MTRX3700 Mechatronics 3

Major Project David Rye, 2015

GAME OF DRONES: ROBOT JOUSTING

You are to work in a group of 6 or 7 students to design and implement a microprocessor-controlled robotic system that is able to compete in a robot jousting tournament. The robotic system is to operate as described in the Specification, following as Attachment A. Members of one Group may be timetabled for different lab days. Each Group must work independently of all other Groups. The design, implementation and documentation presented by a Group must be the work of the Group members only.

1 Allocation of Students to Major Project Groups

Each student will be allocated to a Major Project Group containing 6 or 7 students. Members of one Group may be timetabled for different (Wednesday or Thursday) lab days. Students will be notified by email of their allocation to groups.

If any student has a substantive objection to their allocation to a particular Group, the Subject Lecturer may be notified of this objection via an email that sets out the objection in detail. Any such email notification must be sent before 5:00 pm on Tuesday 8 September. The Subject Lecturer may (or may not) decide to change group allocations on the basis of such information at his sole discretion.

Each Group is required to nominate one member as their Group Representative, and this person must contact all other Group members and inform the Subject Lecturer of their response or otherwise by email sent before 5:00 pm on Friday 11 September. All formal communication between a Group and the Subject Lecturer must be via the Group Representative.

2 Implementation of the Jousting Robot System

Each Group will design and build microcontroller-based circuitry and software to implement a robotic jousting system. Basic mechanical, electrical and electronic components required to build the robotic system will be provided to each Group. These components are nominated in the Specification and are documented on the MTRX3700 Major Project web page. Additional circuitry must be built on 'Veroboard' perforated strip board, or equivalent. Circuits and software may be prototyped and tested using the PICDem 2 and solderless breadboards, but circuits in the robotic system that is presented for assessment must be built on strip board.

3 Walkthrough

Each Group is required to present their preliminary design for a formal review ("walkthrough") covering the Group's proposed implementation strategy and proposed hardware and software design. The purpose of the walkthrough is to allow for a review of the design at a relatively early stage, so that potential pitfalls can be identified and alternative solutions suggested by the Subject Lecturer, Tutors and Students. The design need not be finalised at the time of the presentation, but *all major decisions must have been made*.

Two walkthrough sessions will be held:

- **2:00–5:00 pm on Wednesday 23 September** and
- **2:00–5:00 pm on Thursday 24 September.**

Both sessions will be held in the Faculty Conference Room, Level 2 in the Link Building J13. Each Group will be scheduled to present their walkthrough on one of these days, and as a consequence it may not be possible for all group members to attend their Group's presentation. Each presentation must take no more than twenty minutes and must present an overview of the high-level design and implementation plan. All Group members must contribute to the preliminary design phase that leads to the walkthrough, although all Group members do not have to participate in the presentation.

Warning! Rehearse your presentation, as it will be *stopped strictly at 20 minutes*.

Since twenty minutes is a short time, you must prepare slides for presentation. These slides do not have to be fancy – the content is far more important than the look of the slides. Electronic presentation using *PowerPoint*, *Word*, etc. and a data projector is preferred. Bring your presentation on a (virus-free) USB memory stick.

Your presentation should address, but not be limited to, the following areas:

1. Implementation plan
   - Roles and responsibilities of each Group member
   - Staging of implementation activities, including timing and dependencies
   - Management of code and documentation
   - Plan for testing
2. Hardware requirements and architecture
   - I/O requirements and pin assignments
   - Connections, terminations and enclosure
   - Power supply during development and "in production"
3. User interface(s)
   - Start-up behaviour
   - Default operating mode and parameter settings
   - Input hardware – choice and physical arrangement
   - Input sequences and menus
   - Output hardware – physical arrangement
4. Robot controller(s)
   - Structure of the control system
   - Arrangements for tuning the controllers
   - Arrangements for shared control and/or for transfer between manual and automatic control modes
5. Software organisation
   - High-level architecture – state-transition diagram and/or RTOS task definitions, data flow diagram, etc.
   - Objects / Modules required and their public interfaces
6. Calibration, 'Factory' Settings
   - Functionalities in factory mode
   - Factory mode user interface
   - Summary of calibration procedures

Warning! DO NOT TELL US WHAT WE ALREADY KNOW during your presentation. We are all familiar with the assignment and the robotic system specification. We are interested only in how YOUR GROUP plans to build a robotic system to meet the specification; you will stopped if you begin to present known material.

Warning! There are many standard types of diagrams for precisely describing a system's design and/or behaviour. Use standard diagrams rather than inventing your own.

4 Group Organisation

The Group should partition the project so that each member has

- clearly defined responsibilities;
- a fair share of the workload.

