SYSTEM RESILIENCE

ENGN2225 – Individual Research Paper

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ABSTRACT

The topic of System Resilience focuses on a stage of the design process where the design must be 'proven'. This is done by verifying the design, and by prototyping the design. When verifying the system, it must be shown that it satisfies the initial customer and design requirements. Following this, the design is tested using four different approaches at varying stages. The final topics are prototyping and design communication, where the ideas are modelled and designs presented to the user groups. A case study is developed, explaining and relating the theory to new cars and apartment blocks. The report then applies the System Resilience theories to the group project of designing a toothpaste dispenser. It is outlined that the toothpaste dispenser can be verified by comparing with the initial design requirements, and can be tested efficiently by creating a computer-aided design (CAD) model.

BACKGROUND OF SYSTEM RESILIENCE

The theory relating to System Resilience is separated into two sections; Verification, and Prototyping and Design Communication. The topic of Verification requires the design to meet all the initial customer and design requirements. It also includes the processes of testing the design using four different methods throughout the design stages. These separate testing types are 'proof-of-concept testing', 'model testing', 'operational testing', and 'support testing' (Based on Blanchard and Fabrycky, 2011). It highlights the importance of testing the design as a whole or in parts, so changes can be made early on in the development of the project, saving time and money.

Proof-of-concept testing is used during the initial phases of design, to test certain elements of the intended design for functionality, adequacy and compatibility. This could be in the form of a CAD model, bench-test or breadboard test circuit. Model testing is used in the latter part of the design stage, and uses formal tests and pre-production prototyping to test the design for performance, structural integrity, reliability and maintainability. Operational testing and support testing are used once the design is finalised, to analyse how well it works within a user environment and over the period of a full life cycle.

The topic of Prototyping and Design Communication exposes the design to the real world and delivers the design to the user groups. It demonstrates the importance of being able to communicate the design to those who it will be marketed towards in future. The prototype created could be a physical recreation, or could be a ‘rapid prototype’ as a CAD model, a sketch, or an item printed with a 3D printer. A rapid prototype is a ‘method used to accelerate the innovation process’ (Chua C. et al, 2010), and is arguably more efficient than a normal prototype. Tripp and Bichelmeyer believe that traditional prototyping has many faults, stating prototypes ‘identify phases but don’t decrease project time … they describe the system thoroughly but don’t guarantee it's the right system’. It is then argued that rapid prototyping will decrease project costs and time, whilst still being able to communicate and test the design in a real-world situation (Tripp and Bichelmeyer, 1990).

The steps taken to integrate the System Resilience theories into the design can be identified in almost any engineering – based project. For instance, each model of car that Ford produces must undergo rigorous testing before it can be released to the market. Outlined in the article by Kenneth Chelst, when prototypes are made it is noted that they ‘can be very costly to produce, because most of the parts and the manufacturing and assembly processes are unique’ (Chelst K et al, 2001). Ford sets a goal to ‘build as few vehicles as possible to perform the testing and evaluations required’ (Chelst K et al, 2001). This means many of the processes are modelled on CAD programs first to save on cost and time. Just as the System Resilience theory discusses, the next step in Ford’s stages of design is the testing stage. This is where the team may ‘make improvements and changes’ (Chelst K et al, 2001). The article highlights the fact that ‘this stage can include several design iterations, re-testing, and rebuilding vehicles’ (Chelst K et al, 2001). From this case study, it is visible that in any engineering- based project the theories of verification and prototyping are crucial.

Rapid prototyping is often used when undergoing construction of apartment blocks. In New Acton, Canberra, there is an apartment building undergoing construction called the ‘Nishi’ building. In the case of an apartment block, it proves impossible to build the entire complex just for the testing and prototyping phases, so often CAD models and small-scale architectural models are created. These not only allow tests of materials, forces and structural stability, but also allow the clients and potential buyers to visualise the future finished product. This can be seen below in Figure 1, which displays the CAD drawing of the final Nishi Apartment building, used on the website to entice potential buyers. In this case the application of System Resilience theories, particularly design communication and rapid prototyping, are clearly evident.

Figure 1: The CAD model of the Nishi Apartment building in New Acton (Molonglo Group, 2011).

APPLICATION TO TOOTHPASTE DISPENSER PROJECT

The System Resilience theories apply to the group's design project of a toothpaste dispenser. The first topic of 'Verification' can be applied as it can be proven that the intended final design matches the initial customer and design requirements. The initial customer and design requirements are listed in the table below (Table 1).

Table 1: The Customer and Design Requirements.

CUSTOMER REQUIREMENTS	DESIGN REQUIREMENTS
Looks good	Correct amount dispensed
Low cost	Material (low cost and durable)
Clean (no mess created)	Effective interior mechanism
Quick to use	Small dimensions
Dispenses good amount	Ease of use
Doesn't take up space	Safe design

The group's intended final design portrays qualities specifically to fit the requirements listed above. The dispenser is designed with a compact and regular shape, sitting on a bench or attached to a wall. This satisfies the requirements 'doesn't take up space', and 'small dimensions'. The design contains an efficient interior mechanism, ensuring that the dispenser remains 'clean', as well as being 'quick to use', whilst dispensing the correct amount of toothpaste each use. Lastly, the material chosen for the outside casing is a durable plastic, available in various finishes, to match any bathroom. This satisfies the final requirements of ‘looks good’, as well as providing a durable, low cost material. From the analysis here, it is visible that the group’s intended final design can be appropriately verified against the initial customer and design requirements.

