



How to Do a Robot

A Collection of Thoughts and Processes

www.systemetric.org

Table of Contents

Introduction	3
Team Building	4
Start Point.....	4
September	4
Meetings and Activities	4
Responsibilities	4
Continuing Activities.....	5
Fundraising	5
Documentation.....	5
General Administration.....	5
Community Activities.....	6
Links with Teams	6
Designing the Robot	7
Clarity of the Objectives.....	7
Using CAD.....	7
Speed and Traction	7
Robustness	7
Centre of Gravity.....	8
Control.....	8
Autonomous	8
Sensors	8
Building the Robot	9
Construction Techniques.....	9
Tools and Facilities.....	9
Testing and Training	10
Modelling the Game.....	10
Practice Ground	10
Multiple Drivers.....	10
Competing	11
Duties	11
Pre-Competition	11
Practice Rounds	11
Setting and Adapting Strategy.....	11
Being Noticed	12
Maintaining Surprise	12
Awards.....	12

Introduction

The First Robotics Competition programme requires that every year a team is pulled together, funding raised, a robot designed and built within a six week period. The team then has to compete in regional competitions. All this requires significant effort.

This document attempts to gather together our best understanding of how to make it all go smoothly. It is expected that the document is updated regularly with more in depth information, and that it can be used and built upon by each new team as well as being a reference document for our own team, 759.

Team Building

Start Point

The annual cycle is continuous; however it is vital to grow a new team quickly each year. Aim to capitalise on the results obtained in the competition to drum up more awareness in the school. Go for local press coverage and make a lot of noise around the school. Ensure that the robot is made physically visible within the school as soon as it returns. For example, give people a turn at driving it, and show it to prospective new students at open evenings. Write up a summary of our time at the competition for use within any school publications.

September

When the new intake arrives, have a new drive to collect fresh members. Start up regular team meetings. At HRSFC there is a "fresher's fair" where the new lower sixth can take a look at the range of societies available to them. Make use of this and similar events, display the robot(s) in all its glory and have pictures or videos to illustrate the build process and competition.

Meetings and Activities

It is important that the Robotics group has a clear presence and work programme, outside of the 6 week build period. While interest will flag in the run up to exams, it would be good to maintain at least a modest level of regular routine.

Have routine meetings to keep the team together, run publicity and fundraising, and plan work for later on. Examples of work for later on are:

- Analysis of what went good/ what went bad on the previous competition
- Test new software for new control methods
- Measurements on the robot, e.g. torque, frictional force, speed etc
- Develop tools to use new sensors that appeared in the kit
- Develop new mechanisms or drives
- Contact potential new sponsors
- Organise fundraising events

Responsibilities

Assign members of the team with various responsibilities that they can specialise in. For example:

- Team Captain
- Design

- Engineering
- Electronics
- Programming
- Marketing and Fundraising

Continuing Activities

It is important to keep up momentum after the competition. There is a significant period of time that should be used wisely, not just written off. Try and organise events and projects to keep interest up. This may be developing ideas for future robots or fundraising. The most important thing is to make sure that it is enjoyable; people should want to attend these meetings because they want to, not because they are forced to.

Fundraising

The entrance fee to the FIRST Robotics Competition is \$6000, with additional funds required for the production and shipping of robots. Fundraising can take many forms, but the process should begin early.

It is important to secure sponsorship from as many organisations as possible. Do not limit this to local organisations, contact large corporations as well. There is no harm in trying. Mail out a letter promoting the team, making sure to highlight the benefits they receive for sponsoring the team. They may not see this as an advertising opportunity but as a way of investing in engineers of the future. Personalising letters to each company can be an effective tactic, one that should be definitely considered for larger firms.

Potentially good sources of funds are organisations that involve current and past students of the school. Societies for ex-students of the schools are good examples of this. For HRSFC this is The Old Cantabrigian society.

Provide positive feedback for every donation. Do this immediately on receipt, and also immediately after the competition. Keeping in contact with sponsors may also be beneficial.

Documentation

Try and keep decisions and plans collated in one place that everyone has access to, such as an online project manager or forum. Try and avoid loose sheets of paper as these get lost very easily.

General Administration

The team will require leadership, someone to organise people, motivate them and to keep meetings from straying off course. You'll need to persuade people to come along in the first place as well as keeping an eye on all areas of the team. Team members or resources may need to be redirected to certain areas at certain times.

Don't be afraid to delegate tasks. You can't do all the work. Ruling by terror also doesn't work. Try to keep a positive atmosphere. Give people equal chances, but ensure tasks of high importance are handled by those who can be relied on. Say "well done" to people to make them feel appreciated.

