Contents	Page
Preface	i
Acknowledgements	ii
A Short Story My Short Story notes	1 4
Chapter 1: Introduction A 'map' of the book What are assets? Why worry about Asset Management? What do we need to know about our assets? How do we find out what's happening? What's the business benefit? Who is in the best position to carry out Asset Management? What is Servitization? Summary of the book My Introduction notes	5 5 6 6 6 6 6 7 7 8 9
Chapter 2: The Business Imperative Introduction Companies that have embraced Servitization Problems and issues with making services a separate business unit The importance of human factors Strategy Financial evaluation and modelling The value of in-service monitoring of assets Life Cycle Costing PCN Analysis Books and papers Consultant papers Cambridge Service Alliance Aston Business School Other UK Universities Universities outside the UK My Business Imperative notes	10 10 14 16 16 17 18 19 21 22 23 23 25 27 28 30 31
Chapter 3: Modelling and Simulation Introduction Why is modelling and simulation useful? Levels of modelling Simulation Books and papers Some useful sources of information for specific disciplines and equipment types General mathematical modelling Modelling tools Reference material Aerodynamics, fluid mechanics and turbomachinery Thermodynamics Control systems Electrical systems and batteries Heating, ventilation and air conditioning (HVAC) Aero engines and gas turbines Aircraft Automotive Diesels and turbocharging Railways Combined heat and power (CHP) Fuel cells	32 32 33 33 35 35 35 36 36 36 37 37 37 37 37 38 38 38 38

Wind turbines, solar and renewable energy My Modelling and Simulation notes	39 40
Chapter 4: Analysis	41
Introduction	41
Facets of analysis	41
Difficulties with the analysis process	41
The 'Traditional' approach to analysis	42
Iterative Analysis	42
An alternative approach to analysis	44
Optimal Estimation and Kalman Filtering	46
The Kalman Filter equations Problems with the Kalman Filter	47 47
Books and papers	48
My Analysis notes	49
Chapter 5: Observability	50
Introduction	50
Setting up an analysis	50
Generation of Exchange Rate Tables	50
Correlations between measurements	51
Inclusion of sensor bias	53
Correlations between component performance parameter changes and/or sensor biase My Observability notes	es 55 58
Chapter 6: Time Series Analysis	59
Introduction	59
Time series basics	59
Moving Average	60
Exponential Smoothing	61
Kalman Filtering	62
The Optimal Tracker	63 64
Improving the Optimal Tracker Books and papers	65
My Time Series Analysis notes	66
Chapter 7: Data Visualisation	67
Introduction	67
Fundamental information requirements	67
Typical information solutions	67
Typical information building blocks Alerts	68 68
Bar and column charts	68
Dashboards	69
Data export capabilities	70
Fault/event cubes	71
Mapping	71
Parallel Coordinates plots	72
Reporting	73
'Smart' analytics	73 73
Summary statistics Time series	73
User-defined calculations	75
Weighted lists	75
X-Y plots	75
Drill-down	76
Books and papers	76
My Data Visualisation notes	78
Chapter 8: More Complex Techniques Introduction	79 79

Statistics	81
Data Science	81
Bayesian Statistics	82
R and Microsoft Excel®	84
Principal Component Analysis	84
Artificial Intelligence	85
Fuzzy Logic	85
Neural Networks	85
Case-Based Reasoning	85
KEEL	85
Pattern Matching	85
Prognostics	86
Data Mining	87
Machine Learning	87
My More Complex Techniques notes	88
Chapter 9: Data Gathering and Software Architectures	89
Introduction	89
Software schematics	89
Data gathering	90
Books and papers	92
Machine to Machine (M2M)	92
The 'Industrial Internet'	93
Knowledge Management	93
Data Historians	94
Big Data My Data Gathering and Software Architectures notes	94 96
Chapter 10: The Practicalities	0.7
Introduction	97
Reliability	97
Fault Trees, FMEA, FMECA and FRACAS	97 99
Alarms	100
Maintenance	100
Spare Parts Management	100
Computerised Maintenance Management Systems (CMMS)	103
Availability	105
Condition Monitoring techniques	105
My Practicalities notes	111
Chapter 11: Standards and Procedures	112
Introduction	112
Asset Management	112
Books and papers	114
Condition Monitoring	117
A personal observation	118
My Standards and Procedures notes	119
Chapter 12: Summary and Conclusions	120
Summary	120
Asset Management; nine key points	120
1. Assets are used by businesses to create value that can generate profits	120
2. Assets need to be looked after; they are hardly ever 'fit and forget' business fixtures	120
3. Making rational business decisions based on information about the assets used by a	120
business can produce significant financial improvements	401
Proper Asset Management can mean the difference between business success and business failure	121
5. Understanding what has happened, is happening and may be about to happen to the	121
assets used by a business is crucial	1-1
 Current technologies allow data to be gathered as often as required to understand mai issues 	ny 121

