Project “PRAISE”

The Problem-

Goodwana requires a “proof of concept” design for a safe autonomous system which is able to collect and deliver a payload of energy orbs into the bunker as quickly as possible, to advert a famine. This must be achieved without dropping or clamping any orbs, to avoid catastrophe disaster.

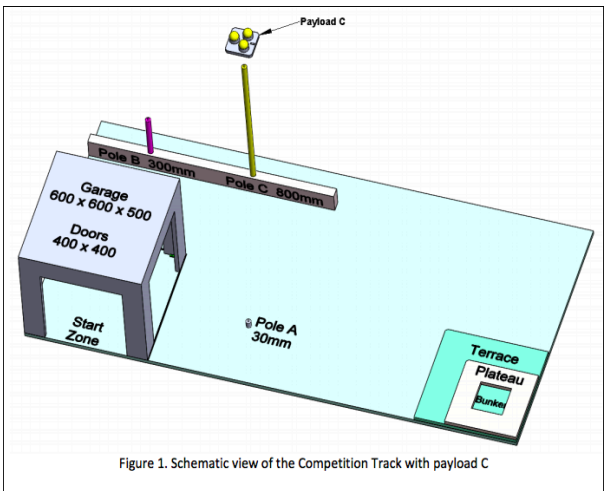


Figure 1. Schematic view of the Competition Track with payload C

There are three payloads located at several heights as seen in *Figure 1*. Teams have assigned payloads to individuals and subgroups who will develop possible solutions. The problem at hand is to develop a solution to collect and deliver payload A located 30mm high.

Brainstorming-

The autonomous system can be broken down into several parts; ball collection, ball delivery, locomotion and navigation. However, only ball collection and delivery will be addressed currently. Furthermore, ball collection and ball delivery are comprised of two components: elevation and collection and depression and delivery. This is because the payload is situated off the ground and needs to be placed in a lowered bunker. Therefore, the system must either be elevated or have the ability of elevation to collect the payload and have the ability to lower the payload upon delivery.

To gather potential ideas a mind map was created, see *Figure 2*. Mind maps are essential in brainstorming, they help bring order while allowing a free flow of ideas overall addressing the core topics while promoting creativity. Moreover, TRIZ and sketching was used to provide further lateral thinking, which helped develop ideas, see *Figure 3*.

Figure 2. Mind Map

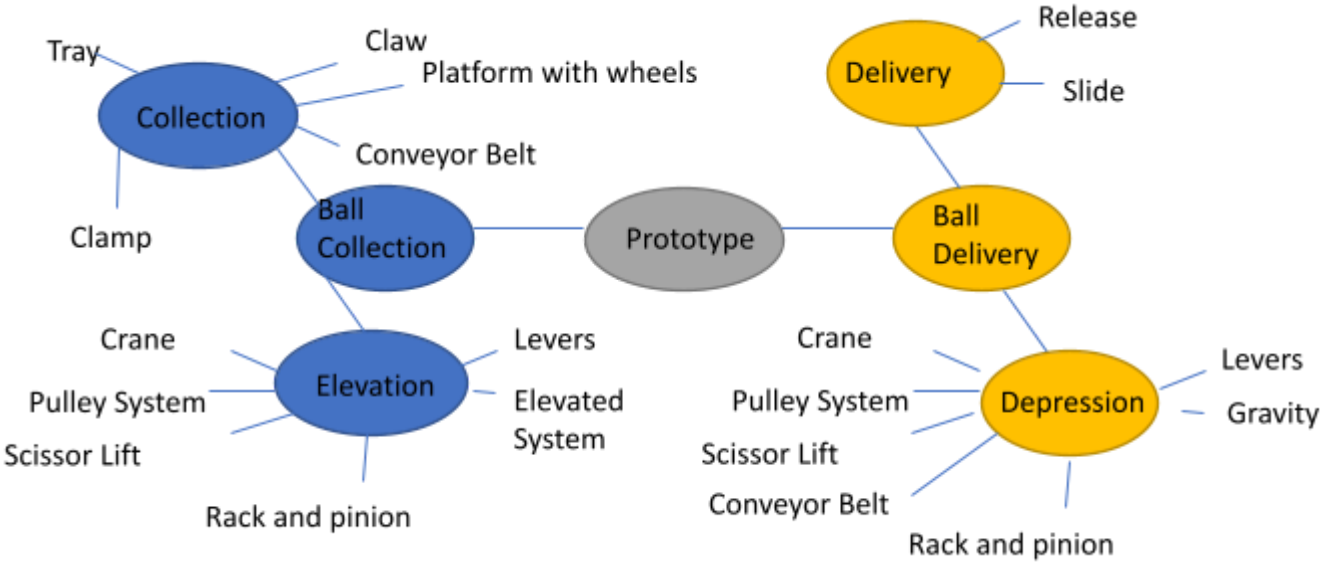
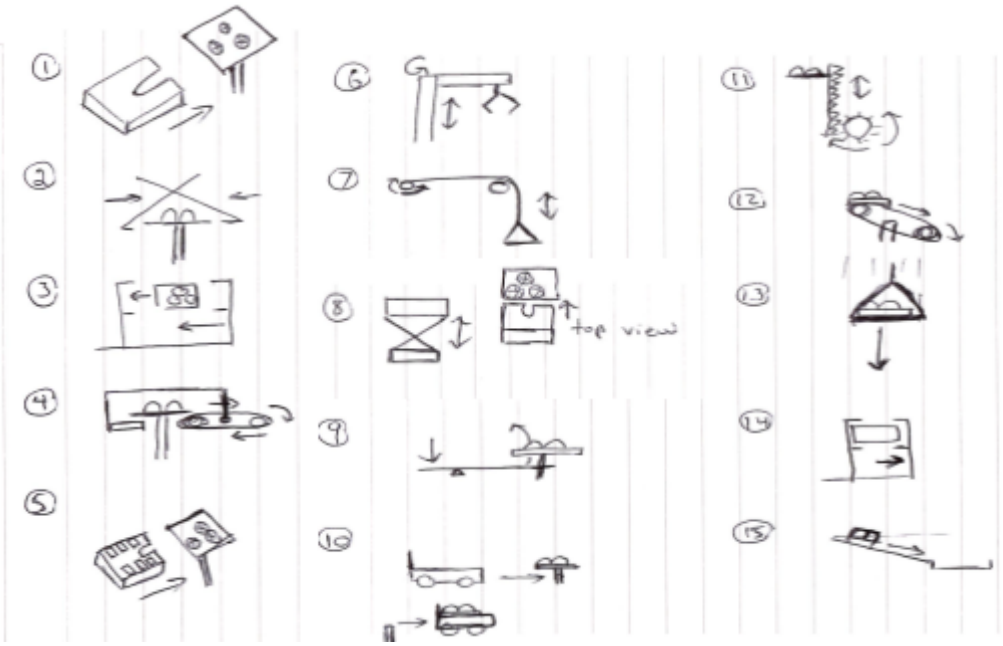


