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# **Event-Based Risk Management of Large Scale Information Technology Projects**

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**PhD Thesis**

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This thesis is submitted in partial fulfilment of the requirements  
for the award of Doctor of Philosophy

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# Abstract

Globalisation has come as a double-edged blade for information technology (IT) companies; providing growth opportunities and yet posing many challenges. Software development is moving from a monolithic model to a distributed approach, where many entities and organisations are involved in the development process. Risk management an important area to deal with all the kinds of technical and social issues within companies planning and programming schedules, and this new way of working requires more attention to be paid to the temporal, socio-cultural and control aspects than before.

Multinational companies like IBM have begun to consider how to address the distributed nature of its projects across the globe. With outlets across the globe, the company finds various people of different cultures, languages and ethics working on a single and bigger IT projects from different locations. Other IT companies are facing the same problems, despite there being many kinds of approaches available to handle risk management in large scale IT companies. IBM commissioned the Distributed Risk Management Process (DRiMaP) model as a suitable solution. This model focused on the collaborative and on-going control aspects, and paid attention to the need for risk managers, project managers and management to include risk management into all phases of projects and the business cycle.

The authors of the DRiMaP model did not subject it to extensive testing. This research sets out to evaluate, improve and extend the model process and thereby develop a new and dynamic approach to distributed information systems development. To do this, this research compares and contrasts the model with other risk management approaches. An *Evolutionary Model* is developed, and this is subjected to empirical testing through a hybrid constructive research approach. A survey is used to draw out the observations of project participants, a structured interview gathered the opinions of project experts, a software tool was developed to implement the model, and SysML and Monte Carlo methods were applied to this to simulate the functioning of the model.

The *Evolutionary Model* was found to partially address the shortcomings of the DRiMaP model, and to provide a valuable platform for the development of an enterprise risk management solution.

Key words: DRiMaP, Evolutionary Model, risk management, distributed software development

## **Publications**

1. Alem M. and Zedan H. (2012) “IT project Development and Risk System Strategies Using IBM’s DRiMaP Model: A Case Study”, in Proceedings of the Saudi International Conference (SIC 2012), Brunel University, London, UK, ISBN-13: 978-0956904508
2. Alem M. and Zedan H. (2013) “Proposing a Distributed Risk Management Process Model for Dynamic Environment in an IT Industry”, International Journal of Management and Marketing Academy, , Vol. 1, No. 2, pp. 126-142, ISSN-2048-8807

# **Declaration of Authorship**

I declare that the work described in this thesis is original work undertaken by me for the degree of Doctor of Philosophy at Faculty of Technology at De Montfort University, United Kingdom.

No part of the material described in this thesis has been submitted for any award of any other degree or qualification in this or any other university or college of advanced education.

Mohammad Alem

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# Contents

Abstract .....	iii
Publications .....	iv
Declaration of Authorship .....	v
Acknowledgements .....	vi
Contents.....	vii
List of Figures .....	xi
List of Tables.....	xvi
Abbreviations and Acronyms .....	xx
<b>CHAPTER 1 .. Introduction .....</b>	<b>1</b>
1.1 Background.....	1
1.2 The research problem.....	3
1.3 Research questions.....	3
1.4 Research goals .....	4
1.5 Value of this research .....	4
1.6 Original contribution.....	5
1.7 Outline of the study.....	5
<b>CHAPTER 2 .. Methodology.....</b>	<b>8</b>
2.1 Introduction.....	8
2.2 Research strategy .....	10
2.3 Research methods .....	11
2.3.1 The survey method.....	12
2.3.2 Structured interviews .....	13
2.3.3 Constructive research.....	14
2.3.4 Simulation .....	15
2.4 Data collection .....	17
2.5 Data analysis .....	18
2.6 Validity .....	19
2.7 Ethical considerations .....	20
2.8 Review .....	21
2.9 Chapter summary.....	21
<b>CHAPTER 3 .. Literature Review .....</b>	<b>22</b>
3.1 Definitions and concepts.....	22
3.1.1 Information technology project performance .....	22

3.1.2	Projects and project management .....	24
3.1.3	Distributed software development .....	26
3.1.4	A definition and introduction to risk.....	27
3.1.5	Risk management.....	31
3.1.6	Crisis management.....	33
3.2	Risk management and Information Technology.....	36
3.2.1	Risk management and software processes .....	36
3.2.2	Strategic risk management relating to IT .....	39
3.2.3	Operational risk management (ORM).....	40
3.2.4	IT risks for the organisation .....	40
3.2.5	Integration of management systems risk.....	41
3.2.6	Risk management in large IT projects .....	41
3.2.7	Risk management in large IT companies.....	46
3.2.8	Risk management in the distributed software development .....	48
3.3	Risk management models and frameworks .....	49
3.3.1	Risk management approaches .....	49
3.3.2	General reviews.....	50
3.3.3	Examples from literature.....	51
3.3.4	Process and activity approaches.....	52
3.3.5	Commercial approaches .....	54
3.4	DRiMaP - a critical review .....	56
3.4.1	Background to DRiMaP development .....	56
3.4.2	Methodology used by the IBM researchers .....	57
3.4.3	Description of the DRiMaP model.....	58
3.4.4	Implementation of DRiMaP.....	59
3.4.5	Conclusions about the original DRiMaP research .....	59
3.4.6	Comparisons with other models.....	60
3.5	Chapter summary .....	60
<b>CHAPTER 4 .. Improving DRiMAP .....</b>		<b>62</b>
4.1	DRiMaP Shortcomings .....	62
4.2	Overview of DRiMaP extensions and modifications .....	65
4.2.1	Model of extensions .....	65
4.2.2	The IT project.....	67
4.2.3	Management of tenders .....	67
4.2.4	Phase input .....	67
4.2.5	Continuous risk management.....	67
4.2.6	Migration risk strategy .....	67
4.2.7	Mitigation risk strategy .....	68
4.2.8	Implementing risk strategies .....	68
4.2.9	The risk alerting .....	69
4.3	The Evolutionary Model.....	70
4.3.1	Associate risk parameters (ARP) .....	71
4.3.2	Activity report .....	72
4.3.3	Information technology risk system strategies (ITRSS).....	86
4.3.4	The real-time event risk management process (RTEMP).....	90
4.3.5	Contributions of the Evolutionary Model .....	92



4.4	Implementation of the Evolutionary Model.....	94
4.4.1	Modelling.....	94
4.4.2	Class diagrams.....	95
4.4.3	Systems implementation.....	98
4.4.4	Web graphical user interface versus core service modules.....	99
4.4.5	Organisation UI versus organisation service.....	100
4.4.6	Project UI versus project service.....	100
4.4.7	Phase web UI versus phase service.....	101
4.4.8	Phase service.....	101
4.4.9	Phase item web UI versus Phase item service.....	102
4.4.10	Strategy layer.....	102
4.4.11	Transaction layer.....	103
4.4.12	Data layer.....	105
4.4.13	Development of a prototype using visual studio 2010.....	106
4.4.14	Alert module layer.....	107
4.5	Implementing RTEMP.....	108
4.5.1	SQL server database.....	110
4.5.2	DRiMaP reporting view.....	110
4.5.3	Deadline reached.....	111
4.5.4	Risk versus Cost.....	112
4.6	Chapter summary.....	114
<b>CHAPTER 5 .. Empirical Findings .....</b>		<b>115</b>
5.1	Survey findings.....	115
5.1.1	Responses.....	116
5.1.2	Experience of using risk management processes in IT industries.....	116
5.1.3	Existence and familiarity with risk management strategies.....	119
5.1.4	Approaches adopt to conduct risk management in IT organisations.....	125
5.1.5	Drivers of risk management adoption.....	132
5.1.6	Benefits achieve by implementing risk management principles.....	134
5.1.7	Other questions.....	138
5.1.8	Synopsis of survey data.....	166
5.2	Structured interview findings.....	167
5.3	Functional tests.....	170
5.3.1	Functional test 1 - register or create a new super user.....	171
5.3.2	Functional test 2 - add a new organisation.....	172
5.3.3	Functional test 3 - create a new project.....	173
5.3.4	Functional test 4 - define new phase for project.....	174
5.3.5	Functional test 5 - assign users to work on the project.....	175
5.3.6	Functional test 6 - move project into a phase or change phase.....	176
5.3.7	Functional test 7 – create a phaseitem for a phase.....	177
5.3.8	Functional test 8 - charting and task functionality.....	178
5.3.9	Summary of functional tests.....	180
5.4	Experiment findings.....	181
5.4.1	Validation with the SysML experiment.....	181
5.4.2	Validation with the Monte Carlo method.....	182
5.4.3	Experiments outcome.....	184
5.4.4	Experiments conclusion.....	185

5.5	Chapter summary .....	186
<b>CHAPTER 6 .. Conclusions .....</b>		<b>187</b>
6.1	Project summary .....	187
6.1.1	Thesis summary .....	187
6.1.2	Summary of results .....	188
6.2	Theoretical Conclusions .....	189
6.2.1	Conclusions for the DRiMaP extensions .....	189
6.2.2	Theoretical implications.....	191
6.2.3	Methodological conclusions (validity).....	192
6.2.4	Conclusions for the aims and objectives.....	193
6.2.5	Recommendations for future research .....	194
6.3	Practical conclusions and recommendations .....	195
6.4	Limitations .....	195
	References .....	197
	Appendices .....	207
	Appendix A. Ethics and Empirical Study .....	208
	Appendix B. Participant Information and Consent Form.....	212
	Appendix C: Questionnaire .....	216
	Appendix D: Experts Interview Questions.....	223
	Appendix E: Modelling and Design.....	224
	Appendix F: Implementation DRiMaP Service .....	228
	Appendix G: Large IT project details.....	232
	Appendix H: Class diagram details .....	234
	Appendix I: Interface detail.....	236
	Appendix J: Functional tests .....	244

## List of Figures

Figure 1.	The research argument.....	6
Figure 2.	The Research Onion (Saunders et al., 2009) .....	10
Figure 3.	Research theory, components and testing (Hoy, 2009, p.15) .....	11
Figure 4.	Research and constructing IS artefacts (Nunamaker et al., 1991).....	14
Figure 5.	The constructive research process (adapted from Labro and Tuomela, 2003).....	15
Figure 6.	Data types (Marketing Research, 2011) .....	17
Figure 7.	Using IT to trigger marketing actions (Marketing Research, 2011).....	18
Figure 8.	sk Attitude as a CSF (Murray and Hillson, 2008, p. 12) .....	29
Figure 9.	Project loss distribution curve for IT systems (Navarrete, 2006, p.2) .....	30
Figure 10.	Hong’s Framework for IOIS (Dury et al. 2010, p. 15) .....	35
Figure 11.	Risks within a system context (Higuera and Haimes, 1996) .....	37
Figure 12.	Project, Process and Software Development Cycle (eOutlook, 2010) .....	39
Figure 13.	Risk management activities .....	43
Figure 14.	Industry risk management maturity roadmap (IBM, 2007, p.5) .....	47
Figure 15.	The traditional risk management model (Bakkar, 2008) .....	53
Figure 16.	Original DRiMaP model (K. Mattsson, 2009).....	56
Figure 17.	Model of extensions .....	66
Figure 18.	Mitigation Process.....	69
Figure 19.	The Evolutionary Model .....	70
Figure 20.	The Evolutionary Model ARP .....	71
Figure 21.	DRiMaP reporting activity .....	73
Figure 22.	Illustration of risk versus cost curve .....	77
Figure 23.	The Evolutionary Model ITRSS .....	87
Figure 24.	The Evolutionary Model EXTRS 2 .....	90
Figure 25.	The Evolutionary Model Migration Strategy .....	91
Figure 26.	The Evolutionary Model Mitigation Strategy .....	91
Figure 27.	Transformation of conceptual design to class diagram part 1 .....	96
Figure 28.	Transformation of conceptual design to class diagram part 2 .....	97
Figure 29.	Evolutionary Model high level implementation .....	98
Figure 30.	Project and Phase relationship diagram .....	101
Figure 31.	Listing for the SqlConnection object: connStr .....	103

Figure 32.	Create Organisation listing.....	104
Figure 33.	Entity Relationship Diagram.....	105
Figure 34.	Listing of the alert functionality.....	107
Figure 35.	Alert delivery message (Email).....	108
Figure 36.	Real-Time Evolutionary process (DRiMaP Task).....	109
Figure 37.	Deadline versus Cost.....	111
Figure 38.	Chart for Question 1.....	118
Figure 39.	Chart for Question 2.....	121
Figure 40.	Chart for Question 3.....	123
Figure 41.	Chart for Question 4.....	125
Figure 42.	Chart for Question 5.....	128
Figure 43.	Chart for Question 6.....	130
Figure 44.	Chart for Question 7.....	131
Figure 45.	Chart for Question 8.....	133
Figure 46.	Chart for Question 9.....	136
Figure 47.	Chart for Question 10.....	137
Figure 48.	Chart for Question 13.....	142
Figure 49.	Chart for Question 13.....	145
Figure 50.	Chart for Question 15.....	147
Figure 51.	Chart for Question 16.....	150
Figure 52.	Chart for Question 18.....	151
Figure 53.	Chart for Question 18.....	152
Figure 54.	Chart for Question 18.....	154
Figure 55.	Chart for Question 19.....	156
Figure 56.	Chart for Question 19.....	158
Figure 57.	Chart for Question 21.....	159
Figure 58.	Chart for Question 22.....	162
Figure 59.	Chart for Question 23.....	164
Figure 60.	Chart for Question 23.....	165
Figure 61.	Login detail .....	171
Figure 62.	Registering a new organisation .....	172
Figure 63.	Create project information .....	173
Figure 64.	Phase GUI for creating phase for the project specified .....	174

Figure 65.	Assign users to project .....	175
Figure 66.	Retrieve Project GUI.....	176
Figure 67.	Move functionality .....	177
Figure 68.	DRiMaP Real-Time Controller .....	179
Figure 69.	SysML simulation and validity in IT .....	182
Figure 70.	Monte Carlo simulation and validity in IT.....	183
Figure 71.	DRiMaP case study risk distribution .....	185
Figure 72.	Research permission granted by University.....	208
Figure 73.	Research permission from GACA .....	209
Figure 74.	Research permission for GACA IT.....	210
Figure 75.	Research permission from KAUST .....	211
Figure 76.	IBM software quotation .....	224
Figure 77.	IBM quotation.....	225
Figure 78.	Project SDLC phases .....	226
Figure 79.	Extensions and modifications .....	227
Figure 80.	Chart service code fragment - Chart Service.asmx.cs .....	228
Figure 81.	Project SVC code fragment - Project Svc.asmx.cs .....	228
Figure 82.	CS control code fragment - CS Control.asmx.cs .....	229
Figure 83.	Project control code fragment - Project Control.asmx.cs .....	229
Figure 84.	Real-Time Event Alert Service and Task .....	230
Figure 85.	Alert service creation email .....	231
Figure 86.	Large IT project system overview .....	232
Figure 87.	Large IT project events list .....	233
Figure 90.	User GUI, authentication and user service.....	236
Figure 91.	User GUI, Register new user vs. user service RegisterUser method.....	236
Figure 92.	Login detail .....	236
Figure 93.	Registered user screen.....	237
Figure 94.	Organisation Web UI for Update request .....	238
Figure 95.	Organisation service.....	238
Figure 96.	Project UI and Project Service .....	239
Figure 97.	Create Project Information screen.....	239
Figure 98.	Register New User .....	240
Figure 99.	Returning User Login form.....	240

Figure 100.	Mismatched credential form.....	240
Figure 101.	Organisation form tab view .....	241
Figure 102.	Project View .....	241
Figure 103.	Create Project View.....	241
Figure 104.	Phase View .....	242
Figure 105.	Create Phase .....	242
Figure 106.	Update Existing Phase.....	242
Figure 107.	Phase Detail View .....	243
Figure 108.	Phase Detail and Phase Item Views .....	243
Figure 109.	Update Phase Item View .....	243
Figure 110.	Listing excerpt for the User proxy .....	244
Figure 111.	User service reference, proxy and wsdl file with endpoints.....	244
Figure 112.	User service and EndPointAddress .....	244
Figure 113.	User service reference, proxy and wsdl file with endpoints.....	245
Figure 114.	User service reference, proxy and wsdl file with endpoints.....	245
Figure 115.	DRiMaP User schema for storing user information .....	245
Figure 116.	Registering new organisation (organisation proxy) .....	246
Figure 117.	Organisation reference, proxy and wsdl file with endpoints.....	246
Figure 118.	Organisation service .....	247
Figure 119.	Organisation schema for storing organisation information.....	247
Figure 120.	Listing for the project proxy generated from project service .....	248
Figure 121.	Project proxy files (Service reference in square box) .....	248
Figure 122.	Project service interface .....	249
Figure 123.	Project schema for storing project data .....	249
Figure 124.	Excerpt Phase Proxy for creating Phase for Project.....	250
Figure 125.	Phase Service reference files .....	250
Figure 126.	Phase Service Interface for creating a phase .....	251
Figure 127.	Phase Schema for storing phase information .....	251
Figure 128.	Assign User to Work on the project steps .....	252
Figure 129.	Listing for User Proxy (CreateProjectManager) .....	253
Figure 130.	User Proxy (CreateProjectManager) .....	253
Figure 131.	Move functionality .....	254
Figure 132.	Listing to move project into phase in service reference .....	254

Figure 133.	View current phase of the Project and other project information .....	254
Figure 134.	Listing to move project into phase in the service reference .....	255
Figure 135.	PhaseItem of the Requirement Phase .....	255
Figure 136.	Listing of mitigation and call activity risk assessment output .....	256
Figure 137.	Listing of mitigation and call activity risk control output.....	256
Figure 138.	Listing of alert and risk activity input .....	257
Figure 139.	Activity report for observation 1 .....	258
Figure 140.	Activity report for observation 2 .....	258
Figure 141.	Activity report for observation 3 .....	259
Figure 142.	Activity report for observation 4 .....	259
Figure 143.	Activity report for observation 5 .....	259
Figure 144.	Activity report for observation 6 .....	260
Figure 145.	Activity report for observation 7 .....	260
Figure 146.	Activity report for observation 8 .....	260
Figure 147.	Activity report for observation 9 .....	261
Figure 148.	Activity report for observation 10 .....	261

# List of Tables

Table 1. Risk management activities of a generic SDLC .....	26
Table 2. Risk management in information systems (Gibson, 1997).....	38
Table 3. Risk management model used by Microsoft.....	54
Table 4. Risk management model used by TCS .....	55
Table 5. Risk management model used by Infosys.....	55
Table 6. Risk management model comparison .....	60
Table 7. Risk versus cost functions.....	79
Table 8. Risk versus cost functions.....	82
Table 9. Project functions .....	83
Table 10. Project Daily Activity .....	84
Table 11. Phase functions .....	74
Table 12. Phase Daily Activity .....	76
Table 13. Phase item functions .....	84
Table 14. Phase item Daily Activity .....	86
Table 15. Question 1 responses.....	117
Table 16. Question 1 subcontractor 1 .....	117
Table 17. Question 1 subcontractor 2 .....	118
Table 18. Question 1 results.....	118
Table 19. Question 2 responses.....	119
Table 20. Question 2 subcontractor 1 .....	120
Table 21. Question 2 subcontractor 2 .....	120
Table 22. Question 2 results.....	121
Table 23. Question 3 responses.....	122
Table 24. Question 3 subcontractor 1 .....	122
Table 25. Question 3 subcontractor 2 .....	123
Table 26. Question 3 results.....	123
Table 27. Question 4 responses.....	124
Table 28. Question 4 subcontractor 1 .....	124
Table 29. Question 4 subcontractor 2 .....	124
Table 30. Question 4 results.....	125
Table 31. Question 5 responses.....	126



Table 32. Question 5 subcontractor 1 .....	126
Table 33. Question 5 subcontractor 2 .....	127
Table 34. Question 5 results.....	127
Table 35. Question 6 responses.....	128
Table 36. Question 6 subcontractor 1 .....	129
Table 37. Question 6 subcontractor 2 .....	129
Table 38. Question 6 results.....	129
Table 39. Question 7 responses.....	130
Table 40. Question 7 subcontractor 1 .....	130
Table 41. Question 7 subcontractor 2 .....	131
Table 42. Question 7 results.....	131
Table 43. Question 8 responses.....	132
Table 44. Question 8 subcontractor 1 .....	132
Table 45. Question 8 subcontractor 2 .....	133
Table 46. Question 8 results.....	133
Table 47. Question 9 responses.....	134
Table 48. Question 9 subcontractor 1 .....	134
Table 49. Question 9 subcontractor 2 .....	135
Table 50. Question 9 results.....	135
Table 51. Question 10 responses.....	136
Table 52. Question 10 subcontractor 1 .....	136
Table 53. Question 10 subcontractor 2 .....	137
Table 54. Question 10 results.....	137
Table 55. Question 11 responses.....	138
Table 56. Question 11 subcontractor 1 .....	138
Table 57. Question 11 subcontractor 2 .....	139
Table 58. Question 12 responses.....	139
Table 59. Question 12 subcontractor 1 .....	140
Table 60. Question 12 subcontractor 2 .....	140
Table 61. Question 12 responses.....	141
Table 62. Question 12 subcontractor 1 .....	141
Table 63. Question 12 subcontractor 2 .....	142
Table 64. Question 12 results.....	142

Table 65. Question 14 responses.....	143
Table 66. Question 14 subcontractor 1 .....	143
Table 67. Question 14 subcontractor 2 .....	144
Table 68. Question 14 results.....	144
Table 69. Question 15 responses.....	145
Table 70. Question 15 subcontractor 1 .....	146
Table 71. Question 15 subcontractor 2 .....	146
Table 72. Question 15 results.....	147
Table 73. Question 16 responses.....	148
Table 74. Question 16 subcontractor 1 .....	148
Table 75. Question 16 subcontractor 2 .....	149
Table 76. Question 16 results.....	149
Table 77. Question 17 responses.....	150
Table 78. Question 17 subcontractor 1 .....	150
Table 79. Question 17 subcontractor 2 .....	151
Table 80. Question 17 results.....	151
Table 81. Question 18 responses.....	152
Table 82. Question 18 subcontractor 1 .....	153
Table 83. Question 18 subcontractor 2 .....	153
Table 84. Question 18 results.....	153
Table 85. Question 19 responses.....	154
Table 86. Question 19 subcontractor 1 .....	155
Table 87. Question 19 subcontractor 2 .....	155
Table 88. Question 19 results.....	156
Table 89. Question 20 responses.....	157
Table 90. Question 20 subcontractor 1 .....	157
Table 91. Question 20 subcontractor 2 .....	158
Table 92. Question 20 results.....	158
Table 93. Question 21 responses.....	159
Table 94. Question 22 responses.....	160
Table 95. Question 22 subcontractor 1 .....	160
Table 96. Question 22 subcontractor 2 .....	161
Table 97. Question 22 results.....	161

Table 98. Question 23 responses..... 162

Table 99. Question 23 subcontractor 1 ..... 163

Table 100. Question 23 subcontractor 2 ..... 163

Table 101. Question 23 results..... 163

Table 102. Question 24 responses..... 164

Table 103. Question 24 subcontractor 1 ..... 164

Table 104. Question 24 subcontractor 2 ..... 165

Table 105. Question 24 results..... 165

Table 106. Structured interview - Point 1 ..... 168

Table 107. Structured interview - Point 2 ..... 168

Table 108. Structured interview - Point 3 ..... 169

Table 109. Structured interview - Point 4 ..... 169

Table 110. Assessment of improvements ..... 190

# Abbreviations and Acronyms

ALE	Average Loss Expectancy
AMA	American Management Association
API	Application Programming Interface
APM	Association of Project Management
AREP	Associate Risk Monitoring and control Environment
ARMCE	Associate Risk Environment Parameters
BCP	Business Continuity Procedure
CHAOS	Chaotic Modelling and Simulation
CRM	Continuous Risk Management
CSA	Control Self-Assessment
CSF	Critical Source of Failure
CSF	Critical Success Factor
CSM	Core service Modules
DRiMaP	Distributed Risk Management Process
EL	Expected Losses
ERM	Enterprise Risk Management
EXTRS	External Relationship
HCI	Human-Computer Interface
HTTP	Hypertext Transfer Protocol
IBM	International Business Machines
ICT	Information and Communication Technology
INTRS	Internal Relationship
IOIS	Inter Organisational Information System
ITRSS	IT-Risk System Strategies
ITS	Information Technology/System
KAUST	King Abdullah University of Science and Technology
MNC	Multinational Companies
OCL	Object Constraint language
OOP	Object-Oriented Programming
ORM	Operational Risk Management
ORM	Object Rational Management
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PRA	Probability Survivability Assessment
PRINCE2	Projects IN Controlled Environments, version 2
RAO	Risk Assessment Output
RAPSA	Risk Analysis and Probability Survivability Assessment
RCO	Risk Control Output
RI	Risk Impact

RMF	Risk Management Forum
RPC	Remote Procedure Calls
SA-CMMSM	Software Acquisition-Capability Maturity Model
SDLC	Software Development Life Cycle
SEI CMM	Software Engineering Institute's Capability Maturity Model
SERIM	Software Engineering Risk Index and Management
SERUM	Software Engineering Risk: Understanding and Management
SRE	Software Risk Evaluation
SRM	Software Risk Management
SSA	Survivable System Analysis
SW-CMMSM	Software Capability Maturity Model
TCM	Tata Consultancy Services
TRM	Team Risk Management
UKeU	The United Kingdom eUniversity
UL	Unexpected Losses
UML	Unified Modelling Language
VAT	Value at Risk
WebGUI	Web Graphical User Interface

## CHAPTER 1 .. INTRODUCTION

*“Multi-site global development creates a new platform for improved competition and co-operation. However, it does not come for free. It introduces high complexity into the management of the distributed software development and thereby brings many risks jeopardizing the future success.” (Kajko-Mattsson et al., 2009)*

This chapter introduces this project by discussing its background, rationale and motivation, identifying the research problem, assessing the research value, significance and original contribution, marking out the scope of the study, defining the aims and objectives, and presenting the research argument and a structure for the thesis.

### 1.1 BACKGROUND

It was whilst studying collaboration in one Saudi education organisation (Alem, 2009) that this student first encountered the problem of managing risk in a distributed environment, saying *“being a part of a collaboration framework, the risk is shared among multiple entities thereby reducing losses in the event of a failure.”* That study recognised the value of a common management platform and the need for programme monitoring and control to include a concrete risk management strategy with contingency. Research relationships were developed with key personnel at KAUST, the King Abdullah University of Science and Technology, and with organisations that collaborated with that institution. Discussions and a brief survey of literature led to a growing awareness of the problems faced by peer organisations that were collaborating on large programmes, particularly the difficulties associated with managing risks.

Practitioner-based literature quickly showed that identifying, evaluating, logging, monitoring and managing risks are daily tasks for project managers. The principles employed in risk management are hardly new, dating back to 1654 when the mathematicians Blaise Pascal and Pierre de Fermat created the first mathematical probability model that pre-empted risk assessment and qualification. Risk management has been identified as a contributor to the success of Information Systems development for many years, with authors such as Alter and Ginzberg (1978) clearly spelling out the need to identify the unknown and prepare for it. Most organisations now undertake some form

of risk management as an integral project activity, and it is certainly a feature of most popular project and programme management methodologies such as PRINCE2.

One would therefore expect that risk management is widely practiced. Problems at KAUST show and literature confirms that this is unfortunately not the case. De Bakker *et al.* (2010) claim that information technology projects “*have a long history of failing*”, and are of the opinion that risk management is not practiced correctly and that more attention should be paid to risk management than to the actual risks. According to the leading professional body for project management in the UK, the Association of Project Management (APM, 2008):

*“...the use of risk management within projects is poor. Often risk management is limited to the creation of a risk log at the start of the project. Further use of risk management is often limited, resulting in projects experiencing problems that could have been successfully avoided or managed.”*

Within this context, risk management may be treated as something philosophical, such as Kloman's (1990) definition of “*a discipline for living with the possibility that future events may cause adverse effects*”; or more specific, such as the APM (2011) definition: “*Project risk management is a structured process that allows individual risk events and overall project risk to be understood and managed proactively, optimising project success by minimising threats and maximising opportunities.*”

Risk can impact very badly on an organisation and its key objectives (Mills and Walle, 2007). The difficulties are more acute for large, complex projects and those involving multiple partners. Kwak and Smith (2009) conclude in their review of large collaborative defence industry projects that including a comprehensive risk management plan would significantly improve overall project management practice. Olsson (2008) identified a gap between contemporary risk management and the risk requirements of complex organisations and project portfolios; finding there were fewer learning opportunities, limited interaction and difficulties in measuring effectiveness in this group. Such an environment is described by Agerfolk *et al.* (2005), who use the term “*distributed software development*” as referring to any software development activity in which the development team members are geographically spread out.

A search for relevant literature exposed a number of candidate theories and models for the management of risk in distributed development environments. Discussed in Chapter 3, these were assessed and the IBM Distributed Risk Management Process Model (*DRiMaP*) (Kajko-Mattsson *et al.*, 2005) emerged as the most suitable. This model therefore became the foundation and focus of this project.

## **1.2 THE RESEARCH PROBLEM**

Prior research and literature show that IT projects are failing, that risk management is important and existing risk approaches are lacking. This is particularly true of software development that involves multi-site and global dispersion and multiple entities involved in the development process.

The research problem for this study is therefore to find, evaluate and extend a conceptually sound model and practical method that is suited to managing risk in a distributed development environment; one that will reduce risk to the project and all its stakeholders, and attend to the problems reported in literature and practice.

## **1.3 RESEARCH QUESTIONS**

This study intended to ask and answer several research questions to investigate the research problem, producing a reliable and appropriate risk management model for the information technology industry and its projects. The research questions are:

- What are the key criteria for successful risk management in distributed environments?
- How can risk monitoring and crisis management in the software industry be improved?
- What are the major risk management models and process steps adopted by major information technology companies to deal with their biggest projects?
- What are the key features and mechanisms of these models when compared with the approaches used by other organisations, and how suitable are they in comparison?
- Can any of the standard models be adapted to suit the needs of distributed risk management?
- How well do the adaptations work in practice?



## 1.4 RESEARCH GOALS

Research goals consist of aims and objectives, and these will steer this project in addressing the research problem and answering the research questions.

The **aim** of this study is to develop a model and tool suitable for managing risk in major information technology development projects in distributed environments.

Four **objectives** will help achieve this aim:

- Identify and assess risk management models and frameworks suited to managing risk in major distributed information technology development projects.
- Suggest novel techniques, improvements and extensions to selected models, paying particular attention to the relationship of risk management to crisis management, and providing a better environment for controlling and monitoring of risk.
- Propose and design ways to practically implement any improvements and extensions.
- Evaluate the effectiveness of the suggested improvements, extensions and its implementation.

## 1.5 VALUE OF THIS RESEARCH

Solving the research problem will provide value to practice and to research, as well as make a significant original contribution to the body of knowledge.

IT companies lose billions of dollars every year due to project overruns. Most are looking at a wide range of risk management models, tools and techniques to analyse and control the risks they face related to information technology development (Wallace *et al.*, 2004). This project contributes an extended and novel model that has been tested for use in environments that are representative of those these companies struggle with.

Wide ranging failure in development projects and the complex nature of large projects has led to centralisation of control in order to mitigate or curb difficulties. The extended model offered by this project supports a distributed network infrastructure and decentralised control of the project risk, as well as introduce elements of collaboration. The value of this lies in better identification of the risks in initial stages of projects, which will help the project development and delivery teams design a more successful project with improved benefits. This in turn will assist those participating

organisations be more competitive on a global scale, which is where they are likely to be if they are working in distributed software development.

This project also conducts secondary research using previous notes and records from various sources, and applies these alongside the primary research. New methods are suggested to solve the risk associated with major IT projects, and these outcomes will be useful to practitioners wanting to identify and mitigate risks in their organisations.

