SRV Goodwill: A Vehicle for Research

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ABSTRACT

The Solar Research Vessel "Goodwill" was designed and constructed at CIT as a challenge to other institutes - to build a vessel that would sail autonomously from New Zealand to Townsville, Australia. Once developed, it was seen to have many potential commercial applications, and the project has since been sold to a commercial enterprise. It has provided, and continues to provide, research opportunities for polytechnic staff and students.

This paper describes the development of the vessel, and discusses some of the features that made this research initiative work: a moderator, a technical challenge, multi-disciplinary skills, and an enthusiastic group of researchers.

1. INTRODUCTION

In 1993, staff members of the School of Electronic and Software Engineering at the Central Institute of Technology initiated a bold research project... the stated aim was to produce a boat which would travel under its own guidance across the Tasman Sea. To add a little spice, a challenge was issued to other tertiary institutions to develop similar boats to race across the Tasman. A date was set - the race would begin at the first dawn of the new Millennium, leaving Gisborne on 1st January 2000.

Although James Cook University accepted the challenge, it gave up long before the race's start date. That reduced the incentive for CIT staff, so their boat also wasn't ready by Jan 2000. Nevertheless, CIT was years ahead of other prestigious institutions (eg Stanford) in developing autonomous solar boat technology.

2. THE BOAT

The Solar Boat 'Goodwill' is 4 metres long overall (waterline length is 3.85 metres), 0.86 metres beam, and 0.34 metres draft. Its upper decks are covered in solar cells, which allow a maximum speed of 5.5 knots.. It is self-righting in all conditions. It has a cruising speed of about 4 knots, so it will cover about 100 nautical miles per day. It can leave its home port under its own power and proceed to its station, which could be thousands of nautical miles away. Surplus solar energy obtained during daylight hours is stored in sealed deep cycle lead acid batteries for use at night.

Being unmanned means that the boat is very cheap to run. Essentially, there are no running costs. A manned boat needs to carry all their life support systems, food, water, somewhere to sleep, wash, cook, work and have some degree of comfort. Normally one person is not enough because they need to sleep and rest. So more people are also needed to take over and share the responsibility. They too need life support systems. The boat suddenly needs a massive increase in size and costs to be able to accommodate people.

In contrast, the Goodwill has the following electronic systems to provide 'life support', navigation, communication, and other functionality:

- Primary energy management software
- Backup energy management electronics
- Battery charging and monitoring electronics
- Global positioning system
- Fluxgate compass
- Satellite Radio
- Bilge pump electronics
- Navigation Light and drogue motor electronics
- Main motor electronics
- Steering motor electronics
- Microcontroller network
- 100v 100KHz AC inverter

The solar electric research vessel developed at the Central Institute of Technology in New Zealand offers a solution for remote areas of the ocean not frequented by ships. The quality of solar energy arriving varies from day to day because of changing seasons, changing latitudes, and daily weather variations. The vessel carries a self-learning energy management system that will adjust shaft speed as required to match the solar energy the vessel is receiving daily.

The boat will radio in its position each day. 'Inmarsat' satellites cover the navigable areas of the world between about 70 degrees North and 70 degrees South. Outside these areas the ocean is frozen and is not normally used by ships. The Inmarsat satellites are in geostationary orbit above the equator. The boat can send its radio signal up to the satellite, which then retransmits it to a ground station in Singapore, for example. The ground station then sends the signal via the usual telephone network to its destination. Alternatively, where the boat is reasonably close to shore, it may communicate via marine short wave radio. Although either of these systems can offer bidirectional communications, in the race the communications would be used solely for monitoring the boat's position.

The vessel is small enough to be lost in sea clutter on radar — therefore a radar reflector is installed. As well, it has strobe and navigation lights.

The boat is electronically programmed to find its own way across the Tasman, find the appropriate hole in the Great Barrier reef, go around Magnetic Island and arrive at Townsville beach, probably about one month after leaving Gisborne, New Zealand, having covered a distance of two thousand nautical miles. The boat will steer itself by using satellites and a Global Positioning System (GPS).

2.1 Application

Satellite weather forecasting gives good information when it is backed by hard data from the oceans. Up till now much of this data from the oceans has been obtained from drifter buoys, moored buoys or ships in transit.

The average depth of the oceans is about 2 miles so if moored buoys were to be used in blue water they might need to support about 2 miles of chain which means the buoy needs to be big to support that weight of chain. And a big buoy requires a heavy chain to hold it. The result is often too expensive for some users to consider in waters off the continental shelf.

Drifter buoys offer a low cost solution. A ship or aircraft can deploy them. However by their nature they drift away from a place of interest to a place of non-interest and have to be replaced. Often the buoy is lost. The solar boat offers an alternative for these applications.

Once at its destination, the solar boat can maintain station. The rudder is rather like a book opening about its spine. When the vessel is required to maintain station the rudder opens up (like a book) and works as a drogue, to reduce drift due to wind. When the vessel has drifted say 1/2 mile the rudder closes and the boat motors back to its station. Once there its electrical propulsion is turned off and the drogue operates again. By this method the vessel can maintain station for as long as required. It gathers data and transmits this back using its communication systems. A shore-based command and control centre could direct the operations of a number of vessels. This may involve moving vessels to new locations, instructing them to gather, analyse, or transmit data, or telling a vessel to return to its home port for a refit. The position of each vessel is displayed on computer at the command and control centre.

