Product Lifecycle Management

Bachelor of Engineering (Honours) Mechanical Engineering

Two themes that run throughout UQ's Bachelor of Engineering (Honours) in Mechanical Engineering are Systems Engineering and Product Lifecycle Management (PLM).

These themes will become increasingly apparent to you as you progress, and you will gradually gain both practical application skills and a deeper understanding of them.

This document focuses on Product Lifecycle Management and how it appears in the BE (Hons) in Mechanical Engineering.

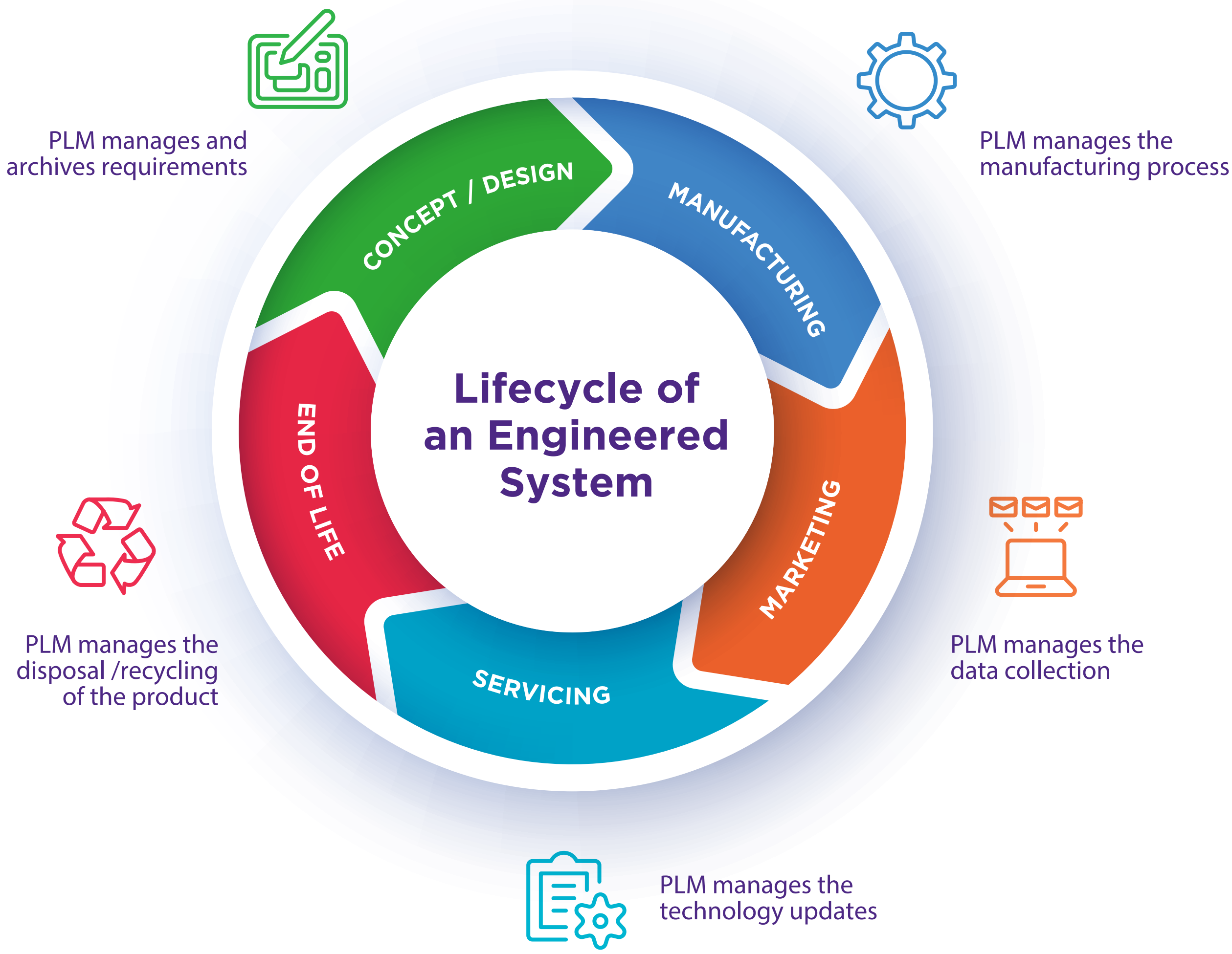
What is Systems Engineering and Product Lifecycle Management (PLM)?