## 1.6 ORIGINAL CONTRIBUTION

The main contribution of this thesis is the “*Evolutionary Model*”, a novel enhancement and extension to a published risk management model (*DRiMaP*). This is original in that it:

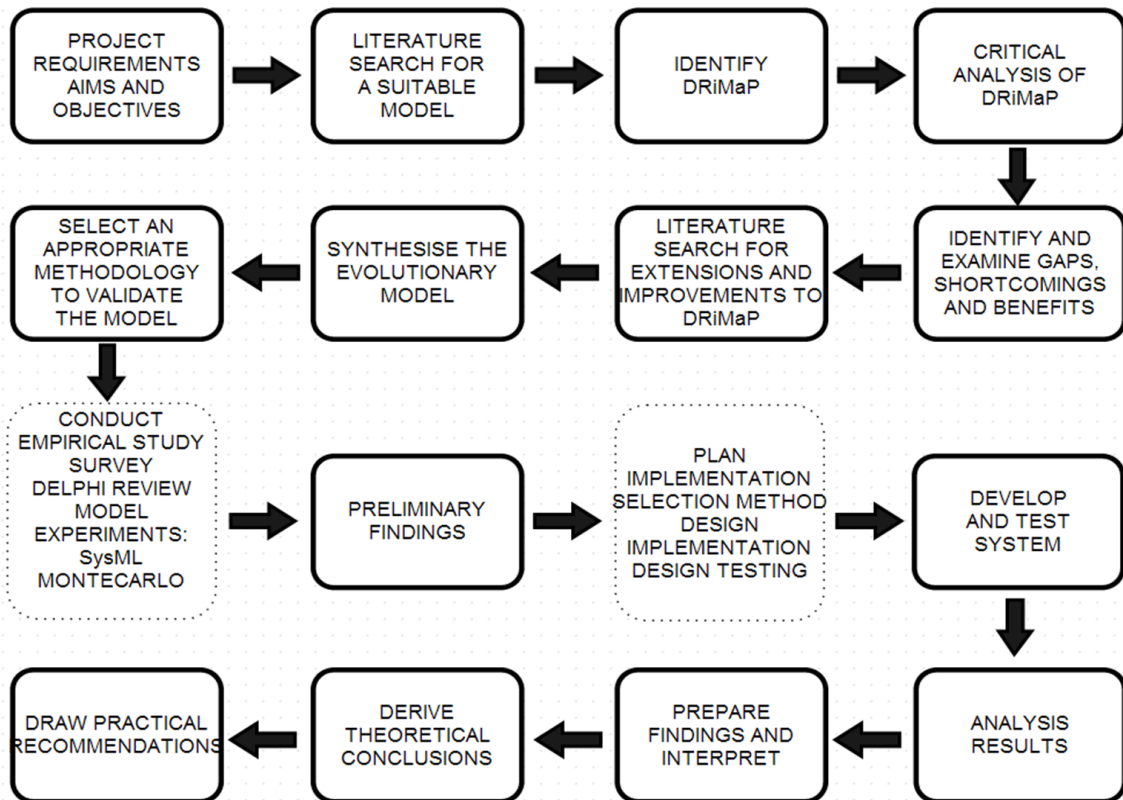
- Enhances and extends the *DRiMaP* model in a unique way.
- Provides unique testing of the *DRiMaP* model that the original authors acknowledge was lacking in their research.
- Emphasises the *DRiMaP* process phase, roles among the phases, collaboration and communication function, and the coordination of risk management with the business cycle. These aspects have been identified as important and lacking in the original model by Mills and Walle (2007) and Kajko-Mattsson *et al.* (2011).
- Fills a gap that Olsson (2008) identified as lying between contemporary risk management and the needs of the distributed development environment.

## 1.7 OUTLINE OF THE STUDY

This project began with the identification of a need for risk management on distributed software development projects. A literature search exposed a number of candidate models. These were assessed against the project requirements and the *DRiMaP* model emerged displaying the most potential. The *DRiMaP* model was critically analysed, and gaps, shortcomings and benefits of the model and its underlying research were isolated. A more focused and in-depth literature review considered extensions and improvements to the *DRiMaP* model, and the *Evolutionary Model* was synthesised. An appropriate research methodology was then chosen, an empirical study conducted and preliminary findings revealed the *Evolutionary Model* to be notionally feasible. Implementation, development and testing of a system based on the model then followed. Results

from operating the system were collected, analysed and the findings are interpreted. Conclusions and recommendations were then drawn.

The argument presented by this thesis can be described diagrammatically, and this illustration is shown in Figure 1 below.



*Figure 1. The research argument*

The argument is also mapped by the chapter structure, outlined as follows:

- Chapter 1** The background and reasons for conducting this research are explained, the problem is outlined, aims and objectives stated and the value of this research broadly set out.
- Chapter 2** Research methodologies are chosen to conduct the empirical study and the implementation assessment. Two methods are selected to empirically study the *Evolutionary Model*; a survey to draw out the observations of project participants, and constructive research to develop and evaluate the theory into a system.

- Chapter 3** A literature review is conducted to define basic concepts, reflect on discussion relevant to the topic, and critically compare models suited to managing risk in distributed software development environments. The *DRiMaP* model is selected, critically analysed, and its key features are discussed and compared.
- Chapter 4** A more focused and in-depth literature review is conducted to consider any extensions and improvements to the *DRiMaP* model, relevant literature and concepts that impact on the design of the model. The *Evolutionary Model* is synthesised and proposed. Since risk management is a practical endeavour, the development of an implementation of the theoretical *Evolutionary Model* is also described, design of the risk management system is specified and testing is planned.
- Chapter 5** The empirical study reviews the *Evolutionary Model* in three ways; a survey, a Delphi technique and two simulation experiments. Data is collected, preliminary findings made and implications for the research hypotheses are drawn and discussed. The outcomes of the evaluation of the implementation system are presented and findings interpreted.
- Chapter 6** This chapter presents conclusions for the study and for the aims and objectives. Recommendations for practice and research, and suggestions for further work are also offered.

## CHAPTER 2 .. METHODOLOGY

This chapter selects appropriate methods for researching the problem, answering the research questions and studying the *Evolutionary Model*. An engineering research approach was adopted as this is a popular choice in information systems research. This approach was then applied through a hybrid strategy, using constructive research and survey research as the research methods. This chapter also considers data collection, data analysis, validity and ethics as they apply to the project.

### 2.1 INTRODUCTION

A brief search of literature reveals an enormous range of methods available to study a topic. Philosophical discussion abounds, and students can easily become overwhelmed by the volume of reading. Fortunately there are several texts that consider the problem of research method selection from an information systems perspective.

Cropley and Harris (2004) tackled the problem by providing a concise comparison of methods that are suitable for research in software engineering. They examine the basic principles of qualitative and quantitative research, and offer a useful comparative table of features. Easterbrook *et al.* (2007) feel that information systems researchers are challenged by methodological questions, saying “*researchers select inappropriate methods because they do not understand the goals underlying a method or possess little knowledge about alternatives.*” They look at the problem of selecting an empirical method for software engineering research, and propose that the five most useful methods are controlled experiments and quasi-experiments, case studies, survey research, ethnographies and action research. They advise the selection should be made on the basis of the kind of research question, what to accept as a valid answer or truth, and the nature of the theory building; and provide clear guidance on strengths, weaknesses and suitability for each of the five methods.

These authors indicate that research choices are driven by several factors. Onions (2012) uses a different approach to explaining research choices, approaching the problem from a practical perspective and offering the researcher a selection matrix. This author uses a comprehensive range of factors, consisting of the researcher (relationship with the subject, bias, personal circumstances and skills), the nature of the investigation (wide and shallow or narrow and deep), subject (nature,

ability to engage with the subject, scope, location and complexity), data analysis (nature and values), the data itself (type, quantity, complexity, content and values), data collection (accessibility, familiarity, ethics and context) and finally theory (ability to produce theory, generalisation required, purpose and application). The value of the matrix is that it drastically narrows down the options available to the researcher in three areas; logic (deductive and inductive), form of research (descriptive, experimentation, explanation and others), and methods (from action research and case study to structured observation and surveys) (p.157).

Saunders *et al.* (2009) offer a model called the 'onion' (p.108) that is illustrated in Figure 2 below. This model and particularly the diagram shown are used extensively by research students to describe and justify their research choices. Each layer of the onion represents a different perspective of the research problem, with abstract concepts on the outside and practical techniques at the centre.

Concepts radiate perpendicularly out from the centre of the research onion. Positivism would therefore be associated with a deductive approach, experiments and surveys and cross sectional research. Similarly on the other end of the scale, the research philosophy of interpretivism would more frequently be associated with inductive research, action research and ethnographic strategies and longitudinal time horizons. The difficulty that student researchers have is that they must understand the meaning and relationships between the various concepts, and these can be quite fuzzy at the philosophical end of the spectrum.

There are two approaches at the end of the research philosophy spectrum; positivism and interpretivism. Positivism approaches research from the scientific perspective, separating researcher from subject, treating reality and the subject as a truth that is independent of the researcher, there is a direct correspondence between truth and the research questions, and data measures this truth (Weber, 2004). On the other hand, interpretivism treats the researcher and subject as inseparable, knowledge is bound to experience and is not a universal truth, and the researcher's subjectivity affects the findings. Cropley and Harris (2004) show that positivism is commonly chosen for information systems research due to the scientific nature of the subject, the desire for 'hard' data and the methodical nature of IS development.

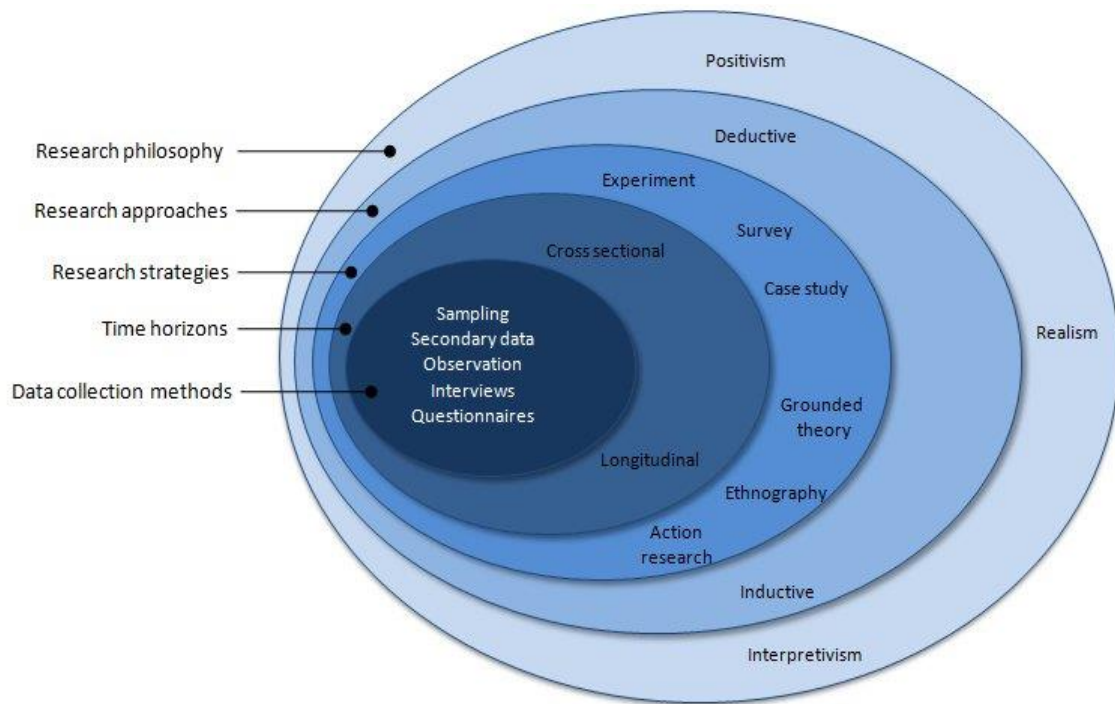


Figure 2. *The Research Onion (Saunders et al., 2009)*

## 2.2 RESEARCH STRATEGY

A hybrid strategy was selected for this research, combining multiple methods to solve the research problem from different angles and answering individual research questions separately, as advocated by Fellow and Liu (2008). Research methods were then sought that could gather information accurately to answer the research questions, whilst addressing the needs of the different research phases involved in this type of research, such as data collection and data analysis from a software system.

The hybrid research strategy used on this project follows the general pattern described by Hoy (2009) and illustrated in Figure 3 below. This proposes that a theoretical model is developed, hypotheses then developed, empirically tested and principles finally derived. The process is iterative.

Following Hoy's model, multiple methods were needed to address the individual research questions. A survey method was employed to gather requirements and key criteria for successful risk management in distributed environments, and to find ways to improve risk monitoring and crisis management in the software industry. The literature review contributed major risk management models and the process steps, key features and mechanisms needed by this

environment. Suitability of models was determined through comparison against criteria drawn from both literature and the survey. The adaptation of the standard models became the *Evolutionary Model*. The practicality and validity of that model was tested by developing an information system artefact from that theory using a constructive research method.

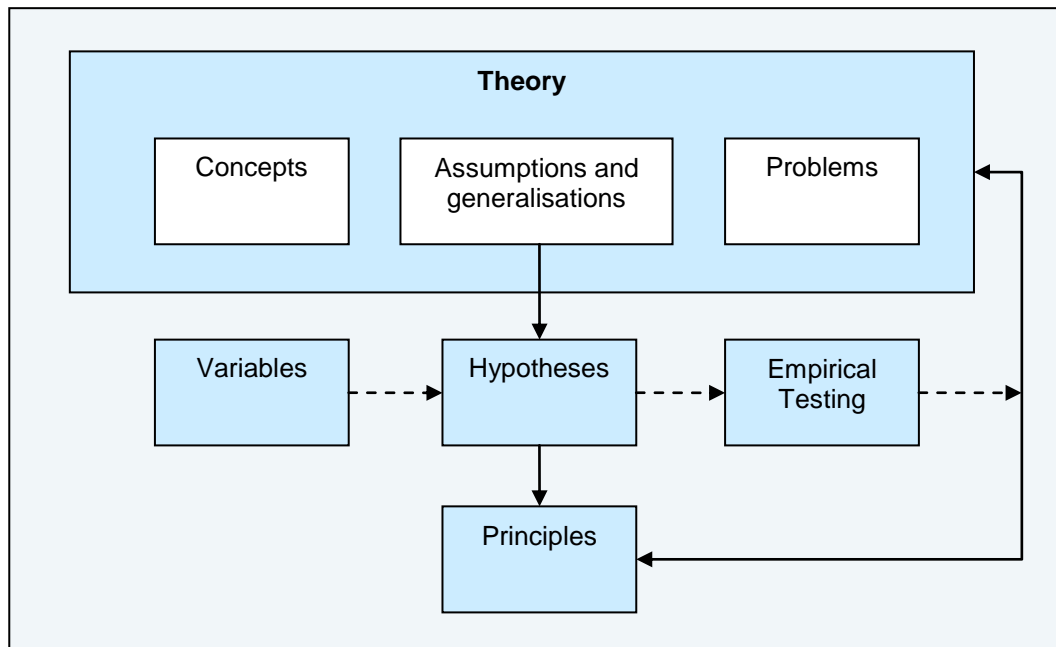


Figure 3. *Research theory, components and testing (Hoy, 2009, p.15)*

## 2.3 RESEARCH METHODS

Multiple methods were used in this research. A survey method and structured interviews were used to gather information about user requirements, and a constructive research method was chosen to study the effectiveness of the model and test the system used to validate the theory.

This selection of methods is similar to that in Lamersdorf *et al.* (2012), who use a survey of 19 practitioners followed by evaluation of their model by experts to validate their theory, and Miler (2005) who uses tool implementation, peer reviews and small scale experiments to validate his model of process risk assessment. Jiminez *et al.* (2009) analysed literature and found that of the methods used, experiments comprised 27% of distributed software development studies, simulation 2% and surveys 9%.



### 2.3.1 The survey method

This project required information about the needs of organisations and risk managers, and to find out where existing models may not be meeting requirements. Surveys are generally considered to be an efficient way of obtaining data from people, usually by posing the questions followed by options and the respondent need to select their choice from the options provided (Saunders *et al.*, 2009). Surveys gather information in order to explain, differentiate or describe knowledge, feelings and behaviour on the topic. Surveys are not only utilised for gathering information. They can also be used to support observation and content analysis (Jackson, 2011).

This method enables the gathering of accurate information from participants as well as allowing them to express their opinions and provide data based on their knowledge of the research problem. The survey will be applied as a set of questions followed by multiple choice options where the answers are selected by the respondents. In so doing the participants ideally read the questions, understand what the researcher is actually expecting, and then choose the appropriate answers without being influenced (Sugandhi, 2003).

Surveys are generally considered to be an efficient way of obtaining data from people compared to interviews with all individuals in bulk. This method enabled the collation or gathering of accurate information from participants as well as given the participants the room to express their views and opinions; also, data were provided based on the knowledge of the research problems. The survey applied a set of questions followed by multiple choice options. With answers selected by the respondents with understanding of what the researcher intended and expected without any iota of influence (Sugandhi, 2003).

This Survey used self-administered questionnaires. The questions were prepared by the researcher as a result of wide and intensive study of existing publications within the domain of the research. Sundry articles were read and models were reviewed on standard risk management models, the distributed development, and IT risk management. The questions were then designed to provide answers that resolved the research questions and resulted to greater understanding of the critical elements of event based risk management. The survey targeted employees of major IT companies who are involved in risk management and part of a distributed risk management process. Whilst IBM's DRiMaP model was formed recently, the IT risk management industry signed up for the improvement of globally distributed collaboration.

The survey was being conducted among these IT companies. The survey sought the opinions from internal employees at IT companies and got understanding of how the DRiMaP has contributed to the large IT strategic goals and benefits. The target population of the survey was based on the number of keys associates currently working in the IT companies. This research will attempt to survey between 50 and 100 participants, and it will be helpful to pick the participants from between 3 and 4 large companies. Time and access to companies may reduce this number considerably however. Data collected from participants will give academic weight to the research proposed as well as enough quantitative data to make inferences.

Participant spread allows **generalisations** to be made. Participants from all levels of the IT organisations were chosen, including senior staff, managers and general employees. The findings of the survey on the use of IT in crisis management in distributed risk management will help the research to summarise appropriate evidence. The survey demonstrates the development of crisis management models and especially the creation of crisis management team that leads to higher degree of actions taken, for instance training or simulations.

### 2.3.2 Structured interviews

Structured interviews are a qualitative research technique used to gather the knowledge and judgement from a limited number of people. Interviews are good for deeper exploration of issues and difficult questions, and are fundamental to gathering stakeholder and user requirements in information systems development. The sample may be chosen on limited criteria, so the results can be specific to a particular system or problem and not suitable for generalisation. Structured interviews will therefore be used as secondary research to support and extend the other studies.

Several respondents to the survey were chosen on the basis of their willingness and expertise to participate in a structured interview. They were asked a series of questions (provided in Appendix D) about how their organisations manage risk and asked for their opinions on the *DRiMaP* model and the *Evolutionary Model*. The questions were closed-ended with deliberation in order to reduce the complexity of the anticipated model and, equally, to give the interviewees chance of comprehending the questions (Polit and Beck, 2003).

Questions aimed to explore the respondents' thoughts about following areas:

- The DRiMaP model and its functions.

- Identifying important and novel extensions to the DRiMaP model.
- Implementing of an enhanced DRiMaP model.
- The ability of the enhanced model to improve the relationship between risk management and intra/inter-organisation crisis management.
- The ability of the enhanced model to provide a better environment for risk monitoring and control.

### 2.3.3 Constructive research

The primary method used by this research is constructive research. This was used to validate the theory by developing and evaluating an information system out of the *Evolutionary Model*. Constructive research proposes that information systems can be artefacts as well as the validation of a theory. Drawing from action research, Nunamaker *et al.* (1991) suggest an approach for the validation of theory through development of information systems. Zimmerman & Forlizzi (2008) call this “*research by design*”, an ongoing process of conception, fabrication and observation. Koskinen *et al.* (2011) expressed the opinion that it is “*design research in which construction – be it product, system, space, or media – takes center place and becomes the key means in constructing knowledge.*” Pechenizkiy and Tsymbal (2005) demonstrated the use of constructive research in studying competitive advantage from data mining. They adapted Nunamaker *et al.*’s model and in so doing described the relationship between research and development. In this model, a theory leads to systems development, which is tested through observation and experimentation, and this in turn contributes to the theory and its validation in an iterative fashion. This is shown in Figure 4 below.

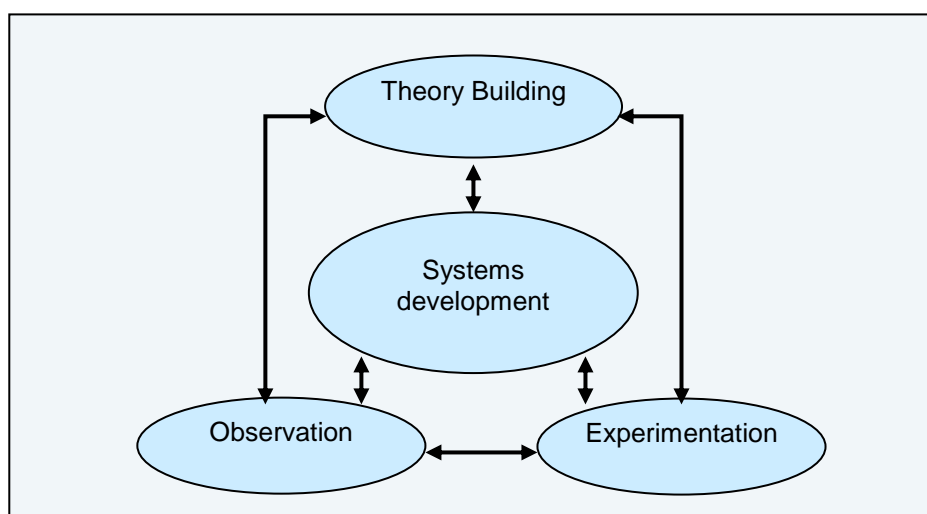
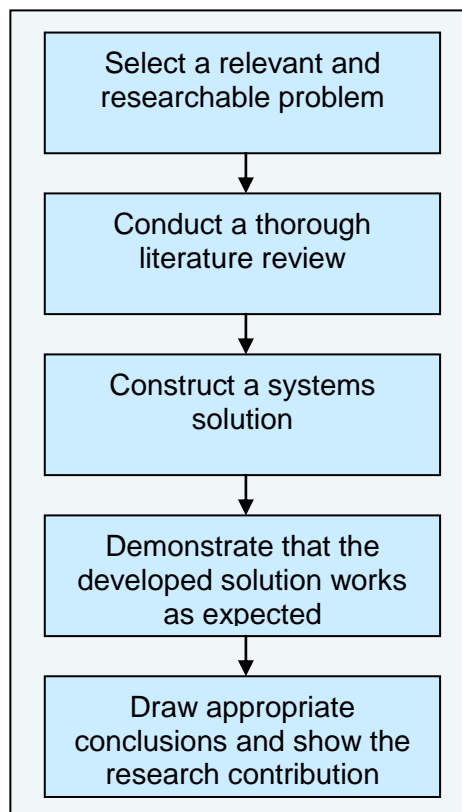


Figure 4. *Research and constructing IS artefacts (Nunamaker et al., 1991)*

Another way to consider constructive research is the linear approach offered by Turki (2013), who simplified and adapted a series of steps proposed by Labro and Tuomela (2003). This provides a clear roadmap for this type of research, as illustrated in Figure 5 below.

This project is more typical of Turki's approach than Pechenizkiy and Tsymbal as the research and subsequent development were not intentionally iterative by design.



*Figure 5. The constructive research process (adapted from Labro and Tuomela, 2003)*

#### **2.3.4 Simulation**

Two methods are used to conduct simulations and experiments to support validation of the constructed software system. Simulation in natural science, such as mathematics or physics, is frequently referred to as an experiment conducted on a model. This section presents a brief overview of simulation and object-oriented programming continuous simulation that was chosen as the simulation method for this project.

Simulation can be seen to be a generalisation of a reality. It depicts a system by modelling and then observing the functionality of such models under a strictly and logically defined set of conditions. It can also sometimes refer to a numerical technique for performing experiments. The way simulation

works depends largely on the type of models and simulation type in used. The following are commonly used simulation categories (Hoover *et al*, 1989):

- **Static simulation:** is a time-independent technique, sometimes referred to as the Monte Carlo technique. This is used in this project investigate the relationship between the risk manager and technical manager. Static simulation cuts across by generating random samples to derive a statistical outcome to analyse the model.
- **Dynamic simulation:** depends entirely on time.
- **Stochastic simulation:** is sometimes referred to as probabilistic simulation, in which one or more input variables are randomly generated.
- **Deterministic simulation:** Deterministic simulation is the type that has no random inputs. Instead it uses constants.
- **Discrete event simulation:** refers to incessant changes in state across discrete points. This change is time dependent and is enacted by event. Changes or an event occur in the following forms: request – response channels trigger mostly by events in real-time or by user interaction to the models, unavailability of resources or its failure, or completion of an action. The change of model state results in aggregation of state of all the elements in the model at a point in time. Variables in a discrete-event simulation are referred to as discrete-change state variables. This thesis employs discrete-event simulation because all the elements of the generated conceptual models are discrete and probabilistic in nature and event driven.
- **Continuous simulation:** the discrete variable changes respectively with time. However, the intersection of this simulation type underscore the rationale for choosing Object Oriented Programming continuous simulation which supports both scenarios presented in this context (see the section on object-oriented programming continuous simulation). A discrete-event model opts to represent the real-world i.e. system being modelled in terms of components. And associated events are classified in Banks (1999) as endogenous (i.e. the event modelled within the system) and exogenous (event modelled outside the system which could result from external interaction to the systems).
- **Object-oriented Programming Continuous Simulation:** The influence of object oriented principles is crucial, in this context on design and implementation of event driven simulation of DRiMaP extensions. Objects are perceived as aggregations of processes that manage a state and determines the message calls through the request-response channels i.e. RPC (Remote procedure Calls) over HTTP (Hypertext Transfer Protocol). Equally, object orientation

conceptualises the notion of classes to produce objects; and the notion of inheritance which underscores reusability of behaviour of one class in defining another new class (i.e. subclass). In this context, object is considered as an instance of a class, and it is referred to as entity with set of defined properties to identify what the object is capable of doing. Additionally, the representation of symbolic interactions of systems which comprises of objects in operations of patterned association. In terms of coordination and organisation, inheritance across objects engages an insight into the abilities of other objects to relate or communicate is an important criterion to adopt this simulation method. These behaviours have to be simulated effectively.

## 2.4 DATA COLLECTION

Primary and secondary data are available to constructive research. Marketing Research compiled a model in 2011 to show the differences between these two types, and this model is presented in Figure 6 below.

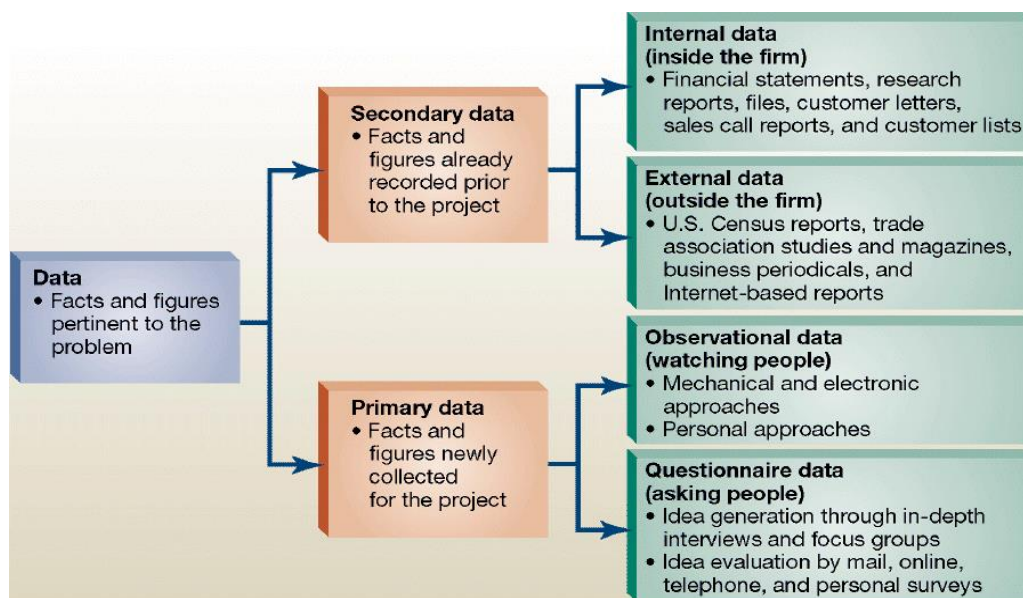


Figure 6. Data types (Marketing Research, 2011)

Jugenheimer *et al.* (2010) explained that secondary data as inexpensive, massive in content, reliable and can be trusted as it will be having support of multiple studies and authorised publications. Generally the data collected in the earlier stages of this project comes more from secondary data, and provides an understanding of the conceptual theories.

The process of collecting information from secondary sources will include a review of books, journals, internet material and various other resources. The primary data will be collected directly by taking interviews or surveys, and by observing and experimenting on the functions of the information system that is developed. Simply, secondary data will be helpful in finding the most suitable method for collecting primary data, by giving appropriate ideas, and suggesting a justified and strong questionnaire tool.

## 2.5 DATA ANALYSIS

Empirical data collected will be analysed in the data analysis phase. Emphasis will be placed on reliability and correct interpretation. Reliability analysis determines whether the data collected on risk management for software system projects is trustworthy or not. Reliability analysis is used for measuring the consistency that can be defined as a degree of consistency for multiple measurements. The most common method for measuring reliability is the internal consistency method, which checks for the consistency between variables. In this project the individual items should measure the same construct and should be highly correlated (O'Connor and Kleyner, 2012).

An example illustrates how data analysis may be used effectively. Data analysis in IT often includes designing and managing computer networks that provide the organisation with data storage and processing and support effective marketing actions (Marketing Research, 2011). A lot of risk is involved in these organisations due to various complex factors, so data analysis must be handled carefully. Figure 7 below shows the approach used in these organisations for data analysis along with different activities.

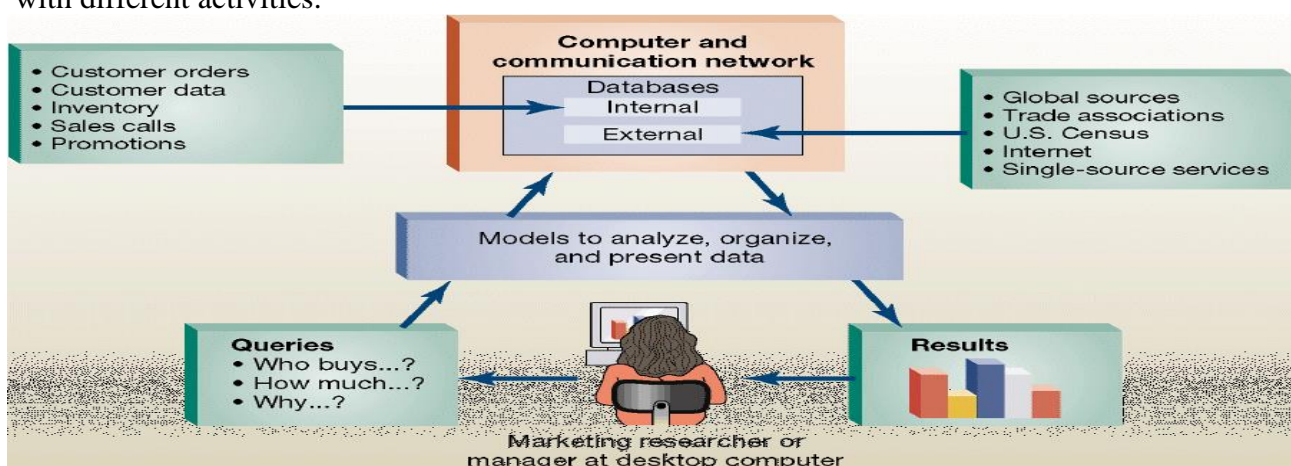


Figure 7. Using IT to trigger marketing actions (Marketing Research, 2011)

## 2.6 VALIDITY

Validity refers to the truth of the research, or the extent to which the measurements and conclusions that approximate reality (Wikipedia, 2013). According to this source, research should be reliable, with results that are consistent and repeatable. Research should also be accurate, on target and correct as possible. Research should demonstrate construct reality, ensuring it measures what it is supposed to. Research should exhibit content validity, measuring all the things that literature says it should. The study should also should internal validity, the degree to which conclusions can be made about causal relationships, and external validity, where the research holds true for other cases. Winter (2000) said that “*validity is not a single, fixed or universal concept*” but is dependent on the context and processes of the research.

Conclusions about the validity of this study will be drawn in the final chapter.

This research will implement the *Evolutionary Model* as a risk management software tool. This is a valid approach to researching an information systems related theory. Pechenizkiy and Tsymbal (2005) showed that developing a computer model is a unique and acceptable form of research. It has a purpose that is directly linked to the aims and objectives of the research project, but it also produces a product that requires testing. Researchers have to take care, as Still (2000) notes when asking the question about validating computer models “*are you assessing the model or the engineer?*”

Still proposes four forms of validation and testing that are needed by this type of research:

- **Component testing:** This involves testing each code fragment to ensure that it performs as intended and without any untoward behaviour (Still, 2000). This testing was primary and undertaken whilst code was being written.
- **Functional validation:** Still (2000) defines functional validation as “*checking that the model can exhibit the range of capabilities required to perform the desired simulations.*” This testing was undertaken once each major component was developed.
- **Qualitative validation:** This form of assessment “*compares the nature of predicted behaviour with informed expectations*”, and “*it demonstrates that the capabilities built into the model can produce realistic behaviour*” (Still, 2000). The system was observed and assessed against soft criteria obtained from the literature review and the survey.



- **Quantitative validation:** Still (2000) regards quantitative validation as “*comparing the model predictions with reliable data generated from experiment. Attention must be paid to the integrity of the data, the suitability of the experiment, and the repeatability of the experiment.*” Simulations were used to test the system and validate it in these terms.

