives this interior a similar expression to the exterior.				
Secondary control features should be easy to comprehend.			Use of commonly recognised ISO 2575 control icons (Figure 056).		

Design evaluation – Experience design criteria

Table 009. *Design evaluation testing of interior design proposal – part 2.*

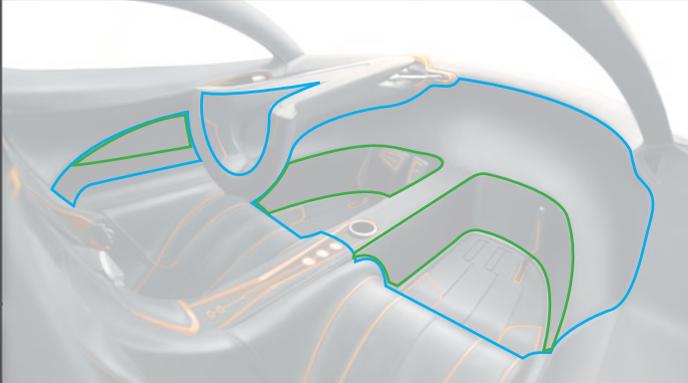
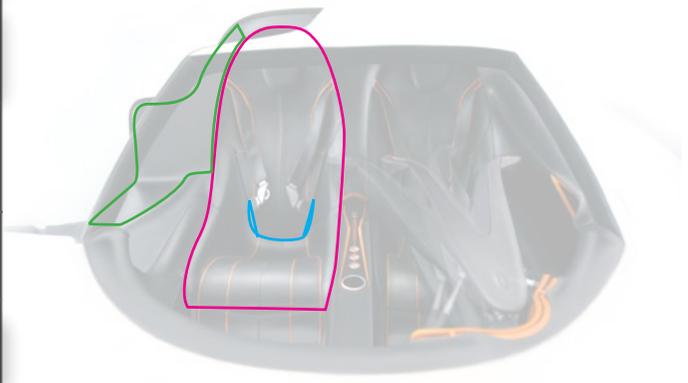
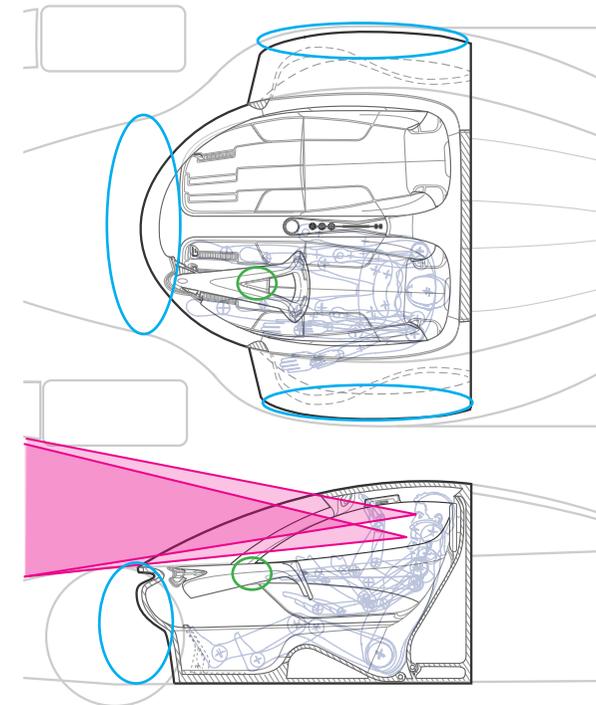
Experience criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)	Key:  Criteria fulfilled  Criteria not fulfilled
Interior aesthetic should reference structural elements					
The carbon fibre monocoque is visually exposed within the foot wells and door sills. Lower section of the doors also expose carbon fibre structure.					
Overall aesthetic composition should not be overly simple or complex. Complex Simple			To achieve an appropriate level of visual complexity, the overall cabin was designed to appear visually simple with the use of a coherent form language (3.1.7). Functional elements were then designed with more visual complexity to offset the simplicity of the cabin.		
Integrate unadorned carbon fibre and leather trim.			Dark grey leather was used to compliment the carbon fibre trim. 		
Control features should be treated with contrasting colours and/or high-performance materials.			Orange accents and brushed aluminium details are used to highlight control features.		
Visual features associated with seat comfort should be visually expressive.	Headrests are emphasised by off setting them from the back rest surface. Bolsters appear prominent because seat pan orange accents visually isolate them.				
Body support system should integrate high-quality leather trim.	Seats are finished with soft-grain dark grey leather trim.				
The aesthetic composition should utilise negative space			Refer to diagrams on the right. 		

Table 010. *Design evaluation testing of interior design proposal – part 3.*

Design evaluation – Performance design criteria

Performance criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)	Key:  Criteria fulfilled  Criteria not fulfilled
Interior must accommodate two occupants		Diagrams to the right illustrate that the interior can accommodate two 95th percentile male occupants.			
The interior design proposal must fit within the existing package		Diagrams to the right illustrate that the interior design proposal fits within the existing package.			
Forward visibility should be free of visual obstructions.			Driver vision is free from visual obstruction.		
In-car display systems positioned as far from the driver as possible (while still legible) and high as possible (without obstructing the drivers direct FOV)			Diagrams to the right show the display position marked in green. The display could be placed further from the driver. However, it was not since placing it further away may afford readability issues, unless the display is very large.		
Adjustable headrest (vertical and longitudinally)	Floating headrests are designed to be adjustable (7.1).				
Body support system meets general design guidelines in 3.4.4		Requirements outlined in 3.4.4 were integrated into the design of the seats.			
The interior must have occupant safety harnesses		Seats are designed with four-point racing harnesses.			
The interior should have occupant airbags units			Steering column has integrated drive airbags (7.3).		
The interior meets general requirements implied by deflection features.	There is adequate space within the door frame and front section to integrate typical deflection features.				



Design evaluation – Performance design criteria

Table 011. *Design evaluation testing of interior design proposal – part 4.*

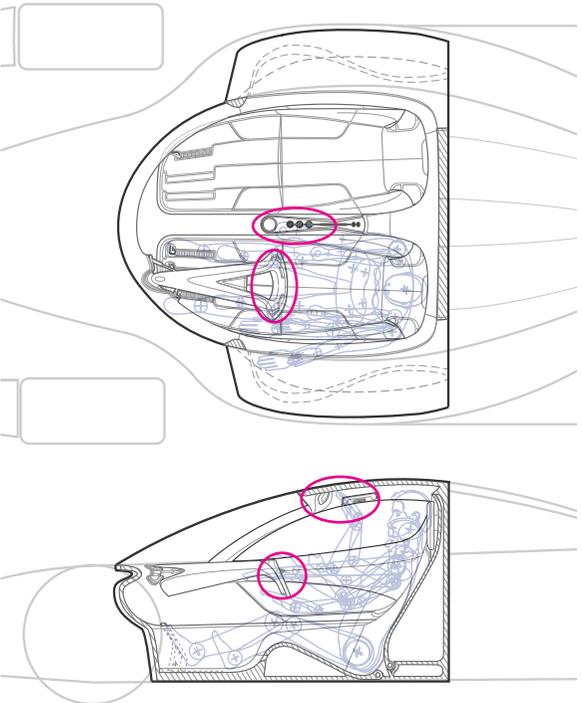
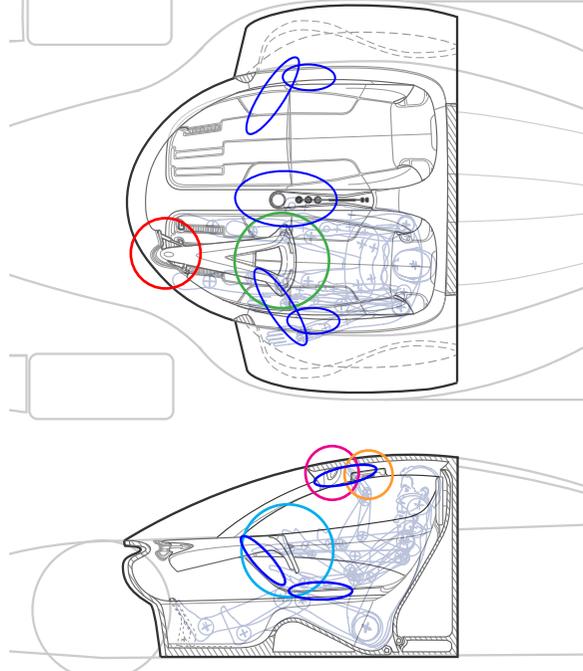
Performance criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)	Key:  Criteria fulfilled  Criteria not fulfilled
Primary controls integrate drive-by-wire technology			Refer to 7.1 outlining the interior design proposal design features.		
Foot pedals designed to allow for left-foot breaking.			Refer to 7.3 outlining the interior design proposal design features.		
Primary controls should be longitudinally adjustable			Refer to 7.3 outlining the interior design proposal design features.		
Body support system should be fixed in position			Refer to 7.1 outlining the interior design proposal design features.		
Entry/exit space should remain as large and unobstructed as possible			Steering column which pivots towards the centre of the cabin ensures an unobstructed entry/exit space (7.4).		
In-car storage features are to be easily to used and accessible.	Final renders of the interior design proposal illustrate the position of in-car storage compartments (7.1).				
Dynamic contouring seat bolsters			Refer to 7.1 outlining the interior design proposal design features.		
Easy access to secondary control features for a wide range of users			The diagram to the right shows secondary control positions highlighted in magenta. Controls were positioned within the maximum reach envelope of a 5th percentile female, or longitudinally adjustable.		