A Statement of Individual Contribution is required in the Technical Manual submitted for assessment, as described in Section 8

Warning: *Responsibility must be split along module lines*, so that each person in the Group has responsibility for *both software and hardware* in one or more modules that include hardware (HAL modules). This will prevent a "hardware expert" from learning nothing about software, and vice versa. Otherwise, severe problems are likely to result.

In addition to the hardware and software that they design and develop, each Group member will need to take on additional coordinating roles. One possible organisation follows. Please note that this is **only one of many possible organisational structures**; your Group should decide on an organisational structure that takes strengths and weaknesses of group members into account.

- *Group Leader*: coordinate the work of the Group, including project planning; make decisions that cannot be resolved at lower levels;
- *Software Design Leader*: Responsible for the high-level software design; coordinate the detailed software design, implementation and unit testing; make software decisions that cannot be resolved at lower levels; coordinate with the Hardware Design Leader;
- *Hardware Design Leader*: Responsible for the high-level hardware design; coordinate the detailed hardware design, implementation, testing and calibration; make hardware decisions that cannot be resolved at lower levels; coordinate with the Software Design Leader;
- *Integration and Test Leader*: coordinate all software integration testing, and testing that involves integration between software and hardware, and for all assurance testing to ensure compliance with the Specification;
- *Document Controller*: responsible for accepting new and revised documentation (including code and circuit diagrams) from all members of the Group and for coordination, assembly and editing[1] of project documentation;

Please note that all Group members are expected to contribute to software and hardware design, implementation, testing and documentation.

It is strongly recommended that each Group *at minimum* should create a shared "project directory" which incorporates electronic versions of documents such as data sheets, documentation, circuit diagrams, code listings, etc. In the interests of controlling Group access and managing change, the number of paper documents should be minimised, ideally to zero. Paper should only ever be used for documents (such as data sheets) that will not change during the project. The Document Controller should be responsible for maintaining this minimal shared resource, including placing new or updated code or documents into the project directory. A practical arrangement would have the Document Controller with read/write access to the project files, and all other Group members having read access only. This is particularly important when several persons will be developing software and hardware and can assist with revision control.

The best practice in managing source code (and other ASCII documents) is to use a revision control system such as SVN or GIT. This solution can also be used with care to manage revisions of some documents stored in binary formats. For example Microsoft Word documents can now be compared and merged from within Word.

We do not currently host SVN or GIT repositories for student use. Fortunately there are sites that

[1] Note that the Document Controller assembles and edits documents, but does not *write* them all.

offer free (or inexpensive) private SVN and/or GIT hosting. The best site at the moment seems to be Assembla which currently offers free SVN and GIT repository hosting of a project with many group members. You could also look at GitHub (GIT only, private repositories not free), CloudForge (SVN/GIT, but not free), Unfuddle (SVN/GIT, but not free) or BitBucket (GIT, free for up to five users). Check the conditions carefully (number or projects, number of users, charge per user) before you sign up; some are free only for 14 days. There is an SVN client (TortoiseSVN) and a GIT client (TortoiseGIT) installed on the Lab computers.

5 Hardware Availability

5.1 Hardware Kit

Section 4 of the Specification lists the equipment that will be provided as a Hardware Kit to each Group. It may not be possible to supply all components of this kit until Week 9. In particular, we anticipate a delay in the supply of the knights and their saddles which are being manufactured externally. We expect that the knights and saddles will be available in Week 10. Groups should allow for this uncertainty in their implementation plans.

1. **WARNING! The robots use rechargeable Lithium Iron Phosphate ($LiFePO_4$) batteries as a power source. These Lithium batteries are much more stable than $LiCoO_2$ or $LiMn_2O_4$ chemistries and do not present a fire or explosion risk if they are charged correctly. The batteries are, however, capable of discharging a peak current of 168 A which will explosively vaporise thin conductors, potentially causing projectile injuries or burns. Do not short-circuit the batteries.**
2. **WARNING! Many of the electronic components that will be used in this project are static sensitive. All will be destroyed if their absolute maximum ratings are exceeded. This includes reverse polarising (connecting power connections backwards) a device, and connecting input signals to an un-powered device.**
3. **Make sure that you read and understand the data sheet for each component before you use it. Note very carefully the Absolute Maximum Ratings.**
4. **Make sure that signals input to a device are within specification before you connect them to the device.**
5. **Do not assume that we can repair or replace any equipment that is destroyed, particularly on short notice.**
6. **Please note carefully the warnings for particular devices.**

The Hardware Kit will generally not be provided to a Group before they present their preliminary design at the walkthroughs. A Group seeking to obtain their hardware kit before this time must apply for the kit and convince the Subject Lecturer and Tutors that they are adequately prepared to work with the hardware. The Group Representative must submit an application by email to `MTRX3700@acfr.usyd.edu.au`. The application must include a written preliminary design document that generally follows the guidelines for the walkthrough presentation as described in section 3 of the present document. Only one submission will be accepted per Group.