## 2.7 ETHICAL CONSIDERATIONS

Research ethics requires the research and its practice to be sound and free of dishonesty (Cooper and Schindler 2008). Diener and Crandell (1978) suggest the basic ethical considerations for the researcher should be privacy, lack of consent, cheating and primarily any risk to contributors. Generally those people who contribute to the research do not want their information and details shared, so the knowledge, consent and confidentiality of participants should be ensured (Bell 2005).

Human participants contributed to this research, and the risk to them is disclosure of their participation. The participants work in commercially sensitive environments and their opinions and viewpoints may be contrary to those of their employers and co-workers. This could affect careers and working relationships. The sample of contributors was chosen from the KAUST team who had experience in the environments and in research, Also, Saudi General Authority of Civil Aviation IT sector as an IT organisation experience in the environments and in research, so the researcher did not exhaustively prepare participants for the survey and Delphi approach. There was a previous relationship with several participants, so approaching and confiding with the researcher was relatively easy. Permission was sought and granted from respondents and organisations (see Appendix A and B).

Responses were made anonymously, and the details of respondents were not referred to in publications or in the body of this thesis. To further protect the respondents, details were not kept on portable media like memory sticks and on public computers. Participants did not physically engage with the project or the researcher, so there were no health and safety issues.

A multiple method strategy was used to validate the model. No data was contrived or changed so as to ensure the validity of results. Proper citation and referencing was used to further improve the ethical quality of this research and its presentation.

## 2.8 REVIEW

The research adopts secondary data collection and modelling approach which assist to seek into the body of knowledge and to produce the evolutionary model. The method are validated on the conformity with Information Systems guidelines, and if the model is the pure representation of the system proposed, then performance of such model becomes inevitable to put in consideration. All the usable techniques are verified from the IS perspective i.e. object modelling and verification testing carried out (see s2.9 for detail). The approach used is object orientation design and modelling (see s4.4.1 for the detail).

## 2.9 CHAPTER SUMMARY

This chapter presents the methodology used on this project and sets out the methods used to empirically develop and assess the theory. The survey and experimental methods used to do this are described in detail, and the chapter also reviews data collection, validation and ethical issues. The primary concepts used in this research are now examined in the Literature Review. This theory will be extended into the *Evolutionary Model* that is explained in Chapter 4. Constructive research is used to design and develop the model as described in Chapter 5. The model was then empirically tested and experiments used to validate the computer model and demonstrate that the developed solution worked as expected.

## CHAPTER 3 .. LITERATURE REVIEW

This chapter reviews current literature to provide a firm theoretical foundation for this study. Definitions are found and a clear understanding is developed of the nature of relevant entities and problems faced when managing information technology project risk in the distributed development environment. Various risk management models are identified and critically compared and the *DRiMaP* model is selected on the basis of suitability.

### 3.1 DEFINITIONS AND CONCEPTS

This section defines and briefly examines the key concepts that underpin this study, including IT performance, projects and their management, distributed development, risk and its management, and crisis management.

#### 3.1.1 Information technology project performance

Information technology projects have been beset with problems for a long time, and nowhere are this more noticeable than on large projects. In 1994 Gibbs wrote of what he called “*software’s chronic crisis*”, referring to the project overruns on the now infamous Denver International Airport baggage handling system. Gibbs isolated three main factors that interfered with the successful completion of projects such as these; human variation, the bespoke nature of large projects and the complexity of large systems.

Gibbs was not alone in seeing the problems. It was during this decade that the Software Engineering Institute’s Capability Maturity Model (SEI CMM) came in being (Marciniak, 1994) and the Standish CHAOS Report on IT project success was first published (Standish Group, 1994). This report has been criticised for the accuracy of its data and the validity of its methodology (Dominguez, 2010), but it is widely used by industry and academia to call attention to what is undoubtedly a problem.

In 1994 the Standish Group published startling figures: “...*in 1995 American companies and government agencies will spend \$81 billion for cancelled software projects. These same organisations will pay an additional \$59 billion for software projects that will be completed, but will exceed their original time estimates.*”

They singled out projects in large companies for particular mention, saying that according to their methodology only 9% of those IT projects were successful. Subsequent reports have suggested the situation has not dramatically improved, with the success-to-failure ratio in the 2009 Standish Report being 24:32% as compared to the 16:31% of 1994. The wide difference between these values reflects the crude approach and low level of research into IT risk management in this period. Little has changed substantively according to the Standish Group, despite considerable research effort in finding and improving development methodologies, project management methodologies, technology, risk management and governance.

The Standish Report is not the only measure or report of issues. De Bakker *et al.* (2010) claim that information technology projects “*have a long history of failing*”, are of the opinion that risk management is not practiced correctly, and that more attention should be paid to risk management than to the actual risks. According to the leading professional body for project management in the UK, the Association of Project Management (APM, 2008):

*“...the use of risk management within projects is poor. Often risk management is limited to the creation of a risk log at the start of the project. Further use of risk management is often limited, resulting in projects experiencing problems that could have been successfully avoided or managed.”*

Risk can impact very badly on an organisation and on its key objectives and goals (Mills and Walle, 2007). The difficulties are more acute for large, complex projects and those involving multiple partners. Kwak and Smith (2009) conclude in their review of large collaborative defence industry projects that including a comprehensive risk management plan would significantly improve overall project management practice. Olsson (2008) identified a gap between contemporary risk management and the requirements of multiple entities and a portfolio of projects; finding there were fewer learning opportunities, limited interaction and difficulties in measuring effectiveness in these environments.

CONFIRM and UKeU (the United Kingdom eUniversity) are two IT projects belonging to an American corporation and the UK government that failed for the same reasons that Bacon (1993) proposed for IT project failure.

Analysis of these projects revealed that risk within any project development does not exist in isolation from the project - rather it is part and parcel of the project lifecycle and stakeholders involved in the project development, ranging from management to the any individual who has influence on the project. Risk management should therefore cover the entire lifecycle of the project development.

The way that performance is measured can impact on perceptions of success. Agarwal and Rathod (2006) propose that definitions of success may be one of the reasons why projects may be deemed unsuccessful. They argue that time, cost, functionality and quality remain the primary success criteria, but measurement should take into consideration the project scope and better initial estimation of budgets and schedule. Selection of risk management approaches should be aware of these factors and support different stakeholders' requirements of performance.

To summarise this discussion, projects are prone to very expensive failure for a number of reasons and risk management is seen as a major factor in remedying this situation. Performance however is a subjective measure and care should be taken when defining it.

### **3.1.2 Projects and project management**

The practice of project management has developed and expanded considerably since the field gained prominence for its successes in delivering large scale endeavours during the Second World War. Formal methods such as PERT and Gantt began to appear, as did publications and an emerging number of professional bodies like the Project Management Institute (PMI) and the Association of Project Management (APM).

What is a project? The United Kingdom's foremost project management body for professionals, the APM, defines a project as "*unique, transient endeavours undertaken to achieve a desired outcome.*" Their definition of project management is equally succinct, "*the process by which projects are defined, planned, monitored, controlled and delivered such that the agreed benefits are realised*", and go on to say "*projects bring about change and project management is recognised as the most efficient way of managing such change.*"

Project management is not a science, it is a management technique. Project management methodologies are only guidelines that lay out the process and activities involved. Project lifecycles are frameworks that describe the evolution of a project over a period of time. The Software (or Systems) Development Lifecycle (SDLC) is one such lifecycle and is frequently referred to in IT research. It roughly corresponds with the more generally known ‘waterfall’ model – a phased and linear sequence of activities from project conceptualisation to completion. Within IT there are however abundant theoretical and proprietary methodologies such as Agile, incremental, Microsoft’s Solutions Development Discipline and PRINCE2. Similarly, there are many lifecycles, including cyclic and iterative options. Organisations such as the APM publish bodies of knowledge like the APMBOK or PMI’s PMBOK that follow a generic methodology and lifecycle, and which detail the activities and provide guidance to practitioners. There are also a number of approaches and viewpoints. Kolltveit *et al.* (2007) document these, identifying six perspectives in project management literature; task, leadership, system, stakeholder, transaction cost and business by project.

This variety indicates that any generic approach that attempts to resolve software development problems should take into consideration the variety of project management approaches, methodologies and lifecycles that may be practiced in organisations. Projects vary and so too does project management. It is unlikely that every large Information Technology project uses the same lifecycle, methodology or approach. Any attempt at a generic model for risk management should be able to accommodate this variety. On the other hand assumptions will have to be made about the environment in which distributed software development risk management will have to take place. These assumptions should enable the development of a generalised model for the purposes of research. As with many IT techniques, these would undoubtedly have to be adapted for use on specific projects.

A generic systems development lifecycle (SDLC) will be employed for the purposes of implementing research recommendations. Table 1 below presents a generic model that will be used for purposes of this research and which has been derived from generic models provided by the APM and PMI.

Phase	Characteristics	Risk management activities
<b>Phase 1:</b> Requirements Gathering	The essentiality and the necessity for designing an IT system will be identified, and the necessary requirements will be gathered from the customers.	Security, resource allocation, financial, etc. risks are identified.
<b>Phase 2:</b> Planning	IT systems are licensed and purchased. Development phase will be started.	The risk assessment in this phase will be helpful to identify the security threats and legal threats. The architecture of the large IT systems will be thoroughly verified by various departments and partner companies to ensure risk free.
<b>Phase 3:</b> Implementation	The security systems are deployed into the main IT systems and will be tested before moving into the live production stage.	Based on the initial requirements, the IT systems implementation will be cross verified to check the implementation process. Before the systems operation (live production), the risks need to be communicated to the phase 2.
<b>Phase 4:</b> Support and Maintenance	The maintenance work goes in this phase. Improvements to the large IT systems will be identified, and necessary support will be provided for the customers.	Mainly, the risk management will be followed in order to identify the need for reaccreditation. The need for the upgrades and the identification of the errors in the IT systems will be identified.

*Table 1. Risk management activities of a generic SDLC*

### 3.1.3 Distributed software development

Agerfolk *et al.* (2005) define the term “*distributed software development*” as referring to any software development activity in which the team members are geographically spread out. This spread may also be temporal – spread over time zones or whenever team members cannot interact face-to-face, and it may be socio-cultural – where there are differences in practice and culture. The authors compare the ideal software development team with the distributed development environment, showing that the latter threatens certain properties that are important to the development process; namely rich interactions, common organisation culture, good coordination, effective control, a good mix of skills and experience, ready access to knowledge, and homogenous tools and technologies.

Jimenez *et al.* (2009) define distribution as geographical and organisational, saying it “*allows team members to be located in various remote sites during the software lifecycle, thus making up a network of distant sub-teams.*”

Keil (2003) agrees that temporal separation is an issue, and approaches the challenges faced by distributed development from a human (anthropologic) perspective. This adds the issues of language, power, culture and trust. The increasing trend towards distributed development has been noted by sources like Herbsleb and Moitra (2001), Sengupta *et al.* (2006) and Ramasubbu and Balan (2007). So too have the challenges. Sengupta *et al.* indentify four areas in which improvements are needed; collaborative tools, knowledge sharing, appropriate testing and process and metrics issues. Ramasubbu and Balan agree on the last point, saying that the negative effects of dispersion can be mitigated through structured software engineering processes.

Sunagawa *et al.* (2003) pay attention to just one aspect of the problem - developing a common ontology across the distributed environment. A common ontology refers to the vocabulary and/or dictionary used by the project participants across the various entities. This could apply to business entities - a pack of beer could contain six 340ml bottles of beer in Africa or ten 300ml bottles in Europe. It could also apply to the technology and to the terminology used in processes and project management. Participants may speak the same language, but they may also apply different meaning to the same words, or use different words to mean the same things.

The authors of the *DRiMaP* model that forms the focus of this paper, Kajko-Mattsson *et al.* (2009), do not define distributed software development, but they do describe the environment to a limited extent. Terms and concepts are referred to, such as global, large, geographically dispersed subcontractors, large teams and limited short delivery deadlines. The authors provide for central control through the formation of a risk management forum, a hub that is the authority for each business cycle.

#### **3.1.4 A definition and introduction to risk**

Practitioner's definitions for concepts are important because they are often used extensively by industry and by research. The APM is a professional body that publishes a well-researched Body of Knowledge (2011), and this defines risk as “*the potential of an action or event to impact on the achievement of objectives.*” James Ward, an independent consultant specialising in systems development project management, similarly defined risk management as “*uncertain future conditions or circumstances that may adversely impact a project if they occur*” (2003).



Academic views can be more abstract or even more specific. Cervone's general overview of project risk management (2006) offers the somewhat humorous definition of risk as “*a problem that has not happened – yet.*” Olsson (2008) reviews several authors' opinions and provides a range of definitions; including “*an exposure or a probability of occurrence of a loss*”, “*a barrier to success*”, as being “*related to concepts of chance such as the probability of loss or the probability of ruin*” and even the more positive view that risk can be exposure to loss or gain. Specific examples include Elky (2006) who regards information technology security risk as anything detrimental to information that emanates from determined or unintended events that cause an untoward impact on the information. Risk can also be thought of as a function of the possibility or probability that a given threat-source can impose or have a potential negative impact on the project development life cycle.

The definition offered by Holton (2004) will be used in this study: “*risk is defined as the exposure to a proposition of which one is uncertain*”. It is constructed from two key perspectives; the subjective and objective views of John Maynard Keynes (1921) and Frank Knight (1921) that Holton cites. The argument between Keynes and Knight was purely about probability, where exposure and ignorance play a major role in determining the probability that a certain event will occur. The level of exposure prior to undertaking project development creates an awareness of project uncertainty.

It is worth remembering however that risk may not be a quantitative entity or phenomenon. Veres (2009) talks about perceived risk as “*evoked by the danger of losing control over events that could have negative consequences.*” Laroche *et al.* (2003) consider risk from the perspective of the customer, and treat it as a perception rather than something finite. They also describe five independent risks that all display subjectivity; financial, performance, physical, psychological and social. Any one individual's perceptions of risk are driven by knowledge and involvement.

Murray and Hillson (2008) demonstrate that **risk attitude** may also be a factor in effective risk management, as illustrated in Figure 8 below.

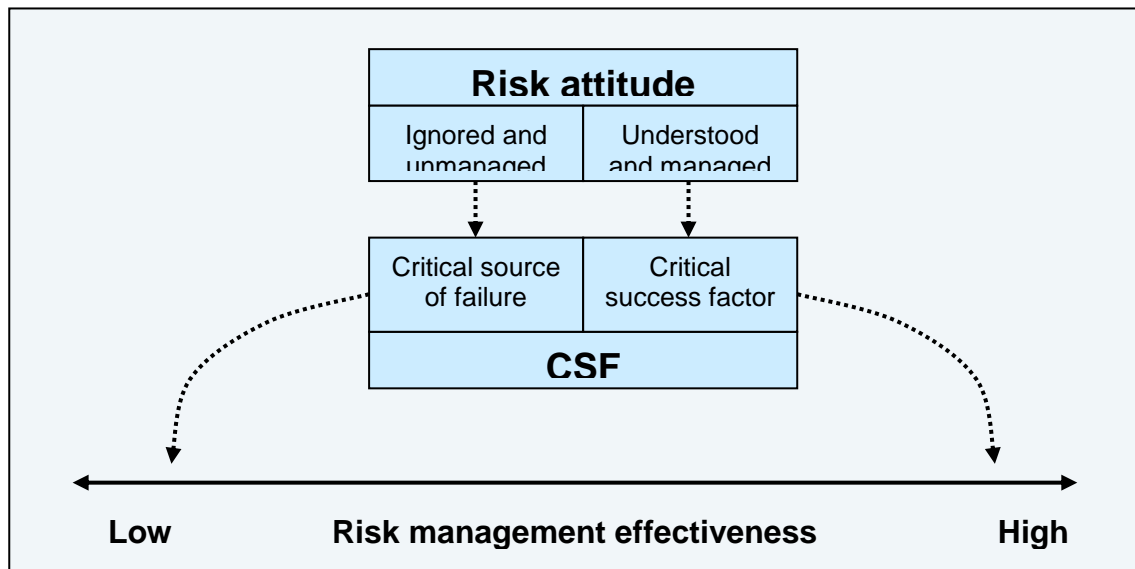


Figure 8. Risk Attitude as a CSF (Murray and Hillson, 2008, p. 12)

**Risk impact** is another important dimension. According to Kajko-Mattsson and Nyfjord (2008), the risks in large IT systems development will lead to increased time deadlines, increased costs, and reduced quality of the final delivered products. Ultimately the risks will cause lost business and market share. Each risk will be associated with two parameters, risk probability and risk loss, that combine to form the risk impact (RI). This is the dependent variable in this research. RI is variable and depends on both the impact and the probability of the risk. According to the Association of Project Management (APM) and the Project Management Institute, these values can be calculated as a product of the probability of an unsatisfactory event and the loss from an unsatisfactory outcome (APM, 1997; PMI, 2000).

**Loss distribution** is a concept that is important to the identification, quantification and mitigation of risk. Risk management in the IT industry can vary. Large IT systems are prone to many risk factors and the quantification of the risk is very important in order to mitigate the risk in the development of secure IT systems. According to Navarrete (2002), there is a need for the IT companies to dedicate resources to manage the operations and thus implement risk management in maintaining the operational risks. The research paper produced by Navarrete (2002) explained that the losses incurred by an IT system were because of the internal weaknesses and inefficiencies and there are no standard ways of identifying them very easily. However the introduction of DRiMaP models introduced by IBM made it very easy to handle the risks in managing the IT systems. DRiMaP models are more concerned about the improvement of the quality of the systems which will in turn help to reduce the operational risks.

According to Navarrete (2002), any risk distribution will depend on the events that are defined for calculating the risk. In this section, the research is interested to explain the methodology to calculate the loss distributions in the IT systems (distributed). Any risk will be associated with the capital flow, resources available and the technology in the IT systems.

Before measuring the risk, a confidence level needs to be established so that the solution to a particular risk can be defined. It is an industry practice to set the confidence level close to 100% even though this is not practical. This is incorrect since a confidence level of 100% chosen for calculating the loss distributions will require an unacceptable and inefficient level of capital investment. A 99% confidence (certainty or point/level at which 99% of losses will be covered) will be a more acceptable as well as being helpful in understanding and calculating the loss distribution.

Expected losses (EL) and unexpected losses (UL) and operational value at risk (VAR) are helpful to understand the loss distribution patterns in the IT systems. According to Navarrete (2006), there will be always a scope for the expected losses in any IT systems whereas unexpected losses cannot be predicted earlier and contribute to the risks of the IT systems. However the unexpected losses can be calculated by the difference between the VAR and the expected losses so as to identify the future capital requirements required for mitigating the risk in the IT systems. If the unexpected losses are calculated then there will be fair chances of identifying the risks and can be distributed among the different departments in an IT system. The graph in Figure 9 depicts the expected and unexpected distribution of IT systems losses that may occur.

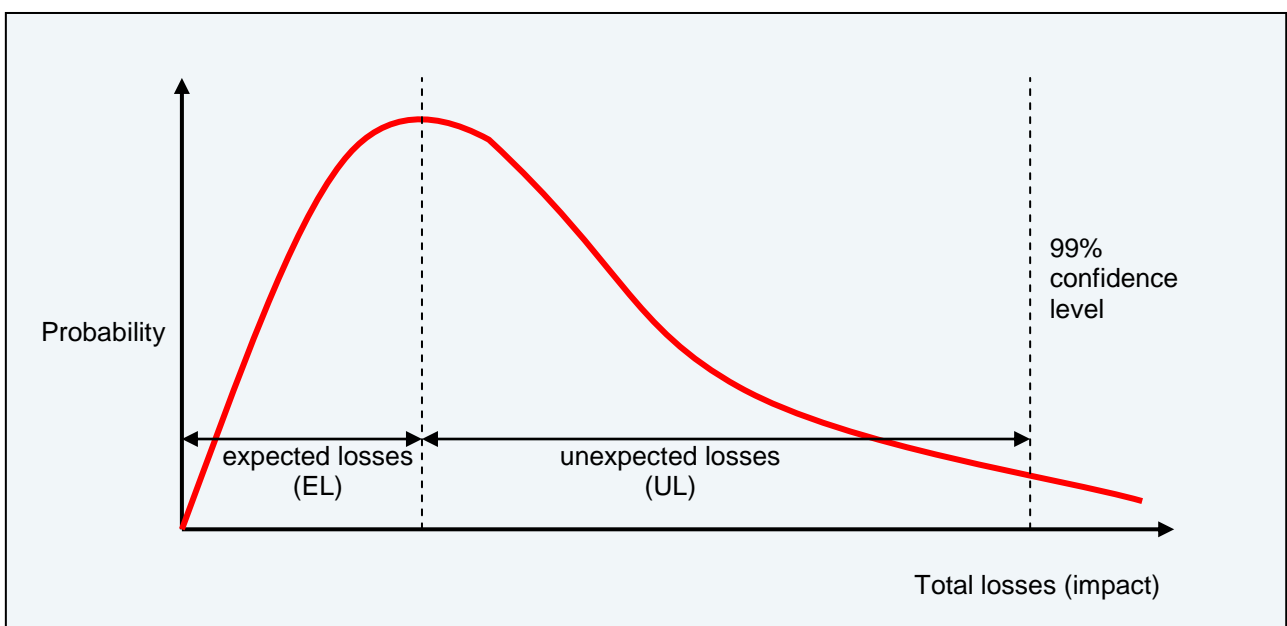


Figure 9. Project loss distribution curve for IT systems (Navarrete, 2006, p.2)

### 3.1.5 Risk management

Literature describes risk management in various ways. It may be treated as something philosophical, such as Kloman's (1990) definition of “*a discipline for living with the possibility that future events may cause adverse effects*”. It can also be more specific, such as the APM (2011) definition: “*Project risk management is a structured process that allows individual risk events and overall project risk to be understood and managed proactively, optimising project success by minimising threats and maximising opportunities.*”

Risk within organisations takes on different forms and causes. Some of them can be large in scope and potentially affect the entire organisation – a crisis. Few organisations have the infrastructure or resources to deal with crises. Mills and Walle (2007) revealed that ability to respond to such occurrence is not an indication of reduction in the damage rather a plain necessity for survival. In research conducted by the Spillan and Hough (2005) and American Management Association (AMA) according to Latto (2007) revealed that not less than 40% of organisations have no risk management plan in place. It is however shown that small firms place high emphasis on risk management plan. Mitroff *et al.* (1989) pointed out why most organisations do not emphasise risk management plans prior to project development and implementation. These can be a perception that a crisis is very unlikely, or reliance on insurers to cover losses. They also found that organisations that disregard the possibility of a crisis also often fail to make provision for risk management.

Risk management is the basic component of corporate governance, and management bear the responsibility for establishing and operating the risk management framework. These have assisted the organisations in setting standards and often acted as basic benchmarks. The process of identifying, assessing, managing and controlling potential events or situations offers assurance that organisation goals will be met (Pickett, 2005).

From a practical information perspective, risk management may be defined as the process of comprehension and response to mitigate the identified potential harm or factors that may affect or instigate the failure of the following factors: confidentiality, integrity, security, and privacy of an information system with a set of predefined measures. It can also refer to the policies, actions and practices involved in identifying, analysis, assessment, control and minimisation of undesirable risks. A firm may use risk assumption, risk avoidance, risk retention, risk transfer or any other strategy (or combination of strategies) in proper management of future projects.

Therefore it can be concluded that risk management is the procedure of analysing experience of risk and shaping of how to best handle such experience.

In terms of information systems, risk management can be seen as a process which allows IT managers to achieve gains in mission capability and bear the operational and economic costs of protective measures by protecting IT systems and data that support their organisations' missions. This process is not unique to the IT environment - spreads through decision-making in all areas of our daily lives. For an example in the general case of home security, many people decide to have home security systems installed and pay a monthly fee to a service provider to have these systems monitored for the better protection of their property. Presumably, the homeowners have weighed the cost of system installation and monitoring against the value of their household goods and their family's safety, a fundamental "mission" need (Stoneburner *et al.*, 2002).

Risk management plays a significant part in modern information system project management in the following ways (Crouhy *et al.*, 2000; Hoosian, 2003):

- It provides many options to organisations wishing to deal with risks easily.
- The cause of risk like lack of information can be identified quickly.
- Risks are natural and will increase with every development in the organisation.
- Risks therefore need to be managed continuously and systematically.
- Risk management units in the organisation can provide suitable training, support and suitable tools for the staff to meet the challenges in their duties.

Whilst risk management has been identified as a formal and important discipline, there are variations in what is called the acceptable standard or practice. Risk management in the context of this study can be considered immature due to the variance of practices used in its implementation to mitigate risk to acceptable or minimal level. Murray and Hillson (2008) show further research is required in areas of development. The rate at which IT projects have failed and continue to fail point to the need for further enquiry and probing the sources of risk. Research outcomes are still unsatisfactory and unacceptable because a number of variant approaches or methods that emanate from the research lead to outcomes that are usually seen in isolation - often in the form of models or frameworks specifically designed by organisations for their own use. Murray and Hillson regard risk management as yet to reach maturity.

### 3.1.6 Crisis management

The concept of crisis management is an important inclusion in this study. Platz and Madsen (2006) focus their research on crisis management in IT projects, and begin by defining a crisis in a succinct but thorough manner:

*“A major unplanned occurrence (King, 2002) with a potential negative outcome (Schrivastava, 1993) that threatens the survival of the organisation (Schrivastava, 1993, Fearn-Banks, 1996, King, 2002, Fink, 1986, Pearson and Clair, 1998, Loosemore and Teo, 2000), by dismantling the internal or external structures (King, 2002, Schrivastava, 1993), or by affecting the legitimacy of the organisation (King, 2002).”*

Due to the scale and scope of a crisis it may be treated as a low probability but with extreme impact. Platz and Madsen do say that the principles of risk management apply to crisis management.

They warn that a crisis may appear to be the occurrence of one or more basic risks in the early stages, but a series of root causes may escalate the risks to a crisis; lack of resources, loss of interest within the organisation, misaligned expectations, personal conflicts, and management or sales become disengaged. Symptoms of an emerging crisis include communication breakdown, refusal to discuss the scale of the issue, delegating the problem downward to operational managers and increased stress levels.

The risks related to crises can be broadly classified as follows: liquidity risk, operational risk, legal risk, customer loss risk, strategic risk, supply chain risk and reputational risk. These may be grouped as financial risks and as business risks. Operational risks are generally examined by the organisations that are taking care of industries and regulatory. Measuring the operational risk sounds to be more fashionable but regulatory risks depend strongly on the legal issues of current policies, regulatory environments and countries policies (Culp, 2001).

Although a low probability, including crises in the risk management portfolio is obviously prudent. Top business models now pay attention to identifying and prioritising risks that have the potential for disastrous consequences. These models are considered and discussed among a team of specialist members in the organisation, and involve the top management of the companies in most of the situations.

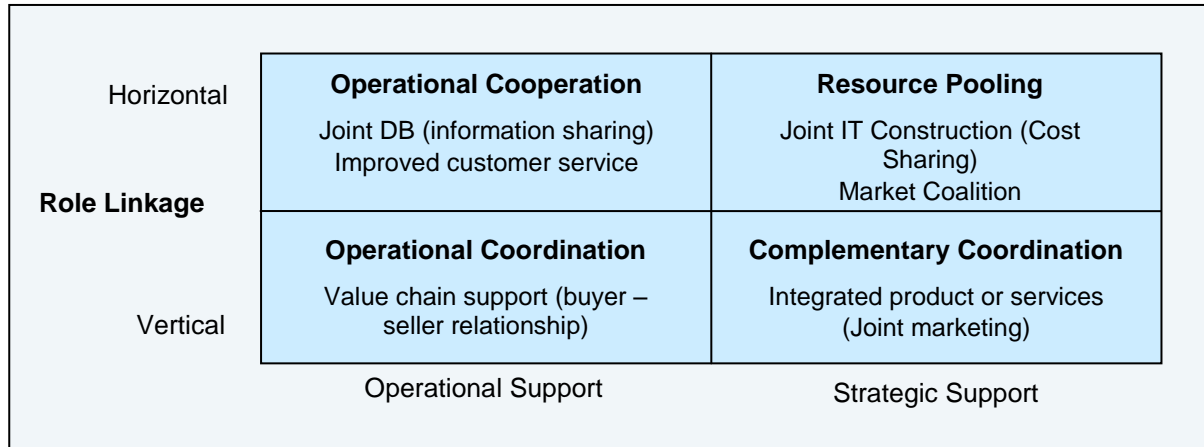
Back up is then provided in the form of proper insurance, by transferring the risks, financial mitigation, involving rigorous planning and using the techniques of crisis management (CAS, 2003). However a company's risk culture and risk management strategy will be vital in terms of making the organisation understand and decide the tolerable risk factors within the company operations. Very few companies in the market are aware of the spectrum of operational risk management and the methods of defining the risk factors vary from company to company and the integration process of work structures will depend on the risk measurement methods (Culp, 2001). Lack of information on the operational losses in many organisations is another reason for the wide range of inconsistency in measuring operational risks in the organisations.

Organisations like IBM are trying to keep a "*Basic Indicator*", which relies on one or two important risk factors that are coarsely defined. However there are other methods considered to be playing vital role in indentifying the risk factors like internal ratings, internal models and operation risk monitoring. Generally the internal ratings method uses a quantitative approach specific to topic and individual business unit to identify and understand the risk (Culp, 2001). The internal model approach to risk measurement will utilise recent and advanced operational risk management tools that are focused on the specific loss data of a particular institute. Sometimes they may also rely on structural economic models.

Inter organisational information system (IOIS) models have been developed to support crisis management from the perspective of cross-organisational collaboration (Dury *et al.* 2010). Links are also made within the organisation. An example of intra-organisation linkage is when the business considers crisis management and communication information to be important public relations material as it presents the corporate reputation in the market (Coombs and Holladay, 2011). Crisis management involves vertical and horizontal links across any organisation, as illustrated in Figure 10 below. Vertical links connect the cooperating heterogeneous entities and horizontal links will connect homogeneous organisations. Hong explains the necessary of two linkages but emphasises the need for different collaboration mechanisms, approaches and procedures (Dury *et al.* 2010).

In case of an organisation like IBM the collaboration mechanism will have to support the horizontal linkage for competing with other similar organisations for the shared documents and regulatory rules that affect entire industries of similar nature of works.

However the mechanism will also have to support the vertical linkage for two parties to view interactively and discuss the effects of dynamic changes in the global market for their business strategies and additional risk factors.



*Figure 10. Hong's Framework for IOIS (Dury et al. 2010, p. 15)*

In the case of public relations, crisis prevention works as a tool to avoid negative media attention. Coombs and Holladay (2011) explained crisis as a dramatic and newsworthy situation where it raises many questions related with preparation, response, media and relations with business managements. The authors highlighted the importance of one bad news creating serious damage to the business planning strategies. However, a good strategic business plan always includes the parameters like crisis prevention, mitigation and communication response. Hence proper communication methods will be the key for a good business planning strategy and thereby one organisation can reduce the risk of negative media effects. Crisis management controls the intensity of crossing all the organisational boundaries. Impact will be directly or indirectly placed on stakeholders, and this may create a positive or negative impact on the business statistics (Caywood, 2004). Due to heavy involvement of information and communication technology in most of the multi-national companies, firms like IBM need to follow a strategic planning in which all modules of work structure needed to be included in appropriate way for reaching the level of global competitors expectations and to stabilise in the market.

Haselkorn (2007) shows that most of the multinational companies are leaning towards organisational operation and management rather than technology to overcome or avoid a crisis. The author suggested few tips for managing complexity related with ICT that can be applied to solving issues of crisis management, as follows:



- Broader and largely integrated efforts are needed to manage enterprise ICT.
- ICT management focus in Multinational Companies (MNC's) must shift from hardware and software to data, knowledge and organisational goals.
- Business planning must include ICT and operational goals.
- Focus of the total information strategy should be on the people, information and goals of the organisation.

## **3.2 RISK MANAGEMENT AND INFORMATION TECHNOLOGY**

Scope of this research covers risk in information technology projects, particularly large projects, and this section examines risk and its management in that field.

### **3.2.1 Risk management and software processes**

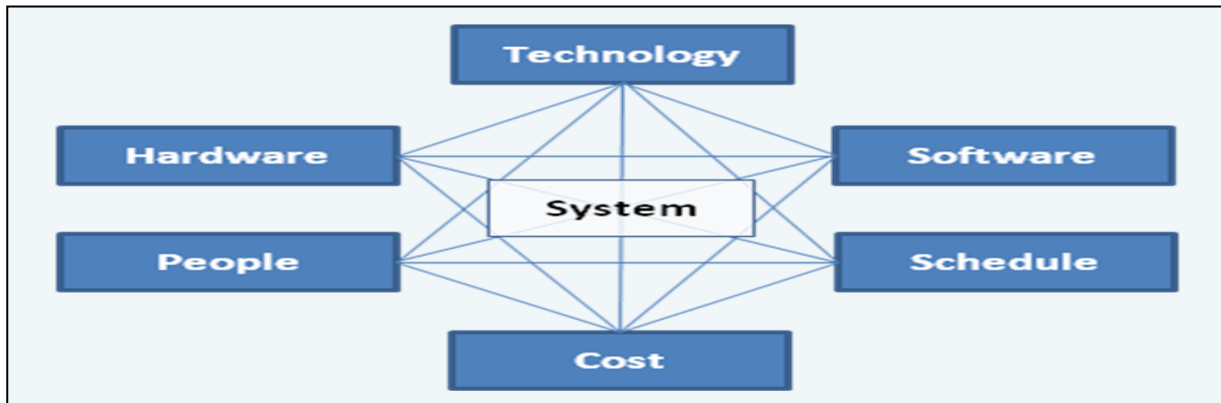
Software risk management (SRM) techniques may be classified as either software acquisition or software development. In large projects both types may co-exist.

