

Project Data Management Implementation for the Formula Student Team

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Thesis Summary

To improve the efficiency and performance of Aston University's Formula Student Team with respect to its engineering configuration management process, successful integration of a Project Data Management System was achieved. This thesis has identified an approach that is both quantitative and qualitative, for establishing a framework of Key Success Factors that are specific to the requirements of the Formula Student Team data handling practices. These Key Success Factors have directly complemented the use of a computer aided design package, SolidWorks Education Edition 2007, during the design and development stages.

In understanding the historical background of Aston University's participation in the Institution of Mechanical Engineering's Formula Student competition, this thesis has evaluated the complexity of the problems experienced within the context of the historical organisational team structures and project teamwork over the preceding years.

A literature based review of the experiences of Industry, engineering business strategies and approaches to engineering organisational structures, contributed significantly to identifying the Key Success Factors recommended for implementing a Project Data Management System. This thesis also demonstrates the direct benefits, including the effect of teamwork, of a strong transformational leadership culture in organisations that can adapt to more efficient working practices. The research further demonstrated the uniqueness of a/the Formula Student Project Team in comparison to Industry based engineering organisations as a result of the small organisational setting and academic framework within Aston University School of Engineering and Applied Sciences.

Successful Project Data Management Systems integration has increased performance, communication and discipline of teamwork and provided an approach to support a learning organisation and an ability to retain and increase knowledge in order to continue the evolving, competitive capability of the Formula Student Team.

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1.0 Synopsis

‘Coming together is a beginning, keeping together is progress, working together is success’¹

Within any major Engineering Design Team, it is important that the cohesion and management of the design data be maintained in a secure, organised and structured environment. One of the key critical factors to ensure the success of the project is Teamwork. This thesis presents the unique situation of how the Aston University Formula Student Team enters an international competition every academic year. The new team members each year rely on the importance of teamwork to design, develop and manufacture a racing car to compete in the competition. Coherent and consistent project and data management structures that extend beyond the team are therefore vital. There is an essential need for implementing a Project Data Management System (PDMS) to control the team’s design data.

This thesis is organised into four distinct Chapters.

Chapter 1 – Aston University Formula Student Team History

The opening chapter presents the background of the Formula Student Competition and the participation of Aston University. Section 3.0 introduces the concept of Formula Student and its development by the Institution of Mechanical Engineers (IMechE), to beat the forefront of undergraduate engineering team competitions with entries from universities around the world.

With the growth of the competition, Section 4.0 discusses the historical background and experiences of the Aston University Formula Student Team, particularly focusing on the evolving organisation and presenting the benefits that these changes have made to roles and responsibilities within the management team.

The investment and development of the University facilities to create a dedicated teamworking environment and how this has assisted the growth and effectiveness of the project is discussed in Section 5.00. An overview is also provided of the technological advances in the design and manufacture of the cars which have evolved concurrently with the university focus and technological investment within the School of Engineering.

An overview of the engineering core design software package, SolidWorks, is introduced in Section 6.0. An analysis of how the software licence agreement is structured and the access rights of the university students, particularly the Formula Student Team, is presented.

¹ A definition of Teamwork by Henry Ford.

Section 7.0 details a previous attempt to implement a PDMS for dedicated use by the Formula Student Team, providing a brief evaluation of the reasons why this was unsuccessful.

The lessons learned and improvements required in order to adapt to the growth and experiences of the project are discussed in Section 8.0. An in-depth overview of the continual problems with Formula Student data management and the key drivers for the need to implement a PDMS are detailed. Areas that require further research are discussed in order to support a potential solution.

Chapter 2 – Analysis of Industry Experiences and Identifying Key Success Factors

The second Chapter of the thesis considers Industry experiences of PDMS. The focus of research content within Chapter 2 aims to give an overview of the benefits of PDMS and the reasons that these systems form an integral part of modern engineering organisations. The research objective is to derive the Key Success Factors (KSFs) that are required when implementing and developing PDMS within an engineering organisation. Particular attention is given to the comparisons between Industry and the Aston University Formula Student Team, highlighting the differences between the needs and the environment of academic undergraduate implementation and those of Industry, whilst summarising the most appropriate solution.

Section 9.0 presents various research papers and journals that have been consulted and evaluated for Industry experiences and established standard practices. This has aided the identification of key factors to be considered when introducing PDMS into (established) management practices. The research of journals has been based on selecting a sample from a time line of 1999 till 2008, associated with Automotive, Aerospace and Engineering sectors. Implementation processes that aid a smooth transition into an organisation are also discussed, in order to ascertain the optimum method to launch and educate the new PDMS users. Business strategies and structures for use of PDMS are also analysed, providing pointers to ways in which a PDMS could be adapted and utilised most efficiently; in line with the expansion and development of the project.

Using benchmark examples of PDMS from the Aerospace and Automotive Industry, Section 10.0 draws comparisons between the organisational structures and identifies why the Formula Student Team is a unique concept. Discussions on common problems are highlighted, evaluating the interplay between personal management structures and the data management systems. Analysis of the past Formula Student Team structures compared to those used in Industry is also discussed, to enable conclusions on how PDMS can be best adapted. The analysis particularly focuses on the team hierarchy and the lessons that can be learned from past attempts, limiting the problematic areas and improving the team organisation and working environment.

Another key area that is vital to the success of the Formula Student Team is leadership and teamwork. Section 11.0 discusses the aspects that are required to build and lead a successful team. An in-depth review is presented on how the initial teamworking dynamic is shaped during the course of the first academic term. The psychological and motivational aspect is a wide and varied subject, but particular focus is given to the skill sets required to develop and nurture the team. (Both from the role as an undergraduate team member and postgraduate team manager; drawing from the point of view for each role from the author's experiences). This section also evaluates the leadership and management styles that could be used to help develop the team going forward.

The data management handling practices are discussed in Section 12.0, providing an in-depth overview of the continual common problems experienced with the SolidWorks data, and establishing the data management requirements to be addressed. Presenting the functionality of PDMS with the requirements and benefits the PDMS will offer, in terms of configuration management, design specification and product life cycle, enables the identification of the KSFs required to evaluate PDMS.

From the theoretical knowledge and practical experiences learnt during the previous chapters, Section 13.0 summarises the identified KSFs associated with evaluating a proposed solution to implement PDMS into Aston University for the Formula Student Team. Specific requirements are identified for the Formula Student Team, providing the necessary tools and capability that is most suitable for the management of the team, in terms of aiding supervisors to assess the progress of the team, as well as assisting with the development and component life-cycle of the car.

In Section 14.0 a proposed solution is deliberated. This takes into consideration the products currently available on the market and how these can be tailored and utilised effectively to suit the team. With all these factors taken into account, the final proposal for introducing PDMS is presented.

The final section (15.0) of Chapter 2, presents the conclusions and recommendations from the knowledge gained from the research. It evaluates why some problems have occurred, what the solutions are and the best practices to be adopted to manage the PDMS by the Formula Student Team. From the knowledge learnt from the research of Journals, hypothetical predictions are discussed on how PDMS could potentially evolve over the next few years.

Chapter 3

The third Chapter of this thesis looks at the application of the research knowledge, from Chapter 2, that is recommended to implement a PDMS successfully within the Formula Student Team. The assessment of the KSFs identified is split into 4 phases.

Section 16.0 explores the hardware and software requirements for PDMS installation. This leads into the project plan, detailing the execution of the required tasks in order to launch the PDMS, in readiness for the 2007 - 2008 academic year. The tasks include server installation, software setup, initial testing and finally PDMS tutorial guidelines and workshops.

Section 17.0 presents Phase 1 of chapter 3. It discusses the PDMS software installation, setup and initial testing within Aston University School of Engineering designated computer labs and highlights the problems encountered and the lessons learned to overcome these issues. A description of the breakdown of how the PDMS Vault functions, the user interaction between the CAD software package and the designated administrators and users are discussed.

In Section 18.0 Phase 2 evaluates the proposed PDMS solution detailed in Section 14.0 in light of the identified KSFs to establish the suitability of the PDMS for the revised organisational structure. The proposed organisational management structure to control PDMS for the Formula Student Team is detailed and tested, formulating the most suitable solution for the new team.

The observations made during the PDMS implementation throughout the initial testing, Phase 3 (Section 19.0) establish the framework to detail the guidelines and tutorials, including the improvements which will be required to efficiently launch the PDMS software for the Formula Student Team.

The final phase, detailed in Section 20.0, presents the pilot scheme developed to assess the PDMS software, which illustrates the initial performance evaluation and testing from the current Formula Student Computer Aid Design (CAD) model files.

The concluding part of Chapter 3, Section 21.0, summarises the observations and conclusions made during the installation, setup and testing of PDMS and recommends solutions to potential risks, in order to mitigate the impact of using the software by the new team.

Chapter 4

The final Chapter thoroughly discusses the approach taken to meet the aims and objectives of this thesis. The conclusions made are discussed and reviewed, providing recommendations and improvements to the PDMS management organisation by the Formula Student Team and how further benefits can be harnessed in line with the expected future growth of the project within Aston University. From the research presented in Chapter 2, hypothetical predication are contemplated on how PDM will evolve and be developed within Industry, concurrent with improvements in global access and computer devices.

2.0 Introduction

Since 2001, the Formula Student project has evolved exponentially and is now at the forefront in leading team engineering challenges available to undergraduate students.

*'Formula Student is about building future engineering talent by designing and producing a single-seater racing car, not just in design and manufacture, but in many of the management, marketing and people skills so vital in the modern world, across all sectors of employment'*²

The increasing status of the Formula Student project within Aston University has presented various challenges, particularly with the evolving working environment and practices for the team in order to enable Aston Formula Student Team to compete more effectively year upon year.

One of the main problems that has been consistently highlighted as an area to be addressed and developed, is the ability to organise and manage the team's data for the 3D CAD design software package SolidWorks 2007.

This became a critical factor in the management of the project, because the data management of the designs had proven so problematic, that it was observed to hinder the progress and ultimately the success of the team. Previous attempts had been made to rectify the growing problem, but were proven to be ineffective due to lack of teamwork and limited knowledge of a potential solution.

The implementation of a Project Data Management System was considered essential in order to provide the foundations of establishing a successful working team.

² Institution of Mechanical Engineers - Formula Student Definition www.formulastudent.com

2.1 Aims

The aims of this thesis are:

- To understand and analyse the team practices (2001 – 2007) and working environment when designing a Formula Student car.
- To establish the leadership tools and organisational changes required to utilise the full benefit of implementing a PDM system for the Formula Student Team.
- To apply the theoretical and practical knowledge gained from the Industry research into PDM software, in order to provide a fully working system capable of servicing the requirements of the team, in an effective and maintainable way.

2.2 Objectives

The objectives of this thesis will cover the following:

- Understand the Formula Student Team roles and responsibilities and leadership requirements.
- Evaluate the previous attempt in implementing PDM at Aston University and understand the root cause of the limited success.
- Setup and install a Project Data Management System for the Formula Student Team at Aston University.
- Establish and provide a tutorial on how to use the software for the Administrators and Users, specific to the Formula Student Team.
- Test and prove a working design assembly of a Formula Student car within the PDM system.
- Launch the PDM system ready for the start of the next academic year.
- Propose developments for the PDM system in order to enable other student teams within the university to use the program effectively.
- From the research, identify future potential development for PDM systems.

Chapter 1 – Aston University Formula Student History

3.0 Formula Student Concept

The Formula Student competition is organised by the Institution of Mechanical Engineers (IMechE), who encompasses a global participation. This has become a high profile event and respected within Industry worldwide. The competition has been held in the United Kingdom since 1998 and has seen a consistent rise in the number of competitors entering.

The concept of the competition is for a manufacturing company to engage a team of engineering students, who are studying at recognised educational institutes, to design and produce a prototype racing car for evaluation. The sales brief stipulates that the intended market is the non-professional weekend autocross or sprint racer. Therefore, the car must have very high performance in terms of acceleration, braking, and handling qualities. The car must be low in cost, easy to maintain, and reliable. In addition, the car's marketability should be enhanced by other factors such as aesthetics, comfort and use of common parts. The design and build of the prototype racing car is controlled by a strict set of rules provided by The Society of Automotive Engineers (SAE). This car would then compete against other cars from different universities worldwide.



Figure 1: Aston University Formula Student Team 2006 Car Launch

The team is assessed on the vehicle design, the business presentation case, the short production run of the design, and the costing analysis. Within this framework, the car is not only judged on the race performance, but also on a static design assessment and dynamic events.

The performance event includes the following tests:

- Straight-line speed/acceleration
- Handling
- High performance endurance event, testing reliability and economy

The competition rules limit the performance of the engine and chassis, in order to encourage ingenuity and resourcefulness. (An understanding of the performance implications of light-weight racing is essential for success.) For the team to be successful an appreciation of lightweight racing needs to be considered, with the understanding of the effects this has on car performance characteristics; cornering and acceleration are a prime example of this.

The brief specifies that the car must be capable of being manufactured by a small company, delivering up to 1000 units per year. To meet the criteria, the design needs to be as simple as possible, using the most cost effective production methods available. This forms a key part of the assessment, not only for the submission of the cost report, but also because there is a prize for the lowest priced manufactured car.

The Assessment marking criteria can be found in Appendix A, 2008 FSAE rules, Pages 116-118.

4.0 Development of Formula Student at Aston University

Aston University School of Engineering and Applied Science began participating in the Formula Student competition in 2001. Over the years this has seen significant growth in participation from students, as well as in support from faculty staff.

Since 2001 the initial team (setup) has been formed by a group of 8 final year undergraduate students from courses within the School of Engineering and Applied Science. The project has been headed by a single faculty supervisor and supported by technical staff. The students have been responsible for various aspects of the production of the racing car, both design and manufacture, which also formed the basis of their final year project. The team has been created in October, the beginning of the university academic year and has worked together until July when the competition is held.

Each year has seen a design and manufacture evolution compared to previous years. This advancement has been in parallel with the rising profile of the project within the university, attracting more secure funding from both the University and external sponsorship.

The remarkable progress or improvement in the design of the cars can be seen from comparing the first entry in 2001 to the 2007 entry considered in this thesis, as pictured in Figure 2 and Figure 3.



Figure 2: Car AM01 2001 Entry

Some of the design technical components of the **AM01** (Aston Motorsports 01) entry consisted of the following:

- Honda CBR 600cc Motorbike Engine
- Tubular Space Frame
- Klicktronic Manual Gear Box
- 55Bhp
- Glass fibre body Shell [to follow style of above: Glass Fibre Body Shell]

The **AM07** car entry is shown below.



Figure 3: Car AM07 2007 Entry

Some of the technical components for the **AM07** are as follows:

- Smart Car 600cc Turbocharged Engine
- Composite front Monocoque, Carbon Fibre & Space frame hybrid rear chassis
- Continuously Variable Transmission (CVT) Gearbox
- Epicyclic gear ratio reduction system
- 55 Bhp

- Features and Mounting Points integrated into the chassis

The comparison between these two cars highlights the continual development over the years that has been achieved through the use of new materials, in particular the advancement of composite technologies and manufacturing processes.

The growth of the project provided further challenges to adapting the team structure of one year to the following year, detailed in Figure 12, in order to harness the extensive benefits available to the project. Consideration was needed to effectively utilise and manage the financial investment in the university facilities, the amount of resource allocated to the Formula Student Team and the extra funding that the project was attracting from external sponsors.

4.1 CarAM04

The appointment of a postgraduate student as Team Manager in the academic year 2003/2004 (Car AM04) was the first real (or significant) organisational change. The reasoning behind this decision was to divide and share the role of the faculty advisor whilst also redistributing some of the responsibilities.

The skill set identified and key considerations for this role led to the decision to appoint a postgraduate with previous experience; either within Formula Student Competition or in managing similar engineering projects. The preference and therefore the outcome was to offer the position to a member of the previous year's undergraduate team.

There were several advantages this presented:

- Provided a transition period from one team to the next
- Maintained the knowledge and expertise for the Aston University
- Shared the work load of the faculty supervisor
- Provided the ability to fully implement lessons learned more effectively
- Provided a dedicated fulltime contact for undergraduate team members
- Continued to build on relationships with faculty staff and Industry sponsors
- Improved communication, direction and advice for team members, from all supporting University staff

The disadvantages that needed to be addressed were:

- The amount of authority and influence on the undergraduates final year project mark.
- With the postgraduate studying for Master Degree, there would be potential motivation aspects and clashes with the project demands
- No cultural changes: bad practices from the previous years could be continued
- No real measure of the potential work load with the increased university staff:- this could impact the studies of postgraduate Masters Degree

With the increased numbers of final year students from different engineering courses within the team, this necessitated more faculty staff support to supervise the student's projects.

The benefits that this new role provided to the team, greatly out-weighed the potential disadvantages, which would be addressed in due process. A dedicated postgraduate Team Manager without doubt set a new precedent on how the Formula Student Project could be developed and run for future years.

A breakdown of the revised roles and responsibilities is detailed in Figure 4 below.

Position	Role	Responsibilities Include
Faculty Manager	Permanent University Member of Staff – Lecturer & Overall Management of FS Project	University contact for all aspects of Formula Student. Budget control. Project and technical guidance. University faculty staff co-ordination. Logistics, accommodation and travel for the team.
Faculty Project Supervisors	Permanent University Member of Staff – Department Lecturer	Supervise and provide direction on project work to undergraduate team members
Faculty Technical Staff	Permanent University Member of Staff – Technical	Support the manufacture and production aspects of the car, in particular the operation and instruction of machinery within the university facility.
Team Manager	Postgraduate Student - Co-ordination and Management of	IMechE team co-ordination, Rules and Regulations adherence. Ensure all deadlines are met for reports and paperwork. Manage the build and testing of the car. Provide assistance and direction where necessary. Improve

	Formula Student	publicity and sponsorship exposure for the team.
Team Member	Undergraduate Student – Final Year Project Tasking	Complete final year project aims and objectives for formula student team Team player in assisting the manufacture, build and testing of the car.

Figure 4: Roles & Responsibilities for Academic Year 2004-2005

The revised and improved hierachal structure, and lines of communication that had been formed for AM04 team, is shown below in Figure 5.

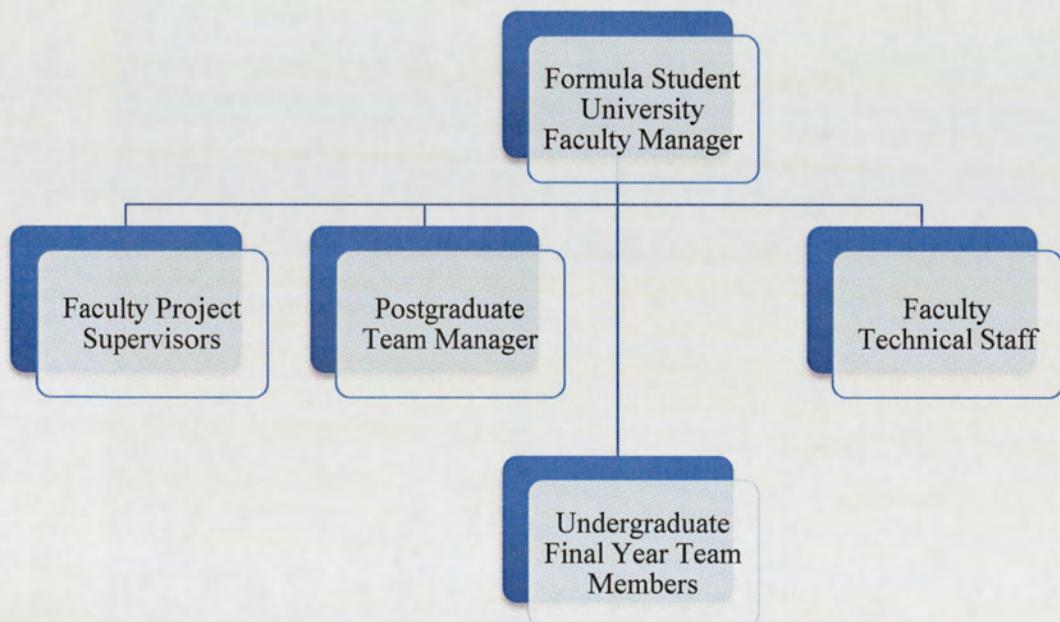


Figure 5: AM04 Team Hierarchy and Structure

In essence, the Faculty Project Supervisor acts as an independent advisory role to the Faculty Manager, providing guidance and direction to the undergraduate students throughout the academic year. The lines of communication are such that the undergraduate students can approach either the Project Supervisors, Team Manager, Faculty Manager or support staff for help in various aspects of their work. There is no mandatory requirement to directly report to the postgraduate Team Manager.

The **AM04** car that was produced by the team is shown in Figure 6.



Figure 6: AM04 Car Entry

Technical Components:

- Honda CBR 600cc Motorbike Engine
- Tubular Steel Space Frame
- 67 BHP
- Continually Variable Transmission (CVT)
- Carbon Fibre Non Structural Body Work

4.2 Car AM05

The success that the new project organisation brought to the AM04 team was continued into the 2004 - 2005 academic year. AM05 had an opportunity to capitalise on the increasing exposure within the University, coupled with the substantial funding and departmental resource, which was now available for the projects disposal. These increased benefits available to the AM05 team, provided the justification to support an expansion of the organisation hierarchy, by creating additional roles for more postgraduate students.

From the networking and project publicity within Aston University, the Business School created an opportunity to provide a postgraduate student to observe and evaluate how the leadership and programme management could be improved for the project. The aim was for the student to assist the Team Manager with the increasing responsibilities and workload. However, the main priority was to deliver the project plan and help with ensuring important milestones were met. The student would also research and suggest a strategy for how the project organisation structure could be evolved for future teams. Figure 7 below details the revised roles and responsibilities for the AM05 team.

Position	Role	Responsibilities Include
Faculty Manager	Permanent University Member of Staff – Lecturer & Overall Management of FS Project	University primary contact for all aspects of Formula Student. Budget control. Project and technical guidance. University faculty staff co-ordination. Logistics, accommodation and travel for the team.
Faculty Project Supervisors	Permanent University Member of Staff – Department Lecturer	Supervise and provide direction on project work to undergraduate team members
Faculty Technical Staff	Permanent University Member of Staff – Technical	Support the manufacture and production aspects of the car, in particular the operation and instruction of machinery within the university facility.
Project Advisor	Postgraduate Student – Project planning	Produce and deliver project plan. Identifying important milestones and assist project manager where possible. Produce business case strategy for developing the team.
Team Manager	Postgraduate Student - Co-ordination and Management of Formula Student	IMechE team co-ordination, rules and Regulations adherence. Ensure all deadlines are met for reports and paperwork. Manage the build and testing of the car. Provide assistance and direction where necessary. Improve publicity and sponsorship exposure for the team.

Team Member	Undergraduate Student – Final Year Project Tasking	Complete final year project aims and objectives for the formula student team. Team player in assisting the manufacture, build and testing of the car.
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Figure 7: Roles and Responsibilities for Academic Year 2004-2005

The lines of communication were maintained from the previous year's AM04 team, but with the benefit of the project postgraduate student working alongside the Team Manager and assisting on the project planning and milestone setting. The project postgraduate student role was to act as an independent advisor, with no direct authority over the project decisions; either technical or design.

The benefit that this approach brought to the team was to allow the project plan to have substantial detail behind the tasks required, with the primary aim to drive for an earlier manufacturing completion date. This would provide sufficient time to allow developmental testing to be performed, and time for improvements to be identified and incorporated into the car before the competition began.



Figure 8: AM05 Car Entry and Team Members

Technical Components:

- Honda CBR 600 cc Motorbike Engine
- Carbon fibre Monocoque chassis
- Continually Variable Transmission (CVT)
- 69 Bhp
- Features and Mountings integrated into the chassis

4.3 Car AM06

The continued success that Aston University Formula Student Team was building upon each year was further demonstrated by the AM05 team competition results. An in-depth review was held to capitalise on the gains made and further integrate the lessons learned, together with the proposed recommendations from the Business School.

An improvement suggested by the Business School was to create an additional Team Managers role, splitting the responsibilities between the two. The 2005 - 2006 academic year provided another increase in funding and resources allocated to the Formula Student project. A decision was taken to appoint two postgraduate students to oversee the AM06 team.

The rationale to support the change in the organisational structure was firstly to meet the growing demand of undergraduate students participating in the team, and secondly, to build on the potential sponsorship, marketing and publicity the project gave the University.

The Business School also ensured that the postgraduate student role of assisting the project management role was maintained, with further responsibilities added for controlling the Business Plan and Presentation required for the competition. The hierarchy and structure had again evolved, as shown in Figure 9.

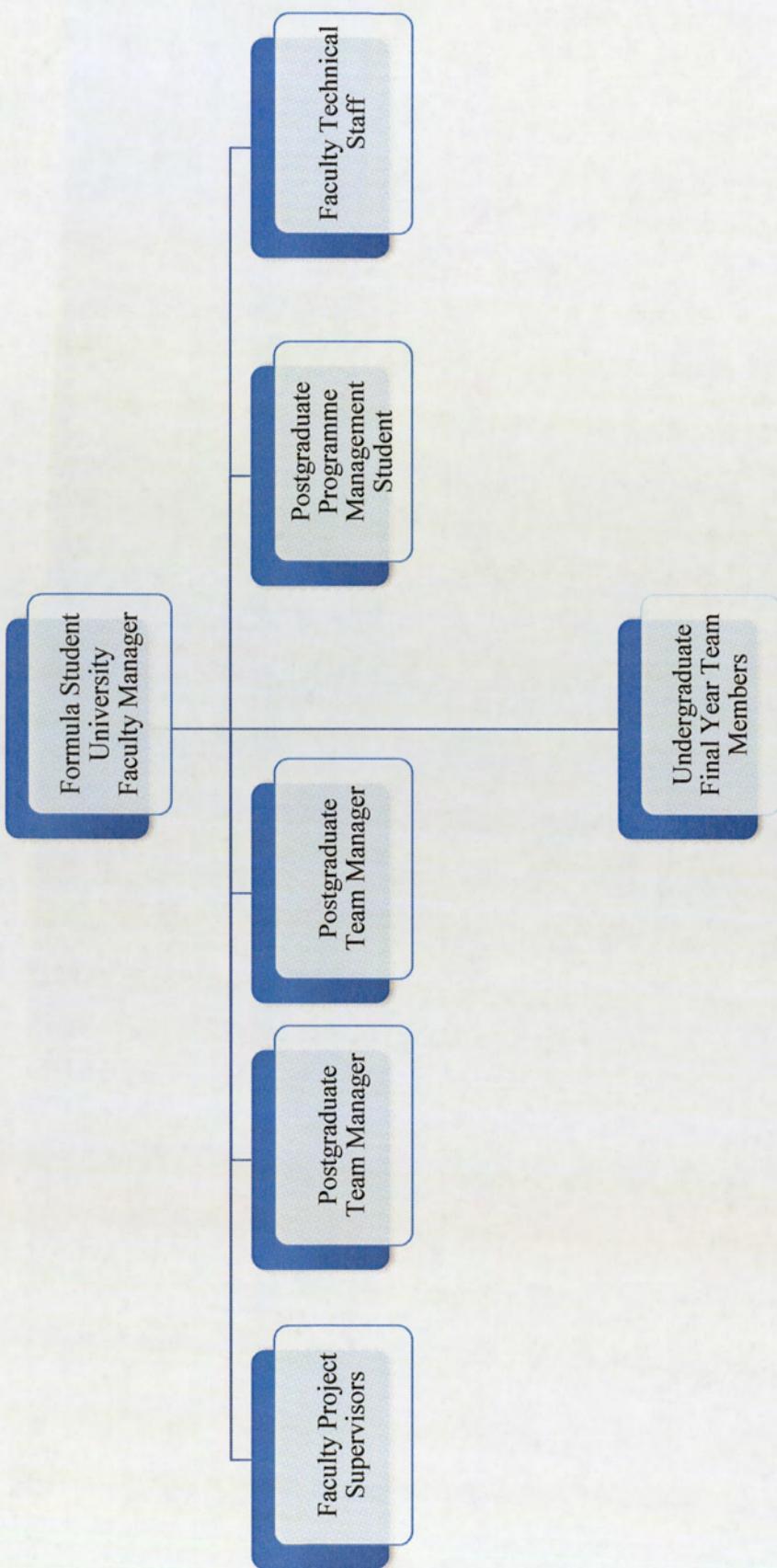


Figure 9: AM06 Formula Student Team Structure

The AM06 team consisted of 12 undergraduate final year students, increased faculty support staff and postgraduate students. The breakdown of roles and responsibilities for project team is detailed in Figure 10 below.

Position	Role	Responsibilities Include
Faculty Manager	Permanent University Member of Staff – Lecturer & Overall Management of FS Project	University contact for all aspects of Formula Student. Technical guidance. University faculty staff co-ordination. Logistics, accommodation and travel for the team.
Faculty Project Supervisors	Permanent University Member of Staff – Department Lecturer	Supervise and provide direction on project work to undergraduate team members
Faculty Technical Staff	Permanent University Member of Staff – Technical	Support the manufacture and production aspects of the car, in particular the operation and instruction of machinery within the university facility.
Project Advisor	Postgraduate Student – Project planning	Produce and deliver project plan. Identifying important milestones and assist project manager where possible. Produce business case strategy for developing the team.
Team Manager	Postgraduate Student - Co-ordination and Management of Formula Student	Ensure all deadlines are met for reports and paperwork. Improve publicity and sponsorship exposure for the team. Manage the build and testing of the car. Budget control.
Team Manager	Postgraduate Student - Co-ordination and Management of Formula Student	IMechE team co-ordination, rules and Regulations adherence. Manage the build and testing of the car. Provide technical assistance and direction where necessary.
Team Member	Undergraduate Student – Final Year Project	Complete final year project aims and objectives for formula student team. Team player in assisting the manufacture,

	Tasking	build and testing of the car.
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Figure 10: Roles and Responsibilities for Academic Year 2005-2006

The project lines of communication remained the same as the previous AM06 team, however, the two Team Managers would work together in matters of design and technical decisions. Guidance from the Faculty Manager and input from the Project Supervisors were provided when needed.

The scope of the postgraduate programme student role was to devise the project plan and important milestones, working alongside the team managers throughout the academic year. The aims and objectives for the role were maintained, the focus being on delivering a manufactured car in sufficient time to test and allow improvements.

The benefits brought to the project by the increase in postgraduate numbers were as follows:

- Shared responsibility and increased team effort to meet the project deadlines
- Project schedule is owned by dedicated resource, benefiting undergraduate students in preparing a schedule for their final year project plan
- Team Managers enabled to focus on technical development of the car
- Further support provided to the undergraduate team



Figure 11: AM06 Car Entry and Team Members

Car Technical Components:

- Smart Car 600 cc Engine
- Full Composite Chassis
- Continually Variable Transmission (CVT) Gearbox
- 50 Bhp
- Integrated Mounting and Fix Points into the Chassis

4.4 Car AM07

In appointing two postgraduate Team Managers for the AM06 team, along with the support for the project planning, the success and performance was demonstrated by delivering a manufactured car with sufficient time to perform test work before participating in the competition – a major break through, compared to the previous years. This achievement allowed time for modifications and improvements to be incorporated, ultimately optimising the performance of the car during the competition. This was a major milestone that each car entry had strived to achieve over the previous years.

The 2007 - 2008 academic year continued with the same overall project hierarchy structure as AM06 and there were no major changes to the distribution of responsibilities. However, from the previous year's recommendations and observations, a realignment of the postgraduate project students' role was made. The postgraduate Project Planners role would be directly supervised and aided by the appointment of a dedicated member of the engineering faculty staff, to bring further advice and skills into the management structure.

The benefits that this brought to the team, allowed the Team Managers to focus more on the creativity and technical development of the design of the AM07 car, which is shown in Figure 3.

The revised organisational structure for the AM07 team is outlined in Figure 12. The lines of communication for the undergraduate students would continue to be the same in previous years.

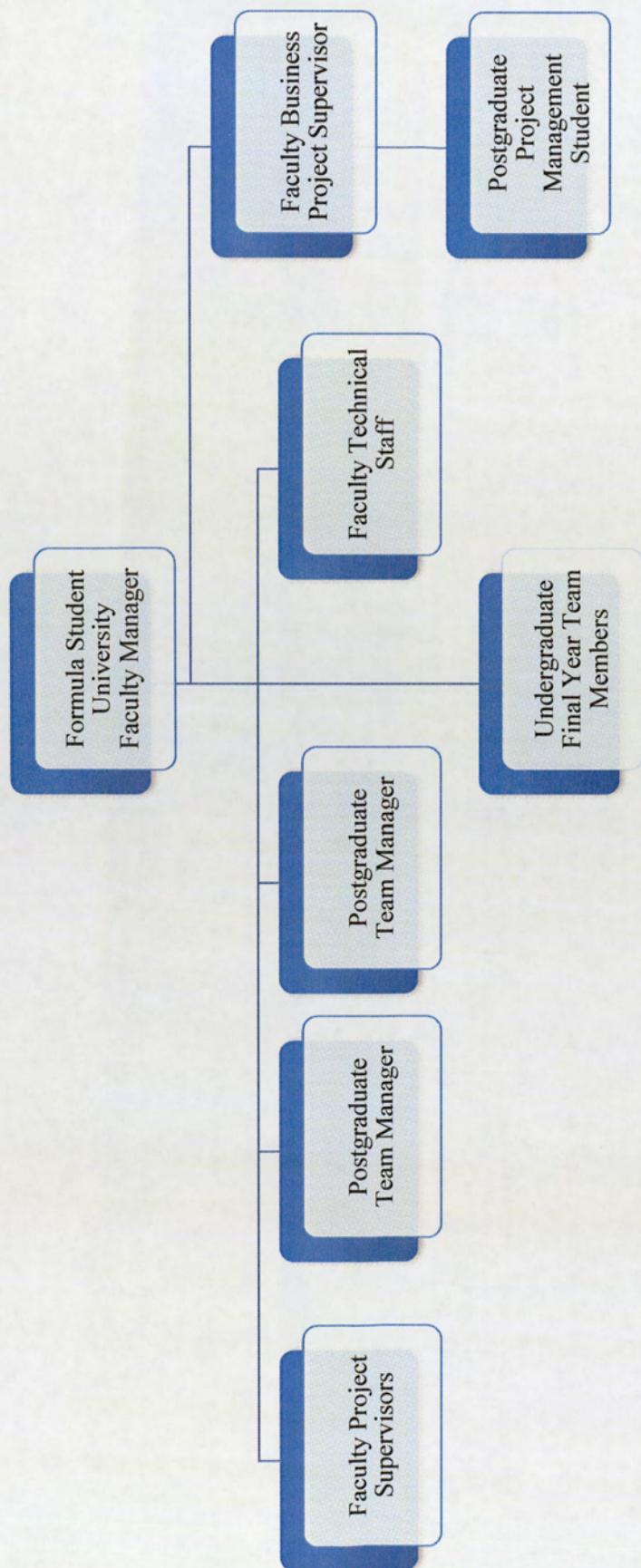


Figure 12: AM07 Formula Student Team Structure

4.5 Car AM08

The academic year of 2008 - 2009 saw the largest resource and funding allocation since the first car entry of AM01. The breakdown of increased resource involved was as follows:

- 12 University Faculty Staff and Technicians
- 5 Postgraduate students
- 10 Final year undergraduate students
- 4 Honorary Members

From the recommendations of the previous AM07 team, further projects were created for postgraduate students. The benefits this approach brought to the team were:

- Dedicated projects to deal with the Business plan and Marketing
- Refined technical and engineering focus for the Team Managers
- Continued development of relationships between faculty staff and Industry sponsors
- Increased support for the undergraduate team members
- Improved communication, direction and advice for team members, from all supporting university staff

The areas that need to be addressed were:

- Establish lines of communication and teamworking to avoid a complete separation between engineering, product design and marketing students
- Minimise the learning curve expected with the co-ordination of a larger team

With the increased numbers and new roles, Figure 13 below outlines the responsibilities across the project.

Position	Role	Responsibilities Include
Faculty Manager	Permanent University Member of Staff – Lecturer & Overall Management of FS	University primary contact for all aspects of Formula Student. Technical guidance. University faculty staff co-ordination. Logistics, accommodation and travel for the team.
Faculty Project	Permanent University	Supervise and provide direction on project work to

Supervisors	Member of Staff – Department Lecturer	undergraduate team members
Faculty Business Project Supervisor	Permanent University Member of Staff – Department Lecturer	Supervise and provide direction to the Business undergraduate student.
Faculty Technical Staff	Permanent University Member of Staff – Technical	Support the manufacture and production aspects of the car, in particular the operation and instruction of machinery within the university facility.
Honorary Member	Technical Specialists and former university staff	Bring technical speciality skills to the project with the development of the manufacturing process. Provide advice and guidance where needed.
Project Advisor	Postgraduate Student – Project planning	Produce and deliver project plan. Identifying important milestones and assist project manager where possible. Produce business case strategy for developing the team.
Team Manager	Postgraduate Student - Co-ordination and Management of Formula Student	Ensure all deadlines are met for reports and paperwork. Improve publicity and sponsorship exposure for the team. Manage the build and testing of the car. Budget control.
Team Manager	Postgraduate Student - Co-ordination and Management of Formula Student	IMechE team co-ordination, Rules and Regulations adherence. Manage the build and testing of the car. Provide technical assistance and direction where necessary.
Team Member	Undergraduate Student – Final Year Project Tasking	Complete final year project aims and objectives for Formula Student Team. Team player in assisting the manufacture, build and testing of the car.

Figure 13: Roles and Responsibilities for Academic Year 2007-2008

The team hierarchy structure is detailed below in Figure 14.

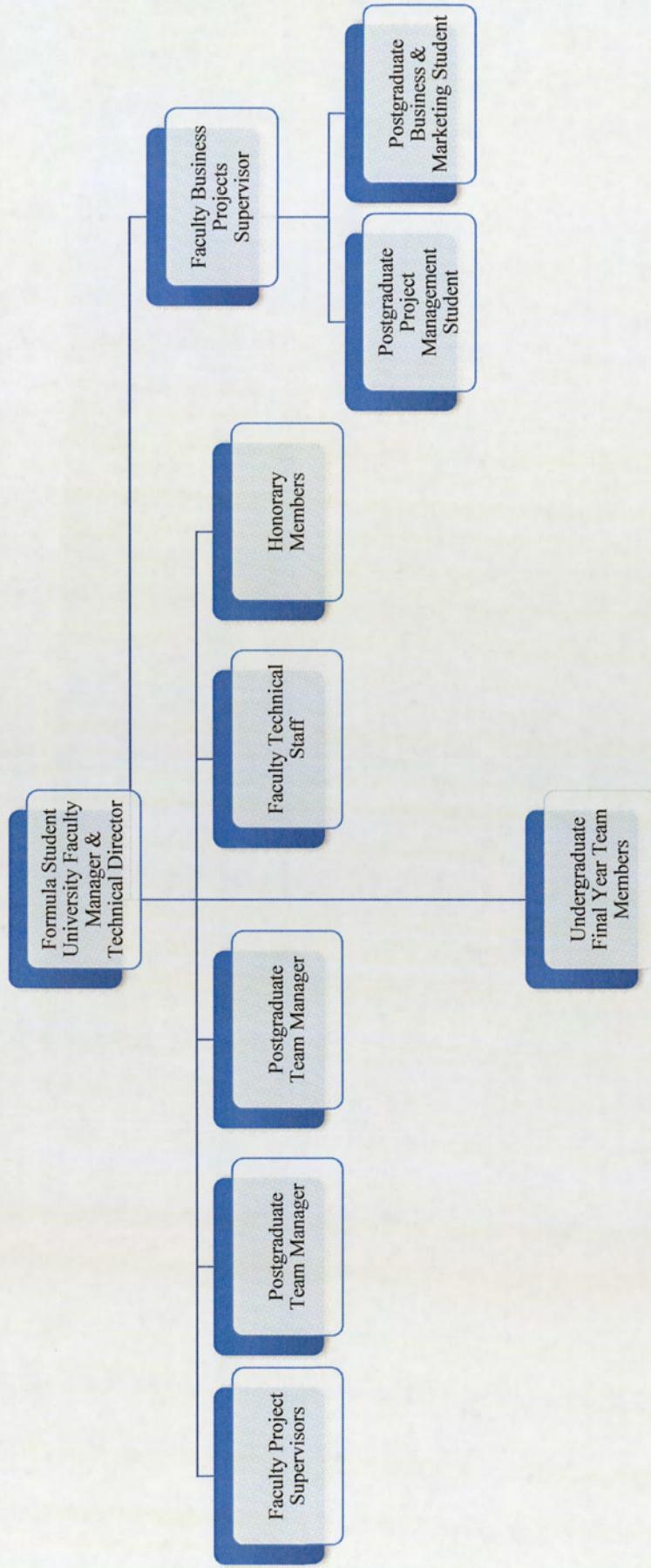


Figure 14: AM08 Formula Student Team Structure

During the initial first weeks of the formation of team AM08, there will be scope for the adjustment and refinement of the responsibilities. The increased university support will undoubtedly benefit the project execution. However, in order to avoid potential problems and conflicts, the following areas should be considered and observed. These are:

- Communication lines between departmental staff and students
- Best use of university facilities
- Technical aims and objectives
- Structure and control of data files
- Introduction of team practices and processes

An ongoing situational analysis, in order to establish the team's strengths, weaknesses, opportunities and threats (SWOT) that affect the organisational performance, should be continually undertaken by the postgraduate management team.³

³ Management Fifth Edition, Richard L Daft, Page 245

5.0 Formula Student Team Facilities

Since the start of the project, AM01, the team has been allocated a separate space within the university engineering laboratories on the Lower Ground Floor. The lab L37A, which was appropriately named 'Formula Student Garage', has been turned into a working environment to enable the manufacture of the car, with the various tools, bespoke car components and equipment that is required.

With the increased funding and resources allocated to the project, a re-organisation of the teamworking environment has been implemented over the years, along with dedicated and revamped storage facilities located on the Lower Ground Floor, to house expanding technical and manufacturing equipment. The general layout provides the team with a small working office area, with university networked computers, facilities to hold team meetings, and sufficient workbench space.

5.1 Introduction of the Modern Design Lab

In 2005 the building work of a new design lab with additional workshops was completed. Space from the old unused laboratories on the Lower Ground Floor was refurbished to give a purpose built facility, now called L77.

The main initiative behind the introduction of the new lab, was the need for space to hold design review meetings for various student projects run within the department, whilst also providing much needed additional workshop space. An influence in the commissioning of the new lab was to help with the design review meetings and aid the composite development work for the Formula Student Team. The new facility provides a 24 hour access computer lab, with an additional capacity of 12 PCs with SolidWorks installed, wood working lab, filtration and extraction room for composite lay-ups, a large general workshop and much need materials storage space.

The benefits seen with the use of this facility by the Formula Student Team have been quite significant, with it now taking over from the Garage as the main assembly area for the car.

6.0 SolidWorks and the Formula Student Team

Over the past five years SolidWorks has evolved to be the essential software design package for the Formula Student Team. The software development and evolution within the School of Engineering is a continual process. There have been various upgrades in the software since its implementation into the university, which have required adjustment with learning new techniques and functions. At the time of writing the latest issued standard installed in the university is SolidWorks Education Edition 2007.

SolidWorks is the main Computer Aided Design (CAD) package that is used in the School of Engineering and Applied Science. Undergraduate students throughout their degree course have timetabled lectured study in using the software, with assessments in competency at the end of each module. The benefits of the SolidWorks package are that it integrates with the various Computer Aided Manufacturing machines in the department, particularly CNC machining. This has provided many advantages in designing various car components, in respect to being able to produce parts “in house” automatically, whilst being cost effective to the project.

By the time students have reached their final year, their skill set would have developed and reached a certain standard of competency from the assessed CAD modules. As with any new team, there are various levels of abilities, but with the increasing reliance over the years on the software package, the Formula Student Team have had to secure additional tutorials and help from various areas in the engineering department.

6.1 Software Package Overview

“A powerful 3D design solution for rapid creation of parts, assemblies and 2D drawings with minimal training.”⁴

Building a model in SolidWorks usually starts with either a 2D or 3D sketch. The sketch consists of geometry such as lines, arcs, conics and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, concentricity and etc. The parametric nature of SolidWorks means the dimensions and relations drive the geometry, not the other way round. The dimensions in the sketch can be controlled

⁴ SolidWorks Product Information. www.solidworks.com

independently, or by relationships to other parameters outside the sketch. For example, one can sketch a rectangle and dimension its height and width. Then you can extrude the rectangle to create a rectangular prism. One can then relate the length of the extrusion to the height of the rectangle so that if the extrusion gets longer, the height changes accordingly. Furthermore, one can subsequently add a hole in the face of the prism and create another relationship so that the diameter of the hole, which was created after the prism, drives the width of the prism. This way, if the hole has to grow larger, the prism's dimensions would also increase to accommodate it.

Additional features that are integrated within the software package are COSMOSworks, eDrawings, COSMOS flow works, to name a few. COSMOSworks provides Finite Element Analysis (FEA) on models and assemblies. The benefit of using this integrated feature is that quick and easy analysis can be completed for a set of constraints and applied loads. This allows constant modification and retesting within a very short space of time. There are other software packages such as ANSYS available for FEA, but this requires design models to be built within them, thereby increasing the time to achieve an analysis. Therefore COSMOSworks is more appropriate in completing design iteration tasks quickly and accurately.

All SolidWorks components and assemblies that are created by individual team members are saved within the students allocated network space.

6.2 SolidWorks Licensing and Computer Labs

The licence agreement with Aston University and SolidWorks comprise 150 user seats, thus limiting the number of users at any point in time within the School of Engineering. The ratio of seats to students however is becoming even more imbalanced with the increased number of undergraduates within the department.

The SolidWorks software package is installed as an 'Image' on a limited number of computer labs within the university. The software in turn is held on the main university server allowing the licence control facility. When a student who has SolidWorks user rights, logs in and activates the software, this in turn reduces the number of seats available to use SolidWorks through the server. It isn't until the students SolidWorks session is complete and the program is closed, that the seat becomes available again.

The number of computer labs that are able to provide a project group of this size with the ability to hold design reviews and meetings is quite limited. Timetable clashes and general everyday university student use limits the amount of time and computers that can be available to the team.

7.0 Project Data Management

The planning, designing, and manufacturing of an engineering project creates large amounts of data; CAD models, drawings, design specifications, stress reports, manufacturing drawings and test plans.

Product Data Management (PDM) is an information management system that provides an infrastructure to manage all Product related data that is produced. The types of data managed include parts, assemblies, and change history for all of these objects; providing the function of complete traceability for the project for auditable approval.

7.1 Previous Attempt to Implement Project Data Management

During the **AM05** project, the postgraduate Team Manager attempted to install and trial run the PDMWorks software package. This is as an additional install optional within SolidWorks 2005 software. The PDM Vault was installed and run from the dedicated Formula Student server hard drive named 'Frank'. The project was created within the PDMWorks vault to house the AM05 car assembly and various components. Initial tests established that the PDM system worked correctly. However, due to the vault being located on the main Formula Student hard drive, combined with the frequent and general everyday usage, this caused the hard drive to breakdown and become corrupt. The university ICT department relocated the Formula Student project to a new dedicated server. An attempt was made to recover the data from the Vault, with most of the documents and files being restored and saved onto the new server. No further attempt was made to setup PDMWorks software again.

Investigating the root cause on why the PDMWorks software caused the hard drive to become corrupt, it was found that the installation and hardware requirements to run the PDMWorks 2005 Vault were not to the required manufactures recommendations. The key element that contributed to the fault was insufficient RAM memory for the server when the Vault was being used, particularly when other documents saved on the Frank drive were continually being accessed when the Vault was running. It was recommended that the PDMWorks Vault be housed on a separate dedicated server.