The topic of Verification also includes the processes of testing the design. This will be applied to the toothpaste dispenser using testing types 1 and 2, otherwise known as ‘proof-of-concept testing’ and ‘model testing’. The proof-of-concept testing has already been applied in the form of CAD models, which were sketched of the initial three design ideas. One of the design ideas that was viewed in the given group presentation is pictured below, in Figure 2. It was purposely designed to fit the criteria of helping dispense toothpaste for a person with a disability, whilst also conforming to the design requirements.

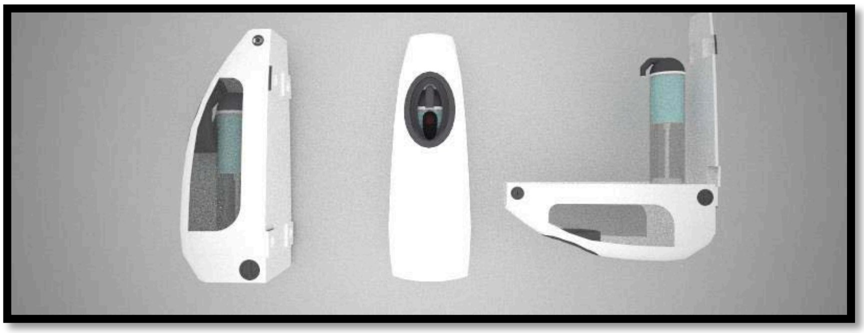

Figure 2: The group’s initial toothpaste dispenser design for a person with a disability (Project Group W14RB, 2013).

Sketching the design early allowed the group to prove that the concept would perform as expected. It allowed changes to be incorporated into our final design early on in the process. This representation (Figure 2) also fulfils the criteria for the model testing, as the CAD model drawn is sufficient as a prototype of the design, and functions well enough on the program interface for individuals visualise its use and effectiveness.

Once the final design has been confirmed, the theories will be reapplied and a CAD model will be constructed of the design. This final CAD model will act as a rapid prototype, as well as an important method of communication between the final users and the design team.

DISCUSSION

The system resilience processes appear both lengthy and costly. This is perhaps why many new designs base sections off already existing and previously tested solutions. This would reduce the cost while ensuring that the concept functioned as intended.

The group recognised the necessity of system resilience, however found it was rather hard to implement as wished. To properly test the internal mechanism and materials over a lifetime period it would be preferable to have actual prototypes and samples available. Nevertheless, the group had CAD models sketched early in the process, allowing us to see that the concept would work, but also allowing changes to be incorporated. The main use of the system resilience concept for the group was that of ‘design communication’. All the CAD drawings created have assisted in the communication of the idea to the client and user groups efficiently and succinctly.

CONCLUSION

The topic of System Resilience was imperative to the design of a toothpaste dispenser, in order to verify the design, and prototype the design for communication purposes. It was shown that the intended final design satisfies all initial customer and design requirements. Through the use of CAD models, the system was tested for functionality and feasibility, further allowing the group the opportunity to change design details early in the process. The final toothpaste dispenser will be drawn in CAD to both prototype the design and communicate the design to the client, before moving forward into the next design topic of ‘System Evaluation’.

BIBLIOGRAPHY

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Chelst K. et al, 2001, *Rightsizing and Management of Prototype Vehicle Testing at Ford Motor Company*, http://www.scienceofbetter.org/can_do/success_stories/Interfaces/1526-551X-2001-31-01-0091R.pdf, Viewed 08/05/13.

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PEER REVIEW 1

Demonstrates that formatting requirements have been met:

It looks like your margins are 3cm and in the formatting guidelines it says they should be 2cm. I got marked down in the paper outline for having 3cm margins so I would definitely change this.

Demonstrates a correct understanding of the theory:

As far as I can tell you have done a good job on the theoretical part of your background, however Chris' outline says the background should be '*half on the theory, half on previous examples'*. Although you have included an example that you have come up with, I would consider changing the last two paragraphs of your background to be about an actual real world example where they have used system resilience or used one of the aspects of system resilience.

Application of the theory to the project:

This is done well and but perhaps in too much detail. You haven't actually included a discussion section, which I'm almost certain you will get marked down for. From Chris' outline '*Discussion (250 words) of interesting observations, such as trade-offs*'. Also try talking about whether your group found System Resilience useful or not. I think you could use some of what you have written in Application section, in the discussion such as '*Sketching the design early allowed the group to prove that the concept would perform as expected. It allowed changes to be incorporated into our final design early on in the process*'.

Quality and relevance of bibliography:

All good here

Suggestions on how could the paper be improved:

I've talked about this in the previous sections so I'll just sum up here (1) 2cm margins (2) Include a real world example in the background (3) Refine Application section and Add Discussion Section

Ross Edwards, Sunday, 5 May 2013, 10:36 AM Sunday, 5 May 2013, 10:36 AM

PEER REVIEW 2

Demonstrates that formatting requirements have been met:

The general format is good, the Figures and Tables are well labeled, but the spacing does looks little bit too big, it would be good to change it to requested spacing.

Demonstrates a correct understanding of the theory:

This article showed a good understanding of the theory of System Resilience, but for this part, it's better to use a literature review or a real world example, but the last paragraph of this part is an example with no source.

Application of the theory to the project:

Good link between the theory and the application, clearly use of System Resilience in analyzing the group project.

Quality and relevance of bibliography:

Good reference and bibliography

Suggestions on how could the paper be improved:

This report can be improved by following points:

1. Change to right spacing
2. Replace the last paragraph in the background part with a literature review or a real world example

Tianrui Pan, Sunday, 5 May 2013, 10:17 PM Sunday, 5 May 2013, 10:17 PM