

William E. Halal

TECHNOLOGY'S PROMISE

Expert Knowledge
on the Transformation of
Business and Society



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E2009001004

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First published 2008 by
PALGRAVE MACMILLAN
Houndmills, Basingstoke, Hampshire RG21 6XS and
175 Fifth Avenue, New York, N.Y. 10010
Companies and representatives throughout the world

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ISBN-13: 978-0-230-01954-6

ISBN-10: 0-230-01954-4

This book is printed on paper suitable for recycling and made from fully managed and sustained forest sources. Logging, pulping and manufacturing processes are expected to conform to the environmental regulations of the country of origin.

A catalogue record for this book is available from the British Library.

A catalogue record for this book is available from the Library of Congress.

10	9	8	7	6	5	4	3	2	1
17	16	15	14	13	12	11	10	09	08

Printed and bound in China

More praise for *Technology's Promise*

"The pace of change mandates that effective leaders understand the implications and promise that the coming technological tsunami holds. Professor Halal has crafted a prescient masterpiece that takes the reader on a journey to the horizon and back. Filled with poignant and practical insights grounded in data and a remarkable network of experts, *Technology's Promise* moves beyond forecasting and delivers. For Dr Halal fans this book is a wonderful extension of *The Infinite Resource*. Put this book on your wish list and, whatever you do, read it before 2010." – **Lieutenant Colonel Nate Allen, PhD, U.S. Army, Co-Founder of CompanyCommand.com, Washington, DC**

"A daring and buoyant excursion into the next few decades, looking at technological change as an integral part of human evolution and human evolution as an integral part of technological change. Should be useful even – maybe especially – for people who will disagree with its forecasts and its essentially hopeful worldview." – **Walter Truett Anderson, President Emeritus, World Academy of Art and Science, San Francisco**

"Clearly, business success in the 21st century requires differentiating between the bleeding edge and the leading edge of technological advancements as they morph from innovation to application. In his landmark book, *Technology's Promise*, William Halal delivers the differentiation key that entrepreneurs have needed. Not since *Mega-trends* have we been given such a clear view into the future of technology and its impact on humanity. Thanks, Bill." – **Jim Blasingame, small business expert, author, and columnist, award-winning radio host, The Small Business Advocate Show**

"Fifteen years ago Bill Halal started a project now known as Tech-Cast to forecast the times at which new, emerging, or anticipated technologies would become significant. The first report was well received and in just a few years became an eagerly anticipated annual event. For those new to the fields discussed, the forecasted dates were an eye-opener. For others making their own forecasts, if they agreed it boosted one's self-confidence. If the forecast was significantly sooner or later than you expected, you were forced to reconsider your assumptions about the future. That re-examination of assumptions is the single most important thing one can do in coming to grips with the future. Bill's book develops in engaging detail how the process works,

the forces driving the changes implicit in the forecast, and the likely outcome of those changes.” – **Joseph Coates**, *Futurist, Washington, DC*

“Bill Halal is a pioneering contributor to the field of science and technology forecasting, especially applied to broader societal issues. He has advanced both the level of technique and the level of wisdom available for more far-ranging and more profound analysis. His work is both a challenge and an encouragement to those of us who believe that it is possible to develop policy for the future on the basis of systematic assessment. It also strongly underscores the now central role of science and technology as drivers in the world civilization that is struggling to emerge.” – **Leon Fuerth**, *Research Professor of International Affairs, Elliott School of International Affairs, George Washington University, Washington, DC*

“In this wonderful new book, Bill Halal gives us an image of a positive future based on advances in AI, green technology and the development of a mature global governance system. While the thrust of his theory is technology focused, Halal takes a broad view of technology seeing biology as a technology of life and spirituality as technologies of consciousness. This book is excellent reading and inspiring.” – **Professor Sohail Inayatullah**, *Tamkang University, Taiwan, the University of the Sunshine Coast, Australia*

“Bill Halal’s personal grasp of emerging technologies coupled with the excellent predictions of the TechCast Panel makes the job of a planner far easier. *Technology’s Promise* is a terrific and dynamic roadmap to the future.” – **Mike Jackson**, *Chairman, Shaping Tomorrow, London*

“*Technology’s Promise* is of great value to those in business and government who are active in forecasting and managing technology advancement.” – **Zhang Jingan**, *Chief of Science and Technology, Daily Vice Minister, Ministry of Science and Technology, People’s Republic of China*

