EASY VEST

CRITERION A: ANALYSIS OF A DESIGN OPPORTUNITY.

Problem identification:

Design need -

During my IB project week, a school sponsored student organised trip, my group and I travelled abroad to Laos. We participated in a service activity aiming to make small differences, which cumulatively will improve our world, and in particular the lives of the less fortunate. We stayed in a village called San Udon on top of a mountain in a rural area in Luang Prabang, Laos with the purpose of building Eco-bungalows. Subsequently, the local villagers would lease the bungalows to travellers passing through a national park corridor hiking trail, in order to provide an alternative source of income for their communities.

In the search for an authentic design problem, I remained empathetic in my approach over several months, towards every task I was undergoing. I observed others around me and the tasks they were performing. This trip provided me with the perfect opportunity to identify first-hand problems. Our home stay unlocked more potential. In preparing the locally sourced materials to construct the houses, many tasks undergone daily by the villagers had to be performed similarly by us. The specific context that I identified as being problematic was the method of transporting equipment and goods back and forth, experienced myself in carrying equipment to a steep mountain edge where as much straw as possible was collected and carried back for mixing to create organic bricks. I observed villagers travelling in and out of the village, morning and evening every day. I was immersed in these tasks myself, walking a mile in the same situation, and therefore I felt that these primary strategies had uncovered a design need.



In my left hand photo above you can see us collecting straw for transport to the village from a very steep hill. The middle photo has one of our guides preparing a bamboo pole he had found in order to try and make transport easier, and to allow a greater load to be carried. At the right, the photo of the main entrance into the village demonstrates the difficulty of the local terrain, even within the 'developed' village area.

Interview to justify feasibility -

In working to establish whether this is a real problem within rural communities, I was fortunate to be able to interview Non Tiddin from World Volunteer Organisation. Non is the supervisor and local guide working on development projects within communities in South East Asian countries. I feel her opinion has great credibility due to her years of experience working first hand and communicating with the many families in different locations who may undergo the problem my product is aimed to mitigate.

Excerpts from her response:
"There are two approaches farmers use to transport necessary items. The first one is a motorbike, which is only if the families can afford one and movement is across fairly flat terrain. So is mostly just used around their villages and back and forth from the towns and shops. But from the farms that are located sometimes above and below the villages, they are only accessible by foot so they make carry baskets or just use bamboo."

“Many materials are transported and is dependant largely on the time of year and if any building or repairing is happening in the village.”
“The male villagers will carry the heavier materials just by hand and take as much as they can carry so they can sometimes be occupied doing this for a long time, or the produce or material is just put in their carry basket with anything heavy being carried at the bottom not to squash anything else.”

Non’s response to my initial questions delving into whether her experience and observations had led to noticing signs of difficulty when transporting a wide variety of potential things on a daily basis, has proved to me this problems existence and its substantiality. In particular the excerpts above provide some important information that will need to be considered when addressing an effective solution. The transport system must be designed for use within fairly densely vegetated environments and support the individual's stability due to the use on inclines/declines between farm and village. No specificity of material transported was given. However, this will likely vary throughout the year due to crop harvests and any required building or repair needs. Heavy materials were specified to require consistent carrying and therefore an aid for this could be potentially explored. In conjunction with this, Non described the ordering of carried items to preserve them as multiple items are typically collectively placed within the same basket.

1

Initial background research -

A study conducted by the ‘International Labour Office’ investigating safety and health in the agriculture sector identified the eleven most frequent hazards experienced by workers. One of these eleven states ergonomic hazards, in which they give further detail to “use of inadequate equipment and tools, unnatural body positions or prolonged static postures, carrying of heavy loads, repetitive work, excessive long hours” (Safe Work ILO).

Although not specified that these problems are prevalent due to the difficulty of transporting goods, such movement is a substantially large portion of the work performed and has major links with what has been identified as hazardous to the farmers health. These problems are addressed within the multi-approach design of the Easy Vest (E.Vest) product. The design will be ergonomic, improve body posture, comfort, allowable payload, aid the required repetition and therefore extend daily work hours.

Problem justification -

Through the various forms of primary and secondary research presented above, it is evident that a basic transportation problem for rural farmers exists. Transport is a fundamental component of how they are able to live and is therefore essential for overall wellbeing. Given the limitations in terms of income, no high-tech solutions are adoptable. Common solutions constructed from local available materials are not always the most suitable and generally cause the onset of later health problems or simply increase the work hours due to poor usability. A successful design for this product will reduce health risks through ergonomic design, increase the carriable load and thus reduce repetitive trips. However, there may need to be consideration of load size adjustability. The product should ideally be of low cost, have multi-functionality to cater to all farmers regardless of crop or materials being transported, and allow for use across any terrain traversed by the individual.

<u>Market and user research:</u>

Competing products -

Available products for rural farmers who earn little to no income are very minimal. On top of this, access to the products are strained due to their geographical location and prices are generally too high to be viable. An “agricultural and farming products and equipment information” company called ‘Engineering 360’ provides largely what is available on the market for private and subsistence farmers. In terms of transport there are currently three optional products; a Unimog, a wheel-barrow and hand-truck, shown respectively below.

2

3

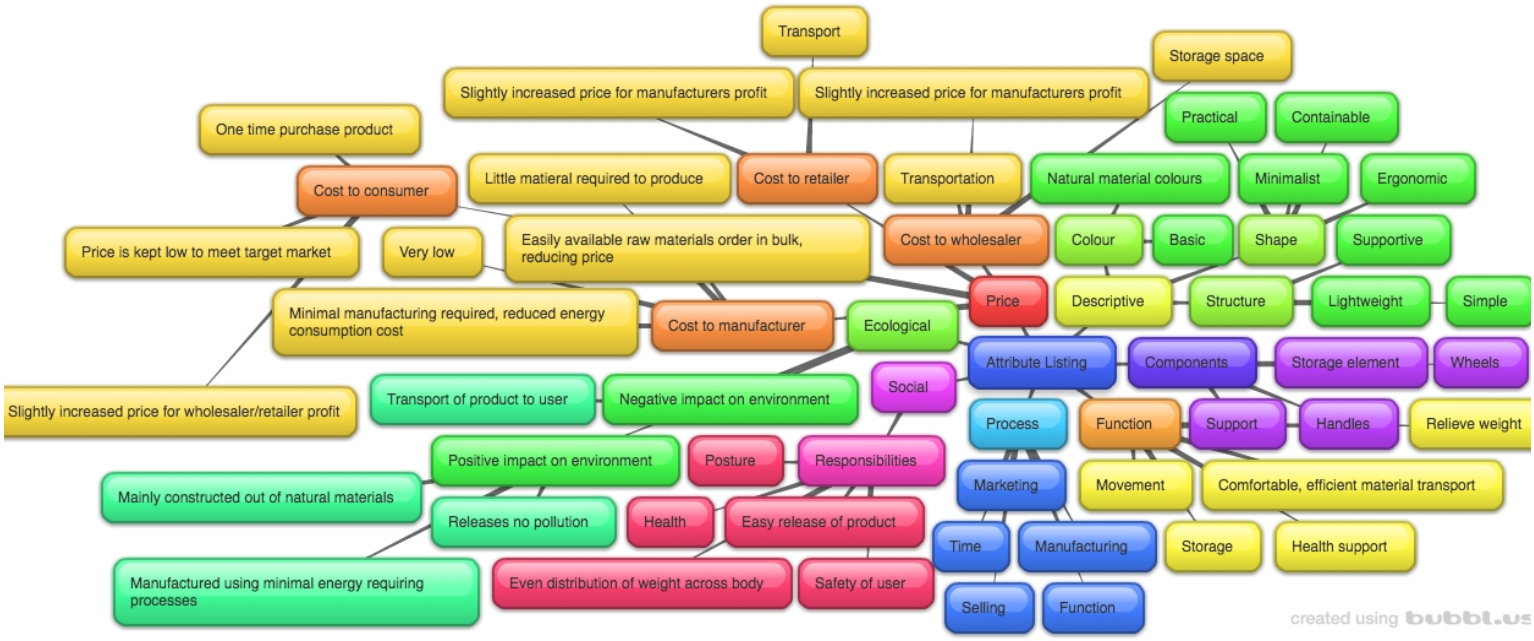
4

2

The Unimog, although designed to be viable on all terrain is not applicable within terraced environments on steep hill/mountain sides. Further, it is not well suited to the small human made paths, which are subject to the constant erosion of human travel over time. The price of one also far exceeds the economic level of rural farmers at prices of minimum US$ 4,000 for a second hand vehicle. The wheelbarrow is a viable option. However, it tends to be limited to terrain that is flat or has gradual angled gradient surfaces, otherwise spillage will occur. Hand-trucks are again limited to level or smooth surfaces and generally for packaged goods, thus minimising usability with the typical materials that rural farmers transport. From the above research it is evident that a genuine problem exists, with the lack of a product designed specifically for rural farmer transport needs, and which caters to the extensive limitations they are posed with.

This product above, named the 'Load Carrier for Labour' won the 2011 Core77 design award for Consumer Products/Equipment. Designed by Vikram Dinubhai Panchal from the National Institute of Design (NID), it is the closest resemblance of the product I envision developing and the only other carrying system for poorer communities to be designed to date. The design has taken into account the different weight loads that will be carried by individuals as well as materials. However, it is more focused on constructional labour as compared to agricultural. Light weights are traditionally carried on the head, medium loads on the back and the heaviest via pushing of a cart or other form of small mobility. Constructed with a fairly minimalist design its main components are made of cane based materials, industrial expanded polystyrene and various metal connecting components. The design allows for three different configurations, altering the carrying technique based on what is being moved, thus increasing its versatility. The manufacture of the product only cost Rs. 400 (SG$8.50) per unit and therefore, is extremely viable for purchase within the intended target market.

Attribute listing -



Market analysis –

Market segmentation: In terms of farming transport products, there are several market segments which are essentially categorised by the range of prices on offer. However, the market segment that is applicable to rural farmers with low incomes is further limited. The higher-end of the market consists of motorised vehicle transport, such as the Unimog, along with other more capable and sophisticated vehicles. Lower segments consist of the wheelbarrow and hand-truck, with greater diversity and which are potentially applicable to our target user. Finally, there is a market segment focused upon providing products for rural farmers with as low a price point as possible, while at the same time aiming to improve their living conditions. I believe this market is currently only served by the 'Load Carrier for Labour', shown above, and it is this segment in which I aim to design my product to compete within.

Competition: Competition within this market as a whole and even more specifically within the market segment I plan to enter my product into is very low. In fact, having conducted secondary research the only product that I would be competing with is the 'Load Carrier for Labour'. There is a genuine need for this product, with end-user access to such products limited, while the benefits it offers the target user clear.

Economic viability: The main purpose of this product is not one of revenue, but to provide a product that is realistically priced, offering an option for rural farmers who routinely undergo hard working conditions that are generally unhealthy and unsafe. Therefore, the product needs to be constructed from low cost materials that are both readily available and durable. Minimal manufacturing processes will be required, while sales will be aimed at Non-Government Organisations (NGO's), with the capability to distribute the product to the appropriate individuals. As a result, this product will be of initial low cost and the profit margin minimal, but sufficient to maintain design development and continue production improvement.

Pricing: The 'Load Carrier for Labour's' retail price is Rs.400 (~SG$8.50), a hard price to compete with! I would like to price mine similarly, at SG$8.00 being the manufacture cost and SG$0.50 being profit. This will make it economically viable, target market viable, sustain production and provide a minimal profit to further develop and improve the product and manufacturing system.

Environmental considerations –

In considering the environmental impact this product will potentially have, I would like to mitigate the negative impacts. The product itself will require minimal materials due to its simplicity, of which some will be locally sourced. The manufacturing processes required is anticipated to be limited due to its minimalism. This factor in turn saves on energy usage. This product is being built to be robust for the individual user, thus achieving a long usage life. Additionally, various optional elements will be replaceable locally as required – all adding to reducing environmental impact.

Materials and local/traditional sourced product use -

In researching the potential materials that will be used within the design of the product, I have had to keep a constant focus on low cost materials. However, I need to avoid a hindrance to the functionality of the product. Potential materials include polyester fibers, due to their extreme strength and durability, while providing a comfortable fit for the user. Bamboo as one of the mainframe materials that also has the potential to be sourced within the local area. This material has great toughness, is light and very cheap. As well as these materials, various components and joint mechanisms may be made of aluminum or other light, durable metals in order to provide the required tensile strength and durability required.

Given the need to minimise overall costs as well as meet the requirements of my target user, it makes sense to examine the existing aids and implements used by the rural farmer. Items such as baskets and trays that they use to carry their crops may be taken into consideration within the design, allowing for these to be incorporated into practical use. This increases versatility, allows for traditional practices to still be performed and applied, but in a more efficient manner. Typical transport aids or temporary storage items include:

Bamboo Pan (Moonghil Thattu) - made of bamboo sticks, used for collection of plant produce as well as sowing of seeds. It has an average life of 1-2 years and costs Rs.25 (SG$0.52) per unit. Specification = Depth: 12cm, Diameter: 25cm.

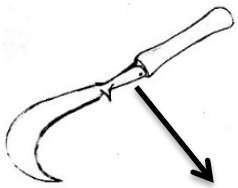
6

Other larger baskets, typically used for transportation vary significantly due to factors such as locational, custom and local materials being used. While such variation makes designing to incorporate these devices problematic, the visual representations offered here likely offer sufficient guidance.

In addition to farm-based materials, water also needs to be transported from source to its usable location, as water accessibility is not always convenient. Due to the presence of vertical terrain, this needs to be carried and is usually done so in clay, metal or plastic pots carried in unhealthy position, while minimising the requirement to undertake repetitive trips. A design element to improve or supplement this occurrence also needs to be incorporated. Some examples are shown above.

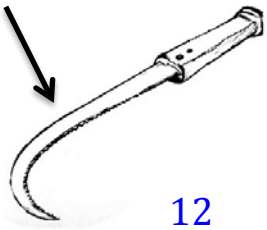
There are three main tools used by subsistence farmers in order to achieve all necessary crop cultivating activities, regardless of area in the world and therefore crops being grown. The size of these tools varies greatly and therefore, approximate consideration will be taken in the design to accommodate the ability of carrying any of these three tools when necessary by the user. Typical farm tools are drawn below.

The first is the spade, which is used for cutting irrigation canals, for repairing flood banks (especially on rice fields) and for deep-plowing gardens, necessary for crops such as tea.

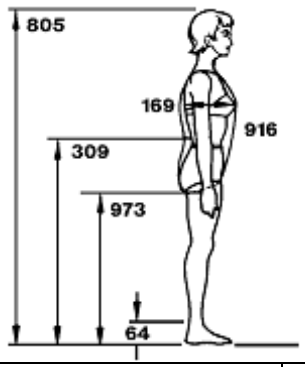


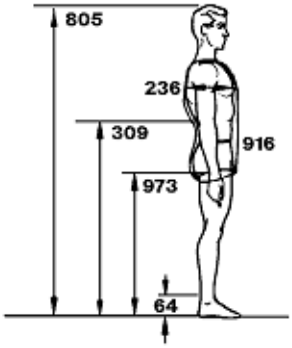
A billhook is a general tool used for cutting branches for building hut frameworks and feeding livestock, as well as pruning of fruit trees.

The toothed sickle is used for harvesting grown crops.

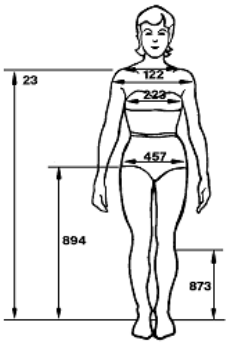


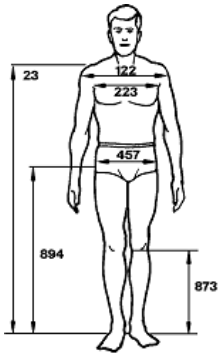
Anthropometrics -

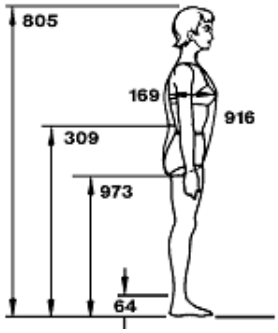


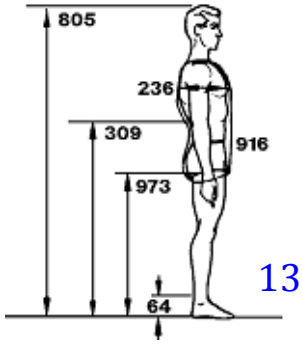


Dimension:	5th percentile female (cm)	50th percentile average (cm)	95th percentile male (cm)
Stature	158.6	166.3	174.8
Vertical trunk circumference	53.9	62.4	71.9
Waist back	13.9	16.9	20.3
Neck circumference	13.6	14.9	16.5
Shoulder length	4.4	5.9	7.5









13

Dimension:	5th percentile female (cm)	50th percentile average (cm)	95th percentile male (cm)
Chest breadth	9.7	11.8	14.4
Hip breadth	12.0	13.5	15.4
Chest circumference	28.8	35.9	43.6
Waist circumference	21.8	30.1	40.1

Above is the relevant anthropometric data, which will be used to produce a comfortable and ergonomic, user centered design. The data will provide useful guideline measurements for the various product components situated between the hip and neck of the user. Statistics were collated from several sources, with the female 5th percentile, male and female 50th percentile average and the male 95th percentile collated here. The product will be designed using 50th percentile average measurements and incorporate some degree of adjustability features in order to cater to both ends of the spectrum. (Note: diagram data above from NASA USA, units are imperial.)

Load capacity and items -

The product is designed to be versatile due to the varying needs of each farmer, which is affected by season, geographical location and task. The E.Vest should be able to transport building materials, such as rocks, bricks and wood, along with harvested crops, small livestock and water. The average weight carried by farmers exceeds 35kg at a time and over prolonged periods this may result in serious musculoskeletal disorders.

However, by dispersing weight and causing the activation of larger and more muscle groups, the designed system will reduce these health risks. Additionally, the intention to only support a total weight of approximately 25kg is aimed at influencing behaviour and thus improving the overall long term health of users.

Problem requirements interview -

Conducting a second interview with World Volunteer Organisation employee Non, I asked her if she would be able to share some characteristics of the product that would need to be implemented in order to meet the needs of the users as well as result in a successful product. Here are some of the key elements mentioned.

"I believe versatility is an important component for a product such as this as the materials being moved will constantly differ and always having a product that works will be of increased use for the villagers."
"Allowing sufficient movement of the user's arms and legs is important as restrictions will increase difficulty to walk and climb the difficult paths as well as reduce the safety for them"
"The way the product is used should be very simple with as little parts that are complicated as it is likely that this be misused and broken."
"The product overall needs to be made of strong materials if it is to last the constant use and dirt it will ultimately be covered in."

The aim of this follow-up interview was to acquire specifics, therefore I posed Non an open-ended question. I have extracted the relevant responses which address features that I must be sure to consider and implement within the product, based on her perspective. Requirements I take away from this interview are, the product requiring good versatility, in order to function in as many scenarios as possible. Provide the required comfort and room for user movement. The design to be minimalist, simplistic and that the materials although of an economically viable cost, to be durable and weather resistant in order to provide a long term, working product.

Research summary –

Market research has highlighted the following aspects. There is only one competing product in the market that is a carryable transport option, sold for SG$8.50. To ensure economic viability the product should optimise cost in materials and manufacture, and be aimed for sale at SG$8.50 with a profit margin of SG$0.50 due to the prioritised social purpose of this product. Materials such as bamboo and a durable synthetic textile will be proposed in order to ensure high strength to weight ratio as well as ensure comfort. Minimal simple fixings/fastenings to be used as much as possiblee to aid local repair or self-maintenance if necessary. Incorporation of optional local tools/materials will also be factored into the design, reducing the purchase requirements of storage items such as baskets which can be locally procured. The dimensions of the product will be designed for the average male and female 50th percentile, although some adjustability to cater for those that are towards the extremes. Key elements of the design will be the versatility of use, movability and safety of the product, and durability of the materials based on suggestions from my 'client', Non.

Design brief:

Design goal –

I intend to design a wearable transport system for rural farmers that live and work in harsh and un-even environmental terrains. The product will be of high versatility allowing the carrying of all necessary items from farm produce, to building materials and water. The smart, ergonomic design will improve the efficiency of their physical work as well as improve the health of users, in comparison to current traditional transport methods. This product should be of low cost, therefore obtainable to those with a low income and be of a sustainable nature.

