Title: , Autonomous Helicopter Navigation System, System Level, Progress Report

*“A Project”*

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**Foreword**

This document outlines the progress report for the Autonomous Helicopter Navigation System semester one 2010. Throughout the first half of the year, all members of the AHNS team have been working towards defining and researching the project, designing and development of key components, and initial testing of individual components. All members have been following the work breakdown structure, along with the Gantt chart timeline, to complete all necessary roles within the desired schedule.

The work packages were analysed against the current timeline, and it was found that the project is on schedule. The work packages that are not complete have been allocated contingency time during the mid semester break, with the goal of completing stages 1-3 before semester two commences.

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**Definitions**

|  |  |
| --- | --- |
| AHNS | Autonomous Helicopter Navigation System |
| QUT | Queensland University of Technology |
| HLO | High Level Objective |
| GCS | Ground Control Station |
| PM | Project Manager |
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# Introduction

The 2010 AHNS project is made up of several sub-systems that interconnect to achieve the high level objectives outlined from conversations between the project supervisor and group members. In order for the HLO’s to be completed in an ordered and within time constraints, a project manager is required. The PM’s roles range from organising equipment, parts, timelines, work breakdown and meetings between team members and supervisors. This document will outline the work completed by the project manager, Michael Hamilton, of the 2010 AHNS project is semester one.

## Scope

This document is bounded to the work completed by the project manager in semester one for the 2010 autonomous helicopter navigation system project. This document will draw material from the High Level Objectives RD/1, System Requirements RD/2, Project Management Plan RD/3 and the Risk Management Plan RD/4.

## Background

The AHNS undergraduate project has been attempted by fourth year students from 2007, each year making progress to the ultimate goal of an autonomous indoor flying helicopter. Each year has used a similar approach of organisation, which has lead to successful steps forward in development. In 2010, the AHNS team will follow a similar organisation technique to ensure the available time, equipment and resources are available.

# Reference Documents

## QUT Avionics Documents

|  |  |  |
| --- | --- | --- |
| RD/1 | AHNS-2010-SY-HL-001 | AHNS, High Level Objectives of |
| RD/2 | AHNS-2010-SY-SR-001 | AHNS, System Requirements of |
| RD/3 | AHNS-2010-SY-PM-001 | AHNS, Project Management Plan of |
| RD/4 | AHNS-2010-SY-PM-002 | AHNS, Risk Management Plan of |

## Non-QUT Documents

|  |  |  |
| --- | --- | --- |
| RD/5. | Roman Czyba, Silesian University of Technology | Attitude Stabilization of an Indoor Quadrotor |

In the event of any conflict between this document and any RD referenced herein, such conflict shall be notified to Dr Luis Mejias.

In the following text, RD/x identifies referenced documents, where "x" denotes the actual document.

# S/N 06219314 Project Summary

The 2010 Autonomous Helicopter Navigation System high level objectives were developed through discussions between the project customer and team members. The aim of the AHNS project is to develop a hardware and software solution to automate a small size electric helicopter for indoor environments. The project goals have been split into six HLO’s, with encompasses all requirements that must be achieved to complete the project.

Table - High Level Objectives

|  |  |
| --- | --- |
| HLO Description | |
| HLO-1 | A platform should be developed and maintained to facilitate flight and on board hardware integration. |
| HLO-2 | The system should be capable of determining its position with the aid of image processing within an indoor environment to an appropriate time resolution. |
| HLO-3 | A method of estimating the states of the helicopter system should be designed and implemented. The resolution of the estimations should facilitate their employment in the control system design. |
| HLO-4 | An autopilot system should be developed to enable sustained indoor autonomous hovering flight. The control system should be designed to enable future ingress and egress manoeuvre to longitudinal and hovering flight. |
| HLO-5 | A ground control station that supports appropriate command and system setting inputs and data display and logging should be developed. The design should be derived from previous AHNS developments and enable future ground station developments. |
| HLO-6 | The communications system should enable transfer of control, state and localisation data to the ground control station. It should provide with a flexible wireless data link available on consumer-electronic devices. |

The helicopter will have three switchable modes in which it can operate manual RC flight, augmented flight, and station keeping modes. Standard radio controlled flight will be used to maneuver the helicopter while not under the control of the onboard flight computer. Augmented flight mode incorporates velocity vectors being sent to the flight computer, which then moves the helicopter while keeping the attitude stable. Finally station keeping mode allows the helicopter to remain in a specified co-ordinate while keeping stable.

