

Engineering Innovative Products

A Practical Experience



EDITED BY

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ENGINEERING INNOVATIVE PRODUCTS

A PRACTICAL EXPERIENCE

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The authors dedicate this book to the many students who have actively engaged in the company and product creation activities described here.

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The authors are most grateful to the experts who have helped to develop the course material and who have also contributed individual chapters.

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Foreword

Engineering Innovative Products is more than just a description of the innovation process. The book is based on experience of running an inspirational and popular course which takes students through the process of starting a new company. A number of ventures that have come into existence through the course are described, with the twists and turns of their journey demonstrating the culture required for success.

The topic of innovation has attained much importance with universities and governments in their quest for economic growth and wealth creation. This is because the pace of technological change has accelerated, precipitating further acceleration in the development cycles of products and consequently in the changing shape of industrial sectors. Hence, what were established models of innovation are being replaced by new ones, with even large enterprises having to adapt and change. New opportunities are frequently based on new business models for getting product to market, something a startup company is able to do easily. This is particularly true in sectors where digital technology either makes up the product itself, or is used more generally as a means of marketing and selling it. At the same time, the barriers to starting a new venture have much reduced, not least because of the training, support and incentives offered. New ventures are a prerequisite for a dynamic economy and now is the time when they have an excellent chance of success.

This book takes the reader through all the essential steps in creating a successful business. Practical insights are given about how new product concepts can be identified and prototyped. The role of product engineering and

marketing is discussed. What makes a good business plan is described, alongside illustrations of successful elevator pitches to communicate it succinctly. Teamwork and the roles of each team player are presented. At the same time, the role of finance and raising investment capital is described. Sections on marketing, branding and intellectual property are contributed by expert practitioners. Finally, and of most interest to educators, suggestions for exercises and assessments when running a course are presented.

But there is more. The creation of a new venture is a process of discovery as much as of academic study, and the authors demonstrate this through a number of case studies. The benefit of a cluster with inbuilt experience, partners and competitors is made clear. Members of the cluster can mentor and present critical advice from the earliest stages. The need to respond to critical input and be prepared to significantly adapt the venture is shown by example. The role of crisp presentation and description of the most important components of the new venture is emphasized, particularly when seeking investment. Finally, the benefit of a competitive element at all stages - including assessment by an expert panel - completes the excellent formula.

I warmly recommend this book to the reader for both information and inspiration. Educators using it as the basis of a course on business creation will be well served. The individual reader will become familiar with what it takes to be an entrepreneur. The chances of successful innovation in engineering will be much improved. The book is timely because the opportunities for success are there to be grasped.

Andy Hopper
University of Cambridge, UK
24 February 2014

Preface

Innovation is currently a hot topic and is related directly to economic development. The creation of companies resulting from innovative projects and processes is seen as central to the economic development in many countries. Like many governments worldwide, the UK government's main industry division, the Technology Strategy Board, uses the 'innovation' word all over their web pages and highlights that their goal is 'to accelerate economic growth by stimulating and supporting business-led innovation'.

Whilst most university management schools have embraced the concept of company creation and innovation, some engineering schools have still to incorporate product design as a core element in their courses. This is probably because it represents yet another module amongst the increasing number of technical subjects that need to be covered in the degree programme. We would argue that it is now becoming a core topic and, combined with engineering skills, represents a very interesting skill set for engineers to develop.

A number of years ago, the Schools of Electronics, Electrical Engineering and Computer Science and Mechanical and Aerospace Engineering at Queen's University Belfast embarked on separate activities to introduce students to the concept of product design, company creation and commercialization. However, rather than just create a series of talks to introduce the students to the topic, both schools introduced hands-on practical courses which acted to get the students engaged in developing their own product ideas and then building on this work to create a full commercial proposition. The course has matured to such an extent that the students are

now getting shortlisted for, and indeed winning, local and national commercialization competitions.

The purpose of this book is to capture the process, and provide examples of best practice and insights into the practical experiences and development that have been undertaken over the past three years. It is based on the material that has been developed in the courses by topic experts external to the university, whom we engaged to interact with the students; topic areas include finance, marketing, branding, presentation and intellectual property. Also, two of the authors have founded their own companies and brought this experience to bear on the enclosed material. For completeness, two of the groups that undertook the course have provided detailed insights into their practical experience of going the full distance and creating their own companies. In addition, the text builds upon the experiences of some 12 business propositions that have been created during this time.

Throughout the book, the authors have relied on their own experiences and student examples to emphasize the points made and illustrate both good and poor approaches. In addition, the text includes a number of exercises entitled '*Try this*', which stretch the reader to apply directly some of the material covered in the various chapters; this acts to help future students and readers who are engaged directly on the commercial activity.

The activity has been rated highly by external organizations which are involved in linking entrepreneurs to commercial opportunities, such as the Northern Ireland Science Park. The Institution of Engineering and Technology, a professional organization which undertakes evaluation of degree course material (termed accreditation), highlighted the activity as 'exemplar' on their most recent visit. It is hoped that lecturers interested in developing their own

courses will find this text invaluable; we also firmly believe that any budding entrepreneur will find valuable lessons contained within this book, as the example business plans developed by the groups have stood up to commercial scrutiny.