8.0 Formula Student Team Lessons Learnt

Being able to present the historical perspective on management is important, as this gives consultants and company executives a way of thinking, a way of searching for patterns and understanding trends. An historical perspective provides a context or environment in which to interpret current problems.⁵

Based on the Formula Student Team organisational changes from AM01 - AM08, common themes have been observed and identified. The key areas that need to be considered and researched further are:

- Project Chain of Command and Conflict Resolution on Car Design Changes between Undergraduates, Team Managers and Project Supervisors
- Lines of Communication and Team Formation
- Supervisor Assessment on Student's Work and Performance
- Team Data Handling and Access Practices
- Team Leadership and Motivational Issues
- Organisational Structure

8.1 Project Chain of Command & Conflict Resolution

The chain of command within the organisational structure can become distorted and potential conflict can arise between the Team Managers and University Project Supervisors. A primary example of this would be a technical design change on the car, which would potentially impact the students' original final year project brief, resulting in negotiations between all parties. This was particularly evident during the AM04 to AM06 academic years with the introduction of more postgraduate students within the team. Clarification at the immediate start of the project on the responsibilities and authority to be able to make significant changes to individual's project scope would avoid confusion and time lost during the important design stages.

⁵ Management Fifth Addition, Richard L Draft, Page 38

8.2 Lines of Communication and Team Formation

Formal lines of communication, channels that flow within the chain of command or task responsibility defined by the organisation⁶ need to be established early within the project standard practices. This is critical to team formation and progression through the “five stages of development”, Forming, Storming, Norming, Performing and Adjourning⁷. A process that each new Formula Student Team goes through during the course of the academic year. The project is a learning organisation, where everyone within the team is engaged in identifying and solving problems, enabling the team to continually experiment, improve, and increase capability⁸. This is important in order to help the team hierarchy adapt and evolve to new ideas and technology advancements available to the Formula Student Team.

8.3 Supervisors Assessment and Formula Student Rules Distribution

Another problem that was originally highlighted during the AM04 academic year, and has subsequently remained an issue for the AM05 - AM07 teams, is the ability to distribute the applicable Formula Student rules to each of the individual projects, in order for examiners to independently assess student performance and work. There have been several instances recorded during the AM04 - AM07 years, where specific rules and regulations that are applicable to certain areas of the car design, have either been overlooked or incorrectly distributed. This has lead to misinterpretation of the design specification requirements and understanding of who is responsible for delivering and meeting these needs, whilst also impacting the project schedule. The increased incidents seen from this problem can be associated with the evolving and more technically complex rules and regulations issued each year, and with no formal process established to track and trace the applicable rules the priority for this issue to be addressed has increased.

The ease with which supervisors can continually assess the students’ design progress and performance, particularly identifying the latest work to provide any feedback, is an area to address. The access to the students’ design files within the Formula Student hard drive (‘Frank’) was continually problematic.

⁶ Management Fifth Addition, Richard L Draft, Page 575

⁷ Management Fifth Addition, Richard L Draft, Page 609

⁸ Management Fifth Addition, Richard L Draft, Page 40

8.4 Team Data Handling and Access Practices

Throughout the AM04 - AM07 academic years the team data handling and access practices is a vital area to be resolved. The ability to share and assess the latest design models is crucial to an efficient and effective car design phase. The common issues highlighted were:

- The latest version of data files being used is confusing and not known
- Consistent access to the data files on the network from university computers
- Conflict with saving latest files on the server
- Frequent SolidWorks software crashes when altering design files across the network
- Continual reiteration of car assembly models due to file saving issues

The guidelines issued to the project team on accessing and saving car assembly drawings were continually improved throughout the duration of the academic year. These necessary changes led to confusion on which access practice is being used at any one particular time, resulting in files and time lost on the project.

The out-of-hours access to university facilities during the project had caused additional problems with SolidWorks data storage. The control of the Car Assembly model file presented problems with individual access, with respect to being unable to identify which user is currently working on the latest version, resulting in valuable time lost; a common problem encountered during the AM04 to AM07 academic years.

The basic elements of management information systems, particularly data access and storage practices needed to be considered when identifying the key deliverables for implementing a PDM system. This is a critical process in order to aid the expansion and development of the Formula Student Team.

8.5 Team Leadership and Motivation

The step change seen from the AM04 academic year onwards in the management hierarchy, introduced postgraduate students into a leadership and management role. The postgraduate team leadership style is primarily based on the student's previous experiences and is a continually steep learning curve. The gradient of this learning curve could be significantly reduced if their skill set could be developed before

the formation of the team. Distinguishing the difference between leadership and management is an important lesson, particularly when dealing with the challenges that the project offers throughout the year. It is vital to the success of the team that the key traits and style of leadership are appropriate to the Formula Student Project.

The team motivational aspect is something to be continually addressed throughout the year. The concept of Motivation – the arousal, direction, and persistence of behaviour⁹ is a key area in order for the team to succeed in delivering a car to the proposed plan and overcoming obstacles during the course of the year. There are various motivational attributes within the Formula Student Project that can be related to McGregor's motivational Theories of X and Y¹⁰, which describes an approach to work in general, where motivational traits and assumptions of adopting a working environment can be distributed into X or Y categories. The understanding of this theory could help lead to developing more effective and efficient team members.

With the unique situation of the Formula Student Team being composed of unpaid students, and the variety of these students joining from different university courses, it is essential to maintain an objective goal for the team. A common problem that occurs during every academic year is the ability to maintain interest and enthusiasm from team members during the difficult design decisions. The project motivational factors are an area to be further explored, to aid a commitment and a balanced goal setting approach to meet the project aims and objectives. The Formula Student Project is a time consuming effort, with the students constantly having to balance university course commitments, Formulas Student deadlines and social interests and activities.

8.6 Organisational Structure

Selecting an appropriate organisational structure that is relevant and commonly found within engineering teams in Industry, particularly in comparison within the Automotive Industry, needs to be evaluated and further researched. This will establish whether the adopted Vertical Functional approach, used from AM01 - AM08, is the most suitable organisational structure. Alternatively, if a Horizontal Matrix can be

⁹ Management, Fifth Addition, Richard L Draft, Page 534

¹⁰ Juran's Quality Control Handbook, Fourth Addition, J.M.Juran, Page 10.5

adopted because there is more than one factor around which a structure can be built¹¹. A Horizontal Matrix is a combination of structures and often takes into account both geographical and product divisions. This could be implemented to improve the decision making process and harness the resource benefits that are available to the team. The advantages and disadvantages of changing the organisational structure should be researched and evaluated, in parallel with Industry practices of installing and managing PDM systems. This will help propose the optimum solution for which the Formula Student Team organisation should be best adapted. Considerations should be taken into account of how to best utilise the investment in technology within Aston University School of Engineering facilities.

8.7 Summary

In summary, Chapter 8.0 has presented the common, yet complex, problematic themes associated with the development of Aston University Formula Student Team from AM01- AM07. In analysing the steps taken to improve the management structure and data handling practices, this has provided key focal points for the research to consider in order to determine what benefits can be gained from similar Industry experiences. This discussion supports the aims of this thesis in successfully implementing a Project Data Management System to increase the performance, communication and competitive capability of the Formula Student Team.

¹¹ Exploring Corporate Strategy, Fifth Edition, Gerry Johnson & Kevin Scholes, P409

Chapter 2 – Analysis of Industry Experiences and Identifying Key Success Factors

This chapter covers the research required to ascertain and support a proposed solution to the problems highlighted in Section 8.0, whilst also establishing the appropriate Key Success Factors (KSFs) in order to successfully implement a PDMS within Aston University Formula Student Team.

The aim of this research discussion is to gain a perspective on the experiences of Industry over the last 10 years, with the development of PDMS, consulting literature evidence on implementing PDMS and how business organisational strategy is interlinked with an information business strategy.

The changes and benefits that a PDMS brings to the performance of an organisation need to be considered with an understanding from the literature research on how standard business practices are formulated and KSFs can be derived. This will aid the measurement of management effectiveness and performance for the Formula Student Team, whilst sustaining the benefits of PDMS to Aston University for future years.

The research will investigate what may be learned from business organisational structures, particularly by what is proposed in both theory and teaching contained within text books and discussed in research journals. This knowledge and how it can be aligned to PDMS, will provide comparisons to the Formula Student Team organisation and confirm why this project is a unique case. Furthermore, the research will investigate what can be learned from project design management matrixes for complex and small to medium enterprises and how PDM systems integrate into engineering New Project Development (NDP) processes.

Other important areas that the research will focus on are the initial team formation, leadership, teamwork and motivation required to successfully meet the thesis objectives. The context of this evaluation for these topics is divided between drawing from the author's involvement and experiences, in conjunction with direct comparisons to leadership and management theories discussed in various text books and research papers. In essence, presenting the unique case of the Formula Student Team, what benefits can be drawn from understanding the motivational and teamworking aspects and how this information can be best utilised to provide an additional Key Success Factor for implementing PDM.

The approach and methodology taken was to obtain data from research journals based on PDM research and review papers, and also to investigate the setting of PDMS within the New Product Development process associated with large and small organisations.

9.0 Industry Experiences of PDM

S B Harris (1996)¹² illustrates the interplay between business strategy and Information Systems (IS) strategy, with the emphasis on the manufacturing Industry. It is important to understand the impact on enabling and investing in information technologies as this can change a whole Industry in a short space of time. The relationship and alignment between business and IS strategy can be summarised into five stages consisting of: define the business context; define the strategy; define the business architecture and information architecture; define the information systems architecture. This approach can be used to aid the development of KSF for the Formula Student Team.

The requirements for Information Systems are directly associated with the products and manufacturing strategies and can be interpreted differently; S B Harris discusses the three options to be considered. The first option is how the information is modelled, structured and formatted. The second option is the system software that is used for creating and managing the information. The third option is the technology requirements for the systems to be built to and the data stored. It is important to note the value of the information to businesses and the costs associated with implementing new software. Some businesses consider the data to be a vital asset and should be managed in line with other business assets.

Most communication within and between manufacturing business takes place through using documents that contain product data. The Department of Trade and Industry (DTI) publish a guide for PDM, which defines the requirements of a PDMS as being concerned with: managing the vault of product data; automating workflow process; managing product structures; classification; coding and retrieval of data and program/project management. This will help enforce meeting Quality Assurance (QA) procedures and aid in gaining International Organisation for Standardisation (ISO) status.

The consensus and themes that can be drawn to implement a PDMS cover the following points:

- Education and awareness of the engineering problems and potential solutions. *This relates to the historical background of Formula Student.*
- Analysis of requirements based on business practices related to product life cycles. *The project organisation and life cycle is structured and based on one academic team, the life cycle being refreshed each year.*

¹² S B Harris (1996) Business strategy and the role of engineering product data management

- Analysis of the information and document structures. *How undergraduates' projects are assessed by supervisors: communication of design, manufacturing ideas and feedback. The distribution of rules that are applicable to individual projects within the team.*
- Statement of user requirements from the PDMS.
- Preparation of a business case, detailing costs and benefits.
- Pilot implementation, towards a phased and then full implementation.

Some of the key benefits highlighted from the literature review that PDM brings into an organisation are as follows:

- Ability to locate the correct data quickly.
- Improved work process and workflow between design and manufacturing.
- Cost analysis of the project through the creation of a single bill of materials.
- Cost savings in terms of increased productivity and reduced impact on project schedules.

The areas to consider which could impact the introduction of PDM are the education of new users. PDM usually brings substantial change to an organisation and the culture has to be one that can adapt and respond quickly in order to harness the full benefits that these changes can bring. Also, there is a lack of awareness of the advantages that the technology brings, the costs associated in purchasing a PDMS and maintaining the capability.

S B Harris, J Owen, M S Bloor and I Hogg (1997)¹³ – provides an approach to document management strategy, by formulating an implementation plan for organisations, in order to handle the vast amount of engineering documents that a project generates. Some of the key information gleamed from this research is the importance of a decision making process for the user and functional requirements, which allows guidelines to be formed to address these issues, before committing to investment in the technology. Even though the paper predominately discusses document management strategies, there are many commonalities and themes between the processes required for PDM implementation. Document management is universal practice across all industries, product life cycles and personnel, although engineering organisations have the additional complexity of data formats which include drawings, product structures, manufacturing process and plans. The business practices to access data from global sites at various times, particularly the control of the data: the suggestion that distinguishing between

¹³ S B Harris, J Owen, M S Bloor and I Hogg (1997) Engineering document management strategy: analysis of requirements, choice of direction and system implementation.

‘master’ and ‘copy’ is one of the biggest areas of confusion within organisations. The strategy for dealing with the various formats the document data is created in, particularly design software drawings, and the ability to archive and store appropriately, is also discussed.

The key point that can be derived for the implementation of PDM is how an implementation plan can be developed and executed. The awareness, education and training for the organisation is essential to the success of the project. The areas to consider are the selection of an appropriate system based on user and functional requirements, piloting the new PDMS, the re-evaluation of the user requirements, roll-out with the project team and writing of practices and guidelines.

Yuh-Min Chen and Tien-Heng Tsao (1998)¹⁴ provides a structured approach to implementing engineering data management, discussing a series of steps that could be adopted by business to improve the planning, design and implementation of engineering data management. The importance of concurrent engineering within projects and the collaborative processes between different disciplines, sharing of product and process information through the lifecycle is discussed. These requirements have a direct effect on what approach is to be taken to improve commercially available PDMS that are on the market, in order to suit the business organisation and user needs; this will influence the investment and time required to modify the PDMS. A PDMS implementation procedure is presented, providing a methodical approach of a staged implementation plan and procedure to tackle specific problematic areas in developing a PDMS to suit the organisational requirements. This approach can then be tailored and modelled to the requirements of the business. The need for flow diagrams to aid the analysis and definition of information flow within the organisation and specific user requirements is an important point to note. This allows a top down view of an engineering organisation, considering the various individual inputs from within the project area, detailing the relationships and lines of communication between the data, process, activities and people.

¹⁴ Yuh-Min Chen and Tien-Heng Tsao (1998) A structured methodology for implementing engineering data management. Pergamon.

E J Umble, R R Haft, M.M Umble (2003)¹⁵ indicates the implementation strategy for Enterprise Resource Planning (ERP) systems. As these are highly complex information systems, to assist the organisation's ability to generate and communicate timely and accurate information, the paper discusses key factors to consider in order to be successful. ERP is essentially a database where all business transactions are entered, recorded, processed, monitored and reported. Successful factors for ERP include defining clear strategic goals for organisation and interaction with customers and suppliers. Commitment from the leadership within the business, in parallel with strong project management of defining the requirements and implementation of the software are also noteworthy. The ability to react to changes in organisational practices and structures will have to evolve to in order to benefit from the ERP system.

The steps proposed within the Journal for software installation can be directly translated to PDMS. These are:

- Review prior planning for PDMS and software selection process
- Install and test required hardware, servers, computers etc
- Installation of software and test
- System training
- Establish required security and permissions for PDMS access
- Transfer of previous data into the PDMS
- Document standard practices
- Educate users and roll-out PDMS
- Continually monitor and improve as necessary

It has been shown that the reasons for failure of ERP is due to bad planning, management and lack of organisational support to accept the changes and benefits the system brings.

In-Ho Song, Jeongsam Yang and Beom Park (2008)¹⁶ research presents the need for customising a standardised commercial PDMS to suit the specific needs of an individual organisation, using a Unified Modelling Language (UML) in PDM authoring framework. There are various complex requirements of organisations attempting to implement PDMS. UML provides the ability to model the business process to

¹⁵ E J Umble, R R Haft, M M Umble (2003) Enterprise resource planning: Implementation procedures and critical success factors. Elsevier.

¹⁶ In-Ho Song, Jeongsam Yang and Beom Park (2008) Development of an authoring framework for the simplified customisation of PDM systems. Springer.

build a framework for how the data is managed and stored. This would also allow the PDM authoring to be adapted.

This approach could significantly reduce the amount of PDMS specialism required in changing the software code and object models within the system. The PDMS authoring framework can be directly adapted to suit the organisation data structure.

9.1 Interim Observations

Reviewing the research presented so far, there are common themes emerging that should be considered for the implementation and management practices of PDMS for the Formula Student Team.

9.1.1 Benefits of PDMS

Some of the benefits highlighted for PDMS can be grouped in the following categories:

- Aids Business Strategy objects.
 - Can directly enhance the overall business strategy, allowing the organisation to adapt and maintain competitiveness within the specific Industry.
 - Can provide a secure, worldwide access to a PDMS, improving communication throughout the organisation and the product life cycle.
- Cost Reduction and impact on schedule.
 - Controls the project workflow and practices of the business more efficiently and increasing productivity. Thus providing an overall return of investment to the organisation.
- Product Lifecycle Management.
 - Will be able to fully control the product life cycle: from concept, design, manufacture, to competition completion.
- Improved work process and workflows between design and manufacturing.
 - A centralised and generic approach to managing the PDMS data in a controlled and structured environment.
- Improved traceability of data.

- Enabling the creation of a single bill of materials that will aid the cost analysis project for the Formula Student competition.
- The ability to search and locate the correct data quickly.
 - The PDMS provides correct issue of components, assemblies and documents.
- Audit and Quality Control.
 - This is an important aspect for business requirement and ability to meet the quality management and standards that are governed through ISO10007.¹⁷
 - Product Management.
 - The challenging task of meeting the needs to simultaneously design and redesign products in a shorter time period will be aided by PDMS

9.1.2 Problematic Areas

Some of the areas for consideration:

- One of main points to be highlighted in implementing PDMS concerns the education and awareness of personnel within the organisation. There is documented evidence, as presented by **E J Umble, R R Haft, M.M Umble (2003)**¹⁸, that suggests the more adaptive the organisational culture is, the greater the transition and acceptance to the revised working process and practices with PDMS
- Education and training is an area to focus on, with suggestions within the research of launching a pilot scheme, to resolve problems as they arise and to adapt preliminary working practice before a full roll-out to the organisation is initiated.
- Meeting the PDMS requirements of an organisation is also important. Customising commercially available PDMS to suit the specific needs for large organisation is complex and costly, both in terms of schedule and also specialist time and labour to adapt software code.
- Strong project leadership is required to execute the PDMS plan within an organisation. Maintaining the progress and communicating effectively to resolve problems is essential. As

¹⁷ ISO1007:2003 Quality Management Guidelines For Configuration Management (International organisational standard June 2003)

¹⁸ E J Umble, R R Haft, M M Umble (2003) Enterprise resource planning: Implementation procedures and critical success factors. Elsevier.

PDMS implementation may take in excess of 12 months (depending on the organisational size) it is important to ensure that the project has the support of the senior management during this time.

9.1.3 Differences between the Journals

Some of the key differences highlighted within the research so far is how to address the complex requirements of large organisations. There has been significant consideration and analysis put into how the PDMS programming structure can be customised to the specific needs of the organisation. The basics of searching the data, being able to increase the search criteria in respect to name fields, issue number and the definition of the relationships between them, is a growing research topic. The main aim and purpose for this functionality is to provide an increased performance within the PDMS. The format of how the data is stored and distributed is aided by workflow modelling, detailing the actions and activities required. This provides a framework of relationships between the data information and how they are classified by version and accessed.

The strategy for managing documentation, in respect to the model, which defines the relationship between ownership, authoriser and issue, is a topic for debate. As past experience presented in S Harris research has shown the decision process involved for the organisation can take months or years, due to the inherent change this will require both in a cultural sense, but also in work processes and practices.

The investment required and the duration of the implementation is a delicate balance for an organisation. Ensuring a healthy return of investment from large cost associated with the installation, training and education, particularly for the amendments required to the organisation working practices and process. This also encompasses the complexity of requirements, ensuring the specific needs of the organisation are met; without incurring unsustainable schedule impact and costs in reprogramming the PDM software by specialists.

9.1.4 Approach

Summarising some of the key points from the research to successfully implement PDMS, the general consensus for an approach to take is outlined in the following points:

- Education and awareness of the historical background of the engineering problems and potential solutions

- Analysis of requirements based on business practices related to product life cycles; How the scale of the product life cycle may be determined and over what time scales
- Analysis of the information and documentation structures. Customer specifications, programme schedules, design concepts, technical data, manufacturing processes etc
- The organisation of departments, administrators and users. Distribution of access, specific documents etc
- Statement of user requirements for the PDMS. Interaction, search fields, control of data
- Preparation of a business case, detailing costs and benefits and return of investment
- Pilot implementation and review
- A phased and then full implementation within the organisation
- Continual development and improvement

10.0 Comparisons of Formula Student to Industry

Based on the issues presented throughout Chapter 1 and the research in Section 9.0, to evaluate some of the fundamental and unique differences between the Formula Student Team project and Industry, the following approach is adopted.

In respect to Formula One, manufacturing and commercial engineering projects, the key areas that have been identified to provide a base line for analysis are as follows:

1. Business Strategy – University and project strategy.
2. Organisational Structure – How does Formula 1 and Industry compare?
3. Complexity of requirements – What are the needs for the Formula Student Team?
4. Return on investment – How will this differ from Industry?

Comparing these individual areas, the objective is to highlight where possible, what considerations are needed for identifying potential PDMS requirements for the Formula Student Team. In addition to this, deliberation on how the current AM08 team organisation structure should be best optimised and configured to integrated PDMS, to fully benefit the team.

10.1 Business Strategy

A brief overview of the potential business strategies adopted for various engineering industries, in comparison to Formula Student concept are discussed below.

10.1.1 Formula 1

In reviewing the business strategies of Formula 1 teams, in particular the McLaren Group Limited, their aim simply is “Race to win”¹⁹. The business strategy would therefore be adopted and aligned to meet the ultimate goal of championship victories. That is the direction and scope of the organisation over the long

¹⁹ Information taken from www.mclaren.co.uk

term: which achieves competitive advantage for the team through configuration of available resources with the rapidly changing environment.²⁰

The partnerships involved within the F1 teams, particularly for example with engine manufacturers (if required), would see a complex co-ordination of engineering departments, potentially based at different locations around the world. This will determine the approach required for the IS and PDMS in meeting the requirement of providing access to engineering data, drawings and processes at any given time.

The significant investment and resources typically made available to Formula 1 teams, have resulted in breakthroughs in technology innovation, for example: the development in Carbon Fibre components. The advancement in manufacturing process and technical expertise gained through F1 to be used within the Aerospace and Automotive Industry. The use of carbon-fibre in the construction of aircraft wings, as seen on the Boeing 787, whilst in the Automotive Industry, the material is commonly now used for construction of car chassis and various internal components within luxury sports cars.

The strategy to harness the technical investment is constantly evolving each year, providing the competitive edge to the Formula 1 teams.

10.1.2 Automotive

The Automotive Industry business strategy will be arguably different. Jaguar for instance, is seeking to build beautiful driving experiences²¹, whilst becoming a market leader that is cost effective and provides value for money.

BMW business strategies and decisions are predominately resource focused, shaping the company's future viability. It uses the resources required to design cars to enrich people's lives, inspire new possibilities, through efficient processes as well as mitigating against recognised risks to the business.

The common theme between these competitors is providing value for money whilst not restricting the technological development in designing more efficient and advanced cars.

These large multinational corporations present various complexities and diverse challenges in the organisational structure, which will have significant impact on IS strategy and PDMS investment.

²⁰ G Johnson, K Scholes, Exploring Corporate Strategy, Fifth Edition, Page 10

²¹ Information taken from www.jaguar.co.uk

10.1.3 Aerospace

There is some commonality between the Automotive and Aerospace Industry. The majority of the organisations have various locations worldwide, specific to the business needs. As prudent economic investments and sustainability is vitally important to the growth and profitability of the business, it is not uncommon for the business to be split into various functions distributed around the world. In particular design, technical engineering, programme control and assembly would be traditionally based in Europe or North America, with the manufacturing division based in Asia. One of the underlining strategies for this is to invest in and benefit from low labour cost economic climates, which will sustain the company's growth, profitability and efficiency. There are many economic, environmental and ethical debates around this topic, but for the purposes of this thesis it is sufficient to identify that this is a complex organisational area with which large global business contends.

The IS and PDMS strategy would be developed in conjunction with the business strategy and future customer contracts, primarily directed from the business headquarters. Potentially, large projects could be used to integrate a PDMS strategy, which would provide a baseline for the business to transition to over a period of time.

10.1.4 Aston University Formula Student Team

The concept of Formula Student is to provide a unique engineering education experience aiming to build the future talent of engineering.

A completely different approach is required to the business strategy as this lies within a Higher Education Institution. However, there are distinct similarities between the Formula Student Project and small business, which could form the basis of a business strategy.

Gary Johnson, Kevan Scholes (1999)²² provide an overview of the context for a small business strategy, particularly what is deemed to be the fundamental differences between multinational corporations and manufacturing organisations. In summary, the following characteristics of a small business can be drawn from the information presented.

²²G Johnson, K Scholes, Exploring Corporate Strategy, Fifth Edition

1. Single market or limit number of markets. I.e. Products for the Automotive Industry only.
2. Scope of the operation is less likely to be a strategic issue
3. Limited resource for central departments: market research, complex analysis
4. Values and expectations are likely to be driven from the core management team, rather than stakeholders or investors
5. The competitive strategy and technology would be influenced and driven by the people with past experience
6. Likely to be a private company, which effects ability to raise capital for investment

Not all of the points raised above would directly apply to the Aston University Formula Student Team, but there are certain factors that should be considered. At present, no formal strategy exists to develop the project within the university for future years. However, based on the initial research and taking into account the historical context of the project within the University, the following business strategy could be proposed:

- Fully utilise the expansive resource assets available, not only from within the School of Engineering, but the whole university
- Present a versatile business case to market and sell the concept of Formula Student to commercial Industry to secure investment and sponsorship for the team
- Learn from the previous year's history and experience
- Harness the latest technologies freely available to efficiently design, build and manufacture a car capable of winning the Formula Student competition

The PDMS strategy to be adopted for the Formula Student Team would be fundamentally based on the requirements for discrete capital investment, suitable to specific needs of a small business, without the complexities of a multinational organisation. There could also be scope and potential within the requirements to allow for expansion throughout the School of Engineering, for use by other engineering team projects.

Compared to Industry, the Formula Student Team project has relatively little funding available through the university and education system. Additional funding is only secured through direct team sponsorship or based on past funding, a demonstration of continued improvement and success of Aston University participation within the competition. This has gained greater exposure and networking opportunities to promote and the market the project. An element of entrepreneurship is required to secure the additional finances to meet the overall cost of the project and allow technological innovations required to continue

the project's success. In referencing back to the AM08 team roles and responsibilities, this is now a key area of responsibility for the postgraduate Team Manager.

10.2 Organisational structure

For the purposes of reviewing the present AM08 Formula Student Team organisation, it is important to understand the formation of project structures and commonalities between conventional large complex engineering project organisations. From this analysis, an approach can be formed on how to best optimise the AM08 team structure.

The analysis process will cover the Automotive and Aerospace Industry, specifically the engineering organisational models, leading onto the Formula 1 approach.

Direct comparisons can be drawn between Formula 1 and Formula Student organisational structures, with the aim to provide further justification for Formula Student being recognised as a unique case. In particular, it is hoped that a hypothetical comparison can be drawn from the roles and responsibilities between each of the team organisations, based on the information freely available on the Formula 1 sector.

It is also important to appreciate how the engineering project complexity evolves throughout the development and manufacturing stages, as this will be beneficial in presenting the appropriateness of the current AM08 structure is and whether if a more suitable organisational structure can be adopted that will most effectively harness the use of a PDMS.

10.2.1 Automotive and Aerospace

In order to provide a generic overview of the organisational structures existing within the Automotive and Engineering Industry, consideration should be given to the fundamental building blocks of a design and manufacturing organisation. The framework that the majority of organisations (large or small) create to organise specific areas of specialisations, essentially involve the following areas: Engineering, Manufacturing, Supply Chain, Assembly and Test, HR, Accounting, Sales and Marketing. Detailed in Figure 15 is the framework on how the departments are co-ordinated and resources distributed, delineating the chain of command within the organisation.

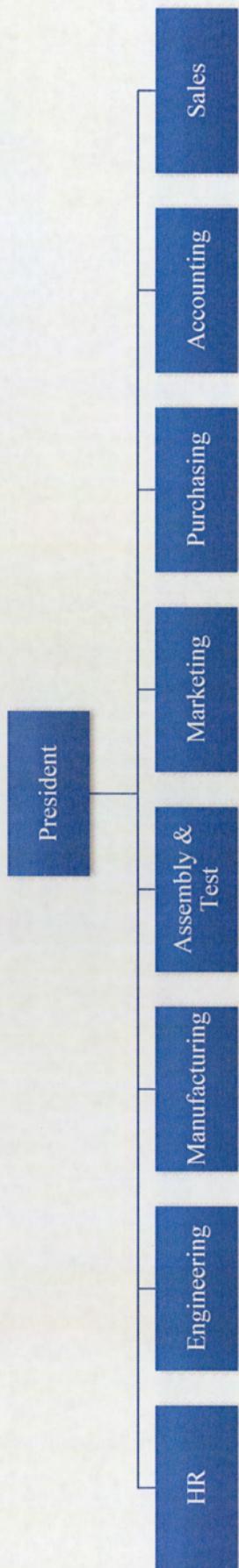


Figure 15: Typical Engineering Organisational Structure

The intent of Figure 15 is to provide a simplistic overview, as there is no strict or autocratic governance on how an organisation should be structured. The adopted approach takes into account variable factors and considerations, either in adapting and developing into a more efficient business or from the in-depth theoretical research available. This should detail the concepts of organisational structures and chains of command, and how each has their own advantages and disadvantages to the business performance and competitiveness. However, for the purposes of this discussion, the research will focus on a generic framework that is commonly adopted for the Automotive and Aerospace engineering organisation and how PDMS is integrated within its departments.

There are various similarities shared between the engineering departments found in both Aerospace and Automotive. The framework presented Figure 16 is commonly known as a vertical functional approach, where people are grouped together in departments by common skills and work activities.²³

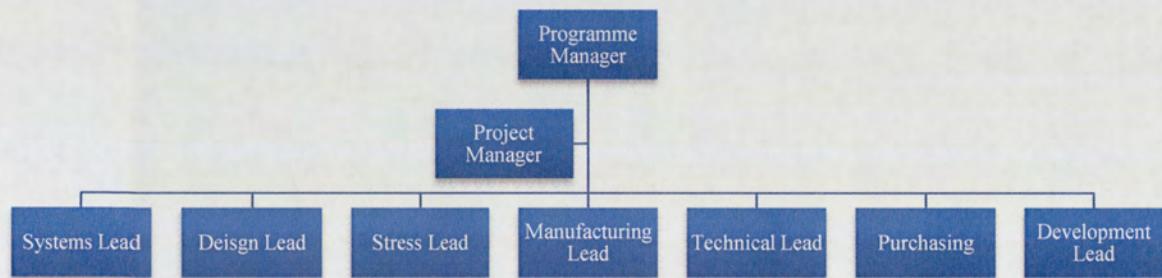


Figure 16: Engineering Project - Vertical Functional Approach

²³ Management, Fifth Addition, Richard L Draft Page P314-316

The relationship between departments within a project is controlled and co-ordinated by either the Project or Programme Manager. The skill sets contained within the project team are not bound to a specific framework, each engineering team structure will be different depending upon the task required and the resources allocated.

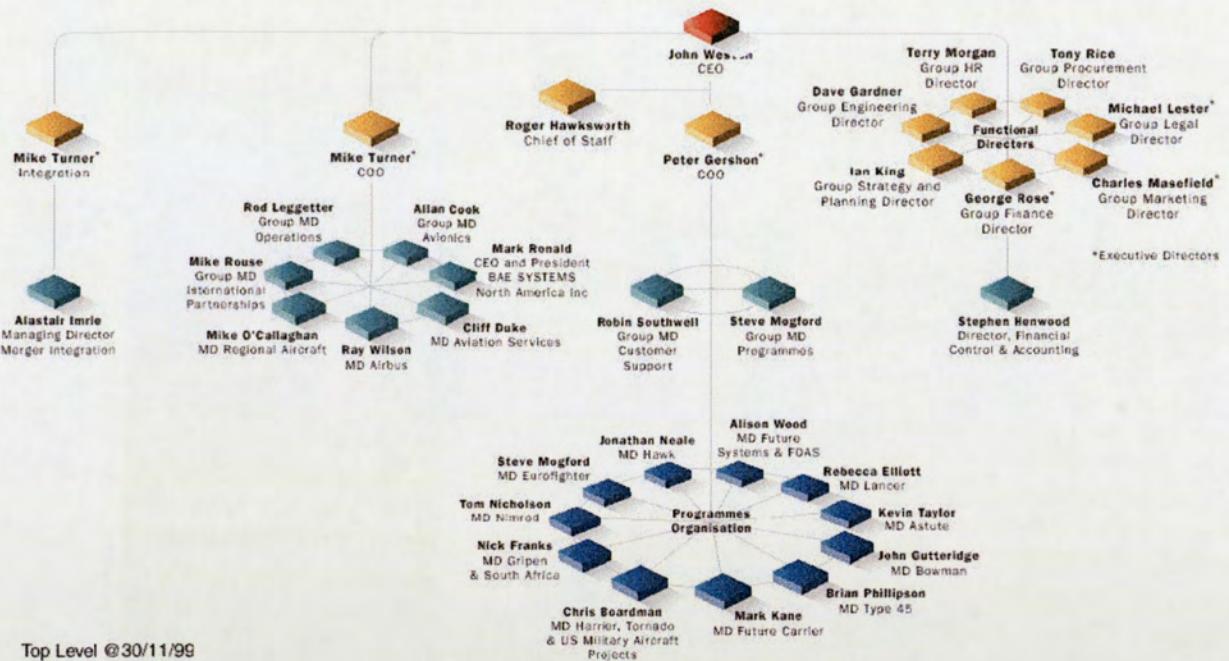
The advantage that this approach provides is the efficient use of resources within the project, due to commonality in skill set and training experience. The expertise is grouped to handle specific problems and challenges, allowing for a more compatible team. However, the disadvantages are that the team will be less dynamic compared with other departments and slow to respond to environmental change²⁴.

For larger projects, a divisional approach is sometimes taken, where each project will be self-contained with a diverse range of skills, which might include but is not limited to accounting and finance. This is mostly adopted for multinational organisations, with disparate geographical locations.

The chain of command would report up to Project or Vice President Director and finally to the CEO of the business.

This provides to the business a more dynamic and flexible approach to project changes and environmental demands. Illustrated in Figure 17 is the organisational structure for BAE Systems, which has adapted the methodology for a division based organisation.

²⁴ Management, Fifth Addition, Richard L Draft Page P316-317



Top Level @30/11/99

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Figure 17: BAESYSTEMS Division Structure

Within large project engineering organisations the use of a vertical structure is not the most suitable option. A matrix approach can be adopted to combine the aspect of both a functional and divisional structure simultaneously.²⁵ This concept evolved from an effort to improve the co-ordination and information sharing between departments. Essentially, this provides two chains of command for the resource contained within the department. The vertical element of the matrix structure provides control within the department, whereas, the horizontal element provides co-ordination across the departments. The Author's experience of a common matrix structure found within engineering projects is presented in Figure 18.

²⁵ Jonathan Gabbi, Emergent Systems, Management and Aerospace - <http://gabbai.com/category/academic>

²⁶ Management, Fifth Addition, Richard L Draft, Page P316

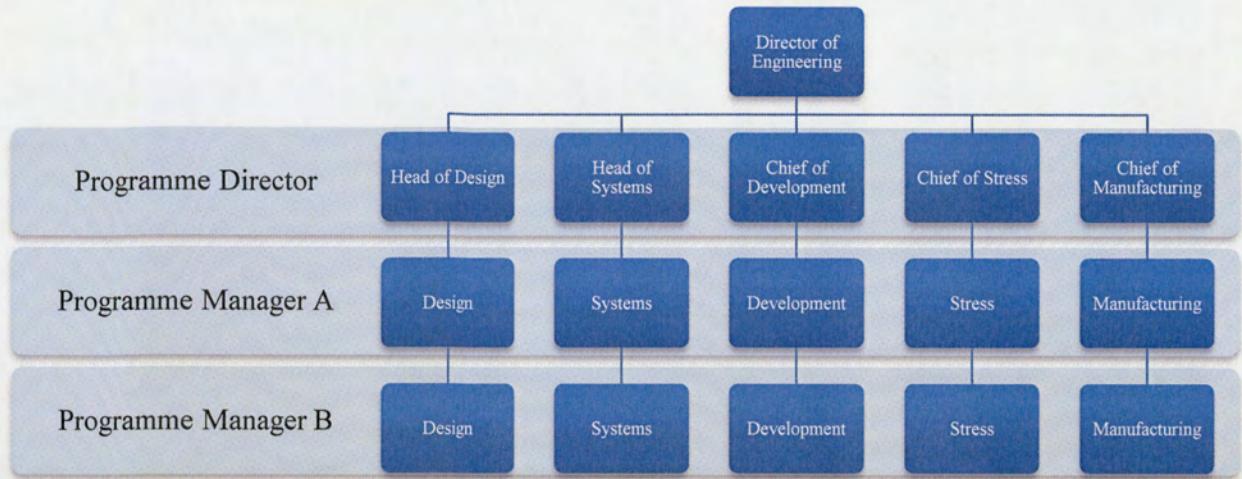


Figure 18: Engineering Project - Matrix Organisation Approach

This matrix based approach is the foundation of the core engineering organisation, particular used within BAE Systems. An additional department that should be integrated into each of the programmes is the Supply Chain element. The Director of the supply chain would be in line with the director of engineering. Both in turn would report to the CEO of this individual business unit.

The benefit that this structure brings is to allow a more efficient use of the resource contained within the project, providing a flexible, adaptable team. However, the main problem that this structure presents is the controversy and confusion surrounding the dual chain of command and potential conflict between the two sides of the matrix.

In comparison between the two Industries, a common approach to the engineering organisational structure is taken for new development projects. There are considerable variations with the formation of organisational structures, which can be associated with the following areas: technical complexity, budget allocation, delivery into service, profitability and return on investment. Particularly with the Automotive Industry the New Product Development process is increasingly becoming a shorter duration, due to the nature of competitiveness and drive for sales. Due to the nature of the projects, the Aerospace Industry tends to have a historical trend of a longer duration development process.

In summarising the organisational differences between the Automotive, Aerospace and the Formula Student Team, the following areas should be considered to improve the approach of the organisation structure:

1. Improved grouping of similar project areas, to be inline with core departments
2. Integration of the Project Supervisors to be more in line with a matrix approach
3. The Honorary Technical Members should be organised suitably on skill set and experience within the team: could act as a sponsor/mentor for students
4. Establish clear lines of communication and chain of command
5. Improve definition of roles and responsibilities

10.2.2 Formula 1 Team Model Compared to Aston University Formula Student

In order to provide a more direct comparison of the organisation structure between the Formula Student Team organisation and Industry, an in-depth look at the Motorsports Industry models is required, particularly with the most prestigious of competitions, Formula 1.

As the nature of both competitions is primarily to win, the contrasts between the two projects will demonstrate and highlight the uniqueness of Formula Student and provide discussion points, whilst also providing for consideration factors that enhance the identification of KSFs and their vital contribution to successfully integrate PDMS into the team. This allows an approach to be formed for an improved baseline model for the organisational structure, on how potentially the Formula Student Team could be re-defined, adapted and improve the work processes to best suit PDM implementation.

Limited information is publically available on Formula 1 team websites and respective literature, due to the commercially sensitive nature of the Industry. Figure 19 summaries and presents the engineering team organisational roles for two individual teams: Renault and McLaren. These two teams were selected primarily due to the amount of information that could be analysed and discussed more effectively. However, there is a certain differentiation of role names between teams required, so a certain amount of judgement and conclusions are made. The intent is to illustrate how a Formula 1 team is potentially organised. Also included are the Formula Student Team organisational roles, placed in line with their respective counterparts within Formula 1.

Renault ²⁷	McLaren Mercedes ²⁸	Aston University Formula Student Team
Location England, France	Location: England	
Executive Vice Chairman and CEO, Renault F1 Team	Team Principal, Vodafone McLaren Mercedes	Faculty Manager
Managing Director, Renault F1 Team	Managing Director	
Executive Director of Engineering, Renault F1 Team UK	Director of Engineering	Team Manager
Technical Director, Renault F1 Team UK (Engine)	Technical Director	Faculty Project Supervisors
Technical Director Design and build of chassis. UK		
Technical Director Design and build of engine. France		
Head of Engine Operations(Engine)	Operations Director	Faculty Technical Staff
Chief Designers	Director of Design and Development Programmes	Undergraduate Student – Final Year Project Tasking
Head of Research & Development		
Race Engineers Car No 1	Team Manager	Team Manager
Race Engineers Car No 2		
Chief Mechanic		
Sporting Manager	Sporting Director	
Head of Communications	Commercial & Financial Director	

Figure 19: Formula 1 and Formula Student Team Organisational Roles

²⁷ Team Information from: www.media.renault.com/download/media/specialfile/4252_1_5.aspx -PDF attachment

²⁸ Team Information from: <http://www.mclaren.com/management-team>

Additional Information: Renault UK Team approximately 420 personnel, France Team approximately 206 personnel. No further detail was available on the breakdown of roles contained within the France Engine design and build organisation.

There have been some considerable assumptions in aligning the roles with counterparts across the 3 teams and this is not intended to be a definitive correct answer, there is considerable information lacking to fully detail the team organisational role structure. This is a prime example of how organisational roles differ between businesses, either due to historical experience or adapting to more efficient and effective competitive business model.

Not all roles from the Aston University Formula Student Team could be distributed, as the intent of the exercise was purely to demonstrate the vast differences between Formula 1 organisational roles and the approach taken for definition of roles for Formula Student Team.

Based on the information provided, commonalities between the roles and the traditional matrix engineering models can be seen. An attempt to visualise a hypothetical organisational hierarchy model for Formula 1, in acknowledging the research presented so far, is illustrated in Figure 20 and Figure 21 for both Renault and McLaren. The current AM08 Formula Student Team organisational structure is also detailed in Figure 22 for reference.

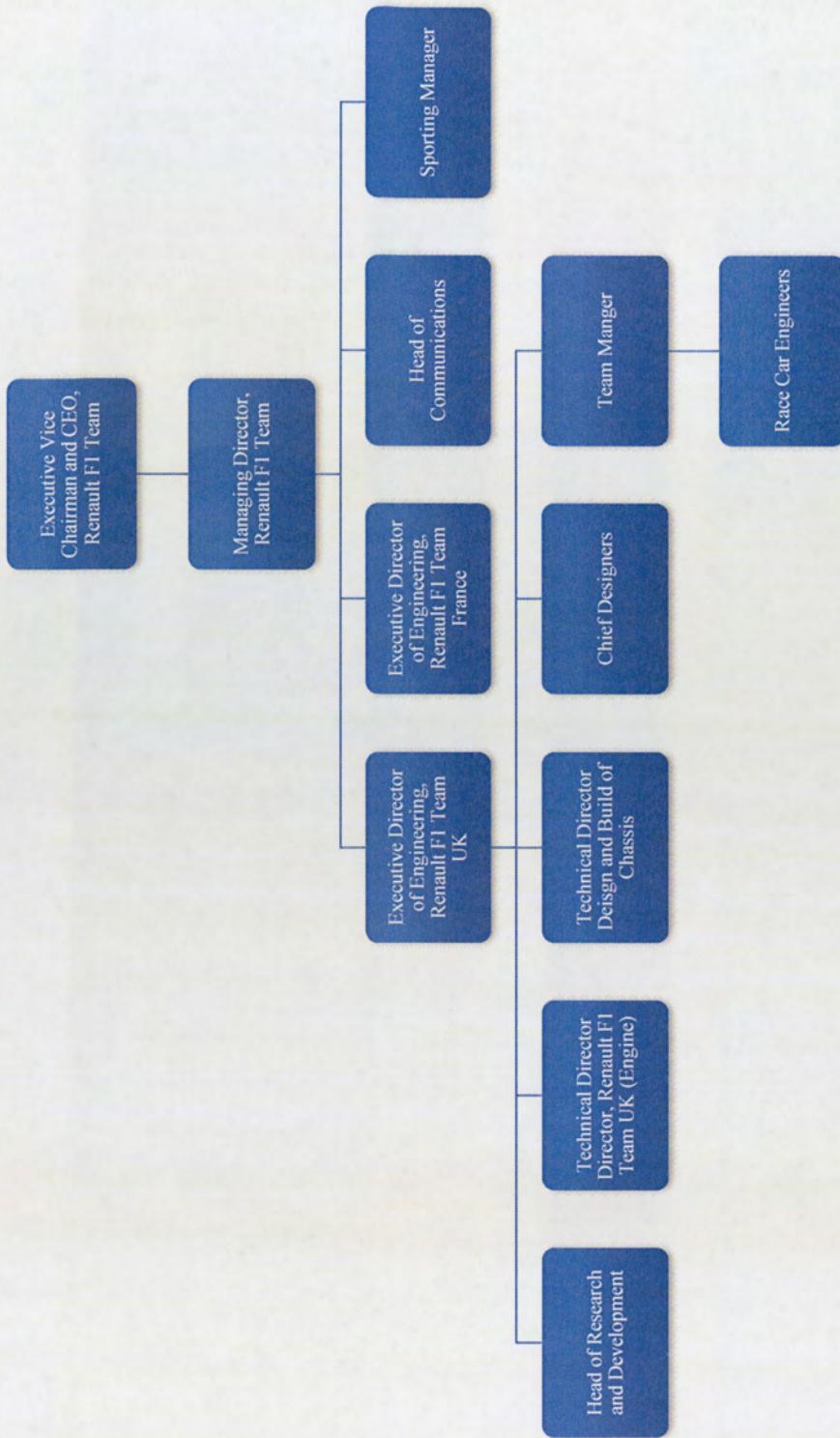


Figure 20: Illustration of Renault Organisational Hierarchy

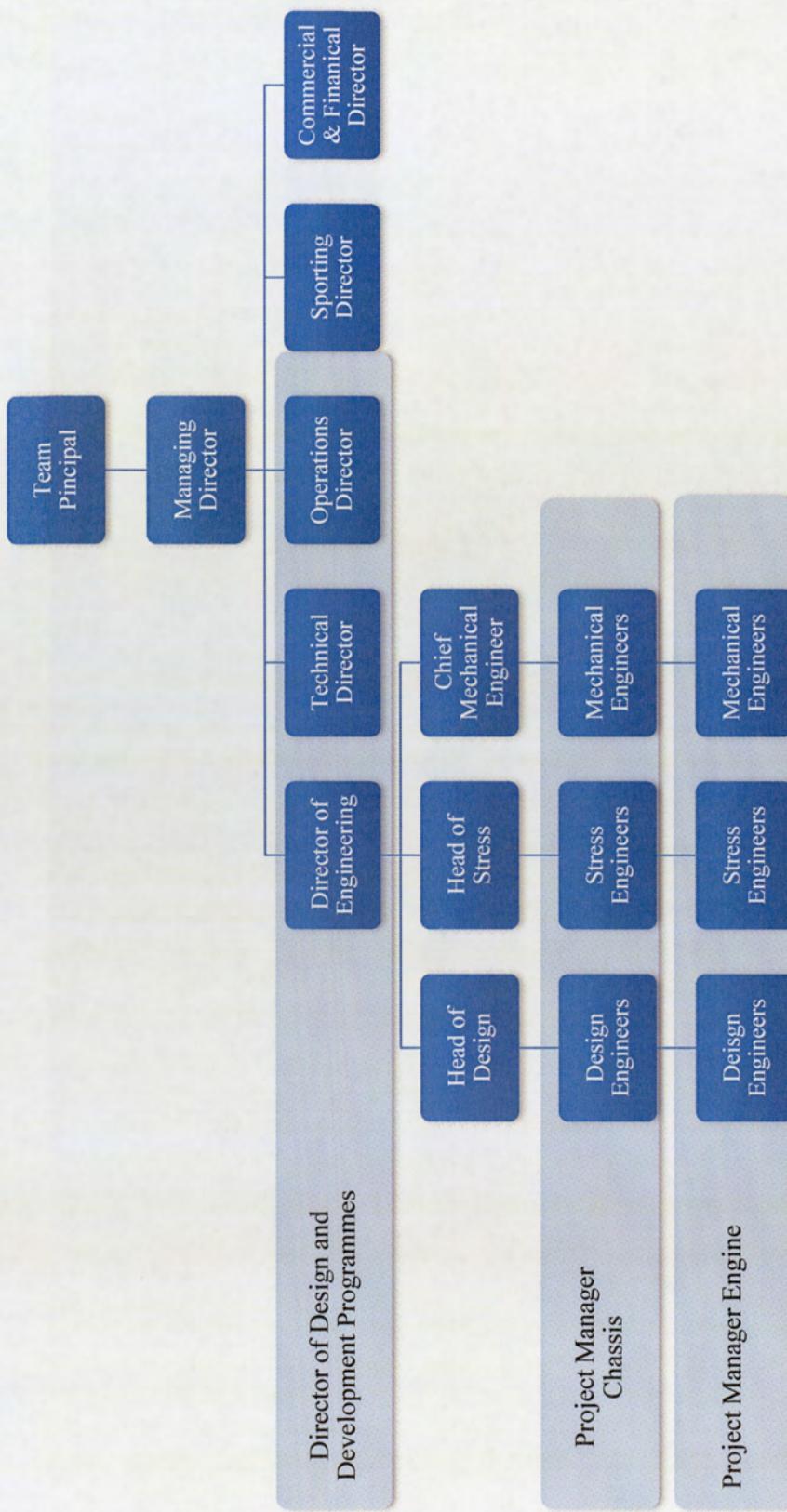


Figure 21: Illustration of Potential McLaren Engineering Organisation Matrix Model

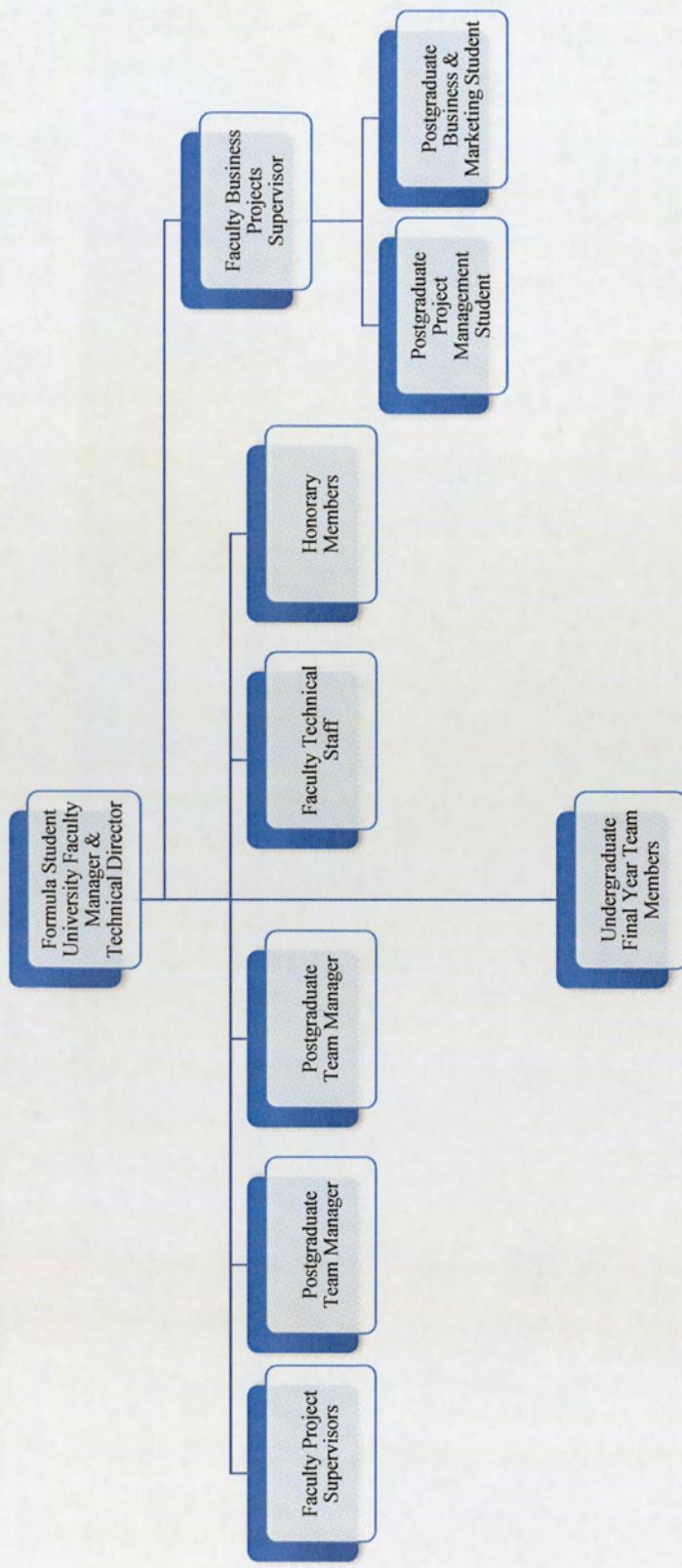


Figure 22: AM08 Formula Student Team Structure

The breakdown of the Formula 1 Teams' organisation is missing considerable departmental information on how the matrix structure within the engineering would be split and co-ordinated. Some questions that cannot be answered is the potential chain of command and lines of communication. An overview of the project areas that would require specific dedicated teams is the car engine, chassis design and driver development. These areas would play a major role in the distribution and organisational matrix within engineering. The resource allocation would be specific to the project requirements and budget allocation. Potentially the personnel which would form the model of the engineering matrix for one of the projects for example, would include but would not be limited to: Design Engineers, Project Engineers, Manufacturing Engineers, Mechanical Engineers, Stress Engineers, Aerodynamics Specialists, Powertrain Specialists etc.

