LOGISTICS TYCOON

Cranes, trains and supply chains

Description, Rules and Procedures v0.2 20200303

Task Description

Your task is to build a freight handling and transport system to move miniature containers filled with cargo from the receptacles of their starting freight yard to the destination freight yard receptacle corresponding with the colour of the container: red, yellow, green or blue. Teams with four students must process freight with four colours of containers; teams with three students must handle freight with three colours of containers.

There shall be 15 of each colour of container, arranged randomly between the starting yards. In addition to the freight yards corresponding to the container colours, there shall also be a white coloured freight yard which may be used as sorting space or temporary storage for containers. The freight yards are arranged in a known fixed pattern, but the assignment of each colour to its freight yard shall be different for each team and unknown prior to the start of the task.

Cargo containers may be transported between freight yards using a rail network constructed from modular 40 mm wooden track segments such Brio, Lillabo, or similar systems. Students may also manufacture their own track units or modules compatible with 40 mm wooden track, but may not use other types of pre-made track systems. The containers must be loaded and unloaded from trains using a cargo handler system. Cargo handler systems may only be affixed to the mounting holes of a single freight yard, and may not span across more than one freight yard.

Rail systems may not cross a painted river, unless supported by a bridge constructed by the team. Pre-made bridges, even those compatible with wooden track segment systems, may not be used. Any bridges must provide sufficient vertical and lateral clearance for a container to pass underneath them, and must start and terminate entirely on unpainted 'dry ground'.

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.

Testing Procedure

During testing, teams shall be shown the arrangement of freight yard colours and containers prior to setup. The containers shall be randomly arranged on coloured starting pads, aligned to the grid. After setup is complete and the cargo system begins operation (ie. moving), the students may not touch or interact with the system without permission of the adjudicator. Any control interactions with the trains or handlers must be done via an electronically-mediated remote interface (eg. joystick, keyboard, gamepad). At no point may students touch or interact with the cargo containers. Any spills or derailments will be handled by the instructor, who will return the train and its contents to their origin.

Points shall be scored for each container that reaches its correct destination, as well as demonstration of key capability milestones. Additional points shall be scored for demonstrating advanced functionality. For bonus functionality, the students may automate the process, such that the only interaction with the system after setup is to instruct it to start or stop; they may elect to reset part way through testing to demonstrate autonomous functionality.

Each demonstration session will run for 25 minutes, during which students must complete all required setup, load containers, transport them, and unload them at their destination. After 25 minutes, the students must cease operations and will have 5 minutes to pack down and clear the testing area, ready for the next team. The time-limits will be rigorously enforced. Build quality may be assessed at any time during the testing slot.

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. All basic functionality must be demonstrated before marks will be awarded for intermediate functionality. Systems which do not meet the construction and budget requirements will not be eligible for anything but basic functionality and build quality points.

Build Quality	**10/10 Points**

Basic Functionality	**30/30 Points**
The cargo handler system moves	10
The train system moves	10
The cargo handler system lifts a container	10

Intermediate Functionality	**30/30 Points**
Load a container onto a train car.	15
Move a train from one freight yard and stop at another freight yard.	10
Unload a container from a train car onto a freight yard pad	5

Advanced Functionality	**30/30 Points**
Deliver a container to its correct destination freight yard pad	0.5/container

Bonus Functionality	**10/10 Points**
Load a container autonomously	4
Move a train between two freight yards autonomously	3

Deliver a container to the correct destination freight yard pad autonomously	3

Apparatus

The provided apparatus consists of a 6 mm thick base plate, placed flat on the ground, with freight yard pads surrounded by 10 mm regularly spaced holes, and standardised containers. The freight yard pads are shaped to allow the containers to align to a 2x2 grid. The containers are 105 mm x 50 mm x 40 mm, and self-align when stacked vertically. They may also be stacked at 90 degrees, with the top container overlapping two adjacent containers. An empty container weighs approximately 40 g, but containers may be filled with cargo up to a maximum total weight of 150 g, including the container. Cargo within a container may not be evenly distributed, and may shift during transport.

