DESN2000 – Project Brief

EE&T – Embedded driving system for a light-rail tram

1. Project description

You are a team of engineers bidding for a contract to develop an embedded driving system for light-rail trams.

The tram will drive through the suburbia along-side vehicular traffic and in close proximity to pedestrians, at a legal speed limit of 50 km/h. Scheduled stops are made at the designated stations to pick up and let off passengers. Each tram will be controlled by a trained driver via the embedded system to be developed in this contract project. It is expected that trams will operate over 16-hour schedules (with periodic driver rotation) under both day and night conditions. The driving system will control the tram speed by modulating the motor and the brake. The control software interface should provide means for speed and brake control. Speed should also be displayed on the LCD screen of the "control console".

The operator that has put out the tender for this contract values reliability, efficiency and safety of those inside and outside the tram. One way they aim for continuous improvement in those areas is through careful monitoring of the tram's and drivers' condition. It is expected that a system diagnostic mode will be offered, allowing custom-written plug-in assembly code to be loaded, executed on-demand, and polling the tram system status via a set of APIs which you will define.

A successful bidder takes great care of the above and shows an understanding of the tram's position and role within a larger road and public transport system. The expectation is that a bidder will consider various users of the tram and take into account their needs when designing the system.

2. Requirements

The operator has outlined mandatory requirements and constraints for your team's bid, which specify a technical baseline in terms of hardware and software. Given the bid is competitive, your team will need to go beyond these baselines to be successful. Teams will need to implement additional requirements which benefit stakeholders and user, these must be supported by research.

Hardware constraints

- The driving system is to be prototyped on the LPC2478 platform with an ARM7TDMI processor. Your prototype assembly code should target the QVGA board.
- All hardware above must be interfaced to the LPC2478 at IO locations of your choosing.
- Locomotion is achieved by a DC motor within each tram, providing a maximum rpm of 1100 at the 300-mm diameter wheel.
- The friction brake is controlled via a SPI interface, with two states: apply / release.
- The dead man's switch (a foot pedal, which must be pressed by the operator, otherwise shuts down the DC motor) is readable as a 1-bit GPIO value.
- The tram speed is an analog voltage (0 – 2.5 V for 0 – 100 km/h).

Software constraints

- At a minimum, speed and braking data should be logged. These data should also be accessible via diagnostic software interface that you will develop.
- Protected access is paramount (e.g. through a real-time OS architecture). Prototype assembly code should be provided and will be assessed for claimed levels of access control.

User requirements

For safety, efficiency and reliability your system must consider additional requirements of your users. Some example users include the tram driver, a diagnostic technician, tram passengers or even pedestrians on the street. You might consider if the controls allow for proper and quick response of the driver in the case of an emergency, or perhaps if the diagnostic tools allow for efficient testing and maintenance of the system. There are numerous other considerations. Through your team's research you must identify, prioritise and implement these requirements into your systems.

3. Deliverables

In your attempt to win the contract, you will record your design process within your individually written design journal. You will also present your design proposal in a pitch and technical presentation at the end of term. In general, your bid will be assessed on the basis of: (1) satisfying requirements, (2) value of system features, (3) the teams' ability to implement the proposed system and (4) quality of documentation.

You do not need to implement the entire driving system, nor are you required to physically demonstrate your prototype on the QVGA board. However:

1. Your design specification needs to be sufficiently detailed for a fellow engineer to be able to build the system using the documents you have written.
2. You will need to write prototype assembly code to demonstrate key system functionalities proposed, providing assurance to the panel that you are technically capable of implementing the solution.

Assessments

Separate documents provide full details on each assessment tasks. The following table provides a summary. In general, labs provide technical skills to support your project. The design journal documents your design process and project management. The pitch is a short format where you try to 'sell' your proposal and the technical presentation is where you demonstrate technical details. The final peer review task will assess your individual contribution to your team's overall project. Peer evaluations will also occur for your pitch and presentation tasks, to assess your individual contribution.

Deliverables	Weighting	Week due
1. Design Journal	25%	5 & 10
2. Pitch	10%	9
3. Technical presentation	15%	10
4. Peer Review	5%	10

Design journal

Throughout the course, you will document your design process, including project management, in a design journal. The journal will be marked two times by your class demonstrator, Week 5 Friday midnight and Friday Week 10 Friday midnight. Design journals can be used to draft ideas, record weekly meeting minutes and task assignments, draw sketches, write calculations and anything else related to your design process. Weekly questions will help guide your writing, but you are encouraged to expand your writing beyond these basic questions.

Pitch

By midnight Friday in Week 9, your team will submit a short pitch video. In the pitch video, you will attempt to convince the audience that your team has created the best system! The system needs to meet technical and user requirements, although the emphasis is on conceptual merits as opposed to details. These details can be addressed in the technical presentation the following week.

Exemplary teams will be invited to a showcase at the end of the term. A panel of industry and university judges will assess the team's pitch videos, and then run a live Q&A session with teams during the online showcase event. Prizes will be awarded to the winning teams.

Technical presentation

During Week 10, each team is expected to give a technical presentation followed by questions and answers. Your team's system shall design for all mandatory technical features:

1. Loading diagnostic assembly code into the system.
2. Control of tram movement in response to the dead man's switch.
3. Data logging facility comprised of (at minimum) data storage and API design.
4. Determining tram speed.
5. Controlling the DC motor for tram speed.

Each group will be randomly assigned two of above five mandatory features at the end of Week 9. You are required to discuss your design during the technical presentation for these two assigned features. In addition, your group should discuss a third technical of your choosing, not included in the list above.

Peer review

At the end of week 10 you will be required to evaluate the contribution of your team mates to the groups' work. This will comprise 5% of your total assessment grade. In addition, your pitch and presentation will have a peer evaluation component for you to assess the

contribution of your teammates for that specific assessment. Marks will be redistributed accordingly. The peer review process relies on confidentiality to be effective, so please do NOT discuss details with your fellow group members. This will be used to scale marks based on contribution.

4. Teamwork

You will complete the project as part of a team, which is comprised of students from your workshop class. Your class mentor will facilitate weekly sessions, where your team will work on various aspects of the project. It is important to work efficiently together as a team to achieve timely deliverables and to successfully complete this project.

5. Support

This design project is a team exercise. We therefore encourage you to discuss with your teammates in the first instance. Post tabs in each of the DESN2000 ELEC – 2020 T2 channels will host online discussion. Reply to posts to keep threads connected and post your discussion in the most relevant channel.

The seven 3-hour laboratory sessions (Week 3-9) involving guided practical exercises (see the Laboratory Manual) are designed to build your knowledge and experience on embedded systems. The contents from these labs are the technical foundation for this design project. You should work through the labs diligently. A demonstrator will be present during your lab session, providing support through the lab exercises and can provide guidance on this design project.

Three workshops (Week 2-4) will support user research, concept creation and concept evaluation, while three workshops in (Week 5, 8-9) will support the development of your pitch assessment.

Also refer to the weekly lecture notes for relevant contents and recommended further readings.