Another application is the monitoring of extreme weather conditions to assess the viability of off shore rigs. In this application, wave height and wind speed, and their respective directions are important parameters.

Other applications for the vessel require different transducers. One application is the continuous monitoring of shellfish beds. As an example the vessel could do a continuous grid search of an area looking for nutrients and toxins. The instruments in use for this application will measure salinity, temperature, depth, turbidity and currents. In this way the health and production rate of the fishery may be constantly monitored.

Further applications include electronically assessing fish stocks, collecting and returning with water samples from predetermined places collecting water samples, and carrying out simple analysis at sea and transmitting the results back.

Given its small radar signature without its reflector, the boat may be useful for covert operations. Fitted with security cameras and guided onto a target located by a shore or satellite-based radar system, the boat can record such things as illegal fishing operations or illegal dumping operations and send video pictures, time, location, and date stamped back to its base. If manned vessel or aircraft are used for this application the offending vessel can see the approaching ship or aircraft on their own radar and temporarily stop their illegal operation and when questioned, claim to be just in innocent passage.

3. THE PROJECT

An important question to answer is: "Why was this project successful?"

3.1. Specific Goals

A collaborative project's focus needs to be a specific goal that is clearly articulated. It could be designing a product, producing a paper, or coming up with a solution to a problem.

In the boat project, there was a clear definition of success; A boat would be built and be ready to navigate itself across the Tasman by 1st January 2000.

3.2. Benefits for Participants

Participants must be motivated because the project is going to require a significant input of their energy and time, either of which may be scarce. When people know that they will gain something valuable for this commitment, they are more likely to want to participate.

These benefits allow a participant to rationally justify participation. It is therefore important to stress the quantifiable benefits to be gained.

A project will not provide the same benefit to every group member. Costs and benefits depend on preferences, prior experience, roles, and assignments. A project is expected to provide a collective benefit, but some people must adjust more than others. In a voluntary effort, everyone must benefit individually, even if some benefit more.

Benefits achieved from the boat project have included:

- publishing papers
- gain new skills
- achieve credit towards an academic qualifica-

tion
- gain access to an expanded network of resources
- travel to conferences
- academic recognition
- television exposure.

3.3. Challenge

One of the reasons for having an explicit goal is that participants need to view the work as important and be motivated and sustained by the task; they need to receive an emotional benefit as well as a rational one.

The boat project is significant enough to present challenges (if something goes badly wrong, the boat itself may be lost entirely), whilst it is clear that it is solvable.

An inherent part of the challenge, caused by the size of the project, is that it must be solved by teamwork... working as a team is part of the challenge.

3.4. Task Suitable for Collaboration

The boat project was large enough that it required several workers for it to be successful. It also required expertise across many disciplines - electrical, marine, electronic, and software engineering were all involved. These two aspects were synergistic - it was easy to divide the work up amongst participants simply by looking at skills/requirements.

Essential to this was the fixed target date... this allowed project contributors to schedule project work into their teaching programs.

3.5 Collaborative Culture

Collaboration should already be valued and viewed as important. The best results come when participants have had experience working collaboratively. When a teamwork approach is not appreciated by either those at the top or those in the group, the collaboration is not as likely to be successful. Having supportive administrators who are willing to give tutors project time makes a collaborative project significantly easier.

In reality, many Polytechnics do not have cultures that support collaborative teamwork. To mitigate this negative effect, a project needs to be better in other aspects to increase its probability of success. A successful collaborative project will engender a more supportive attitude toward the next project.

3.6 Sense of Community

Central to group activity are social, motivational, political and economic factors that are rarely explicit or stable. Often unconsciously, our actions are guided by social conventions and by our awareness of the personalities and priorities of people around us.

Participants must feel safe and secure in the project group. Not only must they trust one another to accomplish assigned tasks, but they have to feel that their conversations are not being critiqued and evaluated by supervisors or superiors, or even peers.

A discussion forum where all participants can be present is important to foster a sense of community within the project. This in turn will raise motivation levels within the project team. On the other hand, electronic communication can make it possible to get connected to others when it's not possible in real life because time or distance is an issue. However, software designed to facilitate collaboration (GroupWare) fails almost every time because it overlooks the interpersonal dynamics of a group.

Conflicts of interest can become major obstacles to success when group members have very different occupations or roles.

Boat project team members all worked for the same department, often sharing offices. Morning tea and lunchtimes were sometimes impromptu project meetings.

3.7 Leader

The role of project leader/sponsor/moderator/coordinator/owner/organiser is critical. It needs someone who is respected by other team members, because inevitably the leader will need to make decisions where the outcome is unclear or unpopular with one or more team members. The leader needs a clear vision of where the project will go, yet be flexible to change direction when an obstacle (or opportunity) appears. Other team members must trust the leader that, when changes are made, they will still receive the benefits (tangible and intangible) that they expected.

4. CONCLUSION

A collaborative research project does not differ greatly from any other kind of collaborative project. The factors that led to the success of CIT's solar boat project are generally the same as factors required for success of other projects.

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