Table 012. *Design evaluation testing of interior design proposal – part 5.*

Design evaluation – Performance design criteria

Performance criteria	Required	Desirable (High)	Desirable (Moderate)	Desirable (Low)	Key:  Criteria fulfilled  Criteria not fulfilled
Steering wheel should have a bevelled top edge		Refer to diagrams on the right. 			
Rear vision display should be set into cabin ceiling and centrally aligned with the driver.			Refer to diagrams on the right. 		
Secondary controls should be positioned within reach envelopes (6.2.7).			All controls are placed within the reach envelopes 		
Top surface of door sill should be relatively flat			Refer to images of final aesthetic model (7.3)		
Door handle should be placed in a central position above the side window.			Refer to diagrams on the right. 		
Ingress/egress handle should be located near the top end of the A-pillar.	The shutline, thin cabin ceiling and rear vision display (located in the same position) did not allow for a practical solution.				
Steering wheel diameter must not exceed 320mm.		Driver vision is free from visual obstruction. 			
Steering wheel should slide or rotate towards the cabin centre.		Rose-joint allows the steering column to rotate towards the centre of the cabin. 			

The results of this evaluation method are summarised in Figure 133. As illustrated in Figure 133, 47 out of 49 design criteria were fulfilled by the interior design proposal. The results indicate that the interior design proposal successfully embodied the desires and requirements of the design criteria.

The results also illustrated two performance design criteria that were not fulfilled:

- In-car display systems positioned as far from the driver as possible (while still legible) and high as possible (without obstructing the drivers direct FOV)
- Ingress/egress handle should be located near the top end of the A-pillar.

Explanations as to why these criteria were not fulfilled are outlined in tables 010 and 012. Their exclusion can be summarised by the identification of unforeseen design issues making them inappropriate or not possible to achieve. This also implies that these design criteria were based on inappropriate assumptions made during the investigation.

Evaluating the interior design proposal against performance design criteria was a straight forward task due to the quantifiable nature of performance criteria. The researcher assumed that evaluation of experience design criteria would have been a more difficult task, due to their subjective nature. Unexpectedly, evaluating the experience criteria proved similar in ease to the performance criteria. Much of this is contributed towards the use of the VPE framework, where its strong

Type of criteria	Fulfilled	Not fulfilled
Experience:		
Requirement	N/A	N/A
Desirable (High)	10	0
Desirable (Mid)	3	0
Desirable (Low)	1	0
Performance:		
Requirement	7	0
Desirable (High)	13	1
Desirable (Mid)	2	1
Desirable (Low)	1	0

Figure 133. Evaluation of interior design proposal results summary.

analytical structure underpinned much of the experience criteria. This in turn allowed the researcher to use the same analytical tools to assess the interior design proposal.

For example, the framework denotes the analysis of aesthetic characteristics through higher and lower order form elements. Analysing the interior design proposal for these higher and lower form elements made it simple to discern whether it had similar exterior form language characteristics to the existing exterior.

As this is an internal ‘design evaluation’ method, it is difficult to objectively determine whether the interior design proposal fulfilled the aim of this research. Initial survey of the results certainly suggest that the interior design proposal fulfilled the research aim. However, this can only be substantiated, if the design criteria are of a credible nature. This method does not assess the credibility of the design criteria. Testing of the design criteria is a focus of the following ‘design evaluation’ method.

8.2 Qualitative questionnaire study

This questionnaire study aimed to assess the aesthetic impression of the interior design proposal and whether it fulfilled the aim of this research. A copy of the questionnaire and reference imagery used in this study can be found in Appendix 2. This questionnaire study received ethics approval from the Massey University Human Ethics Committee (refer to Appendix 3).

As stated earlier, questions 1–3 employ Visual Analogue Scales (VAS). VAS were used to assess the visual impression of the interior design proposal against the descriptive terms ‘luxury’, ‘high-performance’ and ‘exoticness’. Similar studies have demonstrated the effectiveness of VAS as a tool for assessing the visual impression of a design (Warell, 2007). Therefore, VAS were seen as an appropriate means for evaluating the visual impression of the interior design proposal.

VAS feature a line 100mm in length. The left endpoint of this line was labelled ‘not at all’, while the right endpoint was labelled ‘to a great extent’. Participants were invited to answer questions such as ‘How do you think this interior rates in terms of luxury?’ using VAS. They did so by placing a mark on the VAS line according to their assessment of the interior design proposal against the key descriptive term, in this case ‘luxury’.

In total, nine respondents participated in this questionnaire study. All nine respondents were motorcar salespeople from luxury and exotic brands such as Audi,

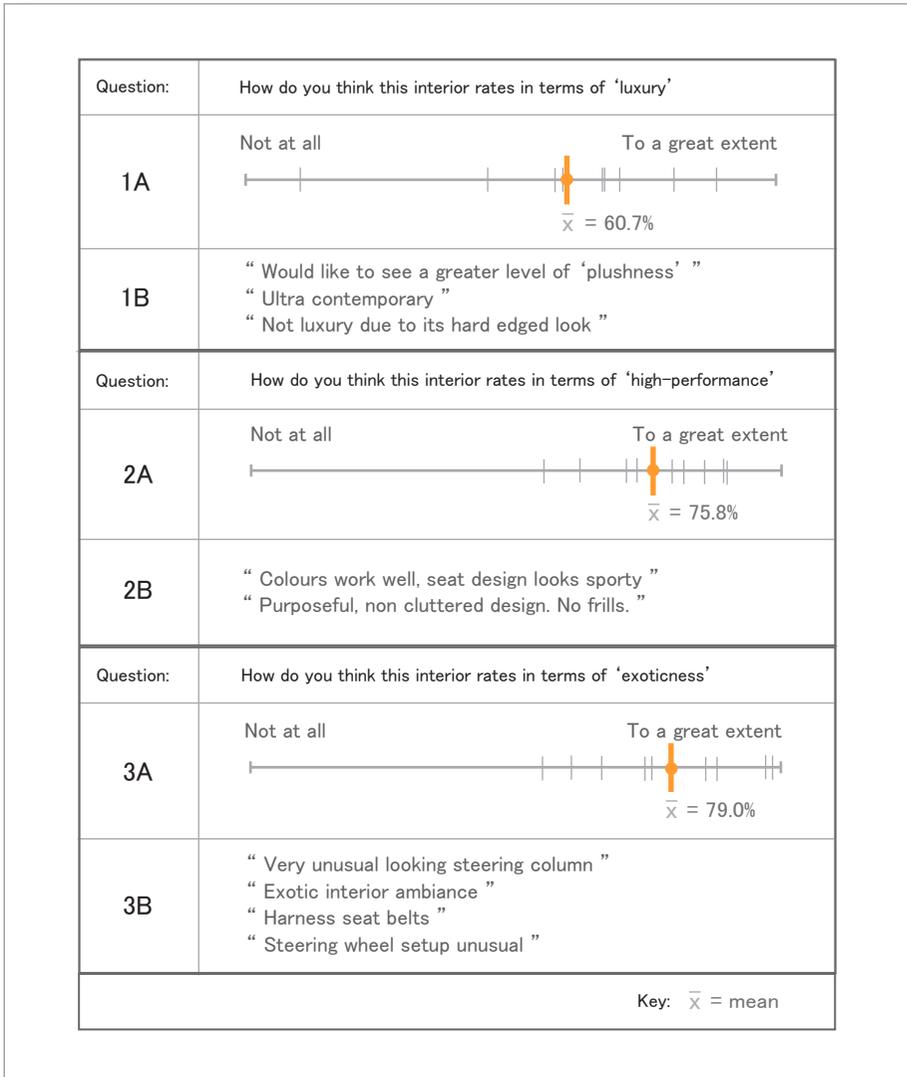


Figure 134. Results for questions 1–3.

Question:	How well does the interior concept compliment the exterior design?					
4A	Tick-box rating assessment	High 5	4	3	2	Low 1
	Participant responses	6	2	1	0	0
	Mean response	4.6 / 5.0				
4B	“ ...interior is a cockpit as expected. ” “ ...compatible DNA ” “ Same design cues, colour and shape ”					

Figure 135. Results for question 4.

Mercedes-Benz, Porsche, Lamborghini, Ferrari and Bentley. Each respondent was approached during early working hours on the sales floor. Early working hours are generally considered as the least busy hours of a typical working day and therefore, proved the most appropriate time to approach sales people for gaining their participation.

The questionnaire began with a brief introduction of the interior design proposal: images of the interior design proposal were provided. Questionnaires were then given to the participants. Participants were invited to answer questions 1 – 3 in reference imagery to the interior design proposal. After question 3, participants were shown imagery of the existing exterior. Participants were then invited to answer question 4. At the end of the questionnaire, participants were invited to make general written comments about the interior design proposal.

Figures 134 and 135 illustrate the results of this questionnaire study. From these results, the following conclusions were drawn and discussed:

- The mean VAS response from question 1 was 61%, this indicates that the interior design proposal has a moderate level of perceived visual ‘luxury’. This outcome is similar to suggestions outlined in the background research stating that the visual expression of the interior design proposal should integrate a moderate level of ‘luxury’ (3.1.3). Consequently, this result suggests that the interior design proposal successfully achieved its desired visual expression with regard to ‘luxury’.

- The mean VAS response from question 2 was 76%, this suggests that the interior design proposal had a high level of perceived visual ‘high-performance’. This result reflects earlier background research stating that the visual expression of the interior design proposal should have strong references to ‘high-performance’ but not be an actual ‘high-performance’ interior (3.1.4). The result indicates that the interior design proposal successfully achieved its desired visual expression with regard to ‘high-performance’. Interestingly, participants did not comment on the steering column in question 2. This was surprising as the steering column was designed to express ‘high-performance’ and ‘exoticness’ (7.5). The implications of this are discussed in the next paragraph addressing the ‘exoticness’ conclusion.
- The mean VAS response from question 3 was 79%, this indicates the interior design proposal had a high level of perceived visual ‘exoticness’. Earlier background research established ‘exoticness’ as an essential expression for the interior design proposal (3.1.2). This suggests the interior design proposal successfully achieved its desired visual expression in terms of ‘exoticness’. Notably, a number of participants commented on the ‘exotic’ quality of the steering column. As mentioned above, the steering column was designed to express both ‘high-performance’ and ‘exoticness’. The results suggest that the steering column has a greater perceived visual expression of ‘exoticness’ than originally intended. This does not undermine the creditability of the interior design proposal, but further emphasises it’s ‘exotic’ expression and

appropriateness as a supercar interior.

