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Quidditch Equipment Design

TESIS

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SUMMARY

In order to optimize the conditions of quidditch development as a sport, the following quantitative investigation with experimental design is made to improve the scoring equipment quality which actual teams have promoting the standardization and better use of human and material resources with which teams count. Given the recent creation of the sport based on the Harry Potter books' game, there's no standardization or regulation in the game components as the sport's equipment. This thesis focuses on the creation of a set of quidditch hoops since it's here where the highest incidence in failures and accidents can be observed due to instability, breaking off or dislodging and crashes against players. At the end of the redesign application of a hoop set that "Don't fall. Don't break. Don't Move" will result in a ascertainable improvement in the use and access of materials and spare parts and the facilitation of storage, transportation and installation in field for the development of the sport.

(Key words: Quidditch. Sports. Equipment. Design. Prototype. Inflatable.)

RESUMEN

Con el objeto de optimizar las condiciones del desarrollo del quidditch como deporte se realiza la presente investigación de tipo cuantitativa con diseño experimental para mejorar la calidad del equipamiento deportivo de anotación con el que cuentan los equipos actuales promoviendo la estandarización y un mayor aprovechamiento de los recursos humanos y materiales con los que se cuenta actualmente. Dada la reciente creación del deporte basado en el juego de los libros de Harry Potter no existe una estandarización o regulación en los componentes del juego como lo es el equipamiento deportivo. Esta tesis se enfoca en la creación de un set de aros de quidditch ya que es aquí donde se observa la mayor incidencia en fallas y accidentes debido a inestabilidad, ruptura o desconfiguración e impacto contra los jugadores. Al término de la aplicación del rediseño de un set de aros que “No se caiga. No se rompa. No se mueva” se tendrá como consecuencia una notable mejora comprobada en el mejor aprovechamiento de los materiales y refacciones, su acceso a los mismos y la facilitación del almacenamiento, transportación e instalación en campo para el desarrollo del deporte.

(Palabras clave: Quidditch. Deportes. Equipamiento. Diseño. Prototipo. Inflable.)

DEDICATIONS

For my parents Iliana and Román, who have been the only ones present all the way long <3

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ILLUSTRATION INDEX

1. INTRODUCTION

Quidditch as a sport is a recently created discipline with few more than 10 years of existence. It has only been played in México for approximately five years and barely a couple more since the birth of the intention to develop a project like the present one whose impact could benefit the largest amount of players worldwide as seen with previous experience and the interaction with players from all around the world during the previous World Cup 2016 and the interconnection with European and Latin-American Associations showed the imminent need of quidditch research which would serve to set the precedent for scientific research that endorses the Quidditch community as a formal institution to ensure its further growth and development

The development of the present investigation will have as a consequence an improvement on quidditch gameplay scenarios as hoop assembly, disassembly, transportation, and risk factors' reduction with a full size model tested on field. This will work as the evidence needed of scientific investigation regarding quidditch and mostly as background for a future mass production and distribution of the design to teams all around the world to improve their further growth and development.

This thesis is divided into seven sections through which the project is developed as following:

First section consists on a small summary of the whole project and the need the sport has for scientific research.

Second section explains the theoretical background in which quidditch is based on. This chapter works as an introduction to the sport and how it was developed from its roots to what it is nowadays as long with the improvement areas it still has unresolved.

Third section is the project justification on the area to be developed: quidditch scoring hoops based on the interaction and communication with teams from all around the world who contributed with their testimonies and experiences.

Fourth section resumes the problem to be solved with the re-design of quidditch scoring hoops based on the sport deficiencies, lack of resources and a consensus about structural, functional, and aesthetic needs for the performance of hoops during a match.

Fifth section details the project hypothesis and objectives in order to solve actual quidditch problematics regarding scoring hoops sets.

Sixth section develops the methodology used on the project starting with a compilation of the players interviewed as well as their gameplay style geographically arranged, actual hoops' structures, a detailed player-hoop interaction analysis and the creative process in order to accomplish the objectives described on the previous chapter to end up with the scale and full size prototypes.

Seventh section presents the results of the scoring hoops set re-design on field with storyboards and an advantages/disadvantages analysis with players' feedback after using the hoops.

2. THEORETICAL BACKGROUND

2.1 Quidditch Theoretical Fundaments

Quidditch is a mixed contact sport inspired on the wizarding world created by J. K. Rowling in the Harry Potter books. Created by Xander Manshel and Alex Benepe in fall 2005 at the Middlebury University, Vermont as an alternative to their curricular activities, soon its improvised hobby sat the foundations for the sport played nowadays, with this, they continued playing regularly at their own college and finally in 2007 they played their first intercollegiate with the team from Vassar University, NY.

2-1. Alex Benepe during the US World Cup, New York 2011

In 2008 the first “World Championship” was played with the presence of the first team from outside the US belonging to McGill University from Quebec, Canada. As more schools created their own teams, the sport started gaining importance until 2011 when World Cup V was played at New York City where 98 teams from the US, Canada and Finland competed. That same year the recently

formed *Quidditch Australia* Association organized their first big tournament outside the American Country, the QUAFL Cup in New South Wales (About: IQA, 2014).

The first IQA's national team tournament called "IQA Summer Games" (Alley, 2017) was played on 2012 where the national teams from USA, France, Australia, Canada and UK competed in the framework of the Olympic Games. Thanks to this quidditch gained a huge international impact that kept growing until 2014 with the Second Global Games played in Canada where México had its first international participation.

Finally last year the World Cup 2016 was held at Frankfurt, Germany with 21 competing nations from 4 continents where Mexico ended up as one of the top 8 country teams.

2.1.1 Field

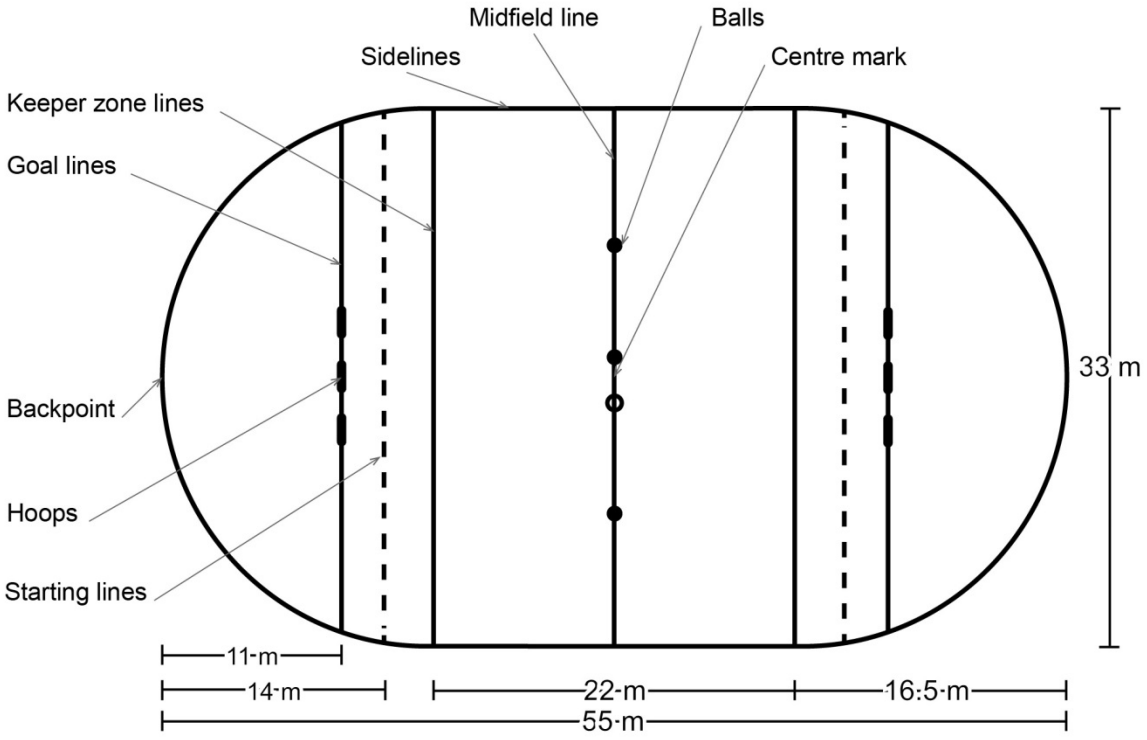
The field is composed of three sections: one rectangle and two semicircles at both endings of this making a pill or oval shape. These zones are delimited by three types of lines:

- Sidelines and keeper zone lines: Those are the boundaries of the main rectangle, being the longest side the keeper zone lines and the shortest the sidelines.
- Backlines and backpoints: The back point is the farthest point of the keeper zone, from this point there are two curved lines that end up at the union with the keeper zone line which are the semicircles that mark off the pitch.
- Midfield line and centre mark: The main rectangle of the pitch is divided into two equal halves by a midline in the centre of which is the centre mark.
- Goal lines: Lines in which the hoops are positioned.
- Starting lines: Lines where players are placed to start the match.

The pitch dimensions are the next ones:

- Size of the sidelines: 22 meters
- Size of the keeper zone lines: 33 meters

- Diameter of the backlines (semicircles): 33 meters
- Radius of the semicircle: 16.5 meters
- Length from the backpoint to the goal lines: 11 meters
- Length from the backpoint to the starting lines: 14 meters
- Length of the field from one backpoint to the other: 55 meters
- Length of the field from one goal line to the other: 33 meters



2-2. Quidditch field

Other of the most relevant zones is the keeper zone, space containing the hoops of the keeper in which they have immunity to the bludgers and adversaries attacks. This zone extends from the backpoint of the field up to 16.5 meters in front, across from the hoops staying 11 meters apart from the midfield line (US Quidditch, 2016).

2.1.2 Hoops

The hoops are the upright and self-supporting structures through which the quaffle must pass to score a goal. Each hoop is composed by a circular loop

attached to a post and it may or not contain base to keep it upright. Hoops must be freestanding and able to resist the game interactions and any referee may reject the hoops if they consider them dangerous for players' integrity.

Each set of hoops must have posts of three different heights located at an specific position at the field.

- The centre hoop (the tallest one) must have a 183 m post (plus the size of the hoop) located at the midpoint of both sidelines of the field on the goal line.
- Seeing the hoops from the midfield line, the smallest hoop of 91 cm must be at the left, 2.34 m away from the middle hoop.
- Seeing the hoops from the midfield line, the medium hoop of 1.37 m must be at the right, 2.34 m away from the middle hoop.
- The circular loops of the hoops must have a diameter between 81 and 86 cm (US Quidditch, 2016).

2-3. USQ Hoops. Nicole Hammer

2.1.3 Balls

One of the biggest complications about quidditch is the “three types of balls on field” at the same time during one match, so each player has to pay twice as much attention to each move, either to score or defend the quaffle, beat or protect with the bludgers and earn extra points and end the match with the snitch.

2-4. Balls' arrangement before a match. Ajantha Abey Quidditch Photography

2.1.3.1 Quaffle

The quaffle is the game’s main ball used by chasers to score on the opponents hoops. It’s a spherical ball made of flexible smooth leather covered with 12 or more panels with a separate bladder, usually volleyballs are used for this purpose, slightly deflated to ease its use with one hand.

2.1.3.2 Bludger

The bludgers are three spherical balls made of flexible rubber such as dodgeballs which stay at the field during the whole match. Beaters use these balls to “beat” the opponent players.

2.1.3.3 Snitch

The snitch is a ball made of a uniform surface of cloth such as tennis balls located inside of a sack or sock attached with *velcro* to the short of a referee called the *snitch runner.* Both the short and the uniform of *snitch runners* is colour yellow to distinguish him from all other players and referees. An additional advantage the *snitch runners* have from the rest is that they're the only one who don't have a broom, so it's a one hand game for everyone but them (US Quidditch, 2016).

2.1.4 Brooms

This is the most essential equipment item of the game. All players must hold the broom between their legs at all times and it must be hold with one hand or grip it with the thighs.

"How can people play with one hand? And learning how to that is the beauty of quidditch" (Benepe, 2008)

2-5. Brooms from World Cup VI. Geekynews

The broom must consist of a rigid pole, usually made of wood or plastic between 81 and 106 cm in length. Additionally it can have “bristles” made of plastic, wood, corn or other material attached to the back end of the broom, with the total length of which must not exceed 122 cm.

Brooms mustn’t have splinters or sharp points. They must not be attached to the player’s body, clothing or equipment. Any player who doesn’t follow these rules may be awarded a higher penalty during a match.

2.1.5 Team

Each team has a bracket of 21 players, from which only 7 are at the field during a match. Each team has unlimited changes due to the extenuating nature of the game. There’s no restriction on how many players of each position a team should have, however there’s the “gender maximum rule” which says:

“A quidditch game allows each team to have a maximum of four players who identify as the same gender in active play on the field at the same time. […] The gender that a player identifies with is considered to be that player’s gender, which may or may not correspond with that person’s sex.”

2-6. Team México during IQA World Cup 2016. Quidditch México

This rule is one of the core principles of inclusion in quidditch, as it opens up not only to the feminine and masculine gender, but also those who do not identify themselves with a binary gender system (US Quidditch, 2016).

2.1.6 Positions

Just like in the game created by J. K. Rowling in Harry Potter books, there are four player positions in quidditch:

2.1.6.1 Chasers

The chasers are three players who wear a white headband to identify themselves from other players. Their objective is to pass the quaffle from one to another up to the opponent's keeper area (or hoops) to score a goal.

