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The Role of Engineering in the Design of Kings of Carnival Costumes in Trinidad and Tobago

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Abstract: *Information is lacking on the design process and key design issues faced by Kings of Carnival costume designers in Trinidad and Tobago. Unlike parade floats, Kings of Carnival costumes consist of large decorative pieces mounted on a three-wheeled frame that is moved around by a single masquerader who enacts a stage performance with the costume. To address this problem, a qualitative study was conducted through semi-structured interviews involving fifteen Kings of Carnival costume designers within the last three years. The study was sought to identify the design process used, extract the factors that influence the design of the costumes, examine the extent to which Engineering principles are utilised, and recommend strategies for improving the design process. Results indicated that engineering input was not utilised in the costume design process and material selection was based on tradition, availability and cost. Designers did not take into consideration the mechanical properties of materials during the construction of costumes. This resulted in a lot of trial and error during the construction and extremely heavy and uncomfortable costumes. External factors such as wind and rain were not being adequately addressed in the design process resulting in sub-optimal and unreliable designs. Recommendations to improve the design process include the implementation of a more rigorous design process, workshops to train designers in specific engineering tools that could be used, a modular costume design platform, revision of material selection and analysis of costume reliability to withstand unpredictable external loads. In addition, it is necessary to provide simple and accessible engineering support to local designers while easing their fears about keeping the art form intact and maintaining their creative edge.*

Keywords: *Carnival, costume design, design process improvement, Trinidad and Tobago*

1. Introduction

In Trinidad and Tobago (T&T), there are three key Carnival art forms, of which masquerade is the oldest. It can be traced to the French planter class who came to the island accompanied by their slaves following the Cedula de Population edict of 1783 (Van Koningsbruggen, 1997). Carnival has always been about social expression and the voice of society which is displayed on the streets. Since its birth, it has evolved into bands led by a King and Queen. These King and Queen carnival costumes are used to portray a specific theme. Unlike parade floats, Kings of Carnival costumes consist of large decorative pieces mounted on a three-wheeled frame that is moved around by a single masquerader who enacts a stage performance with the costume. Despite the creativity on display, the masqueraders carrying these large costumes have been known to fall or have general difficulty in moving with them on. In addition, parts of costumes have fallen off or become damaged while performing on stage. Given these issues, the aim of this research paper is to determine the design process and key design issues faced by Kings of Carnival costume designers in Trinidad and Tobago.

There is limited published information on how Kings of Carnival costume designers execute the design process and how methods and tools from engineering design could improve the quality of designs. Therefore, there is a need for research and documentation of the extant design processes employed and key design issues faced by Kings of Carnival costume designers in Trinidad and Tobago. Specifically, this paper aims (1) to identify the design process used and factors that influence the Kings of Carnival costume design, (2) to examine the existing role of engineering in Kings of Carnival costume design and (3) to recommend strategies for improvements in the design process to improve the quality and creativity of Kings of Carnival costume design.

2. Background to the Carnival in T&T

Carnival in Trinidad and Tobago originated in the year 1785 after the Cedula of Population for Trinidad in

which was a decree proclaimed by King Carlos of Spain in 1783 (Anthony, 2011). This celebration has always been a day of freedom for the population of Trinidad and Tobago, and the Kings and Queens competition reflects this freedom of expression by showcasing thematic portrayals. The King of the Band costume is an exhibition of the Mas Band's skills, craftsmanship, and ingenuity in design. The display of the costume is accompanied by narratives, dance sequences, flashing lights, and fireworks compiled to create an artistic piece to tell a visual story. These costumes often require extensions, wheels, and expert production to assist the masquerader who carries it on stage. An example of a winning Kings of Carnival costume is shown in Figure 1.

Figure 1. Winning Kings of Carnival Costume 2017: Ted Eustace portraying "Crypto - Lord of The Galaxy"

The costume should exude the essence and energy of the idea it is trying to project (Geus, 2006). The role of the costume is identified as essentially performing the following functions: (1) visually defining and enhancing the charter, (2) supporting the overall theme, (3) supporting the dramatic actions, (4) expressing its spirit and (5) providing interest. In the Kings of Carnival competition, the name sets the theme and visual outlook of the character, and it is up to the designer to use the structural and dynamic features of the costume to convey an idea to the judges and audience. The stage performance is carried out by an individual masquerader in a costume that can weigh more than 200 lbs supported with a maximum of 3 wheels for mobility.