During the build phase if you are team captain, consider taking an overview role, not assigning yourself to any particular area. This will help keep all sub-groups on track. Set realistic objectives, impossible ones will lead to little progress, too easy ones will waste time.

Community Activities

A key aspect of the "Spirit of FIRST" is extending the appreciation of engineering to other people. The chairman's award in particular is looking for evidence of a team which has taken these ideas out into the community, involved younger or disadvantaged people, spread design concepts, helped other teams, etc. Think hard about community based activities that we can get involved with. An example is to take the robot to other schools, such as feeder schools, and demonstrate it to interested students

Links with Teams

It is useful to forge links with other teams in the competition. Links with other teams may allow you to take advantage of some of their resources, or participate in social team building events. Why not make this a lot more than just a few emails?

Designing the Robot

Clarity of the Objectives

The kick-off meeting in January defines the game and publishes the rules. Think really carefully about what is important and the strategy you would like to use. From our experience the games have typically involved a number of aspects:

- Movement around the pitch
- Actions by some human players
- Sophisticated actions by the robots (stacking boxes, kicking balls, etc).
- Basic actions by the robots (pushing, shoving, blocking, etc)
- A scoring system based on location of objects on the pitch

Don't lose sight of the importance of basic features such as speed, manoeuvrability, robustness, etc.

Using CAD

The robot will largely be built visually, with dimensions for minor parts measured or calculated by inspection. However a good set of drawings will help to make good use of space and will help to avoid major mistakes. The drawings can also be used as part of the presentation material to show, such as for publicity.

It helps to train a number of people to use CAD packages. If no one has experience with more advanced CAD packages, the use of more simple packages such as PowerPoint and SketchUp are useful.

Many elements of the robot remain largely consistent from year to year, so these can be modelled prior to the kick-off and then adapted as required.

Speed and Traction

Traction is frequently a vital competitive element, but speed is also important. Winning robots are often fast. Shifting gearboxes and multiple motors have both been employed in the past.

Ensure a good distribution of weight in order to get the best traction. Consider also a shaped front/back so that extra downward force is generated when struggling. For some situations more sophisticated drive systems may be useful, such as swerve drive, although these are more complicated to implement.

Robustness

Maintain a solid construction, and ensure the robot is panelled on sides to prevent damage. Avoid fragile arms or probes, the games are usually more violent than anything you can imagine in practice sessions. This is critical to ensure the robot's success; a minor failure during a round can potentially end your chances in the competition.

Centre of Gravity

Consider the possibility of the robot turning over (or being turned over). Keep the centre of gravity low. Check wheely-propensity at full acceleration on a max friction surface. Avoid profiles which could allow another robot to come in underneath. Consider ways to make the robot self-righting. Consider any aspect of the field (ramps, jumps, railings, etc) which might cause an inversion.

Control

The driver's job in controlling the robot is complex. He/she does not have full visibility, and there are probably deliberate obstacles on the field. Design the control system to make it as easy as possible to control the robot. Time spent manoeuvring or reversing away to get a good run at something is time lost. Consider using better or multiple controllers if this makes it easier.

Autonomous

Autonomous mode is a regular feature of competition games. Spend time during the year building and testing increasingly powerful autonomous functions (way points, Yaw sensor for angle reckoning, wheel tracking, etc). A robot able to do things well autonomously will have a great advantage.

Beware of misbehaviour during autonomous mode (e.g. by collision with another robot). Robots driving full power into walls can do themselves a lot of damage (and waste valuable time). Consider sensors to track objects or vision targets.

Sensors

Look at whatever has been provided in the kit of parts and seek to use it for something. Make sure any sensors that have been used can be described enthusiastically or demonstrated to the judges.

Building the Robot

Construction Techniques

Lots of freedom here! Welded steel has worked well for us in the past. If you choose to weld, make sure at least some of the team gets involved with some of the welding! Many teams work with Aluminium. Remember the major weaknesses are the joints. Always over-engineer anything that moves!

Pneumatics is a popular choice. Build a good collection of cylinders so that there is plenty of scope for experimentation. The big cylinders are probably strong enough to use directly as arms, prodders, etc, without further mechanical structures. Better to have lots of functionality, even if it doesn't seem vital on day one.

Build to the weight limit, or take plenty of extra weight to the completion to be added as required to redistribute the load. Try and standardise components where appropriate, e.g. use M6 and M4 cap screws consistently. This means that fastenings can be bought in bulk and less time is spent searching for the right tool.

