MINESHAFT

Borehole Rescue Robots

Description, Rules and Procedures v0.2 20160509

Task Description

The project objective is to build a rescue system for recovering trapped miners following a massive earthquake that has collapsed several tunnel sections of Rotenzimmer Mine. Fortunately, the earthquake occurred during a shift change and only one section of the mine was occupied with a skeleton crew. However, the surface entrance to the mine has completely collapsed and the only way to reach the miners is via a newly bored access shaft. The rescue system must be sized for insertion down the narrow borehole and be capable of locating and, if possible, rescuing the miners trapped below. The project consists of three main tasks:

Enter the mine: Descend through the borehole and return images from inside the mine.

Locate miners: Locate as many miners as possible, noting their location within the mine and health condition if possible~~: 'healthy' (standing), 'injured' (sitting), or 'dead' (laying down)~~.

Rescue miners: Return as many miners to the surface as possible.

A final bonus task will be made available to teams that successfully rescue all surviving miners:

Assess the mine: Full explore the mine and give an assessment of its stability by reporting the status indicated on seismograph readouts posted around the mine.

All-up system testing will occur during scheduled demonstration sessions in week 13. There will also be incremental demos in weeks 7, 9 and 11, allowing partial functionality to be demonstrated. Be aware that this project specification **will** be updated through the course of the semester, with at least one guaranteed project specification change, requiring your design to be flexible to accommodate changes.

Principal components

Mine: Rotenzimmer Mine is a deep subterranean mine in the early stages of construction. The occupied portion of the mine accessible to the borehole consists of two levels, connected via a ramp suitable for traversing heavy mining equipment. The mine contains the miners, mining equipment, seismograph monitoring stations and removed rock awaiting transport to the surface. The mine is divided into named sectors, posted on placards throughout the mine.

Borehole: Entry to the mine is via a newly bored shaft approximately 86 mm diameter. The shaft will be no less than 6 m long, and no more than 10 m long. The mineshaft will descend at an angle of no more than 30 degrees from vertical.

Miners: The miners are represented by LEGO minifigures dressed as miners, with clothing of varying degrees of visibility. There will be five miners in total. Their locations within the mine are not known *a priori* and it is possible that they have moved within the mine following the incident.

Seismograph: The structural status of the mine is reported on paper readouts posted throughout the mine. The seismograph readouts take the form of a 50 x 50mm QR code on paper that must be inspected visually. The display may not be easily visible due to obstructions.

Hazards: It is expected that the mine interior will have suffered severe structural damage, and the rescue system may encounter obstacles and obstructions including (but not limited to) rubble piles, rock falls, overturned mining equipment ~~and collapsed ceilings~~. Boulders of up to 150 g are anticipated. Rubble piles will take the form of assorted LEGO bricks, small rocks, loose gravel, dirt, or sand.

It is known that radio signals do not penetrate from the surface to the interior of the mine. It is not anticipated that any power or lighting will be functioning in the mine.

Testing Procedure

Each demonstration session will run for 20 minutes, during which students must complete all required setup, conduct the rescue and report findings. After 20 minutes, the students must cease operations and will have 5 minutes to pack down and clear the mine ready for the next team. The time-limits will be rigorously enforced. Build quality may be assessed at any time during the 20 minute slot. If the rescue system becomes trapped or incapacitated, the team may elect to have the testing coordinator return the rescue system from inside the mine to the mine entry, at the cost of a 5 minute penalty per retrieval.

IMPORTANT NOTE: The borehole is a shared piece of testing infrastructure. If your system becomes jammed in the tube and you are unable to free it yourself, it will be forcibly cleared with a stiff metal probe. Emphasis will be clearing the jam and returning the borehole to service, rather than on preserving the integrity of your hardware. If your system jams the tube, **expect it to be destroyed** in the process of clearing the jam. It is your own responsibility to build a system that will not jam and is easily removed from the tube.

Scoring

Task performance will be assessed by a points system based on demonstrated performance and build quality. Refer to the separate build quality rubric and guidelines for build quality specifications. Only the performance of the overall system will be considered; no part will be considered separately.