Systems engineering is a formal engineering process that involves identifying and characterising end-user needs, creating system specifications, creating and assembling component parts, and making sure the entire system meets its specifications, that is works properly in its intended setting. Systems engineering is characterised by an emphasis on the conceptualisation, design, and integration of complex systems. Systems engineering entails specifying needs. It involves developing system designs. Its purpose is to make sure that every part of a system functions as a whole to achieve the intended goals.

Product Lifecycle Management (PLM) entails overseeing system from conception to design, manufacture, servicing, and eventual disposal. PLM is sometimes referred to as the "doing" phase ofof product development. It focuses on managing the product from design and development to manufacturing, release, and, finally, retirement.

PLM and systems engineering go hand in hand. Nowadays, PLM software platforms give the methodology its technological foundation. Siemens Teamcenter, Dassault Systèmes ENOVIA, and PTC Windchill are a few well-known PLM tools.

It is expected of a modern mechanical engineer to be proficient in managing this process with the digital tools of PLM. Acquiring these abilities improves both your employability and your capacity to apply sustainable engineering in practice.



The role of PLM in the lifecycle of an engineered system.

An established methodology guides the development of engineered systems. First, engineers generate concepts, create designs, and refine them. To do this, we use Computer-Aided Design, Engineering, and Manufacturing (CAD/CAE/CAM) tools. PLM is responsible for the management and archiving of requirements, specifications, CAD/CAE/CAM files, analysis results, and other artefacts produced during the design phase, holding them together as a single source of truth. The PLM system will also provide version control to keep track of changes made during the various design iterations. . It also provides traceability so designers can track and link various elements throughout the lifecycle of a product or system.

Once the design of a system is complete, the manufacturing process commences. Here, we use PLM to manage various aspects of the manufacturing process based on the design, such as the manufacturing process, supplier liaising, and maintaining product quality.

When manufacturing is underway, the marketing phase commences. This usually involves a go-to-market plan covering marketing strategies, distribution, and sales. Products often lack perfection, especially during their initial release, so gathering feedback is crucial for prompt modifications and enhancements. We use PLM to manage the data collected in this process.

Once a product is in use it needs to be serviced. This includes repairs, maintenance, and providing technical assistance to customers. This phase of the products lifecycle often involves product updates based on user feedback and technological advancements. These activities are managed through PLM.

Throughout the lifecycle, the PLM platform enables the various teams, including design, engineering, manufacturing, and marketing, to work together and supports efficient communication with all pertinent stakeholders, such as partners, suppliers, and customers.

When products reach the end of their life, retirement and disposal are required. This requires detailed end-of-life planning and management, including product discontinuation and support. It is necessary that plans are developed for the environmentally responsible disposal and recycling of the product and its components. The PLM holds these plans. Ideally, they were created during the product design phase, in anticipation of their implementation.

The PLM system enables the various teams involved in a product development to collaborate and communicate efficiently and effectively. This includes the design, engineering team, the manufacturing team, and marketing, to work together. The PLM system also supports efficient communication with all relevant stakeholders, such as partners, suppliers, and customers.

Ensuring adherence to regulations is another vital aspect of product development. This includes adhering to all pertinent legal and industry standards throughout the entire product lifecycle. It's essential to keep accurate records and reporting in order to demonstrate compliance and steer clear of legal or regulatory issues. When used properly, the PLM platform maintains these records and enables generation of required documentation.