- The mean response for question 4 was 4.6/5.0. This suggests that the interior design proposal is highly appropriate for the existing exterior. Therefore, the interior design proposal successfully fulfilled the aim of this research, which was to develop an interior design proposal appropriate for the Hulme F1 supercar. This result also substantiated the credibility of the experience and performance design criteria for the interior design proposal with the intent of complimenting the exterior design in an appropriate manner.

As already outlined in section 6.2, the scope of this investigation did not allow for a lengthy and thorough questionnaire for analysis of the interior design proposal. Consequently, the results from this study were focused towards overall impressions of the interior design proposal. Due to the limitations of the questionnaire, there was no analytical means of discerning whether participant answers referred to formal aesthetic qualities, semantic qualities, a combination of both or what specific features they were referring to.

Despite this limitation, the professional background of the participants proved to be effective for assessing the overall aesthetic impression of the interior design proposal and how well it complimented the exterior.

9.0 Conclusion to the study

This investigation set out with the aim of developing an interior design proposal appropriate for the Hulme F1 supercar exterior. In order to achieve this, experience and performance design criteria (4.0) were generated. The criteria were used as a starting point for the development of the interior design proposal. Underpinning the design criteria were the following main assumptions;

- The interior design proposal required an appropriate balance of ‘exotic’, ‘luxury’ and ‘high-performance’ motifs.
- The interior design proposal should have a similar overall aesthetic expression to the existing exterior.
- F1 references can be used as a means to express both ‘exotic’ and ‘high-performance’ within the interior design proposal.
- The F1 cockpit and ingress/egress rituals were considered appropriate references for the interior design proposal.

Through an iterative design process, the interior design proposal was developed in response to the design criteria, as illustrated in Figure 136.

Internal ‘design evaluation’ testing illustrated that the interior design proposal fulfilled the majority of the design criteria. Further external testing focused on whether the interior design proposal complimented the Hulme F1 supercar exterior. The results from this indicated that the interior design proposal complimented



Figure 136. Interior design proposal and the Hulme F1 supercar exterior.

the exterior to a high degree. This led to the conclusion that the interior design proposal is appropriate to the Hulme F1 supercar and thus successfully fulfilled the aim of this research. To this end, testing also indicated that the proposed process outlined within the central proposition (1.2) was an appropriate approach to fulfil the aim of this research.

10.0 Recommendations for future areas of research

The following are potential areas for further research in future studies:

- Further explore trim and colour opportunities for the interior design proposal.
- Explore and develop the interior design proposal by means of Computer Aided Design.
- Further investigate technical and ergonomic implications of the opening and closing of the proposed butterfly hinged doors.

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13.0 Glossary

Aesthetics	Relating to a pleasurable sensory experience.
Buck	A full size framework on which creative modelling and/or testing is developed (Bayley and Chapman, 1999, p.227).
DLO	Day light opening – design term referencing the side window silhouette (Bayley and Chapman, 1999, p.228).
Door sill	The body part located between the bottom of the doors and the ground (Bayley and Chapman, 1999, p.230).
Forward Cabin	A package configuration where the occupant cabin is positioned far forward in comparison to typical coupes. The benefit to the overall package is space: by moving the windscreen and occupants forward, space was liberated for the rear compartment.
FOV	Field of vision
Glasshouse	The upper glazed portion of the passenger compartment which sits on the bodywork (Cardesignnews, 2007).
Ingress and egress	The process of entering and exiting a motorcar.
Monocoque	A type of vehicle construction where the body is combined with the chassis as a single unit.
Package	The term “package” defines the general arrangement of major components and dimensions within a design (Bayley and Chapman, 1999, p.230).

Shoulder line	An design feature which runs across the entire length of the exterior positioned below the glasshouse (Cardesignnews, 2007).
Shutline	The part line between the door and body panels (Bayley and Chapman, 1999, p.230).

Appendix 1 – VPE analysis results of motorcar exemplars

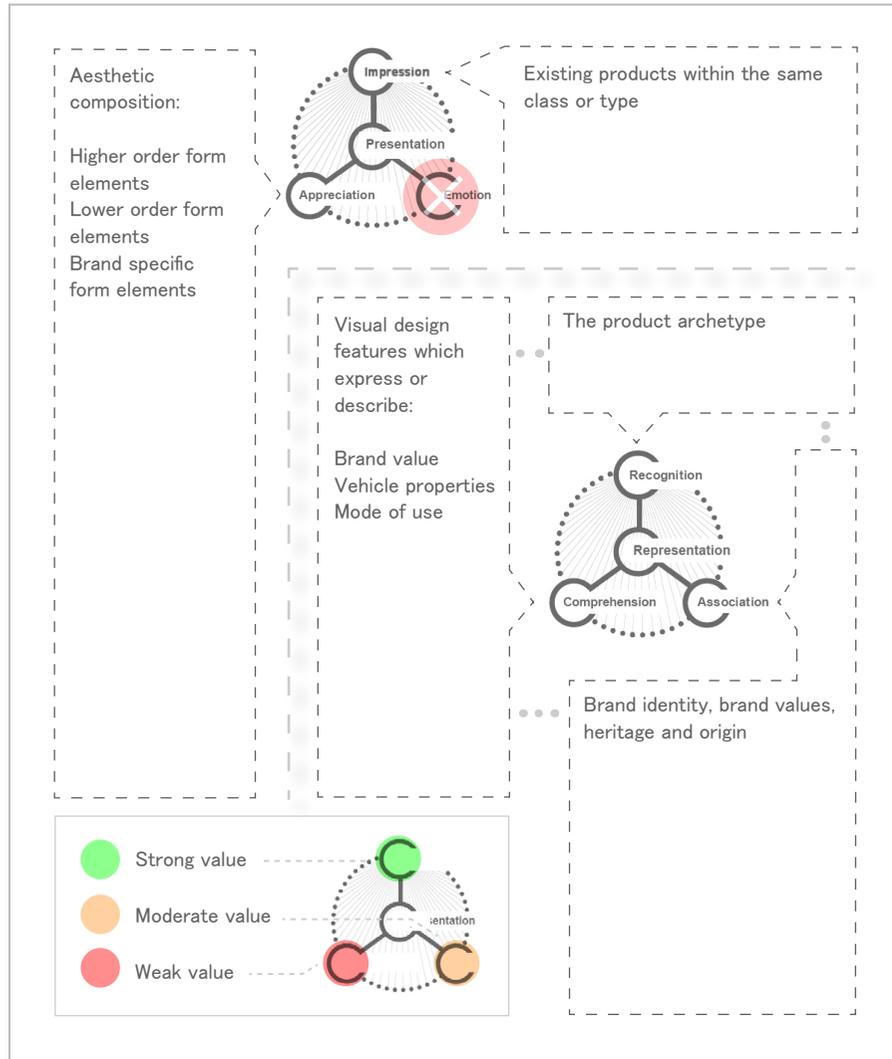


Figure A01. VPE analysis template.

This section discusses the VPE analysis results from the following contemporary motorcar exemplars (in sequential order):

- Mercedes-Benz S-Class (2006)
- Bentley Flying Spur (2005)
- Audi RS4 Quattro (2005)
- Bentley Speed 8 (2003)
- Porsche RS Spyder (2007)
- Ferrari Enzo (2002)
- Pagani Zonda F (2005)
- Bugatti Veyron 16:4 (2006)

Figure A01 illustrates the VPE analysis template used to analyse exemplars. To give each VPE analysis context, this researcher has briefly critiqued the interior and exterior aesthetics of each exemplar.

Mercedes-Benz S-Class (2006)

The Mercedes-Benz S-Class range has been in production for over 50 years and is generally considered the benchmark of four door luxury saloons. As a consequence, this exemplar offers an ideal starting point for understanding the visual concept of luxury in contemporary motorcars.

The 9th generation S-Class (Figure A02) has a confident and commanding exterior road presence, with simple surface language and distinct surface transitions. Pronounced wheel arches and gentle convex surfaces add a muscular element to the overall aesthetic expression. The interior is garnished with high-quality leather and dark Burl Walnut wood trim. In addition, the interior sports a state-of-the-art user interface with elegantly detailed controls and large LCD display screens.

Visual analysis of this exemplar using the VPE framework (Figure A03) reveals several distinct visual findings with reference to the interior and exterior/interior aesthetic relationship. These findings are detailed as follows:

- Higher and lower order form elements (interior and exterior) appear to be derived from the form language of the 'v' shaped grille.
- There is frequent repetition of higher, lower and brand specific form elements across the visual composition, this creates strong interior/exterior visual continuity/harmony.
- Strong use of repeating common form elements, resulting in a simple



Figure A02. Mercedes-Benz S-Class. (Seriouswheels, 2006b).