The judges' expectations for the Kings of Carnival costumes are exceptional craftsmanship, some level of creative authenticity, a visual impact with the various uses of colours, the portability of the costume and the presentation. Based on these judging criteria, Engineering has played an insignificant role in the design of Kings of Carnival costumes. The costume designer must be able to translate the visual concept of the creative crew into the costume design for the stage. The designer must understand the physical space in which the piece will be performed, the people for whom they design and the characters they will play.

Legendary designer Wayne Berkeley outlined the secret of his success with the Kings and Queens costumes which involves taking into account the ability and the temperament of the person who will wear it (Berkeley and Nanton, 1999). When asked about his ability to portray a design he replied, *"Very often I choose my individual masqueraders. If they are new to me but have played Kings and Queen many times previously, I try to get to know them - to understand the way they feel about the costume and what their capabilities are, in terms of showing the costume to full advantage"* (Berkeley and Nanton, 1999).

Costume designers must also be able to (Geus, 2006; Noel, 2016):

1) Supply the design as required, with colour and detailed information.
2) Design a costume that will fit the budget and meet the needs of the presentation.
3) Supply all information on the assemble and disassembly of the costume, and any extra information required such as details on trims and accessories, and
4) Advise on post-production duties regarding maintenance and alterations.

The design process usually begins with the main idea to be portrayed originated by the band leader or a selective sectional leader. Sketches are then created and artistically drawn. After the final imagery is chosen, the craft team moulds and constructs the design through trial and error. The final costume is then tested by the performer and the designer. The designer would not want the performer to be uncomfortable and damage the costume (Berkeley and Nanton, 1999).

Historically, Geraldo Vieira was responsible for some of the more technically involved costumes in the Kings of Carnival competition. He utilised wire bending techniques in designing birds, fish and human-like structures. He also introduced the use of plastic mouldings in costume design to make lighter, stronger costumes. In addition, Vieira introduced special effects such as fireworks, pyrotechnics, and robotic structures to create novel Kings of Carnival costume designs (NIHERST, 2009). Though hailed as a legendary technical and innovative designer, few designers to date have demonstrated the willingness to step outside the traditional boundaries of traditional craft methods.

Though the aforementioned examples of legendary, designers demonstrate innovative design approaches, the state of current Kings of Carnival costume design practice across the sector is not clear. Studies into current Kings of Carnival costume design are practically non-existent, especially studies investigating the role of engineering in the design process. An exception to this is the work of Noel (2013) where the author investigated the practice of wire bending in carnival costume design

with an eye toward implementing computational design approaches based on shape grammars. She also investigated the use of a shape grammar computational approach to encourage a new generation of costume designers. Noel (2016) found that there is a large gap in knowledge of how costume designers design and what support tools are needed to aid in the design process. Designers work with "prototypists" who select materials and construction techniques to bring the design idea to life. Mostly manual tools and process are employed in construction. There is a clear need for further investigation into how Kings of Carnival costumes are designed with an eye to supporting the process with engineering tools and techniques.

3. Methodology

In order to determine the current design process and key design issues faced by Kings of Carnival costume designers in Trinidad and Tobago, a qualitative methodology was employed (Yin, 2003, Robson, 2016). Semi-structured interviews were used as the primary source of data collection as this method provides for deep exploration of the research questions while leaving room for further probing. A list of the Kings of Carnival participants from 2014, 2015, and 2016 (three years) was obtained from the National Carnival Commission and National Carnival Bands Association. From this list, a sample of six Kings of Carnival costume masqueraders were selected for each year – the first two places, middle two places, and last two places in the competition. This resulted in 18 potential interviewees. From the sample of 18 potential interviewees, 13 were willing to take part in the study. To increase the sample size, the research team opted to approach interviewees from other designers in the list (including Queens of Carnival). Thus, two additional interviewees were recruited resulting in a total of 15 participants for the study.