5.2 Additional Hardware

The hardware kit does not contain all of the components that you will need to complete the project so that you will need to source additional components. Please note that

1. We carry supplies of many common materials and components including wire, cable, heat-shrink tubing, mounting hardware, stripboard, passive components, discrete semiconductors, ICs, etc. A partial list with semiconductor data sheets is available on the Lab website: http://web.aeromech.usyd.edu.au/MTRXLAB. Please email us at `MTRX3700@acfr.usyd.edu.au` to ask for supplies before you buy them; it will be cheaper and may well be quicker to obtain them from us.

2. If components need to be purchased, be aware that we can often buy them at prices much less than retail. You must provide both the vendor's and manufacturer's part numbers for any components that you request. Our preferred local vendors include Altronics, element14, RS Components and WES Components.

5.3 Soldering

Good quality soldering equipment is available in the Mechatronics Lab and may be used by students inducted in its use. Personal soldering equipment can also be used, but only by inducted persons. The induction is quite short.

6 Commissioning of the Robotic system

The basic function of the robotic system shall be demonstrated in the laboratory session beginning at

- **2:00 pm on Wednesday 28 October.**

At that time, the degree of conformity of each Group's robotic system with the specification will be assessed by subjecting it to a number of commissioning tests.

7 Jousting Tournament

A Jousting Tournament (Figure 1) will be held in a location to be advised commencing at

- **2:00 pm on Thursday 29 October**.

The Rules of the Jousting Tournament are appended as Attachment B.

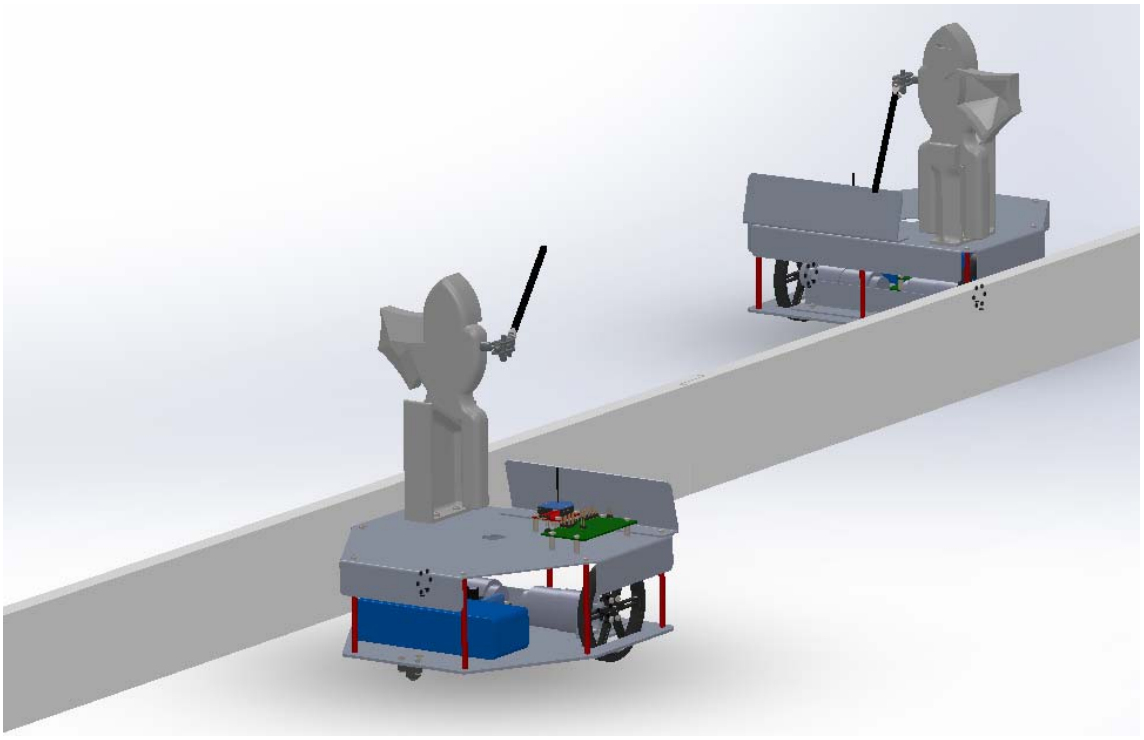

Figure 1: Champions jousting for the honour of their Houses (artist's impression).

8 Documents to be Submitted for Assessment

In addition to the Robotic System, each Group shall submit *four* documents for assessment:

- **User Manual**: due in *paper form* with the robotic system at **2:00 pm** on **Wednesday 28 October**.
- **Technical Manual**: in *electronic form* (PDF) together with the
- **Software**: in a single `.zip` file, and the
- **Contribution Sheet**: in *electronic form* (PDF).

The three electronic documents are to be submitted via Blackboard not later than **5:00 pm** on **Tuesday 4 November**.

