Project "ESCAPE"

A crisis is brewing on the outlying planet Vayu for the Gondwana Home Office. Through secure communications, the Home Office has learnt that Gondwanan expatriates have been imprisoned in an old mine by a rebel tribe.

At the mine, the rebel guards control the only lift and the only alternative access to the ground surface is via a large diameter (relative to the Gondwanans) vertical shaft. The shaft strangely has a centre pole anchored solidly in the floor. The pole, a remnant from past mining activity, projects above the ground surface but is unsupported above the tunnel floor. The pole is believed to be structurally sound but the vertical walls of the shaft are unstable and can not be climbed. However, the horizontal tunnel and passages leading from the vertical shaft are quite extensive, and perhaps unknown to the rebels, they are quite well stocked with tools, building materials and basic engineering supplies.

The rebel tribe guards have chosen to base themselves adjacent to the vertical shaft both at ground level and within the mine. They have shown no interest in monitoring the remainder of the mine system. The prisoners have undertaken surveillance of the rebels and it is evident that there are windows of opportunity for escape but timing and secrecy are important to maximise the opportunity for all to escape. While ferocious, the rebels have poor sight in the low light conditions of the mine. Their behaviour is also curious in that they have never been seen to look up and once a day they all take a break for a game of cards, which appears to have them, totally engrossed and oblivious to anything going on around them.

During the card playing would be an ideal time to mount an escape attempt. The Gondwanan captives are not engineers. If they are to make use of the resources available to them, they need to be given a plan and instructions.

The Gondwana Home Office is keen to assist the expatriates in effecting an escape and safe return to Gondwana. It is proposed that if the prisoners can make it to the ground surface with precise timing, assistance can be rendered through evacuations with vertical take-off and land aircraft at the mine head.

Fortunately, teams of mechanical-engineering students from Earth are about to visit Gondwana as part of their work experience programmes. On previous visits engineering students have rendered invaluable assistance, and the Gondwanans again seek help from these budding engineers.

Objective

The objective is to design, build and prove a prototype device that when constructed in the field would enable the Gondwanan expatriates to escape the rebels' clutches by reaching the ground surface with precise timing. Can your team **E**ngineer for a **S**afe and **C**landestine **A**scent of im**P**risoned **E**xpatriates?

- Competition Rules
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Competition Rules

(Original Released: 25/2/2003)
7th March 2003 – Rule 28 refined
28th April 2003 – Rules 12, 15, 21, 26 and 28 refined / relaxed
16th May 2003 – Rule 28 clarification

ELIGIBILITY

1. Teams of up to four second-year mechanical-engineering students in Australian or New Zealand universities may enter the competition. Teams of three or four are recommended.

MATERIALS AND MANUFACTURE

2. Resources on Gondwana and in the Vayu mine are limited and so the students must manufacture their prototype device themselves using commonly available materials and components.
3. Devices that are deemed by the judges to be hazardous will not be permitted to run. In particular, devices using combustion or which damage the competition site are prohibited.