Prototype aim –

Initial component models and prototypes will be used throughout the design stages in order to test and evaluate the products overall carrying capabilities and ergonomic comfort. Certain specific elements/sections of the design may also be individually modelled to evaluate aesthetics and construction techniques. However, eventually a one-off, functional, scale prototype will be constructed. The design and manufacturing processes used will then be considered and improved in order to ensure the viability of this product for larger scale, commercial production.

End user/target market -

The end user of this product is those in low economically developed countries and more specifically in the rural agriculture sector as subsistence farmers. Those relying upon farming as their only source income and in areas of geographical difficulty.

Major constraints –

- Must have high strength to weight ratio
- Must be comfortable
- Must afford versatility
- Must be low cost
- Must be wearable
- Must be minimalist
- Must be easily cleaned/maintained/serviced

Success criteria –

- Must be wearable for the user
- Must allow for carrying/storage of desired items in a balanced manner
- Must be structurally strong
- Must be constructed using durable materials
- Must be low cost
- Must be durable
- Must afford flexible use of local optional components, such as baskets, bamboo poles, etc.

Feasibility study -

Cost: In order for this product to viable, it has to be of low cost. This will be achievable due to the minimalist design and therefore little or simple manufacturing requirements. Materials will be easy available and durable, with little focus upon aesthetics. This should result in low material cost coupled with the simple assembly techniques. Little or no finishing of the product is anticipated.

Time: The product is to be built as a one-off product and therefore substantial time will be allocated to focusing on its development. Excluding all other stages of its development, the product has a two week long period in which its production can be completed.

Facilities: The Design Technology labs within school provide a wide range of tools and machinery which are anticipated to cover the requirements of the design. Additionally, any potential outsourcing requirements are likely accessible wiithin Singapore.

Sustainability: The key feature is that the product is being built to last as long as possible, with durable main components, in additional to possible renewable optional local materials/parts. Production of a simple design is anticipated to produce minimal wastage of materials. Environmental impact is also hoped to be reduced via recycling at the end of the products usable life.

Scope: The product, aimed at improving physical work for rural farmers will easily meet the requirements for its successful development and use. The appropriate information and tools are believed to be available and the need evidently present.

Marketing specification:

Target audience –

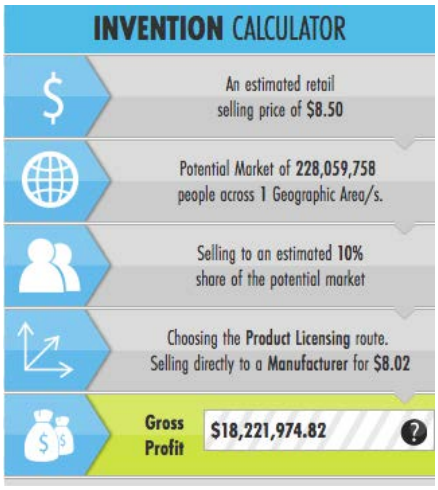
The target audience for this product are NGO's. The product will be aimed and sold to organisations that work with the rural farming communities as they have the access and presence within these hard to reach areas. Advertising, marketing and sale directly to the end user is likely un-realistic. However, the NGO's are able to distribute the life-improving product to a much larger community of subsistence farmers due to their established networks and other supportive programmes. Corporate or personal sponsorship covering production and distribution may also be considered at a later date.

Target market –

The actual targeted market of this product is for the independent farmers in rural and low developed areas. The product addresses a constant problem these individuals face daily and is simple to use. Thus adoption rate is anticipated to be high. The initial sale of the product at SG$8.50 to NGO's hopefully allows for large quantities of the product to be purchased and provided to the communities in need. The strive for low cost should also allow for the product to be sponsored or donated free to my target market via charitable or other donor networks, therefore expanding the market scope.

Market analysis –

Having previously conducted secondary research into the market characteristics within the area this product will be present, it is clear that competition is of minimal concern. The potential market for this product is large due to the large population of people reliant on farming as a source of income within developing countries and the current absence of this product type. Using the invention calculator to provide a rough predicted idea of the potential of the product the following information was considered.



Figures refer to production on a commercial scale: Machinery and labour (fixed costs), materials and energy (variable cost) will total SG$8. This is the manufacturing price. Licensing my product to a manufacturer I will earn a 10% royalty, resulting in SG$0.80 profit per unit. Only a small profit will be made as this product is of socially responsible nature. The product will be sold in one geographical area (SE Asia), covering a population of 228,059,758 people, of which 10% of the market is estimated to be reached. This is thought to be a realistic calculation for these purposes. These variables, result in an estimated gross profit of SG$18,221,974.82.

User need -

Absence of this product is evident and the current practices performed by rural farmers are of obvious ineffectiveness. An important aspect that will ensure this product is useful is its versatility. Farmers are tending to different crops and livestock, performing different infrastructure work, in different geographical conditions and seasons. Therefore a product that can offer some customizability and versatility is important.

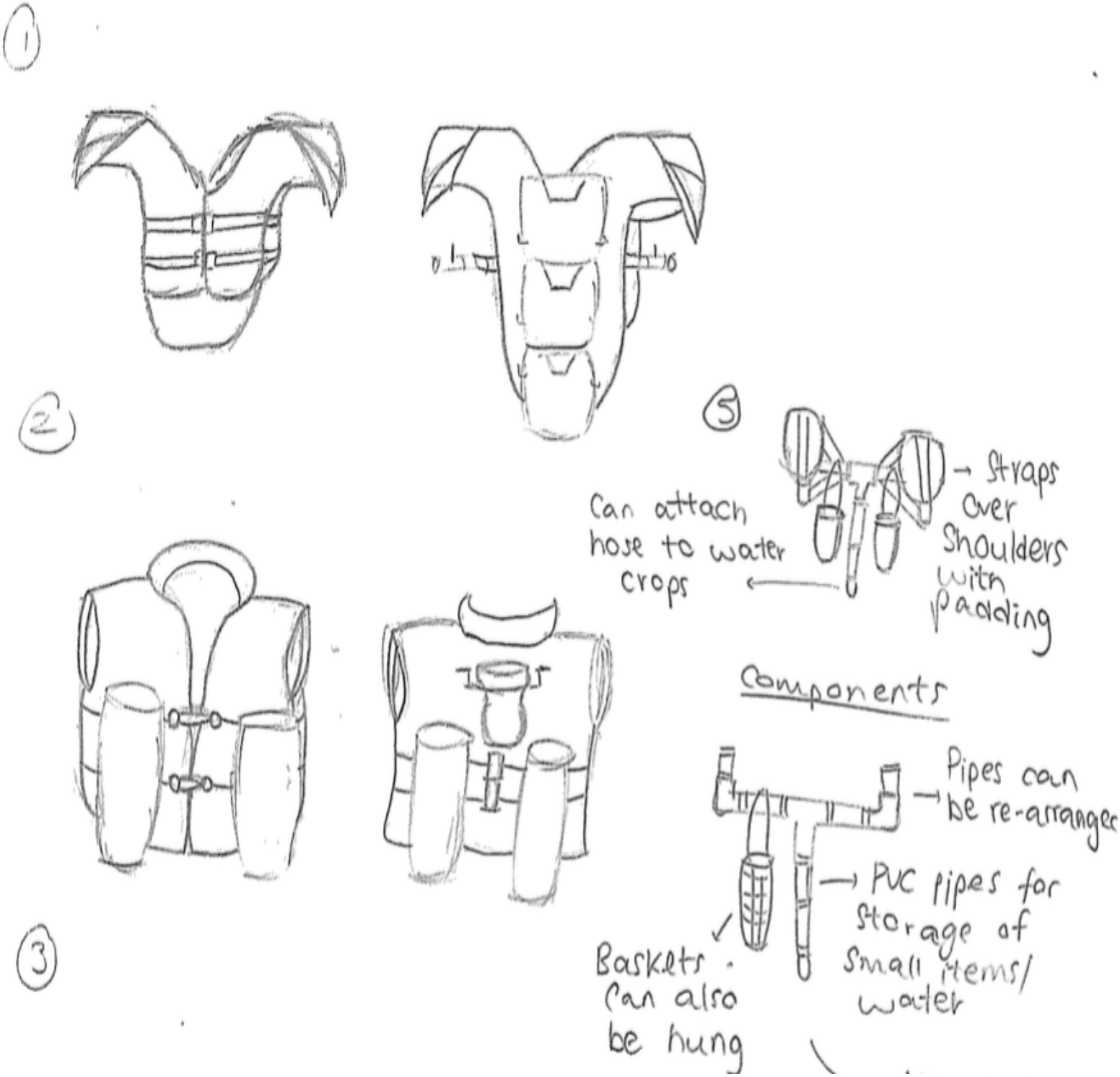
Design specification:

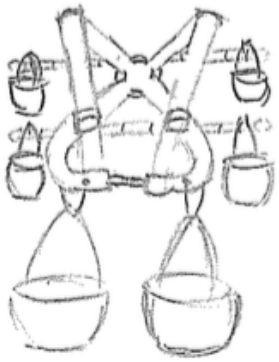
Specification	Requirement	Justification	Testing method
Function	1. It must be able to carry produce, materials and water 2. It must allow interchange of storage equipment 3. It must be wearable 4. It must hold required tools hands free	1. This is the purpose of the product 2. In order to accommodate the various items being transported 3. This is how the product will be used and transportation achieved 4. The tools will also require transport and connection to the product results in both hands being free and therefore increased safety	1. Physical test of all three categorical items placed within the storage components 2. Physical test of storage equipment interchangeability 3. Physical test of product being worn 4. Physical test to mimic tools being attached to the system
Aesthetic requirements	1. It must be of basic colour 2. It must be simple in design 3. It must be appealing to the target audience	1. This product is about functionality 2. In order to improve manufacturability as well as adoption and operation by the user 3. Achieving high sales to the target audience will increase revenue and availability	1. Visual inspection of colours used 2. User interview to establish the affordability 3. Interview to gain feedback of NGO's perception of the product
Customer requirements	1. It must be versatile 2. It must allow easy movement 3. It must be safe to use	1. In order to meet the extensive and changing needs 2. To allow easy and comfortable travel 3. Safety of the user is of utmost importance	1. User trial 2. Physical test to identify any restriction of movement 3. Physical test

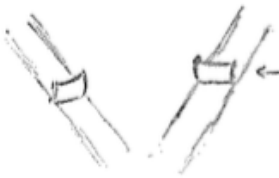
Performance requirements	1. It must be light 2. It must be strong/tough 3. It must allow placement and removal within the storage space	1. In order to ensure that despite the added payload, the load is able to be carried 2. In order to withstand the weight present without breaking 3. So that the user can use the product whilst wearing it	1. Physical test to gain weight perspective 2. Physical test to investigate extent the materials can withstand before damage 3. User trial to ensure desired items can be easily stored and removed as necessary
Environmental requirements	1. It must be made of durable materials 2. It must be made of renewable materials 3. It must be made of recyclable materials	1. In order to withstand the constant use in strenuous conditions 2. In order to ensure that what is consumed, is replenished for future use 3. So that after the products life, components are still of purpose and can be salvaged	1. Cannot be tested, requires long duration 2. Cannot be tested, refers to the end of the products usage life 3. Physical test of disassembly, with material separation available for recycling
Size constraints	1. It must be wearable over the shoulders 2. Storage size must be reasonable 3. It must fit the average 50th percentile (average male/female) measurements	1. As this is how it will be fitted 2. In order not to exceed a healthy/ manageable limit 3. This will ensure comfort for the largest number of users	1. Physical test of placement over/around shoulders 2. Physical test to ensure easy and comfortable long-term carrying 3. Measurement comparison between anthropometric research and product
Safety considerations	1. It must distribute weight evenly across body 2. It must allow hands to be free 3. It must be easily attachable/detachable	1. In order to ensure ergonomic use and distributed pressure on body/muscles 2. In order to allow use of hands and protection if falling/slipping 3. To ensure product and items remain intact and removal if necessary	1. Physical model user test 2. User trial to demonstrate ability to maintain hands free for other tasks 3. Physical test of wearing/removing of the product with little hassle and unaided
Material requirements	1. It should be low cost 2. It should be largely locally source-able 3. It should be weather resistant	1. So that the product cost remains low and it a viable solution 2. Allowing components to be sourced by users from their local area 3. To ensure it works within the environment it will be exposed to	1. Total costs low and reasonable 2. User interview for feedback to see if this characteristic was successful 3. Physical test confirms durability of materials in poor weather conditions
Manufacturing requirements	1. It must be made using processes available in the school workshop 2. It must require the minimum of manufacturing processes 3. It must allow for disassembly	1. This is what is available for the initial production of this product 2. As to increase simplicity of production and reduce energy usage 3. In order to allow replacement of components by the user if necessary	1. Physical test that will be ongoing and conducted during product manufacture 2. Observation of total techniques used 3. User trial of component separation

CRITERION B: CONCEPTUAL DESIGN.

Idea development and refinement:

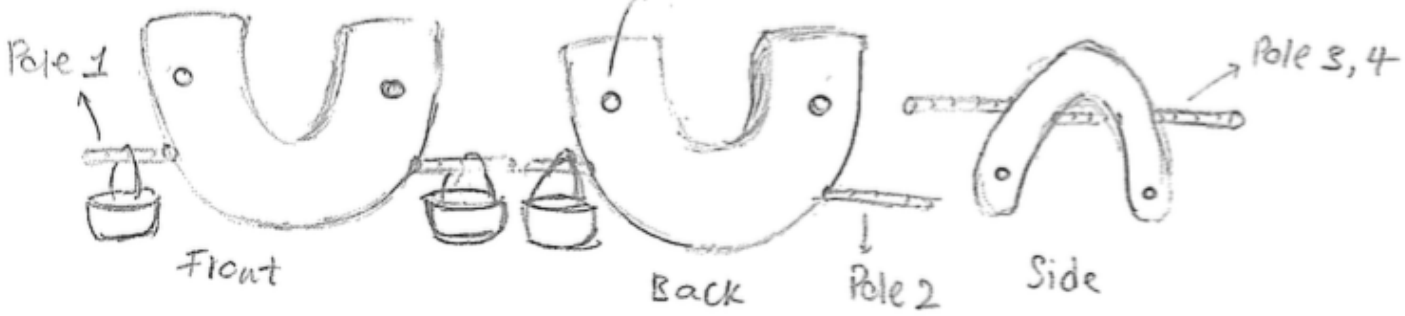




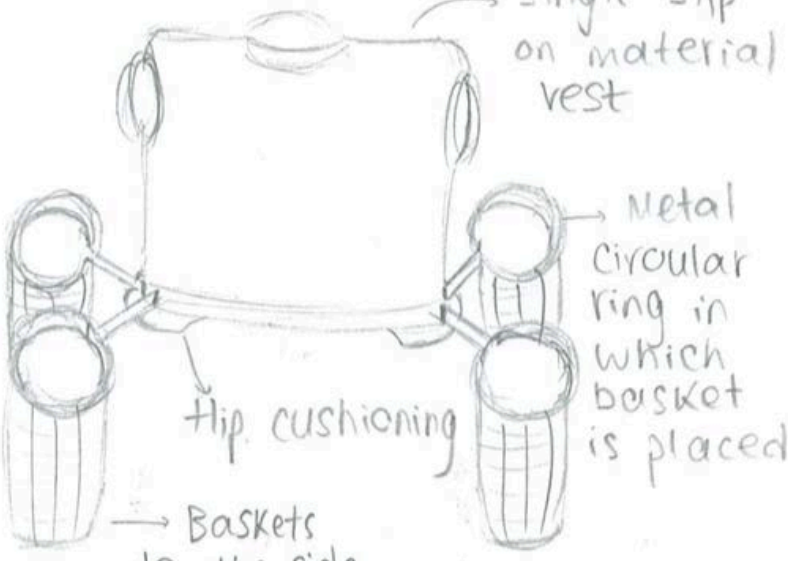


Attach to Shoulder through straps/ padding for comfort

④



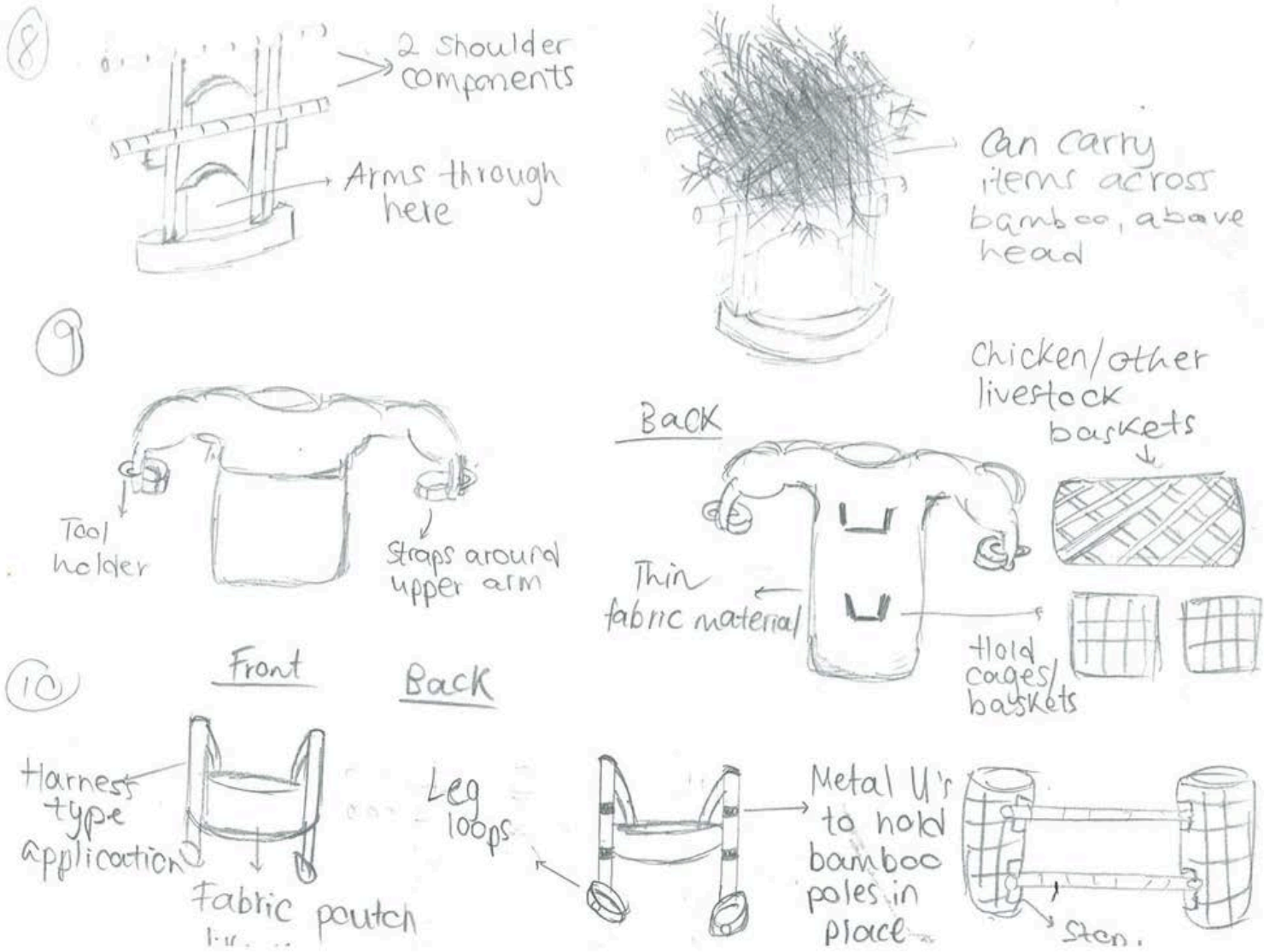
⑥



⑦

Back

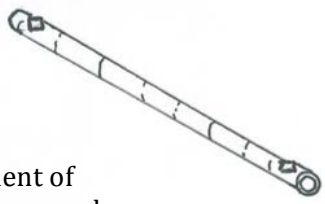
Large materials basket



Bamboo design adjustments:

In testing the use of bamboo poles as a method of carrying items, it was immediately evident that when traversing uneven ground the baskets (in this example) could slide, causing weight distribution problems.

A simple solution in preventing storage containers falling off would be to chop a section at the end of the bamboo and place a wooden stopper.



In preventing directional movement of storage containers a diamond shape wedge should be removed from the top surface of the bamboo, this will provide a depression in which handles or string may remain secure during transportation.