In direct comparison to the Formula Student Team, the undergraduate students select their desired project to undertake and apply theoretical knowledge learnt from their respective degree course. This is in combination with the historical knowledge and university expertise, to design, manufacture and test the designated project area.

10.3 Complexity of requirements for PDM

The technical complexity and knowledge management of engineering development projects is a factor on the organisational structure and in particular the specific requirements for the PDMS. The importance of understanding how to manage complex Product Development projects and the elements that continually impact the programme schedule and delivery of the project needs to be considered.

Before launching into the detail of PDMS requirements, it is important to understand and appreciate the common obstacles and pitfalls in data and knowledge management, which occur during new product development. There are similar problematic areas evident within Industry, compared to the Formula Student Team.

Configuration and control of key workflow data that is networked between departments, is controlled within a safe and secure storage; this is a vital element to avoid costly delays and impacts on the project. The vast amount of information data generated, either design specifications, drawings, manufacturing process, stress analysis, test specification and reports, needs to be strictly controlled and detailed correctly to aid the work flow. It is commonplace to have standardised working practices and procedures, whereby the information data is controlled through configuration management. The importance of adhering to these standardised practices provides quality assurance to the business, meeting regulator approval.

The ability to understand and identify the last issue of the required data is an essential requirement. For example, the control of the latest issue of drawing would require approval from various heads of departments within engineering, before being released and issued. The management of this process will have a measurable effect on the efficiency and performance of the department. PDMS must be able to differentiate between the iteration of drawings and associated data, benefiting the workflow and meeting the organisational requirements for standardised practices and processes of the network relationships within the project. Any disconnection in referencing the correct information data, which is controlled within the IT systems, will not only impact progress within engineering, but at the point of use in manufacturing, build and test. Correct information at the point of use is an essential control aspect to meet quality standards applicable to the Industry.

The organisational structure to best suit the knowledge management and technical detail of the project is an area that will have an influence on the PDMS requirements. How the complexities evolve and are consequently managed, is an important lesson that can be learned from Industry. This is an area to be further analysed.

Klas Eric Söderquist (2006)²⁹ discusses how large global manufacturing companies should best manage New Product Development (NPD), by identifying three organisational structures which are typically adopted to handle Knowledge Management (KM). Analysis is undertaken on how these three structures support the distribution of knowledge and data throughout the functional departments. This forms an integral part in the approach to manage the product development process and how the knowledge from analysis and re-engineering can be efficiently integrated back into the project. The KM approach taken is dependent on the business organisational strategy, either with KM being a central function separate from the core engineering structure (Central KM), or directly integrated (Project –decentralised KM) into the specific project. Presented below is an example of Central KM function.

²⁹ Klas Eric Söderquist (2006) Organising Knowledge Management and Dissemination in New Product Development

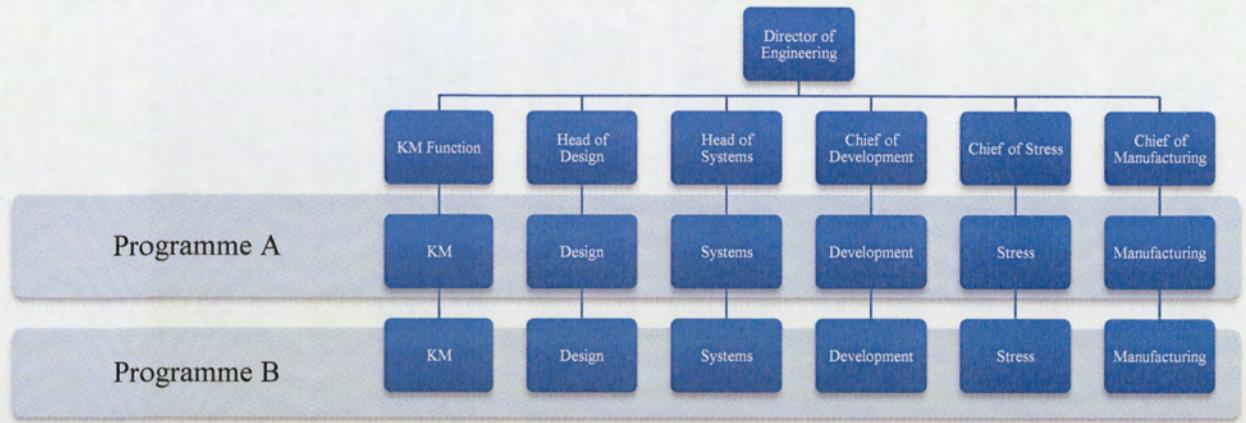


Figure 23: Central KM Function

The practice of managing KM is important to the development of product designs, development and manufacturing process and will play a direct part in the PDMS requirements on how to effectively manage the project data involved.

This is an area to be considered for Formula Student Team: clearer instructions on how to control the project life cycle in terms of knowledge management. Potentially the organisational structure could be realigned for the project supervisor role and a clear definition on the objective of knowledge management will benefit the symmetry between academic years and enhance knowledge retention.

Jonathan D Owens (2006)³⁰ analyses why the product development process is so problematic to businesses and aims to present how an approach should be formed to limit the impact on delivery of the project, whilst also reducing development cost, thus increasing profitability for the business. NPD is an area which business is consistently focusing efforts in accelerating, in order to meet a competitive business strategy, in being the forefront of technology innovation and competitiveness. Some of the areas

³⁰ Jonathan D Owens (2006) Why do some SME still find the implementation of new product development process problematical

that affect the NPD process are presented; one of the considerations is reliance on external sources through the supply chain, or outsourcing. The research and development strategy also plays an integral part in the performance and completion of projects. Understanding the complexity of the innovation process will help to reduce the deficiencies of product development and provide greater risk mitigation. A few of the reasons for an accelerated NPD can be associated with increased competition, technology changes, product life cycle or pressures from management. The common pitfalls identified for the lack of NPD progress are unclear definition of design requirements, technology uncertainty, lack of resource or lack of project management and support. The analysis of the research concludes with a need for assessing the specific working practices, providing a more responsive approach to requirement changes and adapting the technology to communicate the relevant information at the point design and manufacture more efficiently.

This approach is certainly evident in Formula 1, with the ethos of 'Race to win'. The design to test phase is a critical factor to improve the knowledge management and development, in order to become number one. Within the Formula Student Team elements of the product development process exist within the car life cycle, however, the development and testing phase is an area for focus and further discussion to aid the PDM requirements for the team.

10.4 Investment

The investment required to implement an effective PDMS within Industry is something to be closely monitored and controlled. Large corporations expect to see a substantial return on the investment that can be measured either by performance related assessments or by simplifying workflows and practices. The cost of investment of PDMS is quite significant for large business, particularly for multi-national organisations. The challenge of installing, refining and launching the PDMS system worldwide is problematical and costly. Though information data is viewed as an asset³¹, with secure storage and access to the data being vital to the business, eliminating the risk for the data being lost.

Development cost is to refine the PDMS within a large organisation is potentially expensive, amassing to millions of pounds, both in terms of costs to install and network the hardware required and specialist resource in amending or refining the customer PDMS to the requirements.

³¹ S B Harris (1996) Business strategy and the role of engineering product data management

Further costs that are associated with PDMS are the changing and redefining of the standard working practices and the education and training required to use the system effectively. However, the investment required can be offset and measured against the earning potential the PDMS will bring to the organisation, through improved performance and efficiency between the organisational departments, providing greater controlled sharing of information data whilst shortening the NPD process and reducing budget impacts on problematic referencing throughout the business.

Aston University Formula Student Team will only require an off the shelf system, with minimal investment, which will have the potential to be utilised further within the School of Engineering.

10.5 Summary

Reviewing the discussion areas presented throughout Section 10, the research provides an overall illustration of the differences between Industry and the unique situation of the Formula Student Team. It has demonstrated the benefits that PDMS will bring to the organisational performance, whilst also highlighting some key consideration areas that will aid in the selection of KSFS for the implementation of PDMS.

In evaluating some of the lessons learned from the research there are common themes evident that can be directly related to the historical progress of the Formula Student Team. This can be split between two areas. Firstly, the adaptation of organisational structures, which accommodates expansion, either nationally or internationally, maintaining competitiveness and meeting a business strategy. Secondly, the resolution of conflict between workflow practices and processes, with emphasises on data management. The situation of Formula Student organisational approach and concept genuinely reflects a small business model, however, the one differentiation between Formula Student and Industry is the need for establishing a business strategy that is complementary to the growth of the project.

The current organisational structure of the AM08 Formula Student Team is an issue identified for particular consideration. Based on the Automotive and Aerospace Industry approach, a more appropriate framework to adopt is a Matrix structure. The intention would involve the realignment of the project supervisors and technical support staff, creating improved lines of communication and chain of command, whilst minimising the potential conflict areas of technical direction and project management. This is a commonplace issue experience within Industry and documented in the background of the Formula Student Team.

With the continued expansion of the project, the matrix approach will also provide a greater transition and alignment for new additional roles, building a framework that will provide a continuity of knowledge from the core University staff between each new academic year. For example, the implementation of a revised matrix structure combined with the PDMS will allow for a routine working practises to be established and embedded. This will aid maintaining knowledge that can be transferred to the new academic students, in conjunction with reducing the learning process more effectively, in training the new project teams. The organisational structure changes can be assessed and successfully quantified outside of the competition, by evaluating schedule adherence; demonstrating a successful test and development phase and providing greater knowledge retention.

The contribution that the PDMS will bring to the Formula Student Team will provide an improved communication network on latest information data between Aston University staff and the undergraduate students, particularly during critical phases of the project. As previously discussed, this is a systemic issue experienced in Industry in being able to reference the correct information and data.

The PDMS will also aid the operational aspects of the Formula Student Team, as presented in Section 9.0, with the improvement and adherence to standard working practices, which should be controlled by the management team. The areas that will directly improve as a result of PDMS are: quality assurance; communication and networking; efficiency of working practices; rigorous control of approved data; and the ability to reference design requirements.

This compares favourably to the Automotive and Aerospace research information discussed throughout Section 10.0. The importance of maintaining quality assurance and the ability to control the variation of these processes becomes more critical in the performance of the organisation; particularly as the project information expands.

Once the PDMS is implemented and embedded within the Formulas Student Team, an indication of system management, relative to the performance and effectiveness of the PDMS process, is the analysis of key metrics. For example, the iterations of an approved design drawing, reasons for change and the review process between technical management and project supervisor, will identify the associated approval lead times. In comparison to Industry and multinational corporations, the vigorous approval process of key data, combined with the environmental location and the communication between various organisation departments, is a performance measurement which management are responsible for improving. In directly tackling this problem will resolve this issue and will provide improved workflow efficiency, whilst adapting practices and integrating the latest in PDMS technology.

The additional operational benefit that a PDMS consistently delivers is the ability to provide the correct reference data, either accessed from sites globally or confined to small environments. The PDMS is not restrictive or constrained to one access point. This benefit will help in limiting the dangers of working with the incorrect or unapproved information, ultimately affecting the product life cycle.

Refining how a Knowledge Management system can be integrated more effectively within the organisational structure needs to be considered. KM will directly benefit the project life cycle of the car and help with refinement of the workflow. This will improve the standard practices followed during the design development phase, whilst also building a knowledge base for future academic years to reference against and utilise.

The investment required in the PDMS should be minimal, based on the budgetary constraints and costs to the project. Selecting the appropriate software package needs careful consideration, balancing the requirements of the Formula Student Team against the associated hardware costs.

11.0 Teamwork, Leadership and Motivation

Teamwork is the critical component to ensuring that the project will be a success. Referencing back to the opening statement taken from Henry J Ford:

‘Coming together is a beginning, keeping together is progress, working together is success’

It is important to understand how the teamworking relationships are shaped when the Formula Student Team initially comes together. The parallels between this concept and the research available on teamwork need to be considered, in order to ascertain how the management approach could be strengthened to improve the team cohesion during the course of the academic year. The leadership and management of the Formula Student Team throughout the year is the crux of whether the project will be an overall success.

The discussion points that the research areas will focus on are as follows:

1. Formula Student Approach – An account of how the project is currently managed; from initial team formation to competition day.
2. Student Motivation – Comparison between Industry and Formula Student.
3. Team Management – Understanding of the skill set required and how this should be developed.
4. Leadership Attributes – Identify traits of leaders and what can be learnt for the context of Formula Student Team leadership.

An understanding of these areas will aid the development of the Aston University Formula Student Team, whilst also presenting considerations for the KSFs that should complement the implementation of PDMS. The research discussion presented in both Section 9.0 and 10.0, has indicated that the common problem within the implementation process of PDMS, was inadequate leadership or the failing of management. These areas are vital to ensure the challenges arising across the organisation are tackled appropriately and successfully.

11.1 Formula Student Approach

The approach taken to formulate and build a new Formula Student Team happens at the very start of the academic year. Initial invitations to attend a Formula Student start-up presentation are sent to all final year students who are interested in taking up one of the projects available on the car. During the presentation, the projects are discussed and allocated to students, whilst providing a good familiarisation of what the coming year will entail. The initial presentation is designed to be informal, but without failing to state the amount of commitment that will be required. This would usually be held within the environment containing the previous year's car, to help encourage communication, creativity and provide motivation for the new team members. During the presentation and to help accustom the new team to the project, a detailed starter pack is given out. This provides the students with key information such as the FSAE rules, lab working and Formula Student server guidelines, contact details, results of the preceding year's car entry and most importantly, key deadlines for the coming year.

The undergraduate final year timetable has an allocated three hour slot each week for Final Year projects. During this period the whole team meets to review and discuss progress of the project, which now takes place within the new L77 facility. However, more team meetings are usually arranged during the week around undergraduates' availability.

In the initial few weeks of the term, the familiarisation of the car setup and handling is an important aspect for the analysis and development for the new design, whilst also providing a good teamworking exercise. The intent is to allow the students to gain hands-on experience of the previous year's car. This would involve a testing day at the Bruntingthorpe Aerodrome.

Team students are not only responsible for their assigned area of the car, for example suspension development, but also would be asked to help with additional generic components of the car.

During the first two months, some major design decisions are made. The design process involves a retrospective analysis of previous years' designs to establish what is considered to be a good design and manufacturing method. The design philosophy that the team learns to understand in order to succeed at the Formula Student event, is that there are three elements that are important to the car's design: - its ability to accelerate, decelerate and corner.

In experiencing the performance of the car, the students can relate this to the demands of the Formula Student event. The most efficient setup of the car requires the engine and drive train to be functioning at its optimum level, providing quick responses for the short straights, tight corners and meandering track.

To improve the acceleration potential, the weight of the car must be a major consideration for the design of individual components. This is because of the limitations imposed by developing the power output

from the engine, with 20mm airflow restrictor³² being in place. When referring to acceleration being *force per unit mass*, then obviously mass now needs to be the main area of improvement.

The reduction in the overall weight of the car produces better responses to cornering. This is due to the moments of inertia being reduced around the centre of gravity.

The performance and reliability of the components within the car is fundamental. A design that is relatively simple, engineered correctly and tested will immensely contribute towards success in the competition. Design ingenuity, cost appreciation, quality and functionality will also contribute to successful marks within the static and cost event. These philosophies are applied to the design concepts ensuring that a balanced method of approach is maintained.

The analysis and testing of the previous car over the first few months, provides the Team with a grasp and understanding of working collectively to support the design philosophy. The team is also guided into looking at what can be learnt from other teams' cars, but not take too literally the view of adopting other teams' designs without significantly questioning their design theories.

The decision process for the design is collectively made as a team and involves fully detailing the restrictions and specifications, which will limit the car design. These may include: engine; transmission; roll cage; suspension; fuel cell size; wheels and fixings. Additionally, an assessment of resources available is required, in order to achieve the team's design intentions. The teamwork during this period is crucial, in order to ensure a milestone for the design finalisation, which is set through the project time plan.

One of the main problems consistently recurring during the design stage is the control and management of the SolidWorks assembly data files. The background history and analysis behind the problem is presented in Section 8.0.

With the designs fixed, the team members can then concentrate on producing a programme plan for the manufacture and production of their areas. This plan would be made in collaboration with the Program Management and Team Managers, with a perspective on how the car needs to be built and the assembly process.

With the nature of time spent working closely as a team, an active "social scene" is developed and encouraged. Automotive themed events are planned throughout the academic year to provide an

³² Stated in the FSAE rules.

opportunity for a change of scenery, whilst still providing stimulus and creativity that would help benefit the project. Such activities and events organised would include Motor Shows, Formula Student conferences, Go-Karting and Automotive lectures.

The IMechE organise a Formula Student event called ‘Learn to Win’ during the first month of the academic year, the intention of which is to give teams a full breakdown of the competition, particularly in respect to what the judges are looking for. This is an excellent opportunity for the team to attend and to gain vital exposure to what is expected.

The build phase of the car requires a considerable amount of man-hours from all those involved, with the objective being able to have a complete car for testing before the competition event. There is an understanding within the team as the final year students prepare for the examination period, that flexibility is required in commitment during this time. Within the nature and timetable of the university academic year, there is sufficient time available once the exams are completed, for the main manufacturing and assembly phase to take place.

11.1.1 Team Development Stages

Reviewing the “five stages of development”, Forming, Storming, Norming, Performing and Adjourning,³³ the Formula Student Team project exhibits the characteristics of evolvement through these individual stages at the start of the academic year. Controlling and identifying the problems within the team development process is important, as this will maintain motivation and commitment to the team.

The “forming stage” reflects the initial introduction and first meetings of the team, how the management and Formula Student Team is co-ordinated and the working practices and process. The induction into the team during the forming stage is an area that could be addressed, particularly the induction process, as this will increase the prospects of a stronger teamworking relationship at the initial design discussion.

The “storming stage” is the point where team personalities will begin to breakthrough. With an improved forming stage, the potential for conflicts and disagreements can be limited and a more unified team can be formed, this leads into the “norming stage”.

³³ Management Fifth Addition, Richard L Draft, Page 609

Once the established working practices become routine, in terms of team communication, technical assistance, design reviews and an understanding of the balance of Formula Student time allocation to specific course requirements during the course of the first academic term, the “norming stage” is reached.

The “performing stage” happens when the team transitions to a unified focus to solve problems and work effectively towards the objective of competing successfully in the Formula Student Competition. A high level of commitment is reached from team members during this stage.

Finally, the “adjourning stage”. During the course of the Formula Student Competition event, it is usually evident that a realisation that the accumulation of a years work is almost at an end. Once the competition is complete, the team will be disbanded, with only the formal process of graduating from Aston University to remain. A social event is held to signify and acknowledge the contribution from team members and to celebrate the commitment, effort and success of the team.

The appreciation of these five stages will assist in the improvement of the working practices and efficiency of the team, with the emphasis on transitioning from the initial “forming” to “performing” stage in a shorter duration. This will aid both the design review stages, but also improve schedule adherence.

11.2 Student Motivation

A definition of motivation is provided below:

Motivation, the arousal, direction and persistence of behaviour³⁴

Understanding the motivation factors within the Formula Student Team is an important issue, as this will ensure a high level of commitment and performance throughout the academic year. Initially, the concept of designing and producing a functioning racing car would appear to be a daunting and challenging task, particularly combined with balancing other course commitments. The motivation aspect in order to adhere to the schedule throughout the project is essential to the progress of the team. The ability to keep a perspective of the end goal is encouraged throughout the team management structure.

³⁴ Management, R .L. Daft, Fifth Edition, Page 534

“Motivate your staff to be independent. If you have been a good leader, they will have the determination to succeed on their own.”³⁵

Discussing and analysing the individual team member’s motivation will assist in overcoming problematic milestones within the schedule, whilst also aiding the resolution of conflict and potential waning of commitment. The postgraduate Team Managers will need the ability to identify a potential issue quickly, whilst also formulating a solution and deciding on a plan of action. This is an attribute that is needed to help keep the project on track and the team working in a cohesive manner.

J.M Juran (1988)³⁶ presents and discusses theories of motivation, in particularly McGregor’s ‘X and Y theories.’ These describe an approach to work in general, where motivational traits and assumption of adopting a working environment can be split and grouped into X or Y categories. The importance of differentiating between the two Theories could lead to greater organisational performance and efficiency.

The X theory category assumes workers are required to be influenced by management to perform at the required standard. Management need to supervise workers closely in order to achieve the expected work, which is broken down into specific and simple tasks. No trust is evident between management and the worker.

The Y theory takes a different approach in assuming workers are able and willing to exercise self-control and direction. The workers have a drive and determination to accomplish a high standard of work, with a significant level of trust being established between management and the work force.

The Formula Student Team firmly fits within the Y Theory category. However, what can be applied from this knowledge to the direction of the team is a greater establishment of trust. The differences highlighted from the research, both in terms of the context of Industry and Formula Student, is that this research is fundamentally a study of a manufacturing Industry, not a Higher Education Institution.

The uniqueness in motivation between Industry and Formula Student are as follows:

- Higher Education Institution – Students desire to learn and graduate with a credible degree to secure future employment.

³⁵ Margot Morrell, Stephine Capparell. Shackleton’s Way, Page 199

³⁶ Juran’s Quality Control Handbook, Forth Addition, J.M.Juran Page 10.5

- Final year project accounts for 20% of the overall year grade, greater influence on the classification of the degree.
- Benefits of being involved with a world renowned competition throughout the academic year. Networking opportunities and access to further research opportunities.
- Represent the University and directly compete against other university teams.
- Enhance Curriculum Vitae for employability.

11.3 Team Management

With the expansion of the Formula Student Team, the co-ordination and management practices provide a pivotal role in the success of the project. Understanding the fundamental difference between leadership and management and how the current approach can be improved, will complement the implementation of PDMS.

The postgraduate management and leadership style is solely based on the student's previous experience. It is a learning curve for all those involved, which could be greatly improved with some background understanding and initial practice beforehand. With the growing numbers of postgraduates involved within the project, there is scope to provide guidance and development on identifying the fundamental principles of management which will directly benefit the team and personal development,

There is a fundamental difference between leadership and management:

- *A leader is setting a new direction or vision for a group that they will follow, i.e. a leader is the spearhead for that new direction.*
- *Management controls or directs people/resources in a group according to principles or values that have already been established.³⁷*

John Adair is a world leading authority on leadership and management and one of his models covers action centred leaders. The postgraduate student role can identify with and would benefit from learning these characteristics. The success of the project is dependent on the ability to effectively lead and manage

³⁷ Definition taken from www.teamtechnology.co.uk/leadership-basics.html

the complex requirements and demands of the project, working in cohesion with the team and university staff.

Bolden, R. Gosling, J., Marturano, A. and Dennison, P. (2003)³⁸ provide a comprehensive review of leadership theory and management. John Adair action leadership is fully discussed and his model presents the following key requirements:

- Direct the job to be done (**task** structuring)
- Support and review the **Individual** people doing it
- Co-ordinate and foster the work **team** as a whole

How these individual elements interrelate is shown in John Adair's Model of action centred leadership in Figure 24 below.

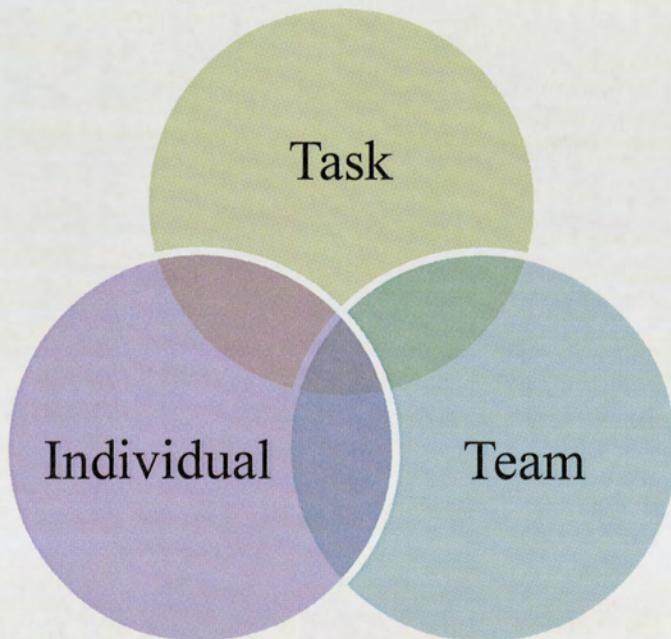


Figure 24: Action Centred Leadership Model (Adair 1973)

³⁸ A review of Leadership Theory and Competency Frameworks - Bolden, R., Gosling, J., Marturano, A. and Dennison, P 200

The three circle diagram is an effective visualisation tool in providing an understanding of how to differentiate between the requirement of being an effective leader or manager, in relation to the task. A situational awareness and evaluation on the required task will determine the necessary response by the leader. The various circles will either grow or contract depending on the emphasis on effort required from the leader.

Each of these circles present the leader with various challenges that have been summarised below.

Task:

- Defining of the task
- Make the plan
- Allocation of work and resources
- Control of quality and rate of work
- Checking of performance in relation to the plan
- Adjustments required to the plan

Team:

- Able to maintain discipline
- Build team spirit
- Encourage, motivate and inspire
- Ensure communication
- Develop the team

Individual:

- Attend to any personal problems
- Praise individuals
- Give status
- Recognise and use individual abilities
- Ability to develop the individual

In recognising the points outlined above, which are associated with Action Centred Leadership Model, the postgraduate students will be able to exhibit some rational to solving particular problems that will arise during the course of the project, and thus improve the overall handling and resolution of the situation. For

example, this can be related to a conflict within the design stage, a logistical issue within the project or an underperforming team member.

The paper also identifies and discusses various leadership styles from Tannenbaum and Schmidt's Leadership Continuum, which the postgraduate team students will exert during the course of the project. In outlining these traits, the intention will be to provide an appreciation on where these can be applied more appropriately to various situations to achieve a more beneficial and effective outcome. There are four main types of leadership identified, which are: Autocratic, Persuasive, Consultative and Democratic. An explanation of each is as follows:

- **Autocratic:** The leader takes the decisions and announces them expecting team members to carry them out without question.
- **Persuasive:** The leader takes all the decisions for the group without discussion or consultation but believes that people will be better motivated if they are persuaded that the decisions are good ones. The leader will explain the decision in order to overcome any possible resistance to the required action. Goals set for the team will have a large element of enthusiasm and energy provided by the leader.
- **Consultative:** Team members will be consulted before the leader makes a decision. Consideration is given on both the advice received, including the team's feelings when forming the final decision. The leader does not always accept the team member's advice, but will have provided the feeling that some influence has been made. Under this leadership style the decision and the full responsibility for it remains with the leader but the degree of involvement by subordinates in decision taking is very much greater than in telling or selling styles.
- **Democratic:** Using this style, the leader would characteristically lay the problem before his or her subordinates and invite discussion. The leader's role is that of conference leader, or chair, rather than that of decision taker. He or she will allow the decision to emerge out of the process of group discussion, instead of imposing it on the group as its boss.

Leadership has been researched and discussed for a substantial amount of time. However, a few essential characteristics the postgraduate students should be aware of and can personally develop are:

- **Integrity:** - Being able to demonstrate appropriate values and standards. This underpins trust between the leader and the team, whilst also inspiring and reciprocating loyalty.

- Vision: - This is underpinned by intuition and being able to create a shared vision of success to the team. A vision comprises three distinct areas:
 - The end goal – the point at which forming the vision starts
 - The way to achieve it – as thinking about the vision matures
 - The means to achieve it – at which point the vision is exposed to other influencing factors

How the vision is achieved comprises the following: The leader alone, the leader with some input from the team, the leader working in conjunction with the team

- Communication: - This can be broken down into three areas: oral, listening and writing. The power of communication will help with influencing and persuading the team, whilst also building confidence and encouraging teamwork.
- Decision Making: - Ability to evaluate information, with clarity of thought. Handle uncertainty and ambiguity. Decisive in actions, with risk management focus.
- Innovation: - Provide creative thinking in raising the standard of achievement, with an element of risk taking. Lead change within the team.
- Focused on Development: - Creating an environment that will enable the team to develop their potential. Can develop people and encourage future project leaders,

11.4 Teamwork and Leadership Summary

It is important to reflect on the concept of the Formula Student project. The experience is designed to provide an educational engineering challenge, with an element of enjoyment. However, to drive towards an effective business strategy and adapting to organisational changes, strong transformational leadership, which creates significant change in both followers and organisation³⁹, is required to succeed. This is a continuing issue highlighted within the research presented in Section 10.0

In understanding the five stages of team formation, the transitional period should be monitored and improved to reach the “performance stage” in a shorter duration. Developing a more suitable induction training package to address the transition speed would aid the team formation. Establishing improved working practices and guidelines, organising design innovation workshops, visiting motorsports

³⁹ Management, R .L. Daft, Fifth Edition, P521-522

competitions or seminars, testing the previous car fully, would have the potential to encourage a strong teamworking bond.

Commitment needs to be sustained by the team throughout the academic year, as this is a recurring problem. From understanding the student motivational aspects, establishing an environment of mutual trust and value balancing project goal setting in respect to university course commitments, would increase full participation during the year.

The postgraduate team leadership is primarily shaped on the student's previous experience. By reviewing the historical lessons learned, there is sufficient evidence to support a greater understanding of the leadership and management skill-set and attributes required, that could be developed before the start of the academic year through appropriate training. The understanding of John Adair action centred leadership model, is a suitable tool and technique that can be used through various design reviews, or conflict during the challenges faced throughout the course of the project. This will contribute to achieving the full potential of the Aston University Formula Student Team to win the competition.

In distinguishing the differences between leadership and management, the approach to tackle various tasks and challenges that the project will present, will aid the learning curve of the postgraduate students and provide considerations for the KSFS for the PDMS implementation. Increased exposure to leadership and management theories, tools and techniques, would vastly improve the running of the project; contributing to tighter control of the project deadlines throughout the year.

12.0 Team Data Handling and Access Practices

The team data handling and access practices was highlighted as a critical area to be further discussed and analysed in the summary of Chapter 1. The guidelines issued to the project team on accessing and saving SolidWorks components, assemblies and drawings were continually improved throughout the duration of the academic year. These necessary changes led to confusion on which practice was being used at any one particular time, resulting in files being incorrect, either at the latest issue or contained within the car assembly model. The additional time to investigate and rectify these problems caused significant delays during the design stage, which ultimately increased the risk on referencing the incorrect information during manufacture. As previously discussed in Section 10.0, the ability to access and reference the correct issue of data is a critical element to business performance and efficiency.

To demonstrate why PDMS is essential to the development of Aston University Formula Student Team the following discussion and analysis is required:

- Review the Formula Student Team historical data handling management issues of the SolidWorks software package
- Detail the functionality of PDMS with respect to the requirements and benefits PDMS will offer, in terms of configuration management, design specifications and product life cycle

In presenting the current position against the functionality benefits of PDMS, the KSF requirements can be fully identified. This also assists in the development of the strategy for configuration management control, providing a baseline against which to standardise the working practices against.

12.1 Historical Analysis of Data Handling Practices

The investigation into the historical data handling practices will cover the following areas:

1. The Formula Student server allocation and access
2. The AM05 data organisation
3. The AM06 data organisation
4. The AM07 data organisation

In providing the context for the current Formula Student Information Systems server allocation and the analysis of the previous three academic years, a detailed understanding of common problems will be highlighted. This will establish vital learning points from previous failures, whilst demonstrating the best approach to be taken to adapt the working practices.

12.1.1 Formula Student Server Allocation and Access

The initial implementation of SolidWorks in the University School of Engineering required the creation of a separate hard drive within the engineering department IT server, detailed as 'Frank' by the University ICS department. The allocated drive was for the dedicated use of the Formula Student Team.

Access to the hard drive required a network directory and password, providing a secure connection in mapping the student's computer to the drive. (A feature requested during the initial requirements of installing SolidWorks, providing control and security to the project data.) As the server was directly connected the university network, the Formula Student Team was therefore not restricted in accessing the server at any point in time. The only criteria being that the computer used had to be connected to the university server system.

To appreciate the time taken and detail required for the working practices to map the computer and access the 'Frank' drive, the following process was taken.

Firstly, the My Computer icon needed to be opened. Then on the Tool Bar, select Tools. This would produce a drop down menu. The option Map Network drive would then be selected. The following screen is then produced, shown in Figure 25.

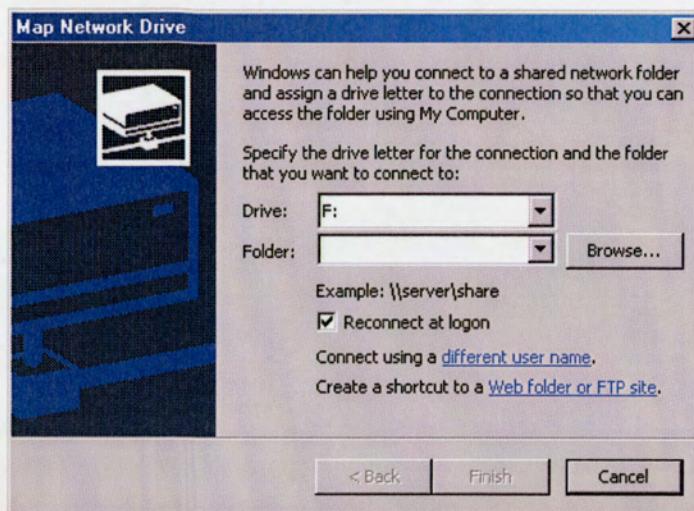


Figure 25: Map Network Drive Log In Screen

In the folder option box, the directory to Frank would be inserted. This would then access the hard drive and prompt for the user to enter the password.

The folder directory on Frank was setup to allow ease of navigation for users to various sections of the project. Each year a new folder would be created for the new team at the top directory level of the Frank. I.E FS2004, FS2005 etc.

Due to a technical problem with the Frank hard drive (the root cause of which is explained in Section 7.1) a new drive and server space had to be found within the university.

The ICT department allocated a separate drive on a new university server. Gaining access to the new hard drive used the same process as Frank, with the network directory name as follows <\\eas-auth\\cad>. Controlling access to the drive was stipulated during the initial setup of the drive, where the ICT controlled which student's login profile would be required for access.

The benefits of the hard drive being on the new university server provided greater storage space to be allocated for the project, which could be increased without affecting access or potentially corrupting the data. Other benefits include:

- Continual backup of drive data
- Ease of maintenance and monitoring provided by the ICT department
- Faults and lost files can be corrected very quickly

12.1.2 AM05 Team Data Organisation

The AM05 team (2004 - 2005 academic year) was the first year that showed prominent signs that SolidWorks was being utilised to its full potential. The most complex CAD assembly was produced to date since the department first upgraded to the SolidWorks software package. The size of the main car assembly is 15.3MB, with over 200 individual components.

The folder directory setup to control and maintain the SolidWorks car assembly within the AM05 project folder is shown in Figure 26.

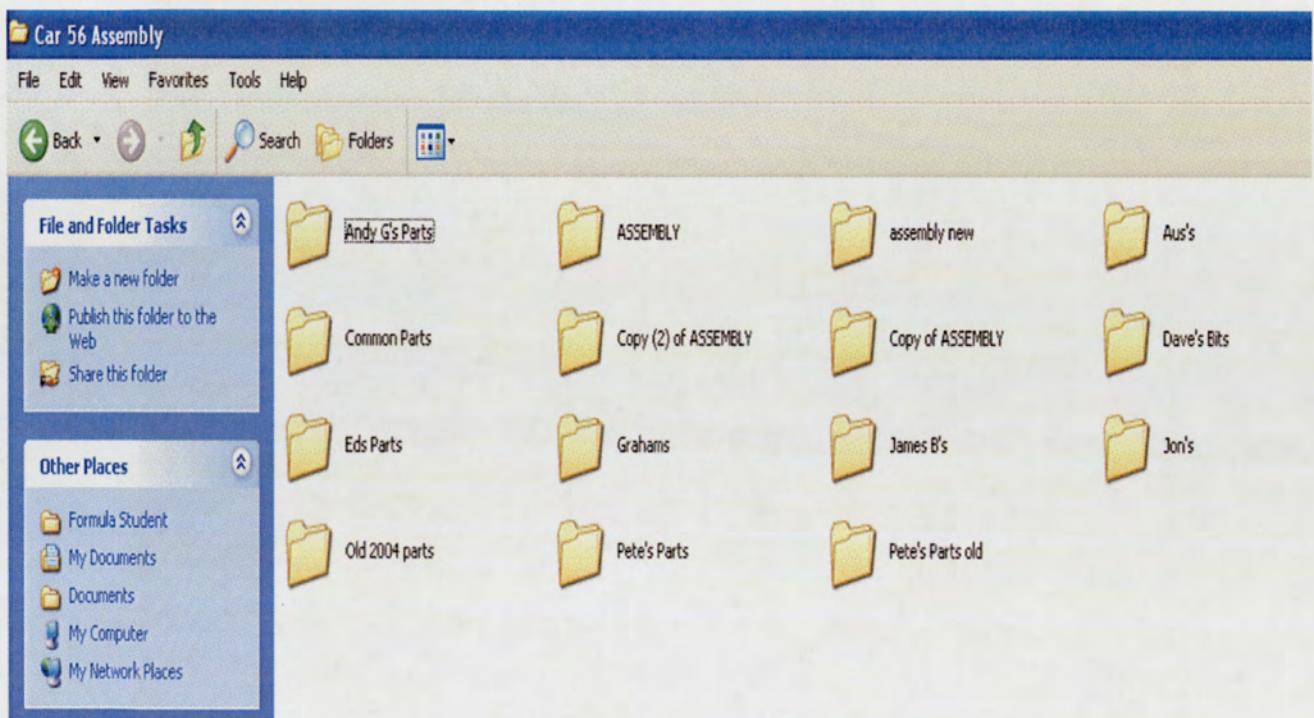


Figure 26: AM05 Car 56 Assembly Folder Structure

The scope for the folder setup was to allocate each student an individual folder for their SolidWorks components, which would then contain any sub assemblies for their assigned responsible area of the car.

The relationship process from drawing components to creating an assembly, is as follows:

In using the example of designing a brake disk, the student responsible would draft a sketch of the component and detail it. When completed, an assembly would then be created for the overall wheel setup. This would consist of several detailed modelled components, which in turn the student had individually drafted. These components would be brought together to form the main wheel assembly, usually consisting of brake disks, brake callipers, wheel hubs and uprights. When the modelled components were inserted into the wheel assembly, SolidWorks would then save the folder path location, creating a reference network.

The next process would be to construct a sub section assembly for a particular area of the car, e.g. full suspension assembly. These subsections assembly names would be as follows: full suspension assembly, engine and drivetrain assembly and chassis assembly.

These individual subsection assemblies would be fully detailed with all the required assemblies previously created for that particular area. In referring back to the full suspension assembly example, this would consist of wheel assembly, suspension design assembly and mount points.

With these subsections complete, a main car assembly folder would be created, consisting of the full car assembly file; this folder would contain all the subsection assembly files of the car. The logic behind this is that the main car assembly would be constructed from the subsection assemblies, thus reducing the number of individual modelled components contained within the main assembly and limiting the referencing network SolidWorks automatically creates. A structured diagram of the relationship logic for the main assembly is detailed in Figure 27.

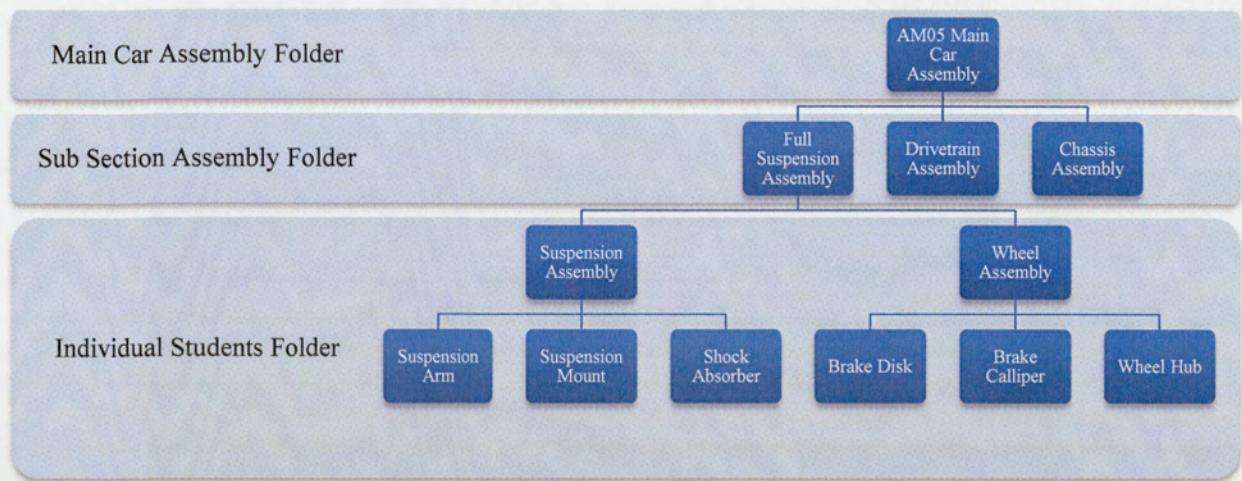


Figure 27: AM05 Assembly Relationship Logic

The idea behind the initial folder logic was to allow the student to be able to modify their individual model/assembly separately, without having to open the full main assembly, risking changing certain relationships and references between the modelled components. Once the student design had been updated and saved, the section assembly would be opened, this would detect that certain component models had been changed and automatically update. In turn once saved, the main car assembly could then be opened.

12.1.2.1 Problematic Areas

In theory this structured approach for setting up the student folders provided a logical way for the reference paths to work. However, during the main design period, the management of the data files proved to throw up quite a few problems.

One of the main problems that consistently arose was not being able to open the main car assembly or components from the Formula Student Team hard drive. The cause of this issue could be due to the following reasons:

- The latest version was closed incorrectly.
- Two people are trying to open and access the same assembly, but are unaware of each others' requirement to do so.
- There are different versions of SolidWorks installed within the university. For example, the two PC's located within the Formula Student Garage had SolidWorks 2005, whereas the design studio Lab L77 had the latest version of SolidWorks 2007. If an assembly is opened and saved on the latest version, when a team member tries to open the file on the old version, this would cause formatting problems and deny access.
- The PC that the student is using SolidWorks from has different ownership settings when the assembly or component was last saved and closed. This would mean that when the assembly or component is closed, the ownership settings would change due to the PC user login settings. The change would take place without their prior knowledge, thus denying access to anyone else who tries to open the assembly. Only through the initial user reopening the file and changing the settings within SolidWorks would the problem be corrected.

This problem led to the abandoning of the standard working practices and instigating a temporary solution, which would involve copying and pasting the assembly file, reopen the copied file and continue to work on that. The confusion caused by this action of copying the original, meant not only would the relationships to the latest components be changed, but also the team would not know which assembly was the correct current issue.

Problems also arose from the reference locations and ownership being changed for individual student components. I.e. they had reorganised their individual folders, thus creating referencing issues with the main car assembly.

Students were also unable to tell if the main car assembly they had opened was indeed the latest issue or that if a fellow team member was currently working on the file via another computer. The software also periodically failed to state who/where the file was open. With the inability to inform the user of the correct version of component, this meant time was lost by students with problems of overwriting the correct files, or issues with saving all the referenced parts within the assembly. This continual access problem meant that further iterations were being created of the main car assembly, as either the referencing of components within the main assembly were being changed or not being able to allocate the correct file. Thus, allowing additional confusion over which file was the latest issue.