TRACK

4. The competition site base, modelling the "tunnel floor", shall consist of two horizontal sheets of 2400 x 1200 x 19 mm Medium Density Fibreboard (MDF) joined together, end to end, as shown in Figure 1. A plinth (suggest 90x35 pine) may be used to support these sheets.
5. A "ground surface" will be modelled in way of the "vertical shaft" by an 1800 x 1200 x 19 mm sheet of MDF supported by vertical columns, and with its top surface 2000 mm above the "tunnel floor".
6. The "tunnel roof" will be modelled in way of the "vertical shaft" by a 1200 x 1200 x 19 mm sheet of MDF, supported by the vertical columns referred to above, with its bottom surface 750 mm above the tunnel floor. The tunnel roof is to be imagined to exist along the length of the track, placing a restriction on the height of the device as it progresses along the tunnel.
7. Both the ground surface and tunnel roof sheets of MDF have 800 mm diameter holes cut in their centre modelling the "vertical shaft".
8. All surfaces of the MDF sheets will be brush coated with one coat of Wattyl Estapol Speed Clear followed by two coats of Wattyl Instant Estapol Matt.
9. With the use of plinths, blocks and/or collars, a rigid pipe will emerge vertically from the "tunnel floor" and stand on the centreline of the vertical shaft. It will extend a minimum of 3000 mm clear above the tunnel floor and may be supported by horizontal ties to the vertical columns or other available structure at or above 3000 mm. The pipe supports shall limit the horizontal deflection of the lower end of the pipe to less than 1 mm and of the upper end of the pipe to less than 10 mm.
10. The pipe shall be "Galv. Extra Light" of nominal bore 50mm, OD 60.3mm [Reference Blackwoods Catalogue, Part Number 01213042, http://www.blackwoods.com.au/].
11. The vertical columns supporting the ground surface, tunnel roof and possibly the top of the pipe are to be positioned outside the projection of the tunnel floor. (The columns shall be used to support the top of the pipe at the National Final.) Material suggestions for the columns are 90x35, 90x45, 70x35 pine or 25mm RHS steel. Cross bracing should be fitted as appropriate without obstructing the tunnel or vertical shaft.

PROCEDURE

12. The Team will nominate the distance they want to start from the pole, x [0, 3.000 m]. A batten or temporary wall placed perpendicular to the longitudinal centreline of the "tunnel floor" by an official will mark this start position.
****** Revised 28/4/03***
***Note:* A device will be deemed to be acceptable and to have an x of 0 if on set-up it touches and/or surrounds the pole fully or partially.**

13. The net mass of the device, devM, will be measured in kg (to the nearest 10 grams). The device must not exceed a net mass of 20 kg.
14. An Official will hand the Team a light bulb (standard bayonet, 75W) and two hockey balls (5.5 oz each) representing delicate scientific equipment and the Gondwanans. The Team will then be allowed a maximum of two minutes to set up their device on the competition site.
15. The device shall not contact the track ahead of the batten or wall marking the start line during set-up.
****** Revised 28/4/03***
***Note:* A device will be deemed to be acceptable if on set-up it surrounds the pole fully or partially and/or contacts the pole.**
16. An official will remove the batten or wall marking the start line when set-up is complete.
17. Prior to its release, the device must be wholly contained within a 500 mm cubic envelope, be stationary behind the nominated starting line and have nothing penetrating the vertical plane of the starting line.
18. On instruction from an official, the run will commence and must be completed within 120 seconds.
19. One team member will activate the device by a single action that does not assist the device in any way. No assistance may be given to the device at any time after commencement of the run.
20. During the run the device must not come into contact with anything other than the top surface of the MDF base modelling the tunnel floor, the bottom and inside vertical edges of the hole in the MDF sheet modelling the tunnel roof, the top and vertical edges (inside and outside) of the MDF sheet modelling the ground surface and the external vertical surface of the pipe to a height of 3 m above the tunnel floor. Devices shall not contact the supporting vertical columns.
21. During the run, no part of the device shall reach a height greater than 3 m above the tunnel floor (in way of the vertical shaft) or project horizontally beyond the MDF sheets modelling the tunnel floor.
****** Revised 28/4/03***
***Note:* Above the ground surface, a device may project horizontally beyond the MDF sheets modelling the tunnel floor.**
22. Teams shall clearly demonstrate to the officials the position of the light bulb and hockey balls, and the vertical height to the lowest point on each must be easily measured at the completion of the run (y_{BULB}, y_{BALL1}, y_{BALL2}). At the completion of the run, the lowest points of the light bulb and hockey balls would all ideally be presented at ground level.
23. At the completion of the run, the whole device or part of it could be sitting on the MDF sheet modelling the ground surface.