Higuera and Haimés (1996) showed a basic methodological framework to manage functions may be composed of the Software Acquisition-Capability Maturity Model (SA-CMMSM) and the Software Capability Maturity Model (SW-CMMSM) and their supporting practices and constructs. This framework is supported by three groups of practices (Higuera and Haimés, 1996): Software Risk Evaluation (SRE), Continuous Risk Management (CRM) and Team Risk Management (TRM). According to this model, two additional visions or dimensions ought to be included: the temporal and human dimensions.

The three dimensions that represent the holistic vision of software risk management are the temporal dimension, the methodological dimension, and the human dimension (Higuera and Haimés, 1996). The element of time referred to by these authors is later raised by Agerfolk *et al.* (2005) as a characteristic of distributed software development projects.

Achievement, growth, and exploitation programs continue to experience great cost overruns, calendar delays, and poor technical quality. These are a result of failing to deal appropriately with uncertainty in the acquisition and development of complex, software-intensive and software-dependent systems. Further studies in Higuera and Haimés (1996) revealed that potential sources of software risks involve technology, software, hardware, cost, people and schedule.

These are shown in Figure 11 below:



*Figure 11. Risks within a system context (Higuera and Haimes, 1996)*

Business needs are essential in laying a base for a discussion about the role of risk management in information systems (Gibson, 1997). Gibson gave three needs to comprehend the role of information system in risk management:

- Most firms are measuring risk to understand the risks they are taking, such as the quantifiable examples of market risk and credit risk.
- Risk-adjusted performance leads to better promotion of business units and individuals.
- Risk management provides shareholders with consistent and superior risk-return exchange over time; firms match the capital they employ to the risks they take.

Gibson also revealed that firms have developed refined risk measuring techniques and make considerable investments in risk management information systems that meet their requirements. Managers expect a risk management information system to provide data they need to meet the three business needs highlighted above. Gibson showed managers expect risk management systems to:

- Calculate value at risk.
- Perform scenario analyses.
- Measure current and future exposure to stakeholders.
- Do all of the above at varying levels of aggregation; across various groups of risks, product types and stakeholder groups.

The problem of designing an information system for risk management is one of **aggregation**. Data available from the firm's trading sites must be aggregated globally to calculate value at risk or to perform a situation analysis on the firm's global group.

Table 2 below shows two examples where the central and decentralised approaches give matching, correct answers to the question of **curiosity**. While reluctance should be shown in making absolute statements about how a particular firm would make these choices, comfortable choices can be made between the two relative claims about the tradeoffs between the flexibility of trading units' systems and the ability of a central risk management function to access position data.

	<b>Example 1</b>	<b>Example 2</b>
<b>Question to be answered</b>	How many financial instruments does the firm have on its books?	How many counterparties does the firm currently have?
Information required from each trading unit	Number of financial instruments the trading unit has on its book?	List of the trading unit's counterparties, identified uniformly across trading units
Calculation required to compute firm wide answer	Sum across trading units	Sum across trading units with duplicate counterparties removed.

*Table 2. Risk management in information systems (Gibson, 1997)*

Another issue is **timing**. Risk management occurs mostly in the early stages of the development process and should be continuous till project knowledge evolves and project information increases in quality and quantity.

Risk management is a key component for project cost **estimating** and **scheduling**. The power of risk management will be completely realised whenever a project manager takes action to respond to the identified risks based on the risk analysis. In an IT project, understanding the project risks will enable the project teams to contribute to fulfilment by assessing the project risks and making the correct project development and delivery decisions. Managers must consider the resources needed for project risk management and build this into their project development budget and schedule (Twain, 2010).

Information technology projects are frequently planned and executed as a series of phases. This helps with the logical planning process, control of execution, testing and even business issues like interim signoff and payment. This research intends to offer suggestions that will be helpful to project managers and software developers throughout the project lifecycle. These participants will understand the major risks associated with IT and software development projects and enable them to plan, organise, direct and control the software project. eOutlook (2010) illustrate how project managers, software developers and programmers can understand major risks involved throughout the lifecycle, shown in Figure 12 below.



Figure 12. Project, Process and Software Development Cycle (eOutlook, 2010)

### 3.2.2 Strategic risk management relating to IT

Strategic risk exposes organisations to potential losses and at the same time provides them with a number of opportunities. Most IT companies invest large amounts on their operating systems and technologies, so their key objectives would include investing in technologies that will enhance their strategic advantage. In order to gain strategic advantage the organisation must eliminate critical risks and determine how to survive and succeed in business (Wallis, 2005). This can be achieved by focussing on any financial and operating flexibility that may help the technological base, operations or financial structure adapt in response to the changed environment. In so doing the organisation will be more agile in an uncertain environment and take faster advantage of opportunities.

### **3.2.3 Operational risk management (ORM)**

ORM in IT organisations is a part of the central risk function. In order to maintain an effective ORM system in the organisation the central risk function must be focussed on by working closely with the business groups to decentralise the core ORM functions and at the same time preserve the goal (Patel and George, 2009). The goal is to empower all the individual business groups to deliver ORM.

Business groups at local levels can manage their operational risks more effectively, so it becomes necessary for all business groups to be entrusted with the responsibility and power to manage their own operational risks. As with strategic risk management, the business therefore becomes more agile by being able to respond quicker.

### **3.2.4 IT risks for the organisation**

As discussed previously, there are five generic risks that business and projects will encounter; financial, performance, and physical, psychological and social (Laroche *et al.*, 2003). Kleim (2000) on the other hand regards IT risks as falling into three categories; technical, operational and financial. Technical risks affect hardware, software and data; operational risks affect systems components and compromise security; and financial risks affect the project costs or profitability. Kaplan and Garrick (1980) offer business, social, economic, safety, investment, military and political risk.

At the enterprise level, risks that many IT organisations now face include continued uncertainty and impact of the credit crunch, global economic and market fluctuations, impact of inadequate infrastructure, economic vulnerability and regulatory risks in developing markets. Many organisations are beginning to recognise the need to employ Enterprise Risk Management (ERM), an approach to manage risks throughout the organisation. It uses a transformation process that changes the way an organisation perceives and manages risks, enabling an organisation to assess and mitigate risk continuously and thereby provides assurance that organisation objectives will be achieved (Finkelstein, 2009).

### 3.2.5 Integration of management systems risk

Failure in integrity and availability of an information system is a substantial risk that the project and subsequent operations face. Business management must manage this risk so as to protect the assets and mission of the organisation, and this not a technical function. A toolset is required to share a common view between the information technology project and business managers (Elky, 2006). This toolset must be consistent and cost effective to reduce risk to a reasonable level. The system should consider which of the four strategies should be employed in controlling risk; *mitigation*, which is a compensatory control to reduce or mitigate risk; *transference*, that allows another party to take up the risk on behalf of the project; *acceptance*, that allows the system to operate with a known risk; and *avoidance* that removes vulnerable aspects of the system (Hortan and Thomas, 2002). Once the risks are understood the risk management strategies that will be used must be clearly communicated to business management.

### 3.2.6 Risk management in large IT projects

The concept of the distributed environment was discussed in section 3.1.3. Projects in these environments are typically large, so the principals that apply to large projects may be found to apply to distributed projects too.

Large projects frequently do not achieve their aim (Gordon, 1999). Some examples mentioned already include the CONFIRM and UKeU projects. Naturally there is a lot of apprehension involved in these endeavours due to the time and capital invested. This is perceived risk (Veres, 2009; Laroche *et al.*, 2003) this is mentioned in section 3.1.4. Risks are a mix of business, technology. The root cause of information technology project challenges is the inability to spot and mitigate risks, whether they are technical, operational or financial (Kleim, 2000) as discussed in section 3.2.4), or technology, software, hardware, cost, people and schedule risks (Higuera and Haimes, 1996) that is mentioned in section 3.2.1.

Millera and Lessard (2001) show large projects experience additional and external challenges. These include the market-related risks of demand, finance and supply; completion issues related to technology, the building of the deliverables and operations; and the institutional risks related to regulations, social acceptability and ownership. Their advice at this level is to treat risk as a managerial problem and not a technical one, and offer a range of tactics like shifting risks to specialised third parties, use of financial instruments and escalation upward to decision makers.

Risks specific to large projects are pointed out by Flyvbjerg (2005) as being related to the long planning horizons, complex interfaces, technology not being standardised, multiple decision makers often with different agendas, scope and ambition levels varying over time, unplanned events not being budgeted for, there is substantial misinformation about costs and benefits, excess optimism about benefits in the early stages,

Wallace *et al.* (2004) found that software tools that identify IT project risk are limited. Also, there are few explanations for the relationships that exist between the phases of software project risk. Literature further proposes checklists and frameworks respectively to establish the missing relationships and provision of tools to identify and analyze IT project risk. Wallace *et al.* (2004) concluded that the difficulty frequently encountered by project managers would only be eased with improved comprehension of risk and its impact on IT projects.

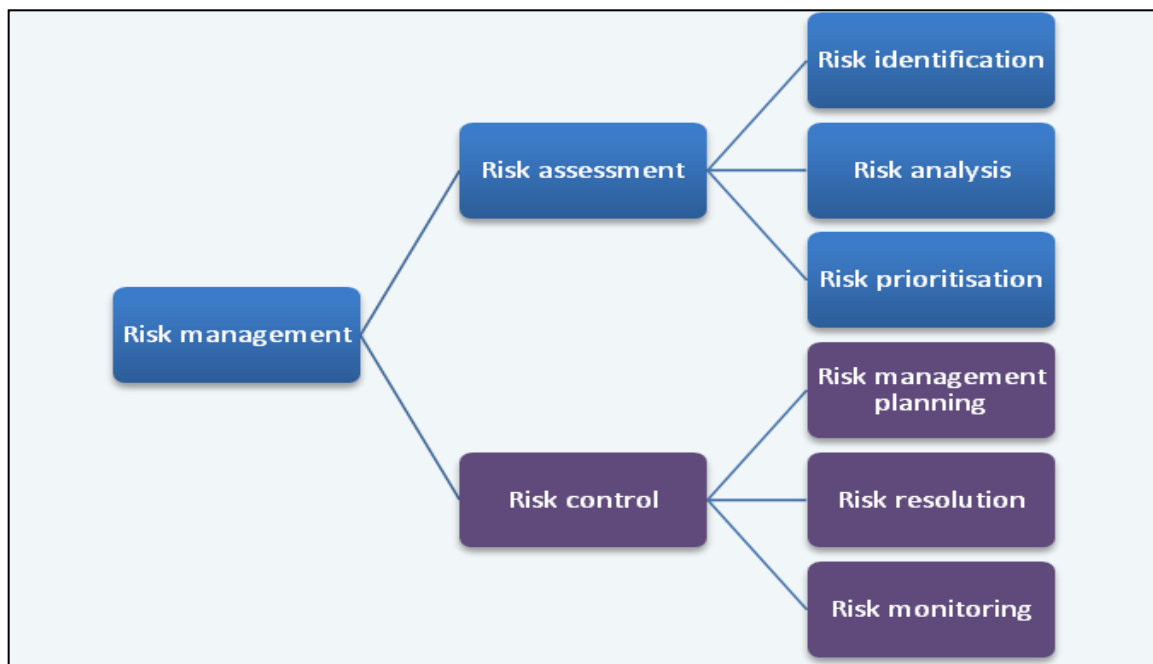
Risk management in massive IT companies provides an opportunity to analyse the risk associated with all project development and execution. This is especially true for those driven by dynamism or incessant changes in IT infrastructure and dynamic market which are global in nature. Due to the strong impact of globalisation, these projects require a different approach to designing an implementation model or framework that meets the associated challenges. Equally, risk management models are generally designed for mitigating the risks involved in individual projects (SAS, 2002). Note: it refers to submission that the risk management models can still be used for mitigating individual projects.

Models therefore tend to work as isolated tools rather than integral parts elements of project planning. The scenario ought to be totally different due to the involvement of strong technical, innovative and strategic content with properly defined structures and systematic approaches. However in practice most of the managements and project managers avoid group risk management process steps so as to avoid wasting time on paperwork.

Muhlbauer (2004) suggested five steps to help the majority of IT organisations find a solution; risk modelling, data preparation, segmentation, risk assessment and managing the risks. Most of these steps are considered to be self-evident once the risk assessment efforts are under way. The role of a model will be key in solving the challenges due to the size of an organisation like IBM and the critical nature of how its work is distributed amongst employees and subcontractors. The tool will

have two roles; improving communication between primary contractors and subcontractors, and reducing the risks involved with major software projects at various times in different locations.

Previous sections reveal that process is important. Misra *et al.* (2007) argue that any distributed IT systems need to perform certain activities in order to face challenges. Risk management can be divided into two categories of activities, namely risk assessment and risk control. These two categories can be broken down further, as illustrated in figure 13 below. The terms used in Figure 12 above should be defined as they are used frequently elsewhere and in this project.



*Figure 13. Risk management activities*

**Risk assessment** is a particularly important set of activities as the type of risk and its implications need to be gauged in order to decide what risks to tackle and when. It consists of several activities:

- *Risk identification:* This is the step where the various risks involved in the large IT systems will be pinpointed. The risks are considered from every perspective of the organisation and the implications are identified.
- *Risk analysis:* Risks identified will then be evaluated to assess the processing time, project costs, timelines and revisions to the implementation that are needed. Any security issues and recurring issues will be thoroughly investigated.



- *Risk prioritisation:* The risks will be categorised into different groups based on the probability, impact and other factors important to the organisation. Calculations underlying prioritisation were discussed in section 3.1.4.

Boehm *et al.* (1998) explained that **risk control** is needed to distribute the risks among the various subsystems in order to mitigate risk. This is particularly important to risk management in large and distributed environments, and involves the following:

- *Risk management planning:* In distributed systems the risk will be spread among subsystems and planning must be undertaken to allocate resources, plan time, design a schedule and make arrangements for completion. This involves setting up a coordination team that will communicate between the various subsystems of the distributed system.
- *Risk resolution:* This step aims to mitigate risks, at least by reducing their probability or impact. Coordination will be needed to calculate the cumulative effects of the risk management from every subsystem, which is important when risks are distributed.
- *Risk monitoring:* Risk resolution will not give an immediate solution, so risk monitoring helps to re-assess and re-plan the risk responses so that risk reduction plans can be iterated.

Further discussion and examples of risk activities are provided in section 3.3.4 in the review of risk models.

The researcher's aim in identifying risk events is to design an efficient distributed risk management system which will help to investigate and identifying the problems that arise in the technical or managerial aspects and thus implement proper actions to reduce the risk impact on the large IT systems.

Specific risk events are being considering for this research are:

- Staff shortfall.
- Unrealistic budgetary constraints.
- Frequent modifications to project requirements.
- Software function failure.
- Real time performance drawbacks.
- Insufficient IT systems testing.

- Technology upgrades and migration.

### 3.2.7 Risk management in large IT companies

There are many needs that must be considered by the information technology industry to be an essential part of any enterprise risk solution, and these may impact the design of a model. Management tools and dashboards may be required. Certain IT security risks for example might need additional features, like data-mining algorithms for modelling behaviour that combine techniques from adversarial risk management with the help of intelligent entities (Ray *et al.*, 2008).

A case study from IBM Global Business Services (2008) reveals that supply chain process related problems should be included with IT specific issues. The glitch in Nike's planning software caused serious shortage for very prestigious Air Jordan footwear, resulting in the company facing a \$100 million loss in sales. Special attention must also be paid to operations, technologies, social issues, natural and hazardous issues, economy, competition, legal and political issues. Many of these business issues are echoed by authors such as Higuera and Haimes (1996) as discussed previously.

Most businesses like IBM will strive to secure their information, assets, systems, processes and human resources. Success relies on collection of information and timely submission of work to take advantage of opportunities (IBM Global Business Services, 2007). The matter is complex however. Software techniques available in the current market make it more complicated to protect the information compared to earlier days of IT industry. Due to increase in competition and regular changing challenges, one cannot consider information as a static element in the business process. Real-time issues with integrated web systems make it more complicated to analyse information.

To solve these kinds of situations IBM began using automation, data warehouses and business intelligence systems to exploit information in faster and easier ways. Their greater IT capabilities and product delivery processes meant they had to adopt higher levels of risk management in their regular work flow. Risk information may also be gathered within the IT industry from the conversations of experts (Ray *et al.*, 2008). IBM developed a web based tool that collects such information based on job roles and the classification of the expert's professional work. This information is collected automatically and based on the ratings from the experts within IBM from the same node. Ray *et al.* recommended the use of what-if analysis which uses a risk quantification method to benefit from various interactive technologies. Human-Computer Interaction (HCI) research suggested behavioural, aesthetic and value sensitive aspects to be included in an interactive system; which is also considered to be a prestigious informative research area of IBM.

Similar risk factors were discussed by Muthu *et al.*, (2005) to coordinate information in a systematic manner in big organisations with different campus areas and different strategies. The authors described handling data from various campus areas of university branches to integrate and handled carefully so as to update database with latest information. However due to the lack of proper integration tools and software techniques the universities studied spent millions of pounds in communicating and updating information across campuses - leading to delays and errors. Such kind of risks can be avoided by using the latest techniques and tools available. Calopus Solutions provides such a tool that integrates all kinds of applications in an affordable package. This ensures risk information reaches the right people at the right time.

Financial risk management strategies are also required. Various advanced mathematical methods in the financial industry provide a great background and framework for analysing risks associated with hedge funds. They also help with other domains like IT project management, workforce management and supply chain management (Ray *et al.*, 2008, p.13). IBM at this stage shares most of its strong knowledge base with other experts such as mathematical sciences departments to find extended risk management methods to apply to other areas. They also provide most of the software applications of an enterprise class that deal with the entire project lifecycle, and provide analytical components of this process to address the risks that arise at specific times in the lifecycle.

This discussion shows that large organisations need to improve their risk management maturity, which Murray and Hillson (2008) called for and was discussed in section 3.1.5. One suggested maturity roadmap is provided by IBM (2007) and is presented in Figure 14 below:

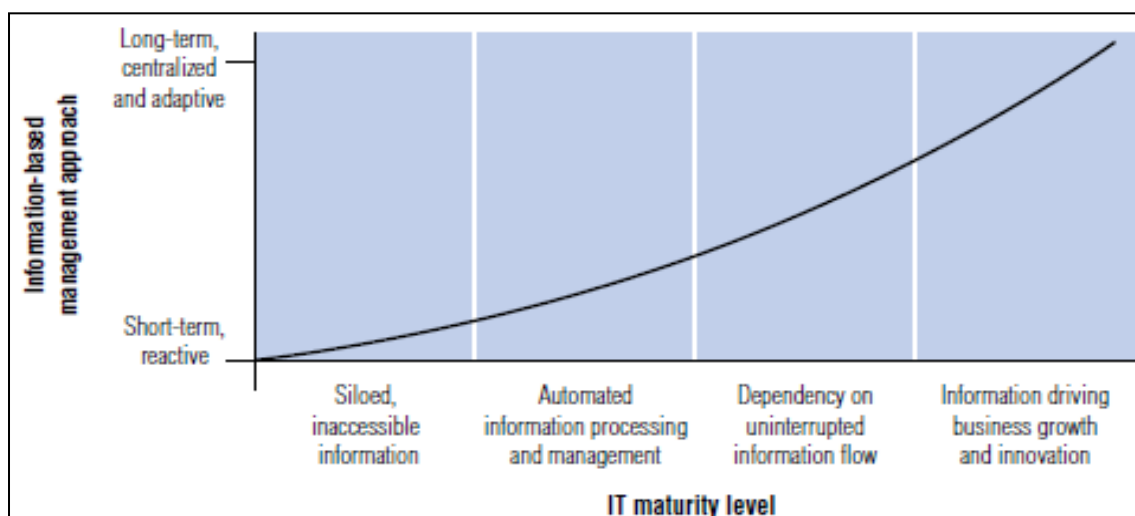


Figure 14. Industry risk management maturity roadmap (IBM, 2007, p.5)

### 3.2.8 Risk management in the distributed software development

Distributed software development is complex. According to Herbsleb and Moitra (2001), “*software development is increasingly a multisite, multicultural, globally distributed undertaking.*” Their study reveals additional dynamics of geography, time, culture and apportionment of work. All of these introduce uncertainty – and hence risk.

Sengupta *et al.* (2006) consider these development environments could be made more effective through paying more attention to collaboration, knowledge management, testing, process and measurement. Gutwin *et al.* (2004) regard insufficient attention is being paid to awareness of others. Prikladnicki *et al.* (2004) found that processes were insufficiently integrated and this made projects inherently riskier. In a limited study of one case, Arlan and Arshad (2013) observed that governance, security, roles and responsibilities were important in managing IT risk at a national university. De Farias *et al.* (2012) are more specific in their study of communications issues. They recommend that projects encourage frequent communication, set up a communications infrastructure, promote socialisation, use communication tools and techniques, build trust through visits, use standardised language, promote informal communication, enhance cultural awareness and use groupware.

Agerfalk *et al.* (2005) were more comprehensive in their study, and identified opportunities and threats in communication, coordination, control, temporal distance, geographic distance, socio-cultural distance, standardisation of work practices, allocation of roles, team structure, reduced trust, lack of team spirit, lack of shared understanding, mixed skills, language, loss of concurrent engineering and different perceptions of authority. No list however can be entirely accurate. Keshlaf and Riddle (2010) state “*Any list of software risk items will need to be updated from time to time, when there are new changes or challenges in software development technology and environment.*” Their study discovered challenges in the form of inadequate informal communications, lack of trust, cultural distance, time-zone differences, incompatible development processes, managing knowledge, technical incompatibilities and security issues. The authors also saw web development as having a different set of problems as a result of impact and significance of certain risks like security, instant deployment, risk estimation and a reactive attitude to risks. Risk clearly should be managed throughout the lifespan of the project.

Jiménez *et al.* (2009) felt the solution was to find new processes and tools. Lamersdorf *et al.* (2012) agree, saying that new methods are needed to identify risks in distributed projects. It is clearly beyond the scope of a PhD to reengineer all aspects of distributed software development in order to mitigate risks. It is also impractical to assume that all organisations will automatically adopt a proposed approach. It is more practical to assume that the real world will remain diverse and that risk management should adapt to that reality.

### **3.3 RISK MANAGEMENT MODELS AND FRAMEWORKS**

Attempts to develop risk management approaches, methodologies, frameworks and tools are not new. Examples may be found in a range of information technology, project management and business literature, and reveal a common theme: IT projects are risky, large projects are particularly risky, risk is not managed particularly well, and risk management approaches in other areas have not been satisfactorily adopted by information technology industry. This section reviews a wide range of risk management models and frameworks.

#### **3.3.1 Risk management approaches**

Risk management approaches are generic strategies for managing risk. A literature search discovered a large number of papers proposing risk management approaches, but almost all were actually discussing specific techniques.

In a thought-provoking article that examines whether risk management contributes to IT project success, de Bakker *et al.* (2010) identify two primary approaches to the management of risk; the *evaluation approach* and the *managerial approach*. The aim of the evaluation approach is to identify and quantify the risks, often after they have occurred, and then input this information as risk factors into the next project to prevent reoccurrence. The managerial approach on the other hand is a sequence of activities that aim to deal with risks to prevent a specific project from failing, and does not look to generic risks or to contribute to subsequent projects.

The implication for risk management approach selection is important. Programmes consisting of many inter-related projects, portfolios of projects and distributed development projects require of risk information. Large IT projects are unique so they also require risk management that is specific to that project. Risk management in large distributed development environments therefore needs to consider generic risks and the risk knowledge of its participants (evaluation approach);

as well as deal with the risks that are project specific as they evolve through the project lifecycle (managerial approach).

### 3.3.2 General reviews

Two general reviews of models and frameworks provide a useful introduction and roadmap to the literature as an aid to researchers and practitioners. The first of these by Misra *et al.* (2007) identifies and summarises the following as popular software risk management models and risk management methodologies that are not complete frameworks:

- Boehm's risk management model (Win-Win)(Boehm, 1988).
- The Software Engineering Institute's Software Risk Management Model (Williams *et al.* 1999).
- Hall's Risk Management Model (P<sup>2</sup>I<sup>2</sup>)(Hall, 1988).
- Karolak's Just-in-Time Risk Management Model (Karolak, 1998).
- Kontio's RiskIT Methodology (Kontio, 2001).
- Foo and Murugananthan (2000).
- Deursen and Kuipers (2003).
- Roy's ProRisk framework (2004).
- Thomas and Keil (2004).
- Misra *et al.*'s model (2005).

Another review by Stern and Arias (2011) discusses fewer models and overlaps with Misra *et al.* to contribute only two additional examples; SERUM (Software Engineering Risk: Understanding and Management) and SERIM (Software Engineering Risk Index Management)(Karolak, 1998). Whilst their review of the many models and frameworks is not thorough, the authors approach to their review is useful in that it compares key characteristics, advantages and disadvantages.

Keshlaf and Riddle (2010), mentioned in section 3.2.8., offer a useful comparison of various models using a wide set of criteria to weight the models. The weighting system is additive and assumes that each criteria is equally important, and identifies the Geographically Distributed Software Projects (GDSPs) method (Presson *et al.*, 2009) as the most suitable software risk management approach for web and distributed development. They also evaluated DS-RM, EBIOS, ProRisk, RiskIT, SoftRisk, CMM-RSKM, PMBOK and Risk&Performance (several of which are reviewed by Misra *et al.*, mentioned above).

According to the authors, all current models do not pay enough attention to process and product perspectives, ignore the evolution of the project, are unprepared for unusual risks, lack monitoring and tracing, are inflexible and do not offer implementation advice. These findings would suggest that the models they reviewed would be unsuitable for the use identified by this project.

### 3.3.3 Examples from literature

There is a large body of literature describing models and frameworks, including Kayis *et al.* (2007), Dey *et al.* (2007), Jafari *et al.* (2011) and the DRiMaP model of Kajko-Mattsson *et al.* (2009). This section examines this literature to understand how other researchers have tackled the problem of risk in large scale IT projects, the research methodology they used, how they validated their models and what gaps their research uncovered and left behind.

Baccarini *et al.* (2004) studied practice in Australian Information Technology to establish how IT risks were being managed in projects. They established the high failure rate of IT projects is the primary driver for IT risk management, and discovered and ranked 27 IT project risks that could help IT project managers better understand the most important risks and select the most appropriate strategy to mitigate those risks. The authors acknowledge that their study is geographically limited, but the study may be difficult to reliably generalise because the sample size of 18 professionals is too small and the sampling strategy of snowballing and the close proximity of the respondents may have introduced bias. The value to this project however is that the event based risk management model produced may be assessed for its ability to manage risks that are identified by these authors.

A concise insight into risk management is provided by Cervone (2006) who also points out the key issues and terminology involved. He defines risk as a problem that has not yet happened, and suggests the risk management strategies are reduction, elimination, transfer, absorption, pooling and avoidance. Practical advice is given that should be considered when designing any risk management programme, such as “*unfortunately, risk management is often not given the attention it warrants*”, and that “*project managers only perform a superficial examination of the issues related to risk and then add a 'margin for risk'.*” Whilst Cervone's paper is only general in its treatment of the subject, it provides examples of risk and risk management that may be used to compare with other theory and the model emerging out of this study.



Chong (2000) felt that IT project managers needed to pay closer attention to technological advances that had changed the development landscape. His paper was prompted by the global changes driven by the dot.com boom between 1999 and 2000, and identified several areas that could affect risk management on a macro-scale; including mergers and acquisitions, advances in computing and telecommunications, the growth of e-commerce and the internet, venture capitalism and the need to adopt a financial viewpoint when considering risk.

Like Cervone, Chong refers to superficial examination and getting risk evaluation wrong, and calls this “*fig-leaf risk management*” in reference to doing the bare minimum. Whilst Chong's paper is an opinion-piece, his warning not to ignore risk-ignorant or risk-seeking behaviour on the part of the organisation and the people involved is clear.

Jafari *et al.* (2011) sought to develop a model for risk management in a project-based organisation in Iran, an objective quite similar to that of this research. Their approach was to examine existing practices, develop a model and then evaluate the model using a case study. The authors based their work on risk management models offered by several major project management and standards bodies; namely the Project management Institute's PMBOK, PRAM, MOR and the AS/NZS4360. The research used a mix of qualitative and quantitative methods to assess the validity of their model, and as such it supports the methods chosen on this project.

Similar to this project, Dey *et al.* (2007) set out to develop a risk management approach for software development projects. Their research is original in that it considers the project from the software developer's perspective, and discovers a number of benefits and advantages to an effective risk management process that may be considered for inclusion in this project. Whilst the generalisation of their research is limited by the single case study the framework was applied to, the authors provide extensive information in their paper that may be used to assess validity and applied to subsequent research.

#### **3.3.4 Process and activity approaches**

Risk management can also be described as a process. Bakkar (2008) explained the standard risk management process as containing a linear relationship between finding and giving solutions for problems in the IT organisations to overcome the problems raised from traditional risk management process. Bakkar compiled a cyclic model from the steps or activities offered by many authors for risk management, and this is described in Figure 15 below.

Two of the key steps in this model are *Assess* and *Evaluate*, and these are referred to by other authors as risk identification and estimation and referred to previously in section 3.2.6.



Figure 15. The traditional risk management model (Bakkar, 2008)

Molenaar *et al.* (2010) show the importance of risk *identification* during project development, an activity that is used to find and classify risks that may hinder the progressive or operatives of the project execution. This requires a close observation of the organisation, market environment, and legal, social, political and cultural environments and broad comprehension of its strategic and operational objectives that are encrusted in the factors that determines the success of project development and execution. However, risk identification should be approached in a logical manner to satisfy every part of the organisation (IRM, 2002). Molenaar *et al.* also show there are few(er) risks on non-complex, low-cost projects with little uncertainty. Further studies reveal that risk involved in a project is associated with complexity.

The outcome of risk identification is a *list of risks* identified early in the development lifecycle. The usefulness of this list depends on the type of risk and project in question. This list helps the project manager track possible occurrence of risk on the list. The risk identification process should avoid further assessment and analysis in order not to inhibit the identification of minor risks; the identification process should enhance creative thinking and align the experiences of the team members in overcoming uncertainty.

*Risk estimation* is an imprecise activity. There is no “*general agreement as to the dimensionality of the software project risk construct*”, (McFarlan, 1981, cited in Wallace *et al.*, 2004). McFarlan further revealed three factors affecting risk estimation as experience, project structure, and project size.

The author remained silent on a derivational approach and instrument to estimate these dimensions, and rather introduced a 54 item risk assessment questionnaire to be used mostly by companies for estimating software project risk. The exact source of the psychometric evidence or properties of this questionnaire unfortunately remain unknown and vague.

Further review showed the work of Barki *et al.* (1993, also cited in Wallace *et al.* 2004) that found thirty-five risk variables after an extensive review of IT projects. Barki *et al.* developed a questionnaire consisting of one hundred and forty four (144) questions. The extensive data collected led to identification of five factors affecting risk estimation; newness of the technology, size of the application, inexperience or lack of expertise, complexity of the application, and the defined environment of the organisation. Contrary to McFarlan (1981), Barki *et al.* (1993) designed an instrument for estimation which is considered to be quite advanced. However, “*there is no excellent beauty that hath not some strangeness in the proportion*” (Sir Francis Bacon, 1561 – 1626, as quoted by Barki *et al.* (1993), and the research had no project managers in attendance during identification and validation of risk items and factors spotted.

### 3.3.5 Commercial approaches

Various models have been developed by large information technology companies in response to their own internal needs. A literature search discovered examples used by Microsoft, TATA Consulting Services, Infosys and IBM. The first three of these models are compared in the following series of tables. Factors in the tables were derived from discussion in this chapter and represent key areas that models should be assessed against.

Microsoft Model	
Factors	Description
<i>Models and shape of reaction</i>	The risk management model emphasises on planning, establishing and maintaining successful risk management process.
<i>Control and monitoring the risk</i>	Measures control effectiveness.
<i>Risk management approach</i>	Seeks holistic approach.
<i>Risk management model</i>	Plans risk data gathering, gathers risk and then prioritise risk.
<i>Risk management control</i>	A part of risk management control solutions.
<i>Environmental consideration within the models</i>	This model does not have any negative impact on the environment as most large part of the model concentrates on operational process (Kouns and Minoli, 2010).

*Table 3. Risk management model used by Microsoft*

The Microsoft model emphasises project control and assesses risk in terms of compliance with the planned project. This does not pay particular attention to temporal changes or specific needs of distributed teams.

