BAE SYSTEMS

concept creation

GENESIS UAV

Years 10 and 11

CHALLENGE

2009

TABLE OF CONTENTS

FIGURES

1. INTRODUCTION

In late 2003 a group of advanced manufacturers in Northern Adelaide joined together to provide leadership in addressing the major skills shortages affecting their businesses. BAE Systems, Tenix Electronics, NTS Global, DANA Australia and IMP Printed Circuits were the founding members who have since been joined by Futuris Automotive, Tenix Defence and Aerospace, Mincham Aviation, Joyce Foam Products and a number of other local businesses.

The industry partners recognised that there was a need to create a program aimed at high school students which would build relationships between schools and industry and which would result in more young people choosing to enter advanced manufacturing and careers in science, mathematics and technology.

The industry partners became known as NAMIG (Northern Advanced Manufacturing Industry Group). NAMIG, in partnership with local schools, University of South Australia and Technical Further Education of South Australia, City of Salisbury and City of Playford and other organisations have developed and delivered the nationally recognised Concept2Creation (C2C) Program to over 500 students to the end of 2006. The C2C Program provides a way for schools and industry in Northern Adelaide to work together to provide students with industry experience and assistance as they create their own C2C projects.

2. UNINHABITED AIR VEHICLES

The field of Uninhabited Air Vehicles (UAVs) holds great promise for accomplishing a wide range of exciting commercial & military missions. There is a need for highly reliable but lightweight sensory systems in order to test performance of these vehicles. Many recent advances in miniaturisation of sensors, computer processors, power supplies, and wireless technology can be incorporated into radio controlled air vehicles in order to develop these systems.

3. GENESIS UAV CHALLENGE

The Genesis UAV Challenge was originally sponsored by Tenix Defence Aerospace and the Royal Australian Air Force in 2006, with the purchase of Tenix by BAE Systems in 2008, sponsorship of the UAV Challenge has been inherited and now proudly sponsored wholeheartedly with the Air Force by BAE Systems.

The UAV Challenge, as with the other C2C projects, was initially designed to promote aircraft trades, engineering and science through project-based learning. It is anticipated that the experiences obtained by the students will help create a future generation of aerospace professionals.

The UAV Challenge aims to:

a. Promote student's interest in Engineering & Science via experimental learning;

b. Provide valuable experience to students, in the design, construction and operation of UAVs;

c. Challenge the current paradigms about electronics and air vehicles; and

d. Inform students about engineering disciplines and test and evaluation programs.

The Challenge has now been broadened from Years 10/11 to a C2C² Challenge² for Years 12. This document covers the Years 10 and 11 program.

3.1 MISSION

3.1.1 Scenario

A group of school students embarked on a camping expedition in the Australian outback. The students were equipped with camping equipment, limited food, a basic First Aid Kit and a satellite phone. While exploring the dry, desolate and hostile environment, a teacher is unfortunately bitten by a venomous snake. The First Aid Kit does not contain the supplies required to effectively treat the snake bite, and the teacher requires urgent medical attention. Time is critical, and the teacher must receive treatment within 30 minutes. An aircraft from the nearest town is loaded with medical supplies, which need to be transported to the injured teacher. The terrain makes it impossible for the aircraft to land, and the medical supplies will need to be air delivered.

3.1.2 Objectives

All Teams will be provided with identical UAVs and representative medical supply package (referred to as the "package").

Students will work as a "Team" to achieve the following UAV Challenge objectives:

a. Design and implement UAV onboard systems that can:

   i) collect imagery;

   ii) calculate position, velocities and angular motion in real time, and

   iii) accurately deliver the package;

b. Conduct test and evaluation of the UAV and onboard systems to verify functionality and determine system performance;

c. Prepare a Technical Report;

d. Conduct a Flight Demonstration; and

e. Deliver an Oral Presentation.

3.1.3 Judging

Judges for the UAV Challenge will be professional staff from within the Aviation industry, and will:

a. Determine Team compliance with the UAV Challenge rules and requirements;

b. Assign scores for the Team Technical Reports, Oral Presentations and Flight Demonstration in accordance with Section 6; and

c. Record official times and measurements during the Flight Demonstration.