List of Abbreviations

API	Application Programming Interface
BIL	Business Innovation Link
BS	British Standard
CAD	Computer-Aided Design
CATS	Credit Accumulation and Transfer Scheme
CEO	Chief Executive Officer
CES	Cambridge Engineering Selector
CFO	Chief Financial Officer
CMO	Chief Marketing Officer
COO	Chief Operating Officer
CTO	Chief Technology Officer
DFMA	Design for Manufacture and Assembly
DIY	Do It Yourself
EN	European Standards
EPSRC	Engineering and Physical Sciences Research Council
EU	European Union
FEA	Finite Element Analysis
FMEA	Failure Mode and Effects Analysis
GPS	Global Positioning System
GPU	Graphical Processing Units
IAESTE	International Association for the Exchange of Students for Technical Experience
IET	Institution of Engineering and Technology
IP	Intellectual Property
IPC	International Patent Classification
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
LLP	Limited Liability Partnership

LVCSR	Large Vocabulary Continuous Speech Recognition
MBTI	Myers-Briggs Type Indicator
MIM	Metal Injection Moulding
MVR	Multimedia Voice Recognition
NDA	Non-Disclosure Agreement
NISP	Northern Ireland Science Park
PDS	Product Design Specification
PLC	Public Limited Company
POC	Proof of Concept
PPC	Pay per Click
PSL@Q	Programmable Systems Laboratory at Queen's University
QR	Quick Response
QUB	Queen's University Belfast
QUBIS	Queen's University Belfast Industrial Services
RFID	Radio-Frequency Identification
SEO	Search Engine Optimization
SME	Small to Medium Enterprise
SWOT	Strengths, Weaknesses, Opportunities and Threats
TDI	Technical Development Incentive Scheme
TPMS	Tyre Pressure Monitoring System
TSB	Technology Strategy Board
US	Uniform Resource Locator
US	United States
USP	Unique Selling Point
VAT	Value Added Tax
VIP	Very Important Person
WFST	Weighted Finite State Transducer

Chapter 1

Introduction

Roger Woods

1.1 Introduction

Over the past 30 years, there has been a shift in the world's economy which has occurred for a number of reasons. Large-volume manufacturing has moved from the West to the East due to much cheaper production costs, largely because of cheaper labour and the optimization of the value chain (Zhu *et al.*, 2006). In addition, economies such as those in Canada and Australia have been buoyed by the availability of natural resources such as the supply of phosphorus and, of course, oil and natural gas. In the absence of these resources, the remainder of the Western economy has looked to rely on the *knowledge-based economy*; one route has been to exploit much of the knowledge that exists in universities and research centres to either undertake technology transfer into industry or to create spin-off companies.

The Bishop William Lawrence University Professor at Harvard Business School, Michael Porter, famously said that 'innovation is the central issue in economic prosperity', a vision to which the West would appear to have been fully committed. For example, the strap line of the UK's Technology Strategy Board (TSB) is *Driving Innovation!* and the recent focus of the UK higher education institutions' upcoming Research Excellence Framework on *Impact of Research* suggests a direct link between research innovation and commercialization. One UK funding agency, namely the Engineering and Physical Sciences Research Council (EPSRC), now has a clear

message on 'fueling growth and prosperity' on their main web page; a clear indication that the work funded in universities should have an impact on the economy.

This approach is being adopted more widely. For example, the EU's Horizon 2020 programme is described as the financial instrument implementing what they call an *Innovation Union*, a Europe 2020 flagship initiative. It is described as 'securing Europe's global competitiveness' and sets the agenda for involvement of small to medium enterprises (SMEs) in EU research.

All of these factors send a clear message to universities about commercializing research, either through the development of spin-off companies which look to directly commercialize the output of university research, or other approaches such as spin-in activity or technology transfer schemes. Indeed, many governments will provide incentives in the form of grants, subsidies and tax breaks to encourage business creation in certain areas of the economy. This has resulted in a clear shift in policy 'to encourage investment and exports as a route to a more balanced economy; and to create a more educated workforce that is the most flexible in Europe' (HMG, 2013). Coming on the back of the economic strife of the past five years, the ability to innovate and bring to market new forms of technology becomes increasingly attractive for many governments.

1.2 Importance of SMEs

It has been recognized that the creation of innovation is directly linked to the commercialization of university research. This can come about either as a result of direct collaboration with large industry in sponsoring university research and then commercializing it, or by undertaking technology transfer by direct partnering with companies

with specific expertise. However, the culture also exists to create spin-out companies from research teams wanting to commercialize a specific aspect of their research and for individuals or teams in an external company to get direct access to university technology with the aim of possibly looking to spin into the university.

In any case, many countries now place a high level of importance on the existence and promotion of SMEs. Indeed, it is clear to anyone reading the European Commission's 2011 Factsheet on *SMEs in Horizon 2020* (EC, 2011) that there is an urge to get SMEs involved in EU research and to exploit innovation. The TSB has a clear strategy of innovation (Nicholas *et al.*, 2009; TSB, 2012) and we clearly see that SMEs are the life blood of the future economy.

Many universities, such as Stanford University and the University of California at Berkeley, have clearly demonstrated their intention to exploit research for commercialization. In the UK, the University of Cambridge stands out in its capacity to be able to commercialize university research, although the host university of the authors, Queen's University Belfast, has managed to 'punch well above its weight' in terms of spin-out activity.

1.3 Inspiring Innovation for Engineers

In many cases, innovation and the concepts of startups have been seen as the *bread and butter* of management and business school courses. Many of the processes involved—such as financial planning, business development and marketing and sales—are seen as central to what is taught on the courses in these schools. Once the innovative idea or product has been created, the key challenge is to look at the development of the business from this initial concept. This is a skilled step and requires a detailed