<b>TCS Model (Tata Consultancy Services)</b>	
<b>Factors</b>	<b>Description</b>
<i>Models and shape of reaction</i>	The risk management model used is set by regulatory requirements, value protection and value enhancement.
<i>Control and monitoring the risk</i>	It defines the risk probability of the organisation.
<i>Risk management approach</i>	Targets for each risk parameter are set.
<i>Risk management model</i>	The model is chosen based on the value the company needs to have and relies on key performance indicators.
<i>Risk management control</i>	The risk management also regards the social corporate responsibility.
<i>Environmental consideration within the models</i>	All the environmental risks are assessed and encompassed by this model.

*Table 4. Risk management model used by TCS*

The TCS model focuses on a business issues rather than the control issues favoured by Microsoft. Again there is no specific attention paid to temporal and distributed environment issues.

<b>Infosys Model</b>	
<b>Factors</b>	<b>Description</b>
<i>Models and shape of reaction</i>	Infosys uses comprehensive risk management model.
<i>Control and monitoring the risk</i>	It practices to avoid needless concentration of revenues in one service, client, industry, or geography.
<i>Risk management approach</i>	High standards of corporate governance and transparency enable it to handle the risks accordingly.
<i>Risk management model</i>	It has set a vision and pursued appropriately framed strategy for dealing with risks.
<i>Risk management control</i>	Most of the risk management processes are oriented towards organisational objectives.
<i>Environmental consideration within the models</i>	In terms of social responsibility or environmental impacts the organisation has launched events to deal with the environmental issues (Infosys, 2011).

*Table 5. Risk management model used by Infosys*

The Infosys model also adopts a business focus and does make allowances for the distributed environment. It is however not dedicated to this environment.

IBM staff researched and published what they termed the *DRiMaP* model, and examination of this showed it to be the most suited to distributed risk management. This is not surprising since the model was developed for this purpose. A more extensive treatment of this model is given to this model in the following section since it is very obviously more suited to distributed development than the above three commercial models and other academic proposals.

### 3.4 DRIMAP - A CRITICAL REVIEW

The Distributed Risk Management Process Model (*DRiMaP*) is both a commercial and academic model. It was proposed by Kajko-Mattsson *et al.* (2005) who were practitioners and researched the model whilst at IBM. This model was discovered during the literature search for risk management models and frameworks. Preliminary inspection showed it to be the most suited of all the models to the needs of this project. This section critically reviews and evaluates the model, using the same general criteria used by Stern and Arias (2011) that were discussed in section 3.3.2; namely the origins, typical area of application, techniques used, effectiveness, advantages and disadvantages.

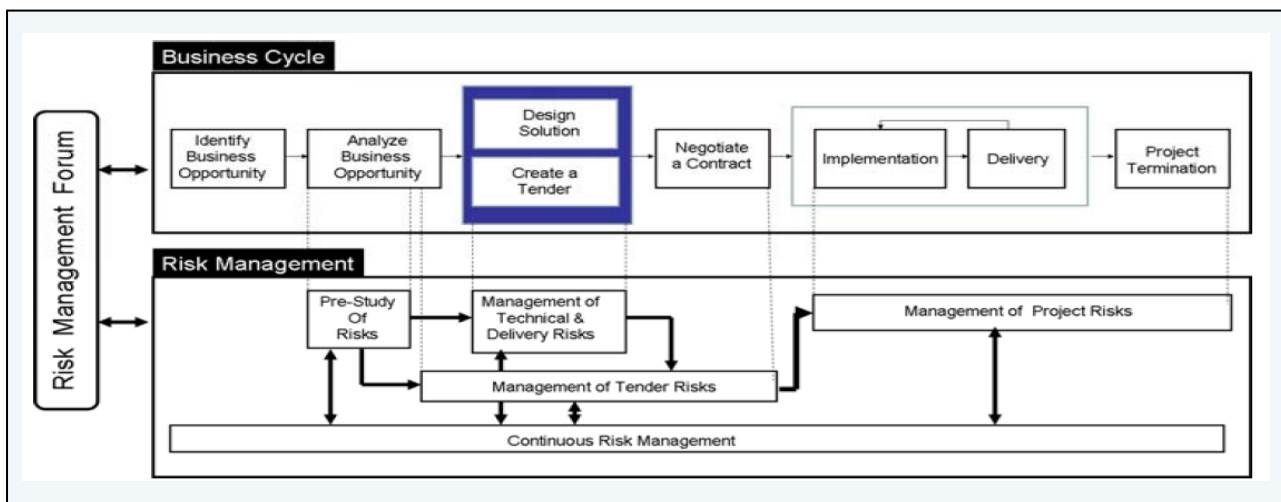


Figure 16. Original *DRiMaP* model (K. Mattsson, 2009)

#### 3.4.1 Background to *DRiMaP* development

The study that led to development of the *DRiMaP* model was conducted by university researchers at the formal request of IBM. The significance of this is the team had the full support of the company, and that IBM felt the problem was sufficient enough to warrant a full investigation. The researchers did state that IBM was forced to develop a distributed development process that would be used by all the collaborating organisations.

### 3.4.2 Methodology used by the IBM researchers

The researchers took a year to complete the research and develop a process model. Although this may appear to be sufficient time, it was probably not enough to evaluate the model throughout the lifecycle of at least one large IT project. This would mean their research failed to adequately evaluate the temporal aspects of distributed development that Agerfolk *et al.* (2005) and others found to be important (section 3.1.3).

The method used by the team was design research, more typically employed in arts and architecture although there have been precedents in software engineering. The more usual topics tend to be Human-Computer Interfaces (HCI), but Vaishnavi and Kuechler (2003) do describe five possible research outputs that consist of constructs, models, methods, instantiations and better theories. Design research is iterative by nature, and the authors did iterate the design but not through the same group of respondents each time. The method is also better at testing a reality first created by the researcher. In the case of this research the authors followed a more traditional approach of reviewing the literature, synthesising a model and then testing it. The methodology does not invalidate their research, but it does call into question its choices.

The model was evaluated in Sweden and this has several implications for validity. Geographically it may be questioned whether the results can be generalised, notwithstanding the single organisation the theory was tested in. Nor could the research completely test the socio-cultural and ontological issues that plague distributed development (section 3.1.3), the social aspects to perceptions of risk (section 3.1.4) and the full extent of globalisation that the authors propose in their introduction as a driver for improving risk management in distributed environments. Again these issues do not necessarily invalidate the research, but do emphasise the need to inspect the underpinnings and properly test the model.

More importantly, the model was not applied to a real project. The researchers chose to use expert opinion, a Delphi-type approach, and discuss the model in a workshop setting and later in interviews. Although the participants were experts from the company, the failure to test the model in a real application and through a complete project lifecycle is of concern and calls into question its validity. The authors admit that the model needs to be “*expanded and validated outside IBM*”, so any subsequent research based on this model needs to be cautious.

### 3.4.3 Description of the DRiMaP model

The *DRiMaP* model provided by the authors consists of four key areas; the roles and responsibilities, the development process model called the *Business Cycle*, the risk management process within the Business Cycle, and the distribution aspects.

**DRiMaP roles** are numerous, and include both risk management and project roles. The risk management roles consist of the risk manager, prospect manager, project manager, internal risk manager, the risk management forum (RMF), the RMF chairman, subject matter expert and the customer. The number and variety of roles raises the question whether the model can easily be ported to other environments and organisations where changing or adding roles will generate resistance or unfamiliarity with job descriptions and responsibilities. This would be particularly true where a number of peer organisations are involved and it would not be possible for one company to impose organisation structures on the others. It also suggests there would be training requirements at project inception, and a learning curve for new partners and combinations of partners.

The **Business Cycle** describes the whole process and all organisation levels involved. The key phases are identify business opportunity, analyse business opportunity, design solution, create a tender, negotiate a contract, implementation, delivery and project termination. This corresponds roughly with the SDLC described in section 3.2.7, but it does not correlate with other lifecycles such as iterative and Agile that are mentioned in section 3.1.2. The authors do provide for iterations by offering a loop between implementation and delivery, and admit this as an issue in the limitations offered in the conclusion. It remains to be confirmed whether this cycle is acceptable to customers with more unusual purchase, contract and project delivery requirements.

**Risk management** is tightly integrated with the business lifecycle and comprises five different process steps; pre-study of risks, management of technical and delivery risks, management of tender risks, management of project risks and continuous risk management. Other risk management approaches would treat these as categories of risks, and the one novelty is that this model provides different processes for each. The authors offer communication mechanisms for project risks and distributed risk management that provide opportunities for collaboration, centralised administration, centralised control and governance – although the authors do not spell these functions out. Again the scope and scale of the processes is large and may appear daunting when trying to justify the expense of risk management on an enterprise scale to the project sponsors.

### 3.4.4 Implementation of DRiMaP

The authors do not provide much assistance for organisations wish to adopt the model. As mentioned, the model requires considerable change in the organisation structure, people, processes and possibly even development methods, project management methodology, purchasing and contracts management. The authors did not appear to take these issues into account when designing the model, and the result is the model may require the organisation to adapt to the model not the other way round. This could have considerable change management implications, forcing organisations who work with IBM or any lead partner using the model to adapt at some expense and lost time. The authors do need to address the needs of smaller project participants – particularly since information technology often requires the skills of niche specialist vendors.

### 3.4.5 Conclusions about the original DRiMaP research

The authors reported that the tacit approach to implementation of the model led to the situation where the *“risk management process was not uniformly managed across the collaborating companies.”* Another shortcoming they specifically identify is insufficient and inconsistent documentation.

The authors discuss problems they had in developing model whilst encountering jargon. These appear to be the ontological barriers that Sunagawa *et al.* (2003) talk about, as reported in section 3.1.3. In their final remarks, the authors also propose a number of areas of potential research interest that they suggest *“may require substantial research effort”*:

- Efficiency of the risk management forum in a distributed context.
- Scalability of the model.
- The relationship between risk management and crisis management.
- Use of the model in joint ventures.
- Placement of risk classes on the business cycle phases and strategic levels.
- Placement of risk classes on support levels.
- The use of the model in agile software development.



### 3.4.6 Comparisons with other models

Evaluation of the *DRiMaP* model against the TCS, Microsoft, and Infosys models that are described in section 3.3.5 reveals the *DRiMaP* model is clearly better - but does have shortcomings. Table 6 below provides a summarised comparison against the models describe.

Factor	DRiMaP	Microsoft	TCS	Infosys
<i>Models and shape of reaction</i>	Communication about risk	Planning and maintaining	Regulation and value	Comprehensive
<i>Control and monitoring the risk</i>	Roles	Effectiveness	Risk probability	Avoid concentration of revenue
<i>Risk management approach</i>	Collaboration	Seeks holistic approach	Set targets	Governance, transparency
<i>Risk management model</i>	Integrated with business cycle	Plans risk data gathering, gathers risk and then prioritise risk.	Value and KPIs	Vision and strategy
<i>Risk management control</i>	Continuous, RMF	Control solutions developed in process	Corporate social responsibility	Organisation objectives
<i>Environmental consideration within the models</i>	As raised by the business	None, model concentrates on operational process	Environmental risks included	Events to deal with these issues

*Table 6. Risk management model comparison*

It is clear that *DRiMaP* uses collaboration and the cumulative efforts of individual entities and participants to achieve more effective risk management. Integration with the business cycle allows risk management to respond to whatever objectives the business has chosen. The Risk Management Forum and operational risk structures allow the project leadership to choose the level and focus of risk management that they deem to be the most suitable. This approach is flexible and responsive to the needs of different business strategies, but it is perhaps not prescriptive enough to be used for governance.

## 3.5 CHAPTER SUMMARY

This chapter provides an extended literature review covering concepts and theory related to risk management; including risk, risk management, crisis management and the concepts of projects, project failure, information technology and loss distribution. The chapter reviews a number of models and frameworks that propose to manage risks, and focuses in particular on the *DRiMaP* model used by IBM.

This literature review partially answers the research problem by finding a conceptually sound model and practical method of managing risk in the form of DRiMaP. The chapter also partially addresses the research questions in determining key criteria for successful risk management in distributed environments, finding ways to improve risk monitoring and crisis management, and examining and comparing some of the major risk management models. In so doing the objective of identifying and assessing suitable risk management models and frameworks is satisfied.

This chapter did not assess the DRiMaP model for its gaps and shortcomings. The following chapter will examine these issues in more detail and propose improvements and extensions to the *DRiMaP* model. It will also critically analyse, expose and explore the new model along with its gaps, shortcomings and benefits in terms of the industry and theoretical issues identified by this literature review.

## CHAPTER 4 .. IMPROVING DRiMAP

The preceding chapter studied a range of models and frameworks, and found the Distributed Risk Management Process Model (*DRiMaP*) by Kajko-Mattsson *et al.* (2005) to be the most suited to managing risk in distributed development environments. It is not a perfect fit however, and limitations were discovered that have to be overcome to satisfy the research questions and goals. This chapter examines these limitations and proposes novel improvements and extensions to that model, producing the *Evolutionary Model* that may be implemented as a management system and will be assessed in subsequent chapters.

### 4.1 DRiMAP SHORTCOMINGS

The discussion of risk management in the previous chapter identified several critical requirements of distributed environments, as well as a number of shortcomings in the various risk management models. This section identifies potential shortcomings of the *DRiMaP* model.

*DRiMaP* shortcomings were identified in four ways; shortcomings identified by the authors themselves (discussed in section 3.4.5), by comparing *DRiMaP's* features to those offered by other models, by assessing *DRiMaP's* ability to function as intended in a distributed environment, and assessing the model in terms of user requirements elicited in the survey and structured interviews.

- Methodological shortcomings:
  - Limited testing in diverse geographical and socio-cultural environments.
  - Limited testing of temporal separation.
  - Limited testing through the entire lifecycle.
  - A need to validate the model outside of IBM.
  - Failure to define a distributed development environment.
- Structural issues:
  - The large numbers of defined roles make it inflexible and difficult to adapt (section 3.4.3).
  - Limited ability to handle an iterative SDLC (section 3.4.5).
  - Lack of ability to manage a common ontology (section 3.1.3).
  - Does not thoroughly describe communications mechanisms.

- Scalability of the model (section 3.4.5).
- Does not address temporal issues sufficiently (section 3.4.2).
- Placement of risk classes is not comprehensively thought out (section 3.4.5.)
- Limited testing through the entire lifecycle.
- Need for greater focus on governance and planning (from the table in section 3.4.6).
- Need for greater focus on effectiveness and value (table in section 3.4.6).
- No provision for crisis management (section 3.1.6).
- Insufficient provision for continuous risk management.
- Insufficient provision for migrating risk from one project participant to another.
- The requirements of large projects (section 3.2.6); including multiple decision makers, the relationships between project phases, learning from other projects, improved communication, excess optimism in the early stages, long project lifecycles and lack of standardisation between participants.
- The need to protect information (section 3.2.8).
- Implementation:
  - The model requires the organisation to adapt to the model, not visa-versa (section 3.4.4).
  - Overcoming organisation resistance to new ways of working (section 3.4.3).
  - It may be too unwieldy and inflexible to meet the needs of smaller participants.
  - The use in joint ventures has not been explored (section 3.4.5).
  - Training in the new model.

The critical review of the *DRiMaP* model and the wide and intensive study of existing publications within the proposed topic domain of the proposed work lead to the deduction that the distributed risk management model had an edge over other models but there were a number of shortcomings and limitations that ought to be improved. *DRiMaP* extensions proposed by this research may not address all of these shortcomings, and some points may be partly or wholly ignored.

Research hypotheses are presented here for several reasons. They provide a foundation for the core improvements needed, may be used as objectives in order to prioritise and select which modifications to make, and may be used as broad tests of the model.

**H1: Risk management process steps will help the IT organisation to improve the quality of their outputs.**

Information Technology companies aim to deliver value with little risk by creating capabilities and outcomes for their organisation. Wallace *et al.* (2004) explained that most real projects are strongly linked to various rewards within the organisation. DRiMaP improvements will target risk-management processes that could help software developers, project managers and senior business manager to evaluate and plan business prospects in a cost-effective manner.

**H2: Adopting risk management techniques will help solve internal issues as well as complex work environments across the globe.**

IT companies that are collaborating through risk management according to the Higuera and Haimes (1996) framework (Figure 10) will tend to operate more efficiently and effectively. DRiMaP extensions will focus on collaboration and inter-relationships to achieve this.

**H3: A risk management model should help IT industries solve and mitigate risks.**

Distributed networks among companies have grown immensely and this has affected the successful delivery of information technology projects, many of which not achieving their objectives (Gordon, 1999). Assertions that DRiMaP or its improvements can solve these problems have to be tested.

**H4: The relationship between risk management and crisis management is a critical element of risk management.**

Crisis management has been identified as a critical element of risk management (section 3.1.6). Few companies are aware of this and make adequate plans, so the relationship must be explored and the ability of the improved model to respond must be tested. Vertical and horizontal linkages between operational and strategic layers (Figure 9) need to be accommodated and then examined.

**H5: Good crisis prevention in the workplace will improve project outputs through the use of suitable communication techniques and methods.**

Paying more attention to dramatic and newsworthy situations will provide benefits in the areas of communication and collaboration. A suitable model will assist with this and prevent serious damage to the business. This will involve improving and testing of communication elements of the model.

## **4.2 OVERVIEW OF DRiMAP EXTENSIONS AND MODIFICATIONS**

The distributed risk management process model (*DRiMaP*) was carefully reviewed in section 3.4 and its shortcomings identified in section 4.1. Improvements that are referred to as *DRiMaP extensions* were made to the model to overcome the shortcomings, test the hypotheses and achieve the research aims and objectives. This section describes these extensions, and from this point onward the original DRiMaP model is used purely for reference and study.

### **4.2.1 Model of extensions**

Extensions to *DRiMaP* began with the risk management approach suggested by Misra *et al.* (2007), leading to the inclusion of the migration risk strategy and mitigation risk strategy for the purpose of distribution risk control. Phased input, managed project risk and alerts were added to deliver continuous risk management. Risk assessment and risk control were extended considerably to improve the risk management function.

The analysis and design of these extensions was undertaken using UML (unified modelling language). Concepts and entities discovered during the study of DRiMaP and reviewing literature review were added and modified. The high-level model presented in Figure 17 below emerged, consisting of four parts and a number of functions. The parts are as follows.

- Part A of the diagram includes the must-do processes for management of risk in IT projects. These are present in concept in the original *DRiMaP* model.
- Part B consists of the Migration and Mitigation Risk Strategies, Phased Input and Management modules that form the core novel extensions that are not part of the original *DRiMaP*.
- Parts C and D include Risk Mitigation Processes that are drawn from Misra *et al.*'s risk management approach.

- Part D contains corresponding outputs, called the Risk Assessment Output (RAO) and Risk Control Output (RCO) that are channelled into the Alert Module.

Selected elements of the model of extensions will now be elaborated on, and further details may be found in Appendix E.

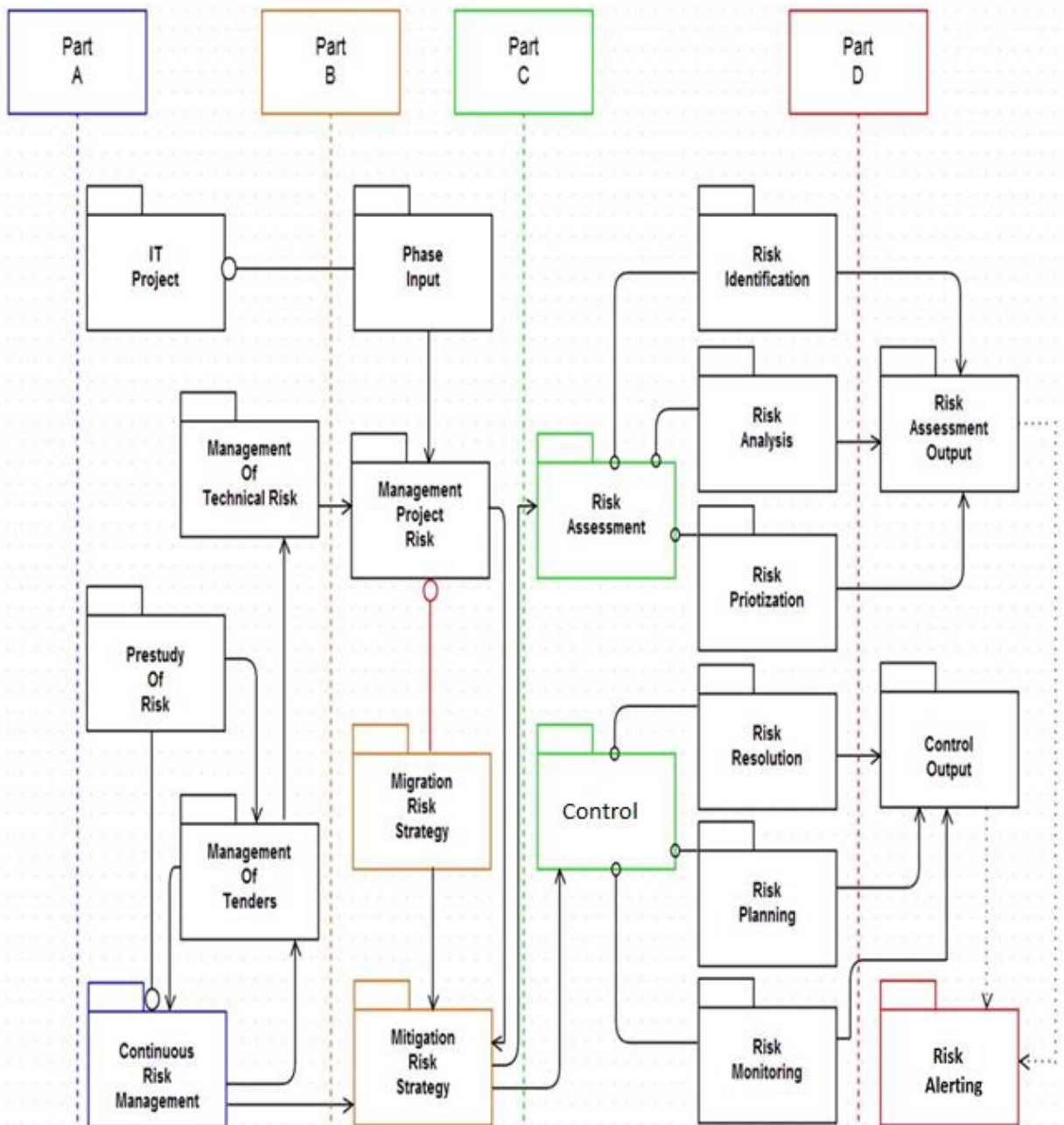


Figure 17. Model of extensions

### **4.2.2 The IT project**

The IT project is the element of the model that depicts any creative and initiated information technology endeavour with innovative or improved functionality and which has a start and end date of development. The IT project can be controlled, planned for, that can be used or adopted by users, and above all constrained by resources. This project is passed into the model through the phase input, where the nature of the project is identified internally.

### **4.2.3 Management of tenders**

This is an extension specific to the tendering or procurement phase of an IT project. It has been included because it is during this phase that many perceptions, conditions and of course requirements are set that later affect the management of risk. Projects that are identified as tenders require approval for further development after careful pre-study of risk management processes.

### **4.2.4 Phase input**

The Phase Input is an innovation that depicts the phase of the IT project lifecycle that is to fall under risk management. This element includes all functions that are particular to each phase.

### **4.2.5 Continuous risk management**

This was identified as a primary risk management improvement. Continuous risk management (CRM) is needed to safeguard projects throughout their lifecycle from present and future risk that may result due to the change in technology of the environment where the project is been used or deployed. CRM ensures the clients' asset, in the context of client-service-provider relationship, is consistently secured, and that the provider provides Business Continuity Procedure (BCP) documents along with the project to do this.

### **4.2.6 Migration risk strategy**

*Migration* in this context refers to the movement of IT projects or technology from developer to user and other participants through the medium of procurement and development. Migration of such technology through the lifecycle tends to be accompanied by risk which can be difficult to identify. In some cases, migration could mean transferring of an IT project from an older platform to newer, flexible, cost-effective platforms.



Other typical examples of migration are moving software from one platform to another; migration of data from one data source to another source - such as the migration of data from an Oracle database to Microsoft SQLServer; migration of a custom-written application between projects managers and developers at different geographical location.

*Migration risk strategy* in this project refers to the approach used to control associated risk that accompanies software development and implementation as the project is migrated, where locations of development team and project managers are geographically separated.

#### **4.2.7 Mitigation risk strategy**

*Mitigation* was discussed in section 3.2.5 as a response to perceived risk, and it practically involves employing a risk management process to limit or counteract a risk with prioritisation as the focus. Risk management is quite expensive, and it is therefore imperative to deal with risks identified rather than respond to unexpected problems. Blum and Bruce (1992) stressed that planning ahead of the occurrence of the risk is advisable and easier to circumvent than any unexpected problem. *Mitigation strategy* in this context is an approach to determining the most critical risks as considered during assessment and prioritisation. The mitigation strategy deals with risk of relative importance, so the impact of such risk must be quantified. Its primary objective should be to circumvent the occurrence of assessed and prioritised risks by employing an appropriate risk management process or practice.

#### **4.2.8 Implementing risk strategies**

The two risk strategies are vital for the management and mitigation of risks during IT project development. Implementation is important, so this section will briefly describe the extensions model in further detail in this area.

Technically these become core APIs that are responsible for risk management. This layer implements the following classes which are defined and named in-line with the core functions of the risk management system. The mitigation strategy uses the data stored about a project to conduct assessment and control using the subclasses identified in the diagram and output the result of each subclass through Assessment Output and Control Output classes.

The Assessment Output class return a string message object created internally into the Alert Module which returns the final output by sending the alert message out in the form of email to the users (i.e. the assigned project managers) in charge of the project. The figure 18 below is referred to as mitigation process which is adopted by migration strategy to mitigate migrated risks.

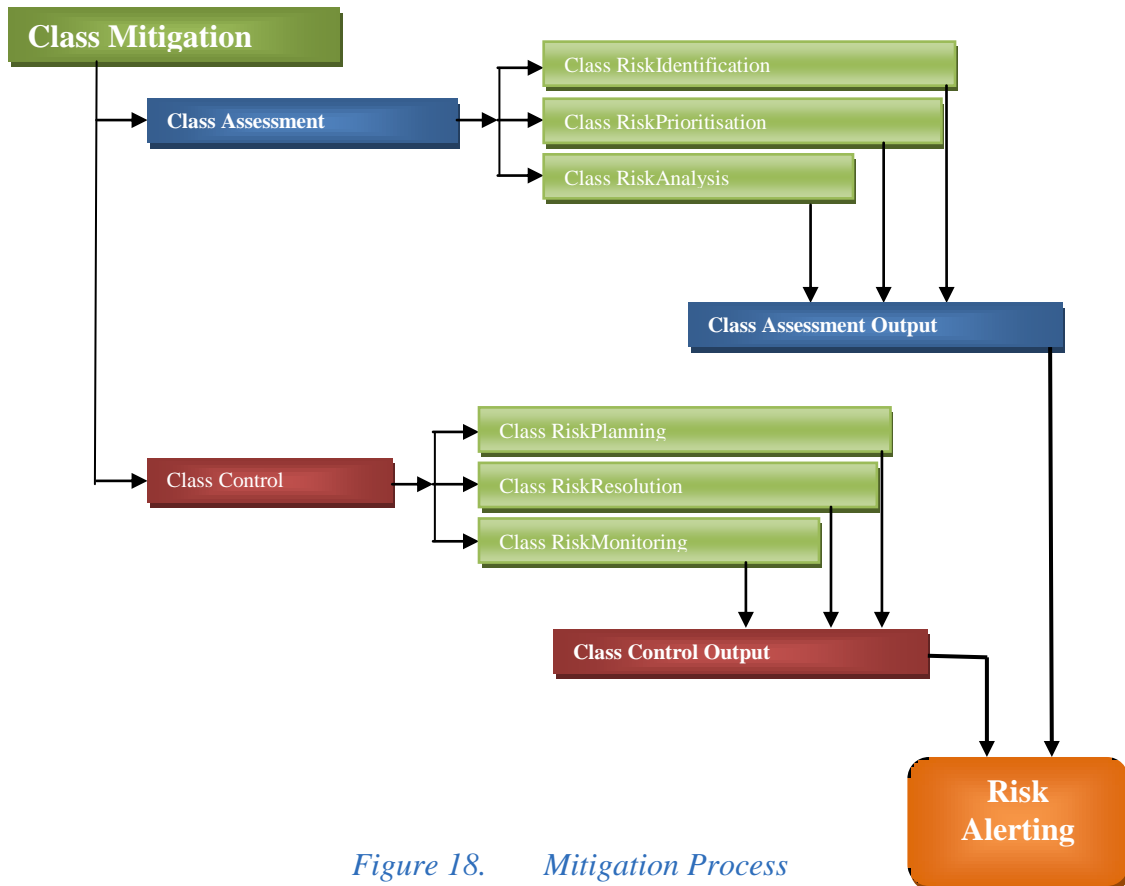


Figure 18. Mitigation Process

#### 4.2.9 The risk alerting

The risk alerting represents the entire model's output channel, the point of dissemination to the external environment. The results of identification, prioritisation and analysis are aggregated into one output called the Risk Assessment Output (RAO). Equally, the Risk Control Output (RCO) depicts a combination of outputs from resolution, planning, and monitoring. These outputs are then channelled into the Alert module.

An alert is triggered when a new item is added to the phase, when a deadline is reached or when a project is assigned to a user.

Implementation of the alert module is discussed in section 4.4.15.

### 4.3 THE EVOLUTIONARY MODEL

The extensions are required functionality described as a set of modules. Individual modules and the relationships between them need to be drawn together in a theoretical model. This section describes the *Evolutionary Model* that emerged from the extensions, and that will underpin this thesis. This model is novel, and is intended to fulfil the aims, objectives and hypotheses.

The *Evolutionary Model* comprises three essential components that are driven in real-time, and intended to be used by decision-makers to make informed decisions. Each component is composed of modules and external/internal relationships between them that define the properties and behaviours of the model. This section presents the model, illustrated in Figure 19 below, and describes the three components in the following subsections.

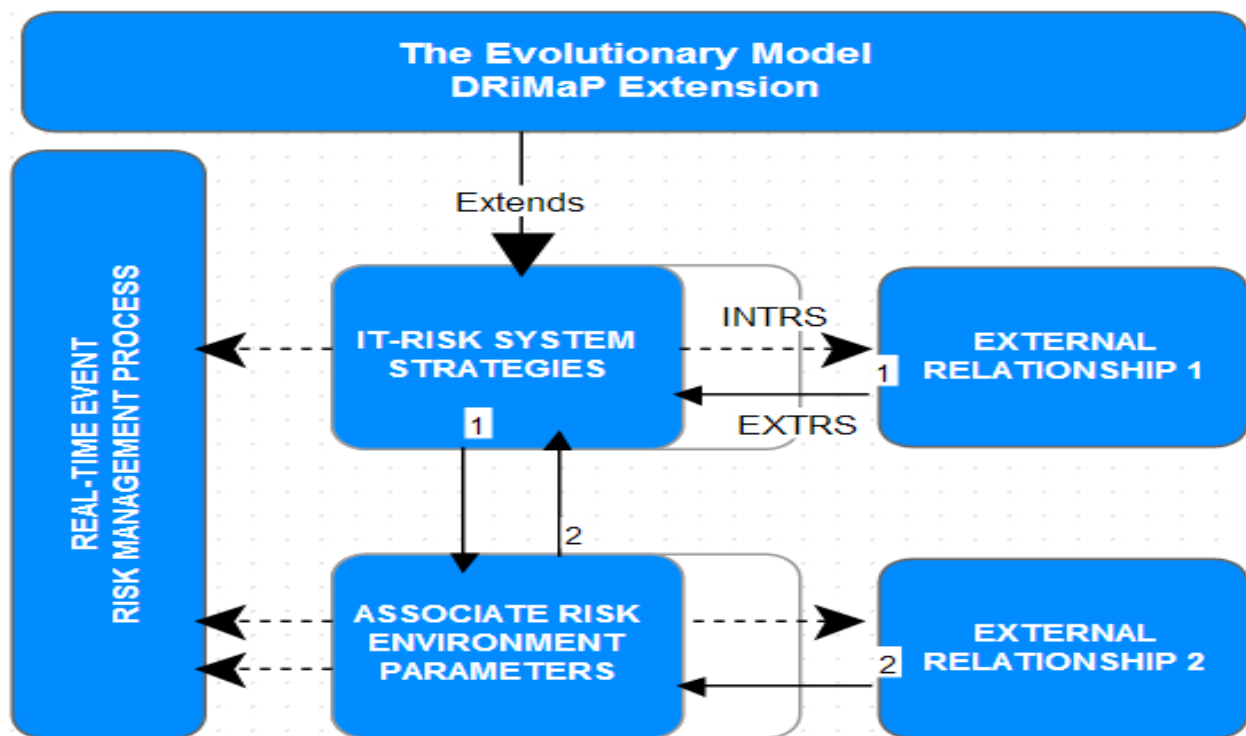


Figure 19. The Evolutionary Model

4.3.1 Associate risk parameters (ARP)

This component is comprised of key variables of time, cost and quality that are used and analysed by decision-makers. The variables are also internally related through relationships (INTRS). These relationships, shown as INTRS5-8 in Figure 20 bellow, may be regarded as the impact of a potential risk in the project, phase or phase item at a given point in time.