Why are PLM skills important for your future as an engineer?

PLM isn't just an academic TLA (three letter acronym) or another piece of software for which you'll forget the login details. It's a comprehensive framework that manages the entire lifespan of a product—from when it's just a wild idea in your head to when it's shipped, used, maintained, and eventually scrapped (hopefully not too soon). Without PLM, keeping track of all that would be like trying to assemble IKEA furniture without the instructions—doable, but not pretty.

Now, Australia's engineering market is what we politely call "compact." Translation: we can't afford inefficiency. In this environment, you'll need all the help you can get to keep projects on track and within budget. PLM is like that friend who keeps everyone organised (and reminds you about deadlines). It's a system that helps ensure you're using resources wisely—because in this market, you really don't want to be the one wasting time or money.

But we're not just talking about Australia. We're deeply entangled in global supply chains—think of it as a never-ending relay race where the baton is information. You'll need to handle both upstream (taking data from suppliers) and downstream (passing it to manufacturers, clients, and distributors) without dropping the baton—or, worse, passing the wrong one. As global trade gets even more interconnected, managing this flow of information is going to become more complex, which means PLM will only get more important. Consider it your safety net, preventing those awkward "we didn't get the memo" moments with your international partners.

Let's not forget regulation. Aerospace, mining, energy—these industries aren't exactly laid-back when it comes to compliance. PLM helps manage the inevitable mountain of documentation and ensures you're ticking all the regulatory boxes. And if there's one thing you'll want to avoid as a professional engineer, it's costly mistakes that could've been prevented by a well-organised system. You know, the kind that makes auditors smile (or at least not frown).

In short, mastering PLM will set you apart. You'll manage projects more efficiently, collaborate across borders (without dropping the ball), and ensure your work meets both global standards and the scrutiny of industry regulators. And as your responsibilities grow—and trust me, they will—you'll be glad you've got this tool in your arsenal. Because when you're juggling that many tasks, you'll want every bit of support you can get.

Sustainable engineering practices can be built around product lifecycle principles

Sustainability is about ensuring that the engineering decisions we make now won't lead to problems in the future. As engineers, our choices will have lasting impacts on the environment, the economy, and society. By prioritising sustainability, we can create systems that reduce waste, save energy, and use resources more efficiently. Sustainability is an essential aspect of responsible engineering.

One of the best tools we have for this is PLM. PLM ensures team alignment by integrating data, processes, and people. It allows us to embed sustainable practices into every part of a project—from the materials we choose to how we manufacture the product to how we handle it once it's no longer in use.

How does this apply, for example, when designing an electric vehicle for the Formula SAE competition? The goal of the competition is to build a high-performance electric vehicle. PLM not only manages this but also incorporates sustainability into the process. It helps the team choose eco-friendly materials. It aids in the design of energy-efficient systems. Additionally, it facilitates planning for the recycling or reuse of components after the year's competition cycle concludes. PLM systems provide tools for estimating the environmental impact. Overall, PLM can help the team balance performance with sustainability.

If you can understand PLM principles and use them effectively you will be able todesign systems that meet performance goals while also contributing to a more sustainable future. As an aspiring professional engineering this is a valuable skillset that is becoming increasingly important to possess.

Digital literacy and workflows are now critical in modern engineering practice

Your ability to navigate industry standard digital tools and workflows also makes you more employable. Your future employer will expect you to be a productive and valuable contributor to their business from day one. This includes using digital tools to capture and manage your work efficiently.

A hallmark of engineering work is working in teams. Whether the team is spread across the office, across Australia, or across the world, digital workflows are crucial. They provide the backbone for communication and collaboration. They ensure that every team member has access to the latest information no matter where they are. They promote effective teamwork by coordinating efforts across time zones and disciplines, reducing errors, speeding up time-to-market, and enhancing decision-making. In this way, digital workflows not only improve product quality but also drive innovation through streamlined, efficient collaboration.