2.1.6.2 Keepers

The keeper from each team, who uses a green headband, is the player defending the hoops as a scorekeeper. When they have possession of the quaffle inside their keeper's zone, the opponents' attack ends and they start the new offensive sequence for its team.

When keepers are inside their own keeper zone they are "protected keepers" which means they have immunity to the opponents' attacks such as physical contact from other chasers and knockout effect from the beaters' bludgers. If the keeper leaves its keeper zone to regain the offensive, they lose immunity and may continue playing as a fourth chaser.

2.1.6.3 Beaters

Beaters are a team's defence. They are two players from each team who wear a black headband as distinctive sign. Their job is to "beat" opponent players from their brooms using their bludgers. If a player gets "beaten" with a bludgers that player is "knocked out" and has to follow the knockout procedure which consist on the next steps:

- Give up possession of any ball the player has at the moment.
- Dismount from the broom.

- Run back to their own hoops.
- Touch the hoops with one part of their body, not with the broom at the hoop loop or the pole, not the hoop base.
- Remount the broom immediately.
- Go back to the game.

2.1.6.4 Seekers

The seekers wear a yellow headband whose job is to catch the snitch to end a match.

Both seekers stay out of the game for the first 17 minutes of the game, at that moment the get called by the referee to take their positions for entering to the field meanwhile the snitch goes in to warm up and recognize the field. At the minute 18 they are released and start chasing the snitch in order to obtain 30 extra points for their team, as well as for ending up the game.

2-7. Hoop defense by keeper and chasers, México vs Turkey match during IQA World Cup 2016. Ajantha Abey Quidditch Photography

2.1.7 Game Objective

The objective of the game is to obtain as much points as possible until the end of the game. A quidditch match may last from 18 minutes with 5 seconds up to more than 90 minutes as in the Victorian Cup Finals from Australia 2015 (Gertler, 2017).

2.1.7.1 Game time

Game time is measured in real time from the “Brooms up!” call at the beginning of the game. The first 18 minutes of a match are called of “seeker floor” in which the snitch may not be caught. At the minute 18 the assistant referee calls both seekers to the game field to capture the *snitch runner*.

2-8. Team México before 'Brooms Up' During IQA World Cup 2016. Ajantha Abey Quidditch Photography

Game can’t be stopped except for severe injuries, equipment dysfunction, player fouls or external interventions. There are no timeouts or half times or time

limits except for extraordinary cases previously discussed by the referees and both playing teams as the case of the match between South Korea and Brazil during the exhibition matches at the World Cup 2016 in Frankfurt, Germany.

The match may only finish with the catch of the snitch, which depending on the ability of the seekers and the skills of the *snitch runner* may take from a few seconds to more than an hour.

2.1.7.2 Scoring

There are two ways of scoring points for a quidditch match, one of them is when a chaser grabs the quaffle and passes it through one of the adversary's hoops, indistinctly from which side it passes through, that is from the front or from behind. Each time the quaffle passes through a hoop it gives 10 points to the scoring team.

The other way of scoring is by grabbing the snitch from the *snitch runner*. With the snitch capture the seeker ends the game and gains 30 extra points for their team.

2-9. Snitch Capture during USQ Tournament. Kevin Freeman Photography

2.1.8 International Outlook

2.1.8.1 International Quidditch Association

The International Quidditch Association (IQA) is the entity in charge of directing and regulating the development of the sport worldwide. Created 10 years ago in collaboration with Alex Benepe, founder of the sport, it only served initially as a regulator of the sport in the United States. It was not until 2014 that the imminent need for the creation of an organization dedicated exclusively to the international approach was present, that the USQ (United States Quidditch) was born as an organization dedicated exclusively to the North American country.

The IQA is now in charge of administrating the international development of the sport, so as the management of national teams in their correspondent tournaments from around the world. This is how it serves more than 40 countries divided in National Governing Bodies, Developing Leagues and Emerging Areas in different national, regional and world tournaments around the globe.

2.1.8.2 National Governing Bodies

Official Members of the IQA are called National Governing Bodies (NGBs), which means they have enough representation of a region's country quidditch activity through the year in regular leagues and international participation. The job of the national organization is to organize quidditch within the country, create membership policies for teams, organize referees, snitches, and coaches and be the bridge between that nation's teams and the IQA. Current full member NGBs are: (IQA, 2016)

- Argentina: Asociación Argentina de Quidditch
- Australia: Australian Quidditch Association
- Belgium: Belgian Quidditch Federation
- Canada: Quidditch Canada
- Catalonia: Asociación de Quidditch a Catalunya
- France: Fédération du Quidditch Français
- Germany: Deutscher Quidditchbund

- Italy: Associazione Italiana Quidditch
- Mexico: Quidditch Mexico
- The Netherlands: Muggle Quidditch Nederland
- Norway: Norges Rumpledunkforbund
- Poland: Polska Liga Quidditcha
- Spain: Asociación Quidditch España
- Turkey: Quidditch Derneği
- United Kingdom: Quidditch UK
- United States: US Quidditch

2.1.8.3 Developing Leagues

Countries with more than two teams competing on a regular league, with independent voice in the IQA Congress but no vote are considered Developing Leagues. Countries in this category are: (IQA, 2016)

- Austria: Quidditch Austria
- Brazil: Associação Brasileira de Quadribol
- Czech Republic: Česká Asociace Famfrpálu
- Ireland: Quidditch Ireland
- Peru: Federación Deportiva Peruana de Quidditch
- Slovakia: Slovak Quidditch Association
- Sweden: Svenska Quidditchförbundet
- Uganda: Quidditch Uganda

2-10. Full Member and Developing National Governing Bodies logos. IQA

2.1.8.4 Emerging Areas

Emerging areas have at least one existing team but no evidence of a governing body or regular competence activity. Countries in this category are: (IQA, 2016)

- Chile
- China
- Colombia
- Ecuador
- Finland
- Hong Kong
- Hungary
- Iceland
- Indonesia
- Luxembourg
- Malaysia
- New Zealand
- Philippines
- Slovenia
- South Korea
- Switzerland
- Vietnam

2.1.9 Influence from other sports

Quidditch may be considered as a combination of the following sports from which it has taken techniques and regulations being the main ones:

- Rugby: Physical contact and interaction among players.
- Dodgeball: Bludger game and beating process.
- Handball: Quaffle game for passes and scoring.
- Flag football: Snitch game and struggle during the catch.

Besides, quidditch uses equipment from other disciplines such as:

- Volleyball: The quaffle or main ball is a volleyball ball slightly deflated.
- Dodgeball: The bludgers are dodgeball balls slightly deflated.
- Tennis: The snitch is a tennis ball wrapped inside a sack or sock hanging from behind of the *snitch runner* shorts.
- Football and/or soccer: Most of the players use cleats from other sports for a better performance on field.
- Rugby: Many teams, especially European, use uniforms with rugby cut due to its best adaptation to quidditch needs. In minor grade soccer and basketball designs are used as official attire.
- Soccer: Most of the training equipment players' use are materials used by soccer players such as floor ladders, fences and resistance equipment.

2-11. Football, soccer and quidditch equipment

2.2 Injury Rate

Based on interviews and surveys made to players from all around the world it was possible to measure trends regarding the most common injuries provoked by the practice of this sport.

- 4 out of 5 players have suffered some kind of injury during their practice of the sport.
- 1 of every 2 players has suffered minor injuries such as scrapes, friction burns and bruises.
- 1 of every 3 players have suffered average severity injuries such as elbow or ankle sprains, bleeding or bruising complications, muscle tears and dislocated limbs whose recovery time didn't exceed 3 months.
- 3 of every 10 players have suffered severe injuries whose recovery time has taken more than 3 months with limited movement. Such lesions include brain concussions and broken clavicles, hips, ankles, ribs and fingers.

2-12. Accident occurred between players from Slovakia and Australia during the World Cup 2016 at Frankfurt. Ajantha Abey Quidditch Photography

With the complexity of the sport by having many different elements at gameplay at the same time, the origin of the injuries is very varied, being the following the main causes:

- 36% of the accidents are caused by tackles or face to face impacts poorly executed or with a bad landing.
- 32% are caused by balls, either from being hit with them or a bad reception.
- 18% from accidents are caused by an inefficient hoop set, either from base instability, rupture during an impact or crash against the players.
- 14% remaining is caused by brooms either from impact against them or material and finishing deficiencies.

2.3 Field Conditioning

From an average of 350 official teams from all around the world, 56% of them are community teams, which means, teams born among people from some city with no affiliation to a college or association to back them up. The other 45% (From which 60% are focused in the USA) are from college teams whose institutions back them up as part of their academic programs.

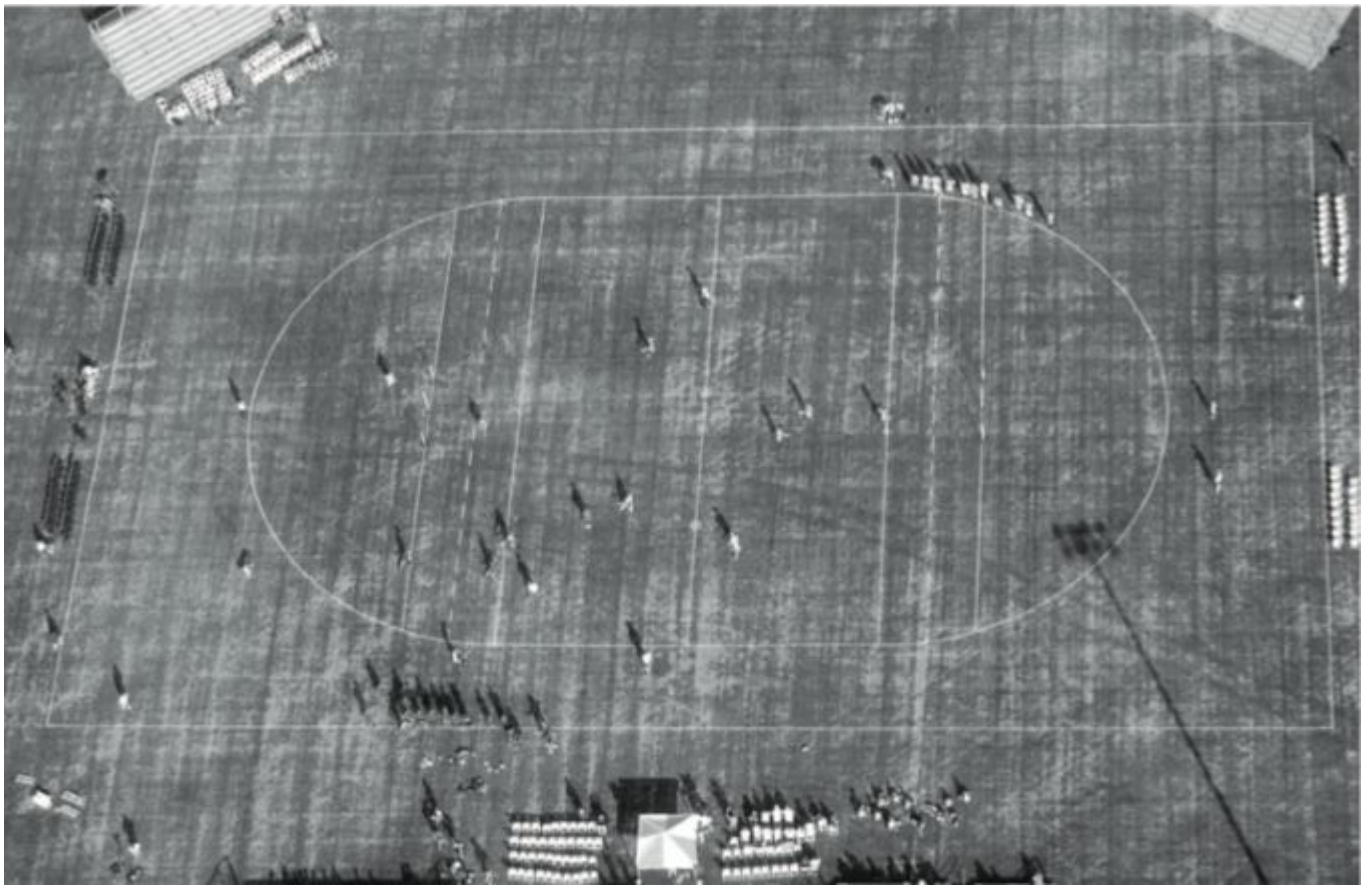
This academic back up translates in benefits the college teams have and community teams don't, among the most important are:

- Training fields for constant use, mostly weekly.
- Safe warehouses for the equipment.
- Opening for the recruitment of new members.
- Logistic and economic support for the sport's development.

While not all the teams count with all the benefits from their institutions, such as the economic support or a space exclusive for quidditch practice, this backup is notorious compared to community teams who have more difficulties to settle down.

Main difficulties community teams have are the next ones:

- Trainings in public spaces, many of them with irregular surfaces or that don't fit with the official requirements for quidditch practice.
- Limited access to the field for equipment transportation and installation.
    - Long and no accessible distances for the players.
    - Anchoring and positioning of the hoops.
    - Marking the field with the official measures.
- Difficulty for official or recruitment event planning.
- Community support in general for the sport's development.