SCORING

24. The time from commencement of the run until the light bulb and hockey balls are stationary in their final position with a "secure" path from the device to solid ground, tsec, will be measured in seconds. The target time for this evolution is 30 seconds. The maximum value of tsec attributed for scoring purposes will be 60 seconds.

25. Elements of the device may continue moving after delivering the light bulb and hockey balls up to the maximum allowable run time (120 seconds).
26. For a non-zero scoring run, the light bulb and hockey balls shall reach a final position a minimum of 750 mm above the tunnel floor ~~and some element of the device representing the secure escape path to solid ground shall be in contact with the ground surface (top face) or the inside vertical edges of the hole in the ground surface MDF sheet.~~ The whole device shall be essentially stationary within 120 seconds and the light bulb must be intact.
*** ***Revised 28/4/03***
Note: **A device will be deemed to achieve a non-zero scoring run if the light bulb and hockey balls reach a final position a minimum of 750 mm above the tunnel floor, the whole device is essentially stationary within 120 seconds and the light bulb is intact. Not making contact with the ground surface attracts a 0.8 multiplier for safe passage (SP).**
27. Each team may attempt two runs and the Warman Competition Score will be the best score achieved from either run. The highest Warman Competition Score wins. The device may be modified between runs.

$$\text{Score} = (LP)*(delX)*(delY)*(delT)*(normM)*(SP)$$

28. Factors of the score relate to secrecy, translation, lifting, timing, net mass of the device and safety.

Secrecy:
Height above floor to lowest point of device, y_{LP},
LP = 1, if $y_{LP} > 0.75m$
= 0.667, if $y_{LP} \leq 0.75m$

***** ***Revised 7/3/03***
Translate: [1,2]
delX = 1 + x/MaxX, if LP = 1
= 1 if LP = 0.667
where x is the horizontal distance of the nearest point of the device to the nearest point of the pole at completion of set-up, measured in metres (to 3 decimal places)
MaxX is min(3.000, greatest x in the competition for devices with LP = 1 and a nonzero score)
***** ***Revised 28/4/03***
Note: A device will be deemed acceptable and to have an x of 0 if on set-up it touches and/or surrounds the pole fully or partially
***** ***Revised 16/5/03***
Note: A failed device (Score = 0) should not influence a successful competitor's score. To be considered in specifying a value for MaxX, the device score should be nonzero and have an LP = 1.

Lift: [0,2]
Y = $\max(|2 - y_{BULB}|, |2 - y_{BALL1}|, |2 - y_{BALL2}|)$
delY = 2 - Y, if Y ≤ 1.25m
= 0, if Y > 1.25m
where y_{BULB} = height to lowest point of light bulb above tunnel floor measured in metres (to 2 decimal places)
y_{BALL1} = height to lowest point of ball 1
y_{BALL2} = height to lowest point of ball 2

Timing: [1,2]
target = 30 seconds
delT = 2 - |target - tsec| / target
where tsec = time until the light bulb and hockey balls are stationary in their final position with a "secure" path established from the device to solid ground measured in seconds to nearest second, with max attributed value of 2*target (60 seconds)

****** Revised 7/3/03***

Device Mass: [1,2]

normM = 1 + (maxM – devM) / (maxM – minM), if LP = 1

= 1, if LP = 0.667

where devM is the net device mass (no Gondwanans) measured in kg to nearest 10 grams
minM is the minimum devM in the competition for devices with LP = 1 and a nonzero score
maxM is the maximum devM in the competition for devices with LP = 1 and a nonzero score

note **if only one device achieves an LP of 1** and a nonzero score**, this device will be assigned a normM value of 1.5**

****** Revised 16/5/03***

Note: A failed device (Score = 0) should not influence a successful competitor's score. To be considered in specifying a value for minX and maxX, the device score should be nonzero and have an LP = 1.

****** Revised 28/4/03***

Safe Passage:

At the completion of the run, is the device contacting the top horizontal surface or the inner vertical surface of the ground, is the device stationary and is the light bulb intact?