Design 1 (Initial 1 + 2)

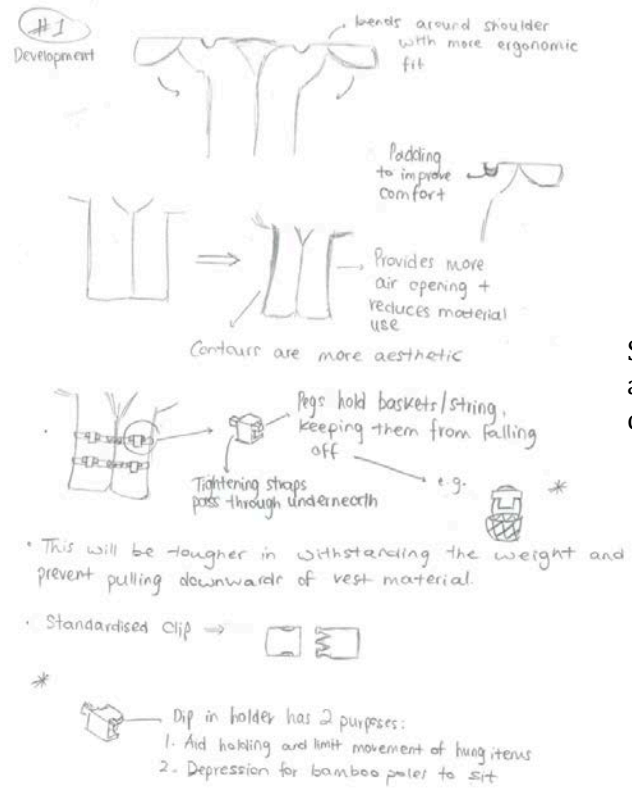
Visual model of vest, with added elements on sleeves, in order to provide better sleeve ergonomics and functionality as the straps now hold users arms.

Main vest body is made of a single component and therefore reduces complex manufacturing and structural weaknesses

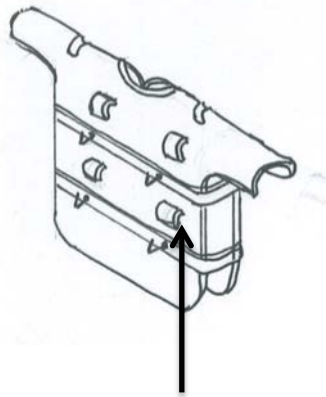
Cushioned depressions in which counter balanced items such as hay bales can be loaded/strung.

Tightening straps pass around the vest to provide secure fit and therefore improved comfort.

Standard hooks bolted through vest providing hold for hang-able items.



Standard harness clip for easy attachment and removal, this component is also a low cost item.



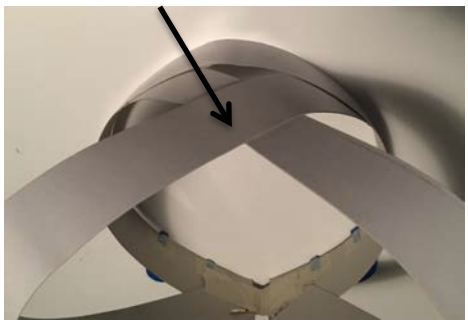
Back view of vest showing stitched U components through which bamboo poles will be slotted.

Design 2 (Initial 3)

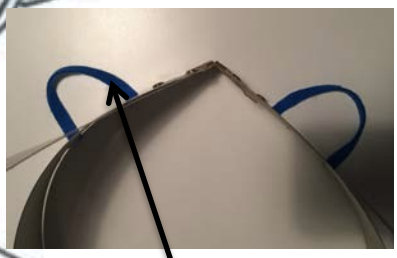
Back view:

Aluminum pipes/rounds will be used in order to provide a secure resting platform for bamboo poles.

Harness elements are adjustable and remain secure due to back plate. The model below identified this problem, with evidence that the harness was too difficult to adjust evenly without it.



Stitching of components is necessary within this design. I therefore experimented with the stitching machine available at the school workshop, varying applicable stitches.



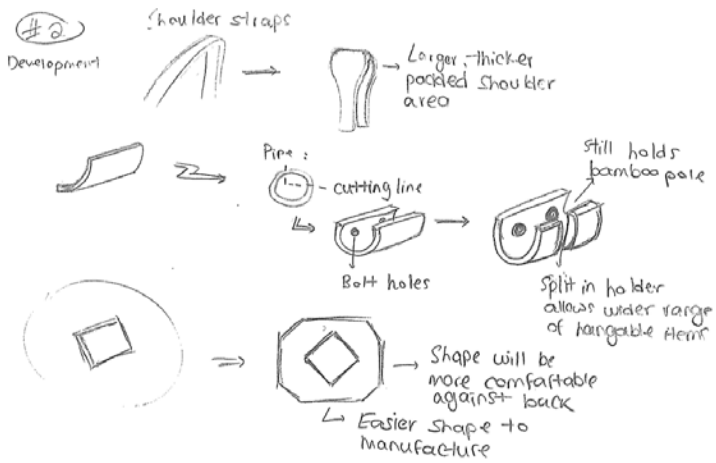
Harness provides two slots for handheld tools to be stored and carried.

Straps allow for hanging of various storage containers as well as other items.

Model highlighted adaption of harness to a squarer like shape in order to rest over the shoulders better. Also resulted in easier attachment of hanging components.

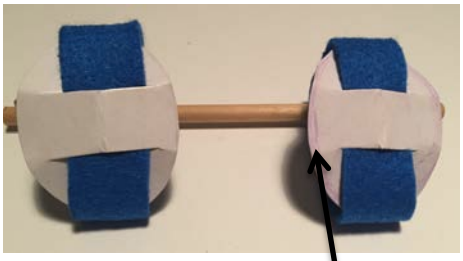
Standard tightening buckles providing easy adjustability.

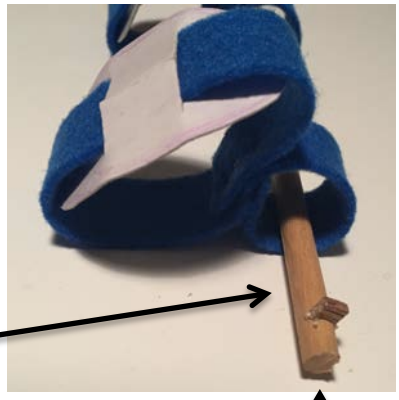
Models demonstrate the connection of components with different materials and its relative simplicity.



Design 3 (Initial 5)

Design just using synthetic material reduces overall weight, improving transportability.

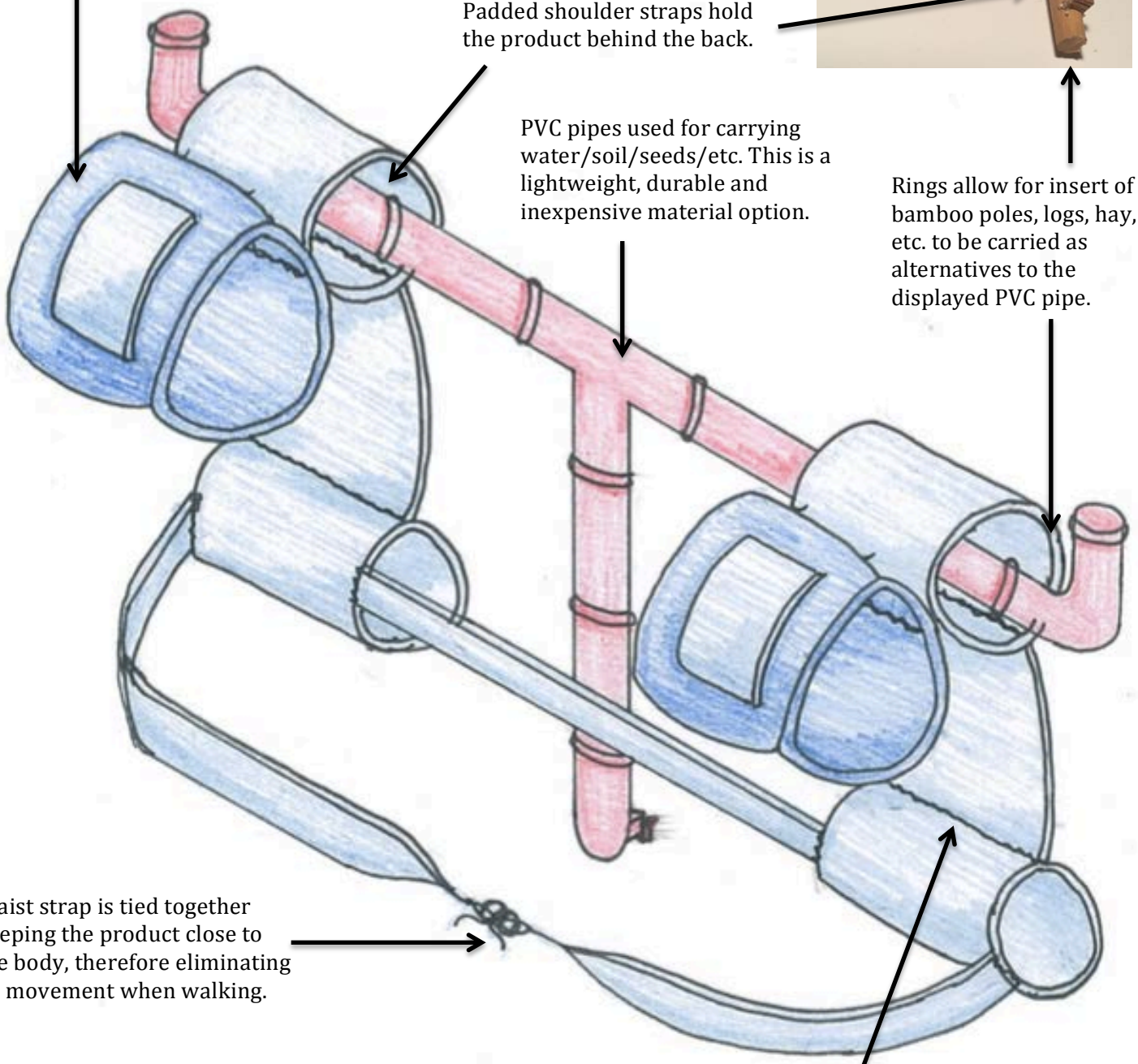




Padded shoulder straps hold the product behind the back.

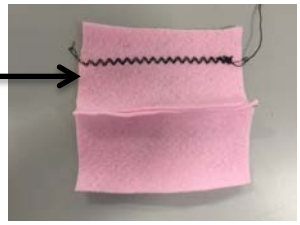
PVC pipes used for carrying water/soil/seeds/etc. This is a lightweight, durable and inexpensive material option.

Rings allow for insert of bamboo poles, logs, hay, etc. to be carried as alternatives to the displayed PVC pipe.



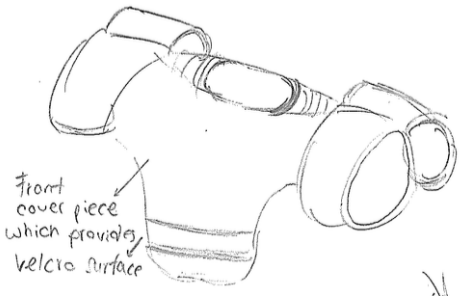
Waist strap is tied together keeping the product close to the body, therefore eliminating its movement when walking.

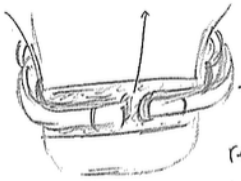
Stitching of components is necessary within this design and I therefore experimented with the stitching machine available within the school workshop and varying stitches applicable.

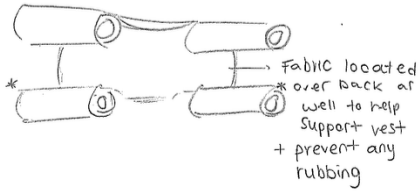


#3
Development

Partial front view :

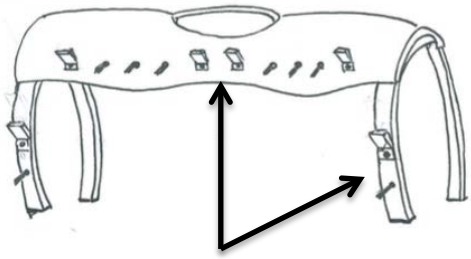




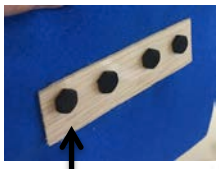


Design 4 (Initial 6 + 10)

Thick padded shoulder component ensures the users are able to carry heavy weights whilst not hurting their shoulders.

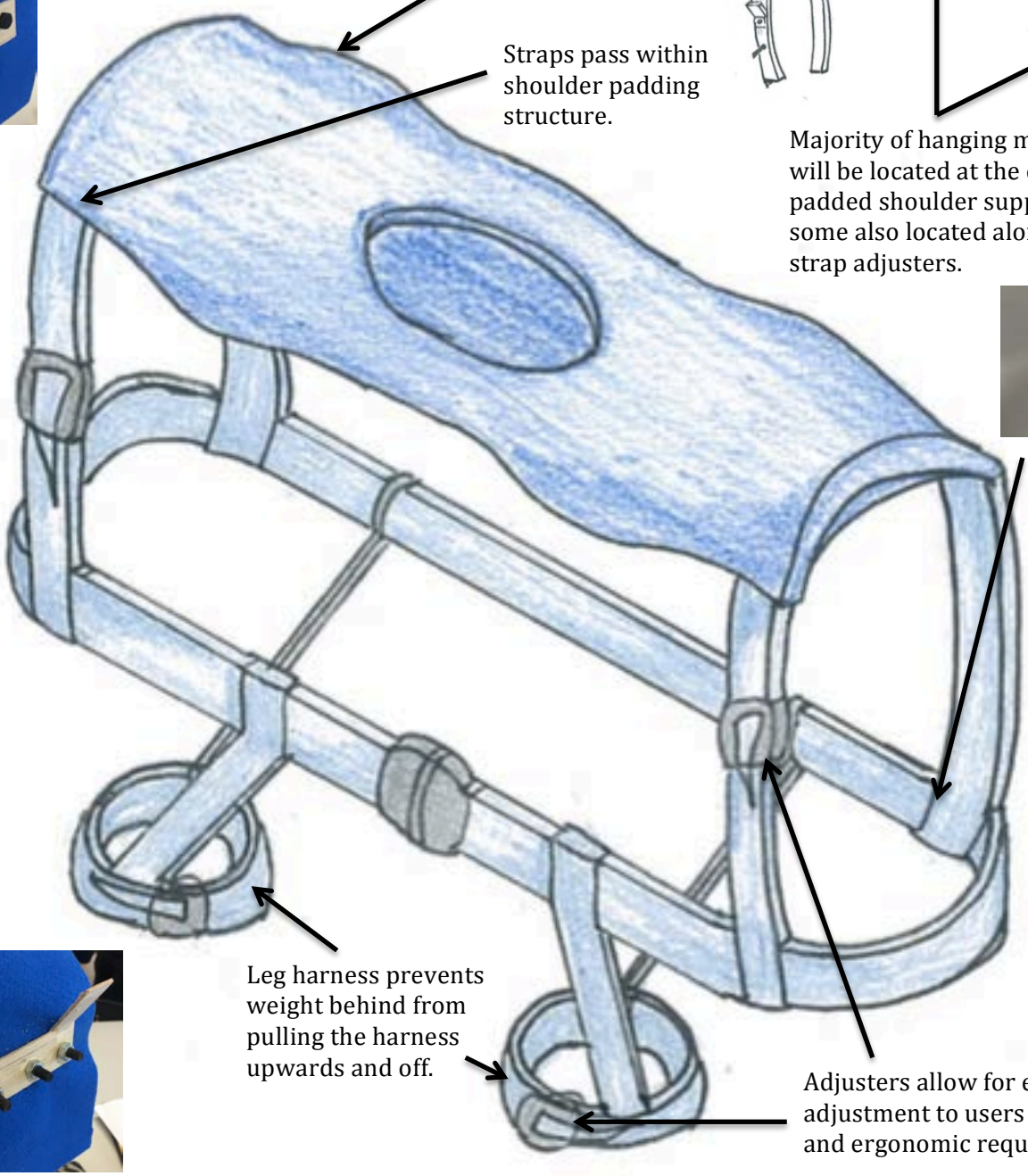


Straps pass within shoulder padding structure.

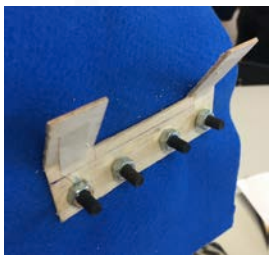


Majority of hanging mechanisms will be located at the edge of the padded shoulder support, with some also located along the back strap adjusters.

Flat head bolts will be used in order to ensure sufficient tensile strength and durability. The flat head still however will provide discomfort and therefore further solutions need to be explored.



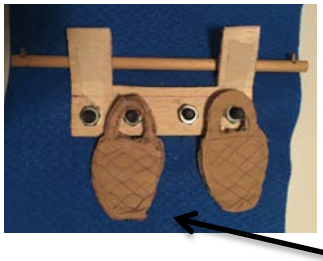
Stitching of components is necessary within this design and I therefore experimented with the stitching machine available within the school workshop and varying stitches applicable.

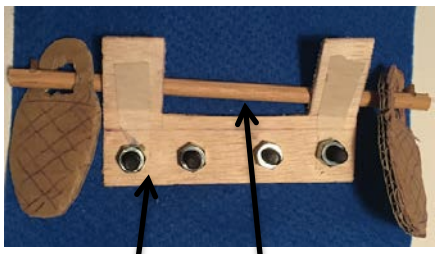


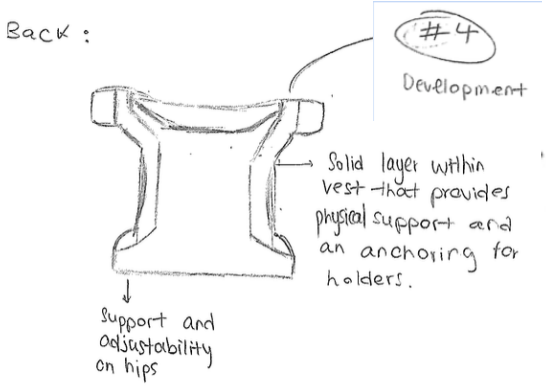
Leg harness prevents weight behind from pulling the harness upwards and off.

Adjusters allow for easy adjustment to users physical size and ergonomic requirements.

Holding components will be lightweight and tough and having a piece on either side of the harness material will maintain its position as connection purely though the fabric will result in eventual wearing away and movement when carrying weight.

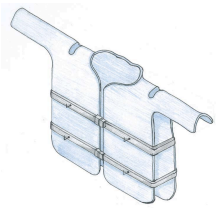
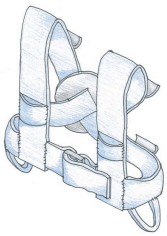
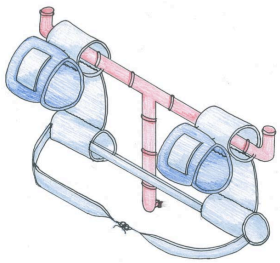
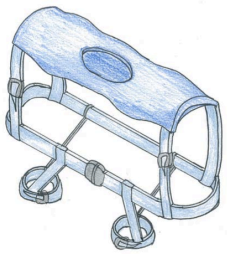






Attached hanging components will provide versatility in what is carried, be it a bamboo pole or basket. Sufficient quantity is also catered for in ensuring reduced trip numbers to transport what is necessary.