12.1.3 AM06 Team Data Organisation

At the start of the AM06 team formation (2005 - 2006 academic year), an attempt to address problematic areas was initially approached by changing the folder network system, and how SolidWorks would reference parts within the main car assembly. The logic of the revised referencing map is shown in Figure 28.

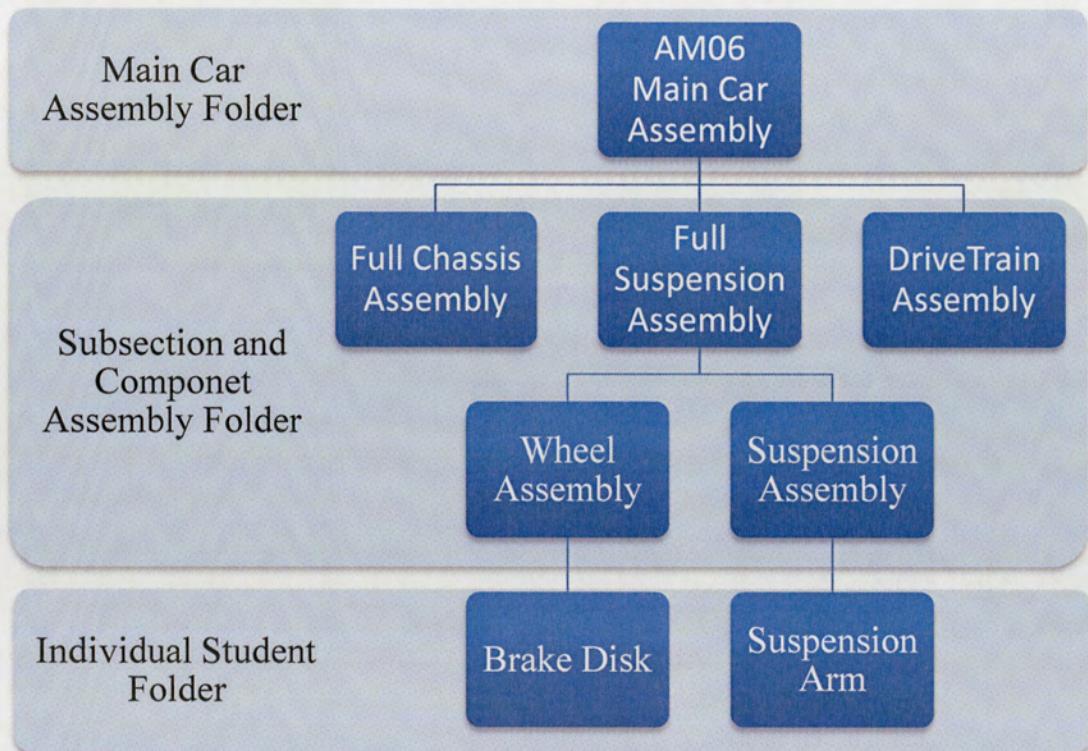


Figure 28: AM06 Assembly Relationship Logic

The proposed solution was based around removing all the assemblies that would be found within the student's folder, and using one subsection assembly folder to house all the required assembly components. This would provide shorter referencing paths and remove the ability of students to rearrange the components within their personal folder.

12.1.3.1 Problematic Areas

The combination of revising the folder relationship logic and with up issuing the instruction guidelines to the team, didn't fully resolve the continual problems seen during the AM05 project. The ownership reference for the assembly files hindered the project, causing repetitive recreation of the main assembly.

12.1.3.2 AM07 Team Data Organisation

The AM07 team (2006 - 2007 Academic year) attempted to continue with the same process used for AM06, but with consistently recurring problems, a radical reappraisal of the folder system was undertaken. The solution proposed was to use a designated stand alone PC with a SolidWorks licence, set up in the Formula Student garage. This had a fully updated master copy of the assembly located on its hard drive. This was then elected as the only work station that could be used in the university by the team. Access would then be limited to one individual at any given time, but would allow full control by the Team Managers. Periodically the master copy would be transferred onto the server hard-drive for backup.

However, to update the main car assembly required the student to redesign the specific component on another SolidWorks PC station and then transfer the saved file onto the main stand alone PC. The referencing system used for the main car assembly follows the same logic as AM06.

12.1.3.3 Problematic Areas

The root cause identified for this problem was identical to the AM05 problematic issues. The inconsistent versions of SolidWorks installed in the university computer labs directly contributed to the underlying systemic problem experienced.

12.1.4 Summary

From the analysis of the data handling issues encountered during the AM05 to AM07 teams, the following requirements to be addressed are:

- Establish a configuration management control system for the SolidWorks data, by defining an index for parts numbers and what the requirements will be for a part number change or up issue; following the criteria of fit, form, or function.
- Provide around the clock access from any of the university computer facilities.
- Allocation of a separate server or hard drive for storage of design data and rules only. The general information and associated departmental files should be separated for Formula Student.
- Provide communication and traceability of the current files being opened and edited.
- Establish a robust working practice.
- Provide the facility to attach and flow down the individual FASE rule requirements to the associated SolidWorks parts or areas.
- Resolve the conflict of saving current versions of files on the server.
- Eliminate SolidWorks software crashes when altering design files on the network.
- Define a project life cycle, with base lining a design through the iterations and development stages of the design period.
- Abolish the need for continual copying and reiteration of the assembly, improving the reference and relationship logic for SolidWorks.

By tackling these identified requirements it will assist the team efficiency and performance. This can be quantified against the following criteria:

- The duration of time required to formalise the final design car.
- Increased participation of project supervisors with the ability to advise and assess the latest designs.
- Reduced quality escapes in manufacturing the incorrect components.
- Traceability of all part numbers throughout the design stages. This will also aid the formation of the cost analysis for the Formula Student Team.
- Each applicable FASE rule is associated and referenced against an index of parts and assemblies.

12.2 PDMS Functionality

To highlight the scope of the functional benefits that PDMS brings, an overview of the approach to the general data management system process will be discussed, with reference to configuration control of the

SolidWorks data files. The facility to implement project life cycles and how this will be managed will be considered, particularly the traceability benefits and the ability to baseline an initial design. A review of the approach required for the infrastructure to be setup, to distribute specific user access and administrators, and how this reflects the interplay between personnel is required.

Through establishing the functionality benefits, comparisons can be drawn to the context of the Aston University Formula Student Team requirements, providing a framework that will identify the KSFs criteria for implementation of the PDMS.

12.2.1 PDMS Functionality Overview

Within the Engineering Industry, particularly Automotive and Aerospace, project data is stored in many different geographical locations, departments and computer servers. Providing networking access to the required data is problematic. The PDMS is constructed to provide the facility of a structured configuration management process and centralised storage system to all the specific elements that are associated with a particular individual component, assembly, drawing and document, in a structured process for information.

The standardised system that PDMS establishes ensures a secure controlled method of traceability, for the creation and associated required changes to the data, in relation to a particular product. As an example for the design development stages, PDMS would provide a configuration management control for the design of a car engine. The associated documents can be linked and attached to the related part or product, either being design specifications, rules, manufacturing process and drawings or assembly methods.

The installation of PDMS within a multinational organisation would see the creation of the designated computer servers, specified to potential storage capacity of the information required, with a certain amount of contingency to provide additional storage space. Access to the server is controlled by a secure network user function interface within the PDM software, which is maintained and controlled by the PDMS server administrators. The configuration of servers and network will provide 24hour multi-user access from around the globe, which is crucial to large organisations.

The functionality of PDMS allows check in and out specific data files to modify, which are tracked by the software, detailing current user ownership and location. The ownership of the data when it is checked out

of PDMS is transferred to the specific user, providing full responsibility, thereby eliminating the conflict of other users seeking access to the same file. This stops duplicate check out and opening of data. The data file will only become accessible again to other users once the file is checked back into the PDMS server, and the user ownership is subsequently released.

As previously discussed in Section 9.0, the complexities of the specific requirements for the PDMS in multinational engineering organisations is substantially advanced. The focus being on the user interface and interaction on the PDMS, networking and configuration process associated with Computer Aided Design (CAD) data that would be produced from software packages such as Catia or SolidWorks.

An illustration of the data interface and product relationships that would be found in PDMS and how they would directly relate to each other is shown in Figure 29 below. The example used is of a generic aircraft design.

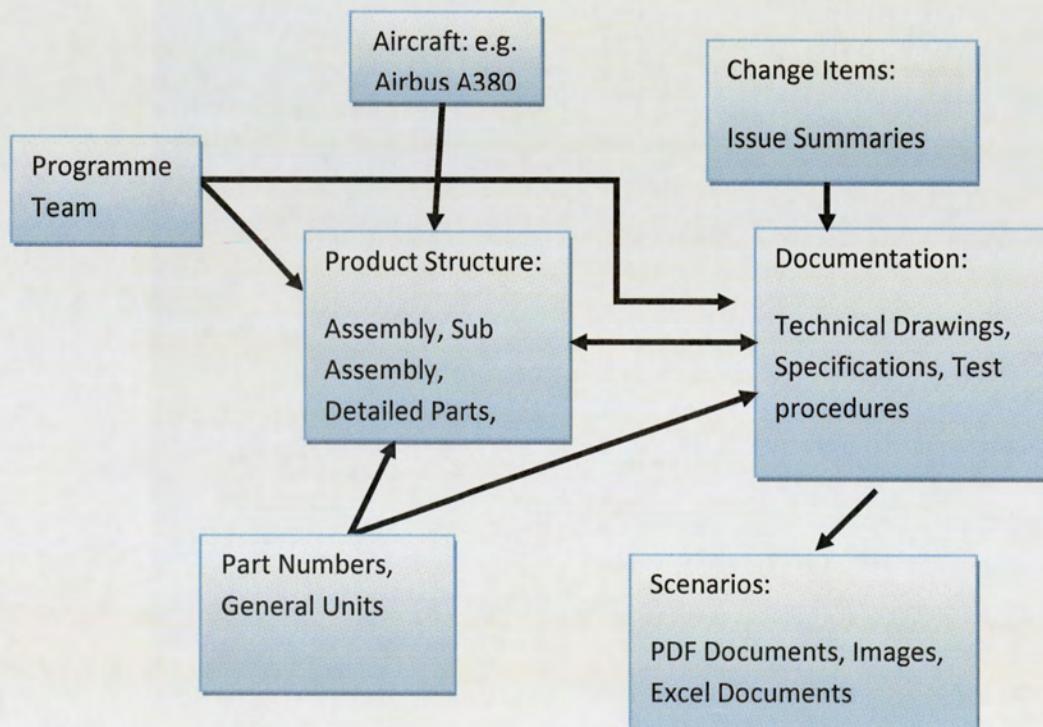


Figure 29: Overview of PDM Object Relationships

Within any new product development process, the CAD data will go through several iterations and issues. The relationship and networking structure that the new design assembly creates, specifically for SolidWorks, and how the data relates to other documents is presented in Figure 30.

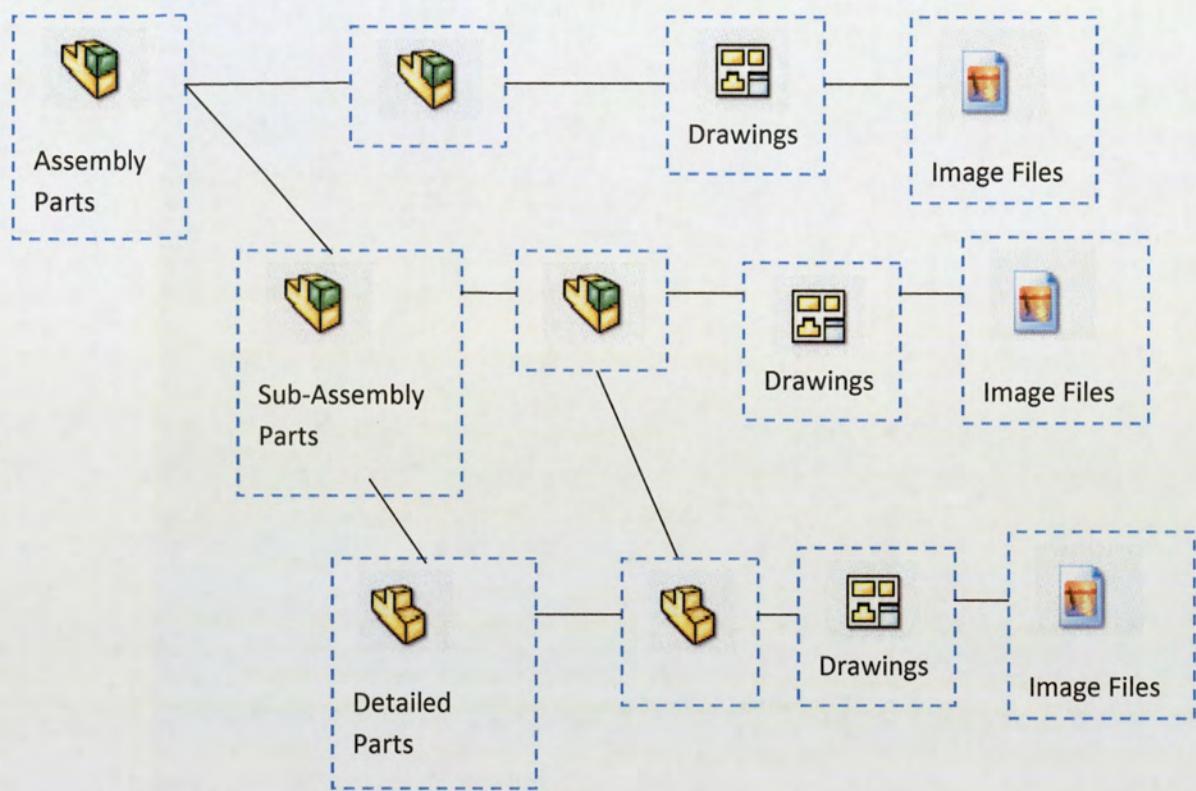


Figure 30: CAD Data Assembly Relationship Tree

Checking in a new CAD data file into the PDMS requires additional part number information for the PDMS, in order to maintain traceability throughout its development and product life cycle. Specific details that would be requested are: part numbers, part descriptions, ownership details (if required), additional CAD drawings, material data sheets, costs, etc.

The PDMS generates a revision index system for new parts that are checked into the system that can be individually tailored to a particular project with either a numerical or alphabetical style.

The revision systems are crucial for the communication on latest part numbers and assemblies. An example of how the configuration management control process for SolidWorks would work for multiple part assemblies, by checking out of the PDM, modified and then checked in, would consist of the following:

If a part assembly is checked out of the PDMS with a revision status of B, with Parts Nos 1, 2, 3 and 4 at B. Then Part No 2 is modified and up issued to a revision C. When the whole assembly is checked back in, the PDM will be able to distinguish that only Part No 2 has been changed, not the whole assembly, and will maintain the current revision at B for the complete assembly. However, if Part No 2 were to be exchanged with a new Part No 5, then the assembly would be up issued to a revision C. This control of revision detail allows full traceability of the Part No changes to be documented. This is an important process for auditable purposes, in being able to meet Quality Assurance for ISO10007 standards. However, no governance as yet exists to control design data.

12.2.2 PDMS Project Life Cycle Management

PDM provides organisations that produce large complicated products the facility to control the data into a Project Life Cycle Management function. This enables the product to be controlled through the various stages of conception, design, manufacture, in service and disposal. It's a crucial process tool for the organisation, in providing controlled management and communication of the product process.

A life cycle defines a sequence of steps through which an object advances to enable moving from one state to another and/or from one location to another.

An object (Part, Document, Drawing) moves through an ordered series of states, typically beginning in a work-in-progress state and progressing through various states to release or obsolescence. This sequence of states is termed a life cycle.

Life cycles are defined for each type of object within PDMS. When an object is ready it may be submitted to its life cycle, subsequent management of the object will be controlled by that life cycle process.

This is an important aspect for the company's ability to be able to control the quality management and standards that are governed through ISO10007.⁴⁰

ISO10007 dictates the Quality management, Quality assurance systems, Quality, Production management, Management, Management techniques, Industries, Accounting, Auditing (financial), Planning, Quality auditing and Identification methods. This vital standard needs to be achieved in order

⁴⁰ ISO 10007: 2003 Quality Management Guidelines For Configuration Management (International Organisation For Standardisation – June 2003)

for organisations to be allowed to manufacture and sell parts within their particular Industry. This is exceptionally relevant for Aerospace and Automotive Industries, with the stringent quality assurance requirements, governed by their respective Industry regulators. However, the software system is not directly governed or controlled by ISO0007, but demonstrates a process of conformity.

12.2.3 PDMS Infrastructure

The initial setup within a company would first establish requirements for the size and capacity of data the PDM program would have to facilitate. A PDM software company that was chosen would consider the size of the organisation, location, management systems used and expected data produced.

The IT hardware required to run the PDM system would be selected for the function and access required. Typically, in large complex organisations the PDM software company will tailor the program functionality to the requests of the company. The setup of the hardware system in some cases would mean the construction of a secure facility, providing protection from attacks and natural disasters. This facility would house all the required servers and administrating tools.

The hardware requirements would take into account the hard drive space required. This would determine the number of servers, RAM, server software, and processing speed.

Once the servers are established and set up, the process of appointing and training administrators, in parallel to identifying and allocating user names and passwords, would commence. The launch of the PDM software into the company would be a phased process, dependent on the scale of the company. For the system to go live, detailed instructions to users would be issued and training courses provided. A team would be setup to maintain and administer the PDM data for the company, this being essential for a global company in the ability to provide any assistance when problems occur at a moment's notice.

The standard layout of the PDM infrastructure of the IT hardware setup would be as follows:⁴¹

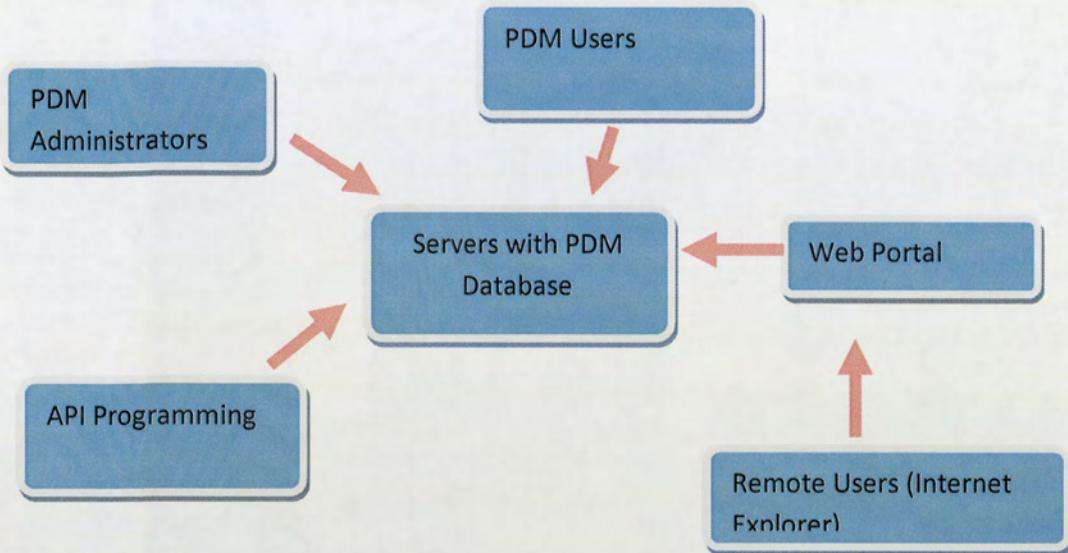


Figure 31: PDMS IT Infrastructure

12.2.4 Summary of Benefits of Project Data Management

In summary, the general overview of the functional aspects of PDMS and project life cycle has highlighted the following benefits:

1. Controlled and secure environment for the data to be maintained and managed, providing global network access to data at any moment in time.
2. Configuration Management Control, providing full traceability of changes throughout the product life cycle; essential for audit reviews.
3. Reduces the duration required to organise data or track data changes, with a centralised access structure.
4. Provides the organisation with a return on investment, due to improved workflow efficiency, communication and performance. This is measurable against money saved in respect to time being taken for tractability and communication of data cross departments.

⁴¹ Information derived from:

http://help.solidworks.com/2012/English/Installation/install_guide/c_workgroup_pdm_overview.htm

5. More effective communication work practices for the organisation and improves collaboration.
6. Provides a Project Life Cycle Management functionality.
7. Provides a user-friendly interface.
8. Provides assistance for quality assurance and ability to meet the ISO10007 standards.

This detail can be used for a scope of considerations for the KSFs identification for Formula Student Team.

13.0 Identification of Key Success Factors for PDM Implementation

Reflecting on the theoretical knowledge learnt, literature evidence presented and the research discussion topics throughout Sections 9, 10 and 11, the Key Success Factors can be identified for the implementation of PDMS for the Aston University Formula Student Team.

The KSFs can be split between two distinct parts:

- PDMS functional requirements for the Formula Student Team
- PDMS implementation requirements for the university

For each of the KSFs identified, a criteria needs to be established in order to consider the most suitable PDMS available; the intention being to limit the potential waivers against the PDMS requirements.

13.1 KSFS PDMS Functional Requirements

The specific KSFs for the PDMS requirements can be categorised into following areas:

- Data Management
- Access
- Cost
- Associated Documentation
- Life Cycle

How each of these areas translates to the Formula Student Team and the issues that are addressed is also presented.

13.1.1 KSF 1 – Data Management

1. Establishes a configuration management control system for the SolidWorks Professional (2007) data which has the facility and the ability to define the design change control definition of, fit, form and function. This should be provided through effective indexing and referencing, aid

support to the approval process for defining, draft, approved, released and obsolete data between the Team Management and Project Supervisors.

2. Provide suitable search facility, in terms of fields available. E.g. part name, ownership, part number, issue number, for review or approval.
3. The PDMS will be able to define user access rights, to support the administration and management of the data, separate from the team member's interface.
4. Allows complete simplistic traceability of part numbers, assemblies, documentation and drawings. Will resolve conflicts of data sharing with a secure user interface process control and communicate and acknowledge present status data, if being edited or available.

Areas addressed:

This will resolve the problematic data handling issues in providing a controlled and secure framework in the context of the data to be edited, reviewed and saved. As no formal configuration management system is in place to control the Formula Student Team Design data, PDMS will provide a traceability function for the team; improving communications and referencing to the latest standard of parts to be assessed during the design and manufacturing stages. The conflict of saving current versions of files on the server will be resolved and eliminate the need for continual copying and reiteration of the assembly; improving the reference and relationship logic for SolidWorks. This will improve the working practices of the team and reduce the time required to organise data for review and editing purposes.

13.1.2 KSF 2 – Access

1. Installation requirements for the hardware and software would be compatible to the specifications of the university computer network server infrastructure, allowing access to the PDMS across the university computer network; supporting 24 hour working.
2. Provide present statement of user ownership when the access is required to the parts for opening, limiting the conflict of multiple openings of the same parts.
3. Differentiate between different access rights for project team, for management and team members.

Areas addressed:

This would resolve the software crashes when editing SolidWorks data, with a controlled and dedicated SolidWorks server and hard drive, supported by the university IT department; full backup service readily available to recover data from any hardware or software crashes. The communication of which parts are currently open and which user has access to that part would be improved. The confusion regarding multiple versions of the same part would be addressed.

13.1.3 KSF 3 – Cost

1. Provide a suitable return on investment, balancing hardware and software costs against the benefits in improvements that can be measured through team working performance and efficiency during the design and manufacturing stage.
2. The ratio should be minimal expense to the Formula Student Team, with maximum identified KSF benefits. However, the requirement for PDMS software code changes to meet all the KSFs requirements should be avoided if possible, as this will increase costs.
3. The costs for maintaining the PDMS system should also be considered

Area Addressed:

The impact and cost associated with the project plan, with the time spent in resolving data management issues during the design and manufacturing stages.

13.1.4 KSF 4 – Associated Documentation

1. Facilitate attachments and flow down of the associated project supervisor review notes, specific FASE competition design rules and specifications for safety control; for referencing against a particular component or area.

Areas addressed:

As no formal practice exists within the Formula Student Team to index FASE rules against part numbers or areas, this would aid a configuration management process for the safety and quality review process during the design stage. Providing the facility to directly append review notes from project supervisors would increase the efficiency of the review process and aid the development of the design. As the associated documents are stored separately within the dedicated server, design rules, manufacturing process, directly linking these documents to parts within PDM would improve referencing time.

13.1.5 KSF 5 – Life Cycle

1. Allow the development of a Project Life Cycle Management facility to be formally implemented through conception, design, manufacture, in service and disposal stages. This can be aligned to the project milestones, but once the competition is complete, the designs should be stored instead of discarded. This would allow the new academic year to transfer the in-service designs to become the baseline point for the new project conception.

Areas addressed:

This provides the facility of determining the current status of the design and approval process, limiting the risk of manufacturing incorrect parts. This would also assist in scoping a clearer project schedule in defining the milestones for the design and manufacturing stages, with the emphasis on completing the manufacturing and assembly stages more quickly, allowing increased time for development testing.

13.2 KSFS for PDMS Implementation

Maintaining the approach used in Section 13.1, the following KSF requirements for PDMS implementation have been identified. These are:

- Organisational structure
- Access

- Cost
- Associated documentation
- Life Cycle

Each of the areas is compared to the context of the Formula Student Team and presents the issues addressed.

13.2.1 KSF 6 - Organisational Structure

1. Realign the organisational structure to a small business framework, either a Matrix approach or vertical structure, to provide most efficient and effective working performance. This should be measurable in terms of schedule adherences and of suitable lead-time for testing and development.
2. The PDM interplay would directly support and adapt to the new structure, utilising the benefits of KSF No 1 & 2; through the distribution of the administrators and user access. This also would support future expansion of the team.
3. Suitable training in leadership and management for the postgraduate team, to enable the transformation of the new organisational approach, ensuring the development and success of the project.

Areas addressed:

Improving the lines of communication and chain of command across the organisational hierarchy would minimise the potential conflict areas of technical direction and project management. This would also establish and maintain a routine for the working practices and process, which would eventually become embedded within the approach of the team and the context of the project. The transformation of the organisational structure would also aid in maintaining the knowledge through a more effective transfer between new academic students.

The leadership training initiative would facilitate the transition through the five stages of team development, maintaining optimal teamworking throughout the academic year.

13.2.2 KSF 7 - Project Plan

1. Generate a detailed project plan defining the stages of the installation covering: setup, pilot implementation and testing, training, workshops and full integration into the AM08 team.
2. Suitable contingency should be built into the plan for the pilot implementation and changes required. Before expediting the plan, agreement will be required from the Formula Student Faculty Manager.

Areas addressed:

Learning from the initial PDMS installation attempt and the knowledge from the research, a project plan would ensure all stages are scoped and accounted for, meeting the planned integration into the AM08 team.

13.2.3 KSF 8 – Testing

1. In combination with KSF No 6, fully test the implemented PDMS within the university facilities using a pilot scheme for a planned phased launch into the AM08 team.
2. Review the performance and lessons learned to refine the requirements where necessary, as this would form the basis for KSF No 9.

Area addressed:

Learning from the initial PDMS installation attempt, this would ensure that PDMS is fully functioning and tested, resolving any problems before integrating into the AM08 team standard working practices.

13.2.4 KSF 9 - Training and Workshops

1. The tutorial guides should enable appropriate supervised training to be given, whilst also allowing the process and practices to be easily continued for the next academic year.

2. The tutorial guides should be developed separately for both the management administrators and users, and distributed during the tutorial training seminar. This should take place at the start of the project.
3. The tutorial guides can also be introduced within the induction pack supplied at the start of the year.

Area addressed:

Whilst highlighting the benefits of PDMS to the university, this would also standardise and improve the data handling working practices, providing a configuration management control system throughout the project life cycle. From the awareness, guidelines and initial training, the transitional period into the team would be sustainably shorter, thus increasing the acceptance of a working routine. A common approach would be established as well as suitable forum for the design reviews and general feedback for the Formula Student Team.

13.2.5 KSF 10 - Business Strategy

1. PDMS business strategy for the Formula Student Team should be developed to provide the capability of expanding beyond the scope of the project and the use of the university facilities.
2. The potential to adapt and support external global access, which would aid an improved flexible working environment for the team, should also be a consideration. A secondary benefit that this factor provides is supporting increased resource available to the team, particularly honorary members and university staff.

Area addressed:

Provides a baseline to build a business strategy for the Formula Student project, demonstrating additional progress on improved work practices and performance, as this would provide an additional marketing tool to the commercial Industry to secure future investment and sponsorship. There is also scope for meeting the requirements to provide expansion throughout the School of Engineering, for use by other engineering team projects.

13.3 KSFS Summary

The identified KSFs would provide a clear assessment tool to evaluate PDMS software options, demonstrating the capability, whilst limiting the waivers on the specific PDMS requirements. In understating the functional KSFs first, this would provide guidance for the implementation of KSFs, due to the complementary relationship. The benefits of the two KSFs groups would achieve the most suitable solution to implementation of PDMS for the Formula Student Team.

14.0 Final Proposal for Introducing PDM

To facilitate the evaluation and derive the final proposal for the PDMS using the 10 identified KSFs, the following methodology was taken. Firstly, the PDMS software commercially available on the market was briefly evaluated against each of KSFs, identifying any potential concessions and ascertaining the suitable PDMS. Secondly, from the optimum PDMS solution, the final proposed implementation plan is presented, with a detailed justification against the KSFs.

14.1 Selection of PDMS Software

There are numerous PDMS products commercially available on the market. Some are specifically catered and designed for directly integrating into CAD software packages, whilst others specialise in documentation control. PDMS is a multi-million pound Industry, with large computer manufacturers such as IBM, specialising in bespoke servers and PDMS packages to large corporations. Other companies manufacture the PDMS software package to be an “off the shelf” product, but most tailor the system to specific users’ requirements.

ConnectPress Ltd⁴² provides a round up of the current PDMS software available, referenced in Appendix B. KSF Nos 1 - 5 are initially applied to the products, with a summary of cost, implementation time and compatibility. A synopsis of the products is presented in Figure 32.

⁴² Appendix C

Product Name	Cost per Seat Exchange rate applied \$1.5/£1	Average Implementation Time	Compatible with SolidWorks
EntraLink ERP2CAD	£1,263	3-5 Days	Yes
@UDROS PLM suite	NA	3-6 month period	Yes
CustomWorks	£581	1 Day	Yes
Design Data Manager	From £667	1 Day	Yes
RevZone	£330	1-10 Days	Yes
RuleDesigner PDM	From £667		Yes
PDMWorks Enterprise	£397	5-8 Days	Yes
DBWorks/DBInventor	£333-£667	2-5 Days	Yes
ToolWorks BOM Manger	£396	A few hours	No
ProductCenter	NA	Less than a month	Yes
Actvault	£667	Less than 1 day	Yes
PDMWorks WorkGroup & Enterprise	£667 - £1333	6-12 days	Yes
PDMWorks Enterprise	£530	4-8 Days	Yes
Synergis Adept Enterprise Data Management	£867	7-10 Days	Yes

Figure 32: PDMS Products Available

Based on the initial costing and accounting for the available compatible products, KSF No 3 played a significant role in selecting PDMWorks WorkGroup for Aston University Formula Student Team.

Primarily, the decision to opt for PDMWorks WorkGroup is down to the package being included in the current SolidWorks licensing agreement with Aston University. The cost charged to the university is supplemented by an educational discount, averaging £200 per user seat. No further expense would be necessary in obtaining the software. The secondary reason is the previous experience gained in testing PDMWorks WorkGroup during AM05 (2004 - 2005 academic year).

However, a second choice, if required, would be RevZone, by Elton Solutions. An overall justification for this selection is as presented in Figure 33 below.

KSF No.	Comments
1	Fully compatible with SolidWorks, with no requirement for software alterations.
2	Meets the criteria.
3	Most cost effective at \$495 US per seat. Product support available within UK.
4	Ability to attach associated data.
5	Feature available.
6	Potential to adapt to configuration management of administrators, users and groups to improved organisational structure.
7	Average lead-time to implement.
8	Familiarity and learning the interface with SolidWorks will be slightly longer.
9	Compatible.
10	Compatible.

Figure 33: PDMS Option 2 KSF Evaluation

14.2 KSF Evaluation

In comparing the 10 KSFs against PDM PDMWorks WorkGroup, the objective is to propose the final implementation solution, detailing any concessions required.

The detailed evaluation is presented below.

14.2.1 KSF 1 – Data Management

The PDMWorks WorkGroup is specifically designed to interact with SolidWorks, providing the required configuration management control systems. The PDMWorks WorkGroup data is housed within a Vault that is installed on a dedicated server, specific to the hardware needs.

The indexing and reference system is integral to the functionality of PDMWorks WorkGroup, with the ability to specify the changes that dictate version change to parts in terms of fit, form or function. Simplistic traceability throughout the design phase is provided, and in conjunction with KSF No 5, an approval process can be standardised for the life cycle.

The interplay and definition of administrators and users can be adapted to the organisational structure; KSF No 6 would detail the administrator and user privileges required.

14.2.2 KSF 2 – Access

The PDMWorks WorkGroup stores data within a Vault, which is housed on the specific designated server. The Vault installation requirement is that it should be on a designated server, with sufficient capacity for data storage and expansion. The general requirements for hardware and software will need to be understood. However, the hardware and software requirements are compatible with the university computer network, based on previous installation experience and with the present installation for SolidWorks 2007.

Access is granted to the Vault through a secure, password protected interface. The Vault has the facility to be accessed independently from using SolidWorks, providing a ‘stand alone’ access for control and storage of associated documents. As the PDMWorks WorkGroup can be supported by, and integrated into the university network, this supports the 24 hour access and running requirement. There is sufficient scope to provide external access to the server from outside the university facilities, though this will need clearance and sufficient privileges granted by the university ICT department. However, this will directly support KSF No 10.

Access rights to the Vault are determined through the Administrator privileges, detailing specific user names, passwords and privileges. In conjunction with this feature, additional security is also provided through the ICT department, as the department determines access to the designated server, governed by specific selection of university login identity.

With governance provided from the ICT department to determine appropriate user login access to the server, this complements and demonstrates that installation requirements for the hardware and software would be compatible to the specifications of the university computer network server infrastructure; allowing access to the PDMS across the university computer network and supporting 24 hour working.

With each user and administrator access being controlled by the PDMWorks WorkGroup software, no conflict would occur due to multiple access issue. This is due to the fact that each data check in and check out through the Vault is controlled, documented and communicated on the user identity, current version state, responsible ownership and location.

14.2.3 KSF 3 – Cost

The university SolidWorks software agreement provides the option of the PDMWorks WorkGroup as a bolt-on package, supplied within SolidWorks 2007 Education Edition. Therefore, no extra cost for seating will be incurred.

Consultation with the university ICT department would be required in supporting the hardware requirements and providing a cost estimate to meet the specific Vault needs. Although the anticipated cost is to be no greater than £1000, a quotation would be required.

The return of investment is substantially high in meeting the KSF criteria, with minimal concessions through the use of PDMWorks WorkGroup. There is no additional cost for software purchase, though the cost of hardware needs to be fully understood, but the expectation of cost is to be minimal. The cost of installation throughout the university facility is covered by the ICT departmental support for SolidWorks 2007 Education Edition.

14.2.4 KSF 4 – Associated Documentation

PDMWorks WorkGroup can be used independently to the SolidWorks software. Associated documents can be checked into the PDMS and referenced against design data contained within the Vault. The search field functionality is sufficient to detail and reference the required documentation, such as FASE rules, cost reporting files and project supervisor comments.

14.2.5 KSF 5 – Life Cycle

This functionality is available within the PDMWorks WorkGroup software, which can be tailored to the timescales and stages of: conception, design, manufacture and in-service. No project data should be deleted at the obsolete stage, as this would form the reference point for the start of the new academic year.

14.2.6 KSF 6 – Organisational Structure

On balance, the matrix approach provides sufficient scope to benefit the Aston University Formula Student Team. Based on the in-depth research findings and the associated measureable improvements previously discussed during this thesis, presented in Figure 34 is the proposed organisational structure for the AM08 team.

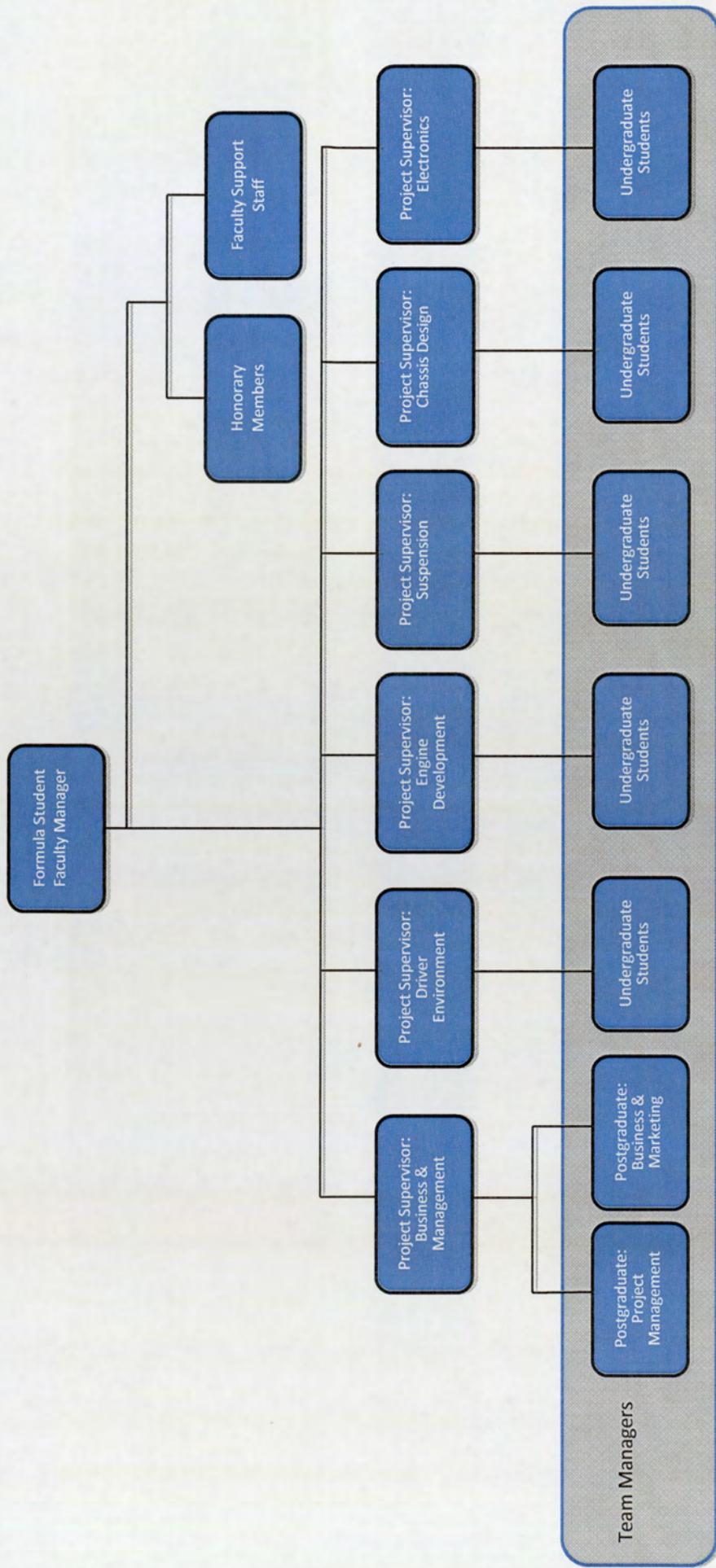


Figure 34: Proposed AM08 Organisational Structure

The PDMWorks WorkGroup could support the revised alignment of the organisational hierarchy structure, with the facility of providing specific privileges across the roles of the team. In conjunction with KSF No 8, the distribution of privileges to the requirements of the organisation could be fully assessed and amendments made where necessary.

The proposed organisational structure would be subject to review by the Faculty Manager and agreement of the Project Supervisors; defining clear lines of communication and clarification of chain of command for the team. Improvements or concessions would be made dependent of satisfactory agreement. The basis of this proposal should present the benefits highlighted throughout the research.

In addressing the development of leadership and management training, Aston University provides the opportunity for students to gain an Introductory Certificate in First line management, run through the Institute of Leadership & Management (ILM). This is available to postgraduate students at no additional cost. This would be a suitable building block for the postgraduate team members, as the syllabus covers: teamwork principles, motivation principles and leadership and management principles. As ILM⁴³ is a recognised institution, further courses gaining more in-depth training can be studied. An additional course identified is level 2 S/NVQ in team leading, providing sufficient overview of the competencies of leadership and management; though this training would require funding.

14.2.7 KSF 7 - Project Plan

Baselining the project plan would be dependent on acquiring lead times for hardware required and availability of resource for the software installation across the university facilities. Once this is established, a review with Formula Student Team Faculty Manger can take place and upon agreement the project plan could be launched.

14.2.8 KSF 8 – Testing

In conjunction with KSF No 6 and lessons learned from the limited success of the preliminary attempt of implementing PDMWorks WorkGroup during AM05, a Pilot test scheme can be developed. This

⁴³ Information taken from: www.i-l-m.com/learn-with-ilm/1048.aspx

should sufficiently test the criteria of the applicable KSFs, providing a full and phased integration into the Formula Student AM08. Refinements can be addressed in adequate time, noting any potential shortfalls and most suitable method for improvements. This would ensure a detailed framework is provided for KSF No 9.

14.2.9 KSF 9 - Training and Workshops

The PDMWorks WorkGroup is a fully integrated option within the SolidWorks software, providing a seamless interface. The scope of training and workshops required is significantly reduced due to the familiarity with the present SolidWorks operating system, minimising the learning curve required from the new users and administrators.

The foundation to support the tutorial guides and workshops will be dependent on the success of KSF No 8. An effort should be made to find the best working practices for efficient ease of use by the Formula Student Team.

14.2.10 KSF 10 - Business Strategy

The PDMWorks WorkGroup directly supports the business strategy with no significant costs, so there is potential for the expansion throughout Aston University School of Engineering. The PDMWorks WorkGroup Vault provides the ability for managing independent projects securely, separated from Formula Student. This supports the requirement of allowing for the PDMSWorks WorkGroup to be utilised for additional projects run throughout School of Engineering.

A business strategy should be developed during the discussions on the organisational changes.

14.3 Summary

The KSFs have been fully evaluated against the PDMWorks WorkGroup, highlighting areas to be investigated further. Overall, there is significant compatibility and benefits gained with the selection of PDMSWork WorkGroup, both in terms of facilitating configuration management control, and in supporting an organisational change for the Formula Student Team.

The key areas that will need particular focus and attention are:

- Understand the specification for hardware costs and source the appropriate funding, either through sponsorship or by a business case assessment by the university School of Engineering.
- Review and agree the proposed organisational changes, presenting the justification and the benefits these changes would bring to the Formula Student Team.
- In relation to KSF No 6, develop a business strategy for the Formula Student Team, which would capitalise on supporting expansion of the project and improving the working environment; providing the facility of being able to work externally.

In establishing the KSFs, the success of the PDMWorks WorkGroup implementation relies on the support and commitment of the university School of Engineering.

15.0 Chapter 2 Conclusions and Recommendations

From the theoretical knowledge learnt and research presented in Chapter 2, the unique situation of Aston University Formula Student Team has been established. Throughout the research, and with direct comparisons to Industry, a framework has been established for identifying the Key Success Factors to select and implement a PDMS capable of meeting the specific needs. This in turn has driven the selection of PDMWorks WorkGroup to be implemented into the Formula Student Team.

The execution of how the proposed final solution is implemented, will determine the success of the research work. The highlighted areas identified by the KSFs will require focus to ensure the full KSF benefits are achieved, particularly in adapting an approach to improving the organisation hierarchy structure.

In combination with the development of the working practices and process, to harness the full benefits identified, the Formula Student Team should aim to formalise a comprehensive induction pack. This will enable a more adaptive approach, supporting transition and acceptance to the revised working process, both for PDMWorks WorkGroup but also improving communication lines and available support. The pack is not limited to, but should include: detail of the project milestones aligned to the Project Life Cycle management, team organisation chart and FASE rule allocation.

The KSFs identified have the scope to be developed further into a matrix scoring system, where each individual element would be appropriately appraised against a scorecard, ranking the commercially available systems in respect to the organisational requirements.

One area that the research highlighted is that organisations need to commit to sufficient resource, funding and support to succeed in the implementation of PDMS. Personnel within the organisation would need to be specially trained in the respective PDMS functionalities, to aid transition into the organisation, whilst also retaining the experience and knowledge. A recommendation to consider is to provide PDMWorks WorkGroup training to a permanent member of university staff, retaining experienced knowledge and thus providing the capability to develop the system further. This would directly support KSF No 10, in the ability to expand the PDMWorks WorkGroup outside the context of Formula Student within the university.

By providing sufficient training to the postgraduate students, with respect to teamworking and leadership and motivation, this will contribute and benefit towards the projects performance. These aspects can be potentially measured against two particular areas. Firstly, the participation and contribution from all team members to meet or surpass the project milestones, and secondly, comparisons of the individual team members performance in Final Year project course grading, against peers not associated with Formula Student project. In considering the benefits associated with

training, it is recommended that a development and training scheme is established for the postgraduate team members, upon selection into the team.

Chapter 3 – Implementation of Project Data Management Software

This chapter covers the application of the theoretical knowledge learnt from the established 10 KSFs, to implement and integrate the PDMWorks WorkGroup into Aston University AM08 (2008 - 2009) Academic year Formula Student Team.

The process begins with identifying the specification of the hardware and software requirements to support the installation of PDMWorks WorkGroup, in consultation with the university ICT department, to gain an understanding of cost, lead-time and installation scheduled. This forms the foundation of outlining and baselining a project plan for agreement by the Formula Student Faculty Manager, which would provide an evaluation against KSF No 3 – Cost and No 10 – Business Strategy, highlighting any shortfalls or waivers required.

The project plan is broken down into 4 phases, detailing the specific tasks for the required testing, Pilot Scheme and refinements of the Administrator and User working practices for the Formula Student Team. Against each of these phases the respective KSFs were evaluated, ascertaining any problems and providing an indication for future recommendations.

The sequence of the approach for the 4 individual phases is as follows:

1. Installation and testing
2. PDMWorks WorkGroup organisational structure assessment
3. Development of Administrator and User Tutorials
4. Pilot Scheme and PDMWorks WorkGroup performance evaluation

The evaluations and recommendations from the organisational structure assessment would form the basis for the proposed Administrator and User tutorials. The completion of the Pilot Scheme in turn would formalise the final issues of the tutorials, based on the feedback and amendments required from the pilot scheme. This action would then signify completion of the integration phase of PDMWorks WorkGroup.

16.0 Project Plan

To develop and finalise KSF No 7 – Project Plan, for agreement by the Faculty Formula Student Faculty Manger, the following steps are to be taken:

1. Understanding the PDMWorks WorkGroup hardware requirements
2. Assess Aston University computer facilities and specifications
3. Obtain quotations and agree funding, assessing KSF No 3 and KSF No 10
4. Finalise delivery and installation schedule

Upon completion of these 4 steps, the full implementation and integration phases could commence.

16.1 PDMWorks WorkGroup Hardware Requirements

For the installation of the PDMWorks WorkGroup software, consideration was taken for the hardware requirements needed to run the Vault. The current system recommendations supplied for the PDM product are detailed in Appendix A.

The PDMWorks enterprise requirements encompass the PDMWorks WorkGroup specifications as the former is designed for large organisations, producing more than 60,000 data files. There is little difference in the functionality and specifications between the two versions of software supplied from SolidWorks.

In analysing the past data produced from the Formula Student Team, the data file ranges were in excess of 1,000 files. On consultation with the ICT department, to determine the possibility of utilising an existing server which could be dedicated to PDMWorks WorkGroup, the initial quotations supplied for the server hardware were £2500+ VAT, significantly higher than anticipated. However, further discussions within the university ISA Server team provided a solution that would not incur any costs.