3.1.4 Flight Demonstration

All Teams will be required to flight manage their aircraft and deploy the package such that its first point of contact is in the centre of the Target Zone. The Target Zone will comprise of a sandpit with dimensions of 1m wide, 2m down-range (in the direction the UAV is flying) as shown in Figure 1.

Before deploying the package, the UAV must be flown down a straight course of 50m, starting over the 0m marker (refer to Figure 1). Two hurdles with a height of 4m, and a width of 3 m, will be placed on each side of the Target Zone. The Target Zone will appear between the hurdles (refer to Figure 1).

Points will be awarded based on the time required to complete the Mission and the proximity of the package to the centre of the Target Zone. A maximum of three drops will be allowed. For each drop attempted, a maximum of three passes will be allowed, noting that a pass may occur where the package is not dropped. The two best results will be averaged and used for judging.

A total allowable time of 30 minutes will be allocated for each Team to complete the Mission. This includes all time for setup, launch, flight, landing, recovery/pack-up and measuring of each dropped package.

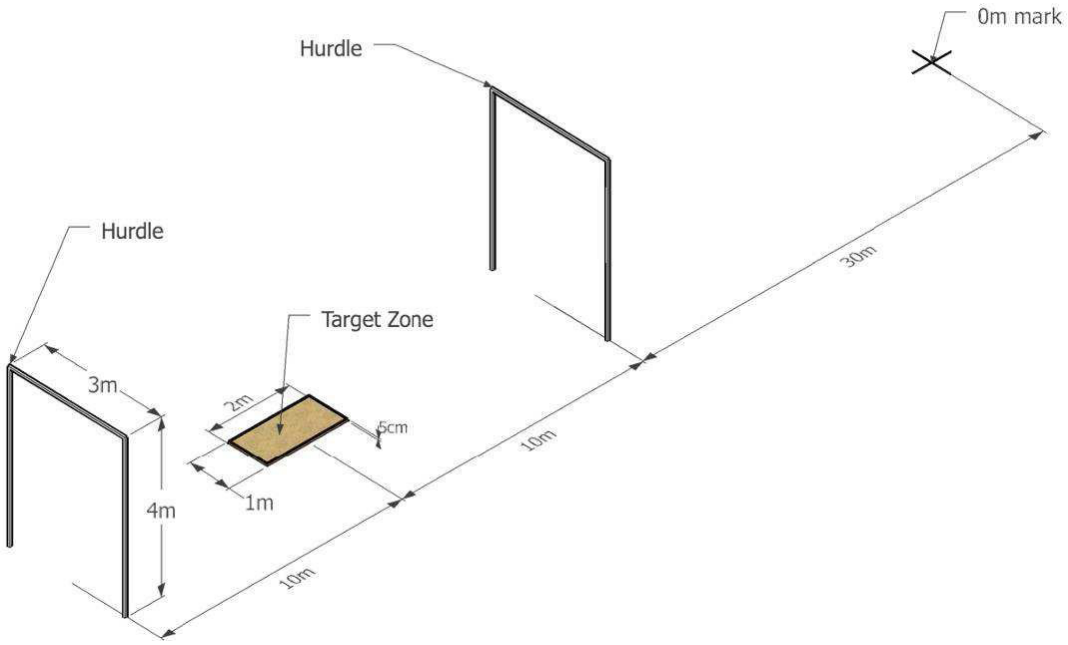

Figure 1. UAV Challenge Schematic

The judges will indicate when the timer starts and Teams can then enter the mission area. The timer will be stopped once all Team members leave the mission area with all equipment.

Teams must adhere to the flight circuit procedures provided by the Judges.

3.1.4.1 UAV Controller

During the Flight Demonstration, the UAVs will be remotely controlled by a Team nominated (student) UAV Controller. The UAV Controller must fly their UAV such that it passes over the hurdles, but must not fly higher than 200 feet (well within CASR101 guidelines).