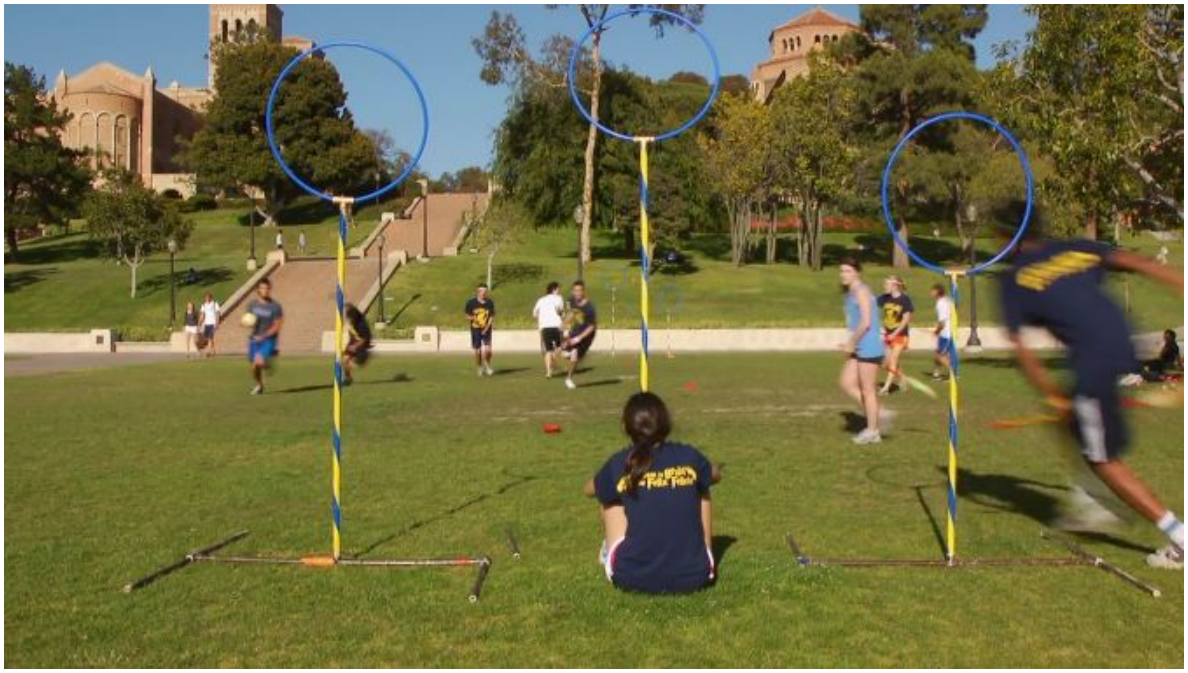
2-13. Field marked at World Cup VII in USA. Rulebook 10th Edition

3. JUSTIFICATION

Thanks to the interaction and communication stablished with teams from all around the world, it was discovered that the biggest problem players have to deal with is the structure of the scoring hoops.

There are players' testimonials from all of the sport categories, as documented scenarios from fantasy tournaments to world cups where it's possible to see the hoops set teams have and how they're not the ideal ones for the development of the game.

Inside the quidditch the quaffle game lead by chasers and keepers is the one that has more interaction with the hoops. Ideally, hoops should work exclusively for scoring and as a starting point for "mounting" after a beat. Nevertheless in practice the non-standardized use of different materials, settling methods and assembly provoke deficiencies during a training or match that can cause from a delay in the game, scoring controversies to moderate or severe injuries for players.



3-1. When losing a base, a player replaces it despite her own safety. UCLA Quidditch

4. PROBLEM DESCRIPTION

Due to the recent creation of the sport, there's no regulation or standardization for the manufacture of the hoops that teams use around the world. Additionally, there has been exponential development of the sport in past years and a lack of resources and orientation of emerging teams. These factors combine to make it difficult to reach a consensus about structural, functional, and aesthetic needs for the performance of hoops during a match. As a result, there have been examples of injuries occurring, disruptions to the rhythm of the game and field conditioning, and controversies with the scoring during international events.

5. OBJETIVES

5.1 Hypothesis

From the design of a set of hoops gameplay will be optimized by reducing risk scenarios, time in hoop reconfiguration, as well as improving the process of assembly, disassembly and transportation, sticking to the current regulations and normativity.

5.2 Main Objective

Design the structural system of quidditch scoring hoops based on the IQA regulations for their optimal field performance, assembly, disassembly and transportation.

5.3 Specific Objectives

- Build a stable autonomous base for each hoop.
- Reduce the incidents provoked by the actual bases set used for the sport.
- Have a connection system among the components of the design strong enough to avoid dislodging during its use.
- Build an intuitive assembly system for all players.
- Count with the optimal components to ease up assembly, disassembly and transportation of the hoops.
- Use resistant materials, easy to fix and accessible worldwide

6. METHODOLOGY

6.1 Current problematics surveys

Due to the recent creation of the sport, there are still many elements not completely functional for a high quality development of a match. As there are no recorded evidences or statistics which can prove these failures, all work here presented is fruit of a first-hand collection of testimonials with players from all around the world including at least one player from each NGB affiliated to the IQA.

Players' commentaries coincide on three main areas where quidditch can be improved which are:

6.1.1 Balls

Given that in the field three types of balls are used at the same time the odds of something failing are bigger compared to other sports whose complexity is lower. Problems in this category can be arranged by ball type: quaffle, bludgers and snitch.

6.1.1.1 Quaffle

By being the main ball at stake during a match, quaffles tend to have much more movement and interaction within the game than the other two balls. Quaffles get hit, kicked, wrapped, teared, bumped, slapped and more during a game by players and other equipment as brooms and hoops.

As it's the most important ball of quidditch, statistics show that players consider having a special ball and not using a deflated ball from other sport for this purpose. Also for the same purpose of specializing the ball, a better material should be proposed in order to have a better grip for players with small hands, especially due to the fact that most of the players handle the quaffle with just one hand.

Some players have dealt with this problem by using football receiver gloves, but its purchase isn't always available at every country making this a not complete solution to the problem (Morton, 2012).

6.1.1.2 Bludgers

Just as with quaffles, one of the biggest problems with bludgers is the gripping factor due to the one hand holding. This together with the fact that dodgeballs aren't as common and commercial as volleyballs brings another issue to the table for quidditch performance.

Dodgeballs aren't standardized sports supplies affordable at every country where quidditch is played, beginning with the fact that some countries as Argentina don't even have access to regular dodgeballs but by being imported from the US to non-affordable costs by community teams. Instead they used to play with an alternate ball with a similar effect and weight than dodgeballs, but with a considerable smaller size which affected their performance at international participations. (Sueldo, 2017)

In the other hand some other countries as Canada have access to many different supplies which led to a greater variation on dodgeball models, which didn't even match with the rulebook requirements for official events.

6.1.1.3 Snitch

From the very beginning of quidditch, the snitch was the most conflictive element that needed a lot of modifications from the original book's game to be really part of the sport.

Historically, the first snitch was only a cloth piece hanging of a player's short as in flag football. Nowadays the snitch is a tennis ball held within a sock, attached to shorts of the snitch runner in a manner that is secure and allows for the removal by the seeker. The most accurate product for these specifications is the Petersons' snitch, but this still has some design areas of improvement such as the *Velcro* grip

which after one or two tournaments loses its power and can even come off with a sudden move of the runner.

6-1. Official Peterson's snitch short with tail.

Besides this there's also the problem of not having a standardized type of short and shirt for the runners, who according to personal preferences and availability at the moment wear many different styles of shorts which may also cause judgment calls due to the alterations they have (VomBaur, 2016).

6.1.2 Brooms

Broomsticks are the visual core of quidditch. They're the first thing people realize when looking randomly at a quidditch match. Considered as quidditch's handicap, brooms are still not as perfected as other equipment elements. Some of the biggest issues they present are:

- Security: With quidditch being a contact sport, brooms are the second reason for body-to-body injuries by not being properly handled during a tackle. Regardless from the material used, brooms tend to get flexed and even broke.

- Caps and bristles: If not handled with attention (which is almost impossible due to the game's speed), bristles and sharp ends with no cap from both sides can cause from cuts and bruises to hemorrhages which compromise players' safety during a match.
- Weight: As there are still different options for building up brooms depending on a team's budget and resources, the brooms' weight is extremely variable. From PVC pipes of approximately 450 grams (Peterson Brooms: Everlour Set, 2012) to wood brooms up to 900 grams, weight differences can cause player's fatigue if not used to the material proportioned by the match host.

6-2. Everlour Brooms. Petersons Brooms

6.1.3 Hoops

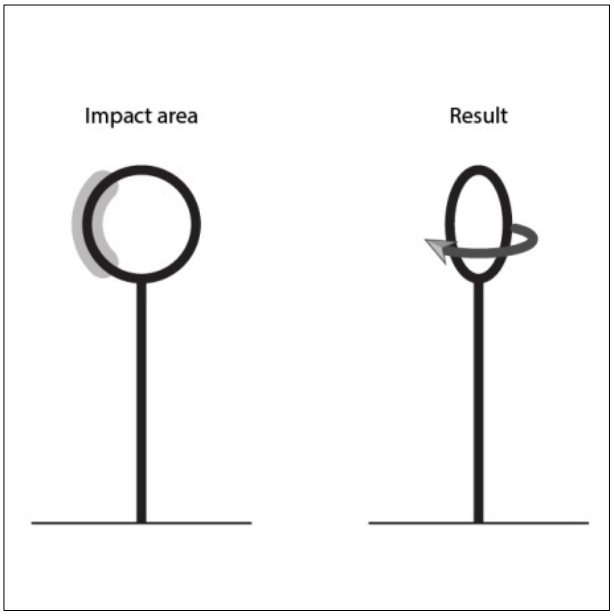
Due to the size and shape of the hoops set, the biggest problems teams have to deal with are the positioning of hoops at field. This can be divided into three different areas:

6.1.3.1 Connections

All kind of actual hoops set are made of three different elements (loop, post and base) connected between with different types of couplers which allow the hoop to be dismountable. Even when this disconnection in pieces eases up the transportation and installation, it has many other disadvantages that can't be solved with the current construction method.

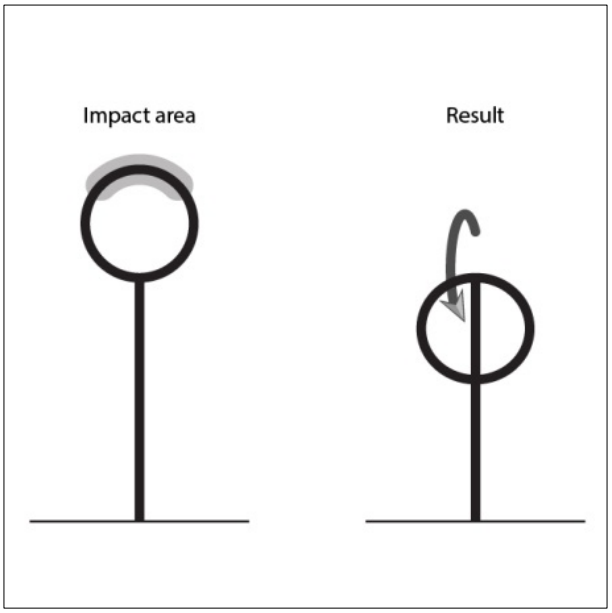
The coupler between the loop and the post is one of the most conflictive points of the set. Due to the different diameters of loop each team has, it's almost impossible to standardize just one "T" coupler that can really prevent the loop from falling apart. If the coupler isn't tight it can cause one of the following:

- Rotation of the loop due to an impact: This happens when the "T" coupler is adjusted for the loop but a little loose to the post, causing rotation mostly when hit with a ball at the sides.



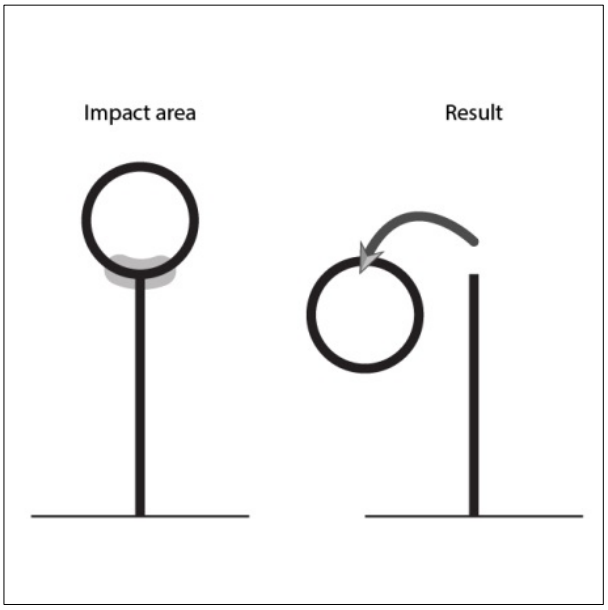
6-3. Rotation of the loop due to an impact

- Loop declining: This happens when the “T” coupler is firm enough at the post, but not at the loop, which causes the loop to rotate according to gravity and rest against the post.



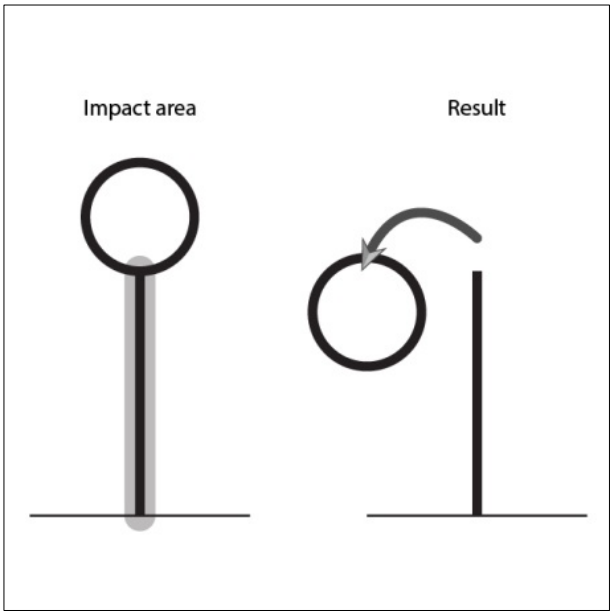
6-4. Loop declining

- Loop dismantling by balls: This happens when the hoop gets hit too hard by a ball and the coupler is too week to hold the impact causing it to fall apart.