Appraisal of ideas against specification requirements:

Specification	Design 1 (developed)	Design 2 (developed)	Design 3 (developed)	Design 4 (developed)
				
Function – 1. It must be able to carry produce, materials and water 2. It must allow interchanging of storage equipment 3. It must be wearable 4. It must hold required tools hands free	Design is simple and functional, with available versatility of storage equipment. It affords easy wearing. However, does not provide components for tool holding. Score = 7 User feedback: Nice looking and comfortable	Design is simple, highly functional. Easily worn & comfortable for long-term use. Equipment interchangeability is slightly limited, but possible with the use of bamboo poles. Design provides tool-holding loops. Score = 9 User opinion: Most functional design	Product can carry all necessary items, including water, which can be stored within a PVC pipe. Other equipment can be carried along with bamboo. However, tools not so. It is worn on the shoulders only and cannot hold tools hand free. Score = 7 User feedback: May be uncomfortable across shoulders	Design is functional and versatile with or without bamboo poles, allowing easy interchanging of storage element. Wear-ability of this is slightly more complex as it requires leg fastening and is harder to remove. Two tool holds are provided. Score = 6
Aesthetic requirements - 1. It must be of basic colour 2. It must be simple in design 3. It must be appealing to the target audience	Blue and black colours are used throughout the products main components and simple design. The aesthetic shape of the design makes it recognizable, like a jacket, and therefore appealing. Score = 8	Blue and black colours are used throughout the products main components and simple design. Its harness structure aids acceptance and aesthetic benefits due to minimal necessary additions. Score = 9	Blue and black colours are used throughout the products main components and design. The design is complex in physical appearance but not in use. However, this reduces its initial appeal. Score = 7 User feedback: The most interesting looking design	Blue and black colours are used throughout the products main components and design. The design is relatively complicated. However, ergonomically structured and elegantly designed. Score = 8
Customer requirements – 1. It must be versatile 2. It must allow easy movement 3. It must be safe to use	Hangers allow versatility of use. But, movement may be restricted due to the amount of material used, especially for shoulder and arm movements. It is safe, providing padding where necessary, distributed weight throughout the upper body and remains attached	Bamboo pole holders and side hangers provide versatility in use, simplistic design allows for easy open and free movement that is safe due to the easy wearing and adjustability to the user. Score = 8 User feedback: Fits user requirements	The design requires bamboo pole use in order to be versatile. Movement is easy, yet may be restricted due to the way in which the product rests only on the users shoulders. The product is safe to use due to the padding, connection of material and components maintains stability and is connected to the waist via a strap.	Storage holders and their locations offer great versatility. Movement is easy, but may be slightly restricted in walking movement, although the leg-tightening component does improve the products safety for the individual. Score = 7 User feedback: seems awakward to wear

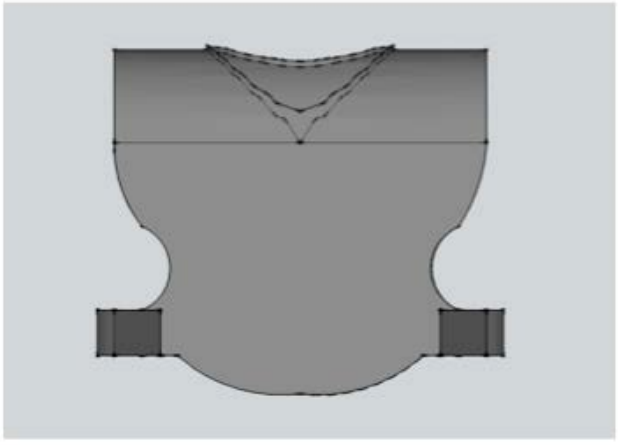
	to the body via waist clips. Score = 7		Score = 6	
Performance requirements - 1. It must be light 2. It must be strong/tough 3. It must allow placement and removal in the storage space	Product is light, material tough with no joints in the main component and hangers allow easy placement and removal. Score = 9 User feedback: lightweight and strong	Product is very light, material tough, although with many stitched joints on the main wearable component. Hangers allow easy placement and removal. Score = 8	Product is light, material tough. However, with many joints that will be under prolonged stress. Storage holds allow easy placement and removal. Score = 6	Product is light although consists of large padding, the material used is tough. With the combination of tightening joints, product offers a range of storage placements, resulting in ease of use. Score = 7
Environmental requirements - 1. It must be made of durable materials 2. It must be made of renewable materials 3. It must be made of recyclable materials	Materials used are highly durable, smaller components are renewable and all recyclable or re-usable. Score = 6	Materials used are highly durable, smaller components are renewable and all recyclable or re-usable. Score = 6 User feedback: seems awkward to wear	Materials used are highly durable, smaller components are renewable and all recyclable or re-usable. Score = 6	Materials used are highly durable, smaller components are renewable and all recyclable or re-usable. Score = 6
Size constraints - 1. It must be wearable over the shoulders 2. Storage size must be reasonable 3. It must fit the average 50th percentile measurements	Product is worn over the shoulders and designed to dimensions of the 50th percentile user, with sufficient provision for storage space attachment. Score = 9	Product is worn over the shoulders and designed to dimensions of the 50th percentile user, with sufficient provision for storage space attachment. Score = 9	Product is worn over the shoulders and designed to dimensions of the 50th percentile user, with sufficient provision for storage space attachment. Score = 9	Product is worn over the shoulders and designed to dimensions of the 50th percentile user, with sufficient provision for storage space attachment. Score = 9
Safety considerations – 1. It must distribute weight evenly across body 2. It must allow hands to be free 3. It must be easily attachable/detachable	Weight is distributed across the body due to the vest structure. Hands remain free as the vest is attached via adjustable clips and therefore also easily attached/detached. Score = 9 User feedback: Safety is vital. This design looks safe/easy to use	Weight is distributed throughout the harnesses contact with the upper body. Hands remain free due to its attachment to the body and its simple front adjustment allows means the product can be slipped on and off. Score = 8	Weight is largely focused upon the shoulders and somewhat down the back of the user. Hands remain free and the product is easily removed from the shoulders and the waist strap untied. Score = 7	Weight is well distributed along the upper body padding and hands free due to its placement over the body. This design is not easily put on or removed, as there are several connection points with the body, including to the upper legs. Score = 6

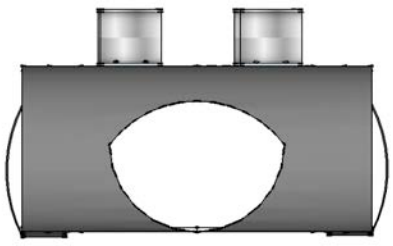
Material requirements - 1. It should be low cost 2. It should be largely locally source-able 3. It should be weather resistant	Materials are all low cost, especially the smaller joined components. The vest itself is not locally source-able. However, the various storage elements are. All materials are weather resistant. Score = 7	Materials are all low cost, especially the smaller joined components. Benefits from minimal material required for the design. The harness itself is not locally source-able, however storage elements are. All materials are weather resistant. Score = 8	Materials are all low cost, especially the smaller joined components. The main body part itself, is not locally source-able. Likewise, the PVC pipe section in unavailable locally. All materials are weather resistant. Score = 5	Materials are all low cost, especially the smaller joined components. The main shoulder section, which constitutes a key element of the design, is not locally source-able. All materials are weather resistant. Score = 6
Manufacturing requirements - 1. It must be made using processes available in the school workshop 2. It must require minimal manufacturing processes 3. It must allow for disassembly	Largely cutting, fixing and stitching methods required to manufacture the product. Simple disassembly, apart from stitched areas would require cutting. Score = 7	Cutting and sewing with limited variation in materials used. Disassembly is easy due to the minimal joining methods, aside from stitching. Score = 8	Cutting, stitching (available within the school workshop), keeps simplified manufacture. PVC pipe section requires cutting, measuring and gluing. Disassembly is difficult for the padded shoulders. Score = 6	Cutting and stitching. Note the padding and harness material are not joined together, and thus allow easy disassembly. Score = 8
Total score =	69/90	73/90	59/90	63/90

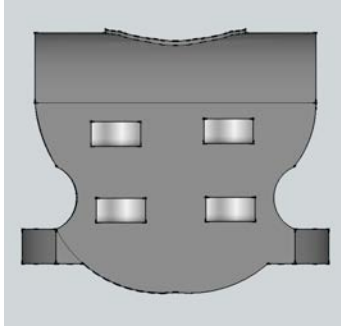
Justification of chosen ideas:

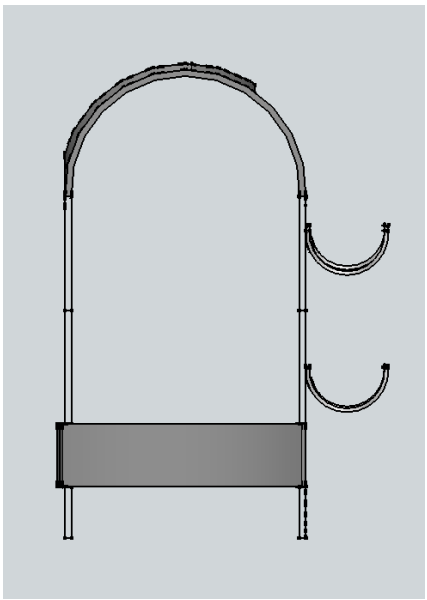
Product designs were scored out of ten within each specification category, allowing for a maximum score of 90 overall. Designs closest to this score best achieve the required capabilities of the desired product. Designs 1 and 2 both scored highly, with 69/90 and 73/90 respectively, although with differing attributes. While design 2 scored the highest and key elements will be taken forward, this will be in conjunction with aspects of design 1. This approach allows for the ability to render a better-combined design and delivers the key aspects highlighted by my client, namely an aesthetic, comfortable and safe product.

CAD model of chosen final design:









CRITERION C: DEVELOPMENT OF A DETAILED DESIGN.

Design development approach –

My earlier design appraisal and evaluation suggests there may be some benefit in considering further product development in three bespoke parts, rather than the product as a one whole. I will therefore look to develop, evaluate and test my initial design ideas by breaking the overall product down into three segments. The three segments correspond to key criterion specified in my primary idea research and are supported by the interview responses received from World Volunteer representative Non. Firstly there is the section or part of my product that is required to provide comfort, usability and protection or safety for the user – the 'vest'. Secondly there is the load bearing, weight support structure, or 'shoulder supports'. Thirdly, the parts to allow baskets and other load carrying devices to be carried - the 'attachments'.

My design development, prototyping and testing will focus mainly upon the first two segments. It is expected that the variety of baskets, pots, jars and other load carrying devices will be those already in use within the local communities of the target users. My product will provide a variety of universal attachments, hooks, loops and fastenings for such locally made storage items. However, the provision of these at the local level is more appropriate to ensure they function as required, will enhance sustainability by using local materials, keep the product costs down and maintain cultural traditions, ultimately increasing my products acceptance in the field.

Conceptual design –

Prototype – Torso vest:

Initial design 1 and 2 proved not strong enough. Issues like load spreading, sagging, hooks and fastenings pulling through or ripping padding/polyester fabrics. These were not sufficiently substantial in achieving required weights. Alternative materials were therefore explored, demonstrated later within this section. A sample of typical multi-layered synthetic padding is pictured below. Note the water resistant outer skin and inner two layers of padding.




My early modeling of a design most similar to design idea 2, one largely constructed of 5cm polyester webbing, quickly highlighted two significant design flaws. I was able via outsourcing (amazon.com) to acquire several lengths of polyester webbing (similar to car seat-belt like straps), and therefore could prototype the harness design shown in idea 2 at 1:1 full scale. As can be seen from the photos below, the harness-model suffered from,
i) Being too complex for the target end user to wear, lost its shape and became easily tangled, and
ii) Suffered from sagging and tearing when the U-shape carrying attachments were affixed.

Design idea 1 utilised a padded polyester material. At the time of prototyping I was unable to procure new rolls or sheets of material. However, I did find that this material was readily available on the mass-consumer leisure market, it being extensively used in the manufacture of bags, rucksacks and a variety of sports safety equipment (e.g. hockey protective pads). Such availability allowed me to recycle a chest/torso protective hockey vest and therefore expand the design development via a 1:1 full-scale model. The photos here demonstrate,
i) A greater level of simplicity, with the 'vest' simply being placed over the head,
ii) A much higher level of comfort, protection and therefore safety for the user, most notably by avoiding carried items banging or pressing directly onto the user's body, and
iii) Providing a larger flat secure surface area for the attachment/stitching of the nylon web load-bearing support guides/loops. Note the strength and aesthetic results achieved where the polyester straps affix the 'vest' through industrial stitching. An added advantage of the single piece torso vest is the ability to provide a central chest space for logo or sponsorship placement, in which to encourage funding for manufacture and distribution through company investment (to be explored later).



In addition to testing some key construction and fixing techniques proposed in the initial design proposal and noted above, the full-scale modeling helped ensure appropriate user measurements could be assessed and concluded. Other general aspects noted in my early product research could also be assessed, such as user (human) comfort and freedom of movement and the weatherproof efficiency. A scaled model would not have achieved all these. Waist straps, secured with Velcro tape to each side, will secure the torso vest at the hip or waist area.

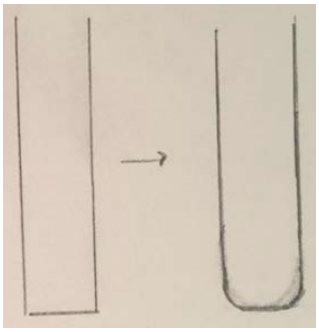
Prototype – Shoulder supports (load bearing):

Having modeled and tested the torso vest initial design ideas, it became apparent that an additional structure would be needed to add rigidity and strength. While design ideas had initially considered natural materials (e.g. bamboo, cane, reed, wood) these are somewhat prone to cracking/splitting, and may not ultimately be sufficiently weather proof as they tend to swell/warp, and so bear less load. Therefore, aluminum sheet material was selected due to its lightweight, malleability, strength, corrosion/weather resistance and availability in the school workshop. Carbon fiber could have been the most ideal load bearing structure, whilst this material offers lightweight and extreme strength, it is very expensive and requires a complex manufacturing process and therefore was dismissed as impractical for this products specification. I was able to model 1:1 full-scale prototypes for the over the shoulder load-bearing section. My tests found that whilst the 3cm wide aluminum strips were lighter and saved material costs, they tended to 'dig' into or pressure the shoulder when a load bearing weight was added. My prototype model also demonstrated that the width provided insufficient surface or strength to attach the U-shape load carrying 'attachments' (see later). The 7cm wide aluminum sheet strip performed much better in regards to comfort, vertical structural stability and attachment fixing points.





The prototype raised two design idea shortcomings. Firstly, the length was insufficient, particularly at the rear. Extending the aluminum strip will offer greater flexibility to attach load and tool fixings and increase comfort and protection to the lower back for the user. The increased material quantity does of course slightly increase production costs. Corners and edges will need to be filed and rounded for safety as sketched below.



Carried loads may hang below the provided metal support strips. Therefore they should be extended in length over the lower back, extending to the upper section of the hipbone.

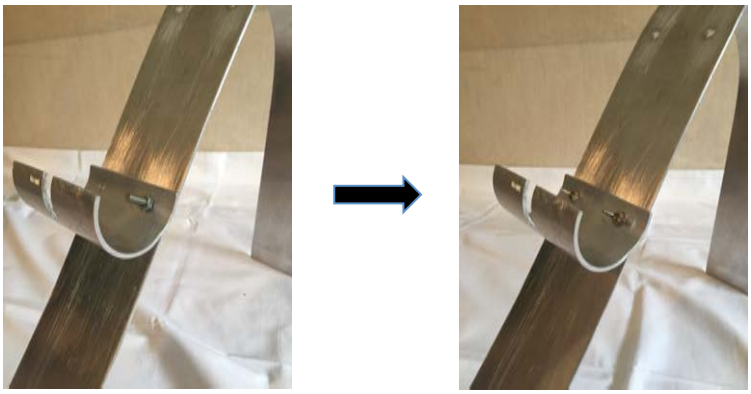

A simple clip system that allows for both the securing of the aluminum load supports, and for their placement/removal proved a successful design development at the top of the shoulders. The clips are secured to the vest by being stitched underneath the vest. Care must be taken to ensure that this stitching does not cause discomfort for the user when loads are being carried, as it is throughout the shoulders that the main pressure of the payload will be borne. The vest shoulder clip is pictured below.



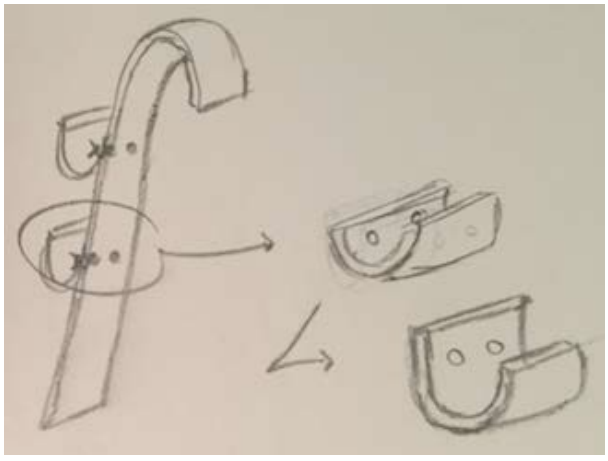
Prototype – Attachments (for load carrying and tool fixtures/fittings):

Initial prototyping lead me to focus upon two types of attachment. One is secured to the aluminium shoulder supports, designed to carry and secure the heavy loads (i.e. ~25kg). The other attachment is for carrying of smaller lighter items, and to secure tools 'hands-free'. These attachments will be secured to the torso vest.

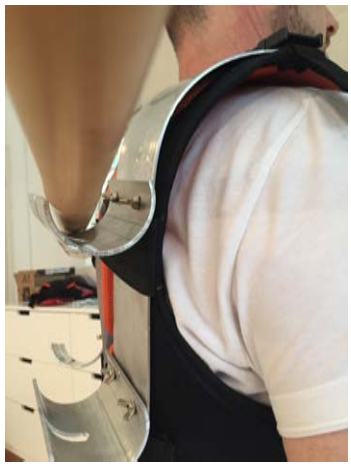
U-shape load carrying attachment – the initial design location of the screws and bolts resulted in fouling of bamboo poles. They also proved difficult to tighten with the required screwdriver and spanner/wrench. Further, it was thought that the need for a screwdriver and spanner/wrench increases the complexity of assembly and such tools may not be available to the rural target user. Therefore wing nuts that can be tightened by hand were considered as an alternative design development, in conjunction with smaller bolt/screw lengths.

Improving the fixation or seating of the U-shape pipe shape bamboo pole holder was also identified as an area of needed improvement. The curvature of the U-pipe hindered the conformity of the joint, its overall strength, as well as resting of the bamboo poles placed upon it. The solution explored was to bend the aluminum semi-circle cut pipe, creating a flattened side to one side of the U-pipe. This flat section rests in place against the aluminium support strip providing a more secure face-to-face fixing with the bolt/screw. The suggested design improvement is sketched below.

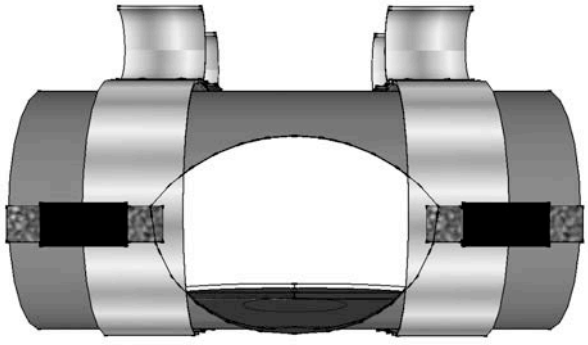



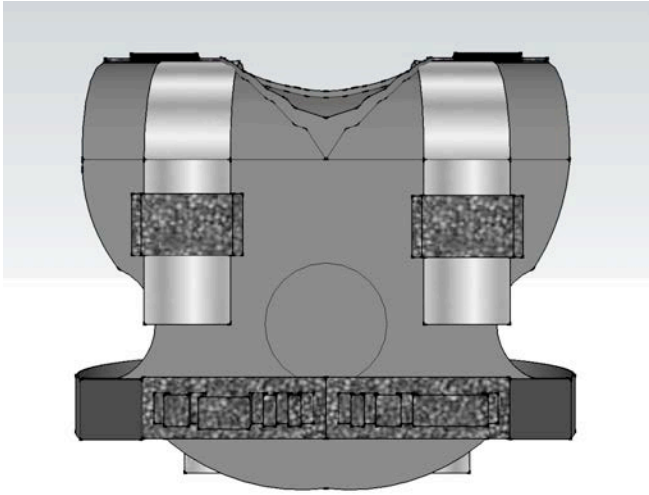
Due to the nature of the human body, our shoulders tend to round downwards. This affects the profile or vertical positioning of the aluminium supports down the back (see photos below). The angle and location of the two 5cm nylon stitched support loops at the rear of the vest needs to make allowance for such body/shoulder profile. Further, the U-pipe attachments can be fixed at a small (~10°) angle onto the aluminium support strips, thus ensuring a better horizontal fit or resting for the bamboo carrying pole.