But they are also valuable for smaller enterprises. For example, suppose you are a member of the UQ Formula SAE race car team, and the team is working on different subsystems for the new car —suspension, powertrain, aerodynamics, and electronics—while also drawing on designs from previous years and incorporating components purchased from suppliers. By using PLM with digital workflows, all team members have access to the most current designs, data from previous FSAE cars, and information about purchased parts. Let's say you're updating the suspension system: with digital workflows, you can instantly reference designs from last year's car, reuse components that performed well, and see how the new design interacts with off-the-shelf components like shocks or tires from suppliers. Meanwhile, changes you make to the suspension are automatically communicated to the rest of the team, ensuring that the chassis, powertrain, and aerodynamics teams can adjust their designs in real-time. This seamless integration prevents miscommunication, reduces errors, and allows the team to make faster, more informed decisions, resulting in a better-performing car overall.

Digital workflows are much more than just using computers to complete tasks. They automate repetitive processes, enable real-time collaboration, and ensure that everyone is working with the same, up-to-date data. This helps teams make better decisions and deliver better solutions.

The Siemens Digital Industries Software Platform

UQ has partnered with Siemens to give you access to the Siemens Digital Industries Software platform. This is a comprehensive toolset for performing the engineering tasks that take place throughout the entire product lifecycle.

These tools include:

- NX for CAD/CAM/CAE
- Teamcenter for product data management and collaboration
- Tecnomatix for managing manufacturing processes
- Simcenter for analysis and simulation tasks.

The Siemens platform integrates these tools so that they work together. This aids in engineering work, but it also enables work to progress from design to manufacturing in a coherent and coordinated manner. Teams and departments can share information in real-time, ensuring everyone works with the most up-to-date information.

By working with this industry-grade platform during your studies, you are gaining hands-on experience with the sort of tools widely used across the engineering sector. This experience will better prepare you for the collaborative and complex workflows you'll encounter in your professional practice. In short it will help make sure you fit and are ready to engage with real-world engineering challenges.

Where does PLM appear in the Bachelor of Engineering (Hons) in Mechanical Engineering?

PLM concepts appear throughout the program and collectively build to provide a comprehensive understanding of Product Lifecycle Management.

MECH2305: Introduction to Engineering Design and Manufacturing

MECH2305 introduces students and develops their proficiency in the use of CAD/CAM/CAE tools for product design, ensuring that manufacturability is taken into consideration and students are introduced to functional testing and optimisation. These foundational skills support integration from design and test to manufacturing. You will learn about various manufacturing processes, including CNC machining, aligning with PLM principles to ensure efficient production and high product quality.

MECH2100: Machine Element Design

This course introduces you to the basic principles of mechanical design relevant to engineering practice. The contents include the design of specific machine components such as power transmission gearboxes containing gears, belts, chains and pulleys, rotating shafts, keys and splines, bearings, clutches and seals. The course also covers the design of machine frames and assemblies including steel structures, fasteners and welded joints, considerations of safety and compliance with standards, assessment of mechanical failure (especially yielding, buckling, fracture and metal fatigue) in the context of machine design, fracture mechanics, and material properties most relevant to mechanical design. The principles of sustainable design and social and environmental responsibilities of mechanical designers are also covered.

Digital tools to help design basic machine elements like gears, shafts, and pulleys are integrated into digital workflows coordinated by Product Lifecycle Management (PLM) systems. These tools combine CAD and CAE software, enabling rapid prototyping, simulation, and optimization. They help ensure that industry standards and regulatory requirements are met throughout the process. MECH2100 will expose you to these methods.

MECH3610: Systems Engineering Principles

MECH3610 teaches students to apply systems engineering principles and PLM to design projects, conduct user needs analysis, perform functional analysis, and manage digital workflows. The course emphasises teamwork and project management, essential for engineering project development and implementation. Practical skills in Product Lifecycle Management (PLM) principles will be developed through the Siemens Teamcenter software platform.