SP = 1, if yes to all

= 0.8 if stationary and intact

= 0, if not stationary or intact

~~= 0, if no to any~~

29. In the case of a tie for first place, there shall be repeated head-to-head runs between these teams until only one team remains. These repeated runs will be conducted at five-minute intervals.
30. The judges' decisions on all matters pertaining to the competition will be final**.**

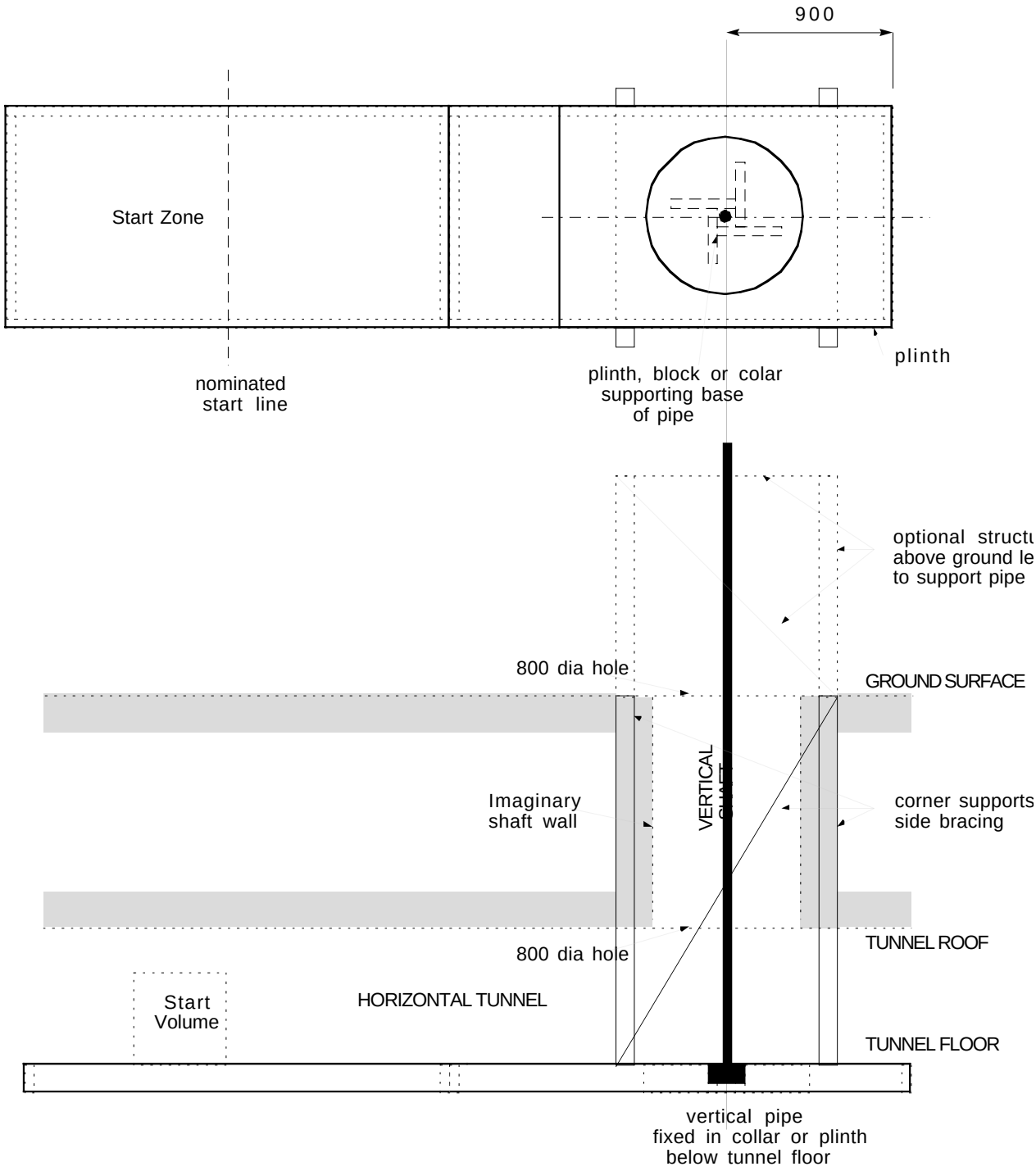


FIGURE 1 - PROJECT "ESCAPE" COMPETITION TRACK

Frequently Asked Questions

(Last Updated: 7/3/2003)