“Through millions of years of striving to be selected for fitness to survive, the crowning achievement of the human mind clearly is the exponential growth in Knowledge and its applications. Modern humans started out pursuing an understanding of the external world, and since the latter half of the 20th century, we turned inwards and are now beginning to understand ourselves and the microcosm. As distinguished Professor Halal correctly points out, we stand as a species on the brink of

boons and banes caused by our technological prowess. Will we justify the salutation of 'homo sapien' or will we fall prey to the inevitability of extinction so strongly foretold in the historical record of evolution? Read Prof. Halal's book. He answers the question brilliantly." – **Walter Kistler and Sesh Velamoor**, *Foundation for the Future, Seattle*

"I was deeply impressed by this remarkable work. Prof. Halal's bold method of forecasting has given us a constructive new way to think about how the Technology Revolution is likely to change the world. We are pondering the implications for South Korea carefully and deeply." – **Young-Tak Lee**, *Chairman, Korean Stock Exchange, Seoul*

"Leaders in business, government and universities need foresight. They take big bets on the future. This book will be an extremely valuable aid to their thinking." – **Michael Maccoby**, *PhD, President, The Maccoby Group, Washington, DC and author, The Leaders We Need, and What Makes Us Follow*

"Bill Halal has dedicated his career to tracking the implications of new technologies. This book is especially fascinating on the social and economic impacts of technological change in manufacturing, robotics, and healthcare; as well as the globalization of commerce, communications and security issues; and the impact all will have on income gaps and global prosperity. A thorough discussion on the critical technology issues facing humans in the 21st Century." – **Tim Mack**, *President, World Future Society, Washington, DC*

"I have for years admired Bill Halal's skillful and determined work in developing the TechCast system. It gathers expert views of the future all around the world in a systematic and inspiring way. Now Bill has done a great synthesis and developed scenarios, which go far beyond what normally is understood with the future of technologies. *Technology's Promise* is a must for any futurist or a person interested in our global future." – **Mika Mannermaa**, *Dr of Economics, Managing Director, Futures Studies Mannermaa Ltd, Helsinki, Finland*

"What Professor Halal has done is truly amazing. First, the methodology defies history; you are not supposed to be able to predict technological innovation. Second, he has represented this clever process and its outcomes in an incredibly readable book. The reader's eyes pop in and out on discovering the pace and space of technological breakthroughs. For those who get paid to be concerned about technology

and its implications – and for those who don't but still care – if you buy only one book this year, this is it.” – **Dennis McBride**, *President, Potomac Institute for Policy Studies, Washington, DC*

“It is likely that Bill Halal has thought more – and more systematically – about the future of technology than anyone you know. For 15 years, his TechCast program at George Washington University has been tracking the likely emergence of technologies that will change your life and the planet. Guaranteed. Here's the big picture in one, easy-to-read place!” – **John L. Petersen**, *President and Founder, The Arlington Institute, Berkeley Springs, Virginia*

“What were once separate scientific disciplines now work together to greatly accelerate technological progress. IT accelerates biotech which accelerates nanotech, which accelerates IT, etc. Bill Halal's method of synthesizing the viewpoints of 100 specialized technology futurists captures the surprising trajectory of this emerging critical mass of technological progress. *Technology's Promise* is a deep, readable and compelling look into our most likely futures.” – **Gifford Pinchot III**, *Co-founder & President, Bainbridge Graduate Institute, Seattle*

“Navigating through game changing technologies is critical to an organization's strategy. *Technology's Promise* provides enterprise leaders with a programmatic view into the future technology landscape, enabling superior strategic decisions.” – **San Retna**, *Vice President, Program Management Office, Safeway, and Chair, Enterprise Portfolio Management Council*

“Bill Halal has written an indispensable guide to the future for entrepreneurs, whom we rely on not only for the growth of our economy but also to benefit from new technologies in the pipeline. Bill's unique access to expert information about what's coming next also provides a powerful tool for strategic planners and thinkers.” – **John W. Rollins**, *Serial IT Entrepreneur and Professor of Entrepreneurship, Washington, DC*

“*Technology's Promise* offers a vision of a unified world emerging from a virtuous cycle of knowledge. Based on expert opinion on the scientific and technological revolution, the book provides an antidote to doom and gloom; not by ignoring the problems that beset us but by demonstrating that we are creating the science, the technology and the tools to remake society and ourselves to reach a new level of civilisation. This book is a primer for change. Read it, absorb and act!” – **Harry Rothman**, *Editor, Technology Analysis & Strategic Management, England*

“Halal offers a breathtaking and immensely practical view of what the future holds for us all. *Technology’s Promise* is a guide and an inspiration for action in the face of the immense changes that lie ahead.” – **Paul Saffo**, *author and forecaster, Institute for the Future, Silicon Valley*