The UAV Controller is to remain in the pilots station (refer to Figure 2) at all times during the Flight Demonstration except when preparing the aircraft for take off and recovering the aircraft after landing.

3.1.4.2 Mission Manager

The delivery of the package will be controlled by a Team nominated (student) Mission Manager. The Mission Manager's zone will be a 2m x 2m square, as shown in Figure 2.

The Mission Manager must be located within this square at all times during the Flight Demonstration.

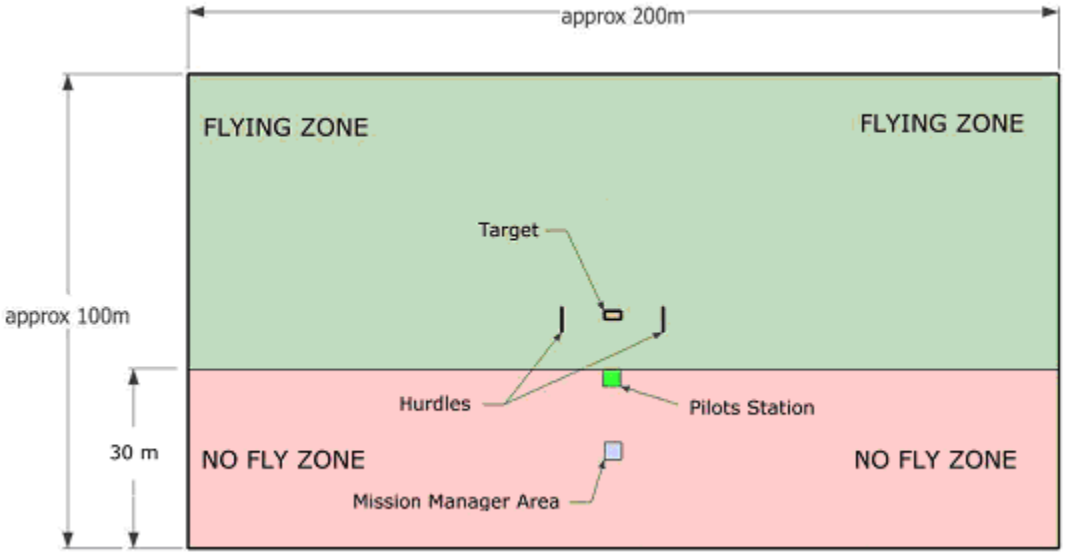

Figure 2. UAV Fly / No Fly Zone Layout

The Mission Manager's area will be enclosed with a barricade around the edges and covered from the top for safety. The Mission Manager will ***NOT*** be able to see the Target Zone during the Flight Demonstration and will ***NOT*** be able to communicate with the UAV Controller during the drop sequence.

The Mission Manager will be required to control the delivery mechanism independently of the UAV Controller, who is flying the aircraft, and deploy the package such that its first point of contact is in the centre of the Target Zone.

3.2 DELIVERABLES

3.2.1 Technical Report

All Teams are required to submit a Technical Report (in hardcopy and softcopy) that describes the design of their UAV and the rationale behind their selections.

The Technical Report should include the following information:

a. Overall UAV system design features:
   i) the UAV platform;
   ii) ground station;
   iii) data link (frequencies, range, etc);
   iv) package delivery;

b. Photographs depicting the UAV;

c. Expected UAV performance;

d. Research and development conducted;

e. Ground and flight results;

f. Safety criteria;

g. Operational and safety procedures; and

h. A budget that lists all hardware, expenses and sources of funding.

The Technical Report should also include a one page fact sheet detailing:

a. A basic description of the UAV;

b. UAV dimensions;

c. Onboard systems;

d. Payload capacity;

e. Radio frequencies;

f. Fuel type; and

g. Battery/s;

Point allocations for the Technical Report are outlined in Section 6.

3.2.2 Oral Presentation

All Teams are required to deliver an Oral Presentation, not exceeding 15 minutes, which should include the following information:

a. Team approach to the UAV Challenge;

b. UAV and onboard systems design;

c. Expected UAV performance;

d. Ground and flight test results;

e. Lessons learned;

f. Unique or innovative features; and

g. Safety approaches.