1. Reliability? Why is the score based on the best of two runs rather than some average of the two as in past years?

Answer: Reliability is a very important feature of good design. A good device will need to be inherently reliable. However, the story relates to escape and in this context only needs to be effected once. One might consider there are only two chances to escape and what matters is that you have to be capable of getting it right once.

2. What constitutes fair contact with the ground surface at completion of the run?

Answer: As indicated in Rule 26, contact must be made with the ground surface (that is either the top and/or vertical edges around the hole of the MDF sheet modelling the ground surface). This can be achieved with any element of the device. Conceptually, it represents a safe path from the device to the ground and ultimate freedom for the Gondwanans. The shaft is large in diameter relative to the Gondwanans so raising them is not enough to ensure safe transition to solid ground. They need a "path".

3. Is the pipe prescribed available in NZ?

Answer: Yes, contact Darren Gunther, at Blackwoods on 09 980200 or supply@blackwoods.co.nz (price quoted, NZ$53.95 per length (6.5 m)).

4. The team will nominate the distance they want to start from the pole, x [0,3.000m]. Does this mean any distance from 0 to 3m?

Answer: The students can nominate any distance between 0 and 3 m from which to start. (See definition of x, Rule 28: "x is the horizontal distance of the nearest point of the device to the nearest point of the pole at completion of set-up, measured in metres (to 3 decimal places)".)

5. "MaxX is min (3.000, greatest x in the competition with LP = 1)". Please expand on the interpretation of this statement.

Answer: MaxX is a normalising value used in calculating DelX. The story suggests that secrecy is important so if the lowest point of the device at the completion of the run is greater than 0.75m above the tunnel floor, LP is set to a value of 1 for this device. For all devices achieving an LP value of 1 in either run, MaxX is defined as the greatest x achieved by this subset of devices in the competition.

6. In calculating Timing, it is written: "...measured in seconds to the nearest second, with max attributed value 2*target". Please explain.

Answer: In the scenario, timing is important to coordinate ascent with the arrival of the evacuation flight. The score multiplier for time has been restricted to be in the range of 1 to 2. If the target time of 30 seconds is achieved, DelT is equal to 2. If tsec is 0 or equal to or greater than 60 seconds, DelT takes a value of 1. If the time taken for the light bulb and hockey balls to be stationary in their final position with a "secure" path from the device to solid ground is in the range of 60 to 120 seconds, the value attributed to tsec is still only 60.

7. 7th March 2003

Rule 28 – explanations. If no device elevates above 0.75m (eg LP=0.667), then how are MaxX, minM and maxM determined? The same problem occurs if only one device scores LP=1.

Answer: A key aspect of the competition is "secrecy". Translation and mass may be thought of as secondary issues. The interpretation to be placed is that a multiplier greater

than 1 for translation and mass is only available when an LP of 1 is achieved. The definitions in Rule 28 have been refined.