6-5. Loop dismantling by balls

- Loop dismantling by players: This can happen in two ways, either when a player dunks the ball when scoring without taking the arm off and pulling the loop with themselves or when a player fully crashes against the hoop (mostly the smaller and medium hoops) causing the coupler to fall.



6-6. Loop dismantling by players

The coupler between the base and the post is also another point of break where hoops tent to get dismantled. This point gets broken by only two types of contact:

- Foot contact: This happens when players step on the base or kick the post at its lower point causing the coupler to break with the impact.
- Full body contact: This happens when a player fully tackles the hoop at the whole post extension causing the hoop to bend and even break at the base.

Most of this disconnection issues could be solved by making permanent joints among the different pieces of the hoops, but this will cause other problematics like the ones listed below.

6.1.3.2 Storage and transportation

Other of the biggest problems regarding the hoops set is the transportation fact for a team's training. As result of the interviews previously made, the next conclusions were made:

- Most teams have to carry by hand the whole equipment for an average of 10 to 200 meters from where they have it to the place of practice.
- It takes about 2 to 4 people to carry all the hoops set (not including balls and brooms).
- Most of all community teams have to carry the equipment by car or public transportation from someone's house to the field for every training session.
- About half of the college teams have a small spot at college to storage their equipment, but usually the space isn't enough for the whole equipment and some team members have to guard the rest. Mostly brooms and balls which are the least bulky.
- Hoops sets weight about 10 to 30 kilograms depending on the thickness of the post and the loop and the setting of the base as it will be explained more detail below.

6-7. Equipment transportation with bags and trolleys

Ass conclusion all players agree that is necessary to have a detachable set of hoops, otherwise transportation would be extremely hard due to the shape and weight of traditional hoops sets.

6.1.3.3 Stability

Bases are the most complicated part of a hoop. These have been built in many different ways since the beginning of the sport with different kinds of results, but none of the actual bases satisfy all of the needs of an optimal hoops set. The most common problems with stability are:

- Area they occupy: Despite the type of base the hoops have, there is always the chance of a player stepping on it due to the area it requires to maintain on foot by itself. This can cause injuries which can be from a twisted ankle to a broken bone.
- Not enough weight: In an effort of making the hoops a bit more transportable, weight is often disparaged causing the hoops to balance with the wind, or being easily tackled by intense players.
- Anchoring: Joined to the last point, if hoops don't have enough weight or a base area big enough to hold the hoop on position, the other possible solution would be anchoring the hoops to the field, but as most of the fields don't allow holing the grass due to aesthetics and maintenance, this becomes an inaccessible option.

6.2 Hoops current use, structure and assembly

6.2.1 Hoops materials

Regular hoops sets are built with three elements from different materials joint with different types of couplers:

- Loops: Hula-hoops, polyethylene pipes.
- Posts: Wood or PVC pipes.
- Bases: PVC pipes, wood surfaces.
- Joints: PVC couplers.

As an additional comment, any hoops set can't be made out of metal, concrete or any other material the head referee considers ´dangerous as it could be a risk to players' safety (US Quidditch, 2016).

6.2.2 Types of bases

The most common structure used at official events is the thick wood base, widely popularized by Petersons Brooms, nevertheless due to economic and logistics issues, not all teams have access to this type of base, which develops team's imagination in order to create a more accessible and useful support for their hoops. Some of the most common base types are listed below along with their advantages and disadvantages on field.

6.2.2.1 Peterson's hard wood base.

6-8. Hard wood base. Peterson's Brooms

Official USQ base, featured at USQ Cup 9 and IQA World Cup, this is the most durable and stable Peterson's base. 23" hardwood base of approximately 5

kg each with a dismountable coupler hub (the white piece) to ease up storage and handles for transportation. (Petersons Brooms, 2016)

Advantages

- The weight they have is more than enough to resist almost every impact a hoop receives during a match.
- They've worked for standardizing almost every official event in the US
- The replaceable hub helps works well as a break point to ensure the base, but it's still breakable.

Disadvantages

- The wood surface is too smooth and it has caused accidents when stepping on it.
- The shape of the base is still bulky and uncomfortable to carry by one person.
- After much use the couplers tend to loosen causing the loop to turn.
- It's not affordable for every team and exportations outside the US are too complicated.

6.2.2.2 Umbrella Bases

6-9. Australian wheelchair quidditch match. Ajantha Abey Quidditch Photography

Umbrella bases are often used by European teams as an already built alternative instead of building something by themselves.

Advantages

- They don't require any additional assembly on field
- All of them are designed to weight enough for a post to stand safely on top

Disadvantages

- Due to the materials they're built with, they're too bulky an uncomfortable to carry around from one point to another
- Some of these need a water filling to increase its weight which is often inaccessible at practice spots in public parks
- They're too hard and can cause accidents when a player falls and gets hit with it

6.2.2.3 Anchored bases

6-10. Metal spikes. Bluehawk Quidditch Supplies

Anchored bases consist on different varieties of spikes and claws that perforate the grass of the field leaving a top to insert the post. This type of bases is sold by the European vendor Bluehawk as an economic alternative for anchoring hoops on grass pitches.

Advantages

- They're the most portable fitting elements for a hoops set.
- Once attached to the ground their almost impossible to take off due to an impact.
- They don't occupy extra area of the ground which completely avoids foot injuries
- They're the most economic bases for hoops sets

Disadvantages

- Many training spots around the world don't allow players to anchor their hoops to the grass.
- They require additional tools for its installation such as hammers or mallets.
- If they're not well installed from the beginning, they can't be fixed because the grass has already been damaged.

6.2.2.4 PVC bases

6-11. Common "H" shaped PVC base. Own authorship

PVC bases are the most common, accessible and easy to build bases teams from all around the world use. The shape and diameter of these can be extremely different one from another with the only common concept of pipes and couplers to assemble with the pole for keeping it straight

Advantages

- Materials required for building them are the easiest ones to get worldwide.
- If one piece gets broken it can be easily replaced by another at a low cost.
- It presents a lot of design variations for each team needs and resources

Disadvantages

- They’re to light and can be easily blown under bad weather conditions
- They don’t support strong impacts
- The area they need to have in order to keep stability is too big compared to other bases
- If stepped on it can be easily broken and/or cause injuries to the player’s feet.

6.2.3 Hoops assembly

With all the previous materials presented there are still more options of hoops assemblies teams have come up with all around the world, the most significant are listed next

6.2.3.1 "H" shaped hoops

6-12. "H" shaped hoops. Rocket City Quidditch Club

This is the easiest hoops set to put together, they use less pieces of PVC pipes and give good stability from scoring through either sides.

6.2.3.2 “H” with reinforcements shaped hoops

6-13. "H" with reinforcements shaped hoops. Nothwestern University Quidditch

Similar as the previous construction style, the additional pipes on the middle give extra stability obstructing more ground area and making it a bit harder to transport.

6.2.3.3 Squared shaped hoops

6-14. Squared shaped hoops. Own authorship

Easier to carry around than the previous two shapes, the area they obstruct is bigger all around the hoops, but this same shape gives more stability to the set from every side.

6.2.3.4 Squared with reinforcements hoops

6-14. Squared with reinforcements shaped hoops. University of Virginia Quidditch

This shape gives an extra support on impacts from the front, but not from the back.

6.2.3.5 Round shaped hoops

6-15. Round shaped hoops. Australia's QuidCamp 2017

The principle is the same as the past set, with the difference of the material used: loops instead of PVC pipes with reinforcement from the back.

In the picture the lack of support is clear as two of the three hoops lay down on the floor towards the front where no reinforcement is placed.

6.2.3.6 Bucket hoops

6-16. Bucket hoops. Nottingham Nightmares

Most of PVC bases don't weight enough for the hoops to stand on their own, bucket hoops work as an alternative to increase base's weight by using concrete or other hard materials which is now illegal.

6.2.3.7 Two posts hoops

6-17. Two posts hoops. Notre Dame Quidditch

When there aren't resources to get the right couplers for building up the hoops, this is used as a temporary solution using only duct tape, two posts and a loop.

6.2.3.8 Inserted hoops

6-18. Inserted hoops. Quidditch Uganda

Other alternative for newly formed teams is to easily insert the loop into a groove at the top of the post; this can only serve as a temporary solution due to its low impact resistance and loosening of the post groove.

6.3 Player profile

Quidditch players can come from two backgrounds

- Harry Potter fans who are just interested on the game as a materialization of their favourite book as an spare activity
- Former athletes with some sports background who are hooked by the complexity of the sport.

Despite the background a person has as a motivation, almost everyone who starts playing quidditch, immediately “falls in love” with the challenge quidditch represents.

On top of it, as quidditch is now a sport played officially in more than 20 countries, physical and tactical differences are remarkable when the time of competing against each other comes.

6.3.1 Australian player profile

Australian quidditch history comes back to the time when they had their first QUAFL tournament gaining immediate attention from Australian’s youth in the sport almost 7 years ago. Nowadays Australia is the world’s number one team after their impressive victory over the former champions and developers of the sport from the US.

Australia’s gameplay is strongly influenced by rugby style which is much more developed in their country than in the rest of the world. As a result of this, their game style is very physical and fearless, but at the same time fast enough to keep audience’s attention.

Most Australian players’ height goes from 1.70 meters onwards, which gives them a wider advantage for defensive interceptions when opponents approach to the hoops for scoring. Also when approaching to the hoops either for defending or for attacking, Australians don’t tent to crash to them, instead the defensive line

(including chasers and beaters' bludgers) prevent them from entering to the keeper zone, which leads to more long shots for scoring.

6-19. Team Australia during IQA World Cup 2016. Ajantha Abey Quidditch Photography

6.3.2 European player profile

As the only regional committee in the world, Quidditch Europe has two regular championships and more than ten national events happening across the continent each year which gives Europe the biggest amount of quidditch played in the world, this can be translated into greater reach for the sport across the continent thanks to local means who are most constantly summoned by all NGBs.

With four countries out of the top eight of the world, and more than 15 countries regularly playing every year, Europe's competitiveness has increased exponentially in the past 5 years. Also due to this expansion it has the widest variety of quidditch players whom regarding their origin country show different types of game play according to their experience more than geographic factors.

Despite the fact of being the cradle of Harry Potter's book, UK isn't the cradle of quidditch, but its constant effort and long trajectory has led the country's national team to be the third best team in the world. UK game play is known by their strong line of offensive chasers and an amazing defensive line of beaters, which makes their game more focused on long shots and midfield contact rather than physical encounters at the keeper zones.

6-20. Team UK before their last match at IQA World Cup 2016. Ajantha Abey Quidditch Photography

Following up is France, who got fifth place during the 2016 World Cup, first place on the past 2015 European Games (Championship between national teams) and 2015 and 2016 European Cup (Championship between clubs) represented by Titans Paris. French teams are some of the greatest scorers from Europe, whose top strengths are short shots to the hoops and very little physical contact against each other and to the hoops.

6.3.3 American player profile

According to international appearances and NGB's development, North America is considered the elite of American quidditch with its three continents belonging to the top eight of the world. Despite the similarities at scoreboards and world rankings, and the relative closeness between countries, Canada, USA and Mexico have extremely different game styles and even more different player profiles that cannot be fitted into one simple description of the American profile, so as trying to consider South American countries which due to distance and country's economies haven't been able to transcend frontiers into bigger leagues.

In order to determine with more accuracy the American profiles, the next list is made considering the top 3 countries of the continent:

6.3.3.1 USA player profile

As the country where quidditch as a sport was created, USA has the longest trajectory and experience translated to its players. Counting with a one of a kind regional divisions system, USQ is the biggest NGB with more than 100 teams from most of the states of the country competing firstly against each other in order to gain a spot on the national tournament where only the top teams from the eight regions dispute the cup to be considered the top team of the country.

6-21. Team USA gathering before the final match during IQA World Cup 2016. Ajantha Abey Quidditch Photography

USA game play is strongly influenced by football in its full-contact roots and by dodgeball leagues where “beating to death” is more common than in other countries. As for scoring “dunking” the ball is very frequent as seen on professional basketball leagues.

Team USA players were chosen given the talent and experience showed on their regional leagues and past official presentations. They are the greatest example of diverse types of athletes who combine accurate offensive beaters, strong defensive chasers and fast offensive chasers which makes their game play the most aggressive one worldwide.

6.3.3.2 Canadian player profile

As the second country where quidditch appeared as a sport, Canada has much more experience than the rest of the countries. Actually led by a former Paralympic athlete, Quidditch Canada is the strictest nation with its elite players whom are trained as professional athletes before their international competitions. Their strategy is also one of the best of the world where speed plays a key factor that almost none of the other countries have developed as them by making short runs directed towards scoring with fast attacks and constant players’ changes in order to tire the opponent and reduce physical contact that could lead into major injuries due to the same speed.