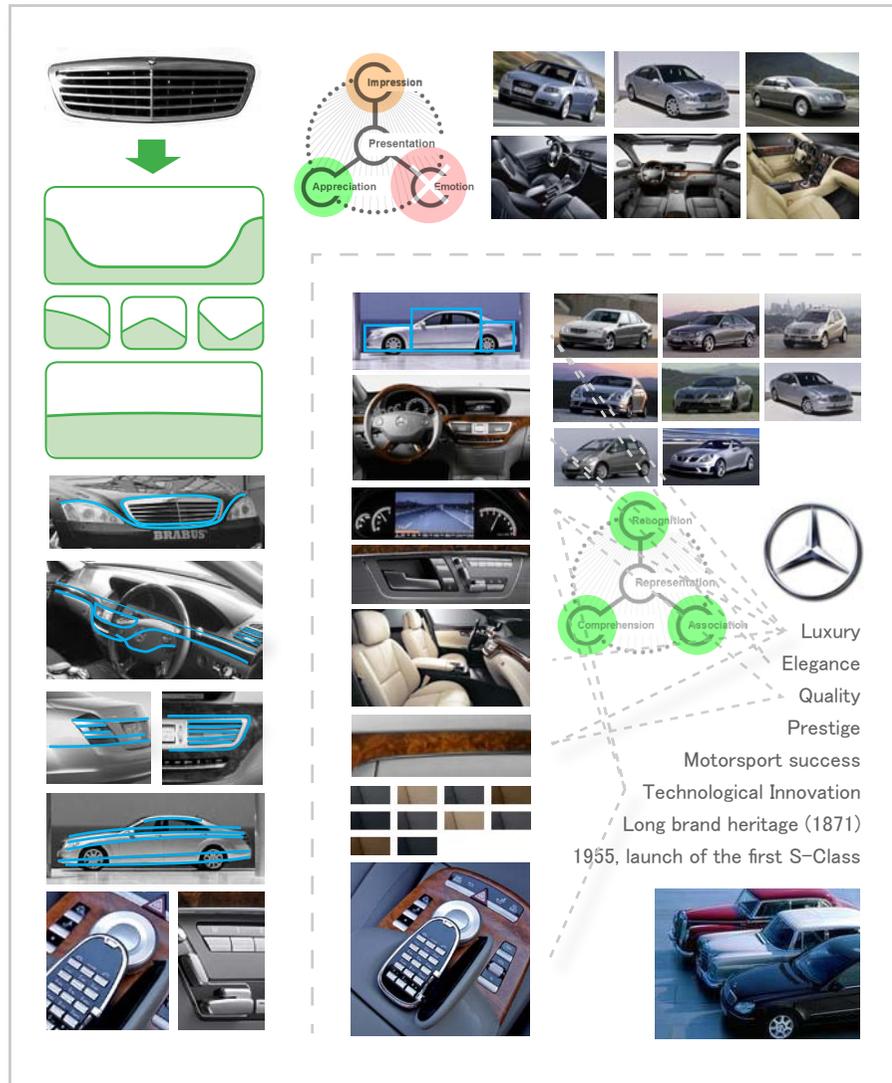


Figure A03. VPE analysis of the Mercedes-Benz S-Class.

aesthetic composition.

- Interior material selection and quality appears to be a defining factor for luxury (high quality leather trim, dark walnut accents and fine chrome detailing around control fixtures).
- Spacious interior cabin visually expresses luxury through associations with comfort.
- High levels of recognition, comprehension and association (in context to a user familiar with the Mercedes-Benz brand)
- Dominant ‘wrap around’ walnut accent, creating strong aesthetic unity.

This VPE analysis affirms the S-Class as a luxury motorcar (with reference to previous research on luxury). However, the analysis did illustrate two unexpected findings:

- Firstly, despite the interior and exterior visual structure and content being dissimilar, both share many common and repeating form elements. As stated earlier, this in turn helps to imbue a visual sense of continuity and familiarity.
- Secondly, the extent of which form elements reference the front grille graphic.

At this point, it is too early to discern whether these findings are aesthetic design trends for luxury motorcars or visual attributes distinct to the 2006 S-Class.

Bentley Flying Spur (2005)

Bentley Motors is a luxury motorcar brand with distinctly traditional brand values, focused on hand-crafted luxury and high-performance attributes (Bentleymotors, 2006). As a consequence, the Bentley Flying Spur (Figure A04) was analysed for its interpretation of traditional luxury in the context of motorcars.

The Bentley Flying Spur has an elegant and confident, almost subdued, exterior presence. A clean uninterrupted shoulder line, tall upright glasshouse and subtle surface language contributes towards this. Looking inwards, the interior aesthetic is furnished with high-quality leather trim, prominent dark walnut accents and finely detailed chrome fixtures. This contributes towards a strong hand-crafted, almost ornate expression.

Visual analysis of this exemplar using the VPE framework (Figure A05) shows distinct visual findings with reference to the interior and exterior/interior aesthetic relationship. These findings are outlined below:

- Frequent form element repetition across the entire aesthetic composition (interior and exterior), similar in fashion to the previous exemplar.
- Dominate use of dark Walnut within the interior, expressing high levels of traditional hand-crafted quality and ornateness.
- Chrome fixture detailing appears to have some correlation with the brand logo (refer to Figure A05).



Figure A04. *Bentley Flying Spur*. (Seriouswheels, 2005a).



Figure A05. VPE analysis of the Bentley Flying Spur.

- Higher order form elements appear to be derived from the Bentley logo
- High levels of recognition, comprehension and association (in context to a user familiar with the Bentley brand)

As for the previous exemplar, this VPE analysis affirms the Flying Spur as a luxury motorcar (with reference to previous research on luxury). However, the analysis did illustrate two unexpected findings:

- The strong visual referencing of brand logo language in context to higher and lower order form elements.
- As with the previous exemplar, the interior and exterior differ aesthetically overall, yet still reference many common higher, lower and brand specific form elements.

The analysis of the Bentley Flying Spur illustrated many similar aesthetic qualities with the previous exemplar. For example, frequent repetition of common higher and lower form elements (interior and exterior), abundant use of high-quality leather trim, dark walnut accents, fine chrome detailing around control fixtures and strong values associated with identity. To this end, these recurring qualities are an indication of possible aesthetic trends for luxury motorcars. However, it is worth noting that the increased use of dark walnut compared to the previous exemplar appears to express a strong ornate or traditional quality.

Audi RS4 2.0T Quattro (2005)

Thus far, research has illustrated the opposing qualities of luxury and high-performance. Therefore, the next exemplar was visually significant for its complimentary use of luxury and high-performance design cues; the Audi RS4 (Figure A06).

The RS4 is a four door luxury saloon with a high-performance sport orientated package. Its overall exterior expression is muscular and aggressive. Design features such as pronounced wheel arches, a defined discreetly rising shoulder line, inward tapered headlights, single-frame trapezoid grille and tensioned front surfaces all contribute towards this expression.

Looking inwards, the interior aesthetic is both confident and reassuring in expression. This was achieved through an elegant carbon fibre accent which extends from the door trim to the centre console. This design feature encompasses the occupants and creates a sense of security and refinement. Other design features expressing confidence and reassurance include the steering wheel and sports seats, with their strong muscular form language.

Visual analysis of this exemplar using the VPE framework (Figure A07) reveals significant visual findings with reference to the interior and exterior/interior aesthetic relationship, which are detailed as follows:

- In similar fashion to previous two exemplars, there is frequent repetition

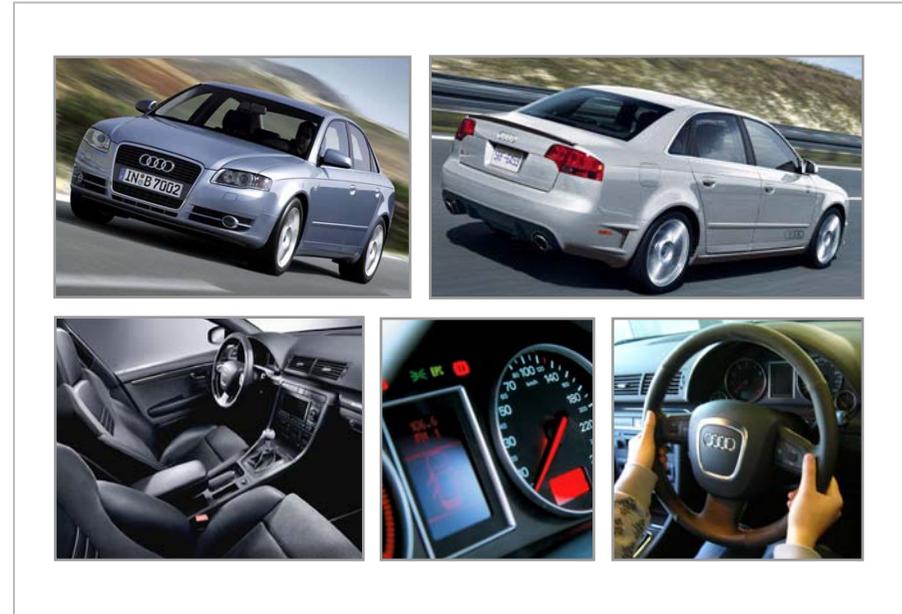


Figure A06. Audi RS4. (Seriouswheels, 2005b).



Figure A07. VPE analysis of the Audi RS4.

- of common higher and lower order form elements (interior and exterior).
- Form elements appear to be derived from the front grille graphic
 - Dominant ‘wrap around’ unadorned carbon fibre composite accent, this creates strong aesthetic unity across the composition.
 - There is less emphasis on ornate chrome detailing around control fixtures (in comparison to the previous exemplars).
 - Unadorned carbon fibre composite is used decoratively within the interior and exterior to express high-performance. The use of this trim has no or little performance enhancing factors.
 - In similar fashion to the previous exemplars, this exemplar has high levels of recognition, comprehension and association (in context to a user familiar with the Audi brand)

This analysis demonstrated slightly different qualities to the previous exemplars. For example, reduced emphasis on chrome detailing, muscular surfaces and use of unadorned carbon fibre composite trim as a dominate accent. The connection between these differences and the sports orientated package are somewhat apparent.