Figure 3. Sketches and TRIZ



Collection
1. Tray
2. Claw
3. Clamp
4. Conveyor Belt
5. Tray with wheels

Elevation and Depression
6. Crane
7. Pulley System
8. Scissor Lift
9. Lever
10. Elevated system
11. Rack and Pinion
12. Conveyor Belt
13. Gravity

Delivery
14. Release
15. Slope

Researching the Problem-

Most likely someone in the world has already solved this problem or a relevant problem, with ideas yet to be brainstormed. Thus, researching can provide new ideas and a spawn point for more ideas. To help focus on priorities when researching the feature matrix can be applied, defining the most desirable features to the least.

Feature Matrix

Desirability	Feature
Must Have	-Light -Simple -Able to fit in the garage at the start -Quick
Strongly Desire	-Low chance of failure -Uses available resources or resources which are cheap and accessible -Easy Construction -Easy to set up
Marginally Desire	-Easy to sketch -Aesthesis
Not Desired	-Resource demanding

Research was conducted based on the above criteria, and new ideas were adopted and adapted.

Some new ideas include:

Quadcopter

Idea-
Elevates and lowers itself, by manipulating the rotation speed of the blades.

Potential Application-
Can fly up and collect the payload in the air, then fly to the bunker where it can lower or drop the payload into the bunker.

Figure 4. Quadcopter (http://smashingdrones.com/hexacopters-quadcopters-and-octocopters-what-is-the-difference/, 2018)

Scooping Mechanism

Idea-
Applies a force underneath an object, scooping it up into a platform where it sits due to gravity.

Potential Application-
Scoops the payload upon collection into a platform, where it rests until it is lowered or slid into the bunker.

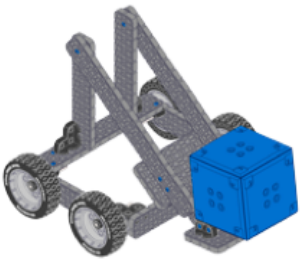


Figure 5. Scooping mechanism (https://www.vexrobotics.com/vexiq/education/iq-curriculum/mechanisms/object-manipulation, 2002)

Screw Jacks

Idea-
A screw is rotated inside a fixed nut, pushing the screw up or down depending the rotation direction.

Potential Application-
The payload can be collected onto top of this, allowing it to be lowered into the bunker.

Figure 6. Screw Jacks (http://www.fiama.it/en/rinvii-angolari-e-flangiati-per-indicatori-di-posizione/167/mar50.html, unknown)

Chain Mechanism

Idea-
A chain connected to two cogs which rotated, spinning the chain.

Potential Application-
The object can be picked up by a platform attached to the chain, where it can be elevated or lowered depending on rotation direction.