6-22. Team Canada celebrating a victory at IQA World Cup 2016. Ajantha Abey Quidditch Photography

6.3.3.3 Mexican player profile

Despite the fact that Mexico has only been playing for five years in comparison to the rest of the top countries, its development has been increased due to the influence of the northern countries and the presence of Mexican players who have played in other countries (mostly US and UK) increasing considerably its odds when it comes to international appearances.

Mexican game play hasn't reached its peak at some certain style due to its relatively early development, one of the biggest areas of opportunity all teams have is the team work collaboration and ability to work on complex strategies more than developing the individual style of top players. Despite this a certain trend into long shots with great accuracy and a fairly defensive beater's game can be noticed among the local representatives of Team Mexico, on the other hand foreign Mexican players' style is more directed to US and UK physical contact style.

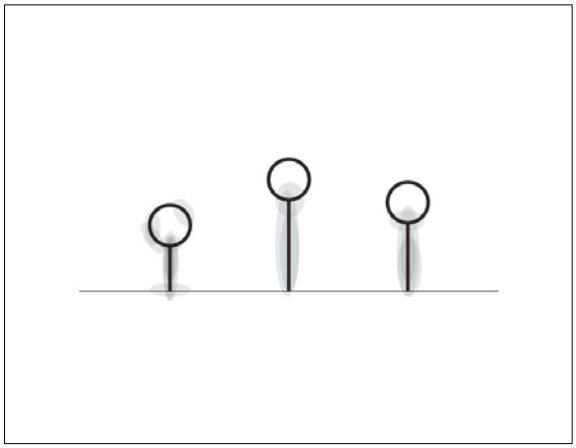
6-23. Team Mexico celebrating their entrance to the top eight teams at IQA World Cup 2016. Ajantha Abey Quidditch Photography

6.4 Player/Hoops interaction analysis

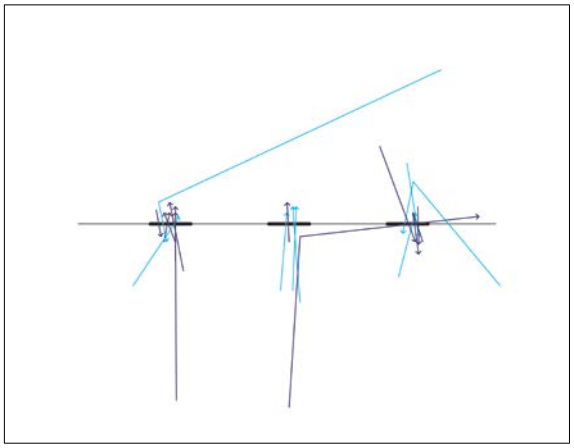
In order to stablish the hoop structure needed to resist a quidditch match, a player/hoops interaction analysis was done to discover the scoring tendencies by impact zones and trajectories. These analyses are resumed in the following graphics where front view diagrams with grey zones indicate the impact zones where hoops get hit and top view diagrams mark with arrows the trajectories balls have for scoring.

6.4.1 Australia's gameplay summary

- As explained before, Australia's game play is more focused on midfield contact rather than keeper zone contact.
- There's still a trend of full body impact with the hoops mostly on the post area which requires a stronger coupler between the base and the post in order to maintain the hoop standing after a crash.
- There are almost zero impacts on the loop area due to balls crashing and not entering into the scoring area.
- Short shots are more common on the smallest/left hoop.
- Low scoring matches are more common due to a great defensive line which prevents offensive attacks to reach the keeper zone.



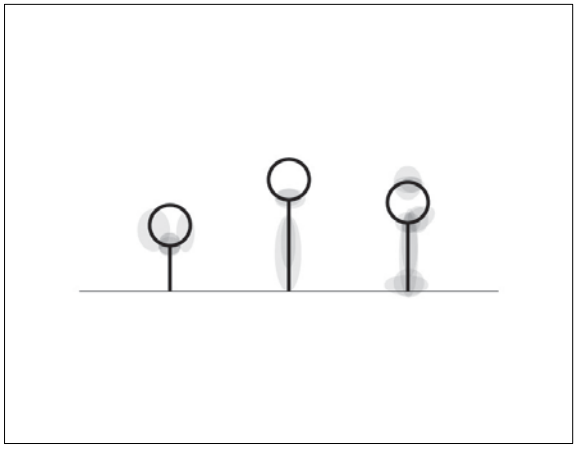
6-24. Australia's impact zones



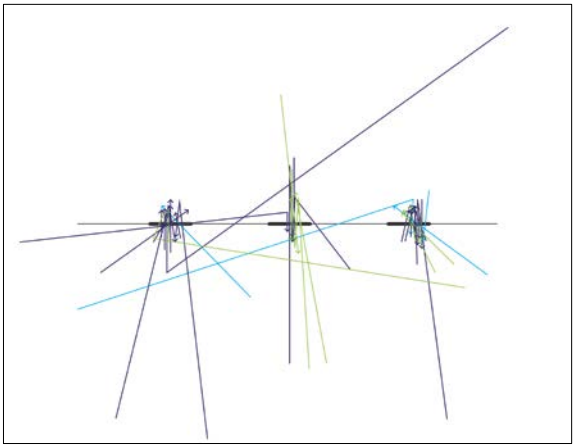
6-25. Australia's scoring trajectories

6.4.2 Europe’s gameplay summary

- As there are more teams and countries playing in Europe, trends are more visible than in Australia or Northamerica
- There’s a strong trend on full impact against the medium/right hoop caused by speed players entering from the right and crashing against the keeper before getting to the hoop which leads into two or more players falling above the hoop (Which doesn’t necessarly prevents the scoring).
- Short shots are extremelly common to the outside hoops either from both sides.
- Offensive chasers tend to stay on the back of the opponents’ hoops to receive the ball from their midfield playmates for scoring without being noticed.
- Long shots to the middle/tallest hoop are often failed due to crashing against the coupler area between the loop and the post.



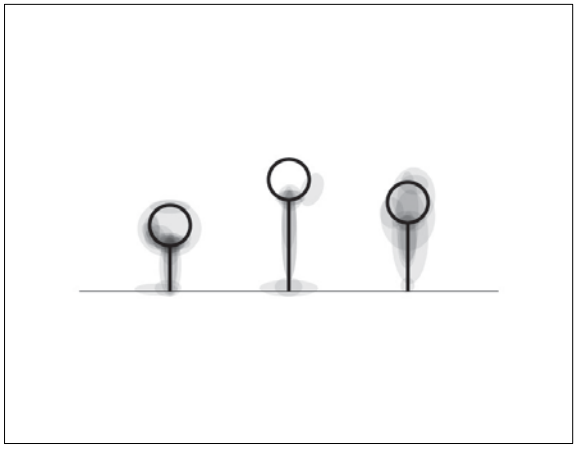
6-26. Europe's impact zones



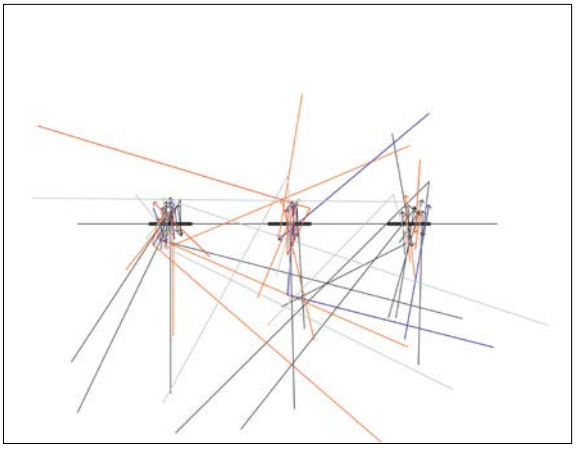
6-27. Europe's scoring trajectories

6.4.3 Northamerica's gameplay summary

- Northamerica has the strongest impact records against hoops.
- "Dunking" is very common for scoring, mostly on the smaller/left hoop.
- Stepping on the bases is also more notorious in northamerica than in the rest of the world.
- The most injured hoop is the medium/right one due to its height (player's height) for full body impacts on the post and missed releases of the quaffle that crash with the loop.
- Scoreboards tend to have higher scores than in other parts of the world given the american's trend of passing through all the opponent players until getting the annotation.
- "Connection shots" are more common where a player passes the quaffle to another standing inside the keeper zone in the right position for making the annotation.



6-28. Northamerica's impact zones



6-29. Northamerica's scoring trajectories

Considering the former description of regional types of players, it was possible to determinate the tendencies each region needs in order to get an optimal hoops set, but given the reach this design is expected, all of the following will apply to the final design:

- Reducing loop dislodging due to ball impacts reinforcing the connection between the loop and the post.
- Reinforce the lower part of the loop (where it connects to the post) to prevent injure by dunking.
- Building up a post capable of standing full body impacts without getting broken nor injuring the player itself (“A strong material, but weaker than a bone […] it must break before a bone breaks) (Alley, 2017).
- Create a small area base in order to avoid stepping on it.

6.5 Creative process

By talking with former quidditch players and people interested on the sport (but who have never played before) it was possible to make a brainstorm of ideas that could solve the problematics regarding the hoops set, which suggested what could be done to make it better:

Quidditch players’ suggestions

- More stability, easier to set up and smaller to store
- Using a more resistant material
- Consistency and standardisation among teams’ hoops sets
- Flat “X” shaped bases
- Cheap heavy bases with a break point setting
- Something windproof

Non-players’ suggestions

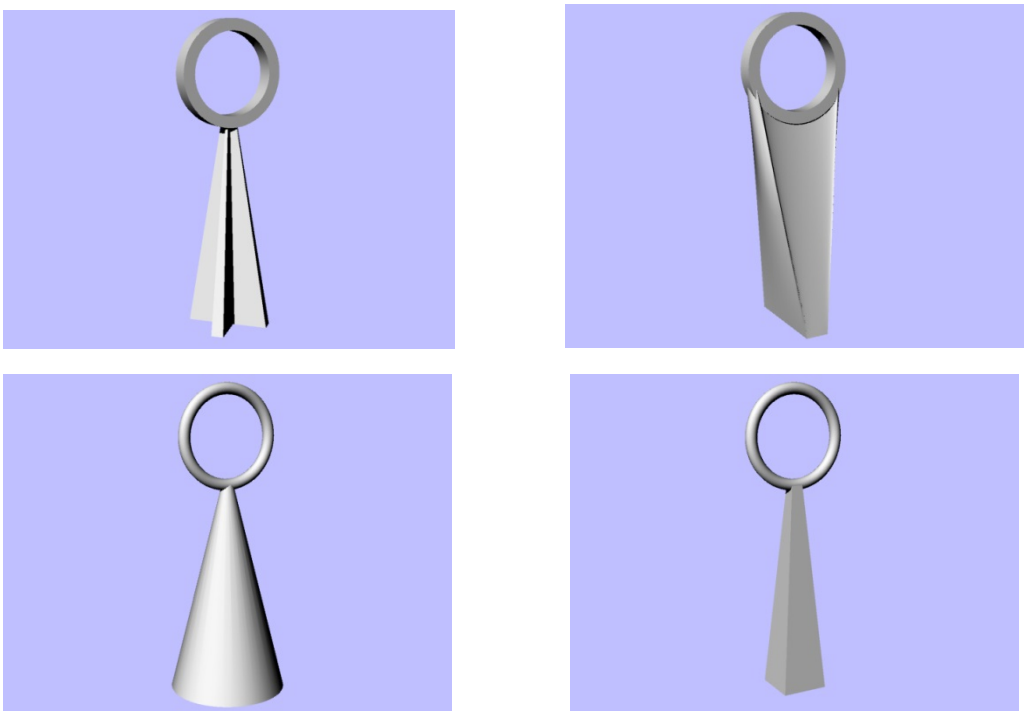
- Anchored posts
- Permanent posts on the ground

- One piece metal hoop
- Metal posts covered with foam (pool noodles)
- Hanging loops from the ceiling
- A single piece base for the three hoops
- Collapsible posts
- “bop-bag” style hoops that return to their position

It can be noticed that quidditch players can only think about “solutions” other teams have already tried whether they know it or not, and none of them fully solves the main problematics the hoops have. On the other hand there are non-players whose ignorance on the rulebook leads to illegal solutions which couldn’t be applied to the game, but some of this ignorance on the rulebook and previous alternatives led to a completely unexplored field by quidditch players: **Inflatable hoops.**

6.5.1 Sketching

Starting off with the concept of an inflatable toy, some first sketches were made considering already known bases’ shapes that could fit the requirements:



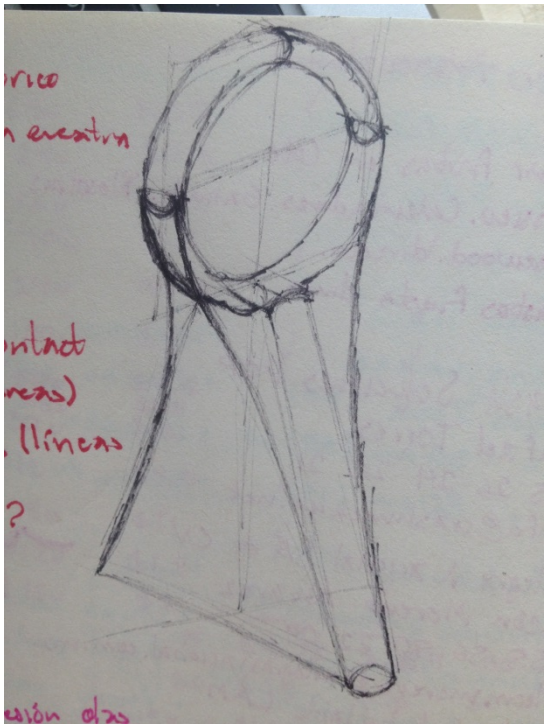
6-30. Sketches

All of the previous sketches have a donut/hollow cylinder shape for the loop and different ground shapes for the base extruded until they meet with the loop. Just with these sketches the breaking connection problem is already solved by dispensing the couplers and building up a one piece hoop.