However, even the carbon fibre composite trim is applied in an ornate or decorative manner. Consequently, this exemplar still demonstrates many similar qualities to the previous exemplars. To this end, it is clear that luxury motorcar interiors have a strong visual archetype and distinct aesthetic design trends. The implications of this are to be discussed at a later point in this section.

Bentley Speed 8 (2003).

The first LMP race car reviewed is the Bentley Speed 8 (Figure A08). In terms of overall aesthetic composition, the Bentley Speed 8 and Hulme F1 supercar share similar characteristics, with the teardrop like glasshouse (designed for two occupants), front nose, front wing, rear wing and headlight units. However, upon further investigation, the Speed 8 appears very different aesthetically. Like many high-performance products, the overall design appears driven by utility and functionality, resulting in a spartan or raw visual expression (refer to 3.1.4). Notably, the interior aesthetic appears almost hostile in expression with a cluttered, confusing user interface and raw material trim such as unadorned carbon fibre composite.

Visual analysis of this exemplar using the VPE framework (Figure A09) shows several significant findings with reference to the interior and exterior/interior aesthetic relationship:

- The overall aesthetic composition (interior and exterior) is very complex, minimal repetition of form elements contributes towards this.
- Interior aesthetic has little relation to the exterior aesthetic, yet still share similar overall expression of high-performance and focus on utility and functionality.
- Interior and exterior frequently use of raw and exposed materials and/or structural elements.
- The unfamiliar and erratic interior composition contributes towards an



Figure A08. *Bentley Speed 8 (2003)*. (7extrememotorsports, 2003).

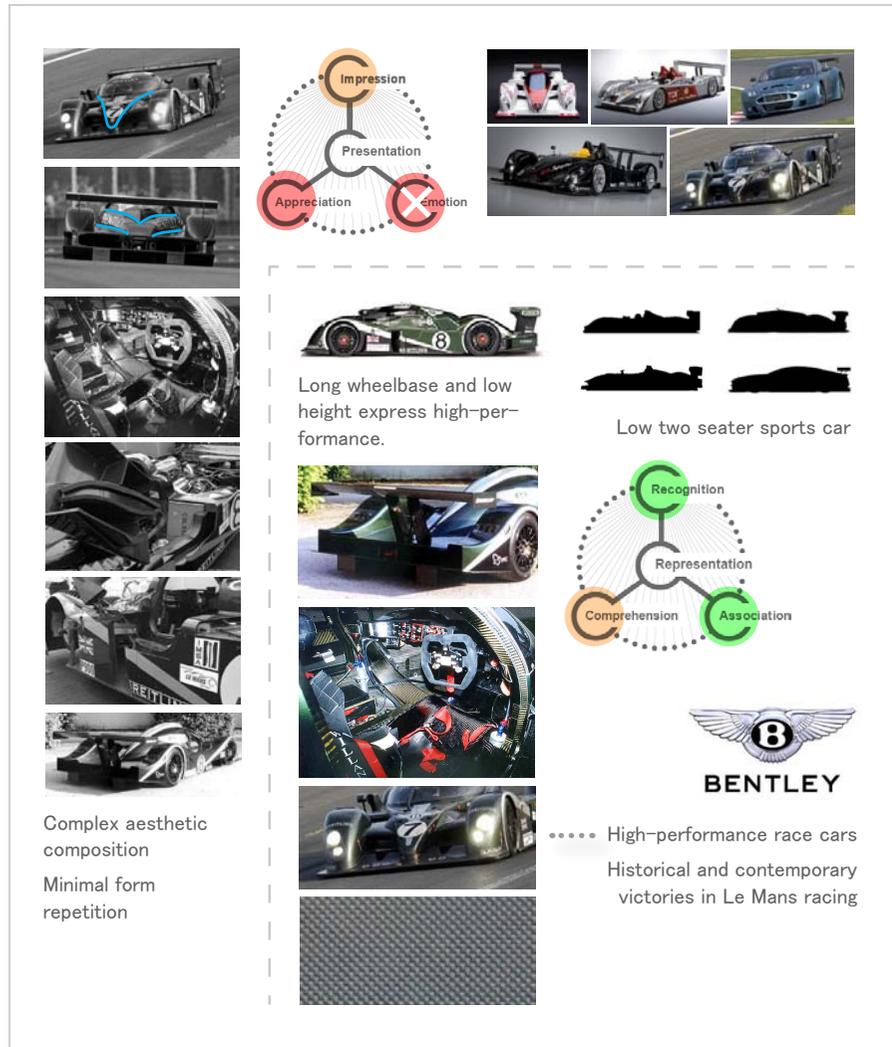


Figure A09. VPE analysis of the Bentley Speed 8.

almost hostile expression.

- Basic interior functional features are easy to understand (i.e. the steering wheel and seat). However, the layout, positioning and design of secondary controls appears unfamiliar and visually cluttered (in comparison to the previous exemplars). The design of these secondary controls appears to require specialised training.
- Interior cabin appears visually and spatially confined.

The qualities identified by the VPE analysis clearly affirms this exemplar as a high-performance race car (with reference to the previous research on high-performance). However, the following are several unexpected findings from this analysis;

- The contrasting qualities between this exemplar and the previous luxury exemplars. For example, the confining interior cabin in contrast to the spacious interior cabin of luxury motorcars, or the complex composition in contrast to the simple compositions of luxury motorcar.
- The almost hostile expression imbued by the interior.
- The complete lack of aesthetic relation between the interior and exterior

At this point, it is too early to discern whether these findings are aesthetic trends for high-performance race cars. Consequently, further investigation into other high-performance exemplars is still required. However, it certainly affirms the issue raised earlier, where a considered balance is needed between high-performance and luxury (in context to the interior design proposal).

Porsche RS Spyder (2007).

Like an F1 race car, the LMP Porsche RS Spyder is an open cockpit race car with a strong emphasis on dynamic performance (Figure A10). In similar fashion to the Bentley Speed 8, the visual aesthetic hosts a variety of discontinuous forms and a diverse range of surface transitions. Consequently, this results in a spartan or raw aesthetic expression.

Research now focuses on the visual analysis of this exemplar using the VPE framework (Figure A11). The following are visual findings with reference to the interior and exterior/interior aesthetic relationship:

- As with the previous exemplar, the exterior and interior aesthetic compositions are very complex. The lack of form element repetition contributes towards this.
- The overall interior aesthetic appears spatially and visually confining. The enclosed driver cockpit and large encompassing head bolsters contribute towards this.
- In similar fashion to the previous exemplar, basic interior functional features are easy to understand (i.e. the steering wheel and seat). However, the layout, positioning and design of secondary controls appears unfamiliar and visually cluttered. The design of these secondary controls appears to require specialised training.
- Frequent use of raw and exposed materials and/or structural elements.



Figure A10. *Porsche RS Spyder*. (Autocult, 2007).

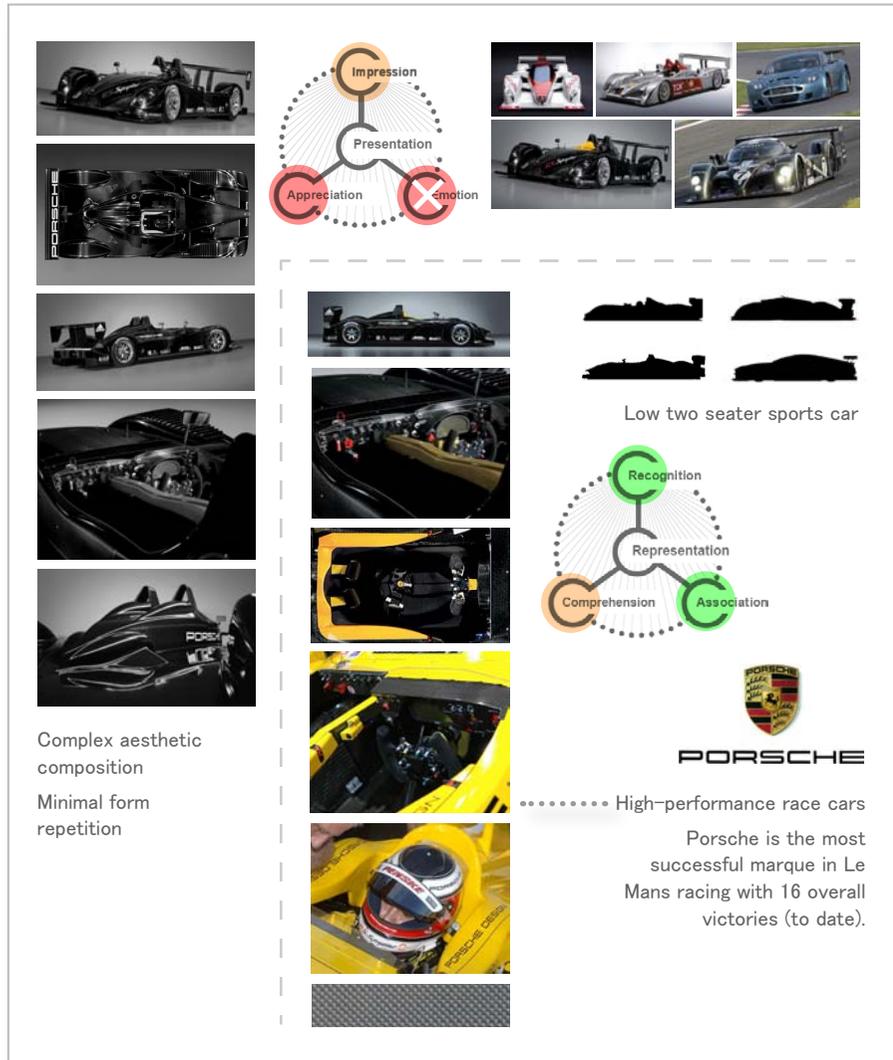


Figure A11. VPE analysis of the Porsche RS Spyder.