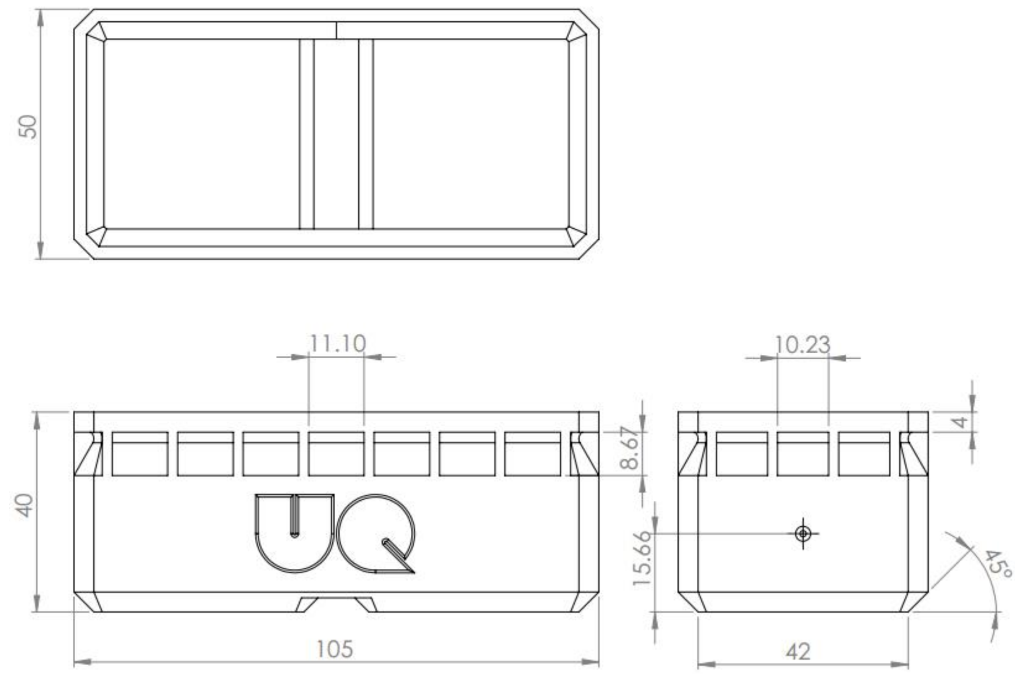

Figure 1: Container dimensions, as designed – manufactured to ±0.5 mm tolerance

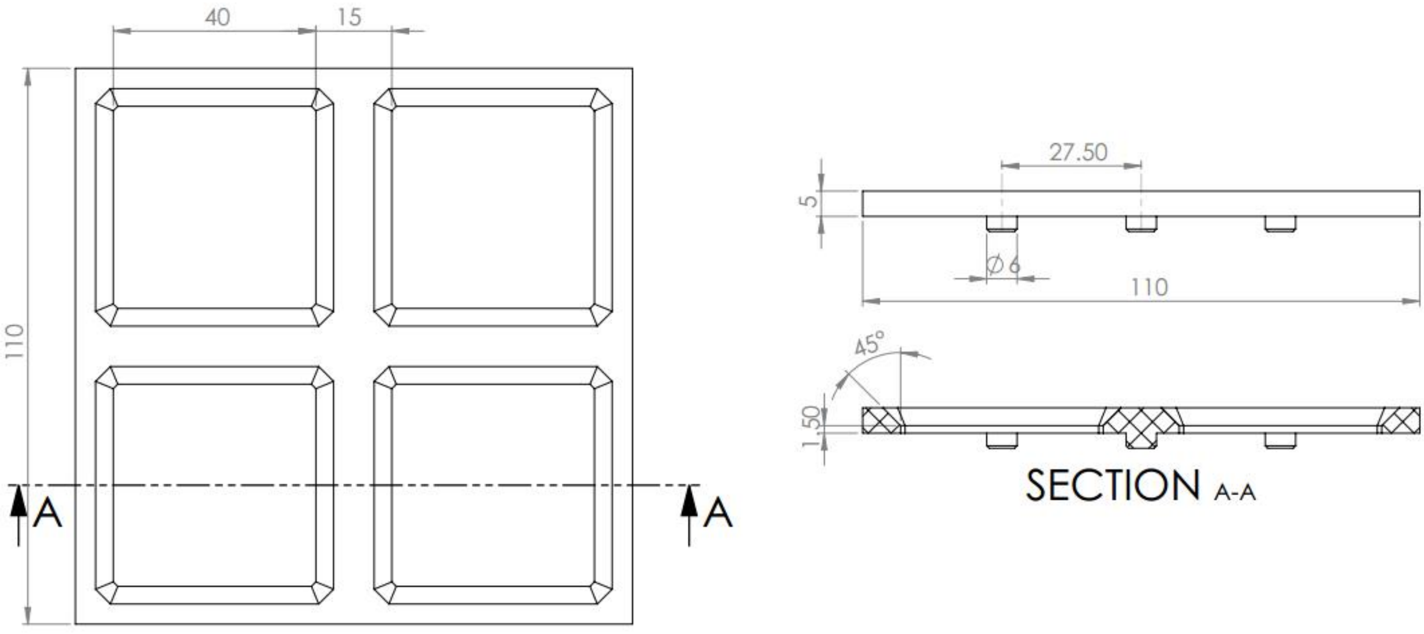

Figure 2: Container pad dimensions, as designed – manufactured to ±0.5 mm tolerance

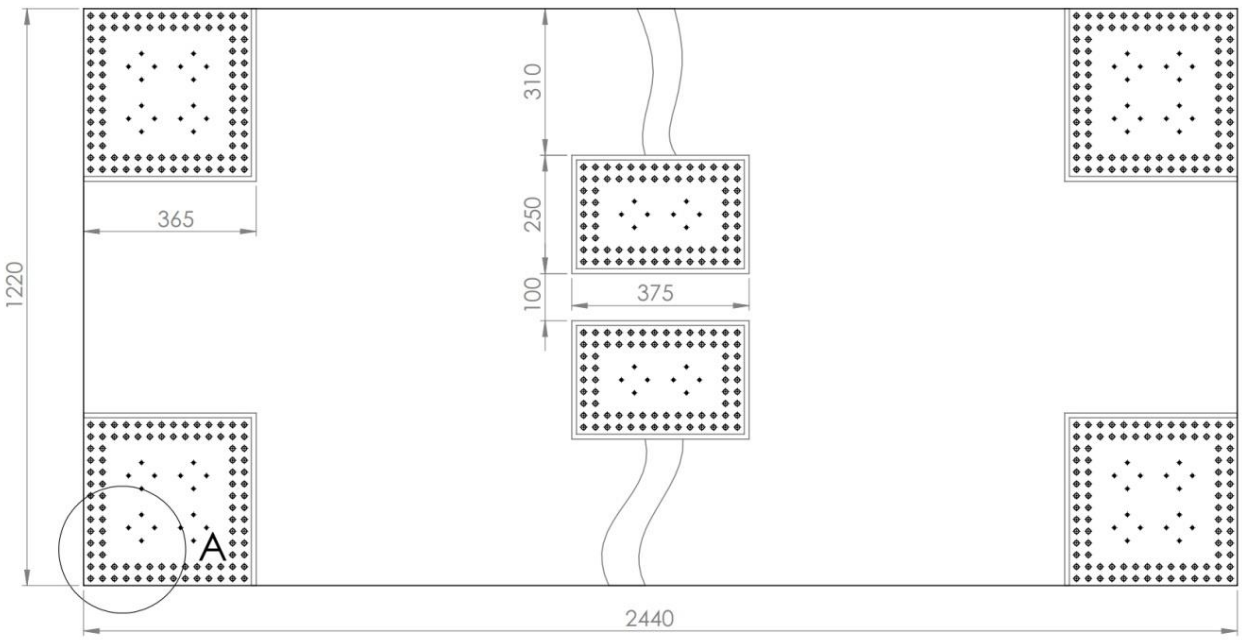

Figure 3: Baseboard dimensions, as designed – manufactured to ±1 mm tolerance

System Design Guidelines

Each team must construct a rail cargo transport and handling syste, system 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 adjudicator shall be the final arbiter of whether any part of the system, or the system as a whole, is legal within the guidelines. Students may provide their own laptops or desktop computers, which do not count towards size or budget limits.