The **User Manual** must be written in the form of a user manual for a commercial product. It should be simple, concise, and written in non-technical language. It should refer only to those procedures and features of the robotic system that are available to an end-user. The User Manual must be submitted in printed form before your robotic system is assessed.

The **Technical Manual** must provide full engineering documentation of the robotic system. It must be a comprehensive technical document that contains sufficient information to allow an engineer to assemble, test, calibrate, or repair the robotic system. The level of detail should be such that a competent person could build a complete robotic system from the Technical Manual only. In this context, it should contain a functional description of the robotic system's hardware and software, circuit diagrams, together with operating instructions, adjustment, testing and calibration procedures, state transition diagrams and data flow diagrams. An annotated listing of all C and assembly language programs should be provided as well. Any assembly language code used should be self-documenting, with well-defined entry and exit states, register requirements, and details of flags affected and of timing.

The Technical Manual must be based on the Word document "Technical Manual Template.docx" that is available via Blackboard. You must delete placeholder headings that are not used in the final Technical Manual.

The Technical Manual will contain contributions from all Group members, but the final versions must be edited by one person so that consistent formatting is achieved. We expect manuals without "padding" – concise, precise writing that says only what needs to be said. The Technical Manual must be submitted electronically as a PDF file.

The **Software** must be submitted electronically in a single `.zip` file that maintains the directory structures of the two MPLABX projects for the Mobile Robot and the Robot Commander. All files required to build the project must be present, but please delete the `project\build\`, `project\debug\` and `project\dist\` directories before creating the zip file.

The **Statement of Individual Contribution** must be submitted separately, and must be based on the Word document "Statement of Individual Contribution.docx" that is available via Blackboard. No work will be accepted without a Cover Sheet signed by all members of the Group.

Method of Electronic Submission: The files submitted electronically must be named `HouseNameContributionSheet.pdf`, `HouseNameTechnicalManual.pdf` and `HouseNameCode.zip`, and submitted via Blackboard.

9 Plagiarism

The University of Sydney is strongly opposed to and will not tolerate plagiarism. It is the responsibility of all students to ensure that they do not commit plagiarism, to report possible instances of plagiarism, and to comply with the University's 'Student Plagiarism: Coursework Policy and Procedure'.

In the context of the Major Project, re-use of code or text written by a person outside of the

Group without acknowledgement of the source is not acceptable and will be regarded as evidence of deliberate plagiarism. The University's policy and procedure specifies the actions that are required to be taken on detection of suspected plagiarism.

10 Assessment

The Major Project is worth 40% of the mark in MTRX3700. The Major Project Mark breakdown is as follows:

- Walkthrough 10%
- Robotic system functionality: 50%
- Robotic system quality: 40%

The Subject Lecturer and Tutors will continue to assess the performance, in terms of understanding and activity level, of individual group members in the laboratory and will moderate each individual's mark based on their assessed performance.

The User Manual and Technical Manual are considered to be integral parts of the robotic system and are not separately accounted for. In assessing the design and implementation of the robotic system, we will consider a number of factors including but not limited to:

- Is the circuit topology and design of high quality?
- Is the program design of high quality
- Are the user interfaces well designed?
- Is the software and hardware well documented?
- How error proof is the system?
- Are input errors detected?
- How easy to use and well-behaved is the robotic system?
- How responsive and easy to control is the robotic system?

Attachment A: Specification for the Robotic System for Jousting

1 Interpretation

1.1 Interpretation

1.1.1 In this Specification, unless the contrary intention appears:

a. Headings are for the purpose of convenient reference only and do not form part of the Specification;
b. The singular includes the plural and vice versa;
c. A reference to a person includes a Group;
d. A reference to a 'day' means a calendar day;
e. A reference to a 'month' means a calendar month;
f. A reference to a 'week' means a period of seven (7) consecutive days;
g. 'Document' includes:
    i. Any paper or other material on which there is writing, marks, figures, symbols or perforations having meaning for persons qualified to interpret them; and
    ii. Any article or material from which sound, images or writing is capable of being reproduced with or without the aid of any other article or device;
h. A reference to a 'clause' includes a reference to a sub clause of that clause;
i. A reference to a '$' means the monetary unit, or unit of currency of Australia;