- The interior and exterior share a stronger aesthetic relationship in comparison to the previous exemplar. This can be attributed to the open cockpit, effectively integrating the exterior and interior together. However, there is still minimal commonality between interior and exterior aesthetic design features.

As with the previous exemplar, the qualities identified by the VPE analysis clearly affirms this exemplar as a high-performance race car (with reference to the previous research on high-performance). With respect to the previous exemplar and the research already conducted on F1 race cars, this analysis illustrated little in the way of surprises.

The 'association' mode of operation is of particular interest with regard to the previous two exemplars. In both analyses, this mode of operation was given a strong value, due to their historical racing success in 24 Hours of Le Mans racing. This strong value is only appropriate for an individual with reasonable knowledge of 24 Hours of Le Mans racing. For most individuals without this knowledge, there is likely to be a lower level of association. Consequently, this further emphasises the opposing differences between luxury and high-performance, where luxury appears dependent on iconic and indexical references, while high-performance depends on associative and symbolic references.

Overall, these findings clearly indicate aesthetic trends for high-performance motorcars. The implications of these trends will be discussed later in this section.

Ferrari Enzo (2002)

The Ferrari Enzo provides an ideal starting point for the review of exotic super-car exemplars due to its similarity the Hulme F1 supercar (Figure A12). Like the Hulme F1 supercar, the Ferrari Enzo is designed as a street-legal F1 race car (Grabianowski, 2004). Therefore, the Enzo's interior and interior/exterior relationship is of particular interest to this investigation.

Overall, the exterior aesthetic of the Enzo has a high-performance expression with strong references to F1 racing. Strong surface transitions, discontinuous forms, typical supercar proportions, exposed engine bay, F1 style front nose and numerous rear exhaust outlets all contribute towards this expression.

Looking inwards, the interior aesthetic appears spartan or utilitarian in expression with the overall intention of promoting high-performance. The use of unadorned carbon fibre composite trim and a structural aluminium crossbeam incorporating the functional elements contribute towards this expression. In addition, the steering wheel references F1 style steering wheels, with a bevelled top edge, 'change up' LED indicator and numerous controls.

Research now focuses on the visual analysis of this exemplar using the VPE framework (Figure A13). The following were significant findings with reference to the interior and exterior/interior aesthetic relationship:



Figure A12. *Ferrari Enzo*. (Seriouswheels, 2002).

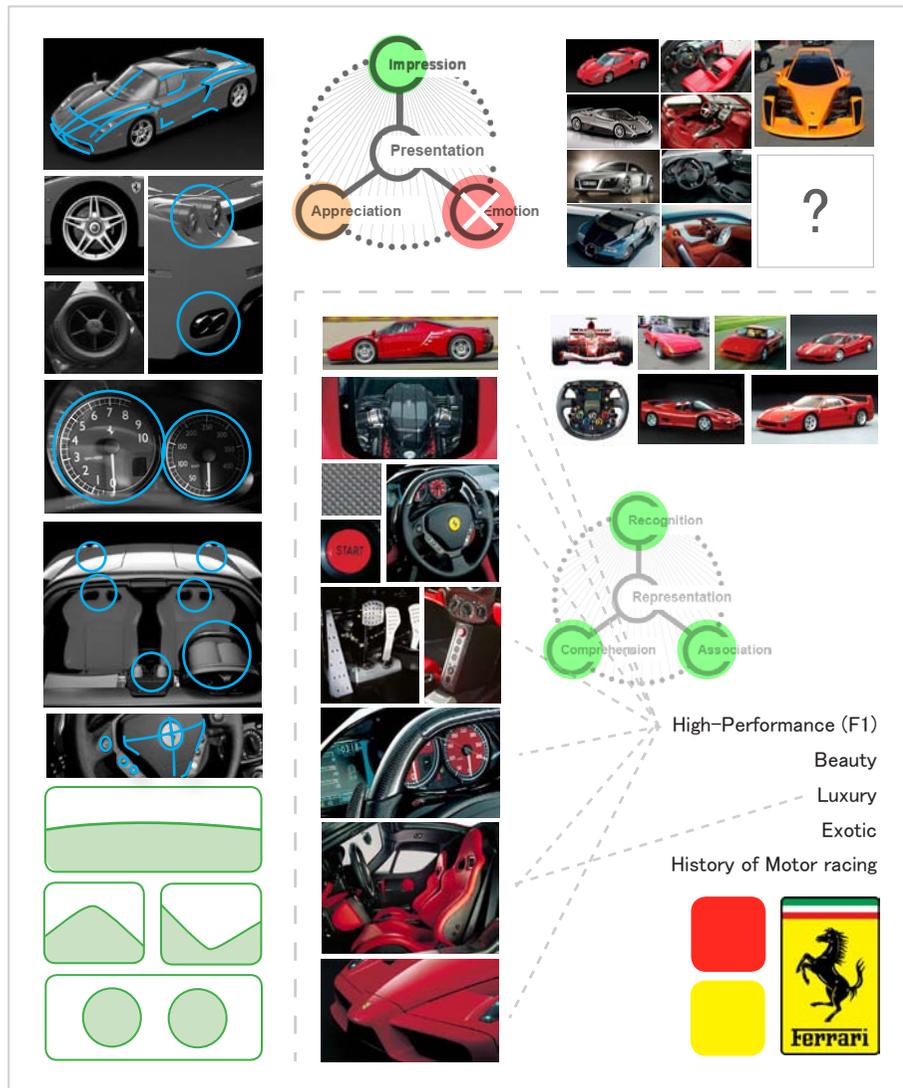


Figure A13. VPE analysis of the Ferrari Enzo.

- Frequent lower order form element repetition across the aesthetic composition (both interior and exterior).
- Aesthetically, the interior and exterior share little in common (aside from lower order form elements). However, they both imbue similar overall expressions of high-performance.
- Although the majority of the interior aesthetic expresses high-performance, the sport seats also express an element of luxury. High-quality leather and soft bulbous forms contribute towards this expression.
- An abundance of unadorned carbon fibre composite trim.
- A significant aesthetic point of difference between this exemplar and the previous high-performance exemplars is the layout and configuration of secondary controls. As mentioned previously, the visual layout of secondary controls typically appear cluttered, confusing and thus appears to require specialised training. However, the secondary controls in this exemplar appear much more civil or domesticated in arrangement. This results in an interior that expresses high-performance, but does not require an expert user.

This VPE analysis illustrates significant issues (and possible solutions) for the interior design proposal. Most notably the treatment of secondary controls, in contrast to 'true' high-performance race cars. However, in the context analysis, it is too early to discern whether these findings are general exotic aesthetic trends or specific to this model and/or brand. Consequently, further analysis into exotic exemplars is required.

Pagani Zonda F (2005)

The Pagani brand (established in 1992) is relatively young in comparison to Mercedes-Benz (1871) or Ferrari (1947). Therefore, like the Hulme F1 supercar brand, Pagani lacks in areas of brand recognition and established brand values. As a result, Pagani's latest incarnation, the Zonda F (Figure A14) deals with visual identity in a manner directly relevant to this investigation.

The overall exterior aesthetic of the Zonda F has typical dynamic supercar proportions. The exterior aesthetic has a high-performance expression and displays it in various ways. For example, the wedge-shaped silhouette and extensive use of unadorned carbon fibre trim contribute towards a high-performance expression. In addition, design features such as the elongated front nose, teardrop glasshouse and large exhaust detail reference jet-fighters, another high-performance motif (MacMillan, 2006).

Looking inwards, the interior has a very different overall impression, expressing opulence or extravagance. The extensive use of leather trim, a glove box styled in similar fashion to leather handbags, wood trim and a finely crafted instrument cluster all contribute towards this. However, there is still reference to the theme of high-performance within the interior, with finely machined metal fittings and large areas of unadorned carbon fibre composite trim.

Visual analysis of this exemplar using the VPE framework (Figure A15) revealed



Figure A14. *Pagani Zonda F*. (Seriouswheels, 2005c).