With these ideas developing, a first-hand construction analysis was made:

- For building processes, it's easier to seal and construct with less faces.
- Having such a small contact area between the loop and the post could cause loop declining
- Despite not having an independent base from the post, having such a large ground area could cause it to remain treaded by players' feet.
- Right angles are harder to seal for inflatable items
- A proportional sand pouch is required to achieve the "bop" effect that fits into the base shape of the hoop

Continuing with the creative process, a final design was selected and perfected to meet with all the design requirements:



6-31. Final design first sketch

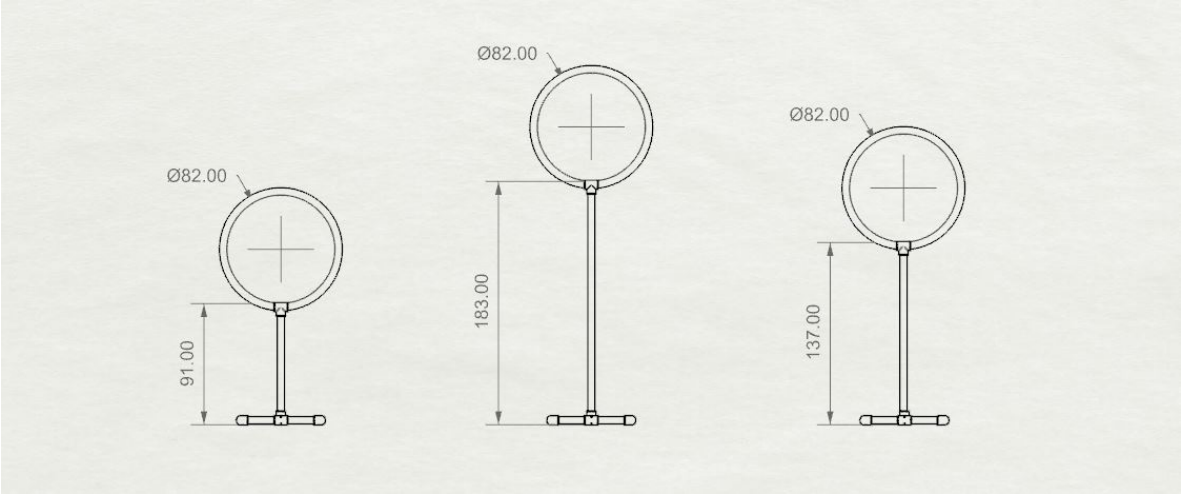
- The round shape of the donut gets maintained as on regular hoops sets
- Aesthetically it keeps the essence of the original hoops just with the material addition at the sides to support the loop.
- Front area of the base is narrow enough only to keep the visual proportion reducing the contact area for preventing feet injuries and base stepping.
- Lateral area of the base is wide enough to make up for the front length which can support the total structure of the hoop with an additional inner sand pouch.
- Break points and/or couplers are dismissed by not using assembly pieces.
- Sand pouch weight works as a counterweight to make up for full body impacts caused by players.
- Inflatable systems can hold impacts better than solid materials thanks to the air filling they have as long as the seal isn't broken.

6.5.2 Measure analysis

Quidditch Rulebook tenth version from the USQ enunciates the following about hoops' shape:

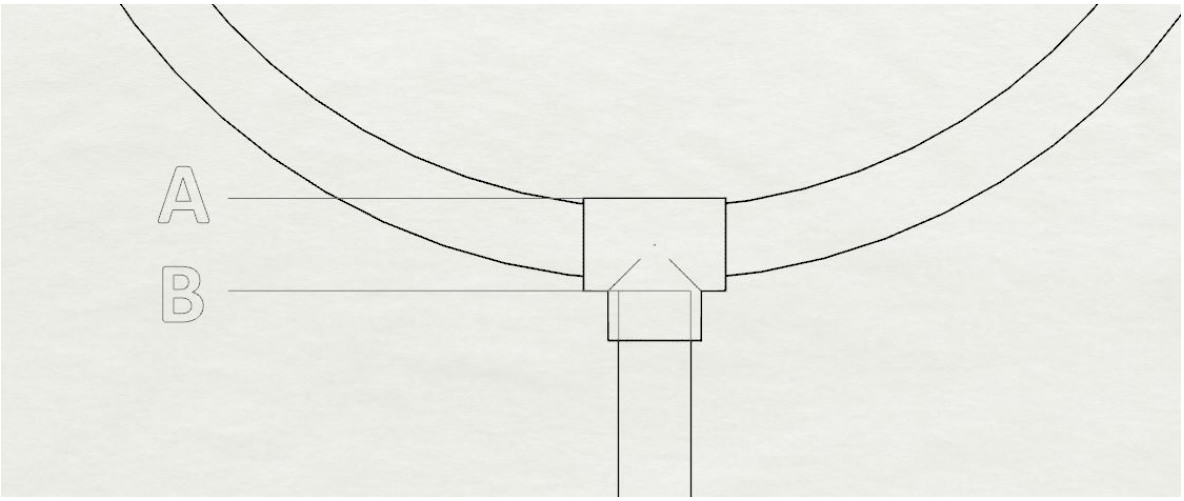
- *Each set of hoops must have posts of three different heights.*
    - *These heights must be 3 feet (.91 m), 4.5 feet (1.37m) and 6 feet (1.83 m).*
- *A loop must be fastened to the top of each goal post.*
    - *The inner diameter of each loop must be between 32 inches and 34 inches (81 cm and 86 cm).*
    - *The attachment of the loop must not make the height of the post exceed the measurements [explained above].* (US Quidditch, 2016)

According to these specifications, an optimum hoops set would look like this:



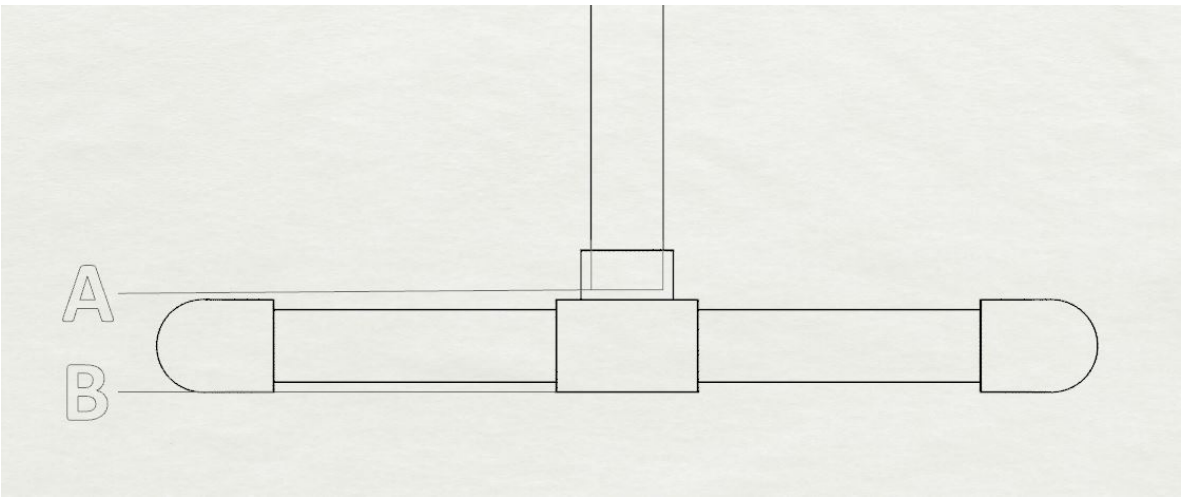
6-32. Ideal hoops' dimensions. Own authorship

Unfortunately, given the misunderstanding of the rulebook and the lack of proper advise and supervision during the teams' hoops construction, there are many teams who have built their equipment incorrectly (Morales, 2017) as on the following figures:



6-33. Hoops' dimensions variations

Given the variations on the loop/post coupler due to materials diameters, it's almost impossible to standardize all of the sets around the world giving the past variation which changes the post dimension from the inner diameter of the loop (point A) to the base of the loop (point B) from the 183 cm for the higher hoop up to 187 cm for teams who use 2" PVC pipes and couplers.



6-34. Bases' dimensions variations

The same happens at the bottom where the dimension is measured from the start of the post (point A) rather from the ground (point B) causing an additional measure variation to the previous one.

6.6 Prototyping

Starting from the previous analysis the first prototypes were made as shown next with the following tools and resources.

6.6.1 Materials

Given the necessities and first resources for prototyping, one type of paper and two types of plastics were used in order to create a functional scale model as close as possible to the final product.

- The first model was made in paper to show the shape of the design and its stability. Given the rigid nature of paper, the “inflatable” properties of the design are not appreciable in this prototype.

6-35. First paper prototype

For only testing the final shape without the heat seals, polyethylene films (LLDPE) sewed with thread were used to try the aesthetic of the design. Due to the size of the models, it wasn't possible to reproduce the inflatable properties of the design.

6-36. First polyethylene prototype

6.6.2 Sealing systems

6.6.2.1 Heat seals

Heat sealing is the welding process of a plastic with another plastic or other compatible material using heat and pressure. Direct contact method uses a die or hot sealing rod to apply heat on a contact area to merge the plastics meanwhile the induction sealing process uses electromagnetism to create the heat necessary for the welding. (Tecnología de los plásticos, 2013)

- Welding is the heat application among the two sheets to seal and the pressure exercised between, hot air melts the plastic and pressure makes it merge into one single piece. Heat pistols are used for this purpose with a special flat attachment at the tip and a roller to press the heated material.
- Heat sealing impulse machines work by generating heat only when an electric current flows between. When plastics are placed among the two heating elements, they stay in place thanks to the pressure made with the non-stick dies or rows.
- Hot wire seals imply the use of a hot wire that cuts the plastics with a cutting blade leaving the seal with the melted border remaining. Depending on the type of plastic, the cutting blade may or may not be needed for disposing the surplus material.

Working with such small prototypes the most accessible seal used was the hot wire method for ensuring optimum sealing. The following picture shows straight seals made with a heated sheet and curved seals created with a wire. Picture was taken filled with water to show the efficiency of the seal for containing air with no leaks.

6-37. First heat sealing test

6.6.2.2 Glue seals

Not so commonly used in large scale, there are different types of glue that can make a strong seal capable to contain the air inside the hoop. These types of glue were only used in the handmade prototype due to its low cost and easy access.

- Flexible plastics contact glue: Created especially to patch flexible plastic materials such as canvas, balls or inflatables made of textile and natural or synthetic rubber. It's made out of synthetic polymers, resins and solvents whose quality, flexibility, transparency, humidity resistance and strong grip allow creating almost unbreakable seals needed for this project (Resistol, 2017).

6.6.3 Scale models

For the final scale models a type of plastic commonly called “plastigel” was used to imitate the properties of common inflatable toys which have impulse seals and inflation valves as the following:

6-39. Impulse seal

6-38. Inflation valve

With this plastic the first prototype was made on a scale 1:10

6-40. Scale model cutted pieces

6-41. Scale model sealed from all the sides

6-42. Inner sand pouch base

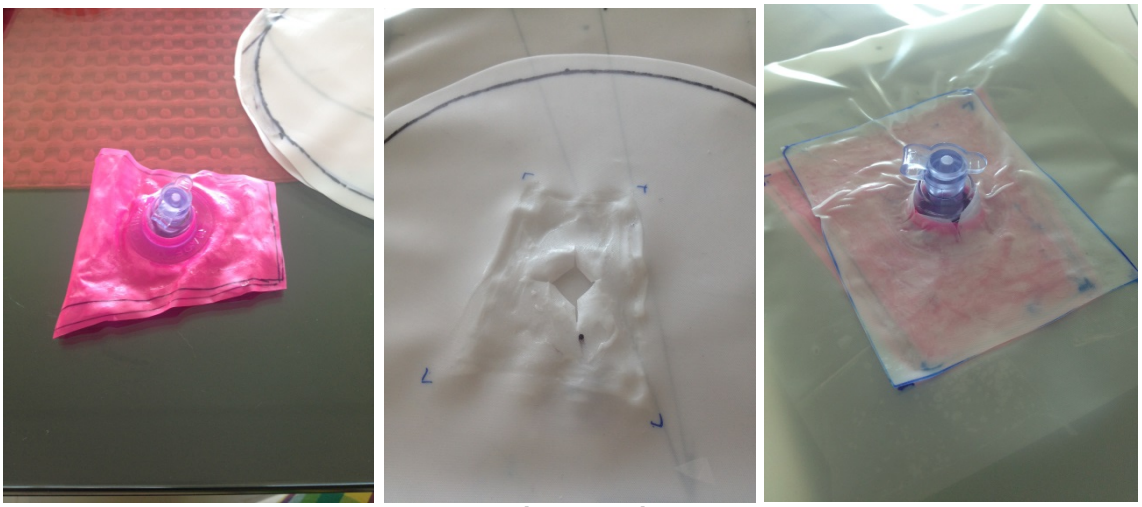
6-43. Inflation process

6-44. Final design scale model

6.6.4 Real size models

Once the scale model was completed, several full size models were made considering all the design's parts.