Judging will be based on technical merit, safety and presentation effectiveness.

Point allocations for the Oral Presentation are outlined in Section 6.

3.2.3 Flight Demonstration

The Flight Demonstration requirements are detailed at Section 3.1.4.

Judges will score each Team's Flight Demonstration according to the following criteria:

a. Takeoff:

   i) Controllability;

   ii) Stability, and

   iii) Safety;

b. Flight:

   i) Altitude;

ii) Flight path;

iii) Control; and

iv) Safety;

c. Package deployment accuracy;

d. Landing:

i) Controllability

ii) stability

iii) safety;

iv) accuracy; and

v) post landing condition of platform;

e. Mission Time – time required from pre-flight to completion of the Mission;

f. Safety – demonstration of safety features; and

g. Overall

i) Competence of the Team;

ii) Teamwork; and

iii) Resources invested.

Point allocations for the Flight Demonstration are outlined in Section 6.

4. SAFETY

Safety is a priority for the UAV Challenge, and the rules and regulations contained in this document have been put in place with safety in mind.

The following safety mechanisms that have been incorporated into the UAV Challenge:

a. ensuring compliance with CASR101;

b. air vehicle safety inspections and structural verification; and

c. a proven history of safe flight operations.

Students are reminded that during their research and development phase, all test flying must comply with the relevant CASA Regulations.

4.1 SAFETY INSPECTIONS

All UAVs will undergo rigorous safety evaluations leading up to the Flight Demonstration. Physical inspections by nominated safety personnel must be passed before each UAV will be permitted to conduct its Flight Demonstration.

Safety inspections will include (but not be limited to) the following:

a. Structural verification of the UAV to ensure structural integrity including,

i) Components adequately secured and fasteners tightened;

ii) Propeller structure and attachment integrity;

iii) Inspection of all electronic wiring;

iv) Controls move as expected;

v) Payload general integrity;

b. Radio range checks with motor off and on; and

5. SCHEDULE

UAV Induction Day ..... 28th July 2009

Deliverable 1: Team Documentation..... Mid October 2009

Deliverable 2: Flight Demonstration..... Late October 2009

Deliverable 3: Oral Presentation ..... One week prior to the Expo in November

6. SCORING CRITERIA

The Judges will evaluate and score the following UAV Challenge deliverables:

a. Technical Report..... 30%

b. Oral Presentation..... 20%

c. Mission Performance 50%

The scores obtained for each UAV Challenge deliverable will be combined to form the total Team Score.

6.1 TECHNICAL REPORT

One Page Fact Sheet.....	5	Points
UAV and Onboard Systems Design.....	10	Points
- *Including engineering decisions and rationale.*		
Ground and Flight Testing.....	5	Points
- *Results and discussion.*		
Budget[1]	3	Points
Safety Considerations	5	Points
Overall Style/Presentation.....	2	Points
Over Page Limit (8 Pages)	*Minus 2*	*Points/page (max 15 points)*
	Maximum 30	**Points**

6.2 ORAL PRESENTATION

UAV Design.....	5	Points
Safety Plan	3	Points
- *Start-up and flight operation procedures; and*		
- *OH&S&W.*		
Ground and Flight Testing.....	5	Points
- *Results;*		
- *Discussions; and*		

[1] One aim of the Challenge is the development of a low cost solution to the problem, and points will be awarded appropriately based on this.

- *Lessons learned.*

Evidence of Good Teamwork ..... 2 Points
- *Distribution of project tasks between group members.*
- *Number of members participating in the presentation.*

UAV Craftsmanship ..... 3 Points

Presentation Style ..... 2 Points

Time Limit (15 minutes)[2] *Minus 1 Point/minute over (max 5 Points)*

Maximum 20 Points

6.3 MISSION PERFORMANCE

6.3.1 Subjective Components

Takeoff: ..... 10 Points
- *Controllability ..... 4 Points*
- *Stability ..... 3 Points*
- *Safety ..... 3 Points*