The project manager’s role within the 2010 AHNS project is to ensure that the above mentioned high level objectives are achieved within the time, weight and financial budget, without controlled risks to the group members. The PM must also organise all meeting between group members and the supervisor, documentation standards, public presentations, and record all meeting minutes.

The project manager also has a secondary role of designing and constructing several testing apparatus to protect the group member and components from becoming damaged though an unforeseen incident.

## Methodology for Delivering Against Milestones

### Project Organisation

Large engineering projects are broken down into five primary stages of development, which are illustrated in Figure 1. This process will be followed closely to ensure that the AHNS project has a structured approach in development. Stage one consists of Defining the objectives and system requirements for the project. Initial research is also carried out within each sub-system which can including overview of previous years documents and performing trade studies. Stage two outlines the chosen design that will achieve the HLO’s SR’s prepared in a preliminary design document. Once the design has been finalised, the individual components are acquired and constructed.

Stage three outlines the individual components testing, which ensures that each component achieves its own purpose before integration with the system. Stage four consists of integration of all the individual components into the whole system. The system is then tested to ensure that it achieves the HLO’s and SR’s. Finally stage five involved the delivery of the product to the customer, which in tales demonstration and presentations.



Figure - Project Stages

### Team Organisation

The Autonomous Helicopter Navigation System follows the NASA standard in project management to strengthen the chances of completed the required tasks prior the due date. The project team was divided into three tiers of management structure. Dr Luis Mejias, the project supervisor and client, is at the top tier overlooking the entire project and the group members. On the middle tier is the project manager, Michael Hamilton, whose responsibility in the management structure is to keep the project supervisor informed of the projects progress. Michael Kincel, Liam O’Sullivan and Tim Molloy make up the bottom tier.

For any project’s success, the duties and roles it in tales must be divided among the team members that are the most suited person for the responsibility, based on their backgrounds and knowledge. The four members for AHNS were split into several sub-systems within the major project. Each student is responsible for their assigned sub-system, but all students will contribute to the completion of all tasks.



Figure - Team Members Sub-Systems

Michael Hamilton’s major role is the project manager, whose responsibility is to ensure that the high level objectives and system requirements are all met, and that the project is completed within the time schedule. He is also responsible for the testing sub-system, which entails organising all testing equipment and procedures.

All airframe construction, maintenance and hardware integration tasks will be organised by Michael Kincel. This includes incorporating all physical sub-systems on the platform to enable autonomous flight. Michael’s secondary role is the pilot for the platform for takeoff, landing and emergency manoeuvres while in autonomous testing. Liam O’Sullivan’s major role is to ensure that the platform is localised under a known co-ordinate system using an array of sensors. Liam is also responsible for determining the state estimation for the platform to determine the underlying behaviour of the system at any point in time with the use of the IMU and other sensor data.

To ensure that the platform can remain stabilised without the aid of the pilot, a control system must be developed and refined. Tim Molloy’s major responsibility is to determine the control theory for the chosen platform and assign appropriate gains. His secondary role is to develop the GCS from AHNS 2009 to operate with the new platform design. All members of the 2010 AHNS are responsible for communication between group members, maintenance of equipment and ensuring safety procedures are adhered to for their respective subsystems.

### Work Breakdown Packages

Work Packages are used in the AHNS project to ensure that team members are informed on the structure of the project. Work Packages outline all the tasks to be completed to achieve the high level objectives and system requirements outlined in RD/1 and RD/2 respectively. The work packages have been produced according to the Work Breakdown Structure in section 3. The work packages are categorised using their related sub-system code and numbered in order of their appearance on the Work Breakdown Structure. Work packages outline each task commencement and due dates, person/s responsible, input requirements and output deliverables. A full list and details of the work packages are located in the Project Management Plan document RD/3.

### Financial Budget

The financial resources will be used for purchasing equipment that the 2010 AHNS team require to complete the projects objectives. All purchases will be conducted by the project manager once authorisation from the project supervisor has been granted. It is the project manager’s responsibility to monitor the budget as purchases are made.

Every student within the subject is provided $100 Australian dollars to put towards their project, supplied by Built Environment & Engineering Faculty at QUT. Additional funding was also acquired from Boeing Australia, to the sum of $2000 Australian dollar. This adds to $2400 dollars total for the 2010 AHNS project.