Build Quality	**10/10 Points**

Basic functionality	**25/25 Points**
Rescue system enters the mine	10
Images of mine interior returned to surface	5
Rescue system reaches second level	10

Locating miners	**30/30 Points**
Miner visually identified	2
Miner's sector location noted	1
Miner's health status reported	2
All miners located	5

Miner rescue	**35/35 Points**
Healthy miner rescued	5
Injured miner rescued	6
Deceased miner recovered	4
All miners returned to surface	10

Bonus Functionality	**10/10 Points**
Sector stability status reported	2

Apparatus

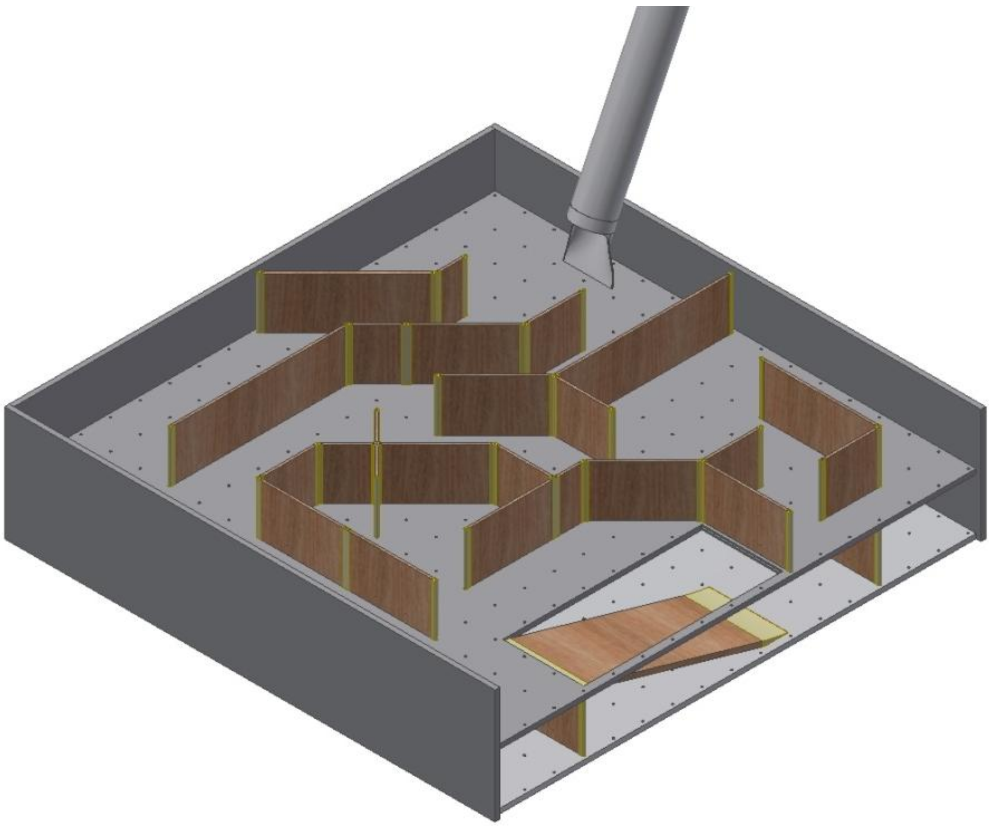
The mine apparatus consists of a plywood box with two levels and an aperture for the borehole. The box will be 1220 mm by 1220 mm, and each level is 130 mm high. The access ramp between levels is 200 mm wide, and 500 mm long. The ramp can be placed in different positions and orientations.