Tools and Facilities

Building the robot requires fairly basic facilities:

- Space to work in
- Simple hand tools:
 - Screwdrivers
 - Spanners
 - Allen keys
 - A selection of files
 - Crimp tools
 - Etc
- Drill and saw (ideally a power saw)
- Chain breaker if you are working on chain drive
- Welder if appropriate
- Access to more complex kit for gearbox and similar

Testing and Training

Modelling the Game

As soon as the game is announced it should be possible to model the game in order to determine strategy, and identify appropriate design objectives. Modelling on a small scale (table top scale – using bits of cardboard to represent the robots and the objects) will make a lot of sense. Using four independent players to control the robots will demonstrate the real “human nature” involved in playing the game. The constraints in terms of speed, ability, etc for each of these robots should be agreed beforehand to simulate real situations.

Ensure the scoring system is properly represented at this stage, it can make a major difference to the way you think! It's also possible to model it at full scale, which will generate more value.

Practice Ground

Find somewhere approximately real size to practice. Maybe buy a roll of carpet to put in the school hall or music recital room. Other options are to hire a local hall, or borrow a scouts hut. Use this for real scale trials, training the driver, working out practical times for manoeuvres, etc.

Multiple Drivers

Although only one person is usually designated as the primary driver, ensure others also know how to drive the robot. It's not worth the risk of the driver becoming ill or injuring themselves and not being able to drive any longer.

Competing

Duties

Appoint individuals to carry out certain roles at the competition. Examples of such roles are:

- Battery manager – ensures batteries are charged and exchanged on time
- Transporters – assist in transporting the robot between the pits and the arena
- Food manager – teams need to be fed, so someone has source the food, e.g. pizza
- Scouts – watches other teams in action and determines what they can or can't do, as well as visiting the teams in their pits to take notes on their robots to help pick alliances in the final rounds
- Photography/video – take photos and record footage for use in promotional materials

Pre-Competition

If other regionals have already taken place, it is beneficial to watch some of the webcasts from them. Meet and discuss your strategy in the light of what you see. You can take bold decisions on the basis of what works in other regionals. Seek to identify key features of the robots that win.

Practice Rounds

The first day is chaos as many teams will still be fixing the robot, while struggling to run a full set of practice sessions. Concentrate on trying all the manoeuvres that you think are valid. Don't aim to maximise your score, aim for the greatest experience. Be prepared to take bold decisions to not do things that you thought were important before. The practice rounds are the **ONLY** time you have to reset your basic strategy.

Setting and Adapting Strategy

Hold regular discussions about strategy, and adapt and improve. Remember to consider:

- Scoring – maximising your own score **AND** working to optimise the losing team's score. Consider some form of ready beckoner to allow split second decisions as to how to end the round. One of your drivers should be continuously checking the current scoring arrangement.
- Human player – The game often allows the human player to drive a large slice of the score. Think very carefully about how to maximise the result here. It's a lot easier than doing anything with the robot!
- Tactics – Work out how to operate with your alliance partner and against your opposition. It may all be about defensive work, or blocking moves, or ways of keeping the opposition busy, etc. Consider worst case scenarios, such as if an alliance robot fails to work.

Make sure the drivers are **FULLY CONVERSANT** with the latest rule interpretations.

Being Noticed

Get noticed. Operate set-pieces that work well. Maintain a presence on the stands by cheering excessively and being loud. Chanting the team number or songs also works. Have team members move around the stands and socialise with other teams. Whatever happens, whatever other teams may do, smile and remain positive.

Maintaining Surprise

Although consistent performance will build a greater level of confidence, try doing something different now and again. This might be human player oriented, or game strategy, or response to a challenge from the opposition.

Awards

Check out the awards list before you start to work. Try to do some good things in several of the categories, and make sure they are known, understood and communicated among the team. Aim to win at least one award per year, even if you don't win the competition. Awards are good for repeat sponsorship, and they are a lot easier to win than the competition itself.

During the competition keep a look out for the judges and ensure there is at least one person who knows a decent amount about the robot near the robot at any one time. If a judge swings by, don't be afraid to talk up the robot. Tell them about all the parts of the robot, no matter how trivial you may think the part is. Give demonstrations to the judges where possible.

There is a sportsmanship award and others on offer for those who show the spirit of FIRST in their conduct on and off the field. However badly you may be doing, whatever things may go wrong, cheer, for your team and for others. This shows that you understand the spirit of the competition. Do help other teams where you can, such as by donating spare parts or tools when other teams require them.