The questionnaire used for this paper was divided into five categories (participant data, design, materials, performer, and external factors) as shown in Appendix 1. Although the questionnaire was focused on specific topics, participants were also free to discuss issues of interest to them. All participants were contacted via telephone to explain the aims of the study, issues to be covered and to schedule the interview. Once the participant agreed to meet, a mutually suitable date and time were set. Interviewers engaged study participants as much as possible to explore and understand their design experiences and views. Eight (8) participants opted to keep personal data private, and the interview team acceded by omitting personal data.

The responses from the participants were recorded and documented and then given to the participants to verify. This approach allowed for the verification of the data being collected. A content analysis methodology was used to organise and simplify the data from the interviews into meaningful and manageable categories for analysis to be performed (Yin, 2003, Robson, 2016). Data was stored in an Excel worksheet in the form of tables, and the documented interviews were categorised, quantified where appropriate and ordered for analysis.

4. Results

4.1 Participant Data

The majority of participants were unwilling to give their personal data or allow such data to be published, and therefore this information will not be divulged.

4.2 Design

All the interviewees stated that their design philosophy is heavily influenced by an ideology or story that they want to portray. Diverse subject areas such as politics and other current affairs play an integral part in influencing the design philosophy. One designer even went as far to say that "*Mas is their own Calypso Review tent"* implying that it is their forum for expression similar to Calypso song composition and performance.

When asked about their design process in creating their final product, the participants described a generic process with three phases: (1) The conceptualisation phase, (2) the sketching phase, and (3) the construction phase. This is a year-round process and is often launched as soon as the previous carnival season ends. Participants also ranked what was most important to them based on the judging criteria of the competition (this is shown in Table 1 and Figure 2). Participants ranked creativity and authenticity as being the most important factors.

With respect to Engineering involved in the design process, there was generally a wall of defence built by the interviewees. All participants reported that they had never once before sought engineering consultation when producing a costume design. Four (4) out of the fifteen (15) interviewees (27%) expressed their fear that bringing engineering into the long-found tradition of the competition would dull the entire culture of it as engineers would not be able to "*feel the mas*".

Table 1. Participant ranking of judging criteria

	Creativity	Authenticity	Visual Impact	Presentation	Craftsmanship	Portability
First	7	3	-	4	1	-
Second	8	4	1	2	-	-
Third	-	1	4	7	2	1
Fourth	-	-	2	8	1	4
Fifth	-	-	1	2	3	9
Sixth	-	-	-	-	5	10

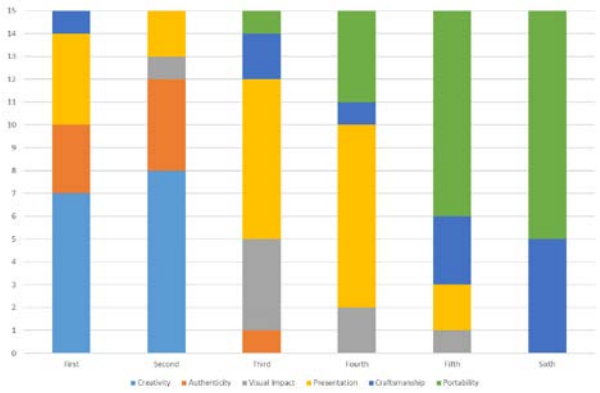

Figure 2. Participant ranking of judging criteria

Participants believed that there is a tension between engineering and the creative arts. There was a continual reference by participants to the costume design process as an art and they seemed resistive to the notion that engineering analysis and application could provide any benefit to their craft. Participants also felt that engineering would rob the costume design process of the "soul" that designers put into it.

As interviews progressed, this antagonistic attitude to engineering was mitigated by informing participants that the aim of the study is not for engineers to take over their craft, but instead the aim is to find out how best engineers could help them optimise their current process and help them be more innovative. However, when asked to discuss the role of Engineering in the future of the costume design process, participants were generally doubtful that the discipline had anything significant to contribute.