Modularity and stand-alone testing

The cargo handler systems and rail transport systems must be modular, such that each can be removed and validated separately. Each part must be capable of being demonstrated to a basic level with any or all of the other systems missing or non-functional. This may necessitate a stub to stand in for the control functionality of a subsystem – eg. an independent control unit to demonstrate train driving. The mechanical and electrical interfaces between each subsystem must be fully-specified and documented, with sufficient detail to allow a third-party to design a system to interoperate with them.

Construction

Dimensions

The cargo handler and rail transport subsystem dimensions must be sized to fit inside a standard box: the entire system, including all support equipment (except laptop/desktop computers), must fit inside two separate ~~typical shoebox~~ BX3 Australia Post mailing boxes[1] for final submission. The system may be partly deconstructed to fit in boxes, with the understanding that students must reconstruct it during the strictly time-limited testing slot for the final demo. Students are strongly advised to design their system with the boxing requirement in mind.

Control

The cargo transport system does not need to be autonomous, although bonus marks may be awarded for demonstrating this capability. The team may manually operate any aspect of the system through an electronic medium (eg. joystick, keyboard, mice, gamepad), but may not directly touch the handler system, train system or containers after setup. Computer mice and keyboards are considered part of the computer system provision and do not count towards the budget; handheld control interface components such as joysticks, gamepads or space mice are not considered part of the computer, and must be accounted for.

Power Sources

Energy sources for the system are limited to wall plug power packs, or charged electrical devices and stored elastic energy; no stored gravitational, kinetic, nuclear or thermal energy systems may be used. Exceptions may be granted by the course coordinator on a case-by-case basis. For safety reasons, any proposed elastic energy storage device must be approved by the adjudicator. **Li-poly batteries may total no more than 15 kJ maximum energy capacity.**

[1] This was changed due to abuse of the definition of what constitutes "shoebox" by previous students. Suffice it to say, if you have to redefine commonly understood terms of reference to make your design meet the specification, your work is probably not going to pass muster.

Processors and programming

Pre-fabricated processor and computer modules are permitted, however, due to abuse by previous students, only PIC and STM32 processors may be used. Arduino software (IDE, scripts, Wiring platform etc) is strictly prohibited. Exceptions may be granted by the course coordinator on a case-by-case basis (for example, a commercial product that incorporates a 328P processor, but which is non-reprogrammable). It is strongly recommended that teams program using C or Python.

Budget

The total cost of materials, parts and components incorporated in the product shall be no more than $400 (excluding 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 $400. Up to $400 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. Circuit boards 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 specified 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, where permitted. The cost of provided filament does not count towards the budget total.

Specific Prohibitions

- **No incompatible rail systems**
  Only rail modules compatible with 40mm wooden rail systems may be used. It is permissible for students to fabricate their own rail modules, but these must be demonstrated to interoperate with Brio, Lillabo or similar rail systems.
- **No outside components**
  No components, structures, or equipment may be installed outside of the base board. The system may not overhang the base board in any way at start time – once activated, it is permissible for the handler system to move beyond the limits of the base board, but it must remain rigidly attached at all times. The rail transport system may not leave the baseboard. No alterations may be made to the Hawken building or apparatus. Systems that cause damage to the apparatus will be prohibited from operating.
- **No internet connection**
  No part of the system may be connected to the Internet. Where WiFi or similar wireless protocols are used to connect between submachine systems or 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. All detritus and debris must be collected and cleared.
    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 non-cleaning work may resume.

3. The following are specifically prohibited inside the lab:
    a. Eating or drinking in the lab (including water), or having food or drink outside of a backpack or bag.
    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. Students are separately and collectively responsible for their group's tools.