Table - Financial Budget

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company | Items Description | Debit | Credit | Total |
| QUT | BEE Unit Funds | $0.00 | $400.00 | $400.00 |
| Boeing | Boeing Sponsership | $0.00 | $2000.00 | $2400.00 |
| HiSystems GmBH | Quad Copter Airframe | $759.86 | $0.00 | $1640.14 |
| Surveyor Corporation | Camera | $248.75 | $0.00 | $1391.39 |
| Gumstix inc | Onboard Computer | $395.92 | $0.00 | $995.47 |
| HobbyRama | V-Tail Mixer | $19.95 | $0.00 | $975.52 |
| HobbyRama | Cable | $13.00 | $0.00 | $962.52 |
| HobbyRama | Cable | $49.00 | $0.00 | $913.52 |
| Bunning’s Warehouse | Glue | $2.05 | $0.00 | $911.47 |
| Bunning’s Warehouse | Tool | $13.98 | $0.00 | $897.49 |
| Eckersley | Wiring Equipment | $29.95 | $0.00 | $867.54 |
| QUT Bookshop | Writing Material | $5.70 | $0.00 | $861.84 |
| Jaycar Autralia | Cable | $10.67 | $0.00 | $851.17 |
| RS Components | Coolum Counter | $37.07 | $0.00 | $814.10 |
| Farnel | Electrical Parts | $86.55 | $0.00 | $727.55 |
|  |  | **Total** | **Remaining** | **$727.55** |

At the end of the first semester the total remaining funds is slightly over seven hundred dollars. Boeing Australia has been confirmed to sponsor another $2000.00 towards the AHNS project for next semester. This adds to approximately $2700.00 that will be used as emergency funds for incidents of platform damage, and used to explore other avenues of research once the current goals are completed.

### Testing Procedures

A secondary role for the project manager is the testing equipment and procedures. To ensure that testing in approached in the safest manner; a stepped testing procedure will be undertaken within the 2010 AHNS project. The first level of testing will be individual component testing on the bench. Following the validation of each individual component, an integrated test of the hardware and software will also be performed on the laboratory bench.

The next stage of testing encompasses attaching the quad copter to a secured ball joint connector, thus allowing the helicopters stability augmentation software to be validated. An example of this is illustrated in Figure 3, a similar technique used by Silesian University of Technology in RD/5.

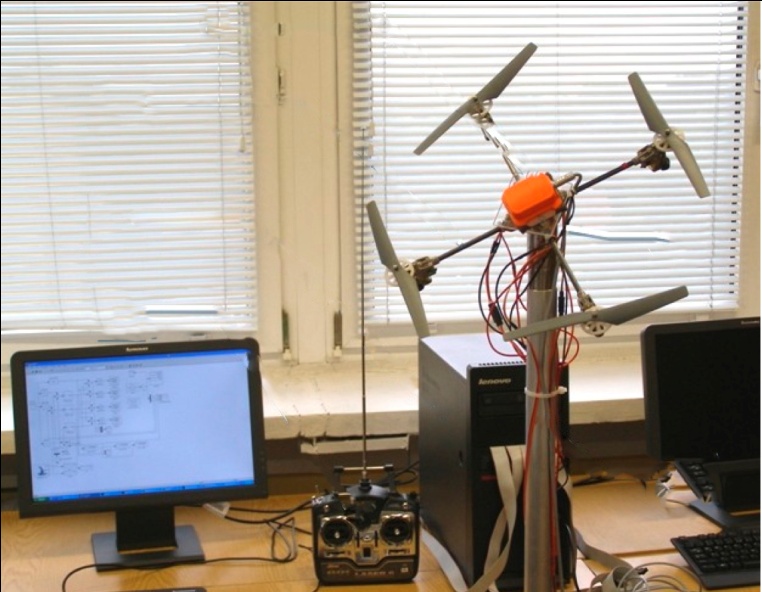
****

Figure - Ball Joint Test Platform RD/5

On completion of the Ball Joint Testing, the quad rotor will be attached to an elastic cord, and suspended off a ceiling. This test restricts the quad rotor from impact with the ground, but allows the helicopter the freedom to move position and attitude. When all members of the AHNS team agree that the quad rotor is safe to fly unrestrained for all subsystems, the full testing will begin.

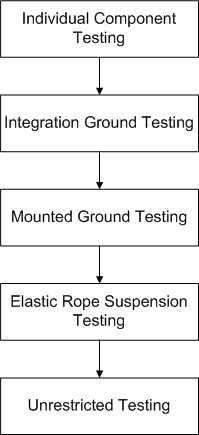


Figure - Tier Testing Levels

## Statement of Progress Against Milestones

The work breakdown structure is an effective way to map the work packages in a logical order. The work breakdown structure is managed using bottom side up approach, which conforms to NASA’s guidelines for systems engineering. Figure 5 outlines the work breakdown structure, with each of the five project stages marked with dotted lines. The bold red line outlines the expected completion of work packages to the current date, sourced from the Gantt chart in RD/3. Finally the work packages colour in green are completed, yellow work packages being currently being addressed, and white work packages have not started.