“Thriving with the accelerating pace of technological change has become a defining personality trait for the 21st century. Now more than ever the regular consumption of high-quality future studies is needed to build foresight consciousness. This passionate, enlightened book with its superlative expert forecasting will help prime you for the staggering opportunities and demanding challenges of our times. Read it and play your own vital part in the transformation of global consciousness now underway. It will help you appreciate both our extraordinary present and the unprecedented future ahead.” – **John Smart**, *President, Acceleration Studies Foundation, Los Angeles*

“The 21st century is one of rapid change and globalization. Those who can create and predict the future, as well as operate in it with confidence and knowledge, are the winners. Professor Halal’s work, *Technology’s Promise*, is a **must read** for those who aspire to be winners. Few scholars and practitioners have access to both a field of oracles as well as research and insights from a life dedicated to this subject. Professor Halal has successfully integrated the ingredients of art and science that are the DNA for success in the new world. Read it, and be a winner.” – **Michael Stankosky**, *DSc, Professor of Engineering Management & Systems Engineering, Co-director, Institute for Knowledge & Innovation, George Washington University, Washington, DC*

“A fascinating analysis on how the Technology Revolution will transform business and society. Prof. Halal’s Virtual Trip Through Time challenges our views of the future. This book can be extremely useful in adapting to the changes we are facing.” – **Dr Sylviane Toporkoff**, *Professor, University of Paris, President and Founder, Global Forum/ Shaping the Future*

“Understanding the future of technology and its impact now has become a must for any critical planning. *Technology’s Promise* does not come out of Dr Halal’s speculation but is based on more than one hundred diversified experts’ collective intelligence. Providing solid, evidence-based implications, the book really offers readers more persuasive trends of technology and its effects on social organization. If you are looking

for an engine of collective intelligence on technology, this book and its engine www.techcast.org provide solid direction.” – **Dr Rong-I Wu**,
*Chairman, Taiwan Stock Exchange Corporation Former Vice Premier
of the Executive Yuan of Taiwan*

Dedication

To the creative scientists, engineers, and entrepreneurs who bring mere possibilities into reality. May this book help guide the path ahead.

Acknowledgements

I am grateful for the support of my publisher and staff at Palgrave Macmillan for producing and distributing a fine book. Many others deserve recognition. Owen Davies provided keen editorial skill in helping me shape my writing into a more inviting form. I want to acknowledge the judgment of colleagues who reviewed the manuscript and offered insightful suggestions at various stages of development: Richard Donnelly, Chairman of the Department of Information Systems and Technology Management at George Washington University (GWU); Edward Cornish, Founder of the World Future Society; Michael Marien, Editor of *Future Survey*; and Tom Lombardo, Professor of Psychology at Rio Salado College. Scholars owe much of what they learn to the stimulation of students. Mine at GWU patiently listened to half-baked ideas while I searched for understanding. A particular student, Evan Faber, should be recognized for helping with the graphics. My former PhD student, now Dr. Ann Wang, provided continued support. I was moved to see so many of my TechCast experts offer useful guidance: Denis Belaguer, Dennis Bushnell, Jose Cordeiro, Adam Gerber, Aharon Hauptman, Henry Heilbrunn, Lester Ingber, Michael Jackson, Peter King, Jeff Krukin, Al Leedahl, Xin-Wu Lin, Robert Locascio, David Luckey, Michael Mainelli, Mika Mannerman, Amy Oberg, David Passig, John Sagi, Yair Sharan, Art Shostak, and Richard Varey. A total of 100 experts listed in the Appendix serve on our Expert Panel doing the hard work of creating forecasts. And the folks at Unifusion brought professionalism to the latest version of our website www.TechCast.org. To all these colleagues, partners, and friends, I express my deep gratitude for their role in producing *Technology's Promise*.

Foreword: Basic Training for the 21st Century

Do you worry that your job may someday be replaced by a machine? Debate whether to buy a new car now or hope that the safety and convenience of a high-end Mercedes will find their way into more affordable models before your aging Ford turns to rust? Wonder how you will cope with tomorrow's consumer electronics when you can't program today's DVD player? If so, you have picked up the right book.

If not, keep reading anyway. Bill Halal has a lot to tell you about the future of technology and how it will affect our lives. These are things you need to know.

Even if you do not worry about the effects of technology – even if “techie stuff” doesn't interest you at all – you can feel the world speeding up around you. This is not an illusion. The pace of change really is accelerating.

Back before World War I, when “high technology” meant chemistry, it took about 40 years for the discoveries of basic science to find their way into daily use. By the 1950s, this product cycle had shrunk to only 30 years. The miracle plastics that Baby Boomers saw on television when they were children grew out of basic discoveries made in the 1920s and '30s – about when the first televisions were invented.