1.2 Definitions

1.2.1 In this Assignment, unless the contrary intention appears:

a. 'Assignment' means this document, including any Attachment and any document expressly incorporated as part of the Assignment;
b. 'Assignment Deliverable' means all Material
    i. brought, or required to be brought into existence, as part of, or for the purpose of, performing the Work, or
    ii. incorporated in, supplied, or required to be supplied along with the Assignment Deliverable, including but not limited to documents, equipment, reports, technical information, plans, charts, drawings, calculations, tables, schedules, models and data stored by any means;
c. 'Attachment' means an attachment to the Assignment containing information about the Work;
d. 'Display' means any means of communication present in the Product including, but not limited to, the visual interface.
e. 'Group' means the six or seven persons who have been assigned to a team to collectively provide the Work to the University.
f. 'Group's Representative' means that person who has the support of the majority of the persons in a Group to act for the Group in dealings with the Unit of Study Lecturer.
g. 'Material' includes documents, equipment, software, goods, information and data stored by any means;
h. 'May' means that provision of a particular service, feature or method of operating is optional, at the sole discretion of the Group.
i. 'School' means the University's School of Aerospace, Mechanical and Mechatronic Engineering;
j. 'Shall' means that the provision of a particular service, feature or method of operating is mandatory;
k. 'Should' means that although the provision of a particular, service, feature or method of operating is not mandatory, it is desirable;
l. 'Product' includes, but is not restricted to, any software, hardware, firmware, or system under or in connection with this Assignment;
m. 'Product Deliverable' means the Product that is
    i. brought, or required to be brought into existence, as part of, or for the purpose of, performing the Work, or
    ii. incorporated in, supplied, or required to be supplied along with the Assignment Deliverable.
n. 'Unit of Study Lecturer' means the person holding or performing the office of the academic in charge of the Unit of Study MTRX3700 Mechatronics 3 in the School of Aerospace, Mechanical and Mechatronic Engineering, The University of Sydney, or any other person appointed under the Assignment as the Unit of Study Lecturer;
o. 'University' means The University Sydney, represented by the Unit of Study Lecturer;
p. 'University Material' means any material provided by the University to the Group for the purposes of this Assignment, or which is copied or derived from material so provided;
q. 'Work' means those activities to be conducted by the Group in accordance with the Assignment, including provision of the Assignment Deliverables.

1.3 Language

1.3.1 All information delivered as part of the Work under the Assignment shall be written in English. Where such

documentation is a translation into the English language, such translation shall be accurate and free of ambiguity.

1.4 Measurement

1.4.1 Measurements of physical quantity shall be in Australian legal units of measurement as prescribed in Regulation 5 and Schedule 1 of the *National Measurement Regulations 1999* as amended or, if items incorporated into the Work are imported, such other units of measurement as are agreed by the Unit of Study Lecturer.

1.5 Entire Agreement

1.5.1 This Assignment represents the entire arrangement between a Group and the Unit of Study Lecturer. This Assignment supersedes all prior representations, agreements, statements and understandings, whether oral or in writing, relating to the subject matter of this Assignment.

1.5.2 No amendment to the Assignment shall be binding unless it is in writing and signed by the Unit of Study Lecturer and the Group's Representative.

2 Specification of the Product Deliverable

The Product Deliverable, referred to hereafter as the Robotic System, shall conform to the following Specification.

2.1 General Specification

2.1.1 The Robotic System shall have an identifying name.

2.1.2 The Robotic System shall be capable of carrying a Knight seated on a Saddle, and of accurately and rapidly manoeuvring when carrying the Knight such that the Knight is able to contest a jousting match of several passes against similar Robotic Systems.

2.1.3 For information, the Tilt[2] will be 4.0 metres long and 100 mm high. Further details will be contained in the Rules of the Tourney, to be released separately.

2.1.4 The Robotic System shall consist of two parts: a) a Mobile Robot that carries the Saddle and Knight and b) a Robot Commander that allows information to be transmitted to and from the Mobile Robot.

2.1.5 The Robot Commander shall be compact, portable and battery-powered. It shall be housed in a protective enclosure.

2.2 Implementation

2.2.1 The logic and interfacing circuits of the Robot Commander shall be powered by 9V DC only, in the form of a PP3 9V battery.

2.2.2 The logic, interfacing and power circuits of the Mobile Robot shall be powered from a rechargeable Lithium Iron Phosphate ($LiFePO_4$) battery consisting of four cells connected in series to provide a nominal voltage of 12.8 V.

2.2.3 During development, power for logic and interfacing circuits may be supplied to the Robot Commander and/or the Mobile Robot using a 9V plug pack and/or the fixed 5V output from a laboratory power supply. Motor power may be supplied from the Laboratory power supplies.

2.2.4 Each power supply voltage shall connect to the Robot Commander or the Mobile Robot at a single point only.

2.2.5 Any logic required shall be implemented principally in software that runs on a Microchip PIC18F4520 microcontroller.

2.2.6 Software may be prototyped and developed on a Microchip PICDem2 PLUS development board fitted with a PIC18F452 microcontroller.

2.2.7 The Robotic System shall be implemented using two Microchip PIC18F4520 microcontroller circuit MNML•PIC•18 (v. 2), to be supplied. Other circuits shall be fabricated on 'Veroboard' strip-board or equivalent prototyping board, to be supplied.

2.2.8 Any additional interfacing circuits required may be prototyped on solderless breadboard, but shall be implemented on strip-board in the Product Deliverable.