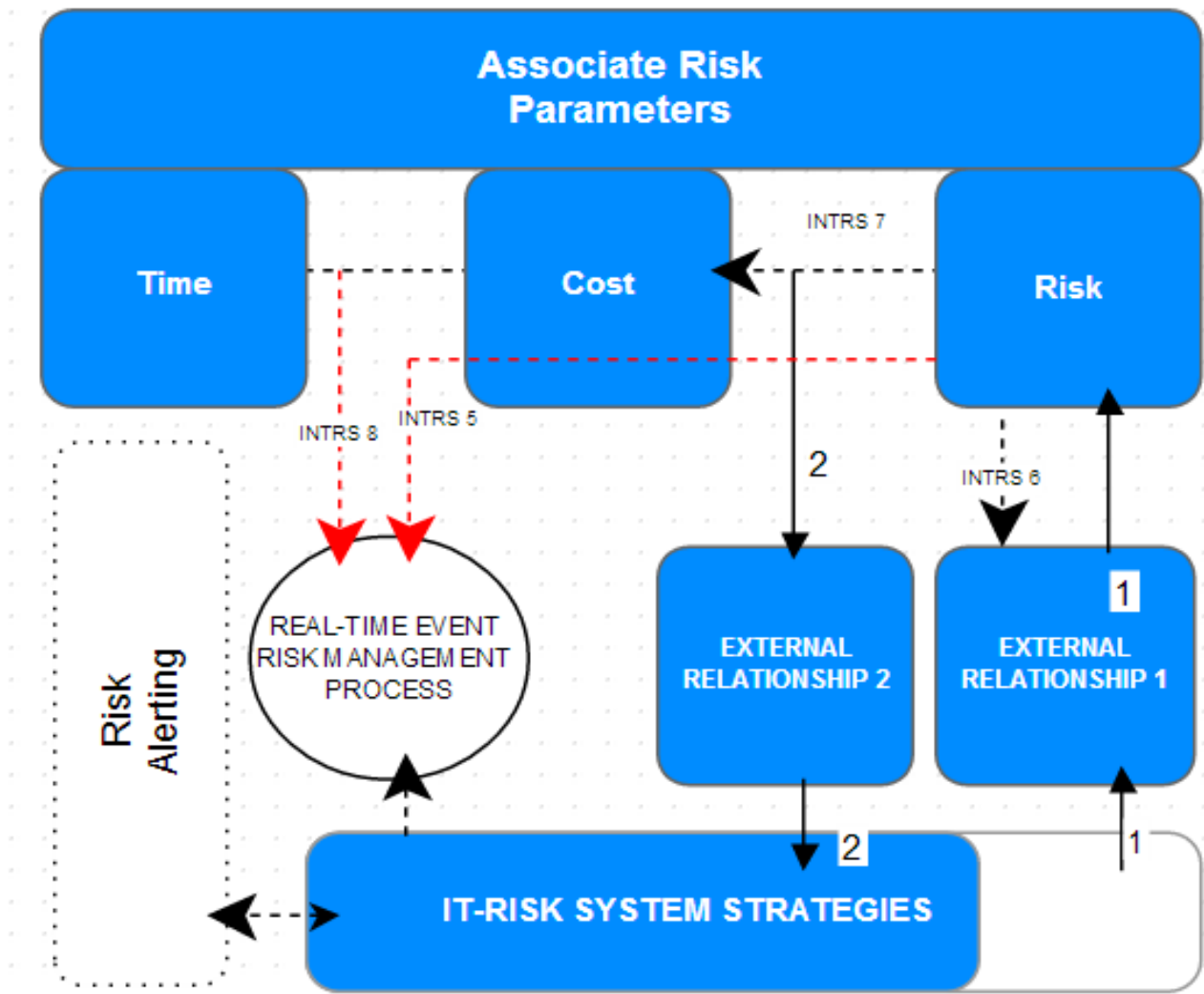


Figure 20. The Evolutionary Model ARP

The impact may be calculated in terms of cost or time at any point in time along the curve. Relationships can be expressed mathematically as well as graphically. For internal-relationships

INTRS6 and INTRS7:

**Probability of risk occurring P(X):**

Where: if  $\sum P(x) = 1$  or 100% then the event will happen,

$$n \in \mathbb{N} \text{ (natural numbers),}$$

$$x_1 \dots x_n \in \mathbb{N} \text{ (natural numbers),}$$

$$P(X) \in \mathbb{R} \text{ (real numbers)}$$

$$P(X) = P(x_1, x_2, x_3 \dots x_n)$$

$$\sum P(X) = P(x_1) + P(x_2) + P(x_3) + \dots P(x_n)$$

$$0 < P(x_n) < 1$$

Probability is graphically represented as the X-axis.

**Cost of the probability C(Y):** the cost if a risk occurs at the point  $\{P(x), C(y)\}$

Where:  $\sum C(Y) =$  the total cost of project,

$$n \in \mathbb{N},$$

$$y_1 \dots y_n \in \mathbb{N},$$

$$C(Y) \in \mathbb{R},$$

$$C(Y) = C(y_1, y_2, y_3 \dots y_n)$$

$$\sum C(Y) = C(y_1) + C(y_2) + C(y_3) + \dots C(y_n)$$

Cost is graphically represented on the Y-axis.

Consequentially:

- INTRS6 is any point on the curve:  $\{P(X), C(Y)\}$
- INTRS6 is any point in  $(\{P(x_1), C(y_1)\}, \{P(x_2), C(y_2)\}, \{P(x_3), C(y_3)\} \dots \{P(x_n), C(y_n)\})$

### 4.3.2 Activity report

The figure 21 below shows deadline against cost on x-axis. X-axis, in this context, is referred to the horizontal plotting of Cost which is measure in Great Britain Pound sterling (£). However, it can be referred to as Cost axis. Equally, the Y-axis is referred to deadline axis which is measured as number of days for completing and delivering the project in question:



Figure 21. DRiMaP reporting activity

The DRiMaP Task creates the activity records which generate the curve above. However, every 24 hours, the DRiMaP Task runs using bottom up approach execution order in aggregated form. It checks the deadlines across all the entities: phase item, phase, and project, and increases cost accordingly. See page 95, section 4.5.2 & figure 35 for additional information.

**Internal Computation:** The tables below and examples represent the internal computation that generates the curves above. Though, the examples here just reflect how the values are computed. The following are the parameters used in the computation:

- Estimated Cost
- Last updated Cost (£)
- Cost (£) per day
- Remaining Cost

**Estimated Cost:** This cost is referred to the cost estimate that would be readily available to finance the project to completion. At the point of configuring the project, the actual value of this cost is keyed in and percentage. A certain percentage of it is assigned to all the phases involves in the project. Equally, certain percentage of cost assigned to phase, is assigned to phase items.

Note, if the deadline elapsed, the risk records are plotted.

**Last updated Cost:** This is the internal cost parameter used to hold the previous total cost balance computed and is used to recompute another by checking the balance prior to computing. Note, if the balance is less than ZERO, then Risk Entry is created and corresponding cost is calculated. As seen in the curve above, when the curve touches the cost axis, at that point the deadline is zero (0 day), and the cost would be at maximum if and only if, the state of the entity in question is not signed off.

**Cost (£) charge per day:** This is cost charged per day on all the entities highlighted above. The calculation of this depends on the certain agreed percentage of the amount assigned to each entity and divided by the deadline. For example, see below computation:

Phase Daily Activity		
Estimated Phase Cost	Total Phase Cost	X % of Project Total Cost
Last Updated Phase Cost For each Day	Daily Phase Cost	£0
Cost Per Day	Cost Per Day	£0
Remaining Cost	R cost	T cost – (Cost Per Day + Prev Cost)

*Table 7. Phase functions*

**Day n = 1, DRiMaP Task computes**

Assuming:

$$\text{Total Phase Cost} = x\% \text{ of Project Total Cost}$$

$$\Rightarrow 10\% \text{ of } \pounds 100$$

$$\Rightarrow \pounds 10$$

$$\text{Daily Phase Cost} = \text{Total Phase Cost} / N \text{ days}$$

$$\Rightarrow \pounds 10 / 5$$

$$\Rightarrow \pounds 2$$

$$\text{Remaining Cost} = T \text{ cost} - (\text{Cost per Day})$$

$$\Rightarrow \pounds 10 - \pounds 2$$

$$\Rightarrow \pounds 8$$

**Day n = 2, DRiMaP Task computes**

$$\text{Remaining Cost} = T \text{ cost} - (\text{Cost per Day})$$

$$\Rightarrow \pounds 8 - \pounds 2$$

$$\Rightarrow \pounds 6$$

$\Rightarrow$  Until Remaining cost = 0. If remaining cost = negative value then a severe risk. See the table below:

	Days	Total Phase Cost £	Daily Phase Cost £	Remaining Cost £	Risk Level
<b>DRiMaP Task</b>	0	10	0	0	0
	1	8	2	8	low
	2	6	2	6	low
	3	4	2	4	low
	4	2	2	2	high
	5	0	2	0	high
	Note if deadline elapsed, and project isn't signed off Severe Risk Occurred i.e. And User is notified				
<b>DRiMaP Task</b>	6	-2	2	-2	Severe



*Table 8. Phase Daily Activity*

**Remaining cost:** This is referred to the overall balance of allocation assigned to the entity in question. Equally, if the remaining cost is less than the cost charge per day, then deadline is tending to zero, and the entity's state (i.e. phase) is not signed-off, then the risk level would be tending from high to severe.

**Summary:** Activity report for the following phase item, phase, and project is generated using the approach and example given above. However, Risk value, as stated above, is determined by the value of the remaining cost and the deadline. By default, the initial risk is zero. As DRiMaP Task runs, and the changing values of both deadline and cost change, the system checks the remaining cost to determine the risk on each entity. Equally important, risk entry is created if and only if the following occurred:

- If remaining cost is less than the cost charge per day
- If remaining cost is zero, and the entity's status is not signed-off

This is illustrated in the example graph in Figure 22 below. In this example, the total cost for this phase item in the project is £13000, at which point 100 % of the possible risk would have been encountered. INTRS6 {70 %, £9100} means that at 70 % probability, the cost of project risk would be £9100, phase risk would cost £2730 and phase-item cost would be £1092.

This example shows that stakeholders or decision-makers can make well informed decisions using these relationships.

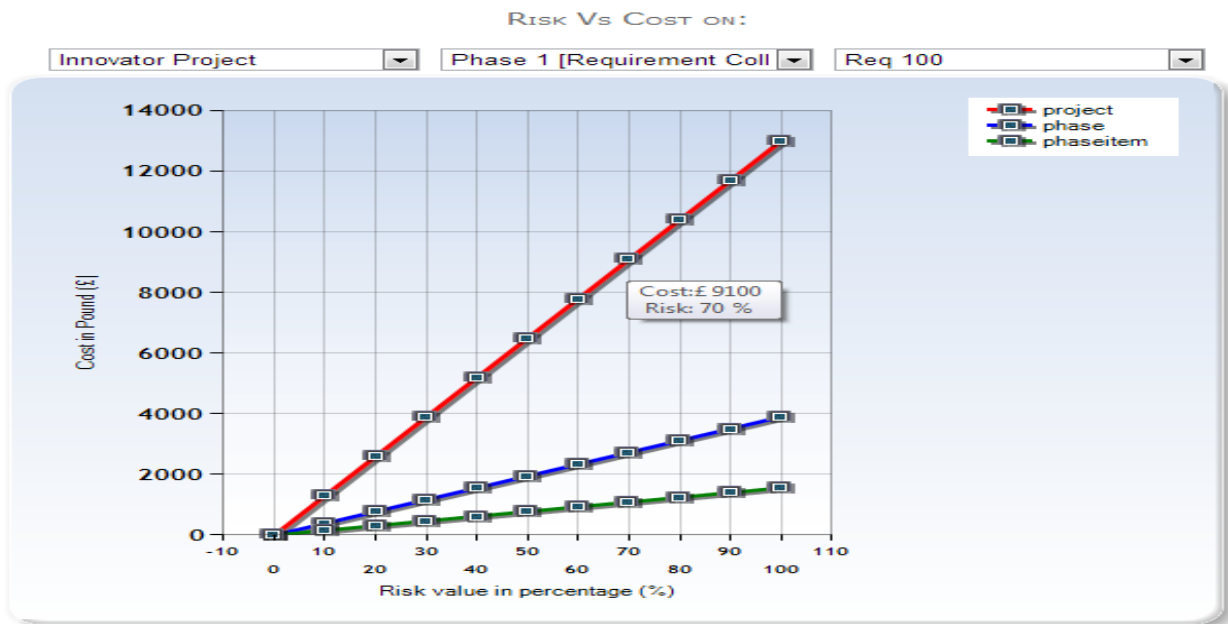


Figure 22. Illustration of risk versus cost curve

The figure above,  $P(x)$  is referred to the RISK VALUE computed in percentage. And the corresponding  $C(y)$  is referred to the COST (£) charged for the every occurrence of the risk as shown in the graph above. In mathematics, a point is referred to  $(x, y)$ . However, in this context  $\{P(x), C(y)\}$  on the curve, a point, for example, at which Cost (£) is £9100 and Risk value is 70% or 0.70.

Note, equally, the cost charged for the occurrence of risk can be determined along the curves in the diagram above.

Also, instance of  $X$ , depicts any value along “Risk Value in percentage” plotted against cost. Equally,  $X$  defines any given real numbers that define the band of risk level. For instance, probability of  $x$  or Risk Value i.e.  $P(x)$  as shown below:

$$P(x) = 0 < x < 100 \quad \text{where } P(x) \text{ is the probability of } x \text{ where } x \in R$$

However, if  $0 < x < 40$  then risk band defined is “low”

If  $40 \geq x < 70$  then risk band is “high”

If  $70 \geq x < 100$  then risk band is severe

Equally, Y is any given monetary values measured in Great Britain Pound. However, from the paragraph above, understanding of C(y) and P(x) would guide in the understanding of these mathematical notations:

**Example from the curve on figure 22:**

If the risk is P(x) 0.70 or 70 % then C(y) = £9100

⇒ {P(x), C(y)} = {70 %, £9100} this refers to a point on the project curve. See the diagram in figure 21.

**Note** at any point on the curve in figure 22, for each curve represented i.e. project curve, phase curve, and phase item curve, every point represent risk and corresponding cost. Equally, X and Y axis are general mathematical depiction of points in any given graph. And it is used so that readers would quickly understand and grasped the concept of this explanation. However, X – axis, in this context is Risk axis while Y – axis is a Cost axis.

**Example:** When you have range of values like  $40 \geq x < 70$ , this defined any value greater than or equal to 40 but less than 70 but not less than 40. I didn't mean this  $x \leq 40$ .

What does P(x) 0.70 mean? 70% chance of what event?

For any give probability falls  $0.4 \geq x < 0.7$  defines high risk. When such probability occurs, DRiMaP task computes high risk. The event that occurs would be to generate risk activities.

What does c(y) = £9,100 mean? The loss if the event occurs?

The c(y) refers to the cost computed when the probability occurs i.e. 0.7. And times two of it is payable to continue running the project.

Cost of preventing the event? To avoid the risk event to continue re-occurring, 2 times c(y) must be paid at once.

INTRS8 and INTRS5 define the relationships that exist between ARP and the Real-Time Event Risk Management Process (RTEMP). These are external versions of the internal relationships of INTRS6 and INTRS7. In this case the change in cost (C) with respect to time (t) when risk occurs on a project. It can be expressed as a function (f) that can be defined as the derivative of cost and time. Computation of DRiMaP Task one of the components presented. This component runs on Time and generates activities and recomputed the cost at that point in time (t). See the example below, in the example:

$$f(t) = \frac{dC}{dt}$$

Where dC is the change in cost with respect to time, tagged as deadline dt. Therefore INTRS6  $\equiv$  INTRS5, the only difference being that INTRS5 is a parameter passed into the real-time evolutionary event process (and which may be graphed on the chart for decision makers). Also, INTRS7  $\equiv$  INTRS8, and similarly used as INTRS5. The above formula addressed the computation of DRiMaP Task one of the components presented. This component runs on time and generates activities and recomputed the cost at that point in time (t). See the examples below:

<b>Daily Activity</b>		
Estimated Project Cost	Project Total Cost	£100
Last Updated Cost For each Day	Cost Balance	£0
Cost Per Day	Cost Per Day	£0
Remaining Cost	R cost	Project Total Cost – (Cost Per Day + Prev Cost)
Project Deadline in Days	Deadline	5

*Table 9. Risk versus cost functions*

**Note: see the day as time value, Day n = 1 at 7pm, DRiMaP Task runs and computes,**

**dc = change in Cost as Time changes i.e. deadline**

Cost per Day = Project Total Cost/ N days on Day n = 1

$$\Rightarrow \text{£}100/5$$

$$\Rightarrow \text{£}20$$

: - dc = Project Total Cost – Cost Per day

$$\Rightarrow \text{£}100 - \text{£}20$$

$$\Rightarrow \text{£}80$$

Also,

dt = change in time (measure by change in deadline)

Give N days as deadline in the table above

dt = N days – n

$$\Rightarrow 5 - 1$$

$$\Rightarrow 4$$

f( t) = dc/dt

$$\Rightarrow \text{£}80/4$$

$$\Rightarrow \text{£}20$$

**When n= 2, Cost Per Day = £20, N days =5**

$$dc = \text{£}80 - \text{£}20$$

$$\Rightarrow \text{£}60$$

Also, dt = N days – n

$$\Rightarrow dt = 5 - 2$$

$$\Rightarrow dt = 3$$

f(t) = dc/dt

$$\Rightarrow f(t) = \text{£}60/3$$

$$\Rightarrow \text{£}20$$

**When  $n= 3$ , Cost Per Day = £20, N days =5**

$$dc = £60 - £20$$

$$\Rightarrow £40$$

$$\text{Also, } dt = N \text{ days} - n$$

$$\Rightarrow dt = 5 - 3$$

$$\Rightarrow dt = 2$$

$$f(t) = dc/dt$$

$$\Rightarrow f(t) = £40/2$$

$$\Rightarrow f(t) = £20$$

**When  $n= 4$ , Cost Per Day = £20, N days =5**

$$dc = £40 - £20$$

$$\Rightarrow £20$$

$$\text{Also, } dt = N \text{ days} - n$$

$$\Rightarrow dt = 5 - 4$$

$$\Rightarrow dt = 1$$

$$f(t) = dc/dt$$

$$\Rightarrow f(t) = £20/1$$

$$\Rightarrow f(t) = £20$$

**When  $n= 5$ , Cost Per Day = £20, N days =5**

$$dc = £20 - £20$$

$$\Rightarrow £0$$

$$\text{Also, } dt = N \text{ days} - n$$

$$\Rightarrow dt = 5 - 5$$

$$\Rightarrow dt = 0$$

$$f(c) = dc/dt$$

$$\Rightarrow f(t) = £0/0$$

$$\Rightarrow f(t) = £0$$

	<b>N days</b>	<b>n</b>	<b>Total Project Cost £</b>	<b>Cost Per Day(£)</b>	<b>dc (£)</b>	<b>Dt (time)</b>
<b>DRiMaP Task</b>	5	0	100	0	0	0
	5	1	100	20	80	4
	5	2	80	20	60	60
	5	3	60	20	40	40
	5	4	40	20	20	20
	<b>Deadline</b>	<b>5</b>	<b>5</b>	<b>20</b>	<b>20</b>	<b>0</b>
	5	6	0	20	-20	-1
	5	7	-20	20	-40	-2

*Table 10. Risk versus cost functions*

From the table above, change in cost (dc) is the difference in cost which can be obtained internally from Remaining Cost = Remaining Cost – Cost Per day

Dc = Remaining Cost

While change in time (dt) is the change in deadline which is measure in days. However,

$$f(t) = \frac{dC}{dt}$$

Deadline elapsed, project reached completion if signed-off else it's running at loss, to bring it back 2 times the starting cost i.e. £200, will take It back to continue. I.e. Loss must be compensated and additional cost to re-run the project. However, f(t ) is defined as the derivatives of time with respect to cost. And it is obtainable, internally for decision-making purpose used by DRiMaP Task during creating activity for each entity in figure 22 to make decision about the cost and time. However, see the example above. And the internal parameters used in the computation.

Project Daily Activity		
Estimated Project Cost	Project Total Cost	£100
Last Updated Cost For each Day	Cost Balance	£0
Cost Per Day	Cost Per Day	£0
Remaining Cost	R cost	Project Total Cost – (Cost Per Day + Prev Cost)
Project Deadline in Days	Deadline	5

*Table 11. Project functions*

### Day n = 1, DRiMaP Task computes

Cost per Day = Project Total Cost/ N days

$$\Rightarrow \text{£}100/5$$

$$\Rightarrow \text{£}20$$

Cost Balance = Project Total Cost – Cost Per Day

$$\circ \text{£}100 - 20$$

$$\Rightarrow \text{£}80.00$$

### Day n = 2

Cost Balance = Cost Balance – Cost Per Day

$$\Rightarrow \text{£}80 - \text{£}20$$

$$\Rightarrow \text{£}60$$



	Days	Total Project Cost £	Cost Per Day £	Cost Balance £	Risk Level
<b>DRiMaP Task</b>	0	100	0	0	<b>0</b>
	1	80	20	80	<b>low</b>
	2	60	20	60	<b>low</b>
	3	40	20	40	<b>low</b>
	4	20	20	20	<b>high</b>
	5	0	20	20	<b>high</b>
	<b>Note if deadline elapsed, and project isn't signed off Severe Risk Occurred i.e. And User is notified</b>				
<b>DRiMaP Task</b>	6	-20	20	-20	<b>Severe</b>

Table 12. Project Daily Activity

<b>Phase Items Daily Activity</b>		
Estimated Phase Item Cost	Total Phase Item Cost	X% of Total Phase Cost
Last Updated Phase Item Cost For each Day	Daily Phase Item Cost	£0
Cost Per Day	Cost Per Day	£0
Remaining Cost	R cost	Total Phase Item Cost – Cost Per Day

Table 13. Phase item functions

**Day n = 1, DRiMaP Task computes**

Assuming:

Total Phase Item Cost = x% of Total Phase Cost

⇒ 10% of £10

⇒ £1.00

Daily Phase Item Cost = Total Phase Item Cost/ N days

⇒ £1/5

⇒ £0.2

Cost Charge on Phase Item per day Cost per Day = £0.2

Remaining Cost = Total Phase Item Cost – (Cost Per Day)

⇒ £1 – £0.2

⇒ £0.8

**Day n = 2, DRiMaP Task computes**

Remaining Cost = T cost – (Cost per Day)

⇒ £0.8– £0.2

⇒ £0.6

Until Remaining cost = 0. If remaining cost = negative value then risk occurs. See the table below:

	Days	Total Phase Item Cost £	Daily Phase Item Cost £	Remaining Cost £	Risk Level
<b>DRiMaP Task</b>	0	1	0	0	0
	1	0.8	0.2	8	low
	2	0.6	0.2	6	low
	3	0.4	0.2	4	low
	4	0.2	0.2	2	low
	5	0	0.2	0	low
	Note if deadline elapsed, and project isn't signed off Severe Risk Occurred i.e. And User is notified				
	6	-0.2	0.2	-0.2	high

*Table 14. Phase item Daily Activity*

### 4.3.3 Information technology risk system strategies (ITRSS)

Information Technology Risk System Strategies comprise two strategy components and a component which is referred to as the 'Alert', as well as four internal relationships (INTRS1, INTRS2, INTRS3, and INTRS4). These are illustrated in Figure 23 below.

The migration and mitigation components address the functionality described in sections 4.2.6 and 4.2.7 respectively. The alert function was discussed in section 4.2.9 above. Two of the relationships (INTRS3 and INTRS4) are functional used internally for mitigation purposes. These two relationships output to an event alert process INTRS9, and that is then disseminated as INTRS10. Equally important, INTRS1, 2, 3, 4, 9 and 10 relationships are used as communication parameters within the IT-risk system strategy component. INTRS2 is used as a migration parameter used to identify the source of the risk.

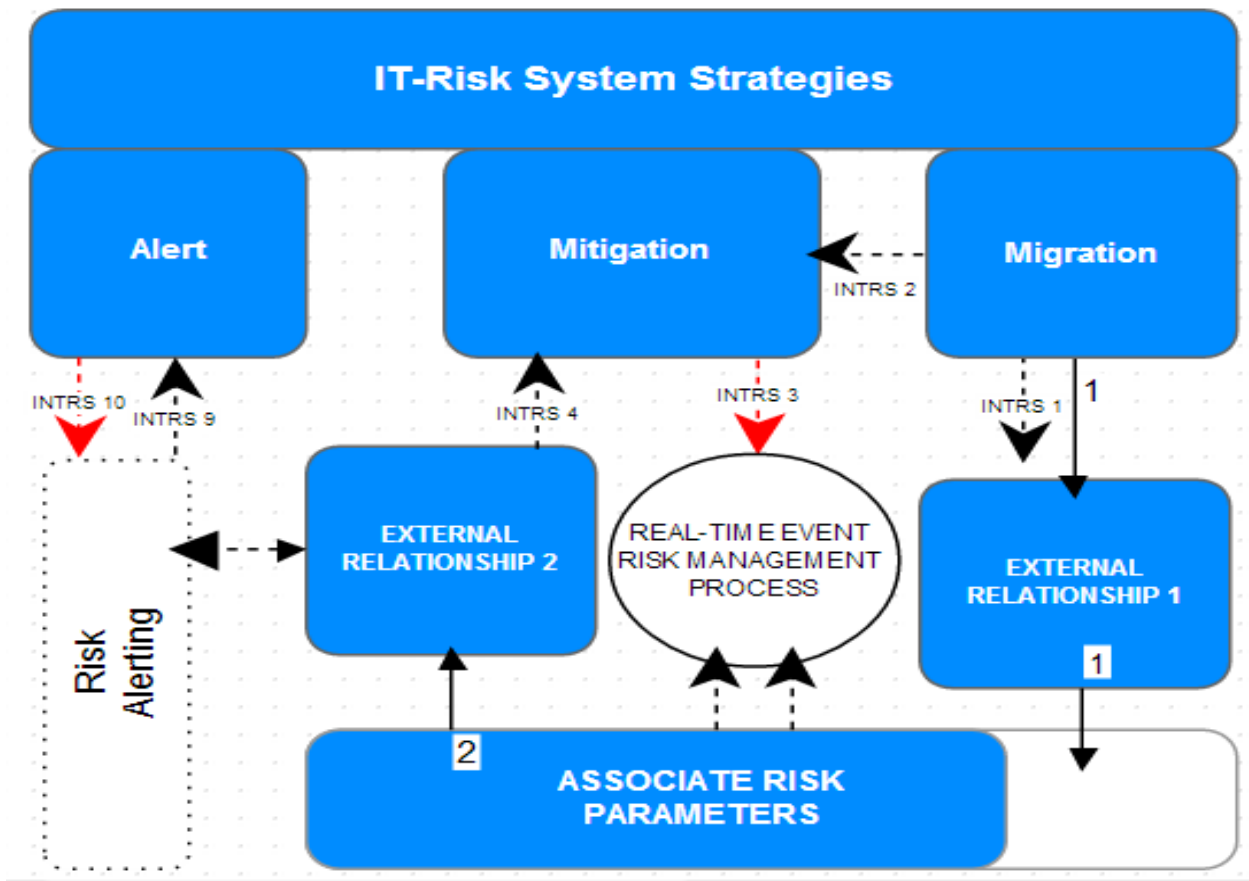


Figure 23. The Evolutionary Model ITRSS

INTRS1 is the output derived from the mitigation strategy for the project entity (Pe).

INTRS2 is defined as the type parameter over project entity (Pe), which can either be an internal or external type. It is passed to the mitigation process for mitigation. INTRS2 is passed along with other parameters from EXTRS-2 (aggregated inputs from Web GUI) into the IT-Risk System Strategies.

- $INTRS2 = \{type(Pe)\}$
- INTRS1 defined as the returned output from mitigation process. And it share a strong relationship with INTRS3

Given that:

- $INTRS3 = \{(Mo, e_1), (Mo, e_2), (Mo, e_3)\}$
- $INTRS2 = \{\text{type (Pe)}\}$  is passed as input for mitigation
- Then mitigation output of type (Pe) is defined as MoPe
- $Pe = e_1$
- $INTRS1 = (Mo, e_1)$
- Q.E.D

$INTRS3$  is the mitigation output  $O$  which is defined as  $\{o_1, o_2, o_3 \dots o_n\}$ . Equally,  $O$  can be any output as assessment output, identification output or control output at mitigation process level  $INTRS3$  is any mitigation output (Mo) on entity  $E$  as seen above:

- $Mo = \{mo_1, mo_2, mo_3, \dots mo_n\}$
- $Mo = \{mo_1, mo_2, mo_3, \dots mo_n\}$  on entity  $e_1$
- $Mo = \{mo_1, mo_2, mo_3, \dots mo_n\}$  on entity  $e_2$
- $Mo = \{mo_1, mo_2, mo_3, \dots mo_n\}$  on entity  $e_3$
- Output  $O = (Mo, e_n)$  where  $n \in N$

Consequently,  $INTRS3$  is defined as mitigation output on any given entity  $E$

- $INTRS3 = (Mo, E)$
- $INTRS3 = \{(Mo, e_1), (Mo, e_2), (Mo, e_3)\}$

$INTRS4$  is defined as mitigation parameter. Mathematically, let  $M$  be the mitigation process on the entity  $E$  (i.e. phase, phase item, or project) with output  $O$  which is synonymous in context to internal relationship  $INTRS9$  prior entry into the Alert component.  $M$  is defined on entity  $E$ , given that:

- $E = \{e_1, e_2, e_3\}$  where  $e_1 = \text{project}$ ,  $e_2 = \text{phase}$ ,  $e_3 = \text{phase item}$
- Mitigation  $M$  on  $\{e_1, e_2, e_3\}$  with output  $O$
- $M = \{m_1, m_2, m_3 \dots m_n\}$  with output  $O$
- $O = \{o_1, o_2, o_3 \dots o_n\}$
- $m_1$  on  $e_1$  with output  $o_1$  is defined as mitigation activity on  $e_1$

- $m_2$  on  $e_1$  with output  $o_2$  is defined as mitigation activity on  $e_1$
- $m_3$  on  $e_1$  with output  $o_3$  is defined as mitigation activity on  $e_1$
- ...  $m_n$  on  $e_1$  with output  $o_n$  is defined as mitigation activity on  $e_1$

From above:

- Mitigation activity ( $M_a$ ) is defined as  $(m_n, o_n, e_1)$  for entity 1
- Mitigation activity ( $M_a$ ) is defined as  $(m_n, o_n, e_2)$  for entity 2
- Mitigation activity ( $M_a$ ) is defined as  $(m_n, o_n, e_3)$  for entity 3

Consequently, INTRS9 is defined as Mitigation activity ( $M_a$ ) of any entity (E) rendered as input to the alert module for purposes of dissemination. This can be seen in the form of email generated by alert component, and the relationship is generated by the DRiMaPTask component in real time.

- $M_a e_1 = \{(m_1, o_1, e_1), (m_2, o_2, e_1), (m_3, o_3, e_1), \dots (m_n, o_n, e_1)\}$  for entity 1
- $M_a e_2 = \{(m_1, o_1, e_2), (m_2, o_2, e_2), (m_3, o_3, e_2), \dots (m_n, o_n, e_2)\}$  for entity 2
- $M_a e_3 = \{(m_1, o_1, e_3), (m_2, o_2, e_3), (m_3, o_3, e_3), \dots (m_n, o_n, e_3)\}$  for entity 3

Consequently:

- $INTRS9 = \{(M_a e_1), (M_a e_2), (M_a e_3)\}$  Note: Where  $n \in N$ , and the value of  $n$  is reached or determined when the signed-off state of any of these entities is true for  $e_1, e_2, e_3$ . The value of  $n = \text{COUNT}(M_a E)$  for any entity in question.
- $INTRS10 = \text{Transformation of INTRS9 for dissemination through alert component}$
- $INTRS10 = \wedge (INTRS9) = \wedge \{(M_a e_1), (M_a e_2), (M_a e_3)\}$  Note INTRS10 depicts derived output for dissemination through email.

The risk alerting is a function that deploys risk information in real-time and services the responses from the migration and mitigation strategies through external relationships EXTRS 1 and EXTRS 2.

#### 4.3.4 The real-time event risk management process (RTEMP)

The RTEMP component sits above the ITRSS and ARP components, and takes their output as inputs for creating external relationships that users or stakeholders may use to make well-informed decisions. These can also be treated as the driver that translates internal relationships (INTRS5, INTRS8, and INTRS10) into the external relationships (*EXTRS-1*) and (*EXTRS-2*). The external relationships are also depicted as external arrows in Figures 24 below, and can be expressed as follows:

- **Risk management event multi-organisational relationship (EXTRS-1):** defined as the aggregated set of information or output of the mitigation process, distributed among stakeholders such as the project manager for efficient decision-making during project development.
- **Real-time event alert relationship (EXTRS-2):** encapsulated in EXTRS-1, and is used in conjunction with it to propagate information resulted from the IT-risk strategies, consequentially as output of a mitigation process.