Electronics really broke open the floodgates. The first practical transistor was invented in 1947. The first integrated circuits were patented in 1959 and 1961, but it was roughly ten years later before microchips were cheap enough to use in consumer products. Pocket calculators reached the stores in 1971, and the first personal computer – the IMSAI 8080 – was in production by December 1975.

Today, if a personal computer can be found in a store, it is already obsolete. The next two generations of PC are already in the labs, waiting to enter mass production. The product cycle, from basic discovery to mass marketing and replacement with an even better model, has shrunk from 40 years to six months or less.

So it is with most consumer products. If consumers welcome a new item, knock-offs will be for sale on eBay within a month and cheaper,

more powerful models will flood the market three months later. Look at mp3 players for just one example. It takes something really special – like the iPod’s eye-catching design and inspired convenience – to hold its market share against the competition.

“This book provides basic material for planning a secure, productive life in an age of constant change. It is a ‘heads up’ that no one but Bill Halal could have given.”

Now that the 20th century is well behind us, this trend is spreading into medicine, materials, and many other fields. Eighty percent of the scientists, engineers, technicians, and physicians who ever lived are alive today, and they are trading ideas in real time on the Internet. No wonder things are changing so fast! These technologists

and their heirs will continue to shake our world when today’s young children reach old age – if by then medicine has not made old age obsolete.

In a world of pandemic change, it is all too easy to be caught unprepared. We easily imagine that our jobs are secure or that the economy will remain prosperous and stable for a few more years. Then Chinese competitors bring out a product that is as good but costs half as much – Detroit, you have been warned! – or turmoil in the Middle East sends the price of oil through the roof and real estate prices fall through the floor. The only way you can afford not to look ahead is if you have already retired with enough money to outlast any conceivable misfortune. For the rest of us, forecasting is a basic part of life – rather like doing our taxes – whether we know it or not. This is where Prof. Halal can help.

There are many ways to anticipate the future. You can collect mountains of data, weigh it carefully, stare off into space for a few moments, and make a wild guess, as many economists seem to do. You can try to identify trends in global affairs and project where they will lead. (This is what we generally do at Forecasting International.) Or you can use what almost certainly is the oldest technique of all: ask someone you believe to be an expert. People have been doing that at least since the classical Greeks consulted the oracle at Delphi, some 2,800 years ago.

At George Washington University, Prof. Halal has modernized the ask-an-oracle method of forecasting. Instead of consulting one seer about the future of technology, he periodically questions roughly 100 of them. And instead of being general-purpose priestesses, Bill’s oracles are experts in their fields, from medicine to computer technology and rocket science.

What this process buys you is confidence. If one supposed expert tells you that in twenty years we will all be flying around the world on woven-titanium carpets, you may just have picked the wrong person to ask. But if several people with solid records in their field all come up with reasonably similar predictions, give or take a few years, you can reasonably believe that they have given you an accurate look into the future.

That is pretty much how it has worked for Bill Halal's TechCast Project, which was born as a college program and has now grown into an independent research project. Since its founding in 1985, TechCast has produced some of the most interesting and accurate technology forecasts now available. At Forecasting International, we have relied for years on TechCast's annual summary prediction of future technology. Other clients who have recognized the value of TechCast's work include the Asian Development Bank; the U.S. Environmental Protection Agency, Food and Drug Administration, National Aeronautics and Space Administration, and Department of Defense; as well as private corporations such as AT&T, General Motors, and IBM.

You are likely to find TechCast's predictions interesting and valuable as well. In the pages ahead, you will find wonders to match those of any old-fashioned carnival sideshow. They had sword swallows and bearded ladies. The future Bill Halal presents has robots that can clean your house, drive you to work, or float through your blood vessels killing cancer cells before they form tumors than could kill you. It has computers as powerful as the human brain and capable of reading our thoughts. There are elevators to space and vacations in orbit. There are artificial organs and medical treatments tailored to our DNA and the promise of healthy, productive lives far longer than our natural span. Yes, there are wonders here to amaze and entertain.

After the show, the Wild Man from Borneo took off his costume, changed into street clothes, and went out for pizza with the no-longer-bearded lady. But the wonders in this book are all real. They just haven't arrived quite yet.

When they do, our lives will change again and our expectations will be obsolete – unless we have looked far enough ahead to see where we are going. And it is here that Prof. Halal makes what could be his greatest contribution. Not only does he tell us what is coming, he analyzes how all these technological changes will alter our world and our lives. Even if the future does not exactly match his scenario – and it won't; no forecast ever survives contact with tomorrow's experience

– these final chapters in the book give us a useful framework for understanding. As we see how the future deviates from this scenario, it will be easier to adjust our own expectations.