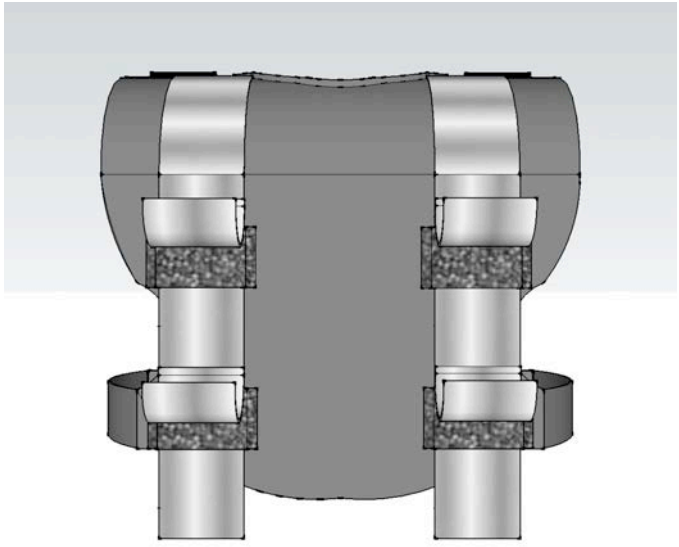


The 1-to-1 scale model of the torso vest prototype ultimately proved to be too short. As noted earlier, it did not extend sufficiently to the waist/upper hipbone area to afford protection. The short length also failed to provided space to model attachments fixed or stitched to the lower part of the torso vest. However, such attachments would be similar in design and construction as the stitched-nylon webbing support loops and the clip stitched to the top of the shoulder area. A variety of simple stitched loops utilising both the 2.5cm and 5cm nylon webbing material is proposed, and would be stitched to the lower torso vest waistband section. These will accommodate various hand-tools.

CAD with design changes:

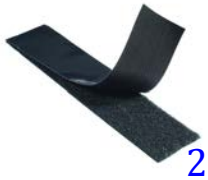






Justification of material and components:

Material/Component	Justification
Torso vest (multi-layer padded synthetic 5mm thickness) 	The main torso vest will be cut and shaped from a single flat piece or roll of 5mm multi-layer padded synthetic material. This material offers lateral strength, lightweight, washable, and weatherproof capabilities. It also provided comfort and protection to the body.
Load support track (nylon webbing standard sizing, two different widths being used, 50mm and 25mm)  15	This material is available in varying standard widths and I have chosen to utilize 50mm wide as it provides the necessary depth for support and strength. The webbing is easily stitched to the synthetic torso vest material and does not give or stretch.
Standard buckle clip (polyoxymethylene, 60mm x 30mm)  16	These clips are cheap and readily available, commonly used in sports equipment/ruck-sack manufacture. In the product this will be secured with the nylon web strapping sewn to the torso vest. This plastic has a crystalline structure and is thermoplastic, making it sustainable and well engineered.
Shoulder load bearing supports (aluminum sheet 2mm thick x 70mm wide x 705mm long)  17	Aluminum sheet material is readily available within the school workshop as are the tools to cut, shape, finish and drill. Aluminum sheet of 2mm was selected providing sufficient malleability to form the shoulder shape required, yet retain sufficient rigidity for the fixing of the load bearing attachments. This metal offers corrosion and weather resistance necessary for its prolonged exterior use and is lightweight. Post product life recycling is possible.
U-support attachment (aluminum pipe 3mm thick x 80mm diameter)  18	Aluminum pipe is readily available within the school workshop as are the tools required to cut, shape, finish and drill. The thickness of the tube chosen provides sufficient rigidity to withstand the force that will be applied via the carried loads. Further, the aluminum pipe can be drilled and bolted easily to the aluminum shoulder load bearing supports. Later recycling is possible.

Bolts & wing nuts (steel 10mm length M6 bolts + M6 wing-nuts)  19	These components are standardised, cheap and readily available. Steel offers the necessary shear strength to withstand the estimated carrying capacity of 25kg and hold the components in place. I have opted for the use of wing nuts over standard nuts as this offers easier self-assembly without the provision of additional tools.
Tool belt/additional attachments/universal loops (nylon webbing standard sizing, two different widths being used, 50mm and 25mm)  15	This material is available in varying standard widths and I have chosen to utilize 25mm as it provides the necessary support and strength. The webbing is easily stitched to the synthetic torso vest material and capable of holding the various tools with a friction fit. The additional carrying clips are cheap and readily available and commonly used in sports equipment/ruck-sack manufacture. In the product this will be secured with the nylon web strapping sewn in loops to the torso vest, allowing for the tools necessary by the user to be carried.
Velcro tape (standard 50mm x 50mm square)  20	Velcro squares sewn to waist fastening straps of torso vest. This minor component is cheap and freely available. Easily sewn to the nylon webbing and multi-layer torso padded material. Allows for multiple/repetitive use with minimal wear and tear or maintenance.

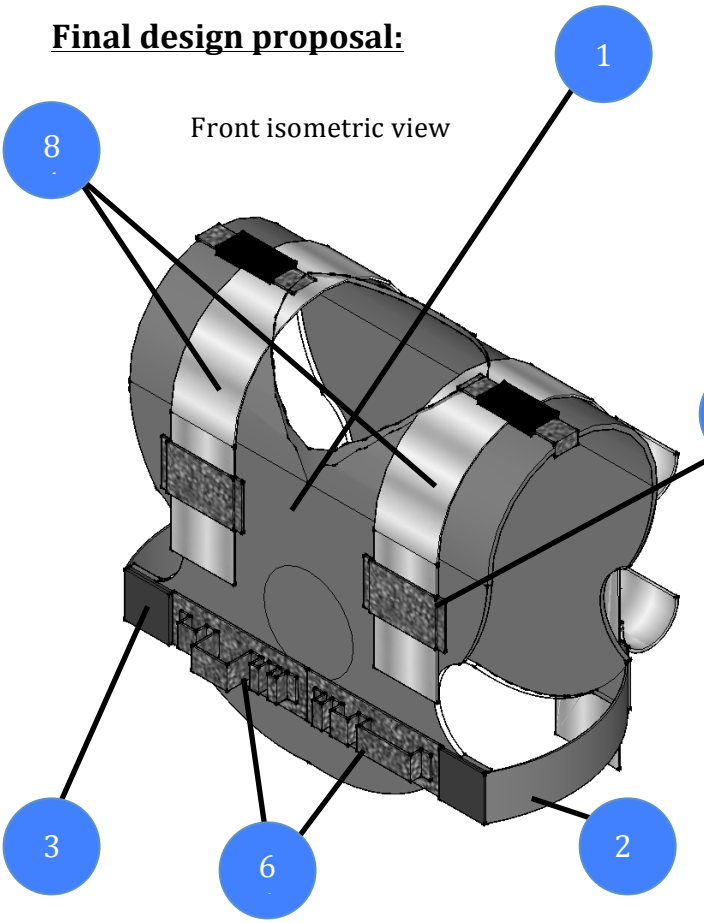
Justification of manufacturing processes:

Process - material/component	**Justification**
Textile cutting machine – multi-layer padded synthetic torso vest, nylon web strapping  21	This machine is available via outsourcing and relatively easy to use. Production of a one off prototype, or larger batch quantities possible. Machine is precise and able to cut the multi-layer padded synthetic material to a high degree of accuracy/tolerance, allowing for seaming and stitching of the materials.
Industrial stitching – multi-layer padded synthetic torso vest, nylon web strapping  22	This provides a permanent joining method, which is obscure and strong, maintaining a good aesthetic appearance. This process is preferable to gluing or stapling, with reduced likelihood of corrosion or failure of joints. Stitching is lightweight, relatively cheap and requires less energy expenditure or technical skill.
Jig-sawing – aluminum shoulder load bearing supports, aluminum U pipes  23	2mm aluminum sheets need to be cut into rectangles with 2 long parallel surface lengths (7mm wide x 705mm long). The jigsaw is easy to use, can achieve parallel/straight lines along the lengths necessary for this components specification. This tool is available within the school workshop and can achieve a near finished edge. The jigsaw can also be used to cut along the curved length of the aluminium pipe to manufacture the U-support attachment piece.

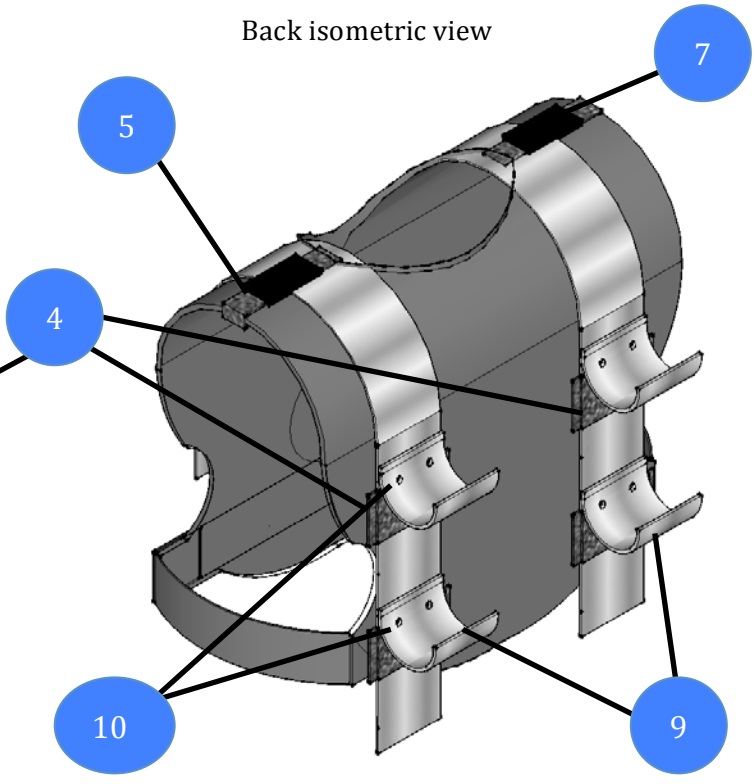
Pillar drilling – aluminum load bearing supports, aluminum U-pipes  24	Pillar drilling is a simple, accurate piece of equipment that will ensure perpendicular drilled holes through the aluminum material. The desired 6mm hole size can be chosen and drilled, with just some potential flashing to be removed via filing as a result of this process.
Metal roller – aluminum shoulder load bearing supports  25	Available in the school workshop, this device will be used in order to methodically bend or curve the aluminum shoulder load bearing supports into the component shape that will rest over the shoulders. This manufacturing technique uses human energy to achieve the end result and causes no damage to the material.
Magnabend – aluminum U-pipes  26	Magnabend forms aluminum U-pipes to provide a flatter surface on one side of the semi-circle tube, allowing for improved alignment when attaching to the shoulder load bearing supports with bolts and wing nuts. This process is straightforward and also available in the school workshop.
Filing/finishing – aluminum shoulder load bearing supports, aluminum U-pipes  27	These techniques (filing, sand paper, emery cloth) will ensure a greater quality finish to the aluminium components. This improves the overall aesthetics of the completed product. Greater safety, via removal of sharp edges of the aluminum components is necessary for the products completion.

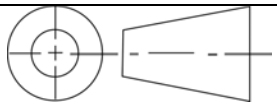
Final design proposal:

Front isometric view



Back isometric view



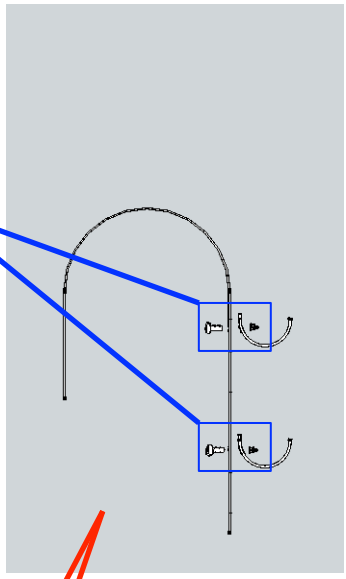
Name: Hugo Nippress	Date: 3/1/17		Scale: 1:4	Title: Final design proposal	Drawing No: 1

Part No.	Part name	Material	Qty.	Length (mm)	Width (mm)	Thickness/ diameter (mm)	Process	Finish
1	Torso vest	Multi-layer padded synthetic	1	415	400	5	Textile cutting machine and sewing.	n/a
2	Adjustable waist strap	Nylon webbing	2	139	50	2	Cutting and sewing.	n/a
3	Velcro tape	Velcro	2	50	50	2	Cutting and sewing.	n/a
4	Shoulder support tracks	Nylon webbing	6	90	50	2	Cutting and sewing.	n/a
5	Top of shoulder support tracks	Nylon webbing	4	40	25	2	Cutting and sewing.	n/a
6	Tool belts	Nylon webbing	2	150/130	50/25	4	Cutting and sewing.	n/a
7	Standard buckle clip	Polyoxymethylene	2	60	30	10	Outsourced standard part.	n/a
8	Shoulder load bearing supports	Aluminium	2	705	70	2	Cut to size using jigsaw, drilled holes with pillar drill and metal roller to form shape.	Filling and emery-cloth.
9	U-pipes	Aluminium	4	-	70	60	Cut to size/shape using jigsaw, drilled holes with pillar drill and shaped via magnabend.	Filing and emery-cloth.
10	Bolts and wing nuts	Stainless steel	8 pairs	10	-	M6	Outsourced standard part.	n/a

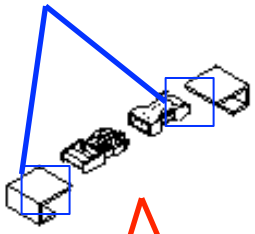
Assembly drawings:

Key:
Red = Zoom in of joint area
Blue = Joint components

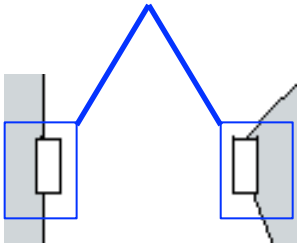
Temporary joining between shoulder load bearing supports and U-pipes through use of M6 bolt and wing nut.

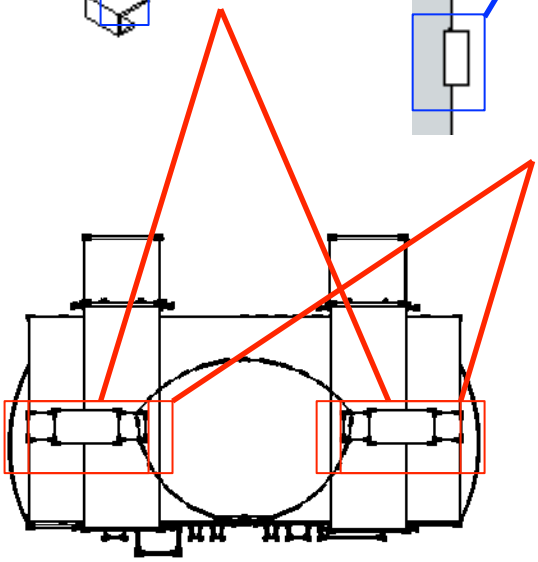


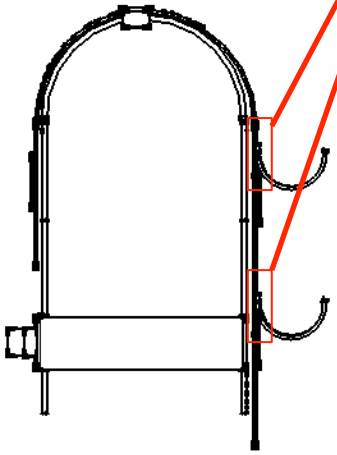
Looped stitching of nylon webbing to attach buckle and hold in place.

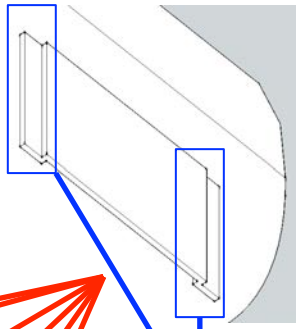


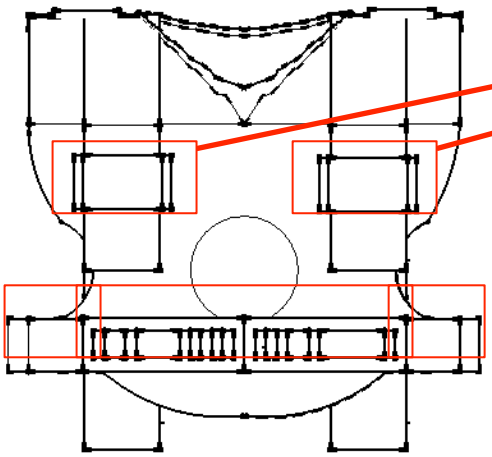
Underside of torso vest shoulder area - Nylon webbing is stitched to the underside of the multi-layer padded synthetic

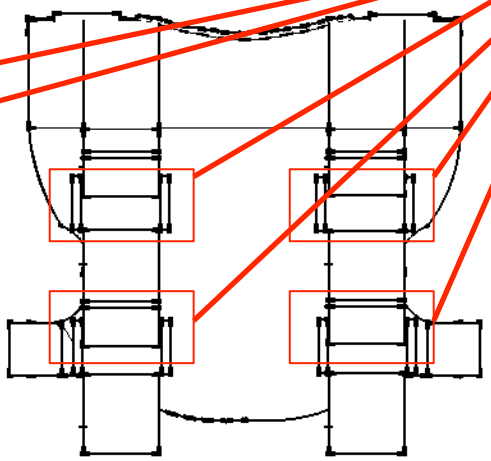




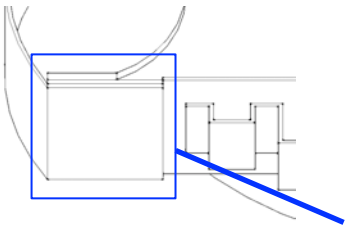


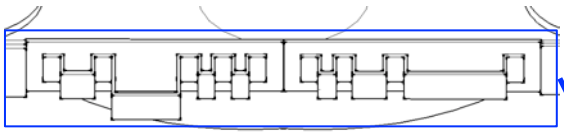






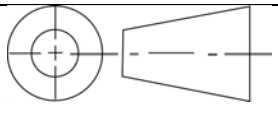
Nylon webbing is sewn to the torso vest on either ends of the material, leaving a passible route between both materials.



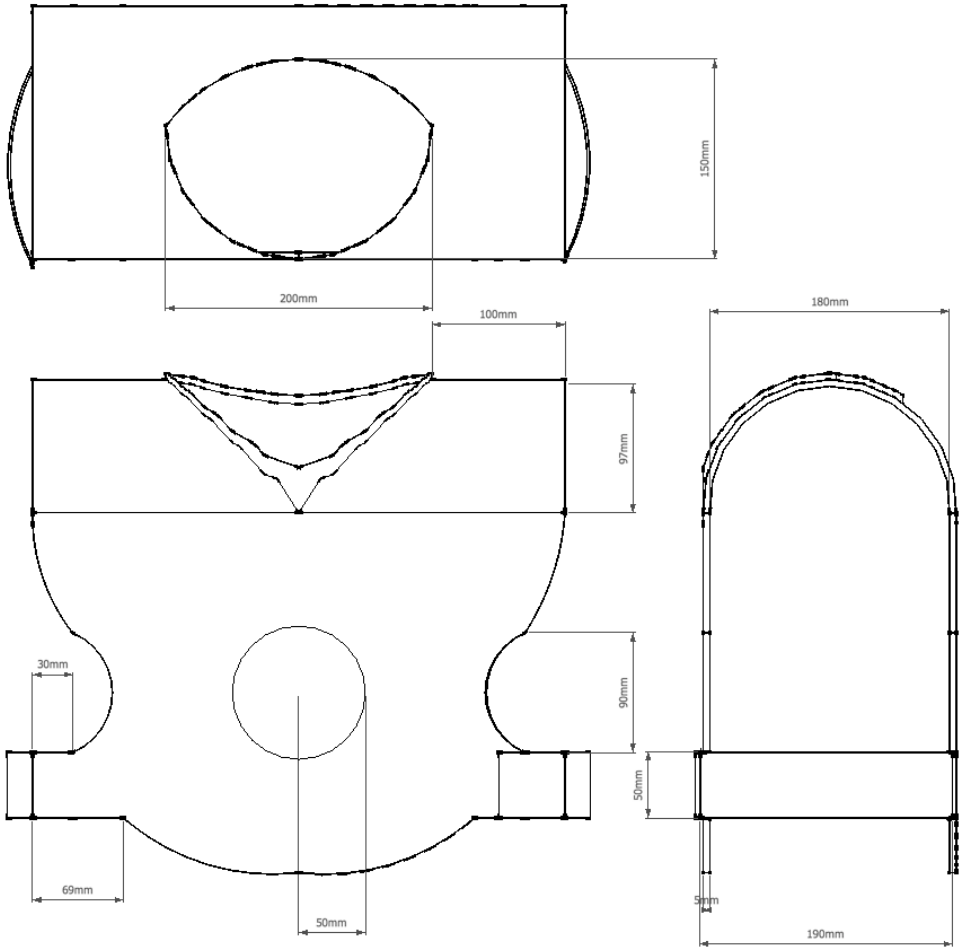


Stitching of a layer of Velcro tape to the torso vest and complimentary part to the waist-tightening strap.