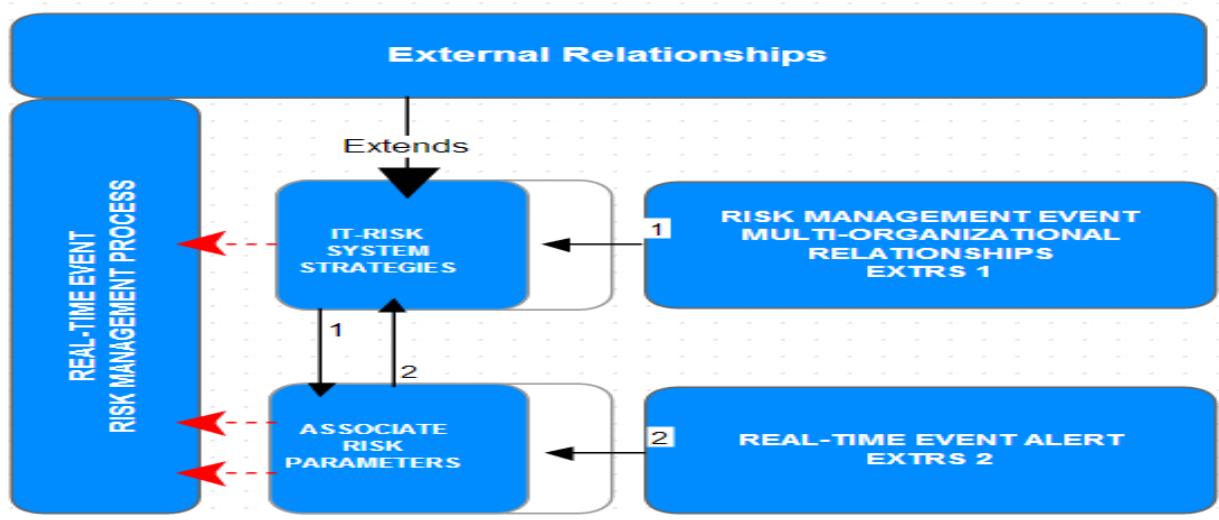


Figure 24. The Evolutionary Model EXTRS 2

The **migration strategy** receives all risk information from EXTRS1 and organises the risk data and sends it to the ARP component. It also plays a vital role in sending and receiving all mitigated risk from mitigation. This is illustrated and explained in more detail in Figure 25 below:

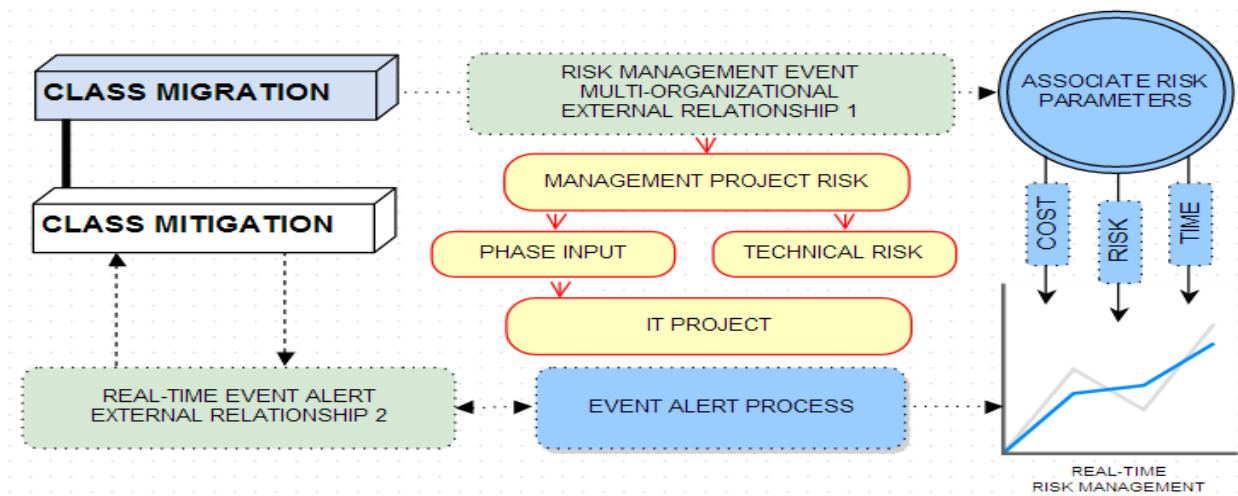


Figure 25. The Evolutionary Model Migration Strategy

The **mitigation strategy** shown in Figure 26 below describes the risk mitigated stages and call activates involvement in the callas mitigation and the output explicit to event alert process. The real-time event risk management process RTEMP is the primary component because its outputs are essential to stakeholders for quick and efficient decision-making, increasing confidence levels which are a significant advantage to the model.

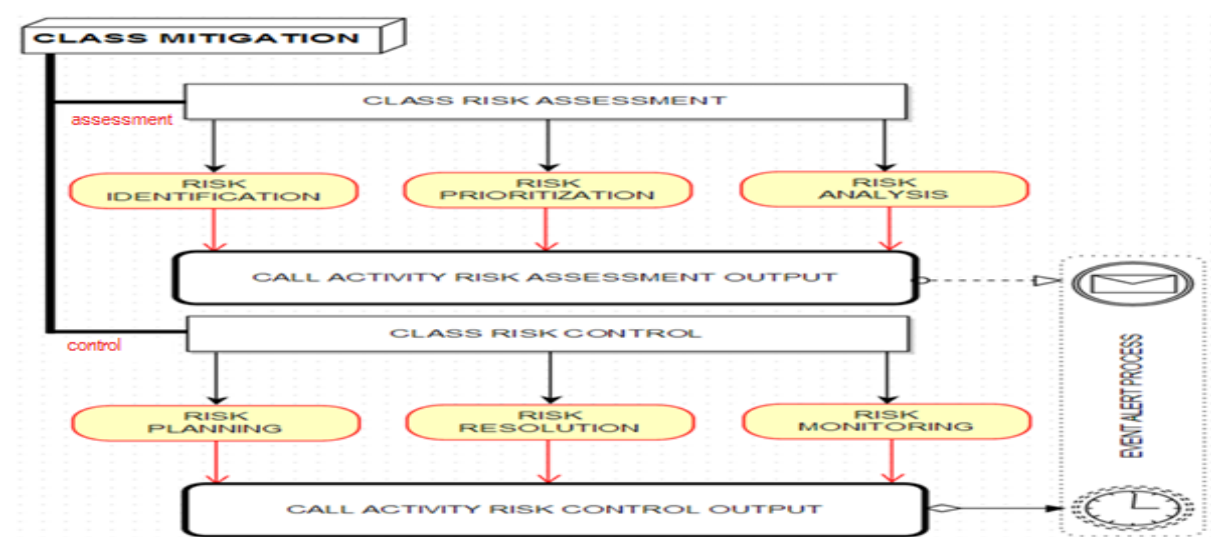


Figure 26. The Evolutionary Model Mitigation Strategy



### 4.3.5 Contributions of the Evolutionary Model and Example

The *Evolutionary Model* has been designed to make several important contributions to risk management.

- **Enabling well informed decisions:** Acceptable risk volumes in the IT industry operations or project development are mostly decided by the Board of Directors or Executive Committee - often referred to as management. However this projects survey shows that IT departments are often considered to be in charge of risk management process during project development. They can use this model to make informed decisions and to report to the stakeholders.
- **Increased confidence levels:** Confidence level is enhanced, increased and sustained during project development through better and more frequent information. Stakeholders are assured the project is being monitored, and there is visible expectation of completion that can be lacking in software development.
- **Monitoring and controlling:** Monitoring and control enhances the likelihood that all of the set objectives and goals of the project are attained. The *Evolutionary Model* helps management take effective, efficient and direct action through project monitoring and control in these environments.
- **Minimising associated environment parameters of risk, time and cost:** Efficient monitoring and control as stated above will safeguard cost and time, and mitigate risk to a minimal and bearable level. The *Evolutionary Model* enhances efficient monitoring and effective control, which mitigates risk and enhances chances of meeting the project deadline and deadlines.
- **Identification of internal and external relationships:** The model identifies two types of relationships; external and internal. Internal relationships INTRS-3 and INTRS-10 are extensible during implementation to generate external relationships. These are a useful complement to other tools for making efficient and effective decisions.
- **Example**

Project manager or Risk manager in IT project development can use the model to make in informs decision using the figure 22, by measuring the risk in the project against the cost. Also, the measurement of project development against the deadline is also possible see figure 21 (DriMap Reporting activities). In the figure, the manager use the activity to measure deadline set on each phase of the project. The curve moves from deadline  $>0$ , i.e. from 16 days to 0, the curve moves downward towards toward 0.

Note: the movement shows an indication that the deadline or time remains for the completion of the phase is approaching. At instance, manager can measure their success or what's has been accomplished before the deadline elapsed. However, measurement of success against the approaching deadline is an informed decision. The data gets processed on daily basis by DRiMaP Task which is run by windows task manager, and in turn generate activity which is plotted against the cost. Note, when the curve touches x-axis, at that point the deadline is elapsed. When deadline elapses it requires additional fund to raise it back for the project to continue running. What the manager does to make sure the phase or project completes before the deadline underscores informed decision derived from the cure. In the figures referred to (i.e. 21 & 22), the data are presented on the graph or curve. (See the figures for details).

These contributions are discussed further in the conclusions chapter 6.

## 4.4 IMPLEMENTATION OF THE EVOLUTIONARY MODEL

Studying the implementation of the *Evolutionary Model* is important for several reasons. Risk management is inherently a practical activity. The *Evolutionary Model* has been designed, in part, to overcome some of the practical limitations of the original *DRiMaP* model. Constructive research involves the development of artefacts that validate the model and contribute to it in an iterative process.

This section describes the implementation of the *Evolutionary Model*, in the form of a software tool that is intended to support the risk management functions of distributed software development projects. The software tool was designed according to the *Evolutionary Model*, using components, sub-components, relationships and functions from that model. This may then be used to prove the concept in a simulated environment.

### 4.4.1 Modelling

The first step to implementing the *Evolutionary Model* is modelling the software system. Modelling is the practice of generating a diagrammatic representation of a functional system, and the resulting model should be comparable and analogous to the system it represents. A modelling language and tools offer a way of developing models, their graphical representations, and a vocabulary for the model in the form of scenarios and notes. A meta-model is defined as a diagram with set of elements that projects the notions of and relations offered by modelling language and whose properties are written in Object Constraint Language (i.e. OCL) which further indicates additional adherence or conformance to models and model instances.

Unified Modelling Language (UML) was used to model the system in this project. Object diagrams are used to depict instances of class models, and the diagrams that represent models adhere to the core meta-model of the adopted modelling language. Several concepts are important to understanding modelling object oriented systems in UML, and these are explained below:

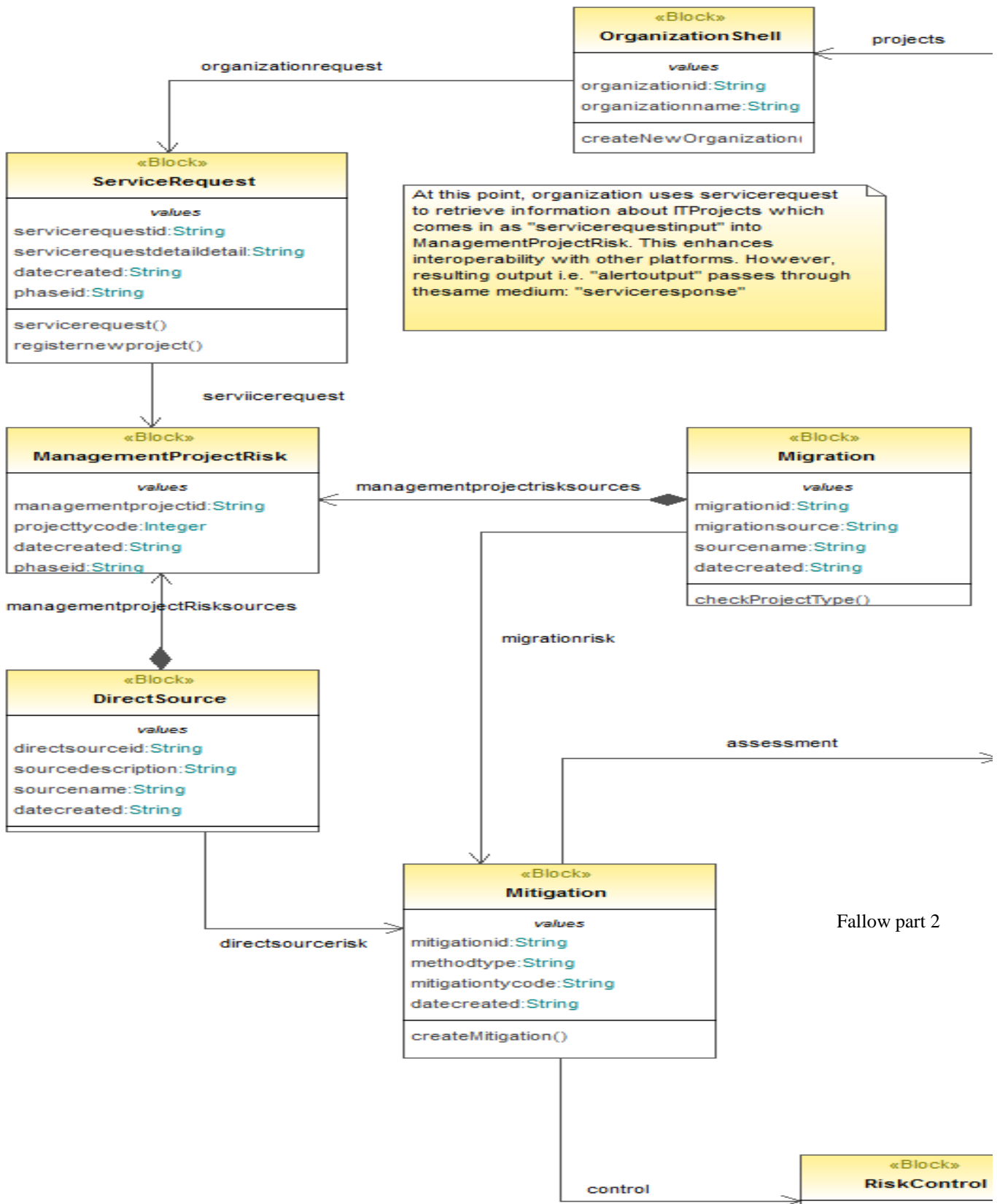
- **Entity and attributes:** An entity can be defined as the instance of real-world object with defined set of attributes or properties to convey the total representation of that instance. An information system entity can be perceived as an object class that exists independently in the real-world and is distinguished by its properties. Examples could include car, customer, organisation, employee and project.

- **Data abstraction:** One of the main features of object-oriented programming (OOP) is data encapsulation, sometimes referred to as data abstraction. It is an approach to aggregate data into single unique entity, with its internal state hidden and limits all the properties or methods of object that would be engaged in interaction. Data abstraction aids data encapsulation by providing the user with a clear definition of the object in terms of well-defined interface. The service requester does not need to know how the object gets the requested information.
- **Inheritance:** The openness of objects (i.e. instance of class) is regarded as one of OOP's advantages over procedural languages like Pascal and FORTRAN. This feature enhances reusability of code where definition of common operations and implementation within a class can be accessed through all objects that are derived from that chain of inheritance. It is useful in maintenance and to implement changes if required during or after the SDLC.
- **Dynamic binding:** Generally a programming language, especially a procedural language, binds operation, function and procedure to their corresponding operations at the point of compilation. This is referred to as static binding, and it is only possible when all operations have defined or declared as unique identifiers and operations. Object oriented programming on the other hand binds operator-to-operation at run-time. For instance, a message call by an operator would invoke specific operation method specific to that object, decided at run-time. This process is known as dynamic binding.

#### 4.4.2 Class diagrams

The first step to building the software tool is to develop UML models for the system. The conceptual design is first transformed into a class diagram, shown in Figures 27-28 below. This describes the class diagram derived from the *Evolutionary Model*, with core entities or classes and corresponding properties and relationships. Details of the entities and relationships are provided in Appendix H.

The diagram is then used to generate several concrete layers; the service layer, data layer, and transaction layer. Prior to delving further into implementation, it is very essential at this juncture to examine closely the underlying design concept of the class diagram from client-to-service and service-to-server.



Fallow part 2

Figure 27. Transformation of conceptual design to class diagram part 1

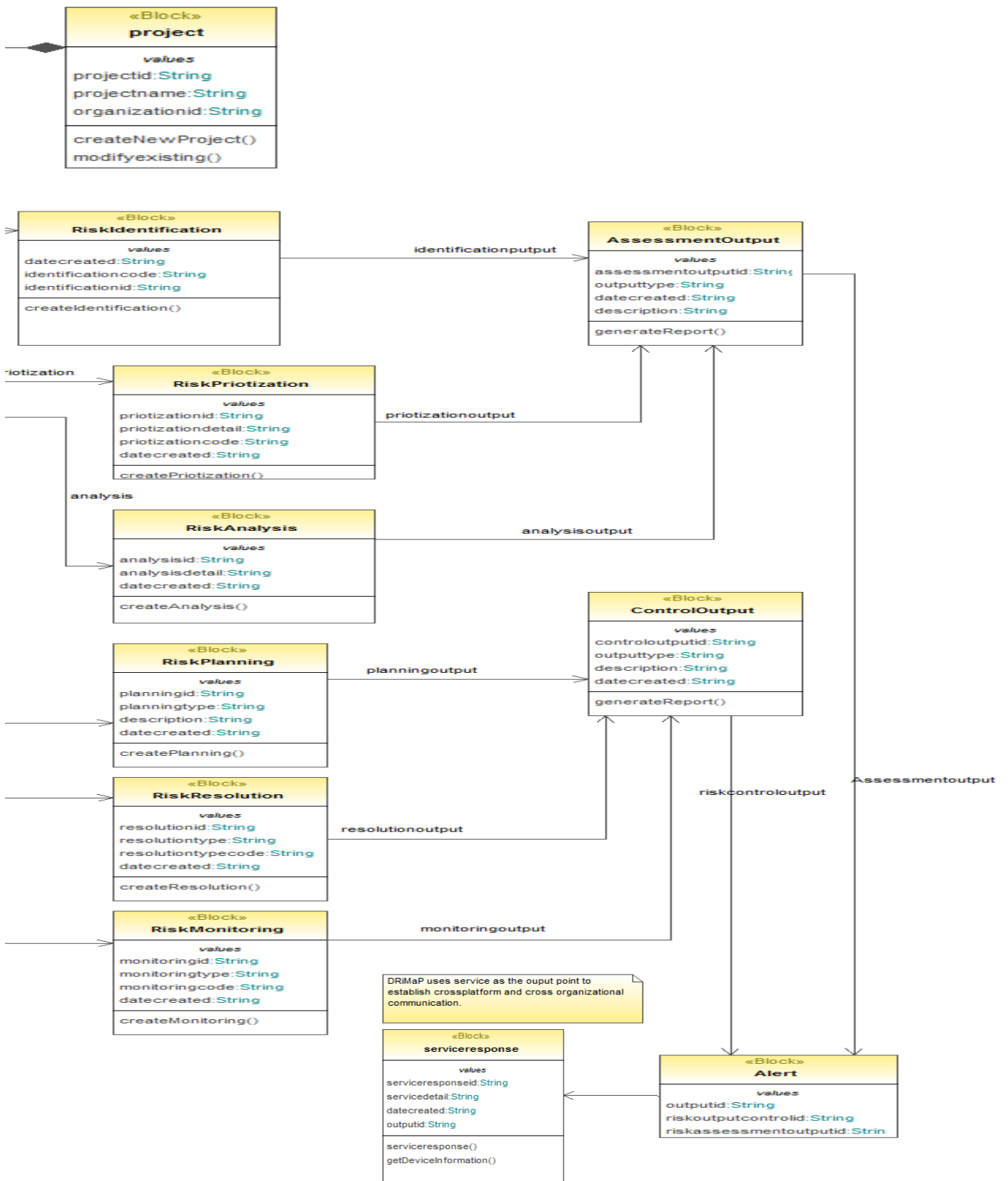


Figure 28. Transformation of conceptual design to class diagram part 2

### 4.4.3 Systems implementation

The risk management system is designed to provide a collaborative platform crossing multiple organisations. It utilises information stored about projects from all the phases, designed to manage and to notify the users about the mitigation process and prioritise the identified risks during development. The system uses data generated from the states of create, delete and update to identify the associated risk, which is evaluated within predefined rules for the mitigation process with the output presented through the alert module - such as automatic email generation. The system is written in web services (.Net 4.0 framework c#), with class libraries for data transaction and a client-side which is provided to test and to evaluate the functionality of the *Evolutionary Model*.

The physical implementation of the *Evolutionary Model* is presented in the high-level diagram shown in Figure 29 below. It is segmented into three layers; the Web Graphical User Interface (Web GUI), Core Service Modules (CSM), and Associate Risk Monitoring and Control Environment (ARMCE).

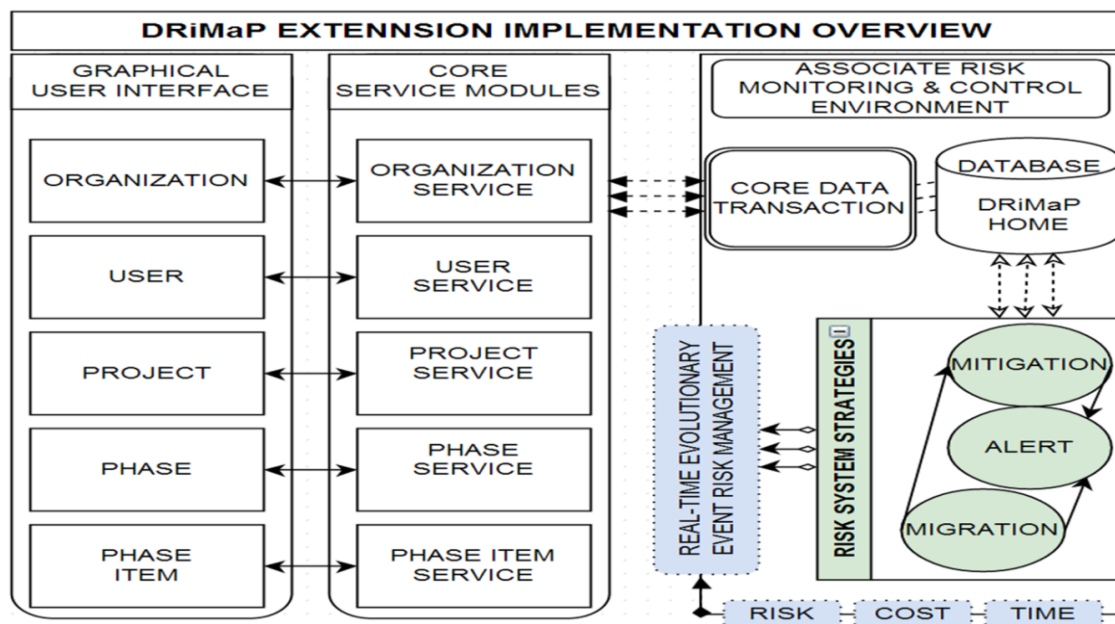


Figure 29. Evolutionary Model high level implementation

The Web GUI implements a user interface that corresponds to the class diagram and the highlighted services. This underscores the advantage of using object orientation principles to separate layers. The CSM is the aggregation of services; organisation service, user service, product service, phase service, phaseitem service and chart service.

The last of these, chart service, is implemented directly by RTEMP, which is why it is not visible in the implantation overview. The ARMCE is the aggregation of risk strategies; real-time evolutionary event risk management, core-data transaction and Database (DrimapHome).

#### 4.4.4 Web graphical user interface versus core service modules

The Web GUI is introduced to test and evaluate of the *Evolutionary Model*. It refers to the graphical user interface and client application which consumes the extension services, and the client application provides several user interfaces; user, organisation, project, phase, and Phaseitem.

User GUI versus User Service: This allows creation of new users who wish to use the application; The UI consumes the User service for the creation, authentication and authorisation of users. The Web GUI uses username, encrypted password (predefined SHA1 Net framework 4.0) and internal org id to bind the user to the organisation. The combination of authentication parameters are used to identify the user before access to other services is granted by the User Service. The client user consumes the User Service class and generates a User Svc proxy file that exposes the methods, Register User (DRiMaPUser userob) and Logon User (DRiMaPUser user). These are defined by the user service for registering, authorisation and retrieving registered users to use the application.

These methods are exposed by the User Service class, and invoke by client as HTTP Post request over HTTP protocol which generates a Soap file as the output. User service exchanges data with data layer through the core data transaction API (application programming interface). The API implements Active Data Objects such as .net classes (Sql Connection, Sql Command, Sql Adapter, Data Adapter, Data Set) to establish connection with SQL Server 2008. Sql Command is used as ORM (object relational mapping). It implements constructs that accept the stored procedure and Sql Connection object and methods that accept the parameters – such as to access the DRiMaPHOME (the database for this simulation).

The Web GUI interface is illustrated in Appendix I, alongside a service listing that is an excerpt from one of the method implements in transaction core to access data layer.



#### 4.4.5 Organisation UI versus organisation service

The organisation Web user interface UI allows new users to create an organisation prior to creating projects. The UI also provides a facility to modify an existing organisation. The interface defines the following fields: Company name, Description, Organisation id, and the internal org id are Active. The parameters are posted over HTTP protocols through methods exposed by the organisation service. As explained in the previous section, the organisation web UI consumes the organisation service and generates a proxy file which exposes all required methods for an organisation (i.e. the client) to create request-response asynchronously over an HTTP protocol.

The interface is illustrated in the screenshot in Appendix I.

The following methods are exposed by the organisation service class in the proxy files generated in the client application are available for the organisation Web UI to create HTTP post requests. Update Organisation (Organisation obj) is used to send a request after dynamic data binding has been completed, await a SOAP response which is serialised and stored into Data Set, then return to the organisation Web UI asynchronously as a response. An organisation service screenshot is presented in Appendix I.

- Retrieve Organisation
- Retrieve Organisation Id
- Create Organisation
- Update Organisation

#### 4.4.6 Project UI versus project service

This allows a super-user to create a new project that is to be monitored and managed by the designated project managers or team members and to monitor the progress of phases and phase items. This service (Project Service class) manages the project from the creation to completion. It exposes the following methods:

- Client Projects
- Create Project Information
- Get All Project
- Get Assigned Project

- Get Project In Phase
- Project Update Information
- Project Type Information

Like other web UIs identified above, Project UI equally consumes Project Service class and generates its proxy for creating HTTP post request using the methods above. The project UI defines the following field parameters: Project name, description, is Active, is Signed off, project type code, project cost, project deadline, and percentage ration which are passed as into the Create Project Information to create project values into the database.

Screenshots of the application are provided in Appendix I.

#### 4.4.7 Phase web UI versus phase service

This interface allows the user to specify development phases involved in the SDLC of the project. In this context of the SDLC, project can be defined as a collection of phases or as a list of phases. The Project entity shares a one-to-many relationship with the Phase entity, as shown in the class diagram above and detailed in Figure 30 below.



*Figure 30. Project and Phase relationship diagram*

#### 4.4.8 Phase service

This service allows the project manager or users to define the number of phases involve to develop the project. Project shares a one-to-many relationship with phase, and phases share a one-to-one relationship with each other. In other words, a project can have many phases. The service exposes the following methods:

- Create Phase
- Update Phase
- Deactivate Phase

#### 4.4.9 Phase item web UI versus Phase item service

The Phase item web user interface allows the user or project manager to provide entry into phases, such as adding requirements to the requirement phase. This service uses the phase item object to create an item in the project phase. For example, the requirement gathering phase during a project development can be taken as instance of a Phase and contains detail of requirements defined for a project in that phase. The phase item object is defined as a discrete item in a Phase.

This service exposes the following methods:

- Create Phase item
- Update Phase item
- Sign Off
- Delete Phase item

#### 4.4.10 Strategy layer

The Strategy Layer consists of core **APIs** that are responsible for risk management. It implements the following classes which are defined and named in-line with the core functions of the risk management systems.

The mitigation strategy uses the data stored about a project to conduct assessment and control using the subclasses identified in the diagram and output the result of each subclass through *Assessment Output and Control Output classes*.

*The Assessment Output class* return a string message object created internally into the Alert Module which returns the final output by sending the alert in form of email to the users (i.e. the assigned project managers) in charge of the project.

#### 4.4.11 Transaction layer

This layer constitutes a set of methods, which are defined in the Transaction class, that are used as an object relational management (ORM) process to handle insertion or creation of data into SQL Server express 2008 using the following connection attributes to establish connection to the server:

- provider Name: System .Data .SQL Client class,
- Initial Catalog which specifies the database name as “DRIMAPHOME”
- Data Source =“local host
- Persist Security Info = “true”

The attributes above are used in setting up the connection string attribute which is used by the transaction class to connect the data-source on the server. The methods used by the transaction class call stored procedures from the server.

Transaction layer, in the implementation, is depicted as a package and is referenced in a class where the methods would be needed. Equally, transaction layer encapsulates the data layer and provides set of transaction methods that can *retrieve*, *insert*, *update*, *deactivate* records base on the client requests. The transaction class object is instantiated in the service that is servicing the request created by the client application. The instance of this object establishes connection to the server, and passes the reference to the calling service, which then use the reference to call the corresponding method of the transaction class that can furnish the result.

The listings are provided in Figures 31 and 32 below:

```
public SqlConnection setconnection(SqlConnection con)
{
    con.ConnectionString = "Data
Source=localhost\\SQLEXPRESS;Database=DRIMAPHOME;Persist
Security Info=True;Trusted_Connection=True;Integrated
Security=SSPI;";
    SqlConnection connStr = new SqlConnection(con.ConnectionString);
    return connStr;
}
```

Figure 31. Listing for the *SqlConnection* object: *connStr*

Note that the Method Connection (Sample), *setconnection* accepts and return *connStr* which hold the connection reference to the data-source or database specified in the *connectionstring* above.

```

/public DataSet CreateOrganisation (Organisation obj)
{
    Transaction _transObj = new Transaction();
    DataSet ds = new DataSet();
    string connect = transObj.setconnection(new SqlConnection()).ConnectionString;

    SqlConnection scn = new SqlConnection(connect);
    try
    {
        SqlCommand spcmd = new SqlCommand("getOrganisation", scn);
    }
    catch (SqlException ex) { ex.Message.ToString(); }
    finally { scn.Close(); }
    return ds;
}

// this method is exposed to the client. Request is made by client through this method
[WebMethod]
public void createOrganisation(string organisationname, string organisationdescription, bool
isVisible, bool isActive, string internalorgid)
{
    Organisation org = new Organisation();
    org.organisationid = Guid.NewGuid();
    org.organisationname = organisationname;
    org.description = organisationdescription;
    org.isActive = true; //default
    org.isVisible = true; //default
    org.createdOn = DateTime.Now;
    org.modifiedOn = DateTime.Now;
    org.internalorgid = internalorgid;

    DataSet orgDs = CreateOrganisation(org);
}

```

Figure 32. Create Organisation listing

Note that from the above listing, the service request is made through this line by calling its *Create Organisation*: method as follows:

***Data Set org Ds = Create Organisation(org);***

This then calls the Transaction class:

***Transaction \_trans Obj = new Transaction ();***

The *\_trans Obj* holds the reference to the *Transaction class* which was instantiated by the calling service to get *connectionstring* from the *setconnection* method of the Transaction class as below:

```
string connect = transObj.setconnection(new SqlConnection()).ConnectionString;
```

The *connect* string variable then holds the connection string detail for the calling service.

#### 4.4.12 Data layer

This layer refers to the data-source where all the records about the progress of the registered projects are stored and used in the mitigation process of the other occurrences of risk. As stated earlier, the data-source is housed in the SQL Server Express 2008 R2 version. SQL Server management studio is used to view and to manage the database and its corresponding objects like: *Table, Views, Database Diagram, Stored Procedure, etc.*

The database schema is derived from the conceptual model Figure 26 in section 4.4.2. The relationship diagram below illustrates how each entity relates to one another. These relationships are drilled down into the implementation phase and the diagram aids understanding of the database structure when querying the schema.