2.2.9 All integrated circuits that have a retail price of $5.00 or more shall be socketed.

2.2.10 Software for the PIC18F4520 shall be written in the 'C' language and/or in assembly language. PIC18F4520 executable code shall be generated by the Microchip C18 and MPASM software tools.

2.2.11 The Salvo real-time operating system may be used.

2.3 Functional Specification

The Robotic system shall conform to the following functional specification:

2.3.1 The Mobile Robot shall be well-controlled whenever it is operating so as to provide stable motion that accurately and responsively follows operator-defined or autonomous trajectories.

2.3.2 The motion of the Mobile Robot shall be controlled using one or more controllers of the form

$$u(t) = k_p.e(t) + k_i.\int e(t).dt + k_d.de/dt$$

[2] The tilt is the barrier running along the tilt yard that separates the two contestants.

where e is the error in the controlled variable, k_p, k_i and k_d are the gains of the PID controller, and u is the output of the controller.

2.3.3 The principal measuring transducers on the Mobile Robot shall be
   a) Two 64 count-per-revolution magnetic encoders, as fitted to the Mobile Robot motor shafts.
   b) Zero to two Sharp GP2Y0A41SK0F Infrared Distance Sensors.

2.3.4 The Sharp GP2Y0A41SK0F sensor(s) may be mounted on any location on the Mobile Robot.

2.4 Operational Specification

The Robotic system shall conform to the following operational specification:

2.4.1 The Robotic System shall power up and power down in a safe and well defined way.

2.4.2 The Robotic System shall operate correctly regardless of the order in which the Mobile Robot and the Robot Controller are powered up or powered down.

2.4.3 The Robotic System shall operate whenever both the Mobile Robot and the Robot Controller are powered.

2.4.4 The Robotic System shall operate in two basic modes: FACTORY and USER.

2.4.5 FACTORY mode shall allow operation of the Robotic System in FACTORY mode by a privileged person such as a member of the Group for testing, adjustment and calibration as necessary.

2.4.6 USER mode shall allow for operation of the Robotic System by a non-privileged end user.

2.4.7 USER mode shall have at least two sub-modes: stand-alone manual operation under direct command of a user in the USER_MANUAL mode and at least one of the two modes USER_ASSIST and USER_AUTO.

2.4.8 When operating in USER_MANUAL mode, the Robotic System shall operate under direct control of a user who manually uses the Robot Controller to transmit motion control set points and other commands to the Mobile Robot. The Robot Controller shall be equipped with one of more input devices that allow for efficient input of user commands, including motion commands, and an output interface that allows the user to monitor command entry and execution, and to display command prompts, status and error messages.

2.4.9 Commands may be validated in USER_MANUAL mode, but the set points of the PID motion controller shall not be modified apart from reducing noise on user inputs.

2.4.10 When operating in USER_ASSIST mode, the Robotic System shall shape user motion control set points and/or modify motion controller outputs to smooth or otherwise improve the quality of the Mobile Robot motion for the purpose of winning a jousting pass.

2.4.11 When operating in USER_AUTO mode, on receipt of a valid SET_PASS_GO command the Robotic System shall enter a fully-autonomous mode where a jousting pass is conducted automatically.

2.4.12 Transitions between USER_MANUAL, USER_ASSIST and USER_AUTO modes of operation shall be possible whenever a transition can safely be made.

2.4.13 Transitions between operating modes shall be “bumpless”[3].

2.4.14 The default operating mode on power-up shall be USER_MANUAL mode.

2.4.15 A visual interface shall be provided on the Robot Commander. This visual interface shall operate whenever the Robotic System is operating.

2.4.16 The visual interface shall be implemented using a 16 character by 2 line liquid crystal display module.

2.4.17 Additional visual feedback devices, such as LEDs, may be added to enrich the visual interface.

2.4.18 An audio feedback device, such as a piezo buzzer may be added.

2.4.19 It shall be possible to mute any audio feedback device using a hardware switch.

2.4.20 When the Robotic System is operating in USER_MANUAL mode the user shall be able to cause the following commands to be executed:

SET_MOTORS_ON
SET_MOTORS_OFF
SET_SPEED_MAX
SET_MODE_USER_ASSIST
SET_MODE_USER_AUTO
SET_MODE_FACTORY

2.4.21 When the Robotic System is operating in USER_ASSIST mode, the user shall be able to cause the following commands to be executed:

SHOW_TARGET_STATUS
SET_MODE_USER_MANUAL
SET_MODE_USER_AUTO

2.4.22 When the Robotic System is operating in USER_AUTO mode the user shall be able to cause the following commands to be executed:

SET_PASS_GO
SET_PASS_ABORT
SET_MODE_USER_MANUAL

[3] Bumpless transfer of control between manual and automatic modes requires that there are no erroneous transients induced by the switch over.