	Accurate information about the functional and operational performance of the assets used in a business enables better business planning and results in fewer unpleasant	121
	Since most businesses want the functionality an asset provides, rather than the asset itself, Asset Management represents a significant business opportunity for the asset manufacturers and/or asset users and/or third parties	121
0	Asset Management removes many significant business risks	121
	clusions	121
	summary and Conclusions notes	125
		126
	g after planes, trains, clean energy and human health: 23 important if I've learned the hard way	126
1.	It's what an asset does, not what it is, that is important	126
2.	Asset Management is a business issue	126
3.	Without senior management support, Asset Management goes nowhere	126
4.	Know your assets	126
5.	Asset Management needs to be incorporated at the start, not brought in later as an	126
5.	'add-on gimmick'	
6.	Break down the silos, open your mind and look for what your customers really need to	127
	help them make money and serve their markets better	
7.	Share to gain	127
8.	Never underestimate the persuading you will have to do, at all levels in your	
	organisation, or the power of the 'heroes' who feel threatened by strange new ways of	
	doing things	127
9.		127
10	. Asset Management is a chain, from sensor to business action	127
	. Don't put the data cart before the business horse	128
12	. Keep it simple	128
13	. A physics-based asset model is a very powerful business and technical tool	128
14	. If at all possible, compare all your asset measurements to a baseline, which ideally	
	takes account of all known external drivers of the recorded values (e.g. load variation,	
	ambient condition changes and other quantified effects)	
15	. A good measurement and/or analysis visualisation, tailored to the person you are	128
	talking to, will make all the difference	
16	. The appropriateness of the analysis is more important than the 'bigness' of the data	128
17	. Cost is not value: keep reminding the cost-cutters of this	129
18	. An asset measurement without a timestamp (preferably GMT/UTC, which avoids time	
	zone and daylight saving time issues), unique asset identifier and some measure of	
	operating stress and environment is a random number from which useful information	
	can only rarely be retrieved	
19	. Inadequate asset configuration knowledge and/or asset configuration control makes	129
	meaningful Asset Management impossible	100
	. Some people just don't 'get it'	129
21	. Don't assume anything	129
22	. Know the limits of what you know and learn to appreciate the contributions	129
	everyone at all levels can make to the whole Asset Management process	120
	. Push, but be patient	130
	mples and Stories	130
	clusions	132
My 2	23 Important Lessons notes	133
		134
Refere	nces	
Websit	es	190
Annone	lix A: Power System Example	197
	•	197
	oduction	197
	scenario	198
	cell and wind turbine modelling	201
	ulation outputs	204
	ysis of simulated power system data	205
Con	ventional Analysis	

Iterative Analysis	205
Kalman Filtering	206
Time Series visualisation	207
The Optimal Tracker	209
Linear Regression	210
Statistics	210
Parallel Coordinates plots	211
Pattern Matching	211
Neural Networks	212
Decision Trees	213
K Nearest Neighbours (KNN)	215
Unsupervised Cluster Analysis	215
Support Vector Machines	216
A final thought	218
My Power System Example notes	219
Appendix B: Human Health Monitoring	220
Introduction	220
Bringing weight and blood pressure under control	220
This example of human health monitoring saved the author's life	227
Current developments in human health monitoring	228
And finally	228
My Human Health Monitoring notes	229
Appendix C: Solar Panel Monitoring	230
Introduction	
Analysis approach	230
My Solar Panel Monitoring notes	230 234
my Solal Faller monitoring notes	234
Index	235