The setup of new MS-SQL servers within the university, that are within the hardware system specifications recommended for PDMWorks WorkGroup, could be used for the dedicated purpose of the Formula Student Team. Agreement was reached between Formula Student and ICT for the PDMWorks WorkGroup Vault to be installed once the servers were fully functional.

16.1.1 Server Details

The specific server hardware details that are allocated to run the PDMWorks WorkGroup Vault, is as follows:

- Dell powerage 2950 VMwear server
- Processor: Intel Xeon 1.6 GHZ CPU
- 384 MB of RAM
- 8GB Virtual Memory for vault data
- Windows Server 2003 Service Pack 2
- WCT Software which is partitioned up

The 8GB memory is sufficient for the Formula Student project, but has the scope to be increased to develop and integrate the PDMWorks WorkGroup further into the university, meeting KSF No 10 – Business Strategy.

The additional benefits of the server being controlled and maintained by the ICA server team provides 24 hour cover, with the capability of back up recovery if any problems occur, as required by the ICT policy for the university. There is no responsibility on Formula Student Team to ensure the server is correctly maintained and managed.

With the server fully networked and integrated into the university ICT infrastructure, this would allow access from any networked computer, whilst also providing the facility in external login and accessing via Microsoft Internet Explorer. This will aid the flexibility of varying the working environment for the team.

No additional software is installed on the server, ensuring complete isolation of PDMWorks WorkGroup Vault.

The allocated server system properties are shown below in Figure 35.

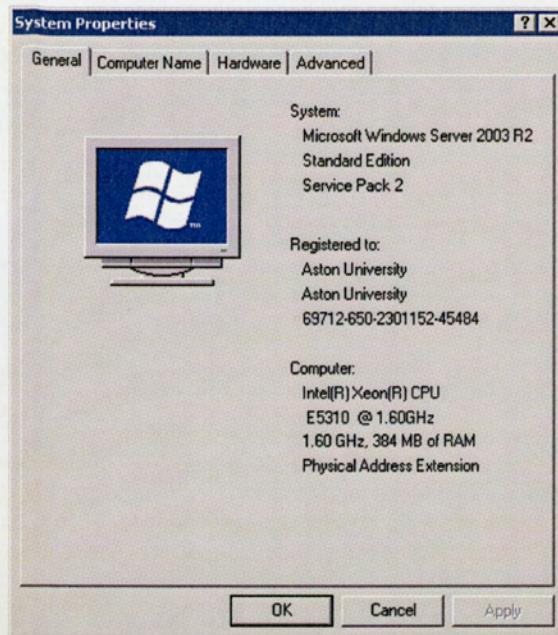


Figure 35: PDMWorks WorkGroup Server System Properties

16.2 Project Plan

Upon confirming the schedule with the ICT and ICA departments for the hardware and software installation, the plan presented in Figure 36 was reviewed and agreed with the Formula Student Faculty Manager.

The plan details the specific tasks and milestones for the 4 phased approach, with sufficient contingency allocated for Phase 4 – Pilot Scheme and Performance Evolution, due to the potential problems that could occur in the extensive performance testing.

Tasks												Milestones												
4	11	18	25	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21

Figure 36: Project Plan

17.0 Phase 1 - PDMWorks WorkGroup Installation and Testing

This phase consists of the installation and setup of the hardware and software for PDMWorks WorkGroup across the university facilities; including the initial familiarisation and testing exercise.

These initial tests aim to evaluate the software access and functionality, both independently and in conjunction with SolidWorks Professional 2007. This assessment would provide the foundation for Phase 2, in assessing KSF No 4 – Associated Documentation and KSF No 6 – Organisational Structure.

17.1 PDMWorks WorkGroup Server Access & Software Installation

The server can be accessed via any networked university computer using the Microsoft Windows ‘Remote Desktop Connection’ function.

The ‘Remote Desktop Connection’ tool can be found when navigating from the Start Menu on the Microsoft Windows operating system. This program is located in the Accessories menu under the Communications tab. On selecting this tool, the following entry screen will appear, detailed in Figure 37.

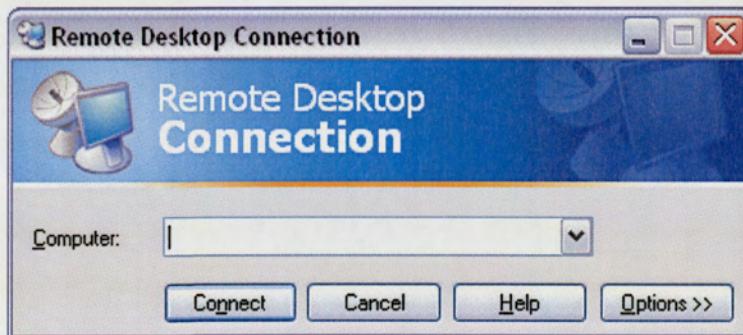


Figure 37: Remote Desktop Connection Entry Screen

The designated IP server address for the Formula Student Team is: **naxos.aston.ac.uk**. This should be entered in the Computer selection box, clicking connect when complete. This in turn will connect to the Microsoft Windows server operating system.

The PDM Vault software tools are then installed onto the Server, using SolidWorks 2007 Professional installation disks supplied to Aston University, to be performed by both the ICA Server Team and Author present. On completion of the software installation the PDM Vault would be ready to be tested and setup.

The server operating system desktop display consists of the PDMWorks WorkGroup Administrator Launch Icon, SolidWorks Explorer Icon and eDrawings Icon. The vault is located within the D: hard drive, with 8 GB of virtual memory.

The desktop screen that is shown upon the Remote Desktop Connecting to **naxos aston.ac.uk** is detailed in Figure 38.

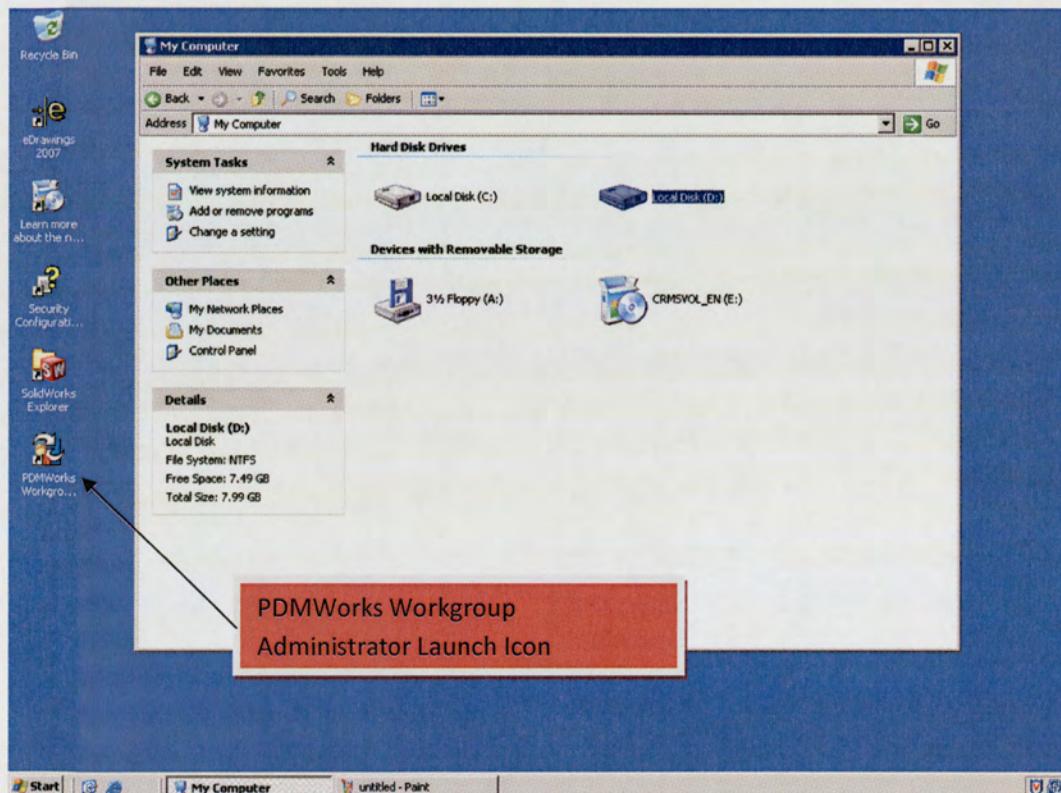


Figure 38: **naxos aston.ac.uk** Operating System Screen

17.2 PDMWorks WorkGroup Configuration in University Facilities

The SolidWorks software setup across the university computer labs requires the PDMWorks WorkGroup tool to be activated and configured. As the SolidWorks software package is installed as an image across the university, the Labs would require reinstallation with the PDMWorks WorkGroup

function enabled. The extent of the re-imaging consists of the following Labs: L37A, L77, MB160 and MB170. In addition to this, the project supervisors and management office computer are also required for re-imaging.

On completion of the configuration exercise, access would be proved to PDMWorks WorkGroup.

17.3 PDMWorks WorkGroup Familiarisation and Initial Testing

The familiarisation tests to be performed with the PDMWorks WorkGroup Vault are:

- Establish the login facility for the administrators of the Vault
- Set up users and groups, along with a test project folder
- Log in to the Vault via SolidWorks through a user account
- Check In an assembly and log out
- Log into the Vault via another Computer and using a different User ID, Check out an assembly
- Modify the assembly and Check back in.

This would provide an overview of the basic functionality of the software, detailing the specific options required for the Formula Student Team.

The following section gives a general overview of the familiarisation process taken for the initial test work. This would form the foundation of establishing a more comprehensive set of instructions for using the PDMWorks WorkGroup by Administrators and Users that would be used in producing the tutorial guides.

17.3.1 PDMWorks WorkGroup Initial Tests

To enable and access the Vault administrating facility, any networked computer could be used to log onto the server, via the Remote Desktop function, using the access process detailed in Section 17.1.

Once connection to the naxos.Aston.ac.uk server has been established, the display screen presented should be identical to Figure 39. The PDMWorks WorkGroup administrator icon should be selected to start the Vault login process.

The following screen should be displayed when accessing the Vault.



Figure 39: PDMWorks WorkGroup 2007 VaultAdmin Login Screen

The default User Name and Password defined by SolidWorks is **pdmwadmin**. The vault computer box should be entered with the server IP Address of **naxos.aston.ac.uk**.

Once the successful login has been completed, the PDMWorks WorkGroup Vault Admin menu screen should be shown, as presented in Figure 40. An overview of the Vault options contained on the Vault Settings screen is also detailed.

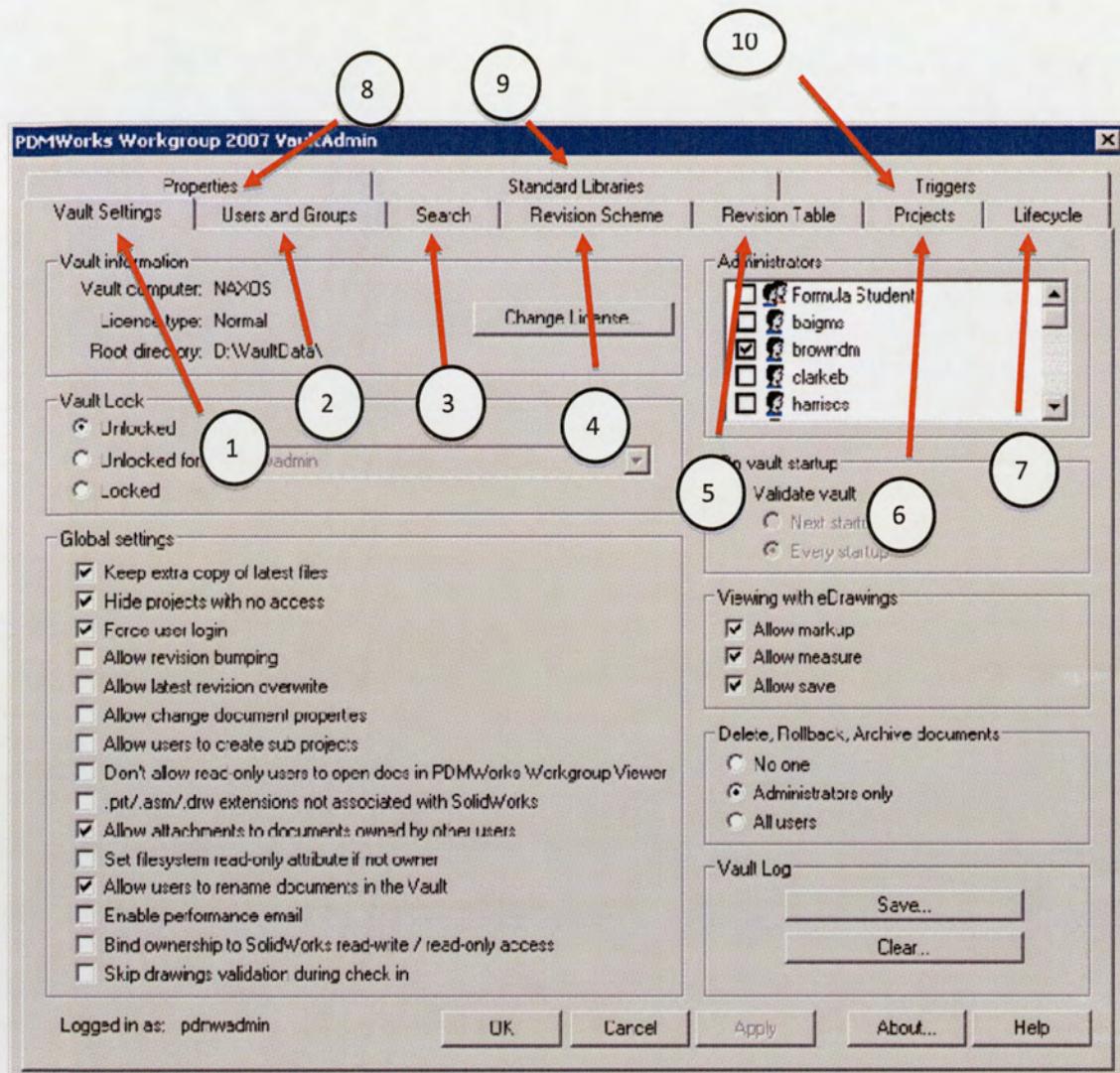


Figure 40: PDMWorks WorkGroup VaultAdmin Menu Screen

A brief overview of the options available on the menu screen is as follows:

1. Vault settings – Provides vault global settings which include: detailing the section of specific administrators, security and access to the vault, revision overwrite control of the vault and control of attachment of documents.
2. Users & Groups – Defines user names, passwords and grouping of users.
3. Search – Indexing search service and detail on data contained within the Vault.
4. Revision Scheme – Details the primary (A-Z) and secondary (0-99) for revision changes.
5. Revision Table – Controls the revision scheme for SolidWorks drawings.

6. Projects – Creation of project folders, bulk data check in and assigning users privileges.
7. Lifecycle – Enables lifecycle function and detailing behind the status, ie time period and user control of status change.
8. Properties – Custom properties for the Vault.
9. Standard Libraries – How the data folders are specified and located within the Vault and document revision management control.
10. Triggers – Provides the facility for server notifications of relevant user events, i.e. document check-ins, changes in projects and changes in ownership.

A complete description of the PDMWorks WorkGroup Vault functionality is beyond the scope of the formalisation exercise and is best found within the detail of the PDMWorks WorkGroup Software tutorial. However, the focus should be concentrated on the functions specific for the use of the Formula Student Team.

17.3.2 Creation of User Groups and Projects

The task to create trial user accounts entails the setup of temporary user names and passwords. In selecting the Users and Groups Tab, as presented it provides the option to setup the detail of specific accounts and the appropriate fields required. The users created could also then be assigned to a specific group.

In establishing the test group with the temporary individual user names, a project folder could then be created. Selecting the Project Tab function (Option 6) provides the following screen shown in Figure 41.

The **New Project** button creates the project folder required in the Vault. In selecting this option, it provides the ability to detail the specific groups to be granted access to the project folder. The project permissions could also be set by the administrator within the tab window, stating which users should have Read/Write access. For the purposes of the familiarisation testing, Read/Write access should be granted for the individual users.

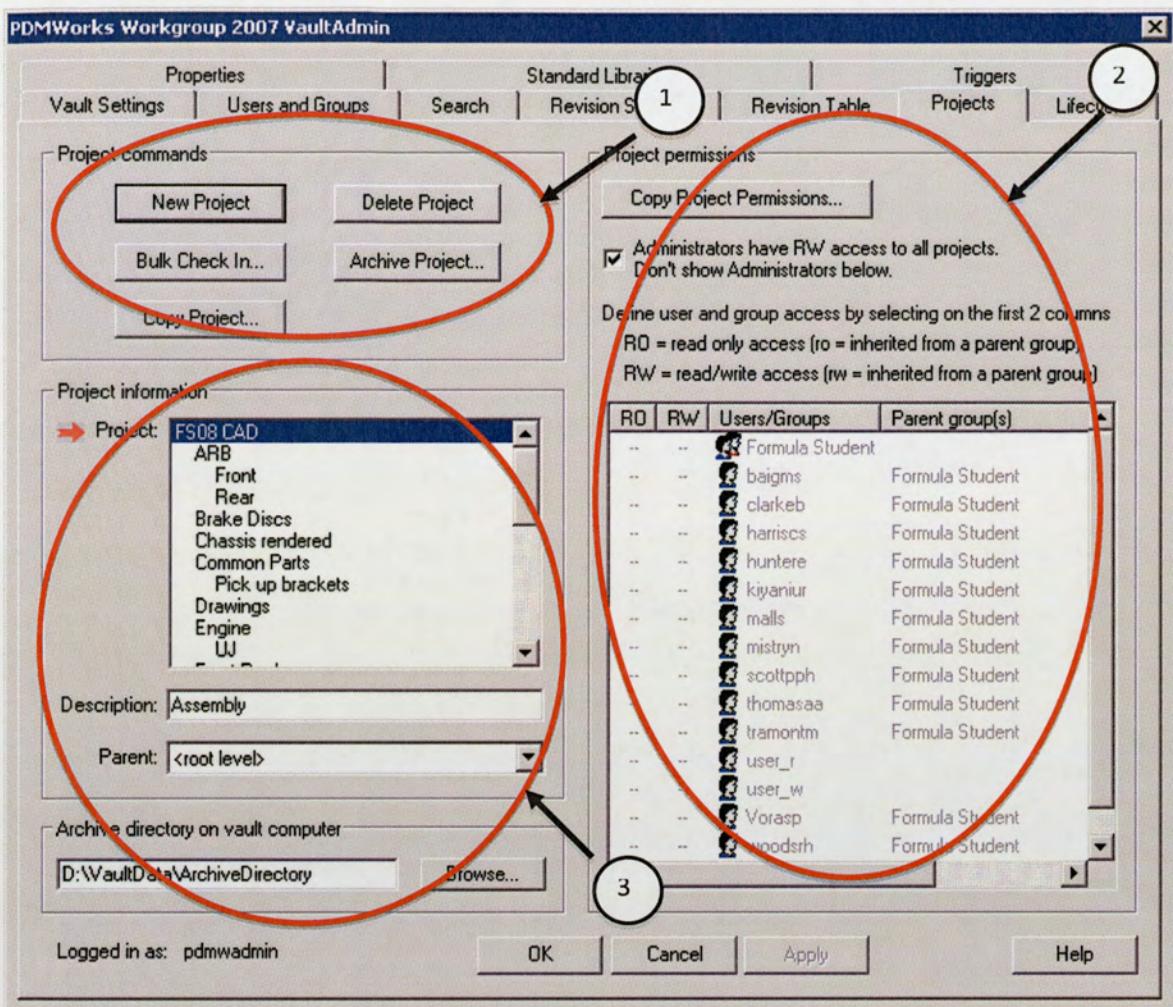


Figure 41: PDMWorks WorkGroup Vault Admin Project Screen

An overview of the functionality presented in Figure 41 is as follows:

1. Project Command: Creates and details projects. Allows bulk Check In of SolidWorks data from external hard drive. Copies and achieves project folders when required.
2. Provide the facility to dictate the specific access rights of the users.
3. Details the files contained within the project folders.

The final options to be selected for the Vault are contained with the Vault Tab screen, as presented in Figure 40 Option 1. The global settings for the Vault should be changed to support the familiarisation tests. The following options should be selected

1. Force enter login - Ensures secure access to vault

2. Hide Projects with no access – additional projects contained in the vaults should not be shown to the user without permission
3. Keep extra copy of latest files – Additional recovery feature for data files
4. Allow attachments to documents owned by other users – Provides the facility to attach relevant document information to files within the Vault
5. Allow users to rename documents in the vault – Provides editing function of document names

With the initial setup of the Vault complete and the settings saved, PDMWorks WorkGroup can be logged off.

17.3.3 SolidWorks Access to PDMWorks WorkGroup

The next task is to access the SolidWorks interface with PDMWorks WorkGroup. In opening SolidWorks 2007 Education Edition from any other university networked computer, the Vault can be connected to by the PDMWorks WorkGroup Icon contained on the SolidWorks Tool Bar.

Upon selecting PDMWorks WorkGroup Icon, the following Vault Login User ID screen should automatically be shown, as presented in Figure 42.

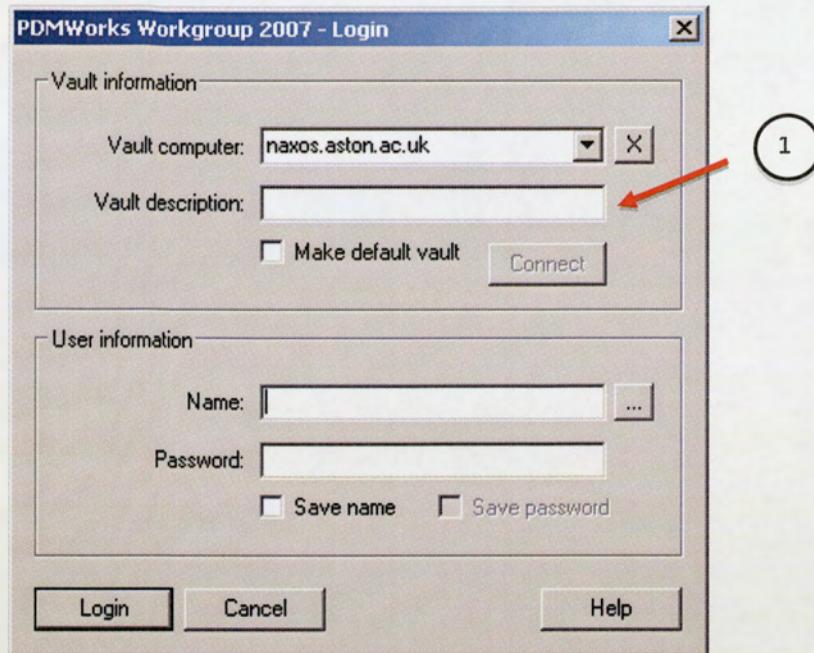


Figure 42: PDM Vault User Login Screen

The vault server IP address information should be entered (**naxos.aston.ac.uk**) in Box 1, the vault description should remain black. However, to reduce the login time the ‘make default vault’ should be selected.

The temporary test username and password can be entered to access the vault. This completes the Vault login access from SolidWorks.

17.3.4 Check In of Data

With SolidWorks connected to the PDMWorks Vault, a simulation can be performed of checking in and out of data. Using a previous SolidWorks Formula Student car assembly file from **AM07**, opened via the Formula Student server <\\eas-auth\\cad>, the assembly can be checked into the vault by selecting the Check In Icon on the SolidWorks tool bar, detailed below.



- Check In button found on SolidWorks tool bar Screen

This should open the vault Check In menu screen, as shown in Figure 43.

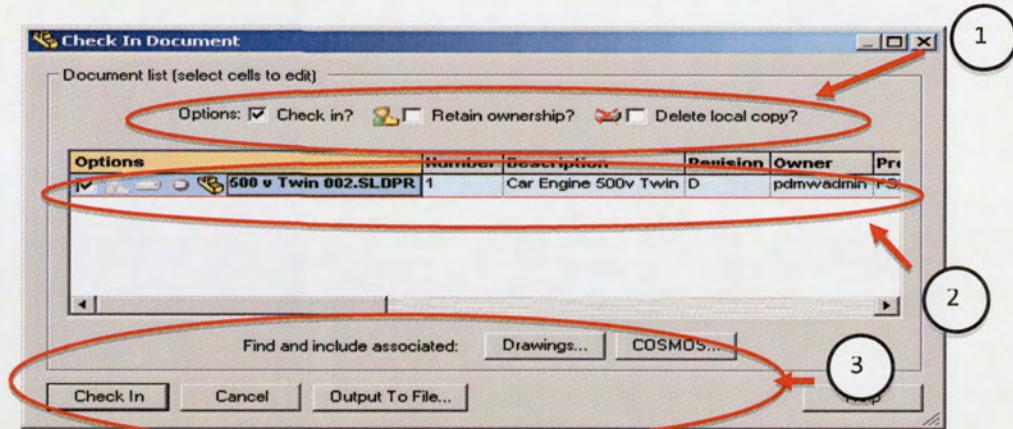


Figure 43: PDM Vault Check In Menu

There are several options to be considered from the menu screen for the user.

Option 1 details whether the file is to be checked in, if the user still requires retention of ownership once checked into the vault and the original local copy saved on the Formula Student server to be deleted. In retaining user ownership, other users will not be able to access this file for editing. Only once the ownership is released to the vault will other users be able to access the file. This should provide a clear indication of the status of the file and which user currently has ownership rights.

Option 2 allows the assembly information to be detailed, such as description, revision no, owner and project group.

Option 3 provides the final decision functions, both in being able to output the file to an external hard drive, but also attach associated drawings and analysis.

In selecting the **Check In** button the assembly is successfully stored into the project folder contained within the PDMWorks WorkGroup Vault. At this point, the SolidWorks and PDMWorks WorkGroup software can be logged off and closed down.

17.3.5 Check Out of Data

To check access from other computers within the university facilities the login process detailed Section 17.3.3 should be followed.

Once SolidWorks and PDMWorks are successfully running, the intention is to open and check out the assembly in the PDMWorks WorkGroup Vault, using alternative user details.

Upon selecting the **Open** button on the SolidWorks Tool Bar, the menu screen that should be displayed is shown in Figure 44.

From this screen, the user can browse through the parts and assemblies stored within the Vault, by selecting the PDMWorks WorkGroup Vault tab in option 1 detailed in Figure 42, on the left hand side of the screen. Alternatively the user can also browse for files located elsewhere within the computer or network.

A preview of the intended files to be opened is also generated, to confirm the correct file is selected. The information on user access rights to the specific folder is also displayed.

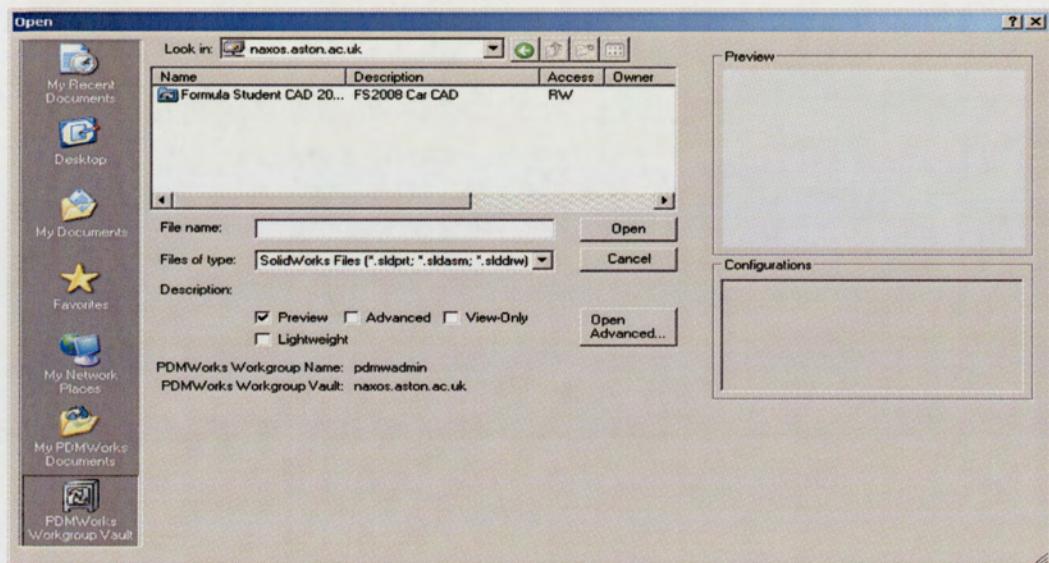


Figure 44: Open Parts or Assembly Menu Screen

On locating the assembly within the Vault project folder, and upon selecting the Open button, the following menu screen presented in Figure 45 should be displayed.

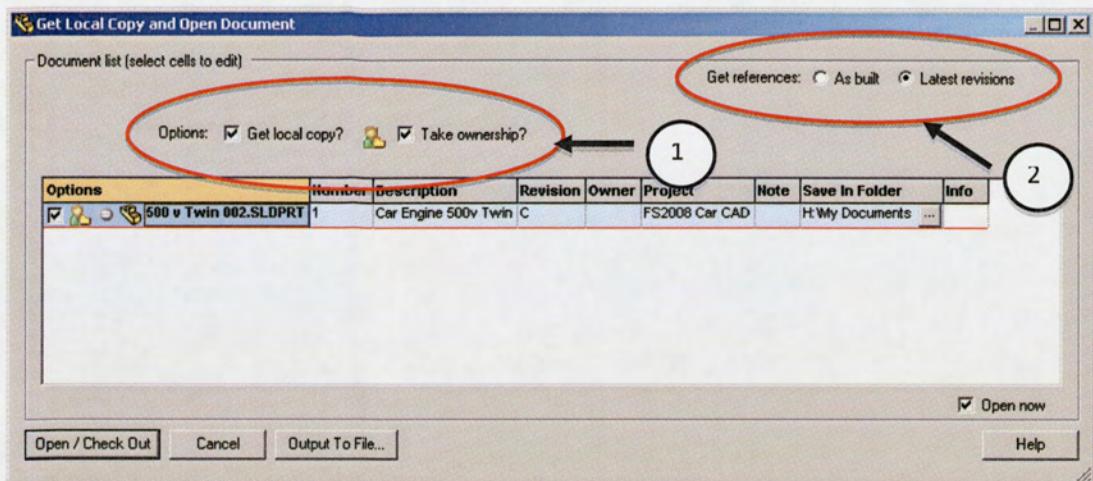


Figure 45: PDM Vault Check Out Screen Menu

Option 1 allows the user to take ownership of the file; the 'get local copy' places the required files on the computer's internal hard drive. This acts as a safety precaution in case the connection to the vault is lost, or a problem occurs in using SolidWorks. As the file is stored on the local computer, this prevents the original vault file being lost.

Option 2 details if the latest revisions of the files associated or linked to the assembly should be checked out or if the user only requires the current as built assembly.

The **Take ownership** and **Get local copy** boxes should be selected on this screen. On clicking the **Open/Check Out** button, it should check out the assembly file for the user to edit.

17.3.6 SolidWorks Editing

Alterations can be made to modify the assembly and the process of Check In, detailed in Section 17.3.4, is repeated. When the Check In Screen is displayed (Figure 43), the assembly revision number is changed due to the alterations. The **retain ownership** and **deleted local copy** should be de-selected once the user is ready for other project users to access the file, before the **Check In** button is pressed.

17.4 Summary

To build up a comprehensive knowledge base on the functionality and interaction of the PDMWorks WorkGroup, the approach is varied on testing various Vault options and settings, in combination with assessing the access from various computers within the university facilities. This process is continued to provide a baseline for the essential functions that would be required for the Formula Student Team.

18.0 Phase 2 - PDM Management Structure for Formula Student

An assessment can be made on KSF No 5 – Associated Documentation and No 6 – Organisational Structure, based on the knowledge learnt from the initial familiarisation testing performed in Section 17.0.

The approach taken to allocate the administrator and user privileges against the AM08 organisational structure, presented in Figure 46 below, was determined by the experience of using the software in combination with the provided PDMWorks WorkGroup user tutorials.

The aim was to create a platform in order to baseline how the team could be managed and co-ordinated through the use of PDMWorks WorkGroup. The allocation of the privileges granted for the specific roles, in conjunction with a preliminary simulation exercise of the Vault, consisting of experimenting with the control functions of the Vault for both the Administrators and User. This would establish any pitfalls or constraints against the organisational structure. It also provides an indication of the framework for how the communication lines between the team members, team managers and faculty supervisors, should be managed during the design review process.

The allocation of the administrator and user access during simulation testing, would also highlight the potential pitfalls and constraints that would need to be addressed. In addition, this would assist in ascertaining the background information required to formulate the specific administrator and user guides, based on the simulation exercise.

In understanding the initial outcome from the simulation testing exercise of the organisational structure, KSF No 6 – could be assessed to ascertain the simplicity of independent documentation control for the AM08 team.

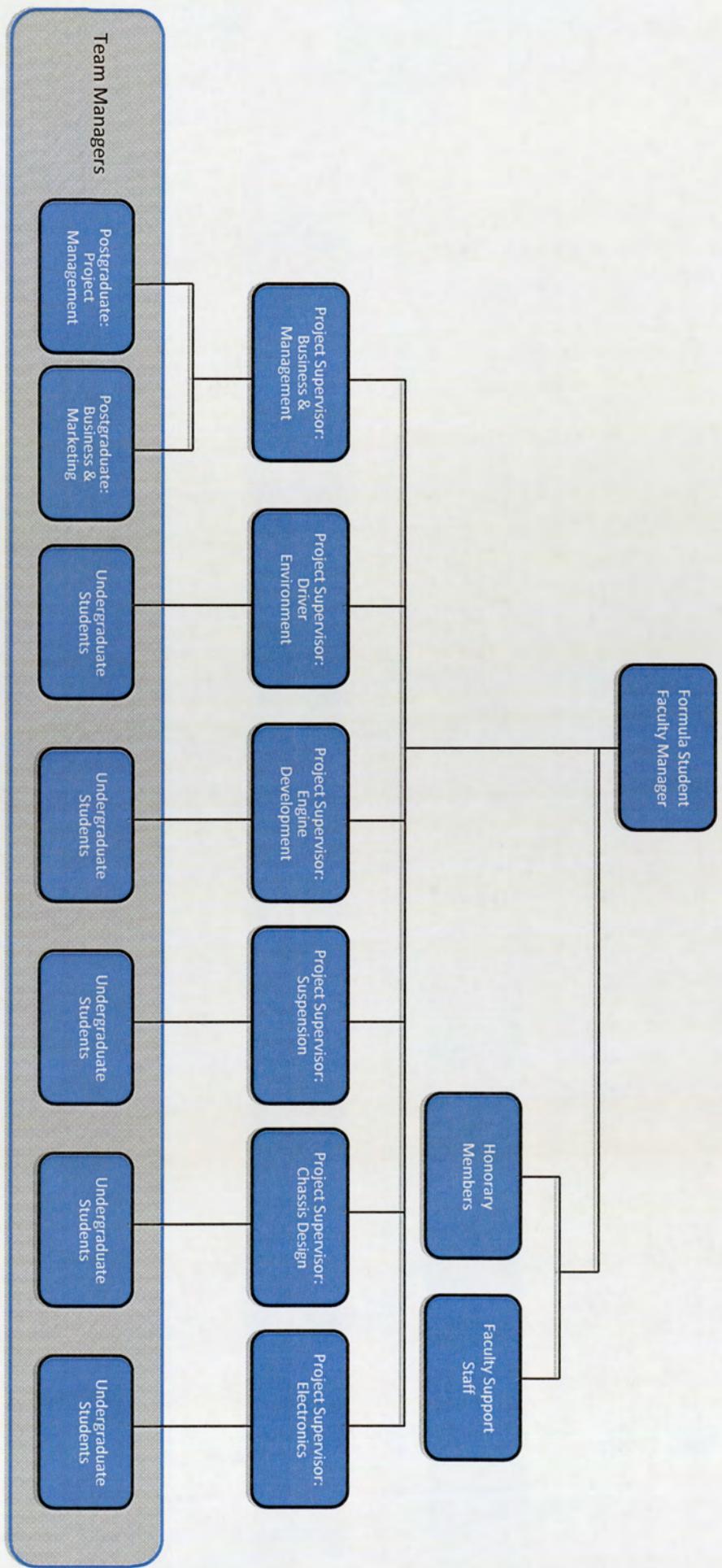


Figure 46: Proposed AM08 Organisational Structure

18.1 Allocation of Access Privileges for AM08

The proposed distribution of the privileges for access control of the Vault against KSF No 6 organisational structure is outlined in Figure 47 below.

Position	Role	PDMWorks WorkGroup Access Privileges
Faculty Manager	Permanent University Member of Staff – Lecturer & Overall Management of FS	Administrator 1
Faculty Project Supervisors	Permanent University Member of Staff – Department Lecturer	User
Faculty Business Project Supervisor	Permanent University Member of Staff – Department Lecturer	User
Faculty Technical Staff	Permanent University Member of Staff – Technical	User
Honorary Member	Technical Specialists and former university staff	User
Project Advisor	Postgraduate Student – Project planning	User
Team Manager	Postgraduate Student - Co-ordination and Management of Formula Student	Administrator 2
Team Manager	Postgraduate Student - Co-ordination and Management of Formula Student	Administrator 3
Team Member	Undergraduate Student – Final Year Project Tasking	User

Figure 47: Proposed AM08 PDMWorks WorkGroup Administrator and User Allocation

A generic flow diagram of the user and administrators to the PDMWorks WorkGroup Vault is shown in Figure 48 below.

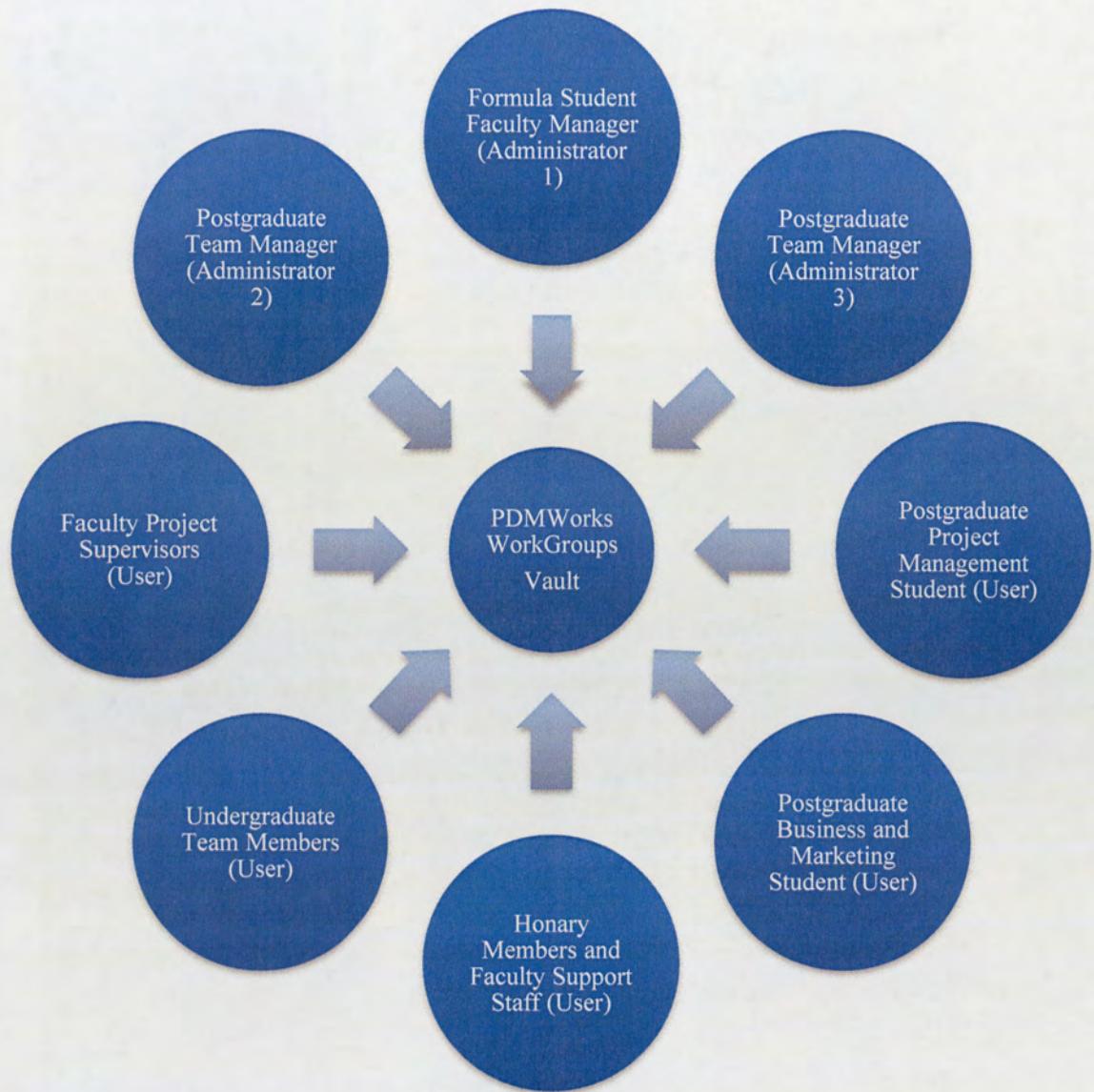


Figure 48: PDMWorks WorkGroup Vault Administrators and User Flow Diagram

The justification of only allocating 3 administrator roles was to limit the overall learning curve during the implementation process for the team and the potential communication problems that could occur in the changing privileges and access functions throughout the year. The benefit this would bring is retaining a simplistic approach to the control of the Vault.

18.2 Simulation Exercise

Based on the familiarity testing detailed in Section 17.0, the simulation exercise consisted of the following steps:

1. Created a temporary administrator and user accounts for the Vault, as per Figure 47, consistent with the AM08 team numbers.
2. Created a temporary project folder within the Vault and allocated the project user group.
3. Selected the preliminary Vault settings for the project.
4. Imported a previous SolidWorks Car Assembly.

With the temporary AM08 team constructed for PDMWorks WorkGroup, the login, data check in and out functionality for individual accounts was systematically evaluated. The variables during testing included: access from different ITC computer facilities, modifications of specific car parts, retention of ownership, revision scheme assessment and experimenting with administrators Vault functionality controls. This also included selecting or de-selecting specific options outline in Figure 40 in Section 17.3.1.

Some of the specific functions that would need to be selected for the AM08 team are:

- Enforced user login
- Revision scheme setup for A – Z
- Allow revision bumping privileges

Once the assessment of the allocation of user and administrators against AM08 organisation was complete, the simulation of documentation control could begin. This simple exercise could be performed using the initial guidelines detailed in Section 17.0, to assess the checking in and out functionality of documentation independently from the SolidWorks software. The approach taken was to simulate access from various login terminals around the university facilities, with the aim to fully evaluate KSF No 6 – associated documentation and how the selection of specific Vault functionalities within the admin of the Vault would aid the documentation configuration control. The main aim of the exercise was to determine the feasibility of allowing project supervisor notes to be amended to specific FASE rules and team member work.

The key functions that would need to be selected are:

- Allow attachment to documents owned by other users
- Allow user to rename documents in the Vault
- Setup of triggers to inform users of document check in via email
- Standard library functionality activated for documentation revision

Assessing the documentation control functionality against the organisational structure and allocation of privileges, has demonstrated the potential for use by the AM08 team, whilst also supporting KSF No 6.

18.3 Summary

The allocation of the administrator and user privileges of the PDMWorks WorkGroup supports KSF No 5 and has provided an understanding of how the Vault should be managed during the course of the academic year. The intention of the simulation exercise was to gain familiarity of how the Vault management and co-ordination would support the AM08 team organisational structure. However, as this simulation was constrained by both time and to a single user, a comprehensive analysis of the integration within AM08 team could not be fully achieved without initiating a pilot scheme and encompassing a multiuser environment.

The administrator role could be expanded to encompass the project supervisors in future, once sufficient experience and knowledge of the PDMWorks WorkGroup software had been established. This would additionally support the development and expansion of PDMWorks WorkGroup within the School of Engineering department.

The ability of accessing the Vault independently from the use of SolidWorks Software has already demonstrated the potential of documentation control for the AM08 team. The full capability of the document management control could be further assessed and developed during the Pilot scheme. The potential of this functionality supports KSF No 6.

The knowledge gained through the simulation testing for both the privileges and access rights would directly benefit the formulation of the specific administrator and user tutorials suitable for the AM08 team.

19.0 Phase 3 –PDMWorks WorkGroup Tutorials

Based on the initial familiarity and experiences gained through using PDMWorks WorkGroup during Phase 1 & 2, the following proposal for both the Administrator and User tutorials could be established.

The strategy for the tutorials is to provide an instructional outline of the interaction process required between Aston University Formula Student Team and the PDMWorks WorkGroup Vault. The objective is not to overwhelm the literature with intricate details for each of the functions and options available, but to outline the critical interaction steps and utilise where necessary the SolidWorks software Help functionality. Balancing the tutorial guide information against the available software Help guides, should ensure that a comprehensive overview is provided, which is specific to the needs of Aston University Formula Student Team.

19.1 Proposed Administrator Tutorial

The Administrator tutorial would need to cover the following topics to provide a good understanding for the setup and control of a PDMWorks WorkGroup Vault Project. The topics are:

1. Connection to PDMWorks WorkGroup Vault Server and Login to the PDMWorks WorkGroup Vault Administrator.
2. Creation of new users and project groups.
3. Setup of a new project folder in the Vault.
4. Detailing the global settings of the Vault.
5. Controlling the revision system.

This would form the framework for generating the final tutorial guide that would be given to the Project Administrators.

19.1.1 Connection to PDMWorks WorkGroup Server and Login to PDMWorks WorkGroup Vault Administrator software

To log into the PDM Server the following steps need to be taken.

Navigating from the Windows Start Menu, select **Programs, Accessories, Communications**, and click on the Remote Desktop Connection Icon. The menu shown below in Figure 49 should appear.

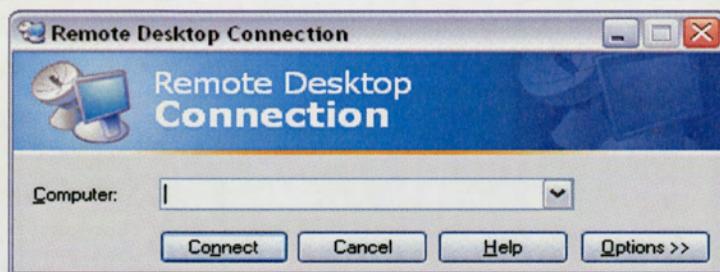


Figure 49: Remote Desktop Connection

The PDM server IP address should be entered into the Computer box. This is **naxos.aston.ac.uk**. Click the **Connect** button to start the login process.

This should request the administrator to enter their individual university Login name and password. This is an additional security facility. Only students who have been selected with permission to access the server by the ICT department would be able to continue the log in request.

When the login process is complete, the Windows desktop screen for the PDM Server should be displayed, as shown in Figure 50.