MECH3780: Computational Mechanics

Mechanical engineers routinely use computational tools in the form of software packages to validate designs and investigate failures. MECH3780 covers the key concepts of the finite element method (FEM) and computational fluid dynamics (CFD) and how to use these techniques to analyse structural mechanics and fluid dynamics problems, respectively. There is both a science and an art in using these methods, and you'll learn to apply engineering judgement, process engineering drawings, simplify complex analysis problems, and interpret functional specifications. You will also learn about modelling non-deterministic problems, modelling non-linear behaviours, and strategies for high-quality discretization of geometries (mesh generation) for FEM and CFD simulation.

In industry, computational mechanics is integral to design and is supported by digital workflows managed through PLM. A typical workflow involves using CAD (computer-aided design) to create the geometry of components and assemblies and specific materials. This geometry forms the basis for downstream analyses using FEM and CFD. Both FEA and CFD can analyse full structures and machines, but when more detailed insight is required, individual components are analysed

For example, in the design of an aircraft, the overall stresses on the aircraft structure under flight conditions will be analysed, as will the airflows over the aircraft body. This is to ensure the integrity of the design and also provide insights on how to improve it. Then, individual components such as the control surfaces (wing flaps) and engine parts (e.g. turbine blades) will also be subjected to detained analysis to confirm that they can meet the service conditions under which they are expected to operate. Similarly, in the design of a car or truck, the aerodynamics of the body are likely to be analysed by CFD and optimised, while the entire vehicle will be analysed using FEM to establish its crashworthiness. Specific components like suspension arms or engine mounts will be further analysed in finer detail to optimise their performance under expected service conditions.

Effective use of computational mechanics analysis calls on engineering judgement to select the appropriate load cases, meshing strategies, and boundary conditions. This course will help you develop this judgement. At the completion of this course, you will be competent in applying computational tools in the design of system components. You will also learn that computational mechanics is about much more than steel structures and aerodynamics, with contemporary applications such as the structural analysis of orthopaedic inserts and the flow assessment of mechanical hearts.

MECH3100: Mechanical Systems Design

MECH3100 integrates knowledge from prior coursework into a hands-on project to design, build, evaluate, and recycle a mechanical system. This course is based on the System Engineering principles you will learn in MECH3610 and your knowledge of PLM to develop a system through each stage of its lifecycle, from inception and design to manufacturing, testing, and eventual disposal. You will work in a group to plan and execute a project. You will use computer-aided engineering tools to design it. You will review and report on milestones to ensure project quality and timeliness. You will work in a team to design, build, and a test mechanical system, and gain practical experience in resource allocation, teamwork, real-world project management, and digital workflows. These activities are coordinated through Siemens Teamcenter.

ENGG4103: Engineering Asset Management

Once a system is in service, maintenance is necessary to keep it operating at its rated capacity, and decisions about when to replace it are also necessary. We call this asset management. In ENGG4103 you will learn the methodologies used to manage assets. This includes the design maintenance support systems, how to calculate lifecycle costs using equivalent annual cost approaches, and optimal replacement policy. These allow you to optimise asset performance, enhance reliability, and ensure cost-effective management.

ENGG4552: Major Design Project

ENGG4552 is a capstone course that integrates and applies the knowledge you have learned throughout the mechanical engineering specialisation. You will collaborate in small teams to design, develop, and test an engineering product for a client over the course of a year. You will establish functional requirements from a constrained brief, create prototypes, conduct tests, and present and document results.

Students participate in different phases of the product lifecycle, weaving PLM ideas throughout ENGG4552. You will use systems thinking from the very beginning of the problem formulation and requirements capture. The course's emphasis on research, ideation, design, and prototype development reflects the early stages of the PLM process, when concepts transform into physical products. Once built you will verify and validate the design against the identified requirements.

What are the Engineers Australia Stage 1 Competencies and how are they developed through exposure to PLM practices?