Landing ..... 15 Points
- *Controllability ..... 4 Points*
- *Stability ..... 3 Points*
- *Safety ..... 3 Points*
- *Accuracy ..... 3 Points*
- *Post landing condition of platform and payload ..... 2 Points*

Safety ..... 5 Points
- *Demonstration of safe mission operation; and*
- *Additional safety measures/features.*

Overall ..... 5 Points
- *Competence of the Team;*
- *Teamwork; and*
- *Resources invested.*

Maximum 35 Points

6.3.2 Performance Measure Components

Delivery of Package
- Proximity to centre of Target Zone ..... 10 Points <1m, or
  7 Points <10m,
  5 Points >10m

Mission Time (30 minutes) ..... 5 Points < 20 mins
- *Total time elapsed from pre-flight to Mission completion[3].* 3 Points < 25 mins
  Minus 2 Points/minute over

Maximum 15 Points

If Teams exceed 45 minutes they loose ALL POINTS for the Mission (max 50 points).

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[2] Oral Presentations will be stopped at 20 minutes – no exceptions.

[3] The time is started when Teams enter the mission area and stopped when Teams leave the area for the final time with ALL equipment including the UAV.

7. AWARDS

7.1 CERTIFICATES

All students will receive a Certificate acknowledging their participation in the UAV Challenge.

7.2 RECOGNITIONS

The Judges will present a number of awards to selected Teams recognising their notable achievements and performance during the UAV Challenge.

7.3 UAV CHALLENGE PERPETUAL TROPHY

The UAV Challenge Perpetual Trophy will be presented to the Team which best demonstrates the aims of the UAV Challenge.

The Judges will award the UAV Challenge Perpetual Trophy based on each Team's:

a. Enthusiasm and approach to the UAV Challenge;

b. Innovation;

c. Teamwork; and

d. Continual improvement.

It should be noted that the Team that receives the UAV Challenge Perpetual Trophy may not necessarily be the Team with the best Total Score.

8. DEFINITIONS

ARCAA	Australian Research Centre for Aerospace Automation
C2C	Concept2Creation
CASR101	Civil Aviation Safety Authority (CASA) Regulation Part101 – Unmanned Aircraft and Rocket Operations
Safety Personnel	Staff responsible for ….
Controllability	The ability to operate the system using only certain admissible manipulations on the control surfaces.
Mission Boundary	The area which the UAV must remain within at all times.
NAMIG	Northern Advanced Manufacturing Industry Group
Safety	The condition of being safe; freedom from danger, risk or injury.
Stability	The condition of being safe; freedom from danger, risk, or injury Refers to both static and dynamic stability. Static stability refers to the aircraft's initial response when disturbed from a given angle of attack, slip or bank and also to Dynamic stability refers to the aircraft response over time when disturbed from a given angle of attack, slip or bank.
UAV/S	Unmanned (or uninhabited) aerial (or air or airborne) vehicle (or system).
Unmanned	Not having or needing a crew or staff

9. ACKNOWLEDGMENT

The sponsors would like to acknowledge the extremely successful UAV Outback Challenge. The UAV Challenge is a joint initiative between the Queensland Government, Australian Research Centre for Aerospace Automation (ARCAA, a partnership between Queensland University of Technology and Commonwealth Scientific and Industrial Research Organisation and Boeing Australia Limited.

The UAV Challenge was developed to promote the significance of UAVs to Australia and focuses on the civil, search and rescue application of UAV technology. The overall goal of this competition is to provide valuable experience to students and aerospace enthusiasts in designing, building, testing and operating UAVs.

Entrants in the UAV Challenge embark on an outback rescue mission, which involves finding and assisting 'Outback Joe', a lost bush walker in Australia's vast outback using UAVs. The UAV Challenge is split into two categories of varying difficulty; the High School Airborne Delivery Challenge and the Open Search and Rescue Challenge.

The objectives developed for the Genesis UAV Challenge are based on the objectives set for the High-School Airborne Delivery Challenge. It is anticipated that the experience gained by students and schools participating in the C2C Genesis UAV Challenge will hopefully motivate them to compete in future UAV Outback Challenges.