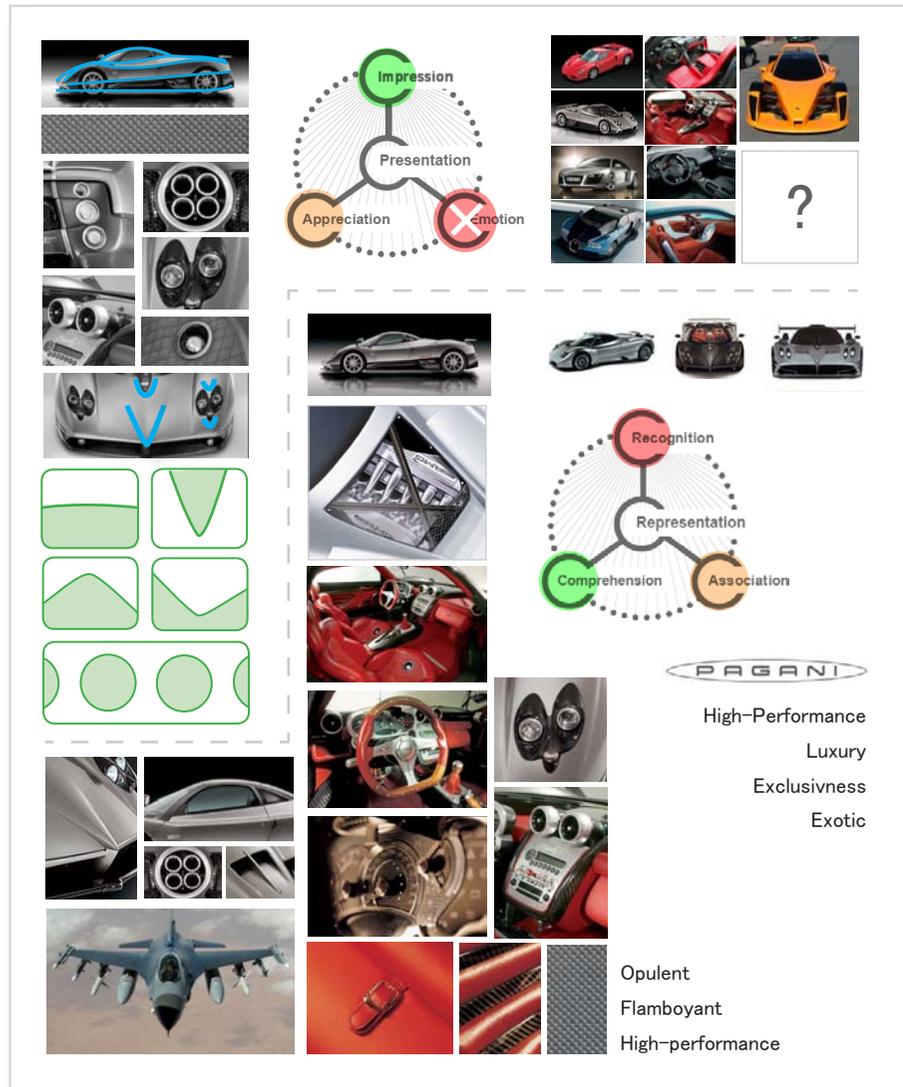


Figure A15. VPE analysis of the Pagani Zonda F.

significant findings with reference to the interior and exterior/interior aesthetic relationship:

- Like the previous Enzo exemplar, the interior aesthetic syntactically contrasts the exterior aesthetic. Moreover, the interior and exterior have different expressions. The exterior expresses high-performance while the interior expresses opulence, hand-crafted quality and high-performance.
- Minimal form element repetition (particularly interior/exterior wise)
- Frequent use of contrasting surfaces (trim, colour and surface change)
- High-performance trim is frequently used to adorn control fixtures.
- Interior integrates high-quality leather, walnut, unadorned carbon fibre composite and metallic trim.
- Use of ‘metonymic’ references. For example, the glove box styled in similar fashion to luxury handbags and the exterior jet fighter motif. This gives the Zonda F stronger intended associations to reference from, since there is little brand recognition to build upon. This in effect is similar in purpose to how the Hulme F1 supercar references F1 race cars.

The findings from this analysis differ greatly from the previous exemplar as little in the way of identifiable trends was discernable. This was somewhat unexpected, as there was an expectation to find at least one major exotic motorcar aesthetic trend. However, when referencing the definition of exoticness (3.1.2), it is apparent that the term of unusualness could easily mean unusual in context to other unusual motorcars.

Bugatti Veyron 16:4 (2006)

The final exotic supercar reviewed is the Bugatti Veyron 16:4 (Figure A16). This specific exemplar was chosen for its distinct aesthetic qualities compared to the previous two exemplar. In addition, the Veyron 16:4 was the world's fastest production road car when released in 2006, making it a well known exotic exemplar.

The exterior aesthetic overall has a confident expression with a strong road presence. This can be attributed to strong convex surface language, generating a almost heavy or dominating aesthetic. Contrasting surface colours are in turn used to lighten the visual mass, providing a sense of dynamism. Also, typical supercar proportions, pronounced wheel arches, an exposed engine bay, large front air-intakes, and the forward tapering bonnet graphic contribute towards high-performance orientated qualities.

Looking inward, the interior aesthetic continues with the confident expression of the exterior. Prominent visual forms such as the metallic centre console, large centre column and bold steering wheel graphic contribute towards this. As mentioned previously, the interior is also finished with an abundance of high-quality leather.

With the Veyron 16:4 now introduced, research focuses on the visual analysis of this exemplar using the VPE framework (Figure A17). The following are significant findings with reference to the interior and exterior/interior aesthetic relationship:



Figure A16. *Bugatti Veyron 16:4*. (Seriouswheels, 2006a).

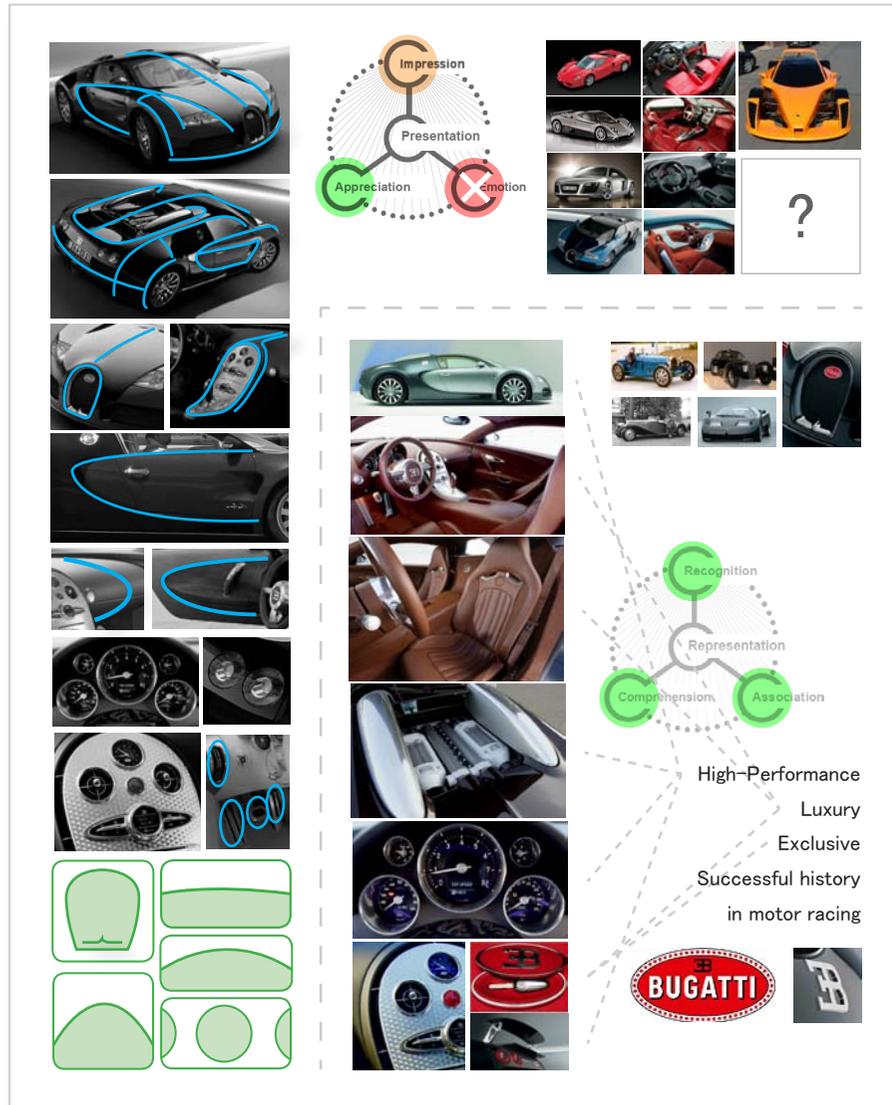


Figure A17. VPE analysis of the Bugatti Veyron 16:4.

- Strong repetition of higher and lower order form elements within the exterior and interior.
- Overall, the interior and exterior are aesthetically different, but share similar expressions and higher order form elements.
- Form elements appear to be derived from the front grille graphic, in similar fashion to the luxury motorcar exemplars.
- Dominant use of metallic trim on visual forms relating to functional or technical aspects of the Veyron (i.e. centre console and steering wheel).
- An abundance of high-quality leather trim.
- Contrasting surface colours imbue a sense of dynamism and lightness
- The overall syntactic composition is less complex in comparison to the previous exotic exemplars.

The VPE analysis of this exemplar further emphasised the differences between the exotic exemplars. In comparison, this exemplar has qualities associated more with luxury motorcars rather than high-performance race cars. Consequently, this exemplar illustrated yet another flavour in contemporary exotic supercars. The analysis did begin to identify specific interior aesthetic design trends. For example, the use of contrasting surface treatments (also seen in the previous exemplars in varying degrees).

This analysis of exotic supercars illustrated numerous issues for the interior design proposal, which, will be discussed in the conclusion of this section.

Appendix 2 – Questionnaire and reference images

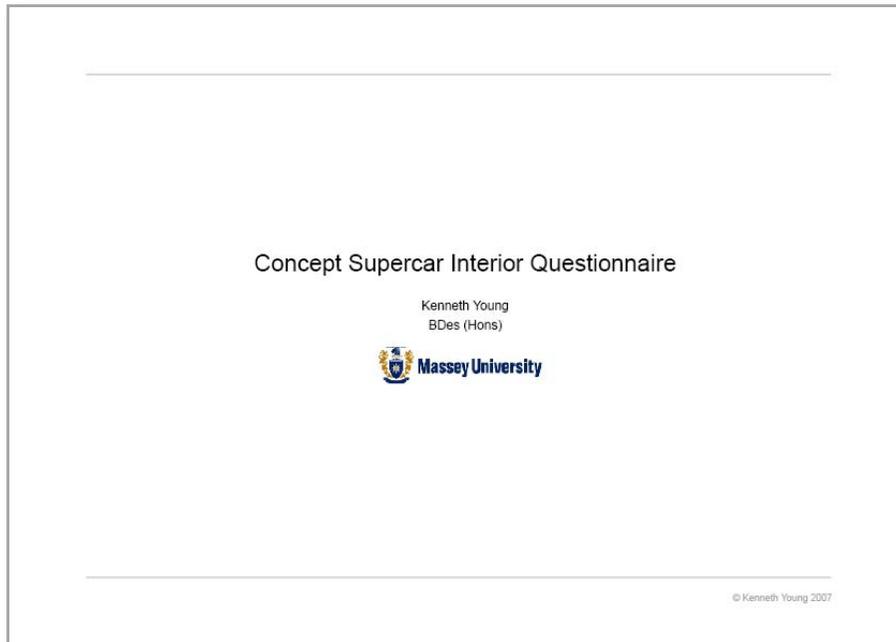


Figure A18. Questionnaire – page 1.