4.3 Materials

Participants indicated that rarely would a costume designer outsource materials for a costume. This is due to the cost of making the costume being a limiting factor - most of the designers bore costume costs out of their own pockets. Therefore, materials are locally sourced predominantly at hardware stores, and should a desired material not be found, another substitute material would be used. The materials generally used are hollow section steel (rectangular, circular or square section), mild steel tubing, PVC, cane, wire, stainless steel sheets, fabric, glue, tape, fiberglass.

With respect to the selection of these materials, little consideration is given to understanding the material's properties. Eight (8) of the fifteen (15) interviewees (53%) mentioned their basis for choosing materials to be one of 'trial and error'. This method is widely used amongst the designers as they only rely on their experience and hands on experiments to select construction materials. There was no weight limit set by designers as the weight of the finished costume would be decided based on how much weight the performer would be able to handle. The average height of a costume is 12-18 ft while the average width is 8-15 ft.

Costume durability continues to be a main challenge for designers. There have been many instances in the past where pieces of the costumes are broken off during the preliminaries or semi-finals. One interviewee said that *"… make the costume and pray to God that it can make it through till the end in one piece."*

4.4 Performer

Participants described the complaints that performers make when wearing and portraying the costumes. The frequency of these complaints is shown in Figure 3. The difficulty in dealing with the wind and moving around with the costume were the most frequent complaints mentioned by eight participants. Seven participants also mentioned the weight of the costume as being an issue. Two participants mentioned the heated conditions while wearing the costume and one participant mentioned skin irritation. The wind, movement and weight factors all point to a larger issue with physical discomfort, because if the performer cannot comfortably move with the costume, then failure at the competition would be likely.

Interestingly, the choice of performer is commonly made after the costume is complete and the process reaches the testing and competing phases. Therefore, it precludes the customised design of a costume to suit a particular performer. This clearly leads to design requirements for a lighter, more comfortable and more manoeuvrable costume that would be minimally impacted by wind loading. Therefore, the structural design of the costume and the dynamics of its movement need to be improved. No engineering analysis is currently conducted on the costume as a means of validation, and this area is ripe for collaboration with engineers to model, simulate, analyse and optimise the structural and dynamic behaviour of the costume.

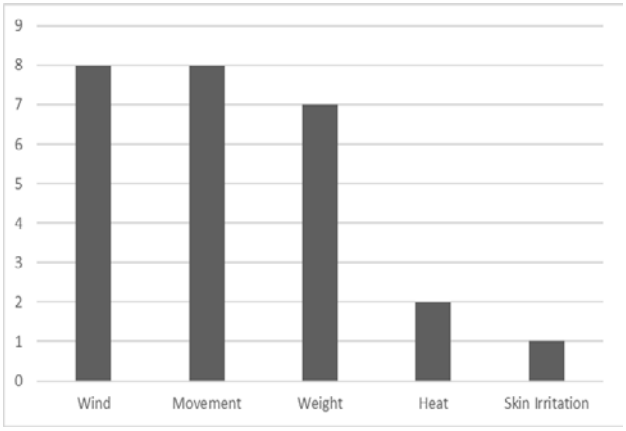

Figure 3. Frequency of Performer Complaints

4.5 External Factors

Participants indicated the range of external factors that impacts the costume design (shown in Figure 4). The size of the stage is used to determine the size of the costume and the ramp of the stage plays an integral role. The length of the ramp determines if one or more costumes can be on standby while one costume is being used on the stage. While on the stage, unpredictable external environmental factors including wind, rain, light, noise and humidity affect the costume design and performer. These factors could lead to failure of the costume and sub-optimal performances.