6-45. Tracing and cutting tools for real scale hoops



6-46. Valve attatchment

6-47. Sand pouch



6-48. Small, big and medium hoop sealing processes

A couple models done had defects due to human failures in the sealing process and material perforations which resulted on air leaks as shown next:

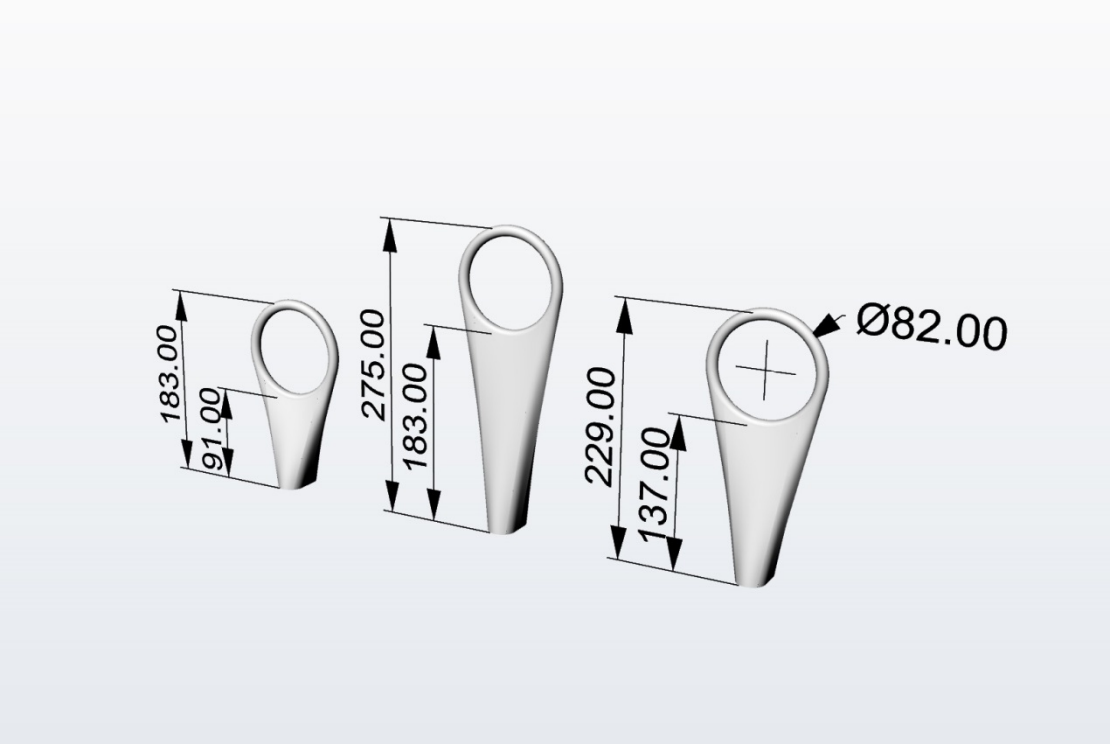
6-49. Defective models

6-50. Perforations repairing process

6-51. Final design prototype

6.6.5 General Plans

With the past prototypes created and several modifications made, the final model plans for hoops sets design which “Don’t fall. Don’t break. Don’t move” is the following.



6-52. Final design renders with general measures

7. RESULTS

7.1 Final product

After several try-outs, a final product was accomplished meeting all the requirements needed for an optimal set of quidditch hoops:

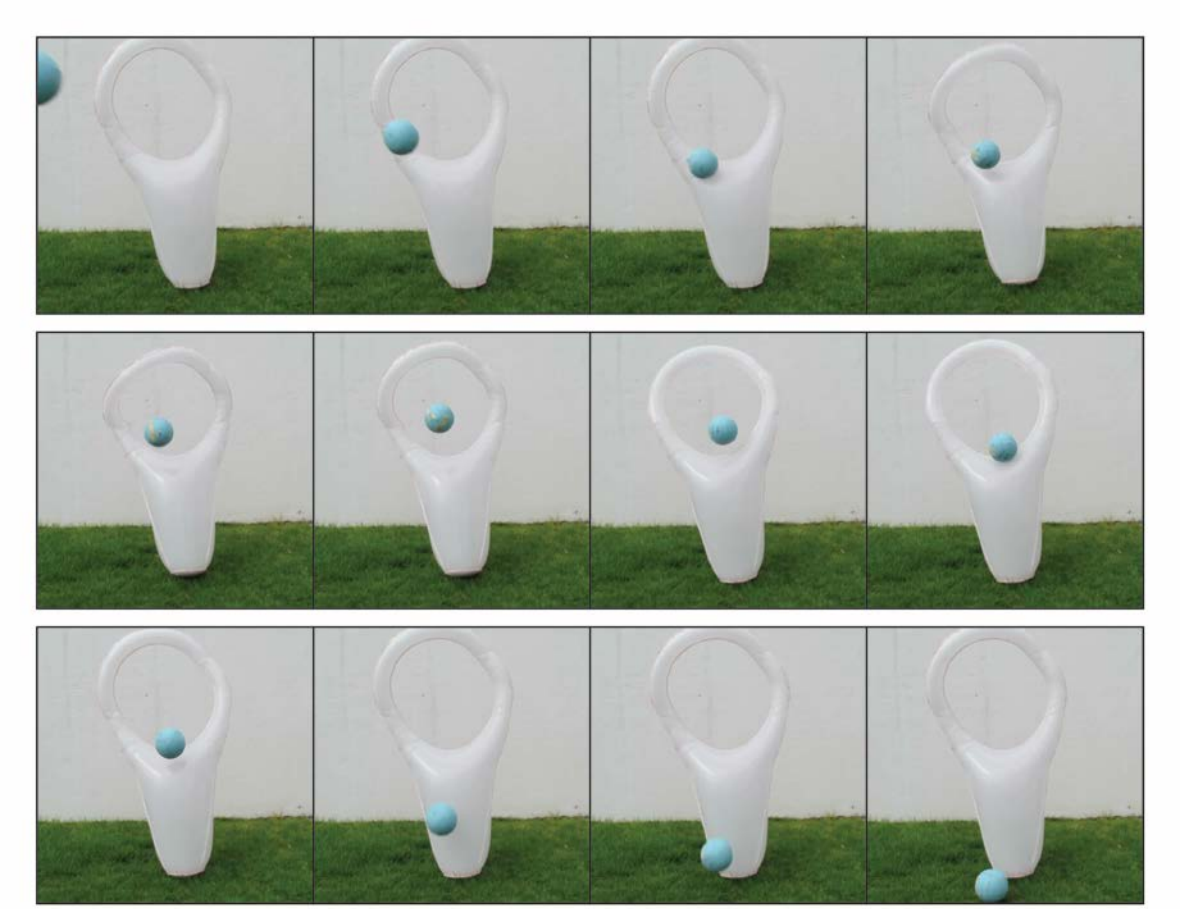
7-1. Final design positioning test

7.2 In use evidence

With the creation of the final product several tests were made in order to try out different aspects:

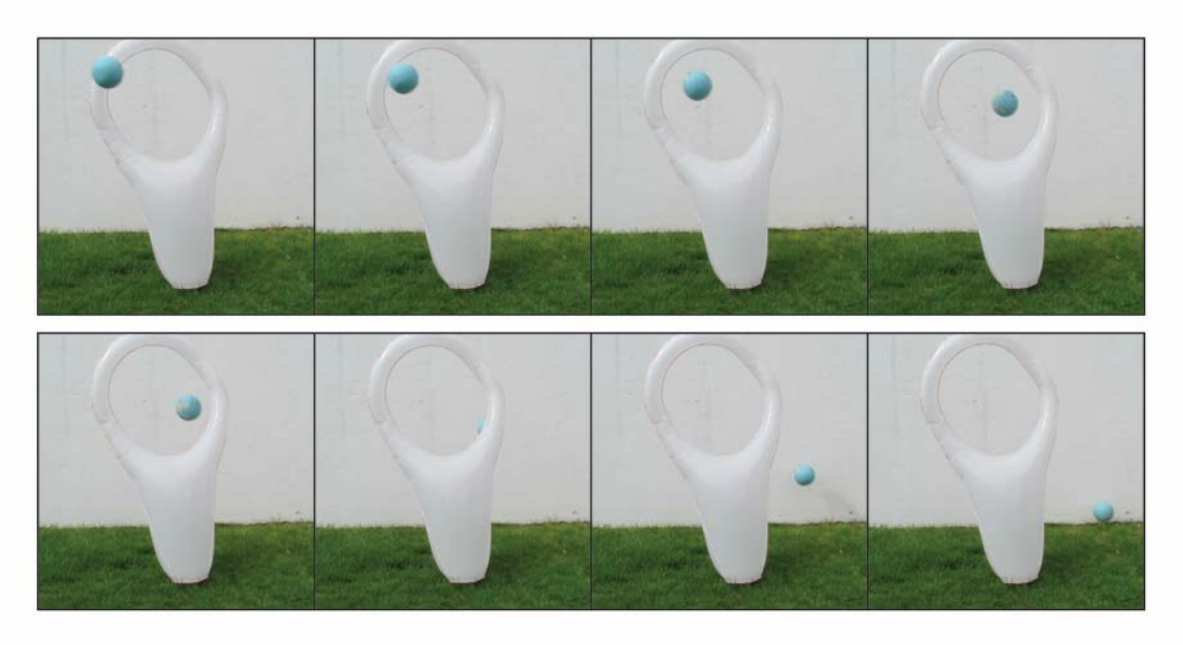
7.2.1 Impact resistance

7.2.1.1 Impact by balls



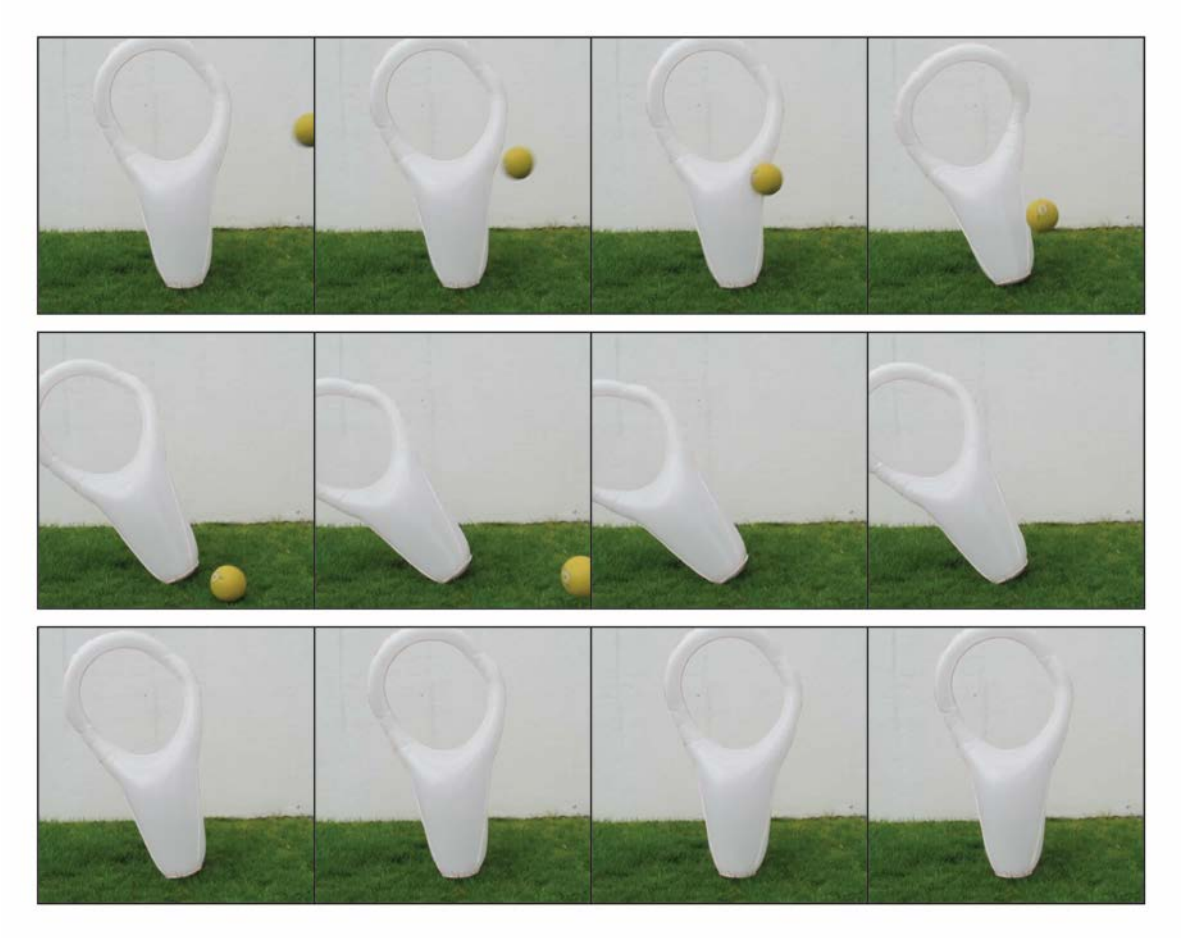
7-2. Impact by balls on the lower side of the loop

- When a hoop gets hit by balls on the lower part of the loop it may get deformed due to the impact, but it goes back to its original form immediately.
- On this point balls may bounce either to the same side from where they were thrown or to the opposite side for scoring. This depends on the exact point where it is hit.
- Falling and dislodging effect is dismissed thanks to the inflatable and “bop” properties of the design with no connections fulfilling the “Don’t fall. Don’t’ break” statements.