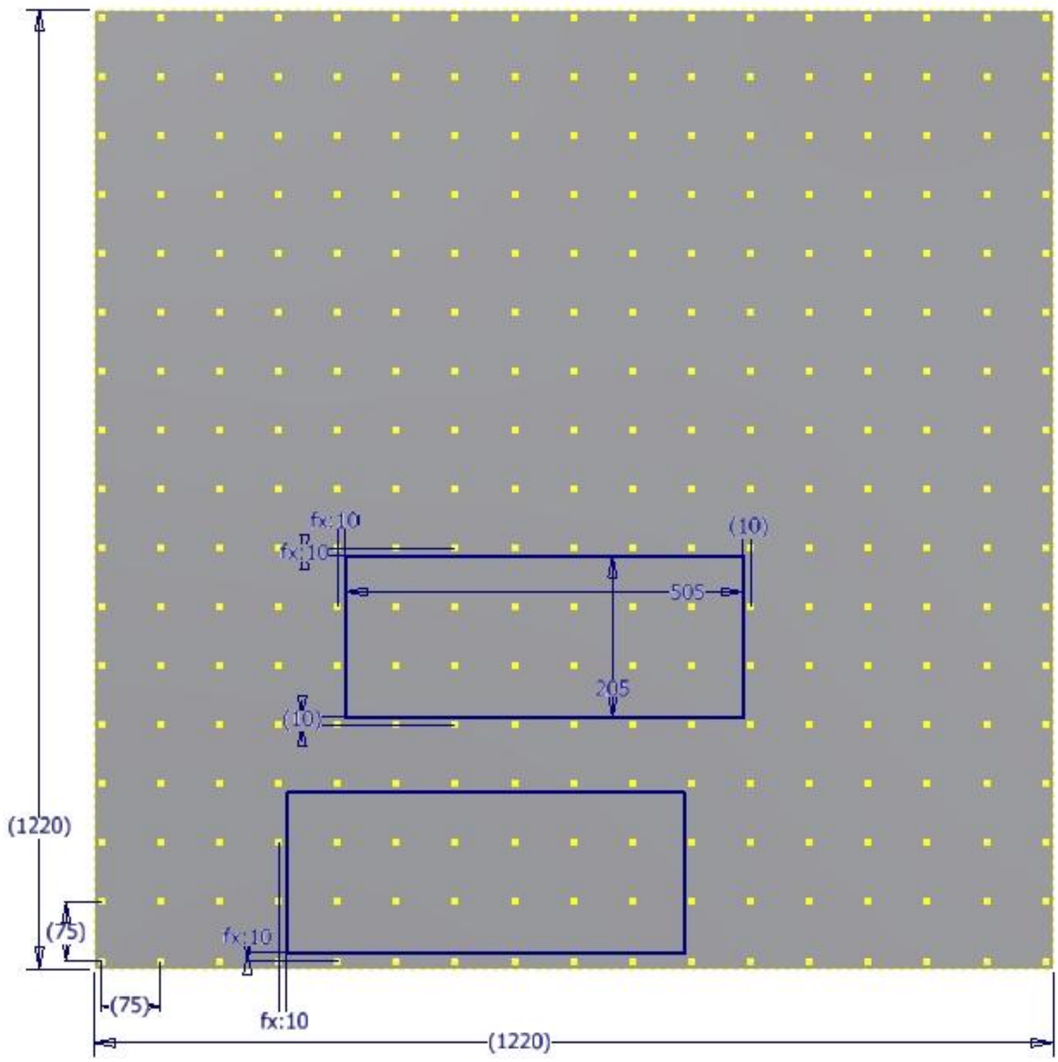
The box will be closed and sealed against light, and may be shielded with RF reflective material. The interior of the mine is constructed from a modular wall system spaced on a 75 mm peg board grid. The walls positions may be changed to new and different configurations between tests. The pegboard holes will penetrate the floor of the mine.

The borehole will be PVC tube with a diameter of approximately 86 mm. The diameter of the borehole will be approximately constant along its length, with the possibility of slight curvature.

A screw plate is ~~may be~~ provided for mounting equipment at the mouth of the borehole. This plate may be ~~removed~~ used to affix your own equipment ~~to the bare tube end~~; it may not be removed from the tube. Geometry for the screw plate mounting holes ~~will be provided later in the semester~~ is provided in a separate document.

Miner health status will be marked with coloured tags on their front torsos indicating their health status: : 'healthy' (green), 'injured' (yellow), or 'dead' (red).





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System Design Guidelines

Each team must construct a mine rescue system and attendant support equipment using a limited budget. At least one component must be machined from metal, using milling, turning, water-jet cutting or any combination thereof. At least one custom PCB must be produced. The instructor shall be the final arbiter of whether the any part of the system, or the system as a whole, is legal within the guidelines. Up to four MS Livecam Studio Pro webcams will be made available to the class; these may not be altered or attached to the rescue system in any permanent way, and must be returned after each use. Students may provide their own laptops or desktop computers, which do not count towards size or budget limits.

Construction

Dimensions

Subterranean parts of the rescue system must enter and leave the mine via the borehole. The borehole is approximately 86 mm in diameter, but the exact dimension is **not** guaranteed. The entire rescue system, including all support equipment (except laptop/desktop computers), must fit inside a typical shoebox for final submission.

Control

The rescue system does not need to be autonomous; teleoperation from a surface control station is allowed. However, no wireless links between surface and subterranean parts of the system are permitted; the subterranean environment may be shielded with radio-reflective material.