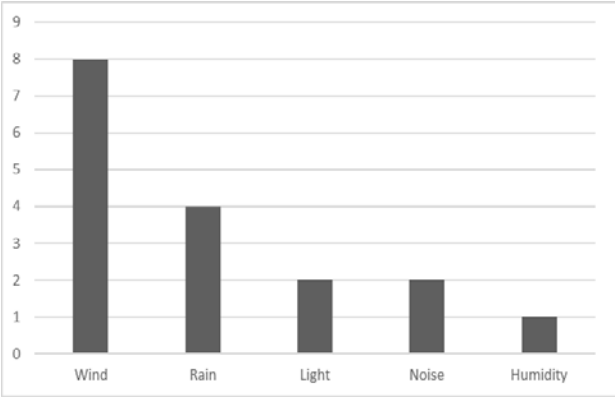

Figure 4. Frequency of mention of external factors

Wind is the most challenging aspect for the masquerading of the costume mentioned by eight participants. It poses a threat to not only the costume but to the person that is parading it. A moderate wind can cause a costume to be knocked down which could result in injury to the performer. An example of this occurred when a performer was toppled over in the 2010 competition and tore ligaments in his knee due to the strain of the 300lb costume. Secondly, rain can cause a slippery surface on the stage causing slips, trips, and falls mentioned by four participants. But it doesn't only have to be a downpour of rain to cause difficulty - dew, spilled liquid, the tracking of moisture onto the stage and sweat droplets can cause a major slip accident. In addition, rain can ruin a costume if it gets wet. A costume that is made of materials such as feathers or kite paper would be destroyed should rain fall during a performance.

Ambient light and noise also affects the performer and performance (mentioned by two participants). The costume is designed to reflect light which forms part of the presentation while the costume is moving on stage. Materials are utilised that are reflective and generate patters of reflection as the costume moves. Noise can contribute to the disruption of the performance by distracting the performer or masking the response of the audience and instructions to the performer. Though humidity was mentioned by one participant as a factor, performers understand and train for this condition. One designer went on to say "*The performer has to know what they getting into, literally, because I need them to execute it exactly as I envisioned or else it is a failure.*"

5. Discussion

Based on the results presented in the previous section, it is evident that designers employ a rudimentary costume design process with significant trial and error. Compared to design process models (Otto and Wood, 2000, Clarkson and Ekert, 2005, Eppinger and Ulrich, 2007), there is room for more conceptual design exploration in the areas of materials selection and structural design. In addition, design analysis and optimisation can contribute to improved costume reliability to mitigate the effects of wind and rain. Designers used a set of steps that they referred to as their own "creative process". However, when asked if they conducted own analysis of their process, most replied in the negative. This showed a lack of awareness in their respective process and how it could be improved.

The design of Kings of Carnival costumes has not changed much over the years due to a combination of cost constraints (the belief that new methods and materials are expensive) and the desire to preserve the traditional nature of the art form. Designers also see a long and involved design process as part of being creative. Participants felt that if it was too "easy" they would lose some of the "essence" of the experience. This issue of cost seemed dominant in the design community and was the major factor behind most design decisions. On the contrary, designers did not see how design process improvement and engineering approaches could help reduce costs.

Designers demonstrated resistance to change and a need to preserve the traditional way of operation. This contradicts the sentiment that many carnival stakeholders have regarding the need for carnival to change and adapt to survive. However, a few designers have seen the need for evolution and are more open to the addition of steps that will help them remain relevant and modernise the art-form of costume design. To remain relevant, designers need to improve and adapt to tools and techniques that can improve their designs while keeping costs low.

Engineering approaches are ideally suited to this task. However, the challenge remains in how to convince designers to use Engineering tools or work with engineers when designing costumes. If the current costume design process is to be improved, designers must first be convinced to partner with engineers and experience the benefit of engineering input. In addition, accessible tools and educational materials need to be produced for designers so that they could be educated in design process improvement. The following section lists some recommendations to achieve these goals.

6. Recommendations

Five (5) recommendations are provided which can be useful in improving the design process for Kings of Carnival costumes.

6.1 Produce Educational Materials for Design Process Improvement

Given that the current costume design process lacks structure and is sub-optimal, there is a need to educate practicing designers on the principles of good design and methods for the different phases of the design process. The main argument should be that an improved design process would lead to cost effectiveness and more innovative costume designs. To combat the resistance to change, engineers should reach out and work with leading costume designers to partner with them in the development of training materials. This would improve the probability of adoption in practice.