You are studying engineering with a view towards becoming a professional engineer. What does this mean?

Engineers Australia (EA) is the national professional body representing engineers in Australia, advocating for the advancement of engineering and setting professional standards. They play a critical role in accrediting engineering degrees, ensuring that programs at universities meet rigorous national and international standards.

The accreditation process involves evaluating curriculum, faculty, facilities, and student outcomes to guarantee that graduates possess the necessary knowledge, skills, and professional attributes. Engineers Australia's accreditation ensures that Australian engineering degrees are respected globally, promoting continuous improvement in engineering education and preparing graduates for successful professional practice.

The Engineers Australia Stage 1 Competencies outline the essential knowledge, skills, and attributes you will require for entry into the engineering profession. These are the things we are seeking to develop in you as you progress in your studies.

The EA Stage 1 Competencies are divided into three main areas:

- Knowledge and Skill Base
- Engineering Application Ability
- Professional and Personal Attributes.

Product Lifecycle Management (PLM) is the glue that supports the development of these competencies as detailed in the following table.

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1. Knowledge and Skill Base

1.1 Comprehensive understanding of natural and physical sciences and engineering fundamentals	PLM integrates scientific principles and fundamental engineering concepts into product development processes, enabling you to apply foundational knowledge effectively in real-world projects.
1.2 Understanding of mathematics, numerical analysis, statistics, and information sciences	PLM tools involve computational models, simulations, and data analysis, reinforcing the practical application of mathematical and analytical skills.
1.3 In-depth understanding of specialist bodies of knowledge	The use of PLM is in itself an understanding of a specialist body of knowledge but it also facilitates access to specialised knowledge and advanced tools enhancing your expertise in those areas.
1.4 Knowledge development and research directions	PLM systems are at the leading edge of contemporary engineering practice and knowledge of these equips you with an understanding of the latest industry trends, research, and technological advancements.
1.5 Knowledge of contextual factors impacting the engineering discipline.	The lifecycle model used in PLM helps engineers consider environmental, social, and economic factors in product development, helping them understand the broader context of their work.
1.6 Understanding of principles, norms, and standards of contemporary engineering practice.	Being familiar with PLM helps you to adhere to industry standards, best practices, and regulatory requirements. This develops and promotes your professional practice skills.

2. Engineering Application Ability

2.1 Application of established engineering methods to complex problems	PLM tools facilitate structured problem-solving approaches and methodologies for tackling complex engineering challenges, enhancing your practical application skills.
2.2 Fluent application of engineering techniques, tools, and resources	PLM tools facilitate structured problem-solving approaches and methodologies for tackling complex engineering challenges, enhancing practical application skills.
2.3 Systematic engineering synthesis and design processes	PLM supports comprehensive design and synthesis processes, from initial concept to final production, ensuring robust and innovative design solutions.
2.4 Systematic approaches to project management	PLM includes project management functionalities, aiding systematic project execution, timeline tracking, and resource management.

3. Professional and Personal Attributes

3.1 Ethical conduct and professional accountability.	PLM promotes transparency, accountability, and traceability in engineering processes, ensuring adherence to ethical standards.
3.2 Effective communication in professional and lay domains.	PLM facilitates clear and effective communication among multidisciplinary teams, both locally and globally, enhancing collaborative efforts and information sharing.
3.3 Creative, innovative, and proactive demeanour.	PLM encourages innovation and proactive problem-solving by providing tools for brainstorming, prototyping, and testing new ideas.
3.4 Professional use and management of information.	PLM ensures efficient information management, data accuracy, and accessibility, supporting professional use and handling of engineering data.
3.5 Orderly management of self and professional conduct	PLM aids in personal productivity, task management, and professional conduct by organising tasks, timelines, and resources.
3.6 Effective team membership and leadership.	PLM supports collaborative work environments, fostering effective teamwork and providing opportunities for engineers to lead projects and teams.

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