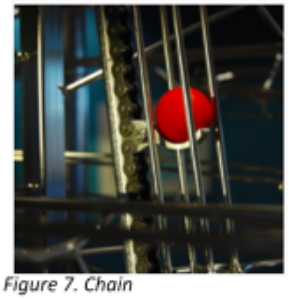


Figure 7. Chain (http://www.eddiesmind.com/basic-lifting-mechanisms.html, unknown)

Identifying Criteria and Specifying Constraints

This project has several restrictions, having specific requirements outlined in the Warman Competition rules, limited time and resources available. There are personal limitations which may reduce achievement. Consequently, these restrictions will greatly reduce success, hindering and eliminating potential solutions.

Device Specification

-6 kilograms
-Able to start inside the Garage and leave
-Completion in 100 seconds
-Successful elevation and collection
-Payload delivered into the bunker
-Autonomous navigation and locomotion

Warman Competition Requirements

-Predefined track dimensions
-No human interaction
-Ground Based system
-No pre-built systems
-Must cause no damage to the track
-Warman scoring algorithm

Personal Constraints

-Personal Commitments
-Technical Skills
-Financial situation

Time Constraint

-Less than 13 weeks to create an autonomous system and test it

Exploring Possibilities

The ideas generated earlier now can be analysed, in terms of the previously highlighted constraints. Eliminating ideas due to them being unfeasible or not meeting the requirements. After narrowing the ideas, the construction process will be analysed pursuing the available materials and resources.

Eliminating Ideas

Idea	Reason
Quadcopter	Must be a ground-based autonomous system.
Levers	It is too unrealistic to use a lever, as it requires too many moving parts to push or pull down one side of the lever.
Crane and Claw	Cranes require to be above the object, which creates instability, potentially dropping the orbs.
Gravity	The orbs cannot be dropped.
Screw Jack	It would be slow to lower which may cost the project.
Clamp	Due to the design of the bunker, there will be a drop when unclamping, however, the clamp can be modified so there is no drop.
Elevated System	This idea is too unrealistic, as it is supposed to travel up to the bunker which has a tough terrain making it hard to program.

This project will be constructed in LaunchPad, a QUT workspace. Which facilitates an array of tools and consumables for QUT projects. The machinery includes: hand drills, hot glue guns, laser cutters, 3D printers, belt sander plus many more.

Material Analysis

Material	Pros	Cons
Balsa Wood	-Light -Easy to cut and shape, due to its low density -Impressive weight-to-strength ratio -Inexpensive and accessible	-Moderately strong material -Screws and nails can be taken, however, they may not hold for long
Plywood Sheet	-Cheap and accessible -Sturdy -Easy to cut and shaped -Can be secured with nails and screws -Various thickness	-Tends to splinter and chip -Difficult to repair -Difficult to connect certain joints
Aluminium Sheet	-Very Strong -Light -Easy to mould and reshape -Relatively cheap and accessible	-Can be sharp if not sanded -Difficult to repair once damaged -Under vibration screws can become loose
Acrylic Sheet	-Very strong -Various sizes -Light	-Costly

Selecting a Viable Approach

The final step is deciding on a final solution, this can be achieved through the application of the decision matrix where ideas are assessed based on criteria. The decision matrix consists of ratings of 1, being the least desirable to 5 being the most desirable for each of the criteria. The idea with the highest total score will be selected for the final solution.

Collection

Upon delivery, the collection mechanism will be either released or sloped where appropriate to avoid dropping the orbs. Thus, this will be considered when analysing the collection mechanisms and rules out the need for an exclusive delivery analysis.

Component	Weight	Size	Task Time	Ease of operation	Construction	Cost	Build time	Feasibility	Total score
Tray	5	5	4	5	5	5	5	5	39
Conveyor Belt	2	3	4	3	3	3	3	5	26
Modified Clamp	4	4	4	4	4	5	4	5	34
Platform with Wheels	3	5	5	5	4	4	4	5	35
Scoop	3	3	4	4	4	4	4	4	30

Elevation

All elevation systems can also be depressed, thus incorporating depression when analysing elevation.

Component	Weight	Size	Task Time	Ease of operation	Construction	Cost	Build time	Feasibility	Total score
Chain	4	4	5	5	5	5	5	5	38
Scooping Mechanism	3	3	4	4	4	4	4	4	30
Pulley System	5	3	4	4	4	5	5	5	35
Scissor Lift	1	3	3	2	4	4	2	1	20
Rack and Pinion	4	3	3	3	5	5	5	3	31
Conveyor Belt	3	3	4	3	3	3	3	5	27

The best solution for the system will combine the tray mechanism and the chain mechanism, having the greatest score in the decision matrix. The tray mechanism allows an easy and quick collection, slotting underneath the payload snuggly due to its design. Then lifting the payload up through the use of the chain mechanism, where it can be quickly lowered and slid into the bunker. An isometric representation can be seen in *Figure 8*.

However, this is no means the final solution, it will be pitched along with other ideas found by the rest of the team. Where the ideas will be assessed, and compared in terms of ensuring the best grade (e.g. pole multipliers, likelihood of completion and completion time).

Figure 8. Isometric Drawings of Proposed Design