Stage one has been completed, with most current work under taken classified under design, development and component testing. The solid red line, indicating expected completed work, has proven that most items have been completed, with the exception of the work packages in yellow. These work packages are currently being completed, and is expected to be finished before the start of semester 2. Several items above the red line are currently being completed, which indicates that the project is slightly ahead of schedule. According to the time schedule outlined with the Gantt chart in RD/3, all work packages in stages 1 to 3 will be completed before semester 2, allowing maximum time for integration and testing. The 2010 Autonomous Helicopter Navigation System project is currently on schedule with the predetermined milestone timeline, with the contingency time of the mid year holidays to catch up any work packages not completed below the red line.



Stage 4

Stage 3

Stage 5

Stage 2

Stage 1

Figure - Work Breakdown Structure

## Risks

A risk management plan identifies the risks that could potentially effect personal and project objectives. These risks are then pro-actively managed to ensure the safety, health and wellbeing of all staff, students and general public that interact with the project. A detailed risk management document is essential for any project under the jurisdiction of QUT. The risk management process involves:

* Determine responsibilities and context of the project.
* Indentify hazards within the project.
* Assess the risks existing in each hazard.
* Determine control measures.
* Implement control measures.
* Review effectiveness of control measures.

A risk hazard log was created to ensure that all members had at hand the actions to mitigate the identified hazards and risks. All risks were categorised into five areas of concern, personal injury, property damage, schedule, technical, and budgetary risks. All risks were analysed to determine the risk rating, and mitigation measures were put into place to reduce the risk to low consequences and likelihood. The full risk hazard log is available in the Risk Management Plan document, RD/4.

Testing exercises contain the highest number of risks and hazards, and as the PM’s secondary role of testing manager all risks must be addressed. The implementation of staged testing as mentioned previously will mitigate the risks for damage to the platform, surrounding ground members and general public. All major testing will be held at the ARCAA workshop in the Brisbane airport area. This facility has first aid and quick response time for medical personal to attend the building if necessary. The outlined risk management procedures will allow all members of the AHNS group to operate safely throughout testing.

# Conclusions

The 2010 Autonomous Helicopter Navigation System has been organised under NASA’s standard for project management. This standard outlines that the project be divided into sub-systems, which group members are to oversee. When each sub-system is completed, they are integrated together to form the final product. Each sub-system was then broken down into work packages to complete, with corresponding dates in which they must be completed by. The work packages were analysed against the current timeline, and it was found that the project is on schedule. The work packages that are not complete have been allocated contingency time during the mid semester break, with the goal of completing stages 1-3 before semester two begins.

Next semester a tier approach will be used for testing procedures to mitigate the potential dangers that are apparent in autonomous gain tuning. After both component and integration testing on the bench is complete, a purpose built ‘ball join’ stand will be used to initially test against attitude gain tuning. Once the group is satisfied, ‘suspended’ testing will be implements. This involves hanging the quad rotor from the ceiling from an elastic rope. This allows a mid range level of freedom with both attitude and position. Once all levels of testing have been completed, unrestricted testing will begin.

# Lessons Learnt and Recommendations

Throughout the first semester the AHNS team have been working towards defining, researching, designing and constructing the components. The main lesson from the first semester that will be applied for the remainder of the project is that the system requirements and high level goals of the project regularly changed. This in turn pushed back the development of key components within the sub-systems. It is recommended that the overall high level objectives are determined early within the project timeline, and that they are only changed in extreme cases.

Another large lesson learnt for the project manager and the team is to research other similar projects completed in different universities. The group originally were set to use the single blade, more conventional helicopter. After investigation through many other university programmes mid way into the semester, it was found that quad rotors are used extensively throughout other indoor helicopter programs. From this point the AHNS 2010 team made the decision to use quad rotor helicopters, which is a very baseline component within the project. By completing this literature review earlier many have saved a lot of time at the beginning of the semester.

It is recommended that the AHNS 2010 team continue to complete the work packages prior to their respective due dates. This will allow maximum integration and testing time next semester, which in turn will increase the chances of completing and verifying all high level objectives.