Power Sources

Stored energy in the subterranean parts of the rescue system is limited to charged electrical devices – no stored elastic, nuclear or thermal energy systems may be used. **Li-poly batteries may total no more than 15 kJ maximum energy capacity.**

Budget

The total cost of materials, parts and components incorporated in the product shall be no more than $150 (excluding the MS Livecams and laptop/desktop computers). Regardless of actual cost to construct, the team must demonstrate that the product produced *could* be constructed from parts costing less than or equal to $150. Up to $150 will be provided for purchase orders through ETSG. **Reimbursements will *not* be permitted.**

Cost of parts shall be calculated on a per-item basis; parts that are purchased in multiple units may be costed per unit – e.g. a bag of 10 nails for $10 may be charged at $1 per nail used. Bulk unit discounts from suppliers may be applied, provided the quantity of items used in the product is sufficient to earn the discount. Items sourced for free (i.e. not paid for) may be costed at half the market purchase price. While it is not necessary to have circuit boards manufactured at ETSG, any boards produced by outside fabricators must be purchased via ETSG in order to be paid out of budget.

Each team will be provided with 500 g of 3D printer filament in a unique colour. Once this material has been exhausted, no further filament will be provided or nor may be purchased with the build budget. Only the provided filament may be used in submitted work.

Specific Prohibitions

- **No additional off-board sensing**
  Sensors may only be mounted on the subterranean part of the rescue system. No offboard FLIr, ground-penetrating radar, or other such remote imaging systems may be used.
- **No outside markers or alterations**
  No signs, structures, markers, radio beacons may be installed outside of the mine; such items may be deployed inside the mine by the subterranean part of the rescue system, but may these not be manually installed ahead of time. No alterations may be made to the mine interior or borehole. Rescue systems that cause damage to the mine or borehole may be prohibited from operating.
- **No internet connection**
  No part of the rescue system, support equipment or off-board processing facility may be connected to the Internet. Where WiFi or similar wireless protocols are used to connect between the surface station and another computer, it must be demonstrated that no computer on its network is connected to the Internet. The instructor may elect to have the connection status of any input device demonstrated prior to testing. The instructor shall be the final arbiter of whether a connection constitutes connection to the Internet.

The Aim of the Project and the Spirit of the Rules

Without a doubt, engineering students are extremely creative and talented at finding clever solutions to difficult problems. This project aims to teach you about the practical trade-offs encountered by engineers when facing a multi-faceted challenge with broad scope and many possible solutions. It is recognised that no set of rules could cover every possible edge-case without becoming cumbersome fodder for ‘rules lawyers’.

Thus, the two cardinal rules are:
1. The instructor’s decision is final.
2. Stay within the spirit of the problem.

If you think what you are attempting might not be in accordance with the spirit of the rules, there is no harm in asking! The instructor will rule whether a particular approach is permissible. Obviously, it is best to ask these sorts of questions early in the semester and before committing to a particular solution!

Other Miscellanea

By-laws, clarifications and addenda go here. This used to be a short section, but previous years' students have shown that it is *depressingly* necessary to spell-out exactly what you should not be doing. But you're going to be smarter and better dressed than them, *right*? ☺

1. All OH&S inductions and procedures *must* be adhered to. You **WILL** be ejected from the lab if you are unsafe or in violation of footwear requirements. Repeat offenders will be barred from the teaching labs for the remainder of the semester.

2. It is the responsibility of all students to keep the teaching labs in clean, functioning condition. Lab cleanliness will be arbitrated by a warning system, as posted on the class blackboard site and class website.
    a. The lab status starts at GREEN.
    b. If the condition of the labs deteriorates and becomes messy, status will change to YELLOW, indicating that a clean-up is needed.
    c. If conditions do not improve or deteriorate further, the status will be changed to RED and the labs will be set to fixed-hours, with after-hours access prohibited.
    d. If conditions still do not improve or deteriorate further, the status will be changed to BLACK and the labs will be locked to students until the next practical session, whereupon the labs must be completely cleaned before any work may resume.

3. The following are specifically prohibited:
    a. Eating in the lab
    b. Sleeping in the lab
    c. Leaving the lab door open (all students have access cards)
    d. Giving non-enrolled students/non-students access to the lab
    e. Non-work related activities (e.g. computer games)

    Students found to be violating these rules will have lab access revoked.

4. Under no circumstances may project infrastructure, test equipment, tools, supplies, furniture, etc. be removed from the teaching labs. 'Vegas rules' are in effect: what happens in c404 *stays* in c404. Transgressors will be barred from the teaching labs for the remainder of semester.

5. No grade will be awarded until all assigned tools and equipment are returned and accounted for, including shared lab equipment such as cameras and testing apparatus. Students are separately and collectively responsible for their group's tools.