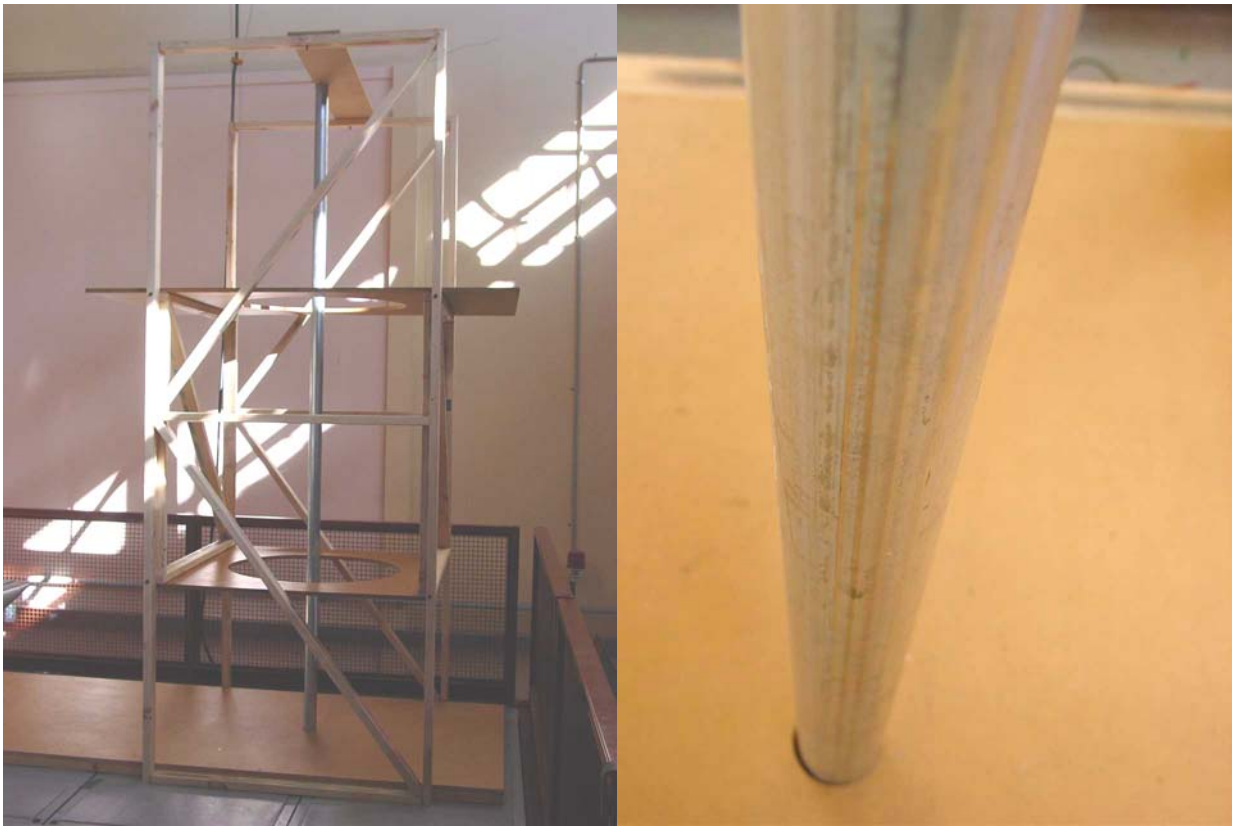
8. 28th April 2003

Rule 20 – We are puzzled as to why the device may contact the outside vertical edges of the MDF sheet modelling the ground surface. This appears inconsistent with the given scenario and in effect means only the outside vertical edge facing the start volume can be contacted because contact with the other three edges would strictly be in conflict with Rule 21.

Answer: Got me. At ground level the intention was to allow students to use the edges for stabilization if required. However, the structure supporting the ground surface and the top end of the pipe will vary from campus to campus. This may interfere with a planned use of the side edges. However, the end edges should be clear. Touching any edge of the ground surface will not be penalised. See modification to rule 21.

9. 28th April 2003

A photo of the ADFA track and close up of the pole is shown for information. This track and or those from Sydney campuses may be used at the Final.



Further Competition Details

(Last Updated: 28/2/2003)

The Weir-Warman National Final has been tentatively set down for Friday 26 - Saturday 27 September 2003 at Sydney's Powerhouse Museum. These dates will be confirmed later in the year.