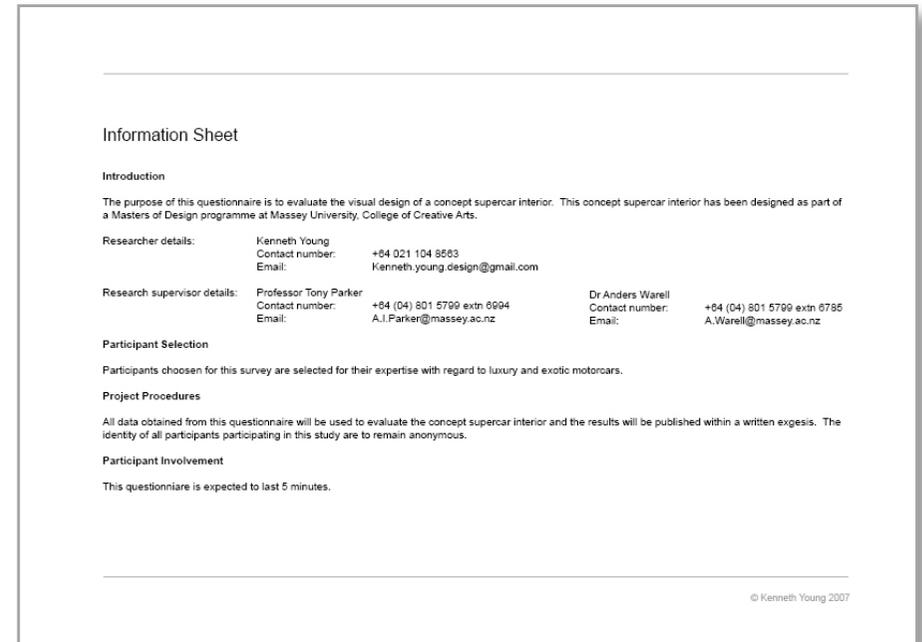


Figure A19. Questionnaire – page 2.

Participant's Rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study at any time
- Ask any questions about the study at any time during participation
- Provide information on the understanding that your name will not be used unless you give permission to the researcher
- Be given access to a summary of the project findings when it is concluded

Massey University Ethical Code of Conduct

This project has been evaluated by the peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher, please contact Professor Sylvia Rumball, Assistant to the Vice Chancellor (Ethics and Equity).

Telephone: 06 350 6249
E-mail: humanethics@massey.ac.nz

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Figure A20. Questionnaire – page 3.

Participant Consent Form

This consent form will be held for a period of five (5) years

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: _____ Date: _____

Full Name - printed _____

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Figure A21. Questionnaire – page 4.

Referring to the images supplied by the researcher, how do you think this supercar interior rates in terms of:

1A) Luxury (comfortable, expensive)	Not at all ----- To a great extent
1B) Please explain	
2A) High-performance (sporty, professional)	Not at all ----- To a great extent
2B) Please explain	
3A) Exoticness (unusual)	Not at all ----- To a great extent
3B) Please explain	

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Figure A22. Questionnaire – page 5.

4A) How well does the interior concept compliment the exterior design?
High Low

4B) Reason for the answer above?

5) General comments regarding the interior concept?

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Figure A23. Questionnaire – page 6.

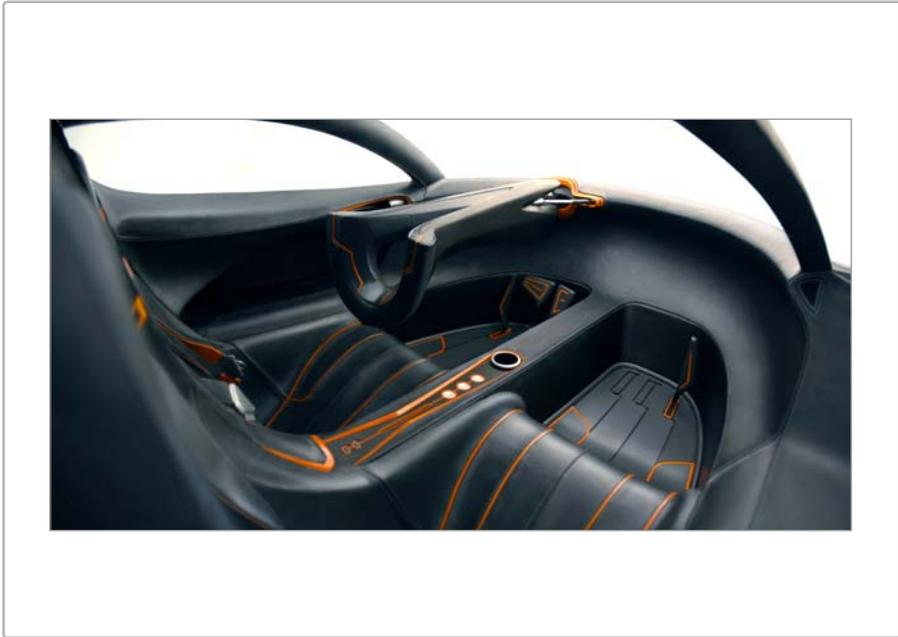


Figure A24. *Reference imagery – page 1.*



Figure A25. *Reference imagery – page 2.*

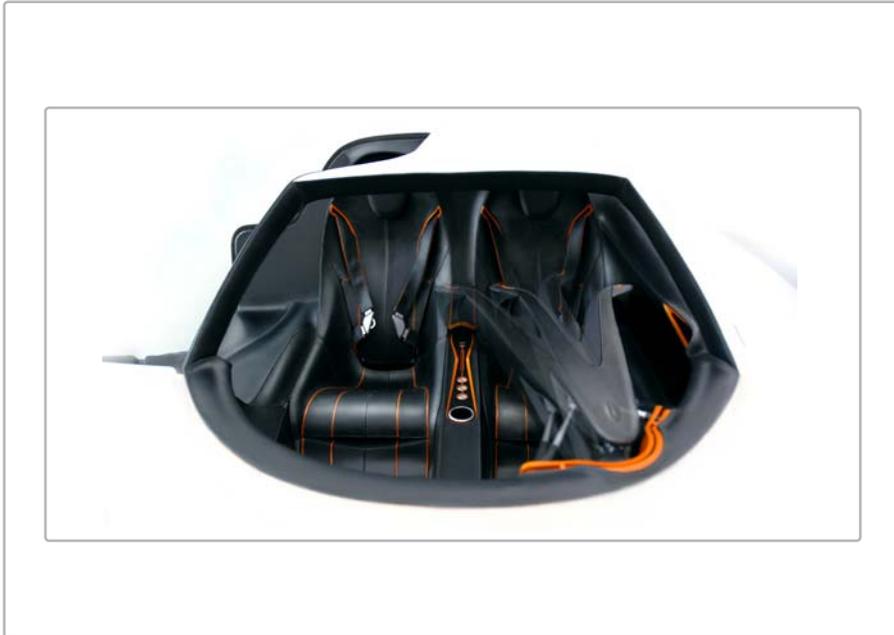


Figure A26. *Reference imagery – page 3.*



Figure A27. *Reference imagery – page 4.*

Appendix 3 – Questionnaire ethics approval

This project has been evaluated by the peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher is responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher, please contact Professor Sylvia Rumball, Assistant to the Vice Chancellor (Ethics and Equity),

Telephone: +64 6 350 5249

E-mail: humanethics@massey.ac.nz

Appendix 4 – Originality declaration



Research Thesis Originality Declaration

Candidate ID: _____
Surname Name: _____
First Name: _____
Paper Number: _____
Thesis Title: _____

Declaration

- I declare that this is original and is entirely my own work.
- Where I have made use of the ideas of other writers, I have acknowledged (referenced) the sources in every instance.
- Where I have made use any diagrams or visuals, I have acknowledged (referenced) the sources in every instance.
- This work has been prepared exclusively for this paper and has not been and will not be submitted as assessed work in any other academic courses.
- I am aware of the penalties for plagiarism as laid down by Massey University.

A copy of the Assessment and Examination Regulations can be found under the Statutes and Regulations section on the Massey University website (<http://calendar.massey.ac.nz/>)

Candidate signature

Date

**Include this originality declaration with your thesis when submitted for examination.
A thesis without this declaration will not be accepted.**

Appendix 5 – Library declaration

MASSEY UNIVERSITY
College of Creative Arts

Masters Research Thesis

LIBRARY DECLARATION

Author's Name: _____
Title of Thesis: _____
Degree: _____
Year of Completion: _____

Except where specific reference is made in the main text of the thesis, this thesis contains no material extracted in whole or in part from a thesis, dissertation, or research paper presented by me for another degree or diploma and has not been submitted for the award of any other degree or diploma in any other tertiary institution.

No other person's work (published or unpublished) has been used without due acknowledgment in the main text of the thesis.

Availability of Thesis

- I hereby consent to the final thesis (including any required amendments) being consulted, borrowed, copied or reproduced from time to time in accordance with the provisions of the Massey University Library Regulations.
- The Assistant Vice-Chancellor (Research) has approved an embargo for this thesis.

Note: The period of the embargo will not exceed two years from the date on which the thesis is presented in its final format. During the period of the embargo the thesis will be treated as confidential and access restricted to supervisors, examiners and candidate. The Library will hold the completed thesis securely until the end of the agreed period; it may be released earlier with the approval of the Chief Supervisor or nominee.

Signature: _____ Date: _____