6.2 Design and Engineering Workshops for Costume Designers

There are currently no workshops focused on introducing simple engineering methods to costume designers. Recommendation 1 would feed into this recommendation where targeted short workshops should be carried out by engineers for costume designers. The workshops could target areas such as design process improvement, low-fidelity prototyping, materials selection, structural design, design for reliability, design optimisation, and cost reduction. Workshops can provide a forum for designers and engineers to work together and allow them to build relationships.

6.3 Develop Modular Structural Costume Design Platforms

Current costumes are mostly built up from scratch every year making assembly, disassembly and transportation unpredictable and difficult. Most current designs already utilise a core upon which additional pieces are attached. This concept could be extended to form a general design approach for modularity. The introduction of a modular design structure would allow for quick assembly and disassembly of costumes and save on costs in the long term.

6.4 Investigate New Materials and Construction Methods

New materials and construction methods need to be presented to designers with ideas on how they can be utilised to serve the creative process. This may be controversial as the materials used are considered part of the art-form itself e.g. wire bending. However, the aim should not be to replace all traditional materials, but demonstrate new ways of working with these materials in addition to selecting new materials, and also how to utilise processes such as three dimensional (3D) Printing and prototyping.

6.5 Analyse Costume Designs for Functional Performance

This recommendation seeks to address the issue of environmental factors particularly wind and rain which have been highlighted as factors which cause the most problems. Many costumes are designed with large plumes and moving parts, resulting in a large surface area for wind forces to act. Through design simulation (fluid dynamics) or the testing of small prototypes, the effects of wind loads could be reduced. Methods from the discipline of Architecture, especially computational design, could easily be applied to costume design and analysis. Designers would need engineering support in developing CAD models of the costume structure and in running simulations.

There is also scope for the development of simple and usable CAD and Engineering analysis software for the carnival costume design sector. For rain effects, non-slip materials could be used for coating both costumes and also stage surfacing materials. There are many water-proofing products that could be used directly on fabrics without tarnishing the material. The use of such products can resolve issues such as the increase and change in weight distribution of the costume due to the water logging of fabrics.

7. Conclusions

The design and creation of carnival costumes represents a significant part of the culture of Trinidad and Tobago. This study showed that the acceptance of engineering support and new ways of making in this traditional practice has been met with resistance. In addition, there are areas in the costume design process where engineering approaches could reduce costs and improve costume quality. To rectify this issue, five (5) linked recommendations were provided for educating designers and bringing engineers and costume designers together. Further work will involve the implementation of these recommendations and the development and evaluation of new costume design methods and tools with costume designers.

Appendix 1. Costume Designer Interview Questions

A. Participant Data

1. Name:
2. Age:
3. Educational Background:
4. Work experience:
5. How many years have you been designing Carnival costumes:
6. Current position/role:

B. Design

1. Describe your design philosophy i.e. how do you approach the costume design problem?

2. Describe the design process when creating a costume i.e. list all the steps you take from start to finish in producing a costume (be as detailed as possible).
3. Out of the weighted judging criteria, rank the criteria from most important to least important when designing.
4. Have you ever consulted with engineers when producing a costume design? (Depending on the answer, ask why?)
5. Do you see a role for engineering design support the costume design process? (If NO, ask why? If YES, ask in what ways engineers can support).

C. Materials

1. What are the types of materials used in costume design? Which are locally sourced and which are sourced from outside the country?
2. What considerations do you take into account with regard to material properties and selection when designing?
3. How does cost factor in to your design considerations?
4. What is your costume design weight limit?
5. What is the range of costume heights that you design within?

D. Performer

1. What are the most common performer complaints/feedback that you receive?
2. Where does physical comfort of the costume rank when designing?
3. What is the most difficult performer design requirement to accommodate in the design?
4. Do you design a costume with a performer in mind or choose a performer to fit the costume? Why?

E. External Factors

1. How does the performance environment affect the costume design?
2. Do you take external factors e.g. wind, ambient light, noise, humidity etc. into account when designing?
3. Which external factor plays the biggest role/has the largest effect on the costume design performance?
4. How do the costume designs fail? How often do these failures occur? (Get a ranked list)

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