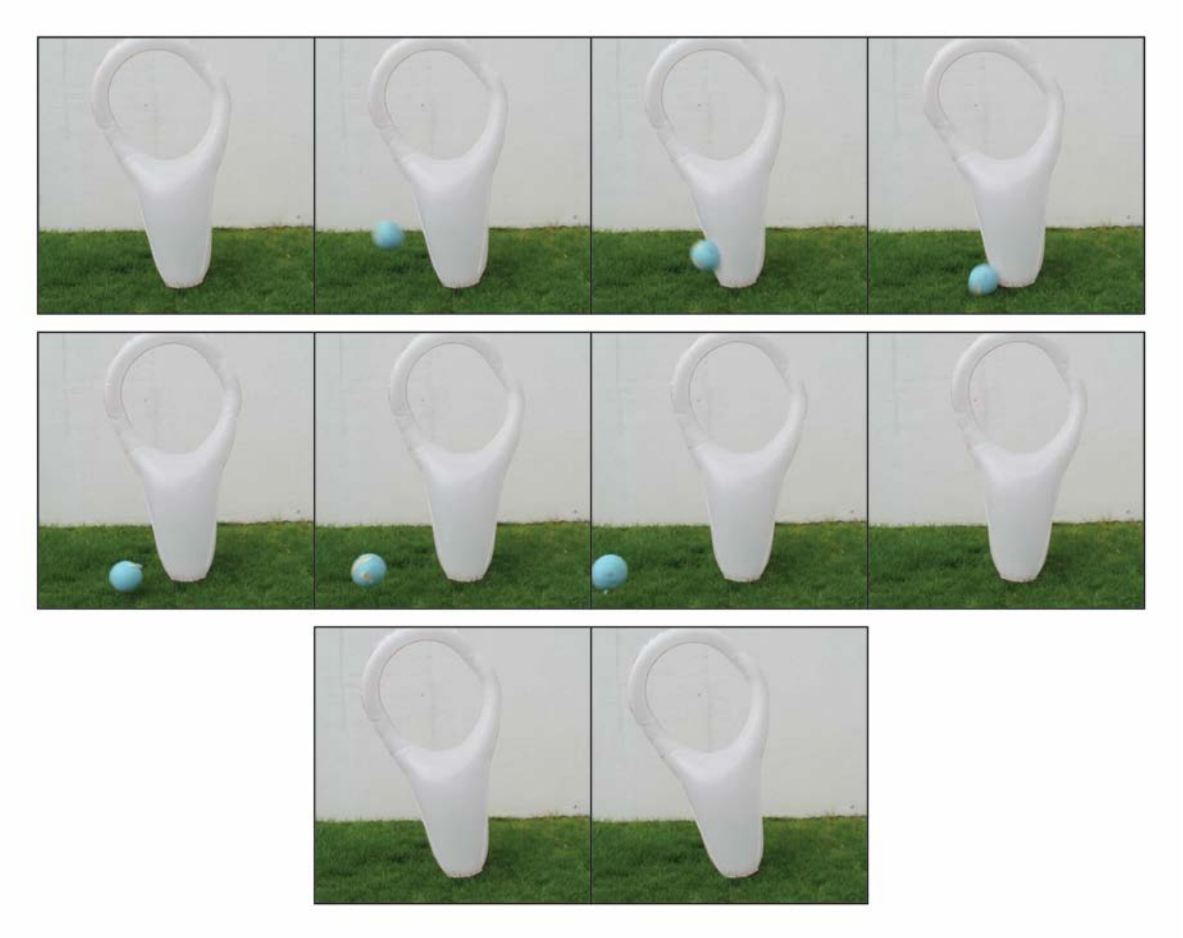
7-3. Impact by balls on the upper side of the loop

- When a hoop gets hit by balls on the upper part of the loop it presents a slight inclination to the back but it goes back to its original form immediately. This movement is barely noticeable on pictures.
- Falling and dislodging effect is dismissed thanks to the inflatable and “bop” properties of the design with no connections fulfilling the “Don’t fall. Don’t’ break” statements



7-4. Impact by balls on the post

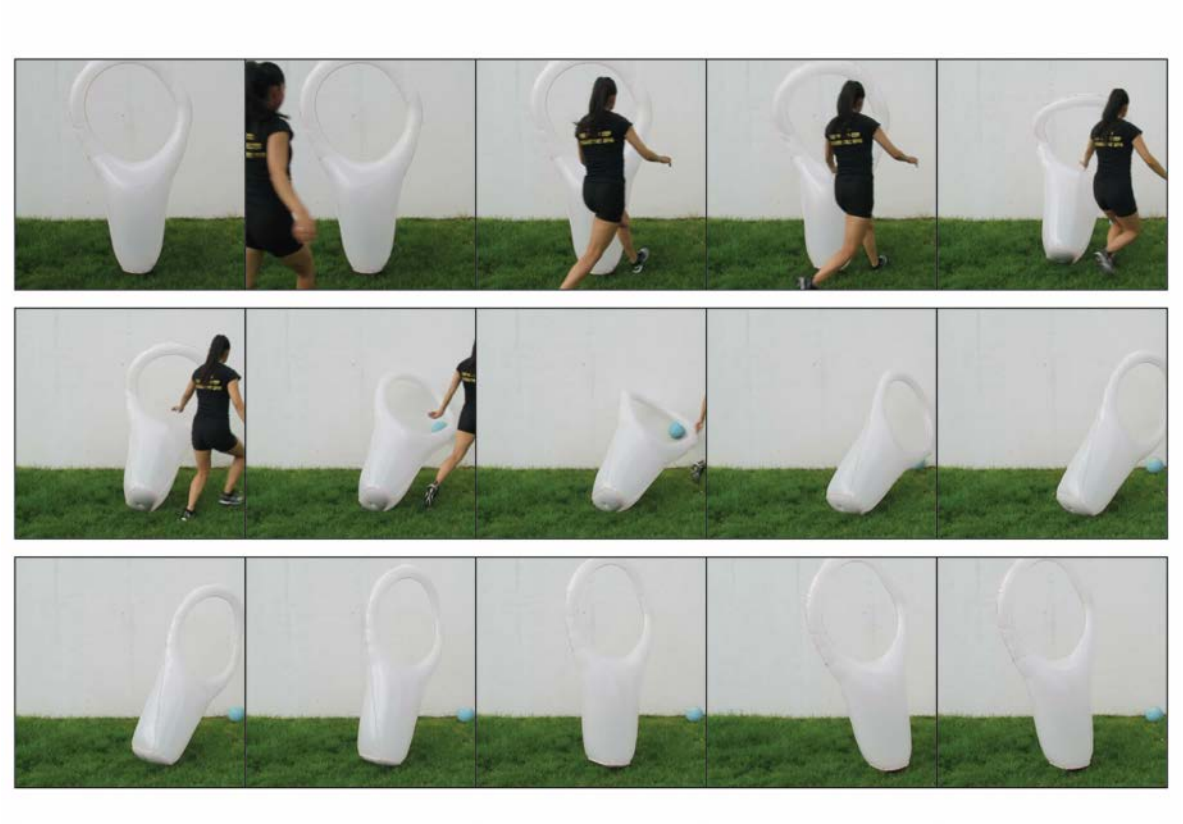
- When a hoop gets hit on the post section, the loop gets deformed due to the impact and it falls completely to the opposite side of the hit.
- Depending on the strength of the crash it may or may not reach the ground before returning to its original position thanks to the “bop” effect given by the sand pouch at the bottom.



7-5. Impact by balls on the base

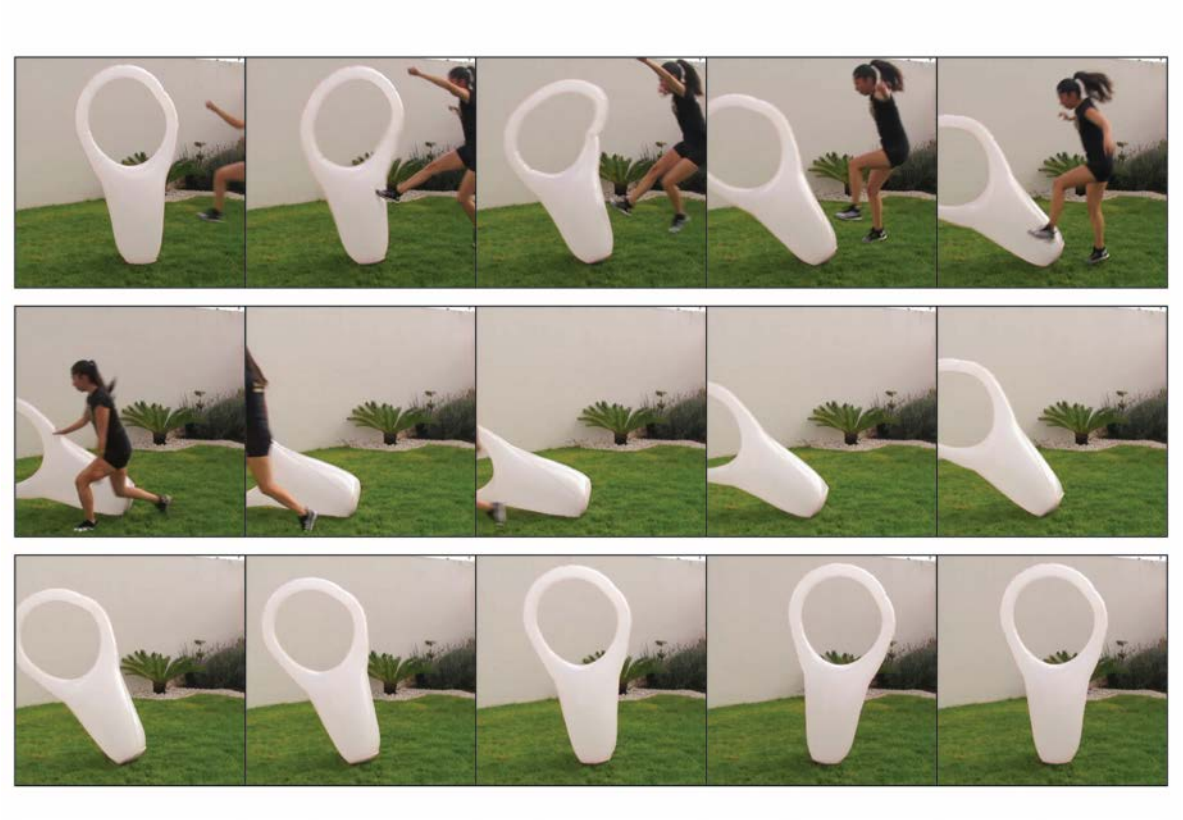
- When a hoop gets hit on the base area it provokes almost no response. There is only a slight deformation of the loop and a small inclination of the hoop to the opposite side of the hit.
- A ball hit doesn't have enough strength to move the hoop from its original position, fulfilling the "Don't move" statement.

7.2.1.2 Impact by players



7-6. Impact by players while "dunking" the ball

- When a player dunks the ball for scoring on the outside hoops (small and medium sized) most of the strength falls on the lower part of the loop but it is distributed to the rest of the hoop with almost no deformation.
- As players do not take out the arm after the ball has gone through they pull the hoop with them causing it to fall. Despite this the hoop returns to its place immediately thanks to the “bop” effect.
- There’s still a slight chance of rotation which can be solved immediately by players putting it back in place after the play is over.



7-7. Impact by players when crashing the hoop

- When a hoop gets crashed by a player either from a kick or a full body impact, it provokes a complete falling of the hoop causing absolutely no harm to the player.
- Even if the hoop reaches the floor due to the impact, its mechanism makes it go back to its upright position right after the player steps away.
- The hoop may have a slight swinging effect before returning to its upright position which does not affect its performance during a match.
- The material of the hoop is strong and flexible enough to avoid tearing caused by cleats or brooms fulfilling the “Don’t break” statement.

7.2.2 Inflation process

7-8. Manual inflation process

Inflation process takes about 8 to 15 minutes by mouth depending on the pulmonary capability of the person. This time can be reduced by half using a pump to inflate balls.

7.2.3 Transportation

7-9. Inflated transportation examples

Each hoop weights 5 kg approximately which can be perfectly fitted into duffel bags by two or three persons depending on the team. The easiest way of transportation is with the hoops deflated but as shown in the previous pictures, one 1.50 m tall person (approximately 5') can carry the small hoop without obstructing its mobility and a 1.70 m person (5'6") can handle any hoop even with one hand.

7.3 Advantages/disadvantages in design

	Advantages	Disadvantages
Structure	The shape of the base prevents it from falling due to player's crashes, wind or ball hits. The flexible nature of the materials used prevents incidents on players provoked by crashes with the hoops. Having a one-piece hoop eliminates the connections that cause dislodging. Having a one-piece hoop eliminates the assembly required for its use. The inflatable properties of the design ease facilitate the mounting and transportation of the hoops. The materials used are common plastics easily found around the world, just as its patches and spare parts.	They are still as heavy as regular hoops for transportation. In order to be usable they require an additional inflation time.
Aesthetic	The shape allows differentiating the hoops from the "magical game" with these from the actual	They don't keep the classical aesthetic of the Harry Potter's quidditch original hoops.

	sport. The area at the front lends itself for personalization with teams or sponsors' logos. The materials used are easy to clean and keep neat even in muddy or dusty conditions	
Economic	Long term economical savings. Patches and spare parts are cheaper than PVC elements Shipping costs extremely accessible worldwide	First disbursement may be considered expensive for emerging areas

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