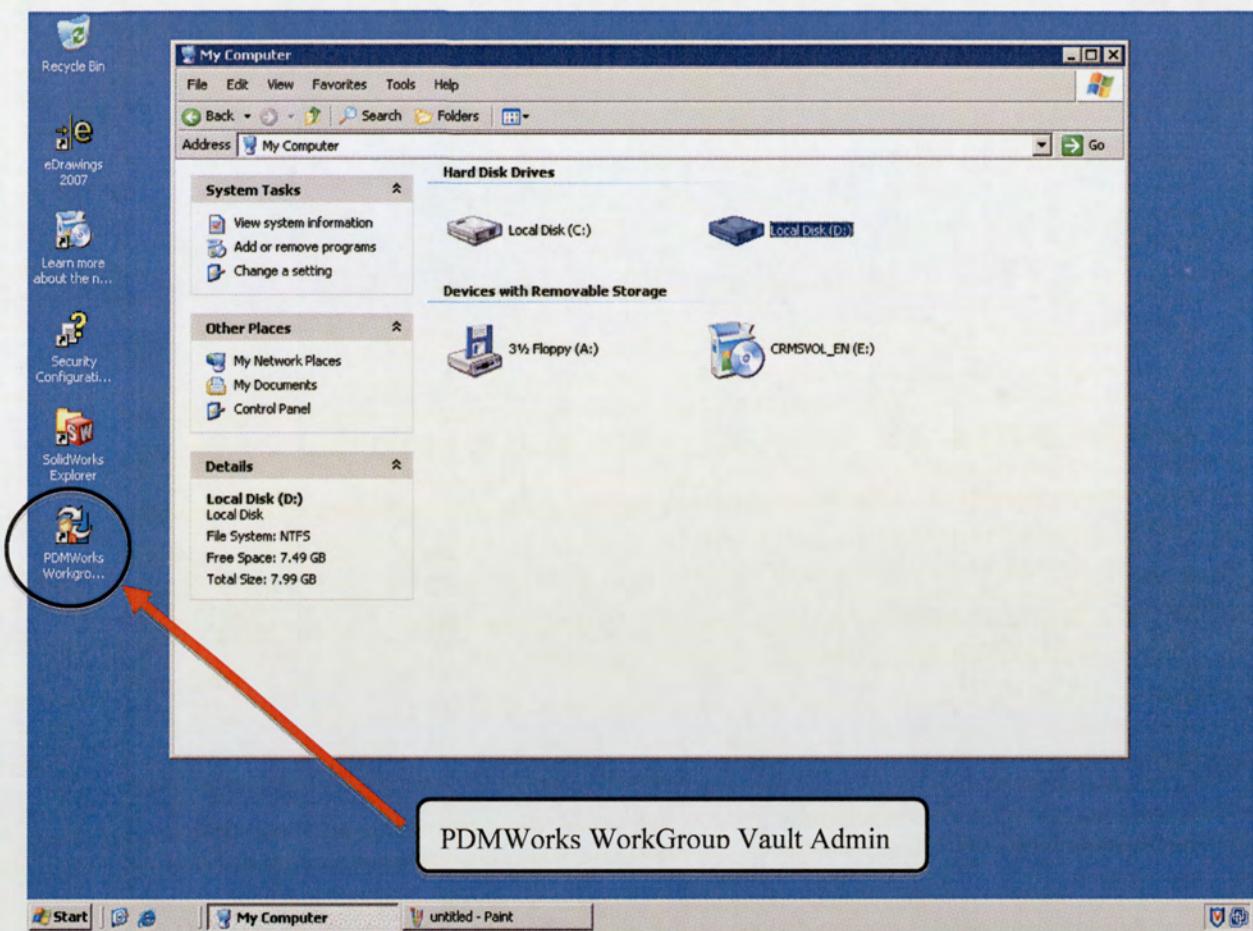


Figure 50: PDM Server Microsoft Windows Desktop Screen

To log into the Vault, double click on the **PDMWorks WorkGroup Vault Admin** icon, displayed on the desktop screen.

This should launch a login screen for the Vault access.



Figure 51: PDMWorks WorkGroup Vault Login Screen

The default Login information is as follows:

1. Name: **pdmwadmin**
2. Password: **pdmwadmin**
3. Vault Computer: **naxos.Aston.ac.uk**

Select the **Save name and Vault computer** box for faster access for further login session.

Once the **Login** button is selected, the PDMWorks WorkGroup Vault Admin should launch the software menu screens, as presented in Figure 52.

Details on changing passwords and user information are explained in Section 19.3.1.

Once the required administrative tasks are completed, to Log out of the PDM Vault admin session simply click on the **OK** button at the bottom of the screen. This will return you to the naxos server desktop screen.

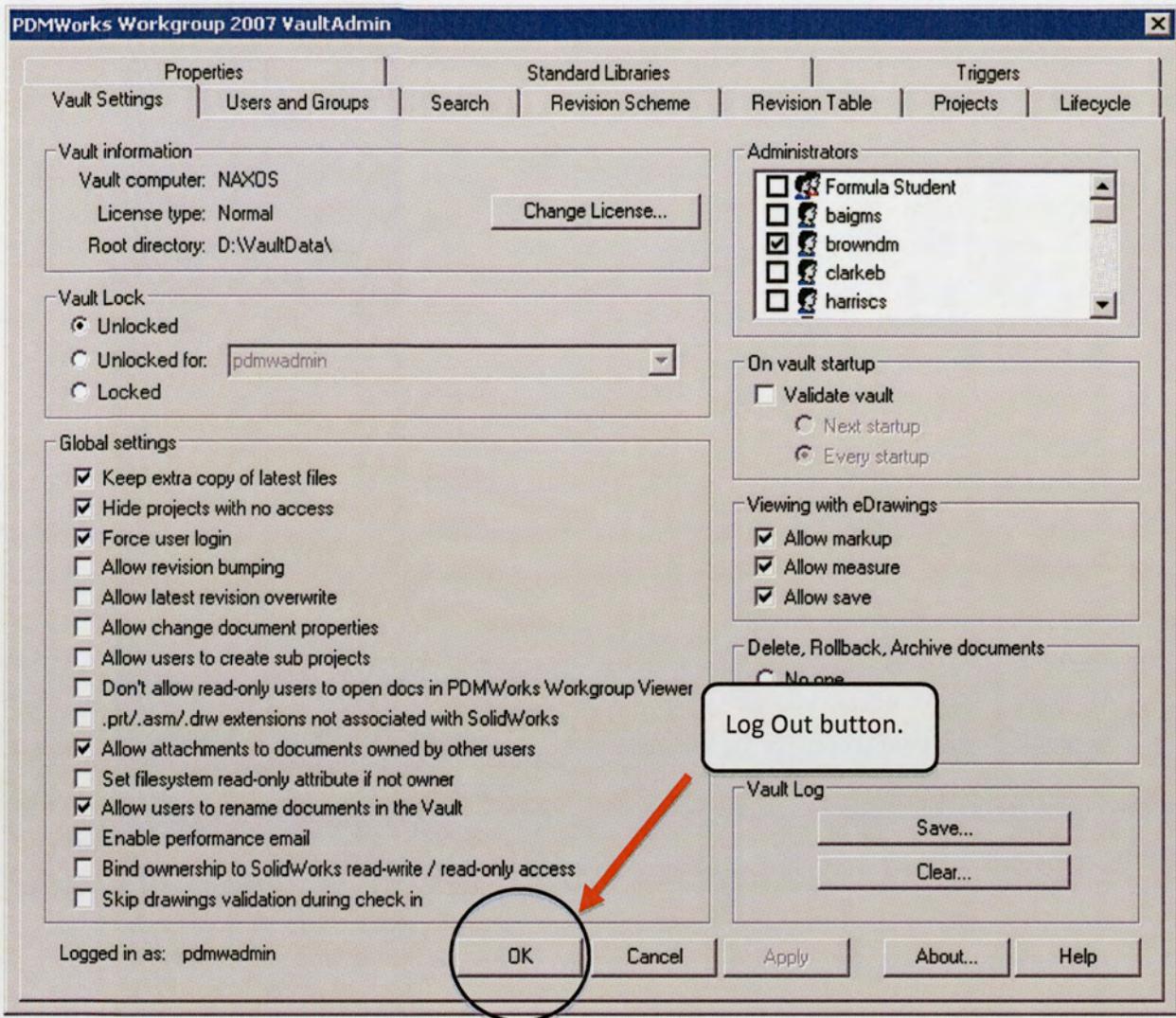


Figure 52: PDMWorks WorkGroup Vault Menu Settings Screen

Finally, to log out of the PDM server, click the Start Button on the Windows task bar and select the **log off** button on the screen.

19.1.2 New Users and Groups Account Creation

To create users and define user groups, select the **Users and Groups** Tab at the top of the Vault Admin screen, as shown in Figure 53 below. Then click on the **New User** button.

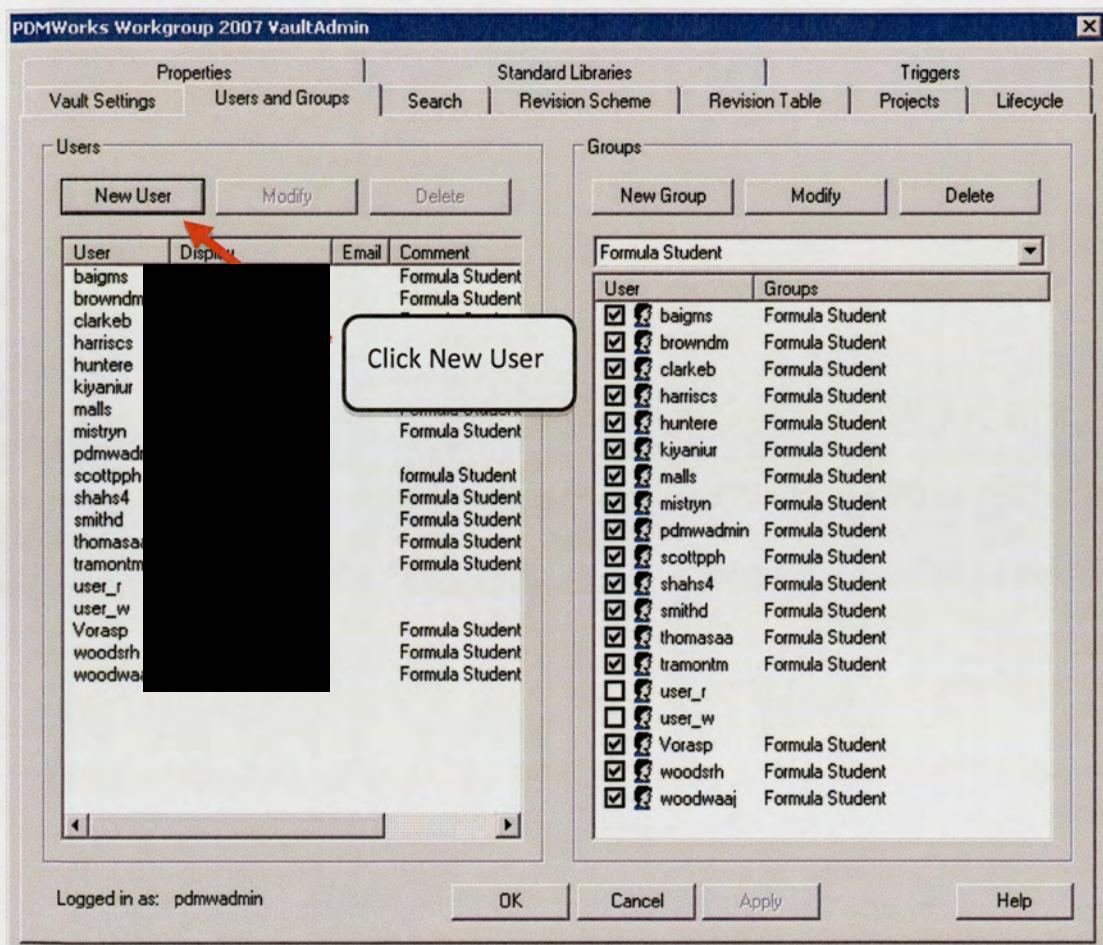


Figure 53: PDMWorks WorkGroup Vault Users and Groups Menu

This should launch the **Add New User** screen, presented in Figure 54. The required new user information can then be filled into the relevant boxes. A generic password should be used for the new user, to ensure ease of access during the first login session into the PDM Vault. The user then has the ability to change the password from the PDM options given within the SolidWorks program.

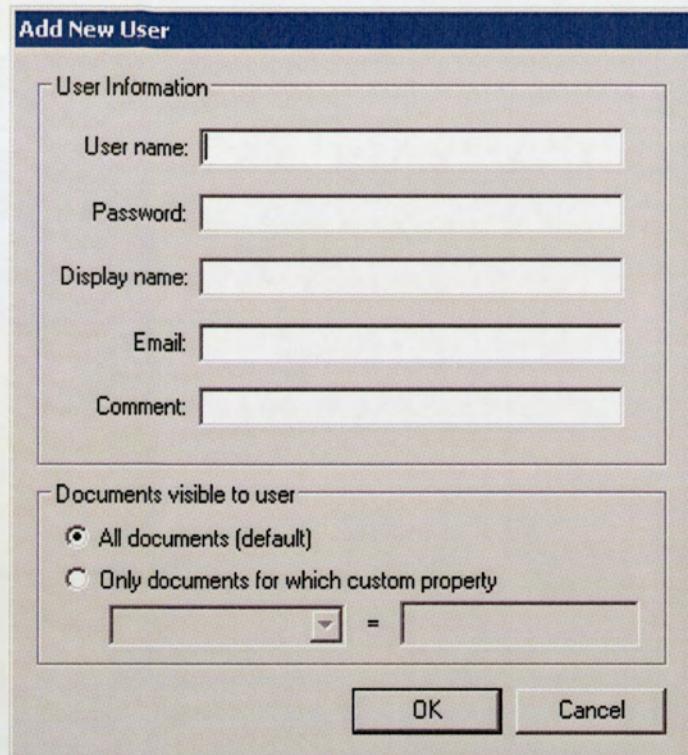


Figure 54: PDMWorks WorkGroup Add New User Screen

The option to modify user accounts can be completed by selecting the **Modify** button on the **Users and Groups** menu; this would also provide the ability to change, or reset User and Administrator passwords. User accounts can be deleted from this screen.

In selecting the **New Group** button on the menu screen in Figure 53, it would allow a group to be formed and detailed, with the specific users assigned to the group.

To add additional users to the group, select the **Modify** button in the group menu; this provides the function to assign further user details. The **delete** button allows the removal of created groups and users assigned within it.

19.1.3 Setup of a New Project Folder in the Vault

To setup a new project within the Vault, click on the **Projects** Tab at the top of the **Vault Admin** screen.

The following menu should be displayed, as shown in Figure 55.

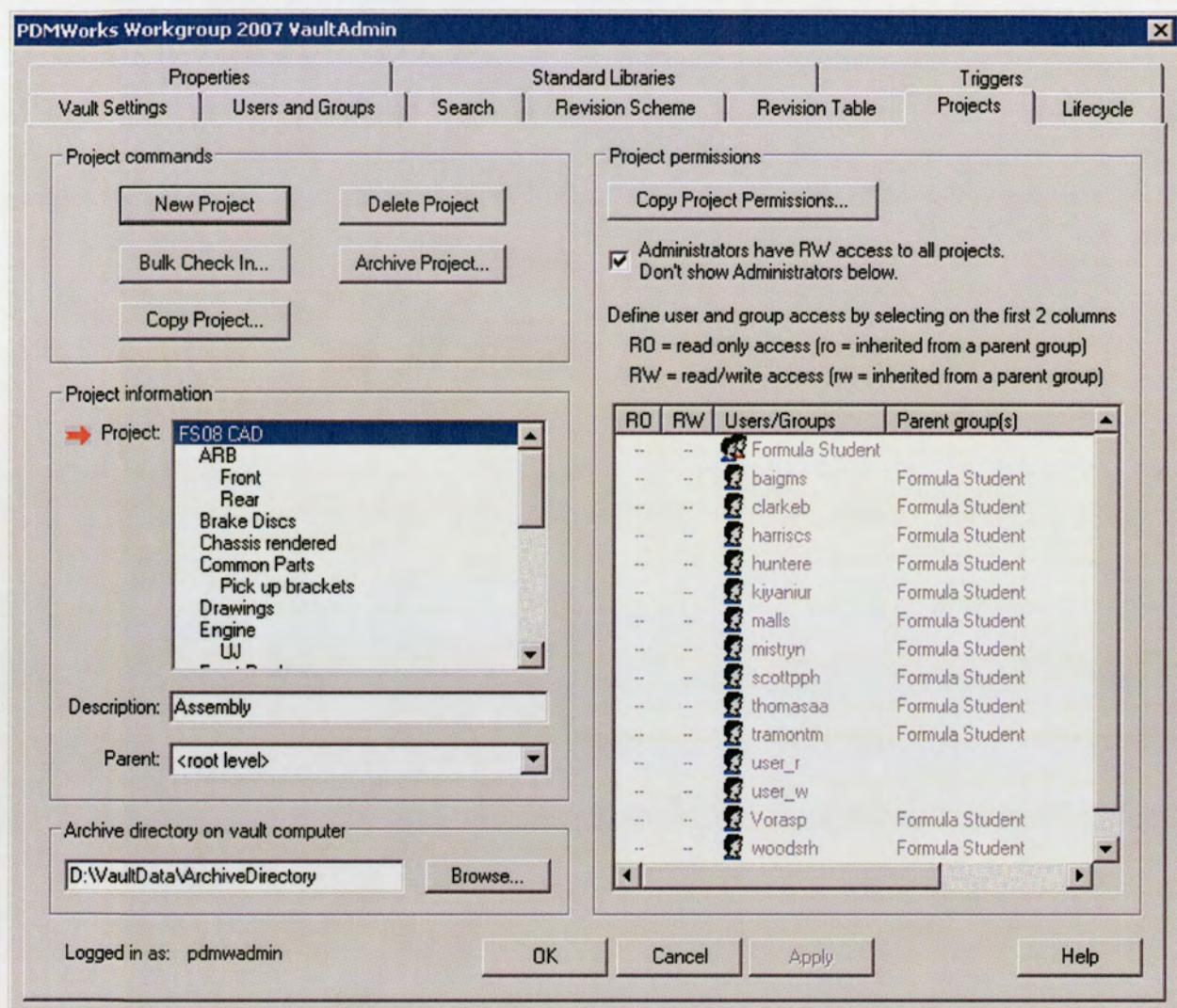


Figure 55: PDMWorks WorkGroup Vault Project Screen

Selecting the **New Project** button allows the naming and creation of the project folders. The **New Project** menu also enables the detailing of which user group should be assigned access to the particular project folder.

The **Bulk Check In** facility provides the facility for large SolidWorks assemblies to be checked into the required Vault project folder.

The **Project Permissions** function allows the detailing of users/groups that should have either **Read/write** access or **Read Only** access to a project folder.

19.1.4 Detailing the Vault Global Settings

Selecting the **Vault** tab, as presented in Figure 52, provides the facility to adjust the global Vault options that would be more beneficial to the needs of the Aston University Formula Student Team.

This screen allows the detailing of specific administrators, security and access to the Vault, revision overwrite control of the Vault and control of attachment of documents. The Help button found at the bottom right of the screen, gives a detailed explanation of each of the options that are available for selection.

Administrators can also be assigned from the list of users registered on the top right hand side of the screen.

19.1.5 Controlling the Revision System

As previously discussed in Section 17.3.1, selecting the **Revision Scheme** tab should present a number of options in the menu.

The Revision Scheme should be selected at the default setting: A –Z primary, and 0-99 secondary. This should ensure that a simplistic revision scheme is established, providing ease of traceability throughout the design review stages. It is not recommended to alter the revision scheme system until a configuration document control scheme is fully outlined. The PDMWorks WorkGroup Help function fully illustrates the changes available to the Administrator.

19.2 Proposed PDMWorks WorkGroup User Tutorial

The origins of the user tutorial would need to comprise of the fundamental operational basics, in order to provide a good understanding of interaction of the PDMWorks WorkGroup software. The areas that should be covered can be split into the following parts:

1. Basic PDMWorks WorkGroup activation and **Sign In/Out**.
2. Opening parts and assemblies from the Vault (**Check Out**).
3. Saving documents to the Vault (**Check In**).
4. Generating new parts and assemblies to **Check Into** the Vault.
5. Best practice guide.

The best practice section would be more specific to certain functions available to the Formula Student Team and finalised once the pilot scheme is completed.

19.2.1 Basic PDMWorks WorkGroup Activation and Sign In/Out

To active PDMWorks with **SolidWorks 2007 SP4.0**, select **Tools, Add-ins** from the software tool bar.

The following screen shown in Figure 56 should be displayed:

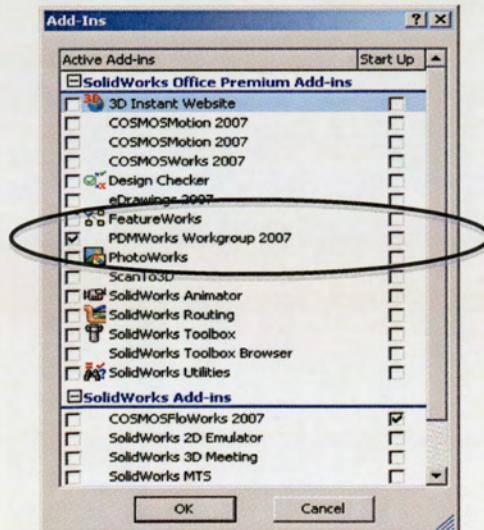


Figure 56: SolidWorks 2007 Add-Ins Options Screen

Select the **PDMWorks WorkGroup 2007** function.

In the main SolidWorks screen, right click on the **Tool Bar** to activate the **Quick Key** tool properties.

Select **PDMWorks WorkGroup** from the list and drag and drop the new toolbox anywhere on the tool bar.

The PDMWorks toolbox should now appear on the SolidWorks tool bar, *Left Click* on the **Gold Key** icon, as shown in Figure 57.

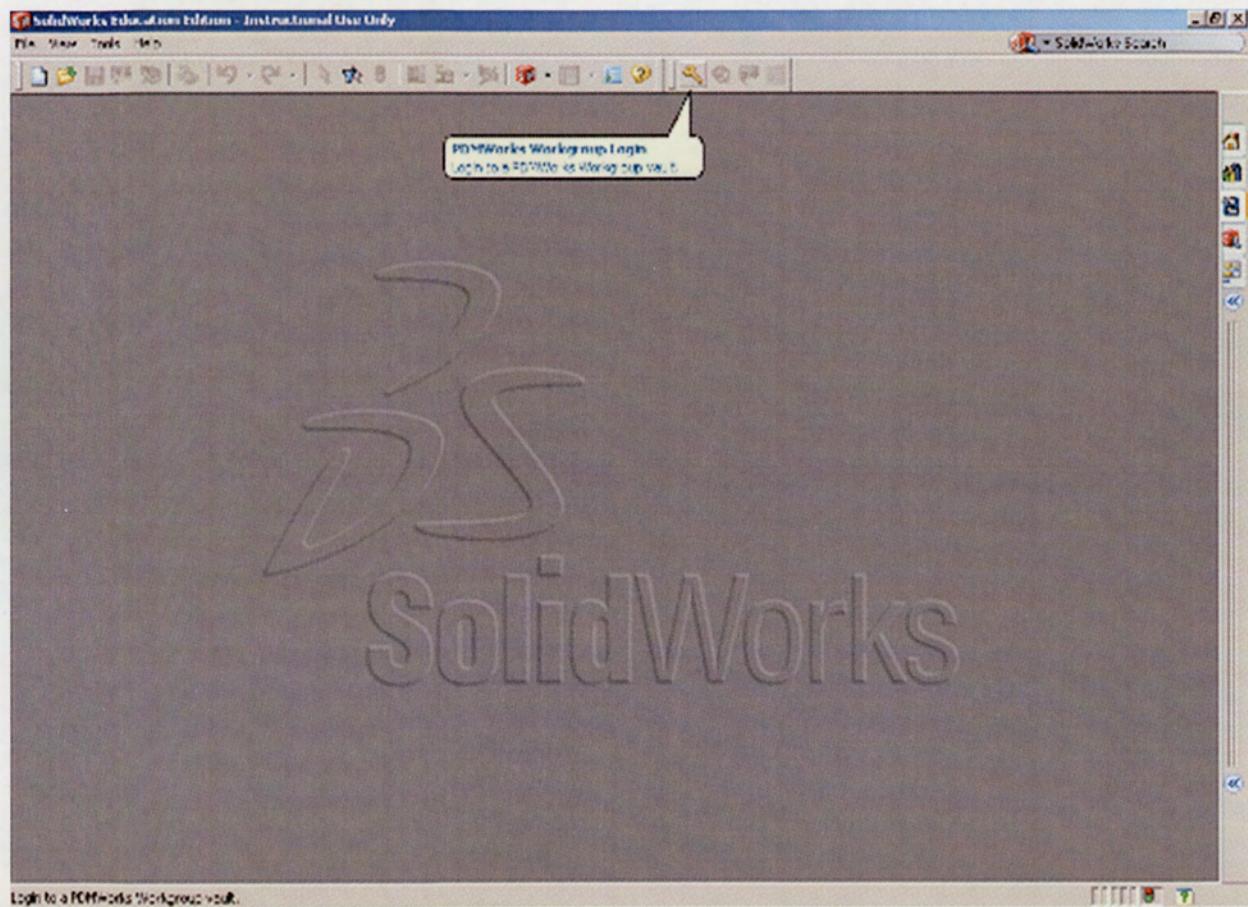


Figure 57: PDMWorks WorkGroup Toolbox in SolidWorks Tool Bar

This will launch the PDMWorks WorkGroup login menu, presented in Figure 58.

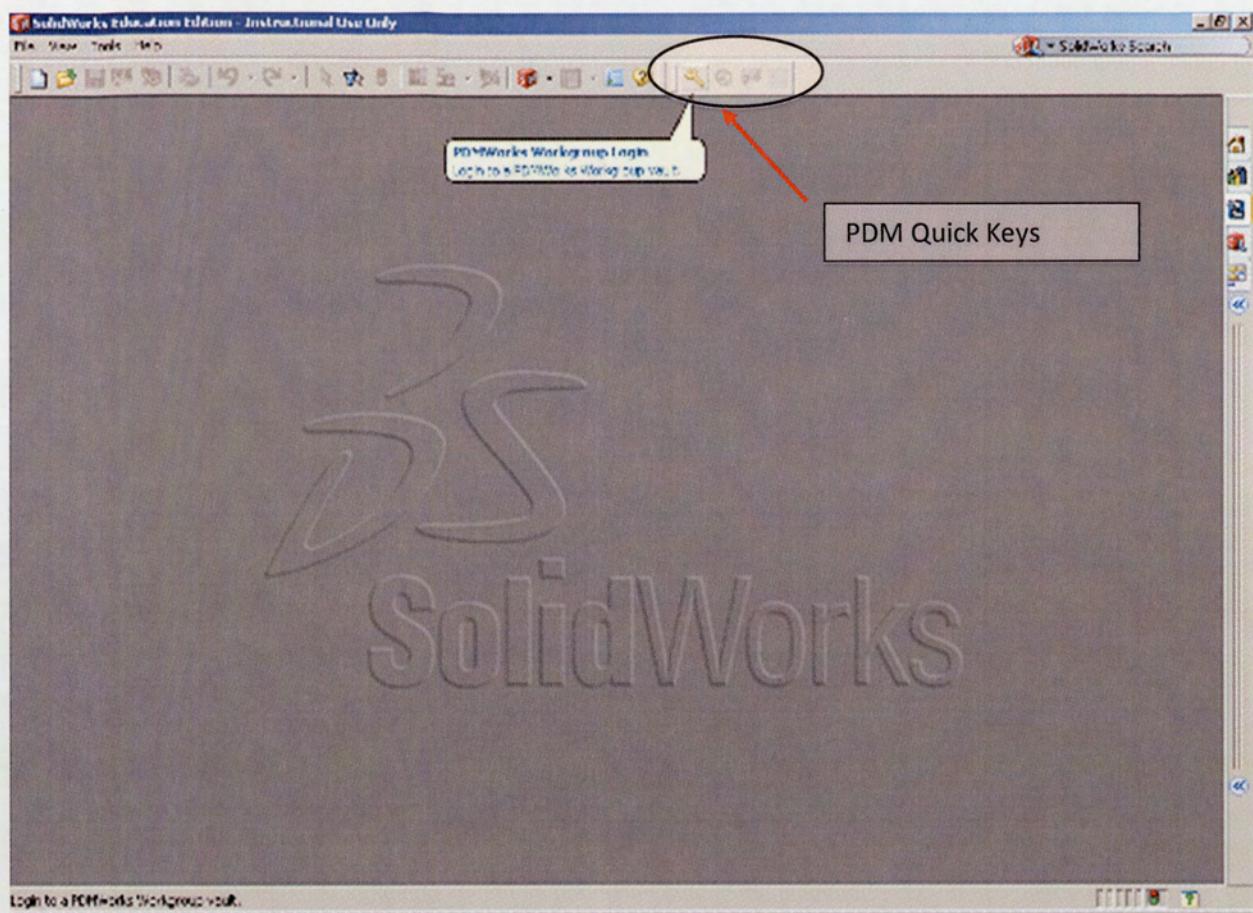


Figure 58: PDMWorks WorkGroup Quick Keys

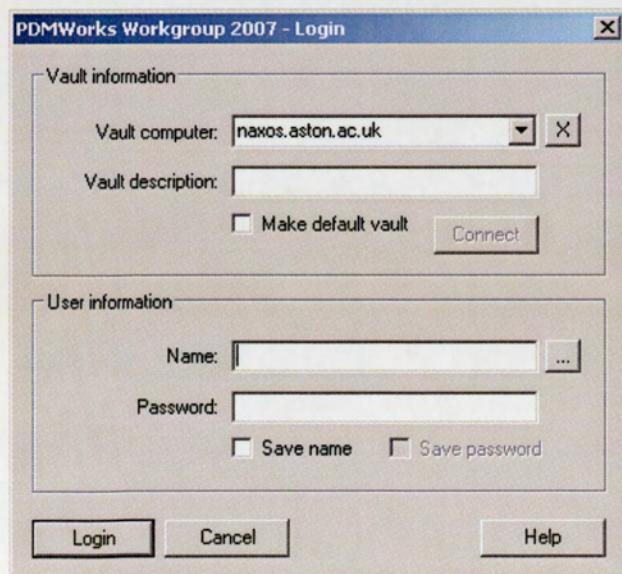


Figure 59: PDMWorks WorkGroup Login Screen

The instructions for the login process are as follows:

1. Vault Computer name is: **naxos.aston.ac.uk**. - Ignore the Vault description.
2. *Left Click* the **Connect** button - this will ensure that Vault server directory/connection is correct and will establish a connection.
3. Enter the specific Username and password that is supplied by the PDM Administrators.
4. *Left Click* the **Login** button.

To log out at the end of each session, before exiting SolidWorks, *Left Click* the **Gold Key Log Out** button on the PDMWorks WorkGroup toolbar, as shown in Figure 60.

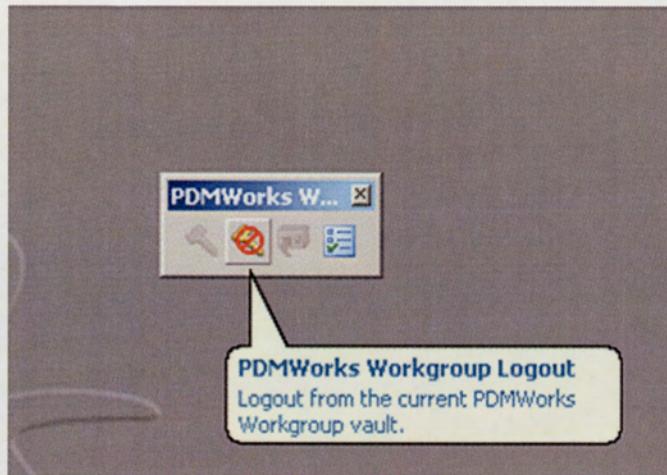


Figure 60: PDMWorks WorkGroup Log out Button

19.2.2 Opening Parts and Assemblies from the Vault (Check Out Function).

Left Click on the **Open Document** icon on the SolidWorks menu tool bar, this should open the screen shown in Figure 61. At the bottom left hand side is the icon for **PDMWorks WorkGroup Vault**, *Left Click* on the icon to see the Formula Student CAD 2008 project folder.

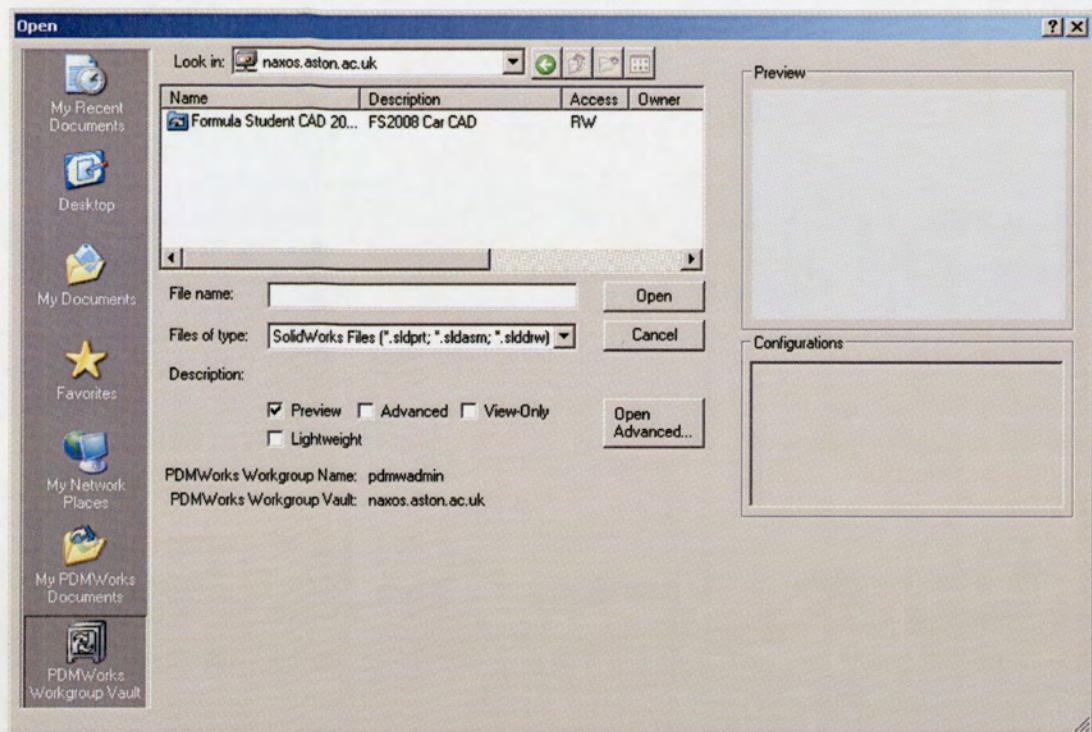


Figure 61: SolidWorks Open Document Menu Screen

Left Click on the Formula Student CAD project folder, this should open and detail all the files currently available and saved within the Vault. Select the assembly or part required and *Right Click* the **Open** button.

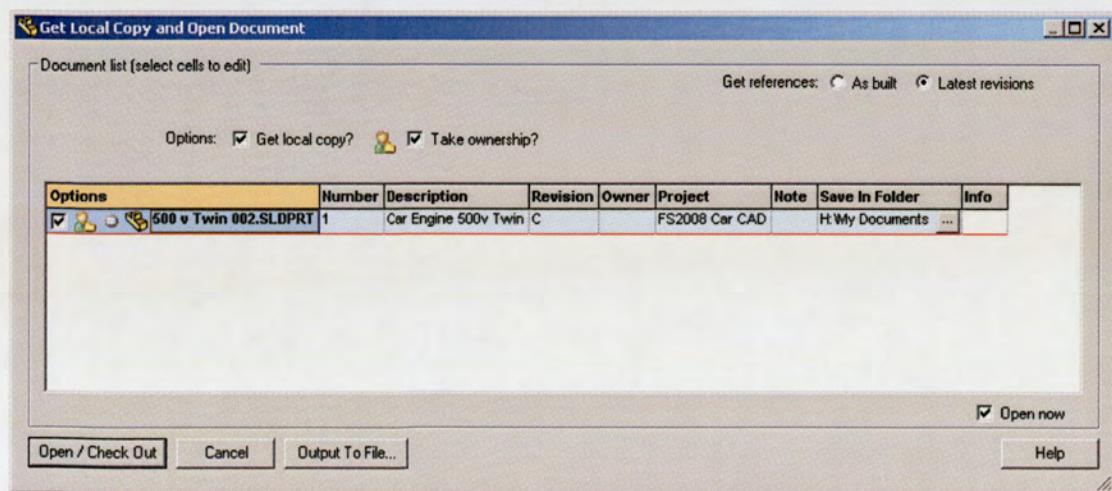


Figure 62: PDMWorks WorkGroup Additional Check Out Menu Screen

PDMWorks WorkGroup should then present an additional screen, as shown in Figure 62, detailing some options to be considered on check out.

The points to note are:

When an assembly or part is checked out of the Vault, it should generate a temporary file within the user **My Documents** folder. It is important to setup a specific folder within the user's **My Documents** folder, as this will keep the user's drive organised and separate from other non-related files. The new folder or location can be set up by clicking on the **Save In Folder** option column in Figure 62, and designating a folder name.

The most important option in Figure 62 is the **Take Ownership** tick box. This should allow the user to take full control of the parts and assemblies, and would not allow other users that subsequently log into PDMWorks WorkGroup to open and save over them.

The user now has full control and ownership of the assembly or part to work on.

19.2.3 Saving Parts and Assemblies back to the Vault (Check In).

To check in a part or assembly, save the file as per the normal practice within SolidWorks. On the SolidWorks tool bar, *Left Click* the **Check In (Active)** button in the PDMWorks WorkGroup toolbox, as shown in Figure 63 below.

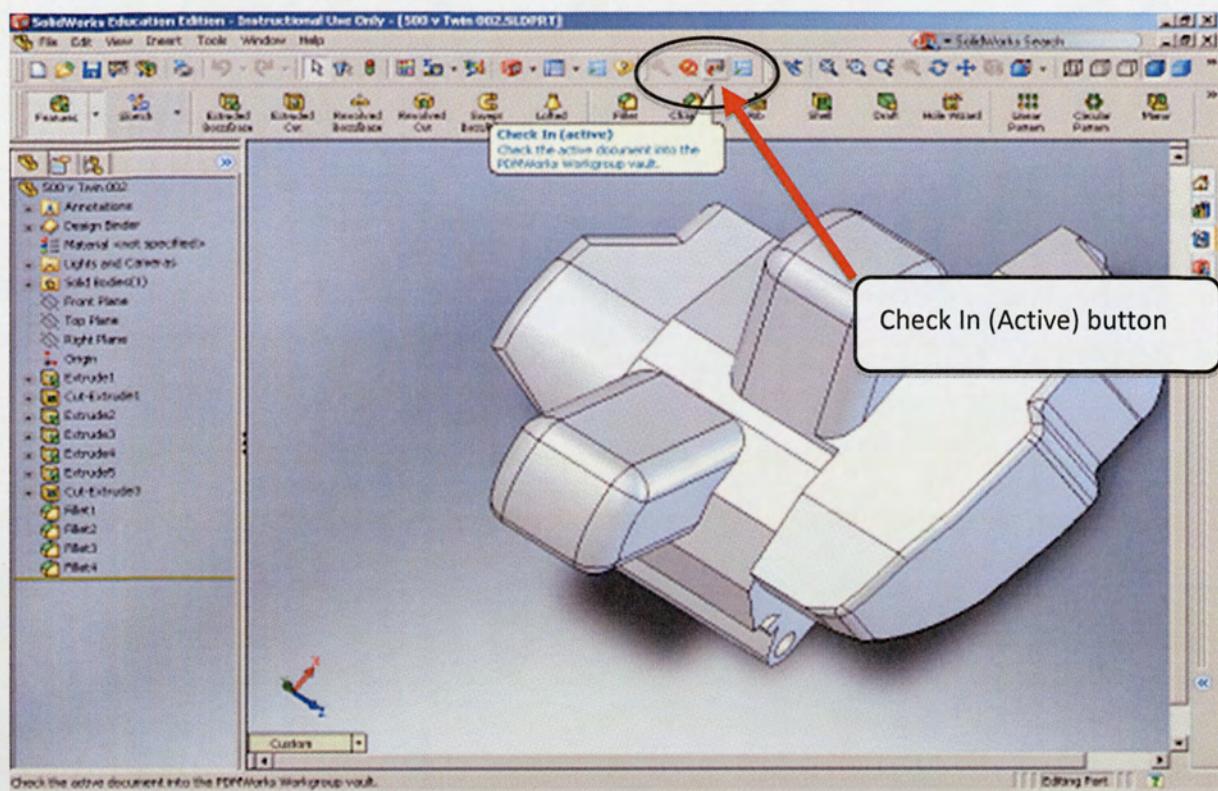


Figure 63: PDMWorks WorkGroup Tool Bar Check In (Active) Button

PDMWorks WorkGroup should then present the following screen shown in Figure 64.

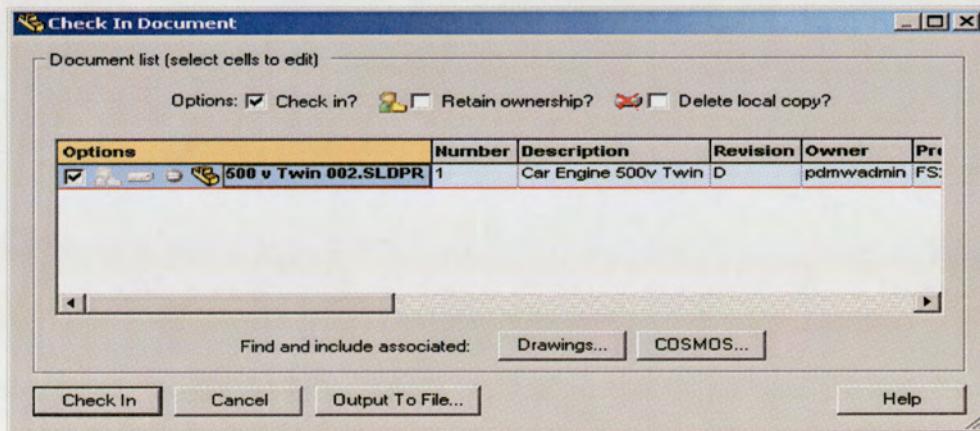


Figure 64: PDMWorks WorkGroup Check In Screen

The Check In Document screen details a number of options to be considered. The **Check In** tick box should be selected. The other additional options are: **Retain ownership** and **Delete local copy**.

Selecting the **Retain ownership** function provides the user the ability to control the opening and editing access of the part or assembly within the Vault; releasing ownership only when the user is satisfied to do so. For the user group, this is a particularly important function when editing a generic team assembly and should be deselected.

The **Delete local copy** option would remove the temporary file saved locally in the **My Documents** folder. This should avoid any potential confusion of duplicate revisions being created and stored.

Additional information displayed within the **Check In** screen details the revision number change, due to the editing of the part or assembly. A primary example of this change process is the previous version of a part or assembly checked out being revision B, with the changes made and saved during the editing session the system should update the issue the part or assembly to revision C on **check in**.

Left Click the **Check In** button and the part or assembly should be saved to the PDMWorks WorkGroup Vault.

19.2.4 Generating New Parts and Assemblies to Check Into the Vault.

The same procedure detailed in Section 19.2.1 should be followed to Log into the Vault. Once the part or assembly has been created, the file should be saved in the normal process in the local **My Documents** folder.

The PDMWorks WorkGroup toolbox **Check In** Tab on the SolidWorks tool bar should be *Left Clicked* to present the screen shown Figure 65.

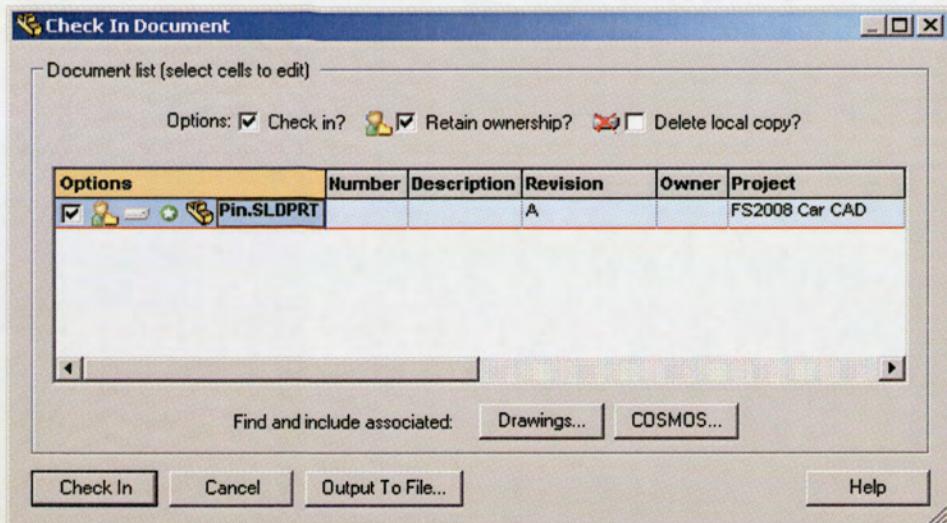


Figure 65: PDMWorks WorkGroup Check In Document Screen

As discussed in Section 19.2.3 the key points to be considered are:

- In the **Number** column, a number 1 should be entered, as this is the first iteration of the respective part or assembly to be checked in.
- The **Description** column should be detailed with a brief outline of the part or assembly.
- The **Revision** column should default to A, as this is the first revision of the part or assembly.
- An option is also provided to attach and create a relationship to the relevant drawings to check in.

Left Click the **Check In** button to successfully save the file into the Vault.

19.3 Best Practice Guide.

There are a number of additional functions that need to be discussed further, as they are specific to the requirements of Aston University Formula Student Team. This would aid the formation of a best practice guide that could be included in both the Administrators and Users Tutorials. These topics are:

1. PDMWorks options icon & password change
2. Revision working
3. Ownership of documents
4. Deleting documents from the PDMWorks WorkGroup Vault

Additional topics could be added once greater understanding is established of the working practices and process in using PDMWorks WorkGroup.

19.3.1 PDMWorks WorkGroup Options Icon & Password Change

Contained with the PDMWorks WorkGroup Toolbox is the options button, as shown in Figure 66.

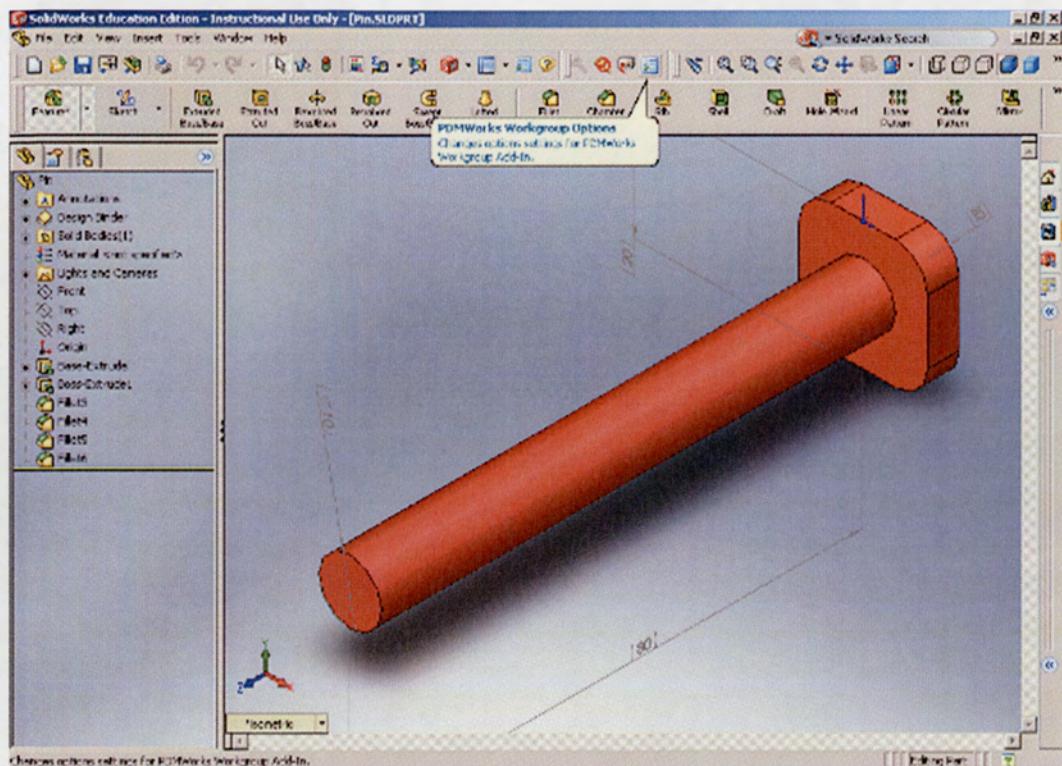


Figure 66: PDMWorks WorkGroup Toolbox Options Button

Left Click the options button to open the screen presented in Figure 67.