SET_MODE_USER_ASSIST

2.4.23 When the Robotic System is operating in the FACTORY mode, the operator shall be able to cause the following *additional* commands to be executed:

SET_PID_GAINS
SET_SPEED_MAX
SET_YAW_RATE_MAX
SET_IR_SAMPLES_PER_ESTIMATE
SET_IR_SAMPLE_RATE
SHOW_RAW_READINGS
SHOW_STATISTICS

2.4.24 Activation of the SET_MODE_FACTORY command shall be protected so that it cannot occur accidentally, or be discovered easily by the user through experiment.

2.4.25 The command SET_MODE_USER_MANUAL shall cause the current operating mode of the Robotic System to transition to the USER_MANUAL mode if this transition can safely be made.

2.4.26 The command SET_MODE_USER_ASSIST shall cause the current operating mode of the Robotic System to transition to the USER_ASSIST mode if this transition can safely be made.

2.4.27 The command SET_MODE_USER_AUTO shall cause the current operating mode of the Robotic System to transition to the USER_AUTO mode if this transition can safely be made.

2.4.28 The command SET_MODE_FACTORY shall cause the current operating mode of the Robotic System to transition to the FACTORY mode if this transition can safely be made. Activation of the SET_MODE_FACTORY command shall be protected so that it cannot occur accidentally, or be discovered easily by the user through experiment.

2.4.29 The command SET_MOTORS_ON shall cause the motor drive amplifiers on the Mobile Robot to be energised.

2.4.30 The command SET_MOTORS_OFF shall cause the motion control set points to be set to zero and the motor drive amplifiers on the Mobile Robot to be de-energised.

2.4.31 The command SET_SPEED_MAX shall cause the maximum Mobile Robot speed to be set to a value determined by the user.

2.4.32 The command SET_YAW_RATE_MAX shall cause the maximum yaw rate of the Mobile Robot to be set to a value determined by the user.

2.4.33 The command SET_PASS_GO shall cause an autonomous jousting pass to occur. The Mobile Robot shall execute a pre-planned motion trajectory, coming to a stop at the end of the tilt.

2.4.34 The command SET_PASS_ABORT shall cause the jousting pass to be aborted by setting the motion controller set points to zero, de-energising the motor drive amplifiers on the Mobile Robot, and causing the current operating mode of the Robotic System to transition to the USER_MANUAL mode.

2.4.35 When the Robotic System is operating in the FACTORY mode, the operator shall be able to cause the following *additional* commands to be executed:

SET_PID_GAINS
SET_IR_SAMPLES_PER_ESTIMATE
SET_IR_SAMPLE_RATE
SHOW_STATISTICS

2.4.36 The command SET_PID_GAINS shall allow the (factory) user to set the values of the gains k_p, k_i and k_d of a PID controller.

2.4.37 The command SET_IR_SAMPLES_PER_ ESTIMATE shall allow the number of infrared sensor measurements that contribute to a single distance estimate to be set.

2.4.38 The command SET_IR_SAMPLE_RATE shall allow the rate of infrared sensor measurements to be set, in samples per second (Hz).

2.4.39 The command SHOW_STATISTICS shall cause the Robotic system to display the mean and variance of the sensor measurements that contribute to the Target Location estimate.

3 Assignment Deliverables

Each Group shall provide following three Assignment Deliverables plus a ‘Statement of Individual Contribution’:

3.1.1 (1) The **Product Deliverable**, consisting of microcontroller-based devices that comply with the Specification, plus all software supplied in electronic form as a single .zip file.

3.1.2 (2) A **User Manual** for the Product Deliverable, in printed form.

3.1.3 (3) Full engineering documentation in the form of a **Technical Manual** for the Product Deliverable.

3.1.4 The content of the Technical Manual shall be based on the document “Technical Manual Template.docx”, and shall be provided in electronic form as an Adobe Portable Document Format (PDF) document.

3.1.5 A **Statement of Individual Contribution** that that identifies the nature and extent the contributions made by individual Group members to the design and development of the Robotic system. The Statement MUST be signed by each Group member to certify their agreement. No work will be accepted without the signatures of each Group member on the Statement.

3.1.6 The Statement of Individual Contribution shall be based on the document “Statement of Individual Contribution.docx”.

4 Equipment to be Provided

4.1 Microcontroller Circuit

4.1.1 Each Group will be provided with two pieces of MNML•PIC•18 (v. 2), a small circuit board that implements a minimal PIC18F4520 system, together with related documentation. The circuit contains

a. +5V 300 mA power supply;
b. PIC18F4520 microcontroller and 10 MHz crystal oscillator;
c. In-circuit programming/debugging port;
d. RS-232 driver and D9 serial port;
e. Single LED on PortB.4.