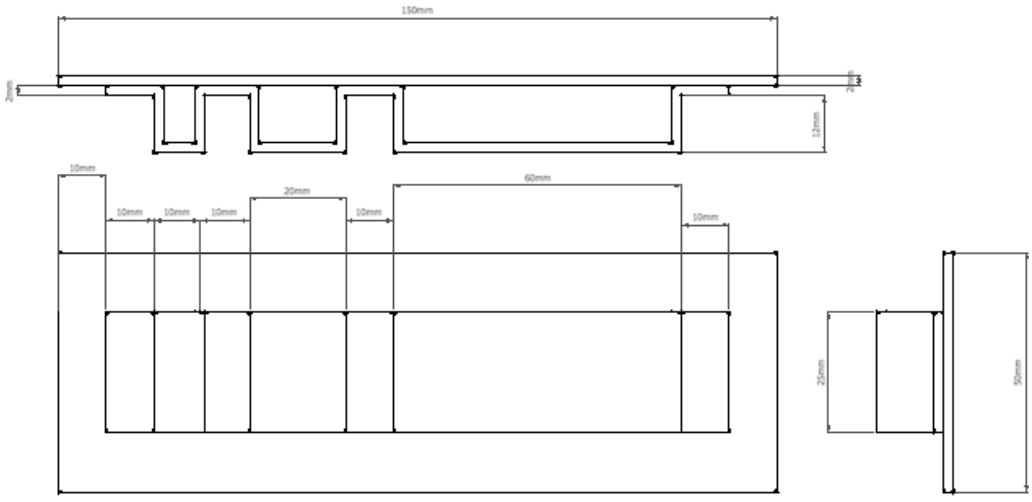
Stitching occurs between three components here. Firstly, a nylon-webbing base is stitched to the torso vest, then a second, smaller nylon webbing is stitched in the presented configuration to the base nylon webbing

Name: Hugo Nippress	Date: 4/1/17		Scale: 1:7	Title: Assembly drawing	Drawing No.2

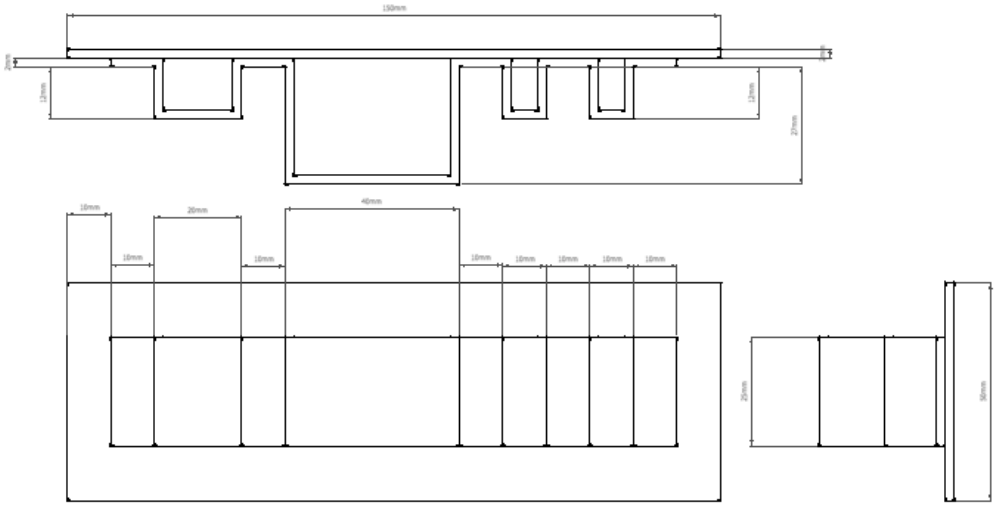
Detailed orthographic:



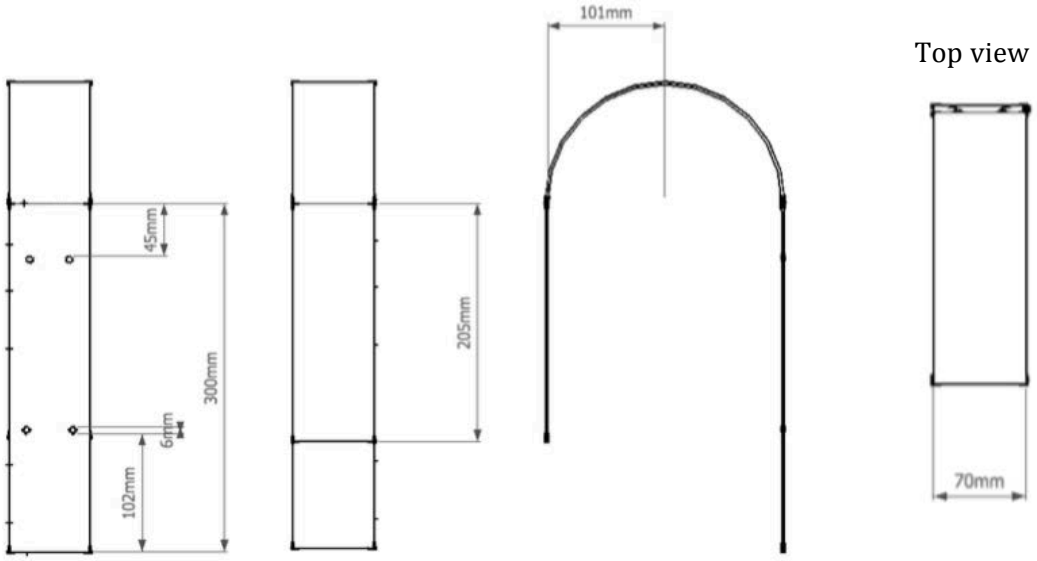
Name: Hugo Nippress	Date: 5/1/17		Scale: 1:5	Title: Torso Vest Orthographic	Drawing No.3



Name: Hugo Nippress	Date: 5/1/17		Scale: 1:2	Title: Right Tool Belt Orthographic	Drawing No: 4



Name: Hugo Nippress	Date: 5/1/17		Scale 1:2	Title: Left Tool Belt Orthographic	Drawing No. 5



Name: Hugo Nippress	Date: 5/1/17		Scale 1:5	Title: Shoulder Supports Orthographic	Drawing No. 6

Name: Hugo Nippress	Date: 5/1/17		Scale: 1:5	Title: U-pipe Orthographic	Drawing No: 7

Production plan:

		Weeks	1							2			
		Hours	1	2	3	4	5	6	7	8	9	10	11
Process	**Equipment**	**Risk assessment**											
Mark out torso vest	Chalk, rule, stencil	Ensure hand is not in the path of the scriber											
Use textile cutting machine to cut torso vest to shape/size	Textile cutting machine	Ensure hands are in a safe area											
Mark out nylon webbing lengths	Chalk, rule	No risk through this process											
Use textile cutting machine to cut nylon webbing lengths	Textile cutting machine	Ensure hands are in a safe area											
Stitch necessary borders and joints between torso vest and nylon webbing	Industrial sewing machine	Ensure hands are in a safe area											
Mark out alumnium sheet shoulder load bearing supports	Scriber, rule, engineers square	Ensure hand is not in the path of the scriber											
Jigsaw shoulder load bearing support sheets	Jigsaw	Eye protection against cut-offs of the material. Ensure secured material to prevent it moving and causing injury. Hand must be kept behind or beside the jigsaw.											
Pillar drill bolt holes	Pillar drill, 6mm drill bit	Eye protection against loose material. Ensure material is secured to prevent it moving and causing injury. Hand must be kept a sufficient distance from the drilling region.											
Using a metal roller bend the shoulder load bearing supports into appropriate shape	Metal roller	Hands must remain away from the rolling region once in use.											
Finish shoulder load bearing supports	Flat file, round file emery cloth	Inhalation of small particles and potential skin tissue damage from sharp surfaces.											
Mark out aluminum pipes	Measuring tape, scriber	Ensure hand is not in the path of the scriber											
Jigsaw into U pipes	Jigsaw	Eye protection against cut-offs of the material. Ensure secured material to prevent it moving and causing injury. Hand must be kept behind or beside the jigsaw.											
Magnabend one end of U pipe into flattened surface	Magnabend	Hands must remain away from the component and bending region once in use.											
Pillar drill bolt holes	Pillar drill, 6mm drill bit	Eye protection against loose material. Ensure material is secured to prevent it moving and causing injury. Hand must be kept a sufficient distance from the drilling region.											
Finish U pipes	Flat file, round file, emery cloth	Inhalation of small particles and potential skin tissue damage from sharp surfaces.											

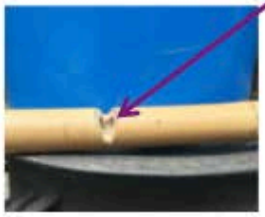
CRITERION D: TESTING AND EVALUATION.

Success of solution against marketing specification:

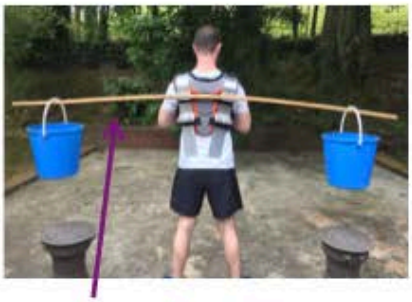
Specification point	Strategy of testing	Testing results	Evaluation against the specification	Success score (0-2)
Target market – The targeted market of this product is a rural subsistence farmer of low income, in underdeveloped areas. These individuals live on often-unfavorable land that makes transport more difficult. The subsistence farmers are self-reliant, and therefore they suffer an inability to invest in expensive equipment in order to improve their livelihood. These users will be adults or young adults, both male and female, who would be relied upon to carry, potentially heavy weights to and from destinations.	Photo images of the prototype, along with sketch pictures will be sent to my client Non, who has agreed to show these to several farming villager households. In this process feedback and perceptions will be recorded and relayed to me.	Villager reports were initially positive. Non stated that they could see themselves using the product. The improved ability to move materials was apparent. However, Non cautioned that they would have to try it for themselves before deciding. Non also mentioned that many believed the product to be or look too expensive for their own use. Afterwards Non explained that the product would likely be donated.	Admittedly a physical prototype test would have been the most effective test. However, due to distance and accessibility to target market location, this proved the most viable way of reaching my target market. Results suggest that the farmers are open, or accepting of the product, and this is often the greater challenge in communities with little exposure to outside influence and who are grounded in their own traditions.	2
Target audience - The target audience for this product are NGO's. They likely have the funding and reach to distribute low cost products, with access to rural farming communities via their established networks and multi-supportive programs. Alternatively companies or private benefactors are a potential target audience through charitable investment programmes. There is a discrete space for advertising /branding strategies, by way of the space on the front panel of the torso vest.	Interview with World Volunteer Organisation representative Non Tiddin. To assess corporate charitable donations and sponsorship, interviewed father's company contact that Chair's Singapore Office Corporate Contributions Committee.	Confirmed that NGO's similar to World Volunteer Organisation would consider pilot program to distribute in Laos. The Corporate Charity Contribution Committee member feedback was more promising. There was clear interest for both a product supply distribution purchase and one that included company employees additionally volunteering hands on work in the field.	Appetite from NGO's appears to exist. In addition there is indicated support via corporate sponsorship and/or purchase programmes.	2
Market analysis – **Market analysis –** The potential market for this product is extremely large due to the absolute number of people reliant on subsistence farming as their source of income within developing countries. This combined with their lack of access to durable quality fit-for-purpose	An estimation of the addressable market will be calculated to identify the products potential. A comparative test with the 'Load Carrier for Labour' competitor	The product sold in 1 geographical area with a total population of 228,059,758, with 10% of the market estimated to be within reach. Directly comparing this product with the 'Load Carrier for Labour' competitor, this product offers greater benefits in	The product achieves the necessary requirements of this specification. The potential market is significant and with identifiable advantages over the competition, is predicted to lead to healthy sales. The competitive price is an important advantage for	1

equipment. Competition is of minimal concern with only one potential alternative available. This product is designed to outcompete, especially in respect of functionality and durability. It is an economically viable solution as fixed and variable costs are anticipated to cost SG$8 (manufacturing price), with SG$0.50 profit per unit. The low profit margin is aimed at maintaining operations and increasing overall long-term sales. It is noted the product focuses on improving lives, rather than achieving wealth.	analysis will be conducted. Manufacturing techniques will be analysed in order to conclude the extent of fixed costs expected. Production commencement will incur start up machinery equipment costs.	most aspects, apart from potentially eco-sustainability. The 'Load Carrier for Labour' is constructed of local sourced recyclable materials, but durability is considerably less. My product offers an equivalent price. However, set up costs will be relatively high, with machinery such as an industrial sewing machine and magnabend machine.	promoting sales, especially for attracting investment or purchases from the target audience. Fixed costs, particularly in initial capital investment of machinery were identified as being high and therefore these require further review and reduction.	
User need – An important aspect that will ensure this product is useful is its versatility. Farmers are tending to different crops and livestock, performing various infrastructure work, in a variety of geographical conditions and seasons. Therefore a product that can offer durability and versatility, is independently customisable depending on the task being performed is highly beneficial. This offers maximum utility and reduces the users need for additional products – a benefit given the low-income levels.	Physical tests will be conducted to assess the ability of the product to carry weight, demonstrating the scale of potential use it offers. Durability testing, specifically within wet conditions will be performed to ensure it maintains functionality and shape. Safety aspects in the differing potential conditions over prolonged periods of time will also be tested.	Evidence of testing is present below on page 37 of this document. The product, using a 25mm diameter bamboo pole was able to easily carry 25kg of water (in this example). The entire product was also submerged under water and re-worn. The water resistant nature of the materials used in the products design was evident. The lightweight material used further reduced absorbency, leading to zero added weight and no malfunction of the design.	Using a narrow gauge bamboo pole, the specified weight of 25kg payload was achieved. Using thicker gauge bamboo poles, typically available locally will further improve stability and use. The bamboo allows alternative storage containers to the buckets tested in the example. Further, various contents other than water also be substituted. All components and joints are water resistant and therefore met full requirements for the weather conditions such as monsoon rains it could potentially be subject to.	2
Competition – Competition within this market as a whole and even more specifically within the market segment I plan to enter my product is very low. Having conducted secondary research the only product that would be of competition is the 'Load Carrier for Labour'. Outcompeting this product is possible through accessibility to the market, a lower sales price, versatility and a design that users are willing to adopt.	Testing of this aspect will be done through conducting product analysis on all specification categories of both products.	The E.Vest I've designed offers greater user benefits in durability, functionality, customer performance and safety considerations. In comparison the 'Load Carrier for Labour' offers greater initial environmental consideration (yet less durable) and prices are equivalent at SG$8.50.	Overall, it's evident that this product excels in comparison to its competition. It will sell due to increased design benefits for the user; it's also a cheaper solution and therefore provides economic advantage. The required versatility is visible within testing below as well as the products acceptance confirmed by responses from the target market relayed to me by Non.	2

Physical testing:

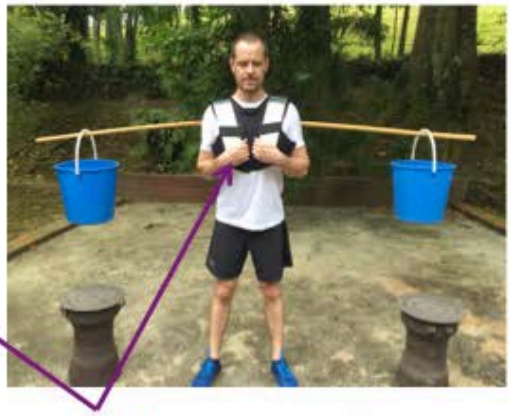


A V-shape cut was made 250mm away from either end of the bamboo to ensure the buckets did not slide off. 2 buckets of water were filled with 12.5liters of water = a weight of 12.5kg.



A bamboo pole of 2200mm and diameter 25mm was used for the testing. However, thicker gauge bamboo is ideal, and is likely the more readily available in local areas.

From the photo at right it is evident that the angle to which the U-pipes are attached needs to be altered in order to better align the bamboo pole across the two shoulder supports. Currently the pole tends to sit at the inner corners; this does not evenly distribute the weight through either the bamboo pole or the U-pipe/shoulder supports.



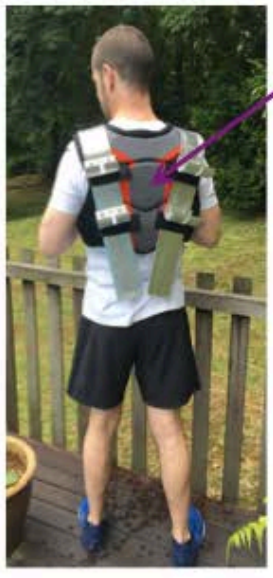
During the test the user experience some pressure from the aluminium shoulder supports against the hips, particularly when walking, moving or rotating. Extending the torso vest lower down the back to reach the hips could alleviate this.

With load applied, fronts of the shoulder load bearing supports would rise away from the body. To solve this, the length at the front should be lessened as its unnecessary and roll bending of the metal increased to maintain its position against the body.

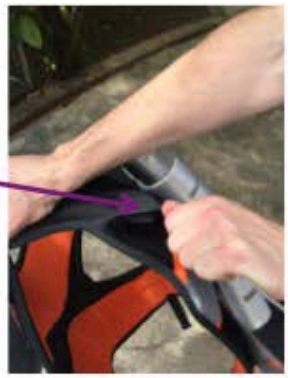
No pulling backwards or up of the vest was experienced. The upper vest area was comfortable and the location of the neck hole appropriate.

The vest was fully submerged under water and then immediately re-worn with no problems. Metal joints sustained no detrimental effects and the torso vest material absorbs minimal water, tending to repel water, therefore aiding quick drying

Baskets and crates tested.



Attempted ripping of the commercial/industrial stitching was performed, with the joint able to withstand the applied force.