No one with any sense drives down a highway without looking at the road ahead. But that is roughly what we are trying to do when we make plans without solid, reliable information about the future of technology, the most powerful force now changing the world. This book provides basic material for planning a secure, productive life in an age of constant change. It is a “heads up” that, among all the forecasters we know, no one but Bill Halal could have given.

If you are a techie, read the pages ahead for pleasure and accept the information as a bonus. If you spend your days making hand-thrown pottery and loathe technology more advanced than your kiln, think of this book as the spinach in your information diet. Either way, read on. This is basic training for the rest of the century.

Dr. Marvin J. Cetron
President, *Forecasting International*

Dr. Marvin Cetron is one of the preeminent forecaster-futurists in the world. For some 50 years, he has pioneered corporate and government forecasting, developing many of the techniques that other forecasters now use daily. He remains one of the most active and respected practitioners in this field. He has consulted for roughly 450 of the Fortune 500 firms, 150 professional organizations, and 100 government agencies. He served as an advisor to the White House for every administration, Republican and Democratic, from the time of John Kennedy through the Clinton years.

Preface: Discovering the Forces of Transformation

The relentless power of technology can be seen in a small, everyday product that receives little attention. Travel anywhere today, and you will find that almost all tourists now use digital cameras. As Liquid Crystal Display (LCD) technology and digital storage capacity improved, we reached the critical point a few years ago when digital photography became feasible, and soon the entire industry of film-based cameras was overturned by simply moving around digital bits instead. Nikon, once a mighty force in film photography, now sells only one model of 35mm camera. Eastman Kodak dominated the industry for decades, but has been struggling to adjust for years, laying off tens of thousands of employees and replacing its entire line of products and services. In terms of social impact, the digital camera unleashed floods of photos and video that now populate the new participative Web 2.0 – MySpace, YouTube, blogs, wikis, and more sure to come.

The same revolutionary force is at work as biotech extends lives, alternative energy replaces oil, robots and artificial intelligence (AI) take over human jobs, and endless other innovations reach the take-off point. As the forecasts presented here will illustrate, today's mounting knowledge in all technical fields seem destined to transform society during the next 20 to 30 years. We had best prepare for the coming upheaval.

Technology's Promise provides a roadmap of the terrain ahead. Based on a program of research that summarizes the available knowledge and the judgment of an international panel of 100 experts, this book presents comprehensive forecasts of breakthroughs in energy and the environment, manufacturing, robotics, information technology (IT), e-commerce, medicine and biogenetics, transportation, and space.

We then draw on decades of social studies to understand the institutional barriers to technological change and the pivotal concepts emerging to transform business, government, and other institutions for a knowledge-based global economy.

Because AI is challenging human intelligence, I also examine the difference between AI and human consciousness and survey the many techniques being used to shape consciousness.

We conclude by integrating all forecasts into longitudinal scenarios that outline the most likely path ahead using “macro-forecasting.” The most prominent feature of this analysis is that a “global crisis of maturity” seems likely about 2020 to 2030. It may be the most important event of our time.

The book’s goal is to provide a compelling new perspective that helps make sense of today’s seemingly insurmountable challenges. It can be used as a framework to guide your organization and personal life more wisely.

ORIGINS

Books are like babies in important ways. Apart from the “hard labor” involved in producing both, their character is largely inherited from different sources. *Technology’s Promise* is the product of two enduring streams of study that came together during a long gestation to produce a lively intellectual offspring.

I was educated as an aerospace engineer, served as an Air Force officer, worked on the Apollo Program and in Silicon Valley, so I’ve always loved science and technology. As a boy I was fascinated by taking things apart and figuring out how they worked. I loved the logic of physics, marveled at flight, and pondered electricity.

However, I also felt the technical world was isolated from the “real world” of commerce, politics, and society. People were sure I’d gone mad when I left the Apollo Program to get an MBA and PhD in economics and the social sciences. Then I taught business, strategy, and other “soft” fields for many years while trying to understand social systems. But this only left a longing for the precision and hard reality of science and technology, which led to the work reported here.

Technology’s Promise integrates the hard world of technology and the soft world of social science into a more comprehensible whole. I think I can now bring a richer perspective to this sixth book of mine, showing not only how the technology revolution is likely to unfold, but also how it promises to alter social institutions, the global order, and even what it means to be a modern human.

This preface offers a short intellectual history of *Technology’s Promise*. Here’s the story of how this work developed, written from the “inside out” to identify the valuable lessons learned over the past 30 years – the power of massive technological change, overcoming institutional