4.2 Mobile Robot Hardware

4.2.1 Each Group will be provided with the following mechanical and electronic hardware to allow construction of the base Mobile Robot, together with related documentation.

a. Top and bottom chassis plates, stiffener, front guard and associated mechanical hardware;
b. Two Pololu 80 RPM Precision Planetary Gearmotors and mounting screws;
c. Two Pololu Machined Aluminium Bracket and mounting screws;
d. Two Pololu Universal Aluminium Mounting Hub and mounting screws;
e. Two Pololu Wheel 90 x 10 mm;
f. One Tamiya 70144 Ball Caster Kit and mounting screws;
g. One Zippy Flightmax 4200mAh 4S1P 30C LiFePo4 Battery Pack;
h. One +5V Power Management Circuit;
i. One Pololu Dual VNH3SP30 Motor Driver Carrier MD03A;
j. One Sparkfun Xbee Explorer Regulated Circuit;
k. One Digi XBee 1 mW Wire-antenna Radio;
l. Two Sharp GP2Y0A41SK0F Analog Distance Sensors.

4.3 Robot Controller Hardware

4.3.1 Each Group will be provided with the following equipment, together with related documentation.

a. One 2 line x 16 character alphanumeric dot matrix LCD module, Altronics part number Z7000A. This display uses the Samsung KS0066F00 display controller;
b. One Sparkfun Xbee Explorer Regulated Circuit;
c. One off Digi XBee 1 mW Wire-antenna Radio.

4.4 Other Components and Materials

4.4.1 Each Group will be provided with the following equipment, together with related documentation.

a. One SkyRC 36 Lithium ion Battery Charger;
b. One Saddle;
c. One Knight;
d. A number of standard wooden lances for testing.

4.4.2 Each Group will be provided with other components and materials upon request, such as ICs, strip board, etc. as described in the Assignment document.

Attachment B: Rules of the Tourney

The jousting tournament will be conducted according to the following rules

1. Each team will field a Champion to joust against All Challengers
2. Points will be awarded in a Joust by the Knight Marshall and the Sargent Marshalls to a Knight who displays skilled, brave or chivalrous conduct, and will be deducted for conduct that is deemed to be cowardly or unchivalrous, according to the Table of Points.
3. The First Round of the Tournament will be conducted round-the-robin with each Champion jousting against All Challengers in a Match of four Passes, or until a Champion is unhorsed. The order of the Match parings will be chosen at random.
4. Points for each Champion will accumulate round-the-robin and will determine the Champions who will be invited by the Knight Marshall to joust for the honour of their Houses in the Second Round of the Tournament.
5. The four Champions with the largest number of points accumulated once all Matches round-the-robin are decided will be invited to contest the Second Round of the Tournament.
6. The Second Round of the Tournament will conducted on the merit of each Match, with only the Champion awarded the largest number of points in a Match being invited to progress to the next Match according to the following Rule.
7. Should two Champions have been awarded the same number of points following the fourth Pass of a Second Round Match, the Champion awarded the larger number of points on the following Pass shall prevail.
8. The order of the Matches in the Second Round will be A) Second challenging First and B) Fourth challenging Third. The Champion defeated in Match B will be eliminated from the Second Round. In Match C, the winner of Match B will challenge the Champion defeated in Match A. The winner of Match C will challenge the winner of Match A for the title of Grand Champion.
9. When Called to the Tilt, a Champion will ride to the Tilt within one minute, or the Match shall be forfeit for Cowardice.
10. New Lances will be provided to the Champions on Presentation at the Tilt for the first Pass of each Match. The Champion's Attendants will have one minute to fix and adjust the Lance.
11. Each Pass will commence within one minute of the end of the previous Pass, or the Champion shall Forfeit the Match for Cowardice.
12. Should a Champion break their lance, a new lance will be provided if required for the following Pass, together with an additional minute to fix and adjust the lance.

Ye Olde Table of Points

Should This Come to Pass	Awarded
Unhorsing the opponent by striking with the tip of the lance on the shield so as to drive the opponent's body past the rantle.	+30 Points
Breaking the lance on the opponent's shield	+20 Points
Striking the opponent's shield with the tip of the lance	+10 Points
Striking the opponent in the body with the tip of the lance	+5 Points
Striking the opponent in the helm with the tip of the lance	-5 Points
Unchivalrous conduct: Striking the opponent's destrier (robot) with the lance	-5 Points
Unchivalrous conduct: Striking the opponent with the lance in "barricade" across the body	-5 Points
Unchivalrous conduct: Riding one's destrier (robot) into the Tilt	-10 Points
Cowardice: Moving into the Counter Tilt during a pass	-10 Points
Cowardice: Failure to Present at the Tilt or to commence a Pass	-30 Points

Extra points may be awarded by the Knight Marshall to those Champions who show higher levels of equestrian ability and/or chivalry.

Information on the jousting terms used in the Rules can be obtained at
http://www.thejoustinglife.com/2013/10/a-dictionary-of-jousting-terms.html