Evaluation of solution against design specification:

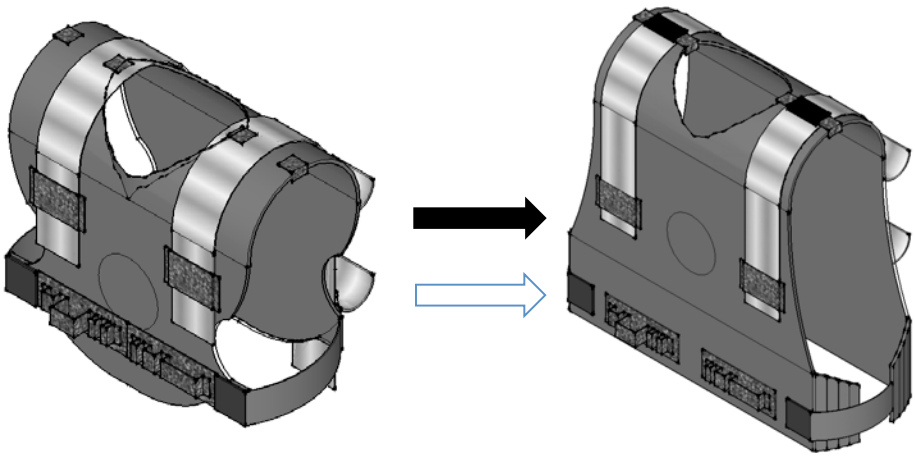
Specification point	Strategy of testing	Testing results	Evaluation against the specification	Success score (0-2)
Function – 1. It must be able to carry produce, materials and water	Physical test of all three categorical items placed within the storage components	Rocks, soil and water were tested within buckets and carryable.	This specification point was met as the product has the capability to carry the different materials required.	2
2. It must allow interchanging of storage equipment	Physical test of successful storage equipment interchangeability	Buckets, baskets and a crate were all succesfully attachable.	This specification point was met, with various attachment baskets/buckets/crates interchangeable and still functional.	2
3. It must be wearable	User trial of product being worn	The product is wearable	This specification point was met as the product affords comfortable wearing and is ergonomic.	2
4. It must hold required tools hands free	Physical test of tools being attached to the product	Four types of hand tool were secured successfully to waist area	This specification point was met as typical tools held securely hands free	2
Aesthetic requirements - 1. It must be of basic colour	Visual inspection of simple colour palate used	Majority of product is black, silver and grey. However, inner vest layer is orange.	The product meets this specification when being worn. However, the inner orange vest material does not fully support the requirement.	1
2. It must be simple in design	User interview to establish the acceptance/adoption	Through Non's interview with the target market it was found to be well understood in application.	This specification point was met as the product with no instructions and shown virtually to users was easy enough to understand.	2
3. It must be appealing to the target audience	Interview to gain feedback from the NGO's perceptions of the product	Initial feedback suggested NGO's had interest to take the product.	This specification point was met to a degree of success. Notably corporate sponsorships exists.	2
Customer requirements – 1. It must be versatile	Model user testing with analysis of the various possibilities of attachments that can be carried	The number of possibilities and interchangeability of storage and stored items is high	This specification point was met, numerous attachments carried with a degree of customisation possible.	2
2. It must allow easy movement	Physical model user trial to identify any restriction of movement	All typical body movements allowed, hands free usage.	This specification point was met as the product does not restrict or impede no muscular or skeletal movement.	2
3. It must be safe to use	User trial to explore both physical safety when in use and health through any after pains	Product was used in a succesful manner with no safety issues and there have been no subsequent side effects reported.	This specification point was met as the product was used safely for an extended period of time under various scenarios, and caused the user no resultant injuries/pains.	2
Performance requirements - 1. It must be light	Physical test to gain weight perspective	The product iteslf resulted in no fatigue due to its lightness.	This specification point was met due to the lightweight padded vest materials used, along with the aluminum sheet	2

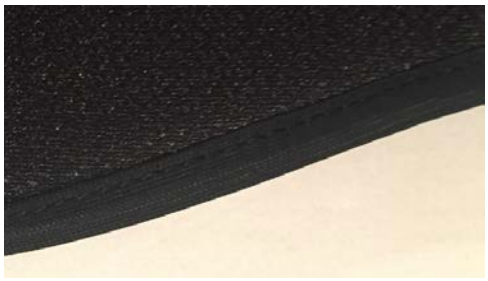
2. It must be strong/tough	Physical test to investigate extents the materials can withstand before damage	Materials withstood required weight, with pressure applied to and through the fixings and stitching in an attempt to break them.	This specification point was met due to the tough materials in combination with minimal load bearing joints.	2
3. It must allow placement and removal in the storage space	User trial to ensure desired items can be easily stored and removed as necessary	All available storage items were easily attached and removed.	This specification point was met as the various storage items were usable and removable, including bamboo pole, baskets, buckets and crates.	2
Environmental requirements - 1. It must be made of durable materials	While long duration testing cannot be performed, a simple hammering, ripping/tearing, dirt and water resistant test can be applied.	All scenarios tested. Hammering marked the aluminium sheet, but did not effect useability.	This specification point was laregely met. Aside some hammer impact marking, and discolouration of the vest from the dirt.	2
2. It must be made of renewable materials	Cannot be tested as this refers to the end of the products usage life	Was not testable.	Was not tested.	n/a
3. It must be made of recyclable materials	Physical test of disassembly, with material separation available for recycling	Simple design, consisting of 3 to 4 bespoke materials, with temporary joining methods, makes seperation easy and effective.	This specification point was met as all components were easily seperable into different materials, with the synthetics not seperated in the test, but ultimately could be by cutting at stitched joints.	2
Size constraints - 1. It must be wearable over the shoulders	User trial of placement over/around shoulders	The torso vest and shoulder load bearing supports are worn over the shoulders.	This specification point was met as the products use is reliant on the placement on both shoulders.	2
2. Storage size must be reasonable	Physical test to ensure easy and comfortable long-term carrying	Use over a supervised period highlighted no discomfort.	This specification point was met with the storage capability or load bearing limited at 25kg.	2
3. It must fit the average 50th percentile	Measurement comparison between anthropometric research and product sizes	Model user selected to conform with average or 50th percentile.	This specification point was met, with good overall fitting, ease of removal and effective safe use.	2
Safety considerations – 1. It must distribute weight evenly across body	Physical test with weight distribution to left and right hand sides.	With even loads on either side of the product, this was verified by the model user.	This specification points was met as long as the weight being carried was either placed centrally or evenly distributed to either side on bamboo pole.	2
2. It must allow hands to be free	User trial where the user can maintain their hands free for other tasks	Due to the upward movement of the shoulder supports at the front chest area, the user was required to press down.	The product was self reliant in use and maintaining weight. However, with the upward movment of the front shoulder supports, the user was obliged to place hands on these components for reassurance.	1
3. It must be easily attachable/detachable	Physical test of wearing and removing	Carried items are easily	This specification point was met by the ease of all	2

	of the product with little hassle and unaccompanied	carried/removed and the vest itself simply placed and lifted over the head.	attachability and detachability of components. The product itself was easily put on and taken.	
Material requirements - 1. It should be low cost	Total costs should be low and reasonable compared to competition	Product costs matches competitive product.	This specification point was met because the product costing a total of SG$8.50 is a low priced solution to the problem and matches competitive product.	2
2. It should be largely locally source-able	User interview to gain feedback on whether this characteristic has been successful in practice	The torso vest and aluminium shoulder supports and U-pipe attachments could not be locally sourced.	While the product is not locally sourced, the specification is met somewhat by the use of locally sourced carrying recepticles (e.g. bamboo poles, baskets, crates, pots).	1
3. It should be weather resistant	Physical test to confirm the durability of materials to poor weather conditions	The product was submerged in water and experienced no reduced functionality.	This specificaiton point was met due to the durable, weather resistant materials used in the construction of the product. No shrinking or coroding evident.	2
Manufacturing requirements - 1. It must be made using processes available in the school workshop	Physical test that will be ongoing and conducted during product manufacture	The prototype was manufactured in the school workshop.	This specification point was met as the manufacture of the prototype was reliant on the school workshop for its completion, which was achieved.	2
2. It must require minimal manufacturing processes	Observation of total techniques used	Techniques used were minimal and not complex.	This specification point was met through the minimalist design, resulting in simple manufacturing process.	2
3. It must allow for disassembly	Phyical trial of component separation	All components are removable due to the temporary joining methods used.	This specification point was met as all different components and materials are seperable apart from the stitched nylon webbing. However, this can still be removed by cutting the stitched joint.	2

Solution improvements:

Functions	**Current flaw**	**Design brief ref.**	**Improvement**
Part: Torso vest			
Provide comfortable, durable, wearable component fitting over the upper body.	Current specification of the torso vest provides a consistent level of comfort and safety throughout the upper torso area. However, testing indicated that the key load bearing parts suffer greater levels of pressure placing discomfort upon the users lower back area.	Comfort/Safety improvement	To improve the comfort and long-term safety of the user, particularly when used to transport heavier loads (e.g. 25kg) extending the torso vest down to cover the hip area.

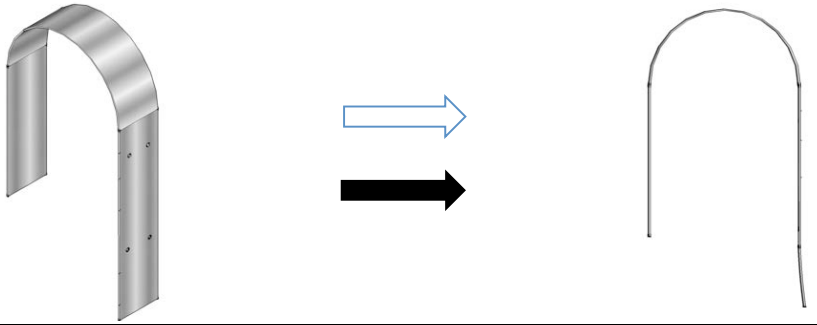




Fabric strap from prototype

Part: Torso vest			
Provide comfortable, durable, wearable component fitting over the upper body.	Hemline stitching detail around the perimeter of the vest is fit for purpose. However, the multi-layer synthetic material specified is prone to fraying.	Aesthetic/ Durability improvement.	The addition of a 15mm wide perimeter tape or trimming, stitched around the perimeter edge will 'seal' the multi-layers of the torso vest material. This will prevent fraying and improve the overall finish 'look-and-feel' quality of the design.

Part: Shoulder load bearing supports (x2)			
Distribute and hold the payload weight in a comfortable safe manner to the user's body.	Although the pair of aluminium shoulder supports function sufficiently to distribute and secure the payload, when carrying heavy loads (e.g. 25kg) the lower end of the strip presses into the user's lower-back area.	Comfort/ Safety improvement.	While the design shape of the bottom corners of the aluminium supports were earlier improved by adding a curve, adding a slight roll-bend to the lower rear-end of the strips would increase the comfort factor further. Inclusion of such a bend or curvature to the end will spread the load more evenly. Care must be taken not to make the roll-bend too severe, as this will cause a fouling or prevent the aluminium strips from being placed through the nylon webbing support tracks. A roll-bend of 10° is recommended.



Functions	**Current flaw**	**Design brief ref.**	**Improvement**
Part: U-pipes (x4)			
Support bamboo poles, baskets, crates and other storage items securely to the load bearing shoulder supports.	The material and part specification is fit for task, but adds to manufacturing costs and complexity. This in turn leads to the need to purchase or have access to additional manufacturing equipment, such as a magnabend machine.	Cost/ Manufacturing improvement.	The current specification requires the cutting of 80mm diameter aluminium pipe into two semi-circles with a jigsaw, and then forming or bending of one long-edge on each semi-circle to form a flattened face. To reduce manufacturing complexity and time, the aluminium pipe material specification can be changed to 2mm aluminium sheet, the same material specification as the shoulder supports. The result is reduced complexity in all of the following aspects: materials procurement, manufacturing processes, machine tool requirements and overall production costs.

Part: M6 Bolts and wing nuts (x8)			
Provides the joining method between the shoulder load bearing supports and the U-pipe *attachments.*	Bolt specification is potentially too small to withstand over the long-term the forces applied by the carried payload (up to 25kg). Despite its small size, this component is crucial in the performance of the overall design function and therefore needs to be highly durable. The risk of metal fatigue due to repetitive use over time is a risk.	Durability improvement.	A simple improvement or solution exists – increase the gauge or specification of the bolts and wing nuts from M6 to M8.

Part: Tool belt			
This lightweight attachment provides utility for securing of hand tools hands-free.	Located at the lower front panel of the torso vest it offers good access and usability, tools of a longer length (e.g. > 15cm) tend to dig into or foul on the users legs when walking.	Comfort/ Usability improvement.	The nylon webbing sewn loops securing hand tools can be added to the side straps. These straps are manufactured from the same material and are to provide adjustability for the user. Provision of a loop(s) to each side, at waist level, will allow longer hand tools (e.g. wood saw) to hang at the user's side, free of fouling on the users legs when walking.

Revised marketing & design specification:

Existing marketing specification point	**Problem**	**Improvement**
Market analysis – The potential market for this product is large due to the absolute number of people reliant on subsistence farming as their source of income in developing countries, combined with their lack of access to durable quality fit-for-purpose equipment. Competition is of minimal concern with only one potential alternative available. This product is designed to outcompete, especially in respect of functionality and durability. It is an economically viable solution as fixed and variable costs are anticipated at SG$8 (manufacturing price), with SG$0.50 profit per unit. The low profit margin is aimed at maintaining operations and increasing overall long-term sales. It is noted the product focuses on improving lives, rather than achieving wealth.	Product price is expected to be equivalent to competitor price, but not below. Further, the need for initial machinery investment may lead to additional costs at start-up.	Whilst the initial marketing specification indicated the need for low cost to meet requirements of low income rural poor, the marketing specification should emphasize sale and supply of the product to NGO's, corporate sponsorship and private charitable benefactors. In these cases absolute low nominal price is not always the driving requirement.

Existing design specification point	**Problem**	**Improvement**
Material requirements - It should be largely locally source-able.	The entire product is not manufactured from locally sourced materials.	An alternative to this design requirement would be to note the compatibility with locally sourced parts, while focus of the product materials has been upon durability. The long life cycle of the materials used in its own way achieves a level of sustainability. All materials are recyclable.

New specification point	**Analysis**
Secondary target market – developed country farmers	Whilst original design brief/specification focused upon a product for low income rural farmers, several of the design features of the product are equally attractive and relevant to farmers in the developed world. The product could therefore be readily marketed and sold to the likes of fruit pickers and wine growers/makers, etc.

CRITERION E: COMMERCIAL PRODUCTION.

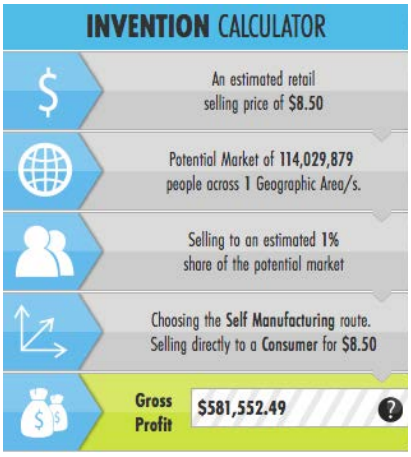
Justification of potential market size and scale of manufacture:

Estimating market size or potential demand for a product is challenging, but necessary if I am going to make my invention a commercial success. I would like to note however, that my project's initial design ideas and subsequent product development have not been driven exclusively by monetary profit motive. "Success" may be measured against the key design and market specification criterion such as the durability and safety offered by the product design, along with the scale of take-up of the product by the end-user, via the market channels of NGO's and corporate/private sponsors.

The acceptance or adoption of the product by the end-user (low income subsistence farmers in developing countries) is critical for success. A high adoption or demand will achieve the original idea objectives: i) fulfill the need observed first-hand in Laos, ii) benefit the productivity/long-term health and safety of the user, iii) be of scale that future product development costs can be met, and iv) allow a reduction in production costs and therefore unit price.

There are several ways to estimate market size. I used the 'Invention Calculator' to help me start to calculate demand, or possible market size. Whilst I hope that the Easy Vest (EV) product could be adopted across the developing world, from Asia to Africa, it might be reasonable to first focus upon South East Asia. This is a sub-region closer to home and one I am more familiar with. It would be good if most households in SE Asia could benefit from using the Easy Vest, with possibly more than one per household. However, the entire population of SE Asia cannot be classified as 'rural inhabitants'. Perhaps an initial assumption of one Easy Vest per household is appropriate (i.e. half the households have zero, the other half have two).

Geographical area = SE Asia
1 per household
1% market share = 11,402,988
Self-manufacturing (manufacture costs = SG$8, 90% of sale price)
Via direct to user channel/via self-funded NGOs
Gross profit = SG$581, 552.49, therefore 1,163,105 units will have been sold.



From the rough calculation above, it is possible a commercial production run of 1,163,105mln units might ultimately be considered. However, conservatively it would likely take say three years to grow this level of product adoption on the ground. I will for these purposes conclude an initial annual demand or production run of 1,163,105/3 = 387,700. A monthly production of 32,300.

14

Choice and justification of manufacturing techniques appropriate for commercial production:

All production materials specified have durable properties and are not subject to deterioration post manufacture or during storage (e.g. corrosion or moisture absorption). Not considering the financial or funding costs associated with manufacturing and then holding finished product in stock, it is not necessary to follow a 'Just-in-time' (JIT) production process. I have little expectation that materials or parts will become obsolete and therefore 'Just-in-case' (JIC) production method may be considered. The JIC system would allow for greater flexibility or variance in estimating demand or product orders, and would allow for larger batch or bulk production runs which could help reduce unit cost price. The Make-to-order (MTO) production strategy is likely the most appropriate for the Easy Vest product, as it allows products to be customized to exact specifications and manufacturing only commences once the customer places an order. This does create additional lead-time for delivery and supply, but will likely match the ordering method of the target NGO's, corporate and personal benefactors.

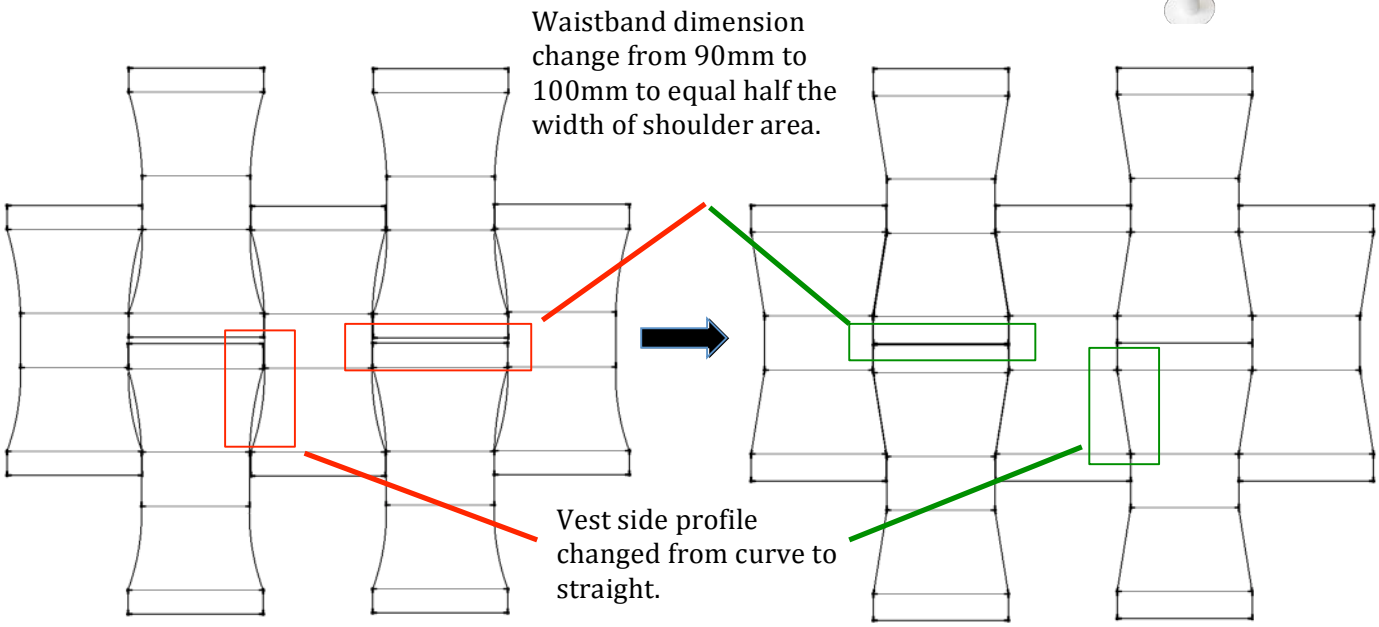
Modification of detailed design for commercial production:

The initial idea and concept development from Criteria A and B, along with subsequent design development of Criterion C, did not have commercial production specifically in-mind. However, my work has focused upon aspects of large or mass scale, both relevant given the population size of my target end-user. Therefore, the Easy Vest's design and materials specification already has several existing 'scale' production attributes. I propose additional design modifications for consideration to improve compatibility with manufacturing techniques for commercial production:

Torso vest -

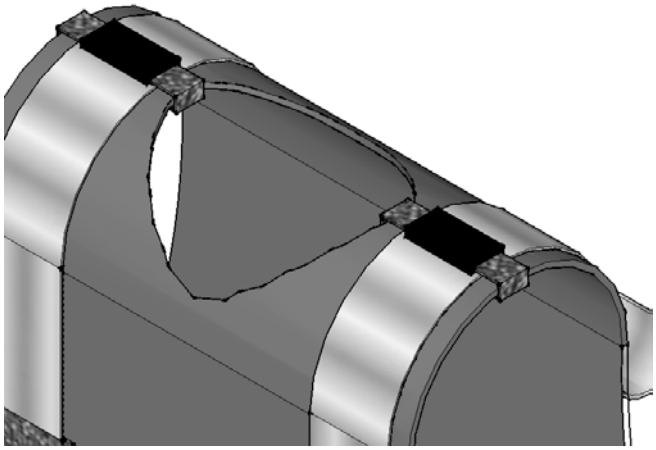
- Vest curves around and over the body, but torso vest can be cut, stitched and trimmed while laid flat.
- Outline or profile shape modified to enhance 'nesting' technique, thus reducing cutting requirements and minimizing multi-layer material wastage (see CAD drawings below).
- Changed vest curvature to flat diagonal profile and increased torso vest length by 10mm at each end in order to fit perfectly
- Manufacture process changes from measuring with ruler and cutting with hand knife to CNC textile cutting machine at right

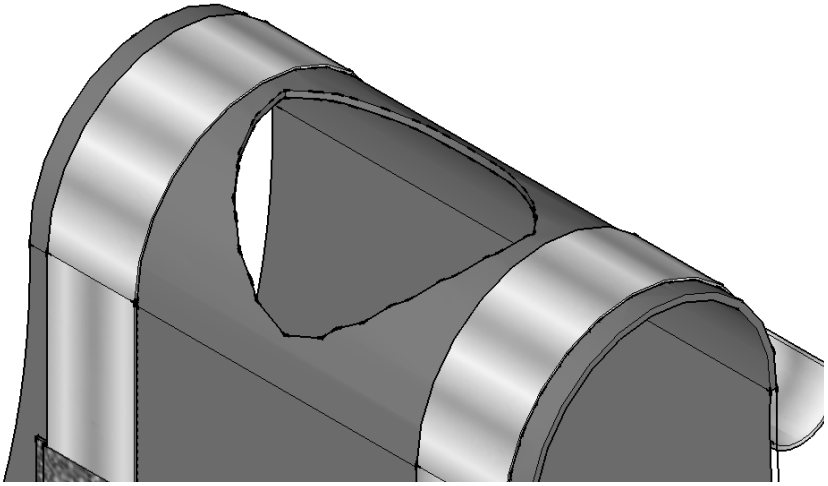
21



Shoulder clip -

- Shoulder clip to secure in place the aluminium shoulder support is beneficial, but perhaps not essentially for comfort, durability and safety (all key design specifications). It could be omitted to simplify manufacture and reduce component parts count (see CAD below).