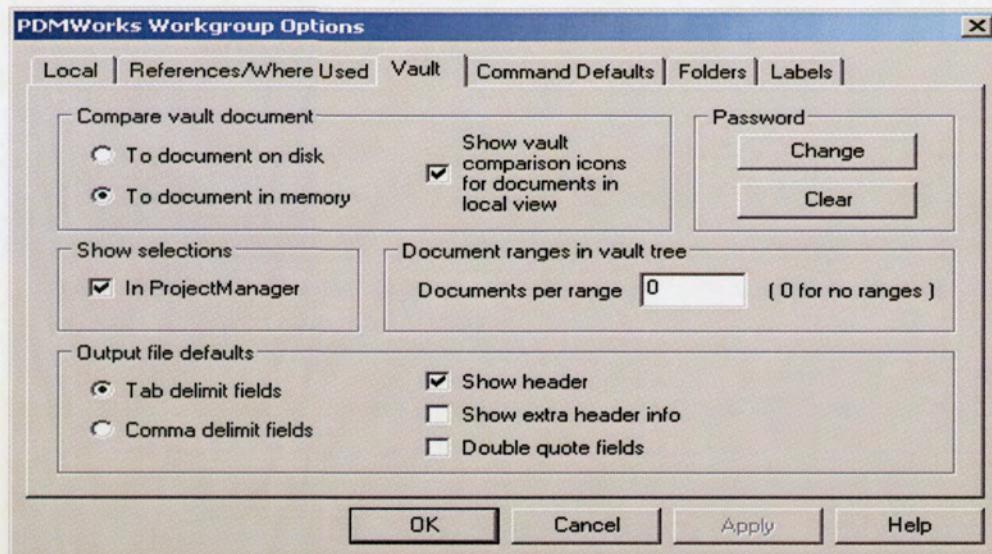


Figure 67: PDMWorks WorkGroup Options Screen

To change the individual user password, select the Vault tab at the top of the screen in Figure 67. The Vault menu provides the password change option. There are no specific requirements restricting the new password to be either numerical or alphabetical.

It is not advisable to change the other functionality options available, as the PDMWorks WorkGroup Vault has already been preset. If required, the SolidWorks software Help function details specific information regarding the individual options.

19.3.2 Revision Working.

As previously discussed in Section 19.2.4, the preset default revision number when a part or assembly is checked into the Vaults is set at A. However, there is the facility to manipulate and maintain the current revision number at the same level during future editing sessions, as each saved change and check in will result in an incremental increase in revision number.

It is possible to keep revision level as it was previously, by selecting the revision column tab and using the A+ or B+ etc. This should state that the part or assembly is still being edited, before a full incremental revision change is actually required, allowing time until all editing has been completed. PDMWorks

WorkGroup provides traceability of all changes made through this function, with the ability to ‘roll back’ files to the previous revision level, by the PDMWorks Administrator privileges, if required.

19.3.3 Ownership of Documents

The ownership of file is an important function to understand, in order to allow ease of communication and co-ordination through the design stages for the whole team. Each time a file is Checked In/Out, the user will retain its ownership, until it is released back to the Vault. The process that should be taken during the design review stage is that the part should only be released back from the user once the design is approved. This should ensure safe revision keeping, whilst also prohibiting other users from working on the same file until formally released at the required revision number.

19.3.4 Deleting Documents from the PDMWorks WorkGroup Vault

Deleting files contained in the Vault requires the privileges of the Administrator, protecting the safe storage of the Formula Student Team files.

19.4 Summary

The proposed Administrator and User tutorials has provided a framework that would directly support the launch of the pilot scheme, whilst also allowing the opportunity to assess the literature detail; evolving the content as required.

The development of the tutorials specific to the Formula Student Team requirements is an important aspect to ensure that KSF No 8 & 9 are fully achieved; directly benefiting the success of integrating the use of PDMWorks WorkGroup in firmly establishing the tool within the team standard working practices. Additionally, the endorsement of the literature content from the pilot scheme will finalise the release of the tutorials ready for use by the AM08 team.

20.0 Phase 4 - PDMWorks WorkGroup Performance Assessment

To meet the criteria identified for KSF No 9 - Training and Workshops, would require the combination of both the lessons learned from the limited success in implementing PDMWorks WorkGroup during AM05, and the KSF No 6 requirement information. This would provide a framework to establish a pilot scheme.

The strategy that needs to be adopted for the pilot scheme is to simulate a Formula Student Team design review phase, demonstrating the capability of PDMWorks WorkGroup and assessing the performance of the software functionality.

A driving factor in ensuring that KSF No 9 is successfully achieved, is the dependency on the content strength for the proposed PDMWorks WorkGroup Administrator and User tutorials. The assessment of the pilot scheme should provide sufficient analysis of the literature, adapting the content to the specific functionality needs of Aston University Formula Student Team, before issuing in order for it to be ready to be integrated fully into the AM08 standard working practices.

The intention is to utilise the current AM07 team for the pilot scheme project, introducing the PDMWorks WorkGroup during the design review stages. In selecting the AM07 team to assist in the pilot scheme, the working practices should provide a direct indication as to how the software functionality benefits the team, aiding the measurement of management effectiveness and performance for the Formula Student Team.

This will provide a true simulation of the software usage, whilst also directly benefiting the current AM07 team. The risk associated with this approach is the short learning curve required by the AM07 team, adapting quickly to the change in working practices. However, as previously discussed during Chapter 3, the team have already been continually adapting the working practice to overcome the consistent problems with the current SolidWorks file data storage system.

20.1 Pilot Scheme

The identified target period to introduce the pilot scheme is during the design review stages for the AM07 team, as shown in the project plan in Figure 36. The intention was to introduce the PDMWorks WorkGroup during the scheduled weekly Formula Student Team meetings held in the university Lab 77.

This was the optimum time identified for launching the pilot scheme to fully assess the performance and functionality of the software, as any future date would impact their workload and preparation for final year deadlines. This would ensure that a quantifiable assessment can be made in terms of measuring the effectiveness of implementation and ease of integration, with the full collaboration from the AM07 team members.

The approach taken is as follows:

1. The PDM Vault administration was configured to the pilot scheme requirements for the present team structure, with full user and administrator access accounts set up, along with the Formula Student project folder being created in the Vault. The PDM system was now 'live' and ready to be used.
2. The latest **AM07** full car assembly was checked into the Vault.
3. A presentation of PDMWorks WorkGroup and a full demonstration was given to the AM07 Formula Student Team during the scheduled design review meeting.
4. The proposed Administrator and User Tutorials were distributed across the team members and followed during the design workshop, allowing for questions and answers to various problems.
5. The team were then instructed to familiarise themselves with the practices in using the PDMWorks WorkGroup software.
6. The author provided a Help desk service during the course of the pilot scheme, in order to overcome any problems and limit any impact to the process of the design review stages.

During the course of the 4 week pilot scheme, an agenda topic during weekly design review meetings was built in for the discussion of progress in using the PDMWorks WorkGroup. This allowed for clarification on any of the proposed working practices or Vault functionalities, feedback on any problems encountered and suggested improvements from the AM07 team.

20.2 Review and feedback

The review and feedback task finalised the requirements for the future AM08 team, whilst also highlighting the areas for additional functionality research and analysis for PDMWorks WorkGroup.

The pilot scheme managed to evaluate the performance of the following functionality options:

1. Basic PDMWorks WorkGroup activation and Sign In/Out

2. Opening parts or assembly(s) from the Vault (Check Out)
3. Saving new files to the Vault (Check In)
4. Ownership of parts and assembly(s)
5. Revision scheme progress
6. Limited privileges assessment of the user and administrators against the team organisational structure

The benefits the PDMWorks WorkGroup brought to the AM07 team were immediately apparent. The reliability of controlling access to the latest parts and assembly, through ownership control, resolved the problems previously discussed in Chapter 3, Section 12.0.

The functionality assessment was constrained by a restricted time period to fully measure the potential of the documentation control, project supervisor design evaluation and revision scheme practices. These are only a few of these areas that if fully analysed, can be developed to greatly benefit the Formula Student Team.

It was evident from the co-ordination and control of the design review stage that the PDMWorks WorkGroup brought improvements both in terms of communication for the latest standards of parts, and in enhancing the productiveness from the team. Due to the limited time frame it is difficult to determine and quantify the benefits achieved by the team.

The feedback session provided a list of recommendations to the working practices and functionality of the PDMWorks WorkGroup.

20.2.1 Recommendations for Future Team Setups

The key areas identified from the pilot scheme to improve the PDMWorks WorkGroup setup, specific to the Formula Student Team working practices are:

- The PDM user ID should be the same as the student's university login ID, with a generic password set which can be then changed by the user.
- More emphasis required for demonstrating that a part or assembly is at a particular revision, identifying the need to construct a revision scheme working practice.
- Emphasis on the requirement to select **Delete local copy** function when checking in parts or an assembly into the Vault.

The functionality assessment of the Vault has demonstrated that the optimum setup for the Vault settings menu, within the Vault Administration, should be configured as shown in Figure 68 below.

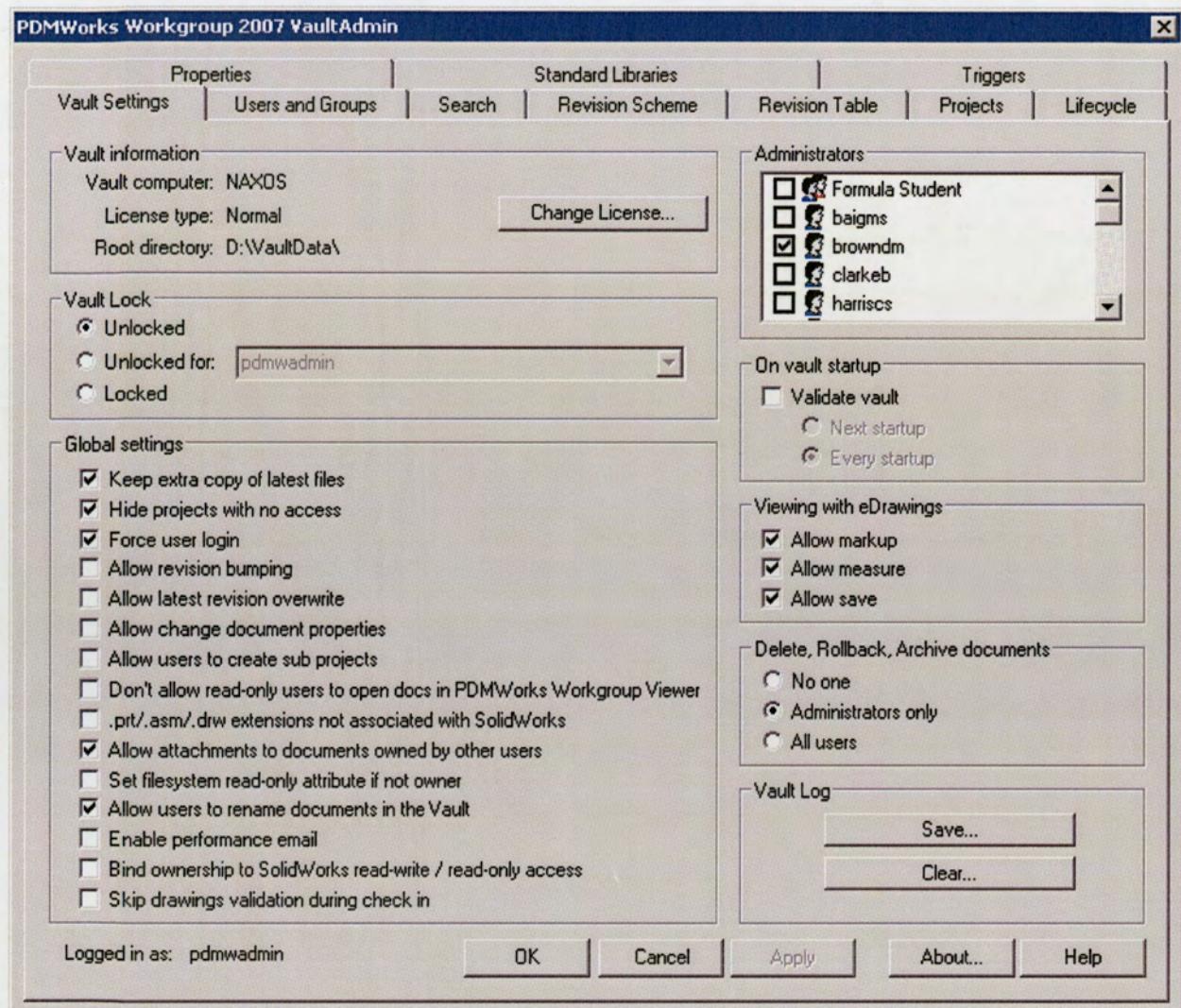


Figure 68: Recommended Vault Global Settings

The options deselected are:

1. Allow revision bumping - This is now controlled solely by the administrator.
2. Allow users to create sub-projects.

The revision scheme should be set to the default: A-Z primary, 1-99 Secondary for future teams.

20.3 Summary

The pilot scheme has provided the facility to meet the criteria of KSF No 9 – Training and Workshops, through evaluating the performance of the PDMWorks WorkGroup by means of the Administrator and User Tutorials. The Formula Student Team management was given sufficient training and exposure in using the PDMWorks WorkGroup, which will maintain continuity for the AM08 team. One of the benefits in utilising the AM07 in the working practices of the PDMWorks WorkGroup software, is the demonstration of new system potential to the future Project Team Managers that are within the undergraduate team.

The areas identified for improvement are: the documentation control management in PDMWorks, and the interaction of the project supervisors to assess and review design and the Life cycle functionality. Due to the limited duration of the pilot scheme, it would have been an inefficient use of time to fully understand and assess the opportunities PDMWorks WorkGroup offers, as this would require more dedicated time. This has the potential to be analysed and developed as a secondary task during the AM08 academic year.

The pilot scheme has directly established a configuration control system for the design stages, assisting the team in improving their working performance during the critical design phase. The feedback and recommendations from the AM07 team have finalised the literature content in the Administrators and User Tutorials for the AM08 team. The issued tutorials can be found in Appendix C & D.

21.0 Chapter 3 Conclusions and Recommendations

21.1 Conclusions

The four-phased approach in applying the theoretical knowledge to implement and integrate PDMWorks WorkGroup, has provided sufficient scope to meet the identified KSF criteria particularly KSF No 6, 7 and 9. Throughout the pilot scheme the content of the Administrator and User Tutorials has been evaluated, allowing for improvement to the specific working practice requirements of PDMWorks WorkGroup for the Formula Student Team.

The strategy adopted has allowed a framework to be generated to assess the PDMWorks WorkGroup functionality and capability performance, with the measurement of effectiveness demonstrated throughout the pilot scheme testing.

In evaluating the execution of the project plan, the main area for improvement would be to increase the duration of the pilot scheme, in order to develop more comprehensive and quantifiable assessment criteria to fully establish a measurement of performance for the software capability, and effectiveness on the team management. In addition, this would also provide the ability to assess the life cycle functionality and integration by the project supervisors during the design review stage. However, even with the limited duration of the pilot scheme, it has demonstrated the direct benefits that the PDMWorks WorkGroup offers to the Formula Student Team, in rectifying the previous data handling practices discussed in Section 12.0.

Initial findings from the distribution of administrator privileges against the hierarchy structure support KSF No 6, prove they are suitable to be continued for the AM08 organisation. The exposure and training given to the team management should reduce the resistance to change, in adopting the revised organisational hierarchy approach, ensuring that the capability and benefits of the PDMWorks WorkGroup achieves its potential for the AM08 team.

The issued administrator and user aids form the creation of a comprehensive induction pack, detailing the revised standard working practices and data handling control. This should directly support the transition to using PDMWorks WorkGroup, adapting revised working process, both for PDMWorks WorkGroup, but also improving communication lines within the team and support network.

In summary, Chapter 3 has demonstrated the capability and benefits that PDMWorks WorkGroup offers to the whole team, in evaluating KSF 6, 7 and 9, whilst providing a suitable framework of success in

integrating the software fully into the standard working practices of Aston University Formula Student Team.

21.2 Recommendations

The identified recommendations that could improve the capability of the PDMWorks WorkGroup for the Formula Student Team and directly benefit the School of Engineering are:

1. Project Life Cycle
2. Documentation
3. PDMWorks WorkGroup access
4. Additional training
5. Engineering Faculty

21.2.1 Project Life Cycle – KSF No 5

More time could be spent in understanding the project life cycle functionality in the administrator Vault menu. This would benefit both the programme management of the design phase and determine stringent timescales for the process within PDMWorks WorkGroup, before the issue status of the design is changed.

There is potential for a specific renew-by-date for status change that would allow for an assessment deadline to be made for the team and project supervisors to review designs. The life cycle status would also help during the manufacturing stages, providing details on final issue of parts to be made.

21.2.2 Documentation – KSF No 4

As previously discussed, limited time was spent fully evaluating the potential of KSF No.4. The client access facility is available on the university computer labs with a SolidWorks and PDMWorks WorkGroup image, and allows users to access the PDMWorks WorkGroup Vault without the need for opening SolidWorks. This function is based on Window Explorer program, with a browse and search

facility for the project folders in the PDMS Vault. Word and Excel documents can be checked in and out through the Client access function, with the ability to specify relationships to SolidWorks assemblies or parts. This would prove beneficial for attachment of FSAE rules and cost reporting spread sheets, with the possibility of providing assessment forms and feedback for the team members.

21.2.3 Access – KSF No 2

Improving on KSF No 2 – Access, with the PDM server being maintained and controlled by the university ICT department, there is further scope to provide access for remote working. SolidWorks provides all Formula Student Team members a free Student Educational copy of the software package, allowing students to have their own private licensed copy to use on their own PC. This gives the potential of allowing access to the PDMS Server from the home environment. There is already a secure access system for university staff and students to access documents and files on the university servers via Internet Explorer. This could be taken a step further and developed with allowing the PDM Server to be integrated within this facility.

21.2.4 Additional Training – KSF No 9

SolidWorks offer PDMWorks WorkGroup workshop courses for Vault Administrators. This would prove beneficial for the new team managers, giving a greater understanding of using the system as well as gaining additional tips and best practices which the Formula Student Team can implement. This could directly support KSF No 10, in the ability to expand the PDMWorks WorkGroup outside the context of Formula Student within the university.

21.2.5 Engineering Faculty Business Strategy – KSF No 10

Access to PDMWorks WorkGroup can be expanded outside of Formula Student, to encompass additional areas that are within the Engineering Faculty; particularly the assessed lectured modules of SolidWorks for the various degree courses. The Vault administration could be used by lecturers for their own project requirements within the Vault and would be separate from the Formula Student Team; specifying various

user access requirements. With the access control options provided by the Vault, it can be guaranteed that the particular work group and assigned users would only be able to see their particular project folder. Therefore there would be no adverse risk of foreign users being able to access the Formula Student project.

In addition, this could also be utilised for different degree modules that require group participation in design work, providing a greater control of how the students are working and progressing together.

There is also a possibility for the Client access function to be implemented in the lecturing and administration areas of the department. It would allow guidelines, degree course information, coursework, and timetables to be checked in and out of the Vault by either students or faculty staff. An initial trial could be run to see what benefits the PDMWorks WorkGroup system could bring to managing a degree course in the Faculty.

These areas identified would support KSF No 10, in developing a business strategy within the School of Engineering for the use of PDMWorks WorkGroup.

Chapter 4 – Thesis Conclusions, Recommendations and Reflections

22.0 Conclusions

This thesis presents the unique situation of Aston University's Formula Student Team requirements for an implementation of a Project Data Management System. The processes followed to successfully implement the PDMS into the Formula Student Team have been split into three distinct Chapters. Evaluating the approach taken and results of the integration of PDMS, the following conclusions are drawn, including the conclusions relating to aims and objectives originally set.

Chapter 1

The entirety of Chapter 1 presents the historical context of the development of Aston University Formula Student Team, with discussion on and focus given to the expansion and changes required to the organisational structure, roles and responsibilities. Analysis is provided on the team design environment for the car and the background, with an overview of the initial attempt to implement PDMS and the problematic processes in managing the data for the SolidWorks software package.

The original aim of: *to understand and analyse the team practices (2001 – 2007) and working environment when designing a Formula Student car*, has been met.

The common themes identified throughout the analysis provided topics for discussion to form the basis of further research covering: the project chain of command and conflict resolution, lines of communication and team formation, the ability for Project Supervisors to assess student work and performance, team data handling and access practices, team leadership and motivational issues and organisational structure changes. This set the preliminary question of: in comparing the unique situation of Aston University Formula Student Team to Industry, what factors can be identified to successfully address these problematic areas and implement PDMS?

The approach of Chapter 1 has also addressed the objectives for:

- *Understanding the Formula Student Team roles and responsibilities and leadership requirements*
- *Evaluating the previous attempt at implementing PDM at Aston University and understanding the root cause of the limited success.*

Chapter 2

From the discussion areas identified throughout Chapter 1, the research objective was to compare and analyse the differences between the Formula Student Team and Industry, gaining a perspective on what lessons could be learned. Particular attention was given to Industry experiences in implementing and developing PDMS within organisations and the approach adopted, identifying shortfalls in requirements or problematic areas. This provided a detailed overview of the benefits a PDMS would bring to an organisation.

The context of the organisational differences, both through business strategies, organisational structures and the New Product Development matrixes for complex technical projects, with specific comparisons to the Formula 1 Industry, was evaluated. The observations of these areas, demonstrating the unique differences between the Formula Student Team and Industry, provided guidance points for an approach to realign the organisational hierarchy of the team.

Establishing the fundamental principles of team formation, motivation, leadership and management provided a baseline of knowledge and how this could be applied to the practices of Formula Student Team formation and the co-ordination of the project throughout the academic year. The impact of implementing this knowledge, through a measurable effect on increased success and performance of the team is identified, suggesting training and awareness initiatives.

Performing a detailed analysis of the historical team data handling practices and process identified the common problems, which in turn, established a list of requirements to be addressed. The PDM functional benefits and operational framework are discussed, presenting how PDMS would directly address the previous data management handling issues, thus enabling the formation of a list of PDMS requirements for the Formula Student Team.

Throughout the detailed research, the areas highlighted that are critical for consideration to benefit the Formula Student Team, aided the establishment of Key Success Factors, which provide detailed criteria to assess successful implementation of a PDMS for the Aston University Formula Student Team. The 10 KSFs covering: data management, access, cost, associated documents, life cycle, organisational structure, project plan, testing, training and workshops and business strategy, formed a framework to evaluate commercially available PDMS software, which ultimately drove the selection of PDMWorks WorkGroup. However, the concessions noted during the KSF appraisal, both in terms of cost analysis for the hardware and agreement of adapting the proposed organisational change, needed to be addressed.

The original aim: *To establish the leadership tools and organisational changes required to utilise the full benefit of implementing a PDM system for the Formula Student Team*, has been met.

Chapter 3

The third chapter of the thesis applied the theoretical knowledge learned through the established KSFs, to implement PDMWorks WorkGroup for Aston University Formula Student Team.

In respect to the concessions raised during the KSF assessment, the hardware and software requirements were discussed with the university ICT department, which facilitated the launch of the project plan. With no expense being incurred, this was a positive benefit to the project.

The initial testing provided sufficient time for familiarity and resolution of problems encountered. The assessment of the proposed organisational structure was made against the distribution of access and privileges, demonstrating the suitability of the recommended users and administrators for the PDMWorks WorkGroup access. This formed part of the evidence to present for review and agreement on the proposed organisation structure change.

In the extensive testing period, based on the KSF detailed requirements, the user guides for administrators and tutorials were outlined, whilst generating a best practice guide for the Formula Student Team. A pilot scheme was used for testing and providing awareness of PDMWorks WorkGroup, through using planned workshops with the Formula Student Team. The pilot scheme tested and explored the PDMWorks WorkGroup capability and performance characteristics via a simulation of design review, utilising previous year's SolidWorks data. This allowed for suitable feedback to be given, a demonstration of PDMWorks WorkGroup capability, familiarisation for new administrators and users and formalising the release of the final issue of the Administrator and User Guides. The completion of the testing against the KSFs, workshops, demonstration of performance capability, signified the completion of the pilot scheme, with PDMWorks WorkGroup now being fully integrated into Formula Student Project for use by the AM08 team.

The original aim: *To apply the theoretical and practical knowledge gained from the Industry research into PDM software, in order to provide a fully working system capable of servicing the requirements of the team, in an effective and maintainable way*, has been met.

Based on the experience with PDMWorks WorkGroup further opportunities for improvements of capability requirements were identified, both in terms of improving external access, and in fully understanding the project life cycle, as regards the definition of the review process and project timescales.

The approach of Chapter 3 has also addressed the objectives for:

- *Setup and install a Project Data Management System for the Formula Student Team at Aston University.*
- *Establish and provide a tutorial on how to use the software for the Administrators and Users, specific to the Formula Student Team.*
- *Test and prove a working design assembly of a Formula Student car within the PDM system.*
- *Launch the PDM system ready for the start of the next academic year.*
- *Propose developments for the PDM system in order to enable other student teams within the university to use the program effectively.*
- *From the research, identify future potential development for PDM systems.*

In summary, the aims and objectives of the thesis have been met. The identification and establishment of the KSFs were an essential element, in order to ensure the successful implementation of PDMWorks WorkGroup. The scope of the thesis proved the unique context of the Formula Student project, with the definition of requirements drawn from both Industry experiences and Formula Student. This established an approach that can be continued to directly contribute towards the success of the team and support forecasting future expansion of the project within Aston University.

23.0 Reflections

Considering the approach of this thesis and the research undertaken, the following is a summary of the strengths and weakness, with regard to the effectiveness of the framework to implement a PDMS into Aston University Formula Student Team.

The strengths of the approach are:

- Established a requirements framework for the PDMS and implementation criteria, specific for the Formula Student Team.
- Identified the need for leadership and management training to assist in the development of the project success, providing greater acceptance and adaptability to changes in working practices, direction and approach.
- Introduced a framework for retaining knowledge in the transition between academic years.
- Improved chain of command and lines of communication within the team organisational structure.
- Resolved the problematic data handling practices of the Formula Student Team, allowing the ability to flow down specific FASE rules that are attached to parts and areas of the car design.

The problems and weakness encountered are:

- The lack of commercially available literature on the Formula 1 Industry. Gaining more knowledge and detail on the engineering structures, the roles and responsibilities, and configuration management control practices would provide a more refined case study between Formula Student and Formula 1.
- Development of a quantifiable system for validating the effect on the scale of performance and efficiency with the integration of PDMWorks WorkGroup. The framework could involve directly comparing adherence to project milestones including: longer duration and testing time and the individual performance of the team members in comparison to their peer group within their respective courses.
- Inability to fully understand and test the project life cycle capability offered within the PDMWorks WorkGroup software due to the limited time period.
- Longer duration of time required for the Pilot Scheme to fully assess all functionalities of PDMWorks WorkGroup.

- Need to develop quality metrics to monitor the performance increase of teamwork through the use of PDMWorks WorkGroup.
- Longer duration to test and develop the documentation control capability.
- Emailing system could be made operational for updates on design changes, reviews process and project life cycle deadlines.

The concept of this thesis, in implementing a PDMS into the Formula Student Team, could be compared to Small Manufacturing Enterprises, as discussed in Section 10.3. Therefore, there is scope for the established framework and methodology within this thesis to be adapted and expanded to the specific needs of SMEs. This may aid the implementation of a configuration management control system, comparable to PDMS.

24.0 Recommendations

In evaluating the problems encountered and the particular areas that would support further developments of PDMS, the summary of recommendations from this thesis are:

- Formalise a performance management matrix to assess the benefits PDMS brings to the project success and management effectiveness
- Develop a modern and flexible working environment, which facilitates the need to work from locations globally, allowing for external input into the design and development process.
- Establish a framework for team management and leadership training courses for the new postgraduate team members.
- Improve the awareness of PDMS within the School of Engineering and integrate PDMS within the assessed SolidWorks lecture modules.
- In measuring motivational aspects of being involved with the Formula Student project, consideration should be given to comparing undergraduate student course marks with the assumption of a higher average in grades against their peer group in the final year.
- In sustaining the development of the PDMS working practices, provide training to permanent university staff to ensure knowledge retention, whilst continuing the capability enhancement of PDMS.

Since the original submission of this thesis in 2008, the following research areas have emerged for consideration of possible areas for improvement to PDMS implementation frameworks and methodology:

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5. Marian Bosh-Rekoldt, Yuri Jongkind, Herman Mooi, Hans Bakker, Alexander Verbraeck, 2010, Grasping project complexity in large engineering projects: The TOE (Technical, Organizational and Environmental) framework.

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Margot Morrell and Stephanie Capparell, 2001, Shackleton's Way. Nicholas Brealey.

ISO 10007:2003 Quality Management Guidelines For Configuration Management (International Organisation For Standardisation – June 2003)

SolidWorks 2007 Tutorial Guide

PDMWorks WorkGroup 2007 Software Tutorial Guide

www.solidworks.com

www.solidsolutions.co.uk

www.formulastudent.com

26.0 Appendix A – PDMWorks WorkGroup Hardware Requirements

Client	Minimum	Recommended
PDMWorks Enterprise (CAD Editor)		
Processor	Intel Pentium 4, 1.7GHz	Intel Core2 Duo, 1.8GHz
RAM	512 MB	2 GB
Hard drive (Free space)	512 MB	20 GB
Operating system	Windows XP SP2	Windows XP SP2
Internet browser	Microsoft Internet Explorer 6 SP1	Microsoft Internet Explorer 6 SP2
PDMWorks Enterprise Contributor/Contributor Web and PDMWorks Enterprise Viewer		
Processor	Intel Pentium 4, 1.7GHz	Intel Core2 Duo, 1.8GHz
RAM	512 MB	1 GB
Hard drive (Free space)	256 MB	10 GB
Operating system	Windows XP SP2	Windows XP SP2
Internet browser	Microsoft Internet Explorer 6 SP1	Microsoft Internet Explorer 6 SP2
Server	Minimum	Recommended
Archive		
Processor	Intel Pentium 4, 1.7GHz	Quad Core Intel Xeon, 1,6GHz
RAM	1 GB	2 GB
Hard drive (Free space)	10 GB	200 GB
Operating system	Windows 2003 Server SP1 or higher (2)	Windows 2003 Server SP1 or higher (2)
Database		
Processor	Intel Xeon, 2,6GHz	Quad Core Intel Xeon, 2,0GHz
RAM	2 GB	4 GB
Hard drive (Free space)	10 GB	100 GB
Operating system	Windows 2003 Server SP1	Windows 2003 Server SP1
Database Server	Microsoft SQL Server 2005 SP1	Microsoft SQL Server 2005 SP2
Web		
Processor	Intel Xeon, 2,6GHz	Quad Core Intel Xeon, 2,0GHz
RAM	1 GB	3 GB
Operating system	Windows 2003 Server SP1 and Internet Information Services (IIS)	Windows 2003 Server SP1 and Internet Information Services (IIS)

PDMWorks Enterprise Notes:

- The PDMWorks Enterprise server components can run on workstations running XP, but in a production environment, SolidWorks Corporation requires the use of a server-specific operating system.
- The minimum requirement is an absolute minimum. SolidWorks Corporation cannot guarantee system performance or behaviour for installations running on configurations not meeting the minimum recommended levels.
- The hard drive requirements are solely dependent on the size of data stored in the system. Therefore, the actual requirements can exceed the values in this recommendation.
- The recommended configuration is based on a typical installation with approximately 20 users and approximately 60,000 stored documents.
- Prerequisites for installing any PDMWorks Enterprise component are Windows Installer 3.1 and Microsoft SQL Server 2005 SQL_DMO backward-compatibility drivers. These are automatically installed when running the PDMWorks Enterprise setup.
- If using an administrative install image for client deployment, these components will not be installed automatically.
- As the Database Server of PDMWorks Enterprise runs on SQL server, we do not recommend installing any instances of other applications on the database server.

PDMWorks Workgroup Vault: (1)

The CPU, Other, and Network requirements listed above plus the following:

- Microsoft Windows XP Professional or Windows Server 2003® (recommended)
- Minimum: 512 MB RAM or greater, Recommended: 2GB
- Minimum: 50 GB hard drive, Recommended: 100GB
(requirements vary based on number of files, size of files, and number of revisions)

 **PDMWorks Workgroup Viewer:** (1)

PDMWorks Vault server requirements plus the following:

- API Triggers
 - Microsoft Message Queuing (MSMQ)
 - Microsoft Message Queuing Triggers
- Web Portal
 - Microsoft Internet Information Services (IIS) 5.1 or later⁴⁴

⁴⁴ System hardware recommendations are taken from
<http://www.solidworks.com/Pages/services/SystemRequirements.html>

ConnectPress Ltd.

SolidWorks PDM: Software Reference Guide

February 2007

2007 Product Data Management (PDM) Roundup!

This year in the 2007 PDM Roundup readers can expect an overview which includes a description of PDM, issues PDM systems address and customer needs/concerns, the latest trends, the key to managing data, PDM verses PLM and also a section on what the future looks like for PDM.

Plus, find out about the PDM software offerings from the top vendors and see what users had to say about the products. Not only will the side bar have information about the hottest PDM software on the market, but also alternative solutions, add-ins and more.

In addition, read the case studies for more product information and success stories.

Questionnaire	Aimasoft	Assetium	CADWorks Software Oy, Ltd.
Product Name?	EntraLink ERP2CAD (Profit for interoperability)	@UDROS PLM suite	CustomWorks
Integrated into CAD Systems?	SolidWorks, Solid Edge, AutoCAD	SolidWorks, CATIA V5, Solid Edge, Pro/E, AutoCAD, ME10, Tell	SolidWorks
Non-CAD Systems Integrated With?	Excel, Access and other ODBC DBMS	MS Office, MS Project, Open Office, Outlook connectors, Integrate ERP or SCM, SMTP server mail	API to create integration to almost any ERP system
Access Data from Multiple, Dissimilar CAD Systems?	Yes, very flexible framework	Yes	PDMWorks
2D/3D Viewer?	Third Party eDrawings	2D thumbnails, Edrawings Pro or Autovue connectors	PDMWorks
Central Database + Remote Doc Vaults?	Yes	Yes	PDMWorks (Enterprise)
Multiple Levels of Security?	Yes	Yes	PDMWorks
Single User Interface?	Yes	2 Types of User Interface (frequent or occasional access)	Yes
Automatic Titleblock Update?		Yes	Yes
Generate Image Files for Previewing?	Yes	Yes	PDMWorks
Extract BOM, Associated Data, & History?	Yes	Yes	Yes
Manage Parametric Parts & Assemblies?	Yes manages product structure	Yes	Yes
Support of Multiple Sites Via Internet/Lan Lines?	Yes via Citrix	Vault and/or database replication	PDMWorks (Enterprise)
Provide Structure "Where Used" Data for Parts, Docs., Folders?	Yes	Yes	PDMWorks
Configurable Restrictions for User(s), Group(s)?	Yes	Yes	PDMWorks
Customer-Defined Change, Release Management?	Yes specialized adaptors	Yes	PDMWorks
Operating System(s)?	XP/NT	Full web architecture: Windows or Linux(server)/Internet Browse for users	Windows XP 32-bit
Database(s)?	Any ODBC compliant database	INGRES (open source), Oracle	PDMWorks
Average Implementation Time?	3-5 days	Generally 10-25 days within 3-6 month period	1 day
Price Per Seat?	\$1,895US	Floating Licenses- contact resellers	CustomWorks € 680euro/\$872US, CustomWorks Xpress € 230euro/\$295US
Web Address	www.aimasoft.com	www.assetium.com/EN	www.cadworkssoftware.com
Contact	Jaye Ramaswamy	Julien Cimetière	Krista Taponen
Email	jaye.ramaswamy@aimasoft.com	jclementiere@assetium.com	krista.taponen@cadworkssoftware.com
Phone	415-453-2063	+33(0)4-78-68-46-41	+358-50-468-6367

Questionnaire	Concurrent Systems	Elton Solutions	Engineering PLM Solutions
Product Name?	DesignDataManager	RevZone	RuleDesigner PDM
Integrated Into CAD Systems?	SolidWorks, Solid Edge, Pro/E, Inventor, IronCAD, AutoCAD, ME10	SolidWorks, AutoCAD	SolidWorks, CATIA V5, Solid Edge, Inventor, AutoCAD, ME10
Non-CAD Systems Integrated With?	MS Office, PDF, any Windows Single File Type	Microsoft Office	Oracle, MySQL Server, Access Office, PDF
Access Data from Multiple, Dissimilar CAD Systems?	Yes	Yes	Yes
2D/3D Viewer?	Yes	Yes	Yes
Central Database + Remote Doc Vaults?	MS SQL database & replicated vaults	Yes, Central data base and Document vault	Yes
Multiple Levels of Security?	Yes	Yes	Yes
Single User Interface?	Yes	Common interface throughout the applications, single user interface for the RevZone Independent Explorer.	Yes
Automatic Titleblock Update?	Yes	Yes	Yes
Generate Image Files for Previewing?	Yes	Images directly from SolidWorks or AutoCAD files	No
Extract BOM, Associated Data, & History?	Yes	Yes	Yes
Manage Parametric Parts & Assemblies?	Yes	Yes	Yes
Support of Multiple Sites Via Internet/Lan Lines?	Yes	Yes	Yes
Provide Structure "Where Used" Data for Parts, Docs., Folders?	Yes	Yes	Yes
Configurable Restrictions for User(s), Group(s)?	Yes	Yes, configurable user and group management	Yes
Customer-Defined Change, Release Management?	Yes	Release management, Engineering Change Processes	Yes
Operating System(s)?	Windows 2000, 2003, XP	Windows 2000, XP (Vista coming)	Windows (client), Windows or Linux (server)
Database(s)?	MS SQL Server 2005 Express, and MS SQL Server	SQL Server 2000, 2005, MSDE/Express	Oracle, SQL Server, MySQL, Access
Average Implementation Time?	1 day	1-10 days. Depends on number of seats and legacy data	5 days. Really depends on size, legacy data, & industry
Price Per Seat?	From \$1,000US	\$495US for SolidWorks Version, \$195US for Independent Version	From \$1000US -- \$4600US
Web Address	www.csi-europe.com	www.eltonsolutions.com	www.ruledesigner.com
Contact	CSI or Resellers	N/A	Gianfranco Biguzzi
Email	info@designdatamanager.com	info@eltonsolutions.com	biquzzi@ruledesigner.com
Phone	N/A	+44-0-152-434456	+39(0)-5-47-63-08-42

Questionnaire	Javelin Technologies	MechWorks	SDH Development
Product Name?	PDMWorks Enterprise	DBWorks/DBInventor	ToolWorks BOM Manager
Integrated into CAD Systems?	SolidWorks, Solid Edge, Inventor, AutoCAD	SolidWorks, Inventor, AutoCAD, ME10	SolidWorks Gold Partner
Non-CAD Systems Integrated With?	All Windows compatible applications	Word, Excel	Only SolidWorks
Access Data from Multiple, Dissimilar CAD Systems?	Yes	Yes	Only SolidWorks
2D/3D Viewer?	Free, integrated in Windows Explorer, and views over 250 file types	Yes	Utilizes eDrawing Viewer
Central Database + Remote Doc Vaults?	Yes	Replicated databases and remote vaults	Stand-Alone or with PDMWorks
Multiple Levels of Security?	Yes	Yes	Supports security systems within PDMWorks
Single User Interface?	Yes	Yes	100% integrated with SolidWorks
Automatic Titleblock Update?	Yes	Yes	Yes
Generate Image Files for Previewing?	Native 2D/3D file preview	Yes	Yes
Extract BOM, Associated Data, & History?	Yes	Yes	BOM export to XML, TXT, or XLS
Manage Parametric Parts & Assemblies?	Yes	Yes	Support for "Dimension Links"
Support of Multiple Sites Via Internet/Lan Lines?	Multi-Site adaptive replication included	Yes	Yes in combination with PDMWorks Enterprise
Provide Structure "Where Used" Data for Parts, Docs., Folders?	Yes	Yes	Managed by PDMWorks
Configurable Restrictions for User(s), Group(s)?	Yes	Yes for groups	Managed by PDMWorks
Customer-Defined Change, Release Management?	Yes	Yes	Managed by PDMWorks
Operating System(s)?	Windows NT, 2000, XP	Windows 2000, XP, VISTA	Windows XP (32/64 bit), Windows Vista
Database(s)?	SQL Server included	SQL Server, Oracle, MDB	None
Average Implementation Time?	5-8 days	2 to 5 days	A few hours
Price Per Seat?	\$595US - \$1,795US depending on functionality	\$500US -- \$1,100US	\$595US
Web Address	www.javelin-tech.com	www.mechworks.com	www.toolworks.info
Contact	Rob MacEwen	Gaetano Tavano	SDH Development
Email	rob.macewen@javelin-tech.com	info@mechworks.com	info@toolworks.info
Phone	905-815-1906 x238	+39(0)-51-58-22-94	978-633-3318

Questionnaire	SofTech Inc.	Solid Partners Inc.	SolidVision
Product Name?	ProductCenter	Activault	PDMWorks WorkGroup & Enterprise
Integrated into CAD Systems?	SolidWorks, CATIA, Pro/E, Inventor, AutoCAD, CADRA, UGS, ME10	All versions of SolidWorks	SolidWorks plus 260 file formats
Non-CAD Systems Integrated With?	MS Office, Adobe FrameMaker	No, but Activault provides a stand-alone UI that works with any file type	260 various file formats integrate to any QDBC-compliant database
Access Data from Multiple, Dissimilar CAD Systems?	Yes	Yes, through stand-alone client	Yes
2D/3D Viewer?	Integration with Autovue from Cimmetry Systems Inc	No, it's not required	Yes
Central Database + Remote Doc Vaults?	Yes	Yes	Yes
Multiple Levels of Security?	Yes	Yes, user access level and an API layer	Yes
Single User Interface?	Yes	Yes, however Activault has a windows interface and a web-based interface which have parallel features	Yes
Automatic Titleblock Update?	Yes	Yes if linked to custom properties of SolidWorks files	Yes
Generate Image Files for Previewing?	Yes	Yes	Yes
Extract BOM, Associated Data, & History?	Yes	Yes, but printing as a report requires an SQL query	Yes
Manage Parametric Parts & Assemblies?	Yes	Yes within SolidWorks	Yes
Support of Multiple Sites Via Internet/Lan Lines?	Yes	Yes	Yes
Provide Structure "Where Used" Data for Parts, Docs., Folders?	Yes	Yes	Yes
Configurable Restrictions for User(s), Group(s)?	Yes	Yes, for users, however Activault does not support group roles/privileges at this time	Yes
Customer-Defined Change, Release Management?	Yes	Yes	Yes
Operating System(s)?	Windows, Solaris, HP-UX	Windows 2000, XP and Server 2003	Windows
Database(s)?	Oracle, MS SQL Server	MSDE 2000, SQL Server 2000	ODBC Compliant SQL Server based
Average Implementation Time?	Less then 1 month	Less then 1 day	6-12 days
Price Per Seat?	Contact Vendor	\$1,000US	\$1,000US - \$2,000US
Web Address	www.softech.com	www.solidpartners.com	www.solidvision.com
Contact	Erin Kelley	David Ondyak	Kevin Curry
Email	ekelley@softech.com	david@solidpartners.com	KCurry@solidvision.com
Phone	978-640-6222 x222	708-308-9244	978-852-2969

Questionnaire	SolidWorks Corp.	Synergis Software
Product Name?	PDMWorks Enterprise	Synergis Adept Enterprise Data Management
Integrated into CAD Systems?	SolidWorks, AutoCAD, Inventor, Solid Edge	SolidWorks, Inventor, AutoCAD design products
Non-CAD Systems Integrated With?	All MS Office products	MS Office, all Windows files
Access Data from Multiple, Dissimilar CAD Systems?	Yes	Yes
2D/3D Viewer?	Yes, standard viewer supports over 200 file formats	Built in Cimmetry Viewer displays over 350 formats
Central Database + Remote Doc Vaults?	Yes, and replication to remote file vaults	Yes
Multiple Levels of Security?	Yes	Yes
Single User Interface?	Yes, the UI is integrated into Windows Explorer and the CAD systems	Yes
Automatic Titleblock Update?	Yes	Yes
Generate Image Files for Previewing?	Yes	Yes
Extract BOM, Associated Data, & History?	Yes	Yes with API
Manage Parametric Parts & Assemblies?	Yes	Yes
Support of Multiple Sites Via Internet/Lan Lines?	Yes	Yes
Provide Structure "Where Used" Data for Parts, Docs., Folders?	Yes	Yes
Configurable Restrictions for User(s), Group(s)?	Yes	Yes
Customer-Defined Change, Release Management?	Yes	Yes
Operating System(s)?	Windows XP, Windows Vista, Windows Server 2003	Microsoft XP (Professional or Home Edition)
Database(s)?	Microsoft SQL Server	MySQL Pro, MS SQL Server, Oracle
Average Implementation Time?	4-8 days	7-10 days
Price Per Seat?	\$1,795US for CAD integrations \$1295US for non CAD users	\$1,300US per for MySQL. \$1,400US for MS SWL and Oracle
Web Address	www.solidworks.com	www.synergis.com
Contact	N/A	Martha K. Lubow
Email	info@solidworks.com	martha.lubow@synergis.com
Phone	N/A	215-529-9900 x110

28.0 Appendix C – Administrator Tutorial

Aston University Formula Student Team

PDMWorks WorkGroup 2007 Administrator Tutorial

Introduction

The Administrator tutorial covers certain topics to gain familiarity with the functional aspects of PDMWorks Workgroup and provide understanding for the set up and control of the Vault. This is to be used in conjunction with the software Help facility available with PDMWorks WorkGroup.

The topics are:

1. Connection to PDMWorks WorkGroup Vault Server and Login to the PDMWorks WorkGroup Vault Administrator.
2. Creation of New Users and Project Groups.
3. Setup of a New Project Folder in the Vault.
4. Detailing the Global settings of the Vault.
5. Controlling the revision system.

Topic 1: Connection to PDMWorks Server and Login to PDMWorks WorkGroup Vault Administrator Software

To log into the PDM Server the following steps must be taken.

Navigating from the Windows Start Menu, select **Programs, Accessories, Communications**, and click on the Remote Desktop Connection Icon. The menu shown below in Figure 69 will appear.

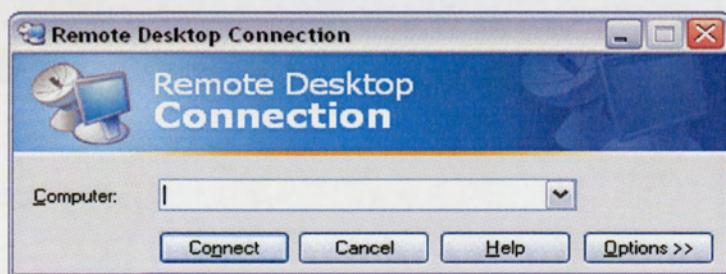


Figure 69: Remote Desktop Connection

The PDM server IP address should be entered into the Computer box. This is **naxos.aston.ac.uk**. Click the **Connect** button to start the login process.

This will request the Adminstrator to enter your individual university Login name and password.

Note: Only people who have been selected with permission to access the server by the ICT department would be able to continue the log in request.

When the login process is complete, the Windows desktop screen for the PDM Server will be displayed, as shown in Figure 70.