Kit form –

- I would propose to deliver the Easy Vest product in self-assembly kit form
- This eliminates factory assembly costs and provides for the separate material components to be manufactured at separate factories, i.e. textile factory to make the torso vest and metal forming factory for the aluminium shoulder supports/U-pipes
- Components will then be centralised for packaging and warehousing ready for delivery
- Kit form also allows for separate replacement parts due to damage or wear-and-tear and improves recycling capability

Justification of materials and components for commercial production:

All the materials included and specified in the table below for commercial scale production, are readily available, with large-scale supply at short order notice. Due to this level of competitive plentiful supply, the materials are cheap in price, and available in numerous colours, grades and size specifications.

Component	Prototype material use	Commercial material use	Justification (e.g. cost, supply, material properties)
Torso vest	Multi-layer padded synthetic	Ripstop nylon	Used extensively in the manufacture of tents, sports bags, etc. Supplied in rolls, easy to cut and stitch with typical industrial sewing machines. Properties include lightweight, tear, scuff, weather proof – and washable.
Torso vest	Multi-layer padded synthetic	Closed cell foam	Cheap and readily available. Closed cell format specification does not allow air to circulate or move between the separate cells, as is the case with open cell foam. Therefore, the padding experiences less compression at heavier loads (25kg), holding its shape and padding comfort capabilities. The foam is durable, lightweight and waterproof.
Shoulder support tracks/ tool belt/ adjustable waist strap	Nylon webbing	Nylon webbing	Chosen for its lateral strength, durability, weather proof and washable. Stitching to torso vest materials is easy.
Waistband fastening	Velcro tape	Velcro tape	Velcro is used extensively in household consumer and garment goods manufacture. Cheap and readily available in multiple sizes and colours. Simple stitching to both nylon webbing and torso vest. Allows for repetitive open/closing over long period with minimal functional performance deterioration. Weather proof and washable.

Stitching thread and trimming tape for torso vest	Nylon thread/ nylon trimming tape	Nylon thread/ nylon trimming tape	Nylon thread and trimming tape are both commonly used haberdashery products. Readily available via wholesale and retail channels, typically in various grades and size specifications. High tensile strength, waterproof.
Shoulder load bearing supports/ U-pipes	Aluminium sheet	Aluminium sheet	Original specification commercially viable. Supply plentiful at short order, multiple finishes, grades and sizes possible. Used extensively in aero, auto, building and consumer industries. Therefore, competitive cost/price available. Aluminium tensile strength to weight ratio high. Can be cut/pressed to size, drilled and bent (malleable). Finishing/ polishing requirements minimal, corrosion free and waterproof.
Bolts and wing nuts	Stainless steel	Stainless steel	Standard part that offers tensile strength and corrosion resistance. Readily replaced if damaged or lost.

Justification of manufacturing techniques for commercial production:

Component	**Manufacturing technique for prototype**	**Manufacturing technique for commercial production**	**Justification (e.g. cost, material properties, quality control)**
Torso vest	Textile cutting/ industrial stitching machines	CNC textile cutting and stitching machines	As with all large-scale capital equipment, CNC textile cutting and stitching machines have high initial cost. They do provide considerable improvement when cutting material. Accuracy and precision is increased, therefore reduction of raw material wastage.
Shoulder support tracks/ tool belt/ adjustable waist strap	Textile cutting/ industrial stitching machines	CNC textile cutting and stitching machines	As with all large-scale capital equipment, CNC textile cutting and stitching machines have high initial cost. They do provide considerable improvement when cutting material. Accuracy and precision is increased, therefore reduction of raw material wastage.
Shoulder load bearing supports/ U-pipes	Jig-saw/ pillar drill/ metal roller/ filling/ emery cloth	CNC metal cutting machine/ metal roll forming machine	The CNC machine will allow cutting, finishing and drilling. Minimising material wastage and reducing need for manual finishing, including removal of sharp metal burs. The roll forming machine will produce accurate and consistent curvature for the shoulder supports and smaller U-pipe components. Drilled hole alignment is vastly improved.
Bolts and wing nuts	Standard part	Outsourced supply	Delivered to collation/packaging centre.

CRITERION F: MARKETING STRATEGIES.

Justification of a target market and sales price:

Target market – My target end-user market via NGO's, corporate and private benefactors are the countries of SE Asia. However, I will plan initially to focus just on the country of Loas, this will allow me to work with my World Volunteer NGO representative Non Tiddin to trial the product. From personal experience, I feel Laos is an appropriate 'test market'. The data below would seem to substantiate this, with a significant amount of the population being rural poor on extremely low incomes.

Data and info below from Wikipedia – Laos demonstrates total size of population, percentage that are rural versus urban inhabitants, and that the country is 'poor' or low income.

To provide some background context, "Laos is a multi-ethnic country with the politically and culturally dominant Lao people making up approximately 60 percent of the population, mostly in the lowlands. Mon-Khmer groups, the Hmong, and other indigenous hill tribes, accounting for **40 percent of the population, live in the foothills and mountains. One third of the population of Laos are currently living below the international poverty line** (living on less than US$1.25 per day)."

Population	
• 2014 (Jul) estimate	6,803,699[2] (104th)
• 2015 census	6,492,228[3]
• Density	26.7/km^2 (69.2/sq mi) (177th)
GDP (PPP)	2016 estimate
• Total	US$40.962 billion[4]
• Per capita	US$5,718[4]
GDP (nominal)	2016 estimate
• Total	US$13.761 billion[4]
• Per capita	US$1,921[4]

If I assume achieving 10% adoption rate or 'market share', I might reasonably estimate a first production run as follows:

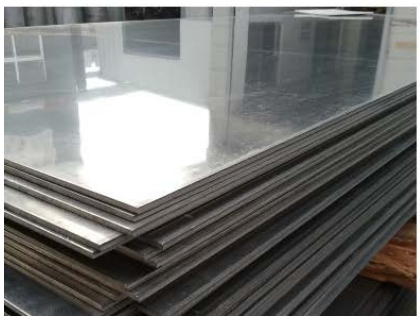
(Laos population) x (Rural living %) x (Adoption rate/market share %) = Production run of E.Vests
6,492,228 x 40% x 10% = 259,689 units

Production of the estimated ~260,000 'test batch', demand which I believe possible working with World Volunteer NGO on Laos, is proposed to be manufactured or outsourced to a factory.

Sales Price - All raw material costs and price data below sourced from Alibaba.com/trade. U$ to SG$ foreign exchange rate used = U$1 to SG$1.40.

28

Aluminium sheet.



Aluminum sheet weight per square meter direct buy china

FOB **Reference** Price: Get Latest Price

US $2,000-3,000 / Metric Ton | 5 Metric Ton/Metric Tons (Min. Order)

Supply Ability: 50000 Metric Ton/Metric Tons per Year aluminum sheet weight per square meter

Port: Shanghai/Qingdao/Lianyungang

29

Mill finished aluminium plate cost = U$2000/t (for 2mm depth). Each shoulder support weighs 0.3kg, therefore I estimate 3,333 shoulder support can be produced from 1tonne of 2mm coil/sheet (1t = 1000kg). 1000kg/ 0.3kg = 3,333 unit. Raw material for a pair of shoulder supports costs (U$2000/3333) x2 = U$1.20 **(SG$1.68)**

Using above data, we could expect 7 U-pipes from the same amount of material as a pair of aluminium shoulder supports [(2x705mm)/15mm =7]. Material for set of 4 U-pipes estimated at [(U$1.20/7) x 4] =U$0.69 **(SG$0.96)**

Ripstop nylon fabric.

breathable waterproof and windproof fabric wholesale 300T 0.5 ripstop/ nylon/polyamide fabric with PU for jacket and bag

FOB **Reference** Price: Get Latest Price

US $1.153-2 / Meter | 1000 Meter/Meters 300T 0.5 ripstop/check nylon/polyamide fabric (Min. Order)

Supply Ability: 10000000 Meter/Meters per Month

Port: Shanghai/Ningbo

29

Ripstop nylon fabric roll = average U$1.58 per 1mx1.5m square. Each vest requires 2 sides of approx. 1mx0.5m fabric (not allowing for hem/seam). 3 sides possible from 1mx1.5m material. Raw material for 1 complete torso vest will cost (U$1.58 /3) x 2 = U$1.05 **(SG$1.47)**

Closed cell foam sheet.

closed cell eva foam sheet/printed eva foam sheet/bulk foam sheet

Quality Choice

FOB **Reference** Price: Get Latest Price

US $0.12-0.5 / Square Meter | 100 Piece/Pieces (Min. Order)

Supply Ability: 1000 Piece/Pieces per Day

Port: SHENZHEN CHINA

29

Closed cell foam = average U$0.31 per $1m^2$. Each vest requires $1m^2$. Raw material for 1 complete torso vest will cost U$0.31 **(SG$0.43)**

Nylon webbing.

50mm nylon webbing with high quantity

FOB **Reference** Price: Get Latest Price

US $0.02-0.8 / Meter | 3000 Meter/Meters

Supply Ability: 50000 Meter/Meters per Day

Port: guangzhou or shenzhen

29

50mm wide nylon webbing = average U$0.50 per metre. Each vest requires 1.5m. Raw material for 1 complete torso vest will cost U$0.75 **(SG$1.05)**

Standard parts. Other standard material parts costs estimated per unit (M8 bolt + wing nut/nylon thread/nylon trimming tape/Velcro squares) estimated at combined total of U$1.00 **(SG$1.40)**

Total estimate of materials cost per unit = 1.68 + 0.96 +1.47 + 0.43 + 1.05 + 1.40 = **SG$6.99**

Sales price calculation logic. When researching a typical wholesale price for a standard backpack, a product that I think has similar design, material and manufacturing characteristics (e.g. cutting and stitching), the Made-in-China.com manufacturing and supplier website displays the models below.

Promotion Waterproof Outdoor Sports Travel **School Backpack** Bag

FOB Price: **US $ 2.8-4.5** / Piece

Min. Order: 800 Pieces

OEM Waterproof Ripstop Fabric Outdoor Sport **School** Laptop

FOB Price: **US $ 4.0-4.6** / Piece

Min. Order: 500 Pieces

2017 Fashion Sport Laptop **Backpack School** Bag Travel Hiking Camping

FOB Price: **US $ 3.3-3.45** / Piece

Min. Order: 1000 Pieces

30

If I take an average of the price ranges above it gives U$3.775 (SG$5.29) per unit (note: minimum order quantity is 500 to 1000, hence considered 'wholesale'). I have found it difficult, to any reasonable degree of accuracy, to determine or find how much it might cost to construct/manufacture the Easy Vest. In other words to effectively evaluate the variable factory costs (excluding raw materials) associated with energy, labour, packaging, storage and transportation. In an attempt to establish a unit sale price I think it is reasonable to compare my total raw materials costs of SG$6.99 with the market wholesale price of a typical backpack which includes all fixed and variable costs at SG5.29. To conclude, on balance I think it fair and reasonable to suggest that my design brief specified sales price target per unit of SG$8.50 is realistic. This would achieve the design brief goal of at least matching the 'Load Carrier for Labour' price. Given Easy Vest raw material prices are SG$6.99 and a comparable mass market consumer backpack wholesales for SG$5.29, it seems likely that total manufacturing cost below SG$8.00 can be achieved. As stated earlier in Criterion A, a 'profit margin' of SG$0.50 is targeted. This will allow the Easy Vest design and production to be sustainable, by covering marketing, promotion, sales and future design enhancement costs. As reminder, the Easy Vest design project was not intended to be a profit 'maximiser', but does need to be self-sustaining.

Target audience/brand development and identity/promotion strategy:

Target audience - Following the conclusion of the 'test market' or pilot programme in Laos discussed above, the data and information collected will be used to evaluate further growth and promotion strategies in other countries. The target audience, or partners/sales channels will continue to be the NGO's or charitable benefactors operating in these countries. I imagine this first expansion phase will include countries such as Cambodia, Indonesia and the Philippines. All have large low-income populations. Longer-term, India and sub-Saharan Africa offer huge rural low-income populations. To fulfil both the original design goals of providing a low cost product for the benefit of low-income users and the nature of the target audience, it likely makes sense to initially structure operations as a small business venture. As designer I will also act as the start-up business entrepreneur, promoting the Easy Vest directly with NGO's, etc.

Product branding/marketing/**placement** - To attract a wider target audience of new NGO's, and help develop a 'sales channel' into corporate and personal charitable schemes, I will need to package and promote the Easy Vest. The Easy Vest is not a consumer product as such, but sales success would benefit from a brand identity. This would aid a more effective charitable sponsorship approach or simpler marketing campaign. To deliver sharper brand or product recognition, especially one that translates or transcends different languages, I will name the company **EZ-Vest Global** and rename the product from Easy Vest to **EZV**. The logo below is designed to have impact in many countries, cultures and geographies. The fonts and styles below will be useful for the alternative branding needs of different media medium, i.e. internet, print and physical promotional items.

To achieve successful adoption of the EZV, a marketing strategy focused on NGO's or charities will need to be effective. This is best pursued via numerous charity donation/non-profit/giving programmes, whether corporate or private. I anticipate pursuing this via various events, fairs, forums and programmes that introduce products and services to the benefit of low-income populations. A few examples are given below.

Washington DC Nonprofit Conference

The *Washington Nonprofit Conference* is an annual two day event where more than 800 fundraising and marketing professionals in the nonprofit and commercial sectors gather to exchange innovative marketing and fundraising ideas, generate insightful solutions, and think creatively.

This conference will be the platform for improving public awareness and receptivity to direct and interactive market-driven philanthropy. The conference will also provide education related to direct/interactive marketing principles and practices, the latest in direct/interactive legislation, regulatory, and standards-setting issues facing nonprofits and address ethical practices related to direct/interactive fundraising and other communications.

31

32

Sales growth/**promotion** - To boost sales further I will also consider alternative markets to those in the original specification. These are not linked to the developing world, NGO's or charities. The EZV would very likely sell to markets in the developed world, notably the farming industry. The EZV's durable, hands-free, safe and simple design characteristics are attractive for farming industry segments such as fruit picking and vine-culture. A premium or customized model of the EZV can be easily developed. This might have increased comfort/padding, alternative tool-belt or a range of colours (customer ordered/specified) to the torso vest. Whilst such design evolution is low-cost and would not especially affect manufacture costs, it would affect production plans and material stock(ing) quantities. Such sales would hopefully demand a higher price point, at a higher or improved profit margin. Any profits made here I would consider reinvesting in product design or manufacturing process cost reductions. In other words profits made from the 'premium' EZV would reduce or 'subsidise' the cost and therefore sale price to the NGO/charity channel.

End-point of sale/packaging/transportation – The EZV will be delivered and packed flat – in user self-assembly kit form (i.e. like IKEA furniture). The flat-packing is possible because the component parts are not built or put together at the factory. This reduces production cost. Each of the key components can be stacked together or inter-locked, minimizing the size or cubic capacity of shipping required, thus keeping transportation costs down. NGOs/charities are expected to order EZV's in 'bulk', perhaps several hundred or thousand at a time and ship to their local on the ground distribution sites.

Bibliography:

General -

Bennett, A E, and Louis J Siy. "Chegg Study." *Chegg*, 2003, http://www.chegg.com/homework-help/blueprint-reading-for-welders-spiral-bound-version-9th-edition-chapter-u24-solutions-9781305142923. Accessed 23 Feb. 2017. (Third projection angle)

Safe Work ILO. "Safety and Health in Agriculture." International Labour Office, June 2000.

Siddharth. "Load Carrier for Labor." *Innovationindia*, Innovation India, 3 Mar. 2015, http://www.innovationindia.in/load-carrier-for-labor/. Accessed 23 Feb. 2017.

NASA. "3 Anthropometry and Biomechanics." *Msis.Jsc.Nasa*, 5 July 2008, https://msis.jsc.nasa.gov/sections/section03.htm. Accessed 23 Feb. 2017.

Image sources -

1. https://en.wikipedia.org/wiki/International_Labour_Organization
2. http://blog.hemmings.com/index.php/tag/unimog/
3. http://www.wisegeek.org/what-is-a-wheelbarrow.htm
4. http://www.ebay.com/gds/How-to-Use-a-Hand-Truck-/10000000178716953/g.html
5. http://www.core77.com/posts/26508/getting-to-know-the-winners-of-core77-design-awards-past-the-load-carrier-for-labor-26508
6. http://nopr.niscair.res.in/bitstream/123456789/3955/1/IJTK%208(2)%20212-217.pdf
7. http://www.gettyimages.com/detail/news-photo/wearing-a-traditional-bamboo-basket-on-her-back-a-hmong-news-photo/527474100
8 http://www.alamy.com/stock-photo/bamboo-baskets.html
9. http://www.gettyimages.co.uk/detail/news-photo/man-holding-a-freshly-harvested-bamboo-basket-of-green-news-photo/527488894
10. https://www.shutterstock.com/search/carrying+water
11. https://www.shutterstock.com/search/carrying+water
12. http://www.iranicaonline.org/articles/gilan-18-production
13. https://msis.jsc.nasa.gov/sections/section03.htm
14. http://www.innovate-design.com/inventioncalculator/
15. http://www.homedepot.com/p/Everbilt-1-in-Black-Webbing-Strap-810146/204808177
16.https://www.walmart.com/search/?query=Clip%20Buckle&u1=&oid=223073.1&wmlspartner=TQiP6m79tRs&sourceid=19996111630550386272&affillinktype=10&veh=aff
17. http://dronesarefun.com/MaterialsAndServices.html
18. http://cngaluminium.en.made-in-china.com/product-group/dMFQzgXDXJkf/Aluminum-Tube-Aluminium-Pipe-catalog-1.html
19. http://www.totalrecessedlighting.com/wing-nut-and-bolt-for-recessed-lighting-housing.html
20. https://www.amazon.com/VELCRO-Brand-Industrial-Strength-Black/dp/B00006IC2T
21. http://www.cuttingtrading.com/taglio_automatico.php
22. https://www.linkedin.com/pulse/what-best-industrial-sewing-machine-upholstery-rhys-gerrard
23. https://www.bunnings.com.au/our-range/tools/power-tools/power-saws/jigsaws
24. https://www.sipuk.co.uk/bench-floor-pillar-drills.html
25. http://www.rdgtools.co.uk/acatalog/SHEET_METAL_MACHINES.html
26. http://www.magnabend.com/en/models/magnabend-1000e
27. http://www.harborfreight.com/8-inch-flat-file-96626.html
28. https://en.wikipedia.org/wiki/Laos
29. https://www.alibaba.com/
30. http://www.made-in-china.com/
31. https://thedma.org/about-us/dma-brands/dma-events/nonprofit-conference-washington-dc/
32. http://www.asiancharityservices.org/

SketchUp 3D modeling warehouse -

Buckle clip – Eiger | Uploaded – 8/8/07
M6 Bolt – Paul | Uploaded – 2/13/09
Wing nut - PARTcommunity | Uploaded – 9/2/11
Tree sapling – thegivecommand | Uploaded – 8/6/13