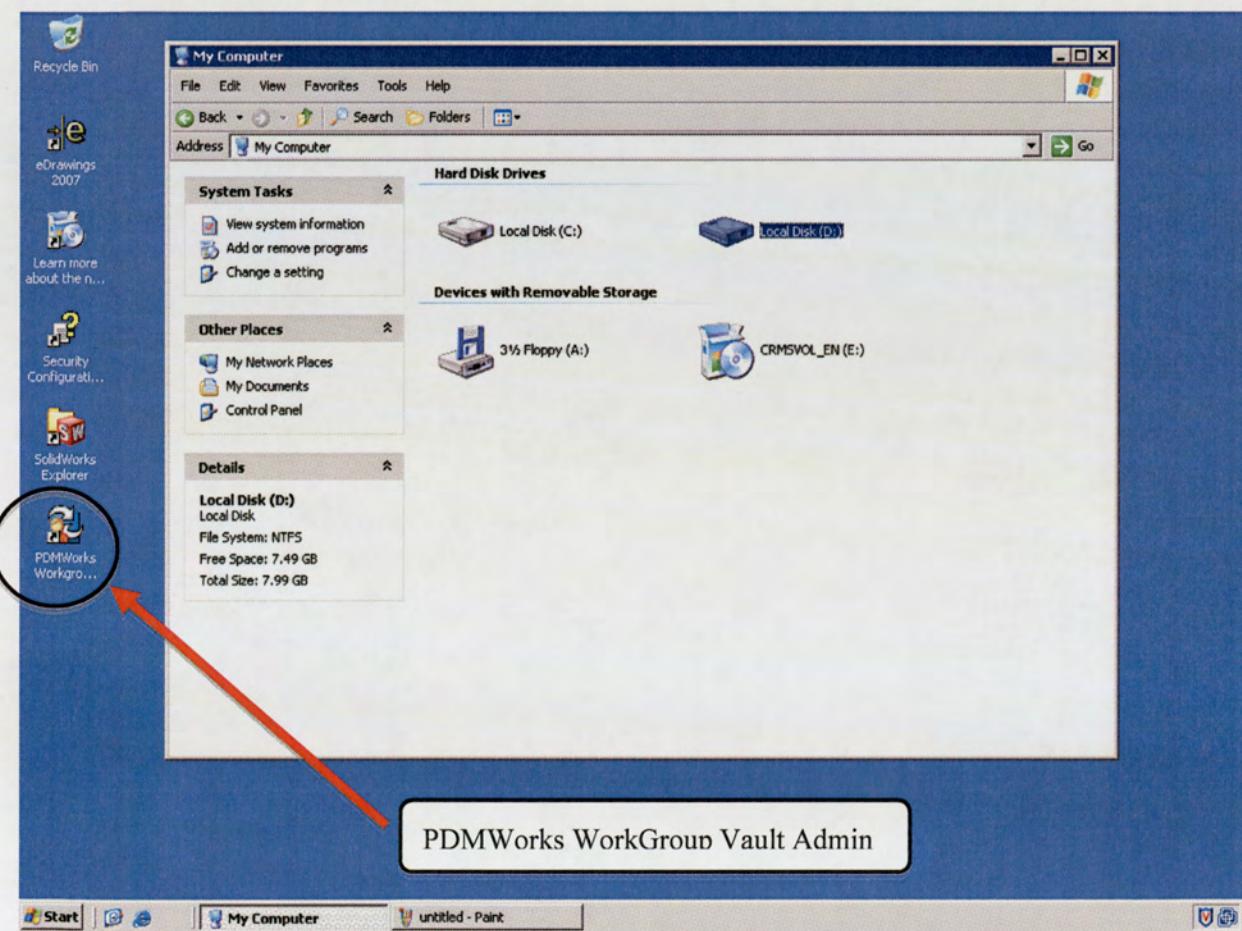


Figure 70: PDM Server Microsoft Windows Desktop Screen

To log into the Vault, double click on the **PDMWorks WorkGroup Vault Admin** icon, displayed on the desktop screen.

This should launch a login screen for the Vault access, shown in Figure 71.



Figure 71: PDMWorks WorkGroup Vault Login Screen

Note: Please refer to the **User Tutorial Guide** to change passwords and user details.

The default Login information is as follows:

4. Name: **pdmwadmin**
5. Password: **pdmwadmin**
6. Vault Computer: **naxos.Aston.ac.uk**

Select the **Save name and Vault computer** box for faster access for further login session.

Once the **Login** button is selected, the PDMWorks WorkGroup Vault Admin should launch the software menu screens, as presented in Figure 72.

Please refer to the **User Tutorial Guide** to change passwords and user details.

Once the required administrative tasks are completed, to Log out of the PDM Vault admin session simply click on the **OK** button at the bottom of the screen. This will return you to the naxos server desktop screen.

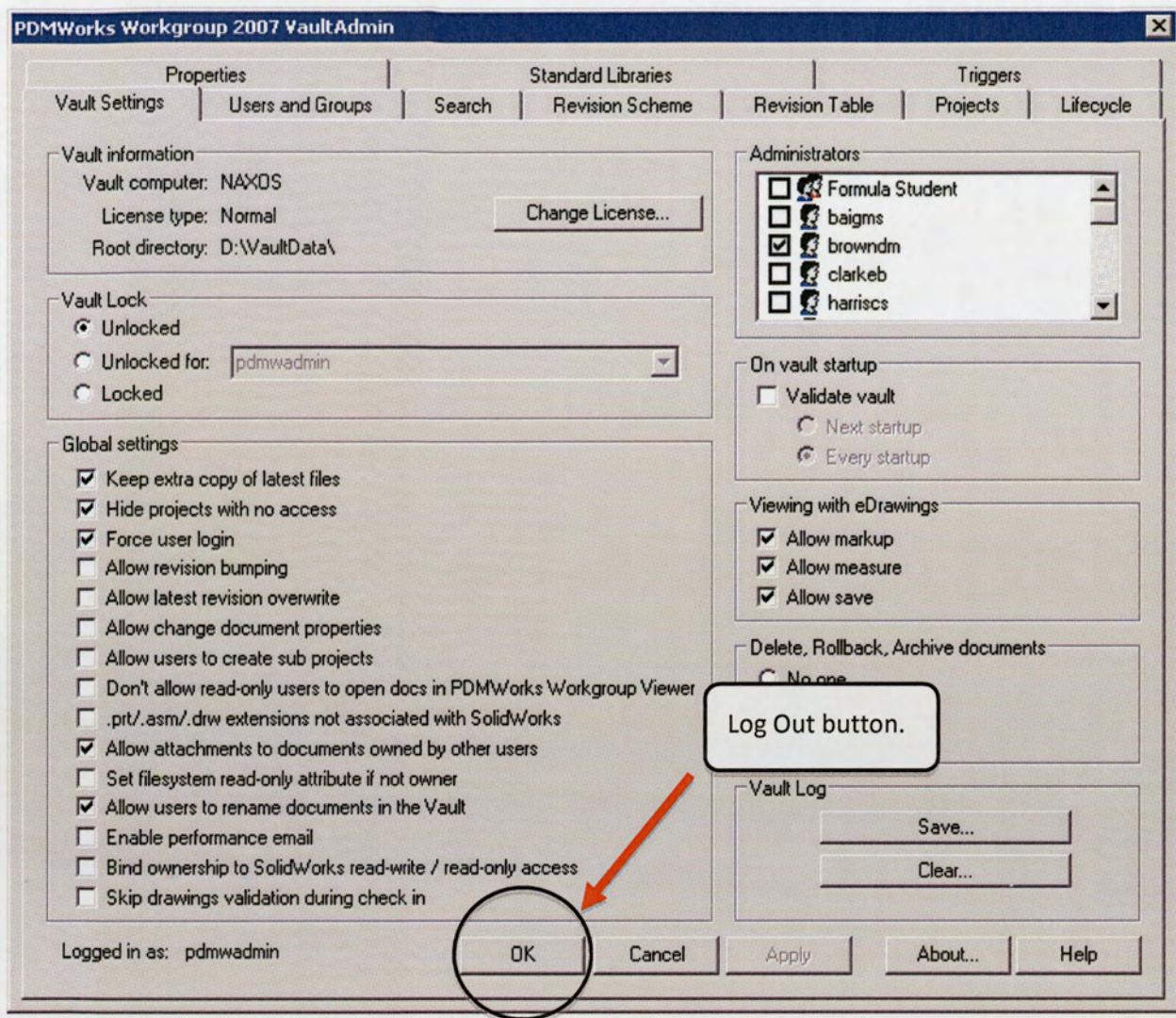


Figure 72: PDMWorks WorkGroup Vault Menu Settings Screen

Finally, to log out of the PDM server, click the Start Button on the Windows task bar and select the log off button on the screen.

Topic 2: Creation of New Users and Groups Accounts

To create users and define user groups, select the **Users and Groups** Tab at the top of the Vault Admin screen, as shown in Figure 73 below. Then click on the **New User** button.

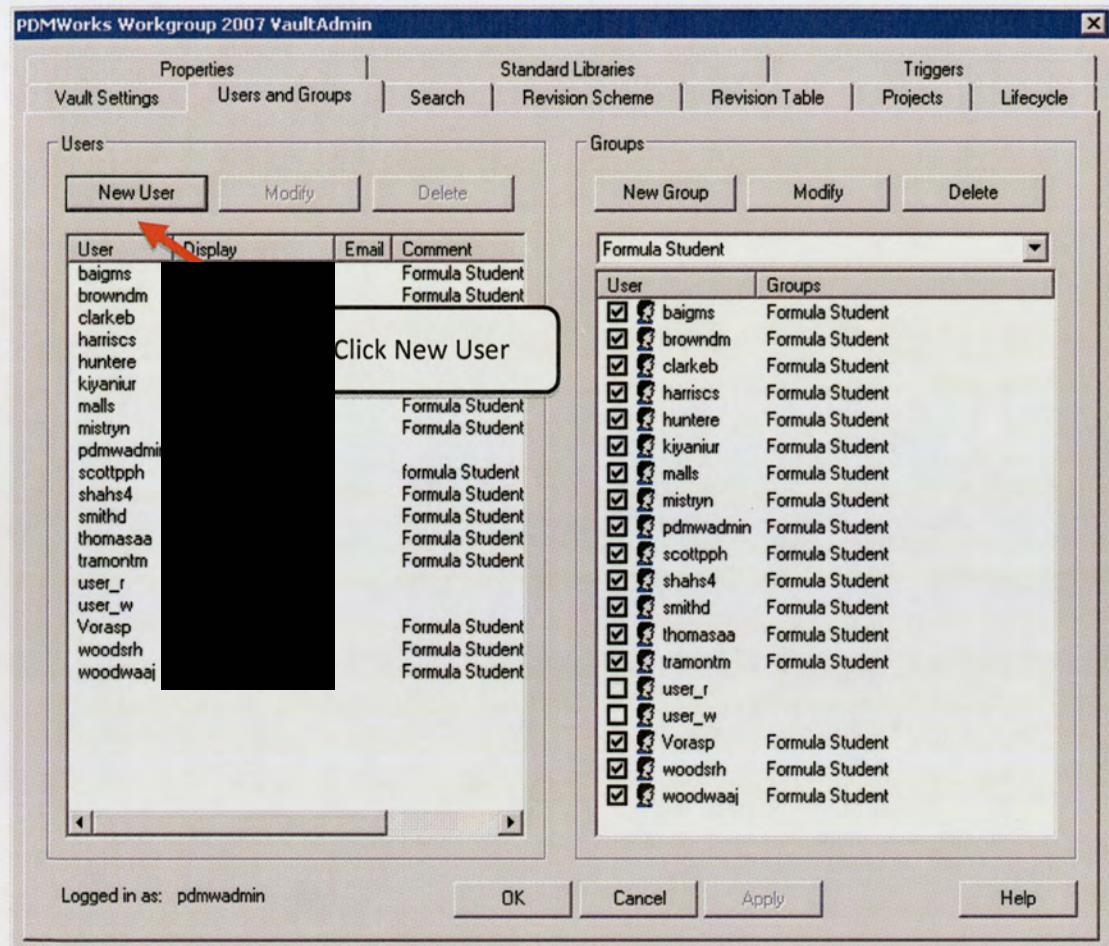


Figure 73: PDMWorks WorkGroup Vault Users and Groups Menu

This will launch the **Add New User** screen, presented in Figure 74. The required new user information can then be filled into the relevant boxes. A generic password should be used for the new user, to ensure ease of access during the first login session into the PDM Vault. The user then has the ability to change the password from the PDM options given within the SolidWorks program.

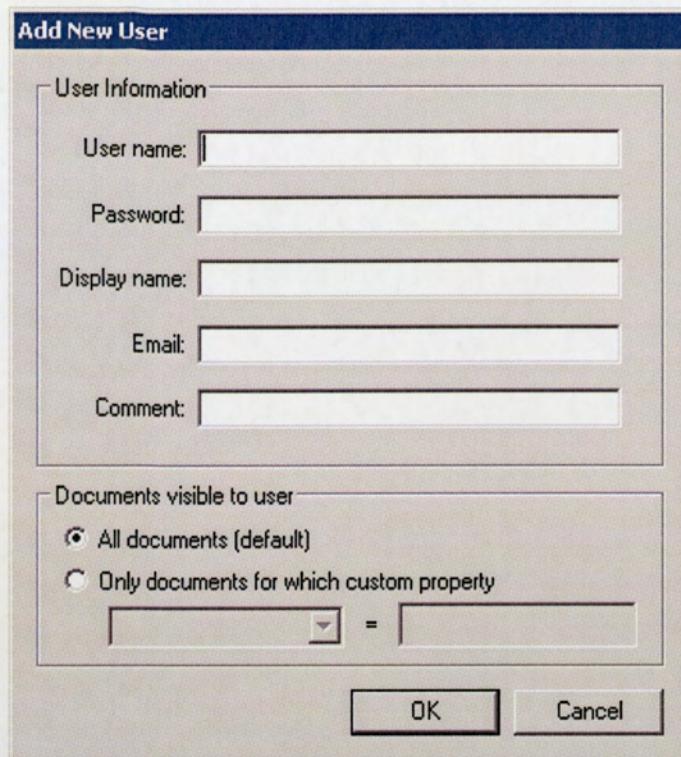


Figure 74: PDMWorks WorkGroup Add New User Screen

The option to modify users accounts can be completed by selecting the **Modify** button on the **Users and Groups** menu; this will also provide the ability to change, or reset Users and Administrators passwords. User accounts can be deleted from this screen.

In selecting the **New Group** button on the menu screen in Figure 74, it will allow a group to be formed and detailed, with the specific users assigned to the group.

To add additional users to the group, select the **Modify** button in the group menu; this provides the function to assign further user details. The **Delete** button allows the removal of created groups and users assigned within it.

Topic 3: Set up of a New Project Folder in the Vault

To set up a new project within the Vault, click on the **Projects** Tab at the top of the **Vault Admin** screen.

The following menu will be displayed, as shown in Figure 75.

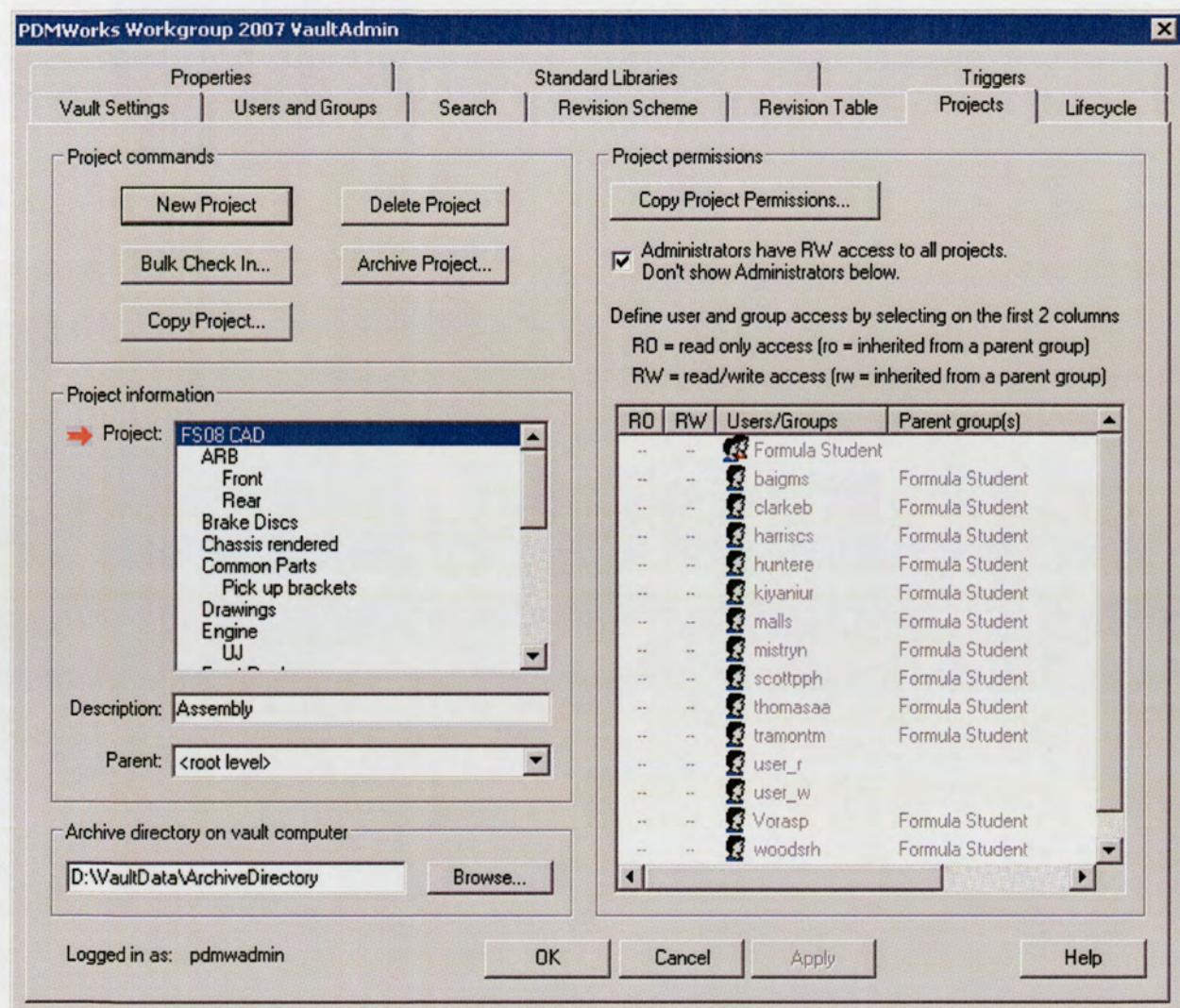


Figure 75: PDMWorks WorkGroup Vault Project Screen

Selecting the **New Project** button allows the naming and creation of the project folders. The **New Project** menu also enables the detailing of which user group should be assigned access to the particular project folder.

The **Bulk Check In** facility provides the facility for large SolidWorks assemblies to be checked into the required Vault project folder.

The **Project Permissions** function allows the detailing of users/groups that should have either **Read/write** access or **Read Only** access to a project folder.

Topic 4: Detailing the Vault Global Settings

In selecting the **Vault** tab, as presented in Figure 72, it provides the facility to adjust the global Vault options that would be more beneficial to the needs of the Aston University Formula Student Team.

This screen allows the detailing of specific administrators, security and access to the Vault, revision overwrite control of the Vault and control of attachment of documents. The Help button found at the bottom right of the screen, gives a detailed explanation of each of the options that are available for selection.

Administrators can also be assigned from the list of users registered on the top right hand side of the screen.

Topic 5: Controlling the Revision System

Selecting the **Revision Scheme** tab will present a number of options in the menu.

The revision scheme will be selected at the default setting: A –Z primary, and 0-99 secondary. This will ensure that a simplistic revision scheme is established, providing ease of traceability throughout the design review stages. It is not recommended to alter the revision scheme system until a configuration document control scheme is fully outlined. The PDMWorks WorkGroup Help function fully illustrates the changes available to the Administrator.

29.0 Appendix D – User Guide Tutorial

Aston University Formula Student Team

PDMWorks WorkGroup 2007 User Guide Tutorial

The following information is designed to give general guide on the operational basics and how to use PDMWorks WorkGroup 2007. This has been specifically set up for the requirements of the Aston University Formula Student Project.

The areas covered are split into five distinct parts.

6. Basic PDMWorks WorkGroup activation and **Sign In/Out**
7. Opening a part or assembly from the Vault (**Check Out**)
8. Saving documents to the Vault (**Check In**)
9. Generating new parts and assemblies to **Check Into** the Vault
10. Best practice guide

Topic 1: Basic PDMWorks WorkGroup Activation and Sign In/Out

To active PDMWorks WorkGroup within **SolidWorks 2007 SP4.0**, select **Tools**, **Add-ins** from the software tool bar.

The following screen shown in Figure 76 will be displayed:

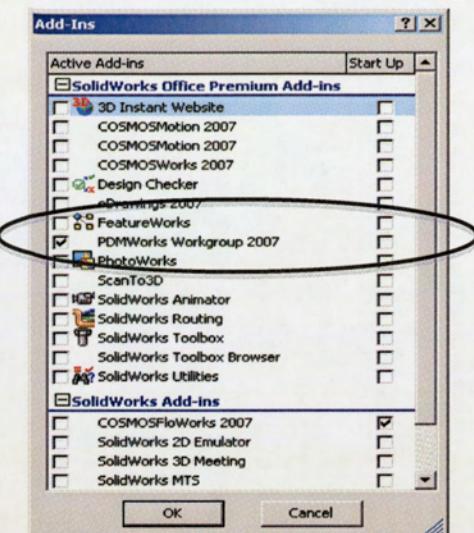


Figure 76: SolidWorks 2007 Add Ins Options Screen

Select the **PDMWorks WorkGroup 2007** function.

Tip: If you are not using COMOSFloWorks deselect the tick-box. This will improve the performance speed of the SolidWorks session.

In the main SolidWorks screen, right click on the **Tool Bar** to activate the **Quick Key** tool properties. Select **PDMWorks WorkGroup** from the list and drag and drop the new toolbox anywhere on the tool bar.

The PDMWorks toolbox will now appear on the SolidWorks tool bar, *Left Click* on the **Gold Key** icon, as shown in Figure 77.

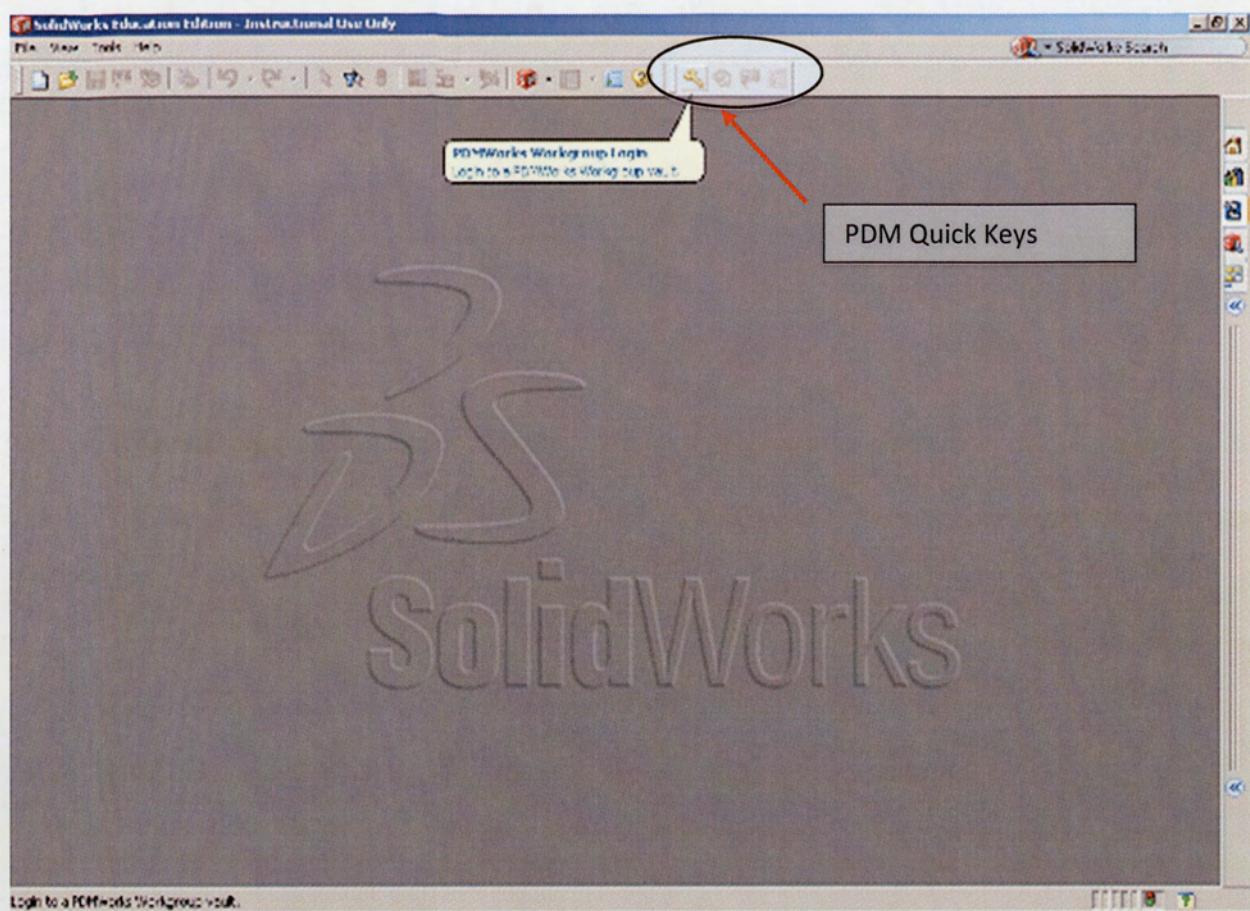


Figure 77: PDMWorks WorkGroup Quick Keys

This will launch the PDMWorks WorkGroup login menu, presented in Figure 78.

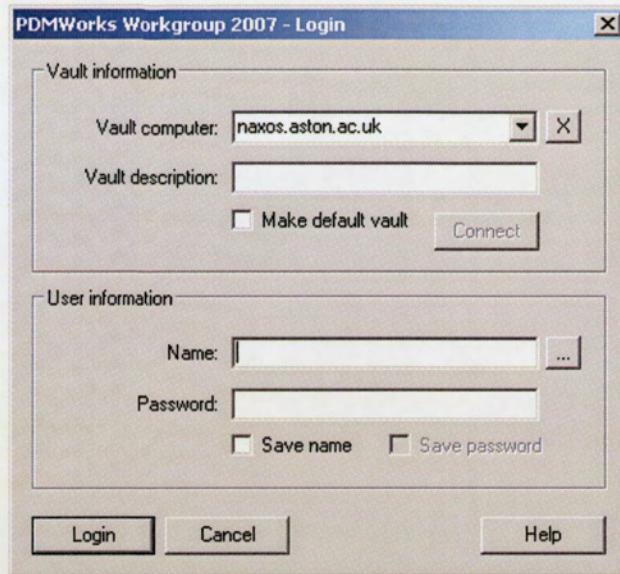


Figure 78: PDMWorks WorkGroup Login Screen

The Vault is housed on a separate server running within the university ICT department.

The instructions for the login process are as follows:

5. Vault Computer name is: **naxos.aston.ac.uk** - Ignore the Vault description.
6. *Left Click* the **Connect** button - this will ensure that Vault server directory/connection is correct and will establish a connection.
7. Enter the your specific **user name** and password that is supplied by the PDM Administrators. This is set as your university login. The generic default password that is set for the team is **formulas**.
8. *Left Click* the **Login** button.

Congratulations you are now connected to the PDMWorks WorkGroup Vault and ready to work!

To log out at the end of each session, before exiting SolidWorks, *Left Click* the **Gold Key Log Out** button on the PDMWorks WorkGroup toolbar, as shown in Figure 79.

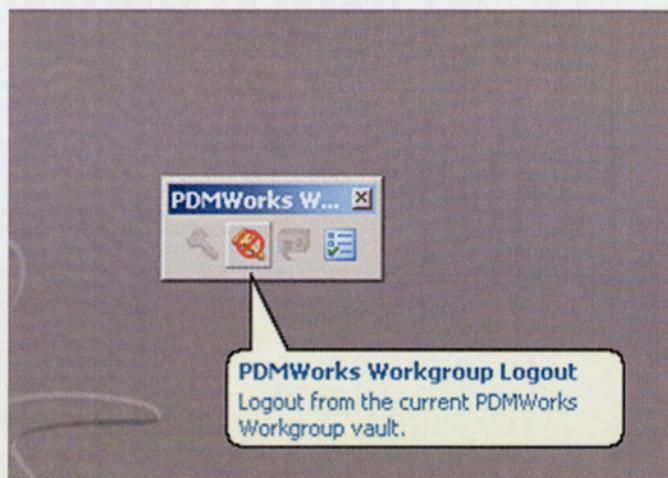


Figure 79: PDMWorks WorkGroup Log Out Button

Topic 2: Opening a Part or Assembly from the Vault (Check Out Function)

Left Click on the **Open Document** icon on the SolidWorks menu tool bar, this will open the screen shown in Figure 80. At the bottom left hand side is the icon for **PDMWorks Vault**, *Left Click* on the icon to see the Formula Student CAD 2008 project folder.

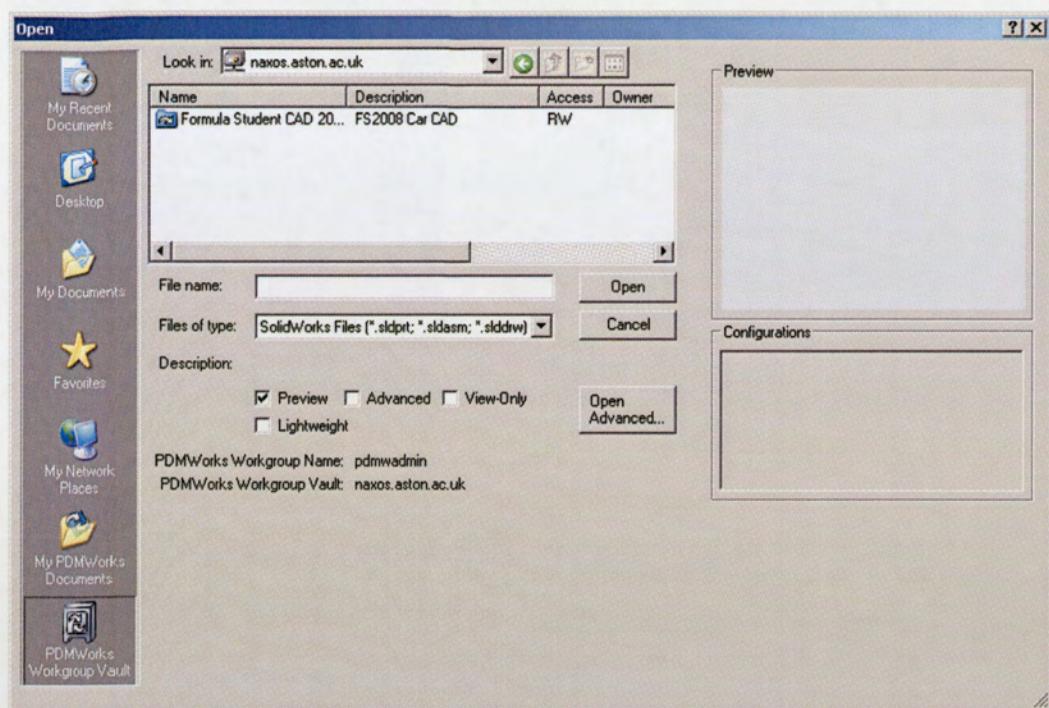


Figure 80: SolidWorks Open Document Menu Screen

Left Click on the Formula Student CAD project folder, this will open and detail all the files currently available and saved within the Vault. Select the assembly or part required and *Right Click* the **Open** button.

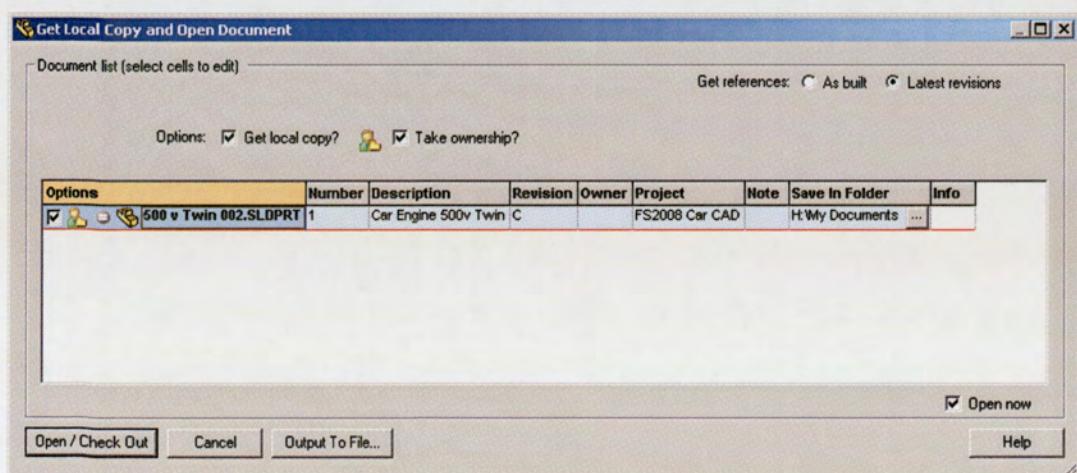


Figure 81: PDMWorks WorkGroup Additional Check Out Menu Screen

PDMWorks will present an additional screen, as shown in Figure 81, detailing some options to be considered on check out.

Important points to note:

When an assembly or part is checked out of the Vault, it will generate a temporary file within your **My Documents** folder. It is important to set up a specific folder within your **My Documents** folder, as this will keep your drive organised and separate from other non-related files. The new folder or location can be set up by clicking on the **Save In Folder** option column in Figure 81 and designate a folder name.

The most important option in Figure 81 is the **Take Ownership** tick box. This will allow you to take full control of the part or assembly, and will not allow other users that subsequently log into PDMWorks WorkGroup to open and save over them.

You now have full control and ownership of the assembly or part to work on.

Topic 3: Saving a Part or Assembly back into the Vault (Check In)

To check in a part or assembly, save the file as per the normal practice within SolidWorks. On the SolidWorks tool bar, *Left Click* the **Check In (Active)** button in the PDMWorks WorkGroup toolbox, as shown in Figure 82.

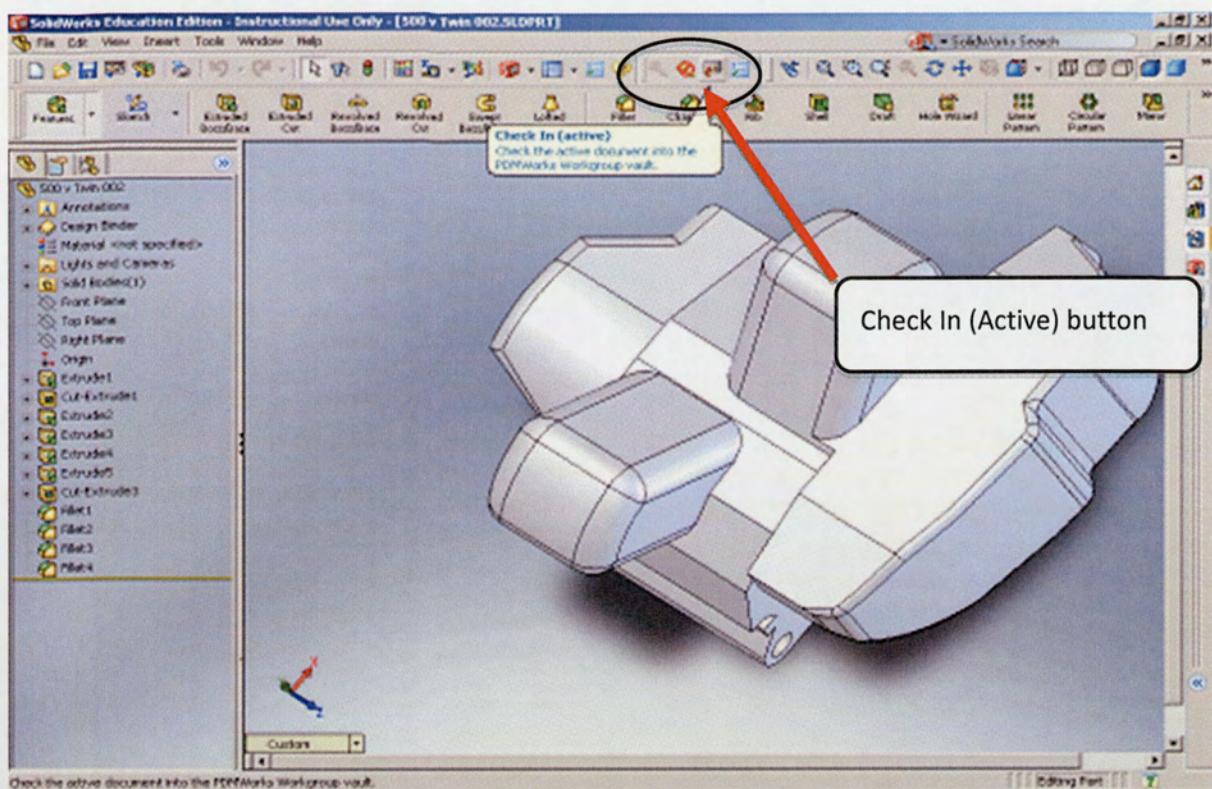


Figure 82: PDMWorks WorkGroup Toolbar Check In (Active) Button

PDMWorks WorkGroup will present the following screen shown in Figure 83.

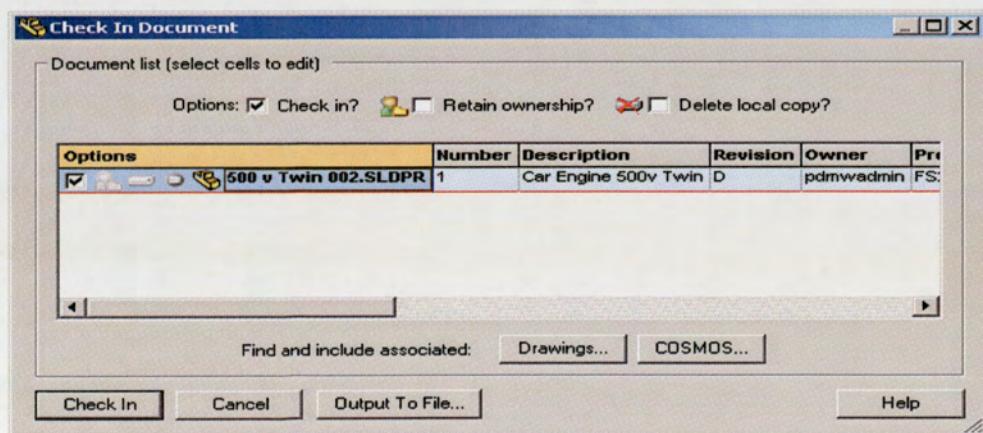


Figure 83: PDMWorks WorkGroup Check In Screen

Click the main **Check In** Tab, and the document will then be saved to the PDMWorks Vault. You can now close the document and **log out** of the PDMWorks Server and close SolidWorks.

The Check In Document screen details a number of options to be considered. The **Check In** tick box should be selected. The other additional options are: **Retain ownership** and **Delete local copy**.

Selecting the **Retain ownership** function provides the ability to control the opening and editing access of the part or assembly within the Vault; releasing ownership only when you are satisfied to do so.

If retaining ownership is required, keep this checked. If editing the generic Formula Student Team main car assembly, this is a particularly important function and should be deselected.

The **Delete local copy** option will remove the temporary file saved locally in the **My Documents** folder. Select this option, as this will avoid any potential confusion of duplicate revisions being created and stored.

Additional information displayed within the **Check In** screen details the revision number change, due to the editing of the part or assembly. A primary example of this change process is the previous version of a part or assembly checked out being revision B, with the changes made and saved during the editing session the system should update the issue the part or assembly to revision C on **check in**.

Left Click the **Check In** button and the part or assembly should be saved to the PDMWorks WorkGroup Vault.

Topic 3: Generating a New Part or Assembly to Check Into the Vault

The same procedure detailed in Topic 1 should be followed to Log into the Vault, whilst also generating the PDMWorks WorkGroup quick keys.

Once the part or assembly has been created, the file should be saved in the normal process in the local **My Documents** folder.

The PDMWorks WorkGroup toolbox **Check In** Tab on the SolidWorks tool bar should be *Left Clicked* to present the screen shown Figure 84.

Click the **Check In** Tab, to produce to screen shown Figure 84.

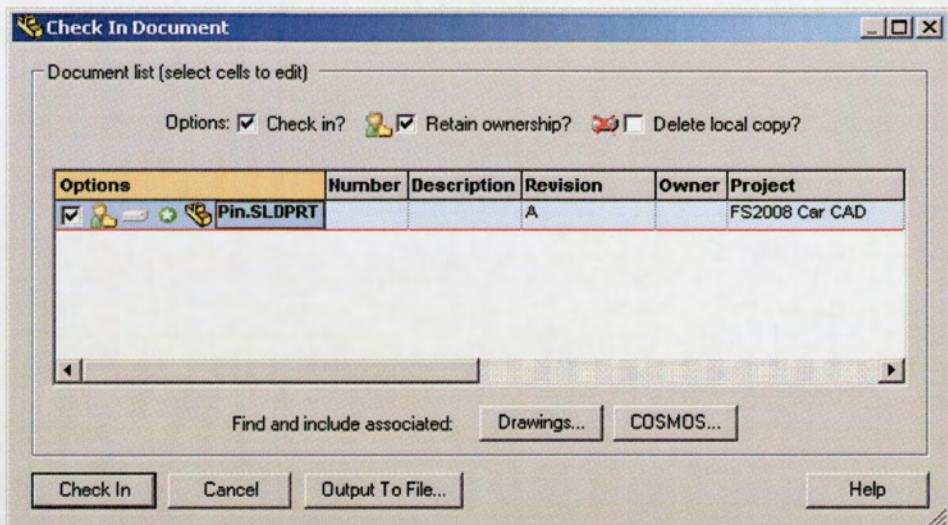


Figure 84: PDMWorks WorkGroup Check In Document Screen

The key points to be considered are:

- In the **Number** column, a number 1 should be entered, as this is the first iteration of the respective part or assembly to be checked in.
- The **Description** column should be detailed with a brief outline of the part or assembly.
- The **Revision** column should default to A, as this is the first revision of the part or assembly.
- An option is also provided to attach and create a relationship to the relevant drawings to check in.

*Left Click the **Check In** button to successfully save the file into the Vault.*

Topic 5: Best Practice Guide

There are a number of additional functions that need to be discussed further, as they are specific to the requirements of Aston University Formula Student Team.

These topics are:

5. PDMWorks options icon & password change

6. Revision working.
7. Ownership of documents
8. Deleting documents from the PDMWorks Vault

No 1: PDMWorks WorkGroup Options Icon & Password Change

Contained with the PDMWorks WorkGroup Toolbox is the options button, as shown in Figure 85.

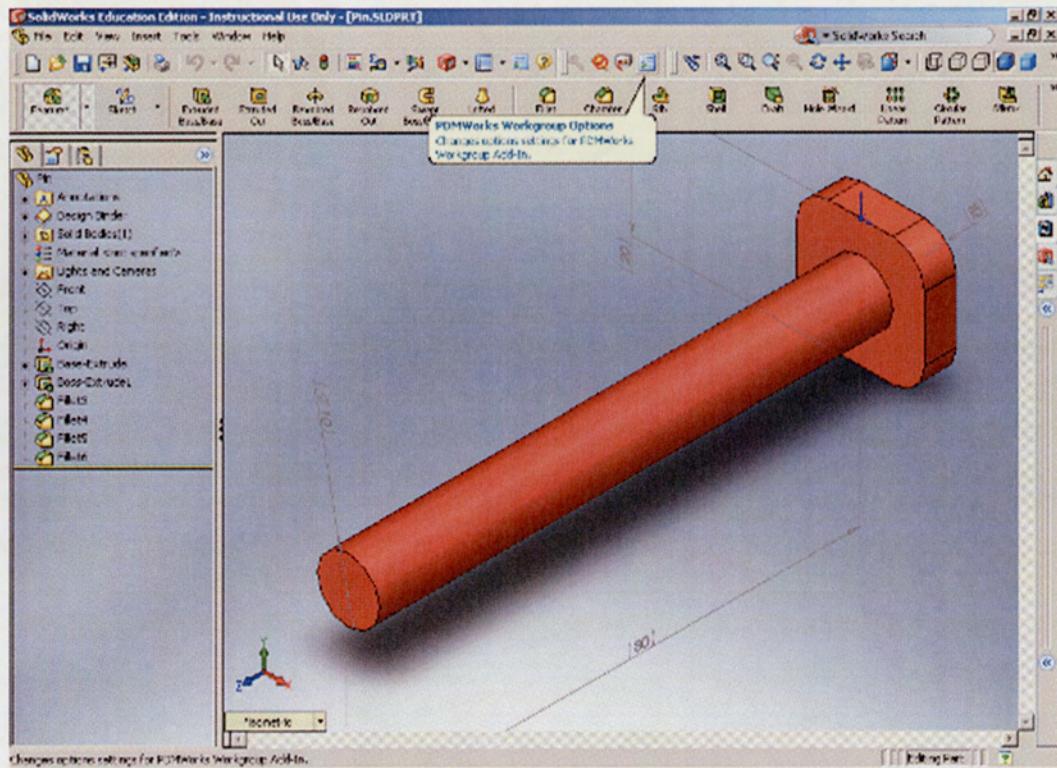


Figure 85: PDMWorks WorkGroup Toolbox Options Button

Left Click the options button to open the screen presented in Figure 86.

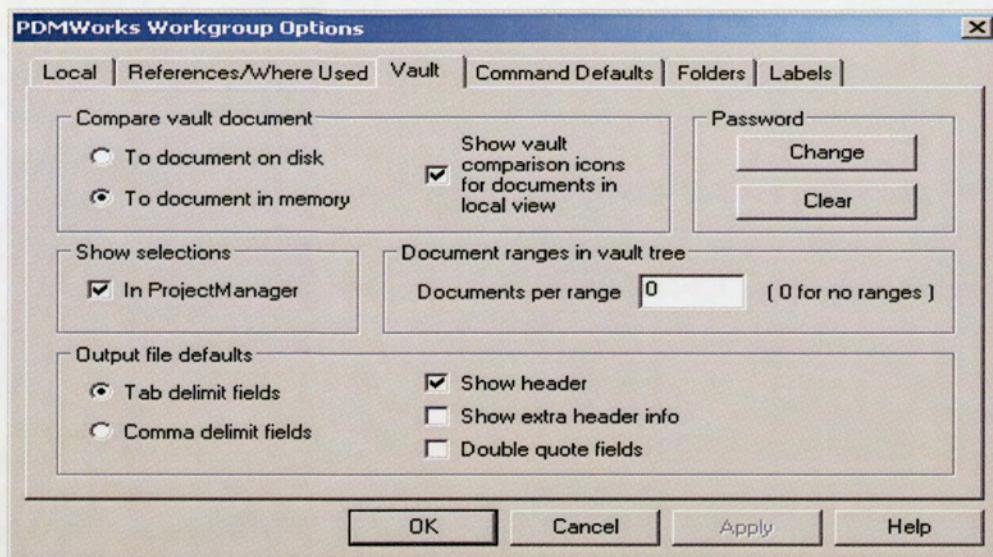


Figure 86: PDMWorks WorkGroup Options Screen

To change the individual user password, select the Vault tab at the top of the screen in Figure 86. The Vault menu provides the password change option. There are no specific requirements restricting the new password to be either numerical or alphabetical.

It is not advisable to change the other functionality options available, as the PDMWorks WorkGroup Vault has already been preset. If required, the SolidWorks software Help function details specific information regarding the individual options.

No. 2: Revision Working

The preset default revision number when a new part or assembly is checked into the Vault is set at A. However, there is the facility to manipulate and maintain the current revision number at the same level during future editing sessions, as each saved change and check in will result in an incremental increase in revision number.

It is possible to keep revision level as it was previously, by selecting the Revision column tab and using the A+ or B+ etc. This should state that the part or assembly is still being edited, before a full incremental revision change is actually required, allowing time until all editing has been completed. PDMWorks

WorkGroup provides traceability of all changes made through this function, with the ability to 'roll back' files to the previous revision level, by the PDMWorks Administrator privileges, if required.

No. 3: Ownership of Documents

The ownership of file is an important function to understand, in order to allow ease of communication and co-ordination through the design stages for the whole team. Each time a file is Checked In/Out, you will retain its ownership, until it is released back to the Vault. The process that should be taken during the design review stage is that the part should only be released back once the design is approved. This should ensure safe revision keeping, whilst also prohibiting other users from working on the same file until formally released at the required revision number.

No. 4: Deleting Documents from the PDMWorks WorkGroup Vault

Deleting files contained in the Vault requires the privileges of the Administrator, protecting the safe storage of the Formula Student Team files.