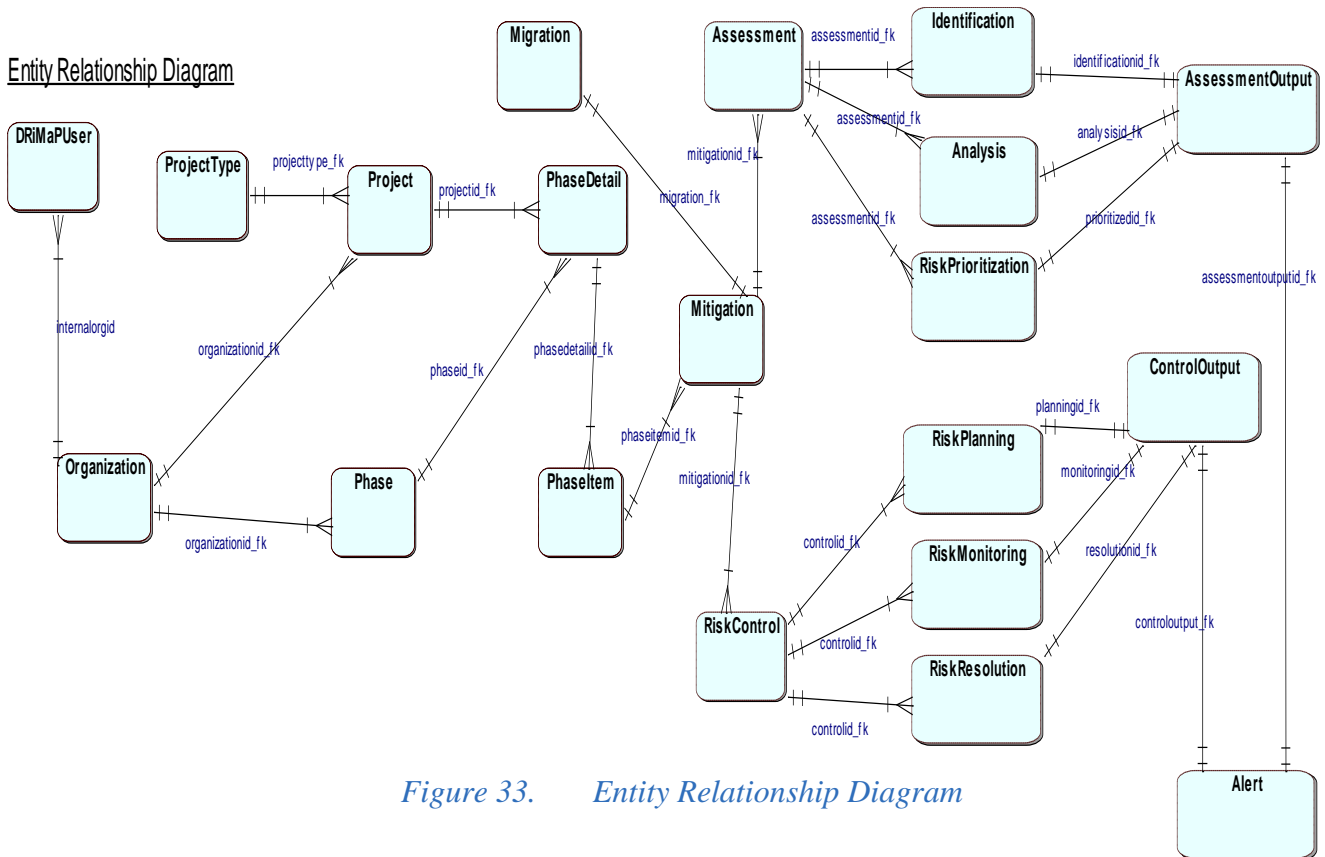


Figure 33. Entity Relationship Diagram

#### 4.4.13 Development of a prototype using visual studio 2010

The simulation of the DRiMaP extensions also involved implementation of the class diagram and entity relationship diagram in the form of a Visual Studio application, used to derive the functional solution illustrated in the snapshots of the GUI or Web UI. This section described various functions of the system, and screens are illustrated in Appendix I, section 9.9.5..

- **Register new user:** The user interface (UI) is for registering to use DRiMaP extension. It requires username, password, and email to create a login account for the user. If “Is Super User?” is checked, then the user will be recognised as super user.
- **Login for existing user:** The user interface (UI) is for login for returning or registered user.
- **Mismatch in user detail:** The user interface (UI) is for login for returning or registered user. The user sees this if the credential provided to access the DRiMaP extension is not correlated to the previously stored credential.
- **Organisation view:** This form tab allows the login user to have access to create the organisation, if not already exists.
- **Project view:** This view allows the user, such as the super-user, to set up project detail for project managers to manage.
- **Phase view:** This allows the user to *create, retrieve, update, and delete (i.e. CRUD)* development phases for the project. In this context, SDLC phases depend on the discretion of the project manager and methodology to adopt. A project manager A may decide that five phases of Waterfall is required to develop the project for his organisation. Equally, project manager B may decide to create ten phases of development (see the figures in appendix details).
- **Phase detail view:** This view allows the user to see projects and corresponding current phases they currently in. For instance, “*Project name: NovaScholar 2 current phase: Requirement Collection*”. “Created on:” refers to the date the project is moved into that phase. The “View” linkbutton, if clicked displays the associated requirement list or collection (or phaseitems) belonging to the phase in question.
- **View phase item:** this view is generated, as discussed above, by clicking one of the phase detail items above. For Instance, a click on Item 2 presents associated items to the specification requirements (see Appendix I illustrations for details).
- **Update phase item:** this view allows the user to modify the items in the phase collection, even if the item is signed off and another item is created.

#### 4.4.14 Alert module layer

Feedback from supervision and interviews with experts in the field showed the value of alerts, and in this functional environment instant notification or awareness of the risk during the project development is vital. A crisis that may result from a risk can be alleviated from the instance it starts occurring. An alert is soft in orientation and its generation at any point in time depends on certain activities carried out by the users and results of the computation in real-time while managing the project. An alert is triggered when a new item is added to the phase, when a deadline is reached, or when a project is assigned to a user. Those activities are tied around CRUD (create, retrieve, update, and delete) operations, time, risk, cost variables.

This layer implements these classes called: *DRiMaP Alert* and *DRiMaP Alert Message*. Those classes declare and implement private variables and public methods for processing string objects that are return from *Assessment Output* and *Control Output*. The main function of the Alert system is to disseminate output per occurrence of risk identified during management of the project development. *Equally, it is* triggered when Update and Delete action from the CRUD occurs. From the implementation, alert function is position at the centre of the two strategies. Currently, the Alert Module sends alert message through the public method called *Alert Message()* which takes *Data Set* object and **internal Org Id** which is used to bind users to organisation, as parameters, to retrieve the message from *Assessment Output* and *Control Output*.

The listing in Figure 32 below presents part of alert functionality:

```
DRiMaPAlert.DRiMaPAlertMessage _alertmsg = new DRiMaPAlert.DRiMaPAlertMessage();
DRiMaPAlert _alartobj = new DRiMaPAlert();
_alartobj.alertid = Guid.NewGuid();
_alartobj.sentOn = DateTime.Now;
_alartobj.createdOn = DateTime.Now;
_alartobj.recipientid = InternalOrgId;
DataSet msgDs = getAlertMessage(assessmentoutputid.ToString());

try
{
    int sentstatus = AlertMessageInfo(msgDs, InternalOrgId);
    _alartobj.status = sentstatus;
}
catch (Exception ex) { ex.Message.ToString(); }
_alartobj.assessmentoutputid_fk = assessmentoutputid.ToString();
AlertMessage(_alartobj);
```

Figure 34. Listing of the alert functionality



The Alert Module functions internally using *MailMessage* and *Smtplib* classes from Visual Studio Framework 4.0 to send email via the *SMTP server* to users assigned to the project. There is no GUI or WebUI for this module, and the email generated is illustrated in Figure 35 below:

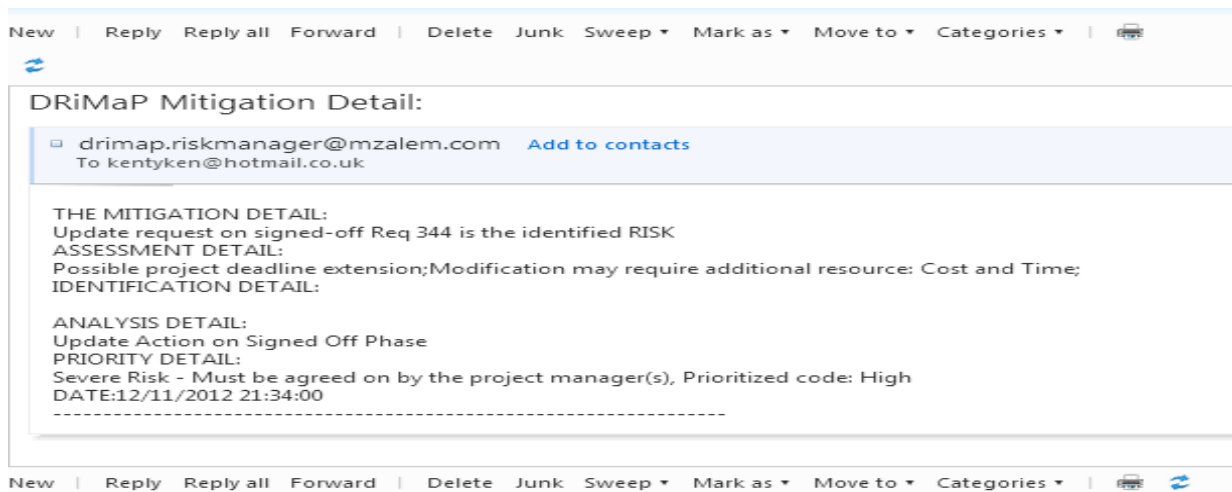


Figure 35. Alert delivery message (Email)

## 4.5 IMPLEMENTING RTEMP

The real-time evolutionary management system is designed to compute the probability of occurrence of risk against cost and deadline i.e. time against cost. These are presented in the form of graphs. Delving further, real-time evolutionary is an event based process that implement a system called DRiMaP Task. DRiMaP Task is a subsystem of DRiMaP extension which extends or inherit properties of Alert Message class to report risk event on real-time. Equally, DRiMaP Task is a console application and it is set up as a Window task. It takes the advantage sequencing and chaining where ordering of series of task is dependent.

However, this referred to as a dependency in batch environment. There are other dependencies to set up task: existence of script, program, or application, a database must be in a certain state before the task can run if and only if the task requires the database to work with, and it is imperative to provide how the database will be connected to during execution. Equally, determinant of success and failure should be handled by the application, in this case the **DRiMaP Task**. The DRiMaP Task takes the advantage of scheduling provided by windows task manager to run and respond to event in real-time and to generate real-time reporting shown below. This console application consumes web service for the purpose of message exchange.

The web service keeps open connection to the SQL Server or schema/metadata for proper completion of the request-response process. When it runs, it requests the execution order provided by the service, this order defines bottom-up approach from phaseItem (i.e. items of requirements), phase, and project. Task is adopted because its execution is flexible and suit its requirement for real-time process, and it is set to occur at every 24 hours and it is managed by the system task scheduler.

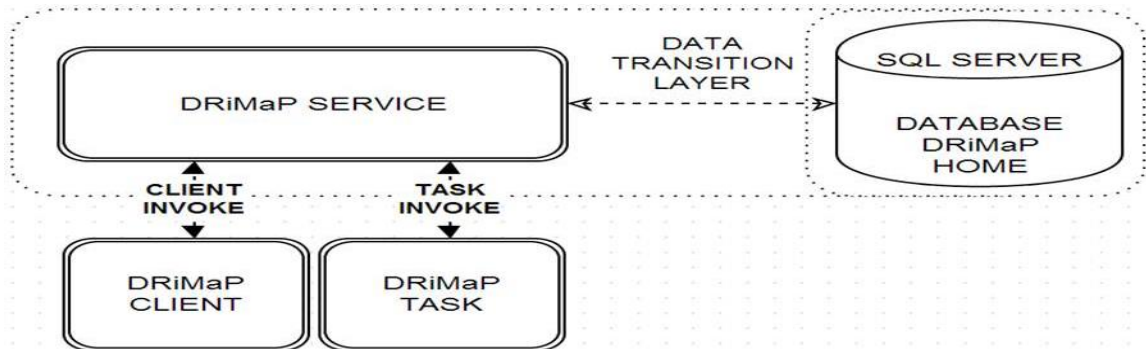


Figure 36. Real-Time Evolutionary process (DRiMaP Task)

The schematic diagram in Figure 34 is a generalisation of a request-response pattern or message exchange design pattern. This design adopts the principle of loose coupling by invoking the service methods from the proxy generated from the service reference in lieu of accessing the implementation directly. However, this pattern is grounded in service oriented architecture and its principle underlying the implementation of web services. Before delving into the detail, let us take a look at the following entities from the diagram above:

- **DRiMaP Client:** This is a web portal or web application that present the GUI by which all the inputs (request) are made and outputs (the response) are displayed. The client application consumes service references called proxies. The client exchanges message through the request response call over http protocol. However, the design maintains a consistent asynchronous channel for request-response from the deployed service. All request and response calls occur asynchronously.
- **DRiMaP Service:** This comprises of six implemented web services: ChartSvc.asmx, UserSvc.asmx, ProjectSvc.asmx, PhaseSvc.asmx, organisationsvc.asmx, RiskParameterSvc.asmx and non-service Transaction Layer. The DRiMaP Service holds the connection to schema/metadata and handles request from client applications: DRiMaP Client and DRiMaP Task. Equally, the response is channelled back through the same medium

asynchronously. Web service holds the object relational mapping i.e. ORM to the schema which enables the service to furnish the exact corresponding response to the client's request. This is possible by exchange of foreign keys or primary keys through invoked methods in the proxies.

Note that relational mapping is implemented in the transaction layer (Data Layer). The DRiMaP Service consistently maintains handles to manage request and response asynchronously.

#### 4.5.1 SQL server database

This is referred to as a relational database management system designed and developed by Microsoft corporation for the purpose of retrieving and storing of data as requested by other applications (Microsoft, 2009). It has distinguished features that separated it to be used in this simulation; one of which is its high-scale complex event processing, and its distributive nature. However, in this context, it is referred to the storage that holds the schema for storing data about projects, phases, organisation, Mitigation and migration related entities, message outputs, deadline, risk and corresponding activities like: Deadline Activity On Entity, Cost Activity On Entity, Risk Activity On Entity, etc; Entity in this regard could be Project, Phase, and Phase Item and they are implemented as schema in the database. However, for each identified activity above replace Entity, for example:

*Deadline Activity On **Entity** = **Deadline** Activity On **Project** (Entity = Project)*

*Cost Activity On **Entity** = Cost Activity On **Phase Item** (Entity = Phase Item)*

These tables are used and populated by **DRiMaP Task** on daily basis and send alert to the users in charge if a condition is met. If a deadline expired and the entity involved is not signed off or completed.

#### 4.5.2 DRiMaP reporting view

In respect to the above, the GUI below represents view of activities for each of the entities mentioned above for deadlines (i.e. Time) versus Cost on Project, phase, and Phase Item or items of the requirement phase. This is illustrated in Figure 37, where dummy data has been used to describe typical plots available to the user.

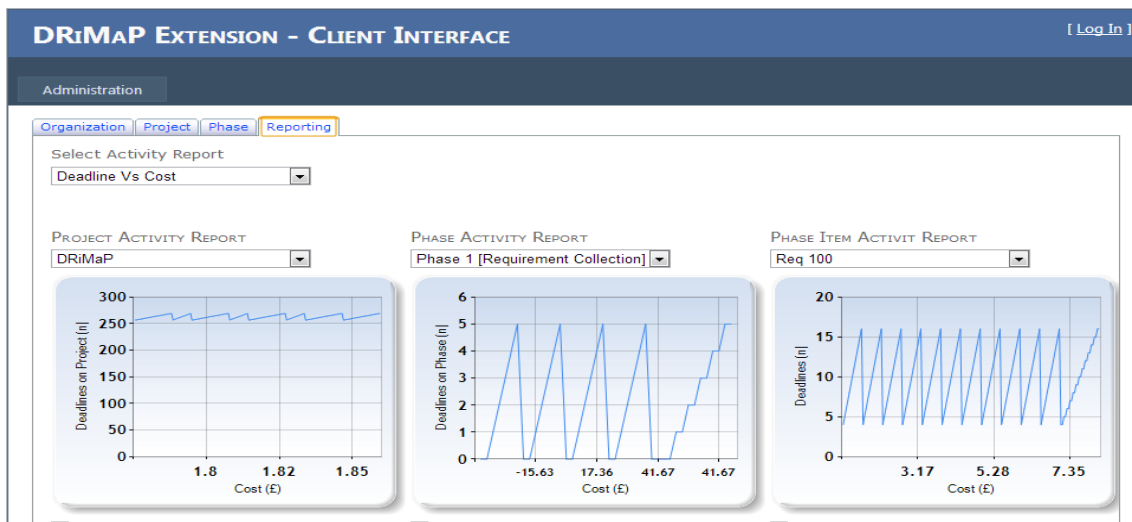


Figure 37. *Deadline versus Cost*

In this diagram Project Activity Report shows deadline against cost on x-axis. In this context, the maximum deadline in days is set to 80 days for the project to be completed. Every 24 hours, the DRiMaP Task runs using bottom up approach execution order in aggregated form. It checks the deadline across all the entities and increases cost. The increase in cost is determined as a result of approaching aggregated deadlines to be met. Also, the aggregated fraction of cost per day is charged on every deadline set. The higher deadline the lower the cost and the lower the deadline the higher the cost.

### 4.5.3 Deadline reached

Note, the cost increases as the deadline approaches the x-axis. That can be seen along the x-axis of each of the charts above. Once the deadline is reached, the chart curve would touch the 0 – point along deadline-axis (i.e. y-axis).

At that point, an alert would go out to the user involve for deadline extension if and only if the entity is not signed off or completed. As shown above the deadlines of Phase and Phase Item are then reached.

#### 4.5.4 Risk versus Cost

The graph below shows the plot of risk against cost. The possibility of occurrence of the risk is calculated on the scale of 1 to 3, equally the impact of the risk is taken on the same scale of risk occurrence. There are other factors that prompts occurrence of risk and mostly distributive in a nature and its certainty is probabilistic, however, in nature. The calculation of the cost as shown above is dependent on the predefined ratio used on each of the entities: Project, Phase, and Phase item. However, the cost assigned to each Phase item per day (Time) is deducted using the predefined ratio set at the point of the creation. For example:

Let  $n$  be the number of phase items created in phase,

Let  $(c_p \in \mathbb{R})$  be the overall cost assigned to the phase.

Let cost per phase item or requirement be  $(c_p/n)$ ,

Let  $(p_c \in \mathbb{R})$  be the project cost, and

Let  $(n_p \in \mathbb{N})$  be the number of phases in the project.

The cost per phase  $(c_p \in \mathbb{R})$  is calculated as  $c_p = p_c/n_p$

The cost charge per day on a phase =  $((p_c/n_p) - \{(p_c/n_p)*r\}/24)$

The cost per day on a phase item =  $((c_p/n) - \{(c_p/n)*r\}/24)$

The cost charged on all the phase items =  $((c_p/n) - \{(c_p/n)*r\}/24) * n$

The risk is spread into three levels of occurrence; Low, Medium, and High. No finer grained analysis is used at this stage, purely for the purposes of the research. This is consistent with Ahlan and Arshad (2013) who use a scale of 1-4, and basic risk assessment models provided by the APM and PMI in their bodies of knowledge. On the scale of 1 to 3, the probability of low, high, medium risk occurrence is calculated as  $1/3$  for each. Probability that risk will not occur in each of the entities is  $(1 - 1/3) = 2/3$ . As the overall estimates lean on other statistics that are not readily available, like economic factors, managerial influence in terms of policy, type of project management tools in use, etc. Owing to all these factors, estimation of cost of risk becomes so difficult to compute. However, in respect to the implementation pattern, the deadline (Time), Cost, and Risk impact are used as the parameters that are mostly and consistently affect project development in IT industries.

Where risk is zero then the cost of risk is zero:

Low= {10, 20, 30} Medium = {40, 50, 60} High= {70, 80, 90};

$P(x) = 0 < x < 100$  where  $P(x)$  is the probability of  $x$  where  $x \in \mathbb{R}$

$P(\text{low}) = 0 < x < 40$

$P(\text{high}) = 40 \geq x < 70$

$P(\text{severe}) = 70 \geq x < 100$

The level of the risk is determined if the percentage calculated fall in any of the range above. As we can see here, the estimate at this point indicates that at a low risk the expected risk cost would be £13.89. Equally, as the deadline is approaching risk tends to increase as the cost.

Note that the deadline and signed off state of the project, phase, and phase items determine if the risk activity occurs or not. However, the project state indicates signed off, and then there would not be activity in the schema above.

This discussion shows the importance of DRiMaP extensions from design to implementation. The rationale for choosing modelling approach for simulation is more than obvious that the benefit of object orientation in event oriented design cannot be over-emphasised. The layers involve from Web GUI, service layer, transaction layer, strategy layer which will be fully discussed in the next chapter prior to conclusion. Equally, overview DRiMaP Task conveys separation of concern in this simulation which makes the process manageable under Windows scheduler manager. The DRiMaP Task as stated above is designed to adhere to the dependency of windows for the task to run effectively.

The overall time estimate to run the task to completion varies directly proportional to the number of records to process. In the course of this simulation, it becomes obvious that Project of this nature should be implemented within a cloud environment where computing resources would be greatly required to have immense efficiency.

## 4.6 CHAPTER SUMMARY

This chapter considers the limitations of the DRiMaP model discussed in section 3.4, and proposes a number of extensions and improvements in the form of the *Evolutionary Model*. These consist of changes to the IT project handling, phase inputs, the addition of continuous risk management, a migration risk strategy, a mitigation risk strategy and the alert module.

Implementation of these extensions is important since the solution is intended to be practical and resolve practical issues. The design and execution of an implementation takes the form of a risk management tool, modelled in UML and written using Visual Studio and SQL Server. This is also described in detail along with class diagrams and interfaces.

Production of a prototype partially validates the underlying theory, showing that a functional database and working system can be derived from the model. Further evaluation of the *Evolutionary Model* and assessment of the tool is presented in the following chapter will present a design for a set of methods for evaluating these improvements and extensions.

## CHAPTER 5 .. EMPIRICAL FINDINGS

A constructive research approach was chosen (Chapter 2) to develop and test the *Evolutionary Model* (section 4.3) and the implementation of that model was designed in the form of a software tool (section 4.4). Three methods were proposed in the Methodology chapter to evaluate the theory; a survey method, structured interviews and constructive research. Constructive research was validated through development of a system that underwent functional testing and simulation, both discussed in this chapter. This chapter describes and analyses the results of the empirical research. Data is presented and interpreted, and implications for the project aims and objectives are derived.

### 5.1 SURVEY FINDINGS

The survey sought to identify how risk management was understood by the respondents and their respective organisations. This would contribute risk management requirements that may be used to build the *Evolutionary Model*, and provide a way to evaluate the software tool and estimate the feasibility of the model.

The survey was designed to highlight and assess the following issues that prompted and guided the modifications to the original DRiMaP model. Question numbers are indicated in brackets:

- Experience of using risk management processes in the IT industry (Q1).
- Existence of and familiarity with risk management strategies (Q2 to Q4).
- Approaches used to conduct risk management in IT organisations (Q5 to Q8).
- Benefits achieved by implementing risk management principles (Q9 and Q10).
- Impact of risk management in IT industries (Q11 to Q14).
- Influence of organisation management on risk management processes (Q15 and Q16).
- Concern for project analysis within and outside the organisation (Q17 and Q18).
- Success and failure rate (Q19 and Q20).
- Rating assessment and risk management in use (Q21 to Q24).
- Experience with distributed risk management processes (Q25).

The individual questions are detailed in this section, along with the cumulative responses, interpretation and discussion for each question.



### 5.1.1 Responses

Participants were invited from the Saudi General Authority of Civil Aviation (GACA) and subcontractors to take part in the survey. Twenty (20) members of responded, from GACA IT Sector, fifteen (15) members of the Binladen company and fifteen (15) members of Safari company as subcontractors giving a total of (50) responses. The difference between responders and responses arose when 5 of the participants answered twice.

The sample was smaller than originally intended, for reasons of time and access mentioned in section 2.3.1. The response rate of 100% (50/50) was very high however, due to the researcher's familiarity with the organisations and respondents.

Graphical representation of responses is provided for questions with high priority. Respondents were not required to answer all questions, so total respondents per question vary. Respondents could also provide multiple answers to most questions, so the total answers per question vary. Data analysis SPP programme descriptive statistics were conducted. Following are the results.

### 5.1.2 Experience of using risk management processes in IT industries

**Question 1.** *What is your total experience with risk management teams in the Information Technology industry?*

Twenty GACA respondents replied to this question. 25 % of the group has 1 to 5 years experience. 10% of these participants have more than 15 years experience of using risk management process.10% of the group has 10 – 15 years experience. However, in aggregate, out of the 100% of the participants, 10% respondents have experience above ten years, indicating that risk management was relatively new to many team members. Data is tabled and charted below:

**GACA respondents**

Question 1		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 12 months	5	25.0	25.0	25.0
	1-5 years	8	40.0	40.0	65.0
	5-10 years	3	15.0	15.0	80.0
	10-15 years	2	10.0	10.0	90.0
	More than 15 years	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

*Table 15. Question 1 responses*

Fifteen Binlden respondents 13.3% of these participants have more than 15 years experience of using risk management process. 60 % of the group has 1 to 5 years experience. Equally, 13.3% of the group has 10 – 15 years experience. However, in aggregate, out of the 100% of the participants 73.3% respondents have experience less than ten years, indicating that risk management was relatively new to many team members. Data is tabled:

**Binlden respondents**

Question 1		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5 years	9	60.0	60.0	60.0
	5-10 years	2	13.3	13.3	73.3
	10-15 years	2	13.3	13.3	86.7
	More than 15 years	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

*Table 16. Question 1 subcontractor 1*

SAFARI respondent of fifteen replied to this question. 6.7% of these participants have more than 15 years experience of using risk management process. 20 % of the group has 1 to 5 years experience. Equally, 40% of the group has 10 – 15 years experience. However, in aggregate, out of the 100% of the participants, 46.7% respondents have experience above ten years, indicating that risk management was relatively new to many team members. Data is tabled:

**SAFARI respondents**

Question 1		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5 years	3	20.0	20.0	20.0
	5-10 years	5	33.3	33.3	53.3
	10-15 years	6	40.0	40.0	93.3
	More than 15 years	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

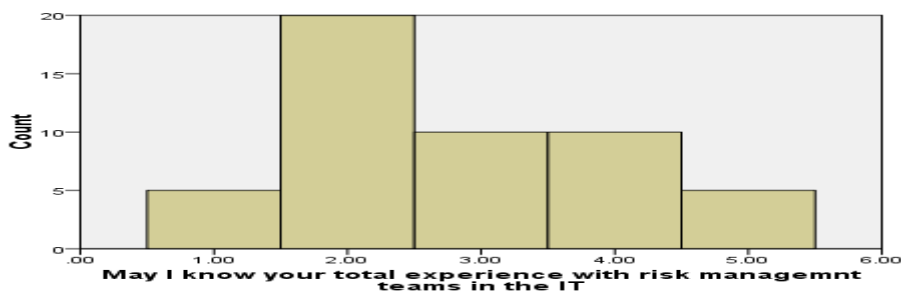
*Table 17. Question 1 subcontractor 2*

All organisations respondents Fifty (50) respondents replied to this question 10% of these participants have more than 15 years experience of using risk management process. 10 % of the group has 1 to 5 years experience. Equally 10% of the group has 10 – 15 years experience. However, in aggregate, out of the 100% of the participants, 70. % respondents have experience less ten years, indicating that risk management was relatively new to many team members. These responses show that there is need for awareness and for introduction of risk management into IT industries. Data is tabled and charted below:

**All organisations respondents**

Question 1		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 12 months	5	10.0	10.0	10.0
	1-5 years	20	40.0	40.0	50.0
	5-10 years	10	20.0	20.0	70.0
	10-15 years	10	20.0	20.0	90.0
	More than 15 years	5	10.0	10.0	100.0
	Total	50	100.0	100.0	

*Table 18. Question 1 results*



*Figure 38. Chart for Question 1*

### 5.1.3 Existence and familiarity with risk management strategies

This issue was investigated in Questions 2, 3 and 4. Each question will be discussed individually.

**Question 2.** *What kind of risk management strategy does your organisation practice?* 20% of GACA Participants use a risk management process for the purpose challenging competitive market, Equally, 20% percent use it for pioneering purpose, and 40% use it for the purpose of implementation and for the update of the market while no response for other purpose. No respondents reported using for the purpose of enhancing speed of their operation strategies for project development. Respondents showed that in general their organisations were actively looking for new ideas, people, trends and updates. This indicates a forward thinking mindset as well as a need to find solutions to pressing problem. Data is tabled below:

		<b>GACA respondents</b>			
<b>Question 2</b>		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Challenging the competition in the market	4	20.0	20.0	20.0
	Filling the organization with Pioneering ideas and people	4	20.0	20.0	40.0
	Reducing the slow times	4	20.0	20.0	60.0
	Implementing latest trends and Cycle methods with updates of market	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

*Table 19. Question 2 responses*

60% of Binlden respondents use a risk management process for the purpose challenging competitive market, 26.7 percent use it for pioneering purpose, and 13.3 percent use it for the purpose of implementation and for the update of the market while no response for other purpose. No respondents reported using for the purpose of enhancing speed of their operation strategies for project development. Respondents showed that in general their organisations were actively looking for new ideas, people, trends and updates. This indicates a forward thinking mindset as well as a need to find solutions to pressing problem. Data is tabled:

**Binlden respondents**

Question 2		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Challenging the competition in the market	9	60.0	60.0	60.0
	Filling the organization with Pioneering ideas and people	4	26.7	26.7	86.7
	Implementing latest trends and Cycle methods with updates of market	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

*Table 20. Question 2 subcontractor 1*

SAFARI respondents 40% of respondents use a risk management process for the purpose challenging competitive market, 20 percent use it for pioneering purpose, and 33.3 percent use it for the purpose of implementation and for the update of the market while no response for other purpose. 6.7 percent respondents reported using for the purpose of enhancing speed of their operation strategies for project development. Respondents showed that in general their organisations were actively looking for new ideas, people, trends and updates. This indicates a forward thinking mindset as well as a need to find solutions to pressing problem. Data is tabled:

**SAFARI respondents**

Question 2		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Challenging the competition in the market	6	40.0	40.0	40.0
	Filling the organization with Pioneering ideas and people	3	20.0	20.0	60.0
	Reducing the slow times	1	6.7	6.7	66.7
	Implementing latest trends and Cycle methods with updates of market	5	33.3	33.3	100.0
	Total	15	100.0	100.0	

*Table 21. Question 2 subcontractor 2*

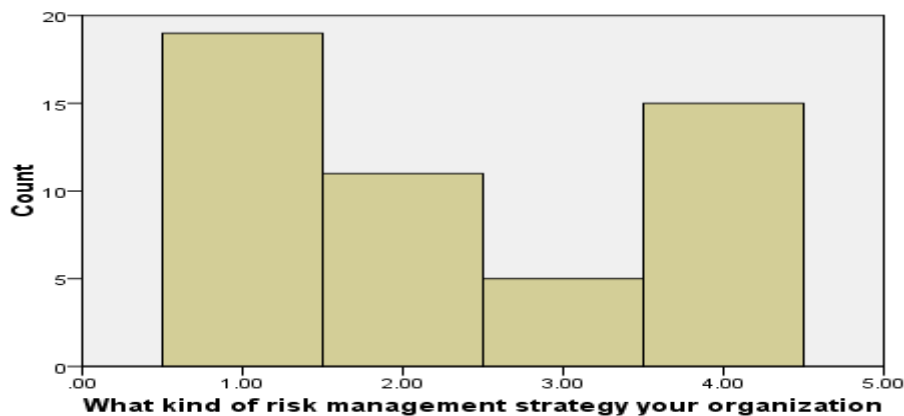
38% of all organisations respondents use a risk management process for the purpose challenging competitive market, 22% use it for pioneering purpose, and 15% use it for the purpose of implementation and for the update of the market.

Respondents showed that in general their organisations were actively looking for new ideas, people, trends and updates. This indicates a forward thinking mindset as well as a need to find solutions to pressing problem. Data is tabled and charted below:

**All organisations respondents**

Question 2		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Challenging the competition in the market	19	38.0	38.0	38.0
	Filling the organization with Pioneering ideas and people	11	22.0	22.0	60.0
	Reducing the slow times	5	10.0	10.0	70.0
	Implementing latest trends and Cycle methods with updates of market	15	30.0	30.0	100.0
	Total	50	100.0	100.0	

*Table 22. Question 2 results*



*Figure 39. Chart for Question 2*

**Question 3.** *What kind of risk management functions does your organisation apply?* The answers reflect the global focus on security issues, driven by the technical accessibility of the Internet, and the important role that governance has come to play for financial and business reasons. A third of the issues were business continuity and another third those of information security. Compliance surprisingly was not a major priority, as this is an essential element of governance. One respondent selected ‘other’ and indicated that the responsible department was “Public services”.

GACA respondents, 50% of the responses in question 3 use risk management functionality for the purpose of information security, equally 50% adopt the process for the purpose of business continuity. Overall, the result shows that the most IT industries use risk management process for different purpose rather than for management of IT projects. These answers are tabled and charted below:

**GACA respondents**

Question 3		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Information Security	10	50.0	50.0	50.0
	Business Continuity	10	50.0	50.0	100.0
Total		20	100.0	100.0	

*Table 23. Question 3 responses*

Binladen respondents, Sixty percent of the responses in question 3 use risk management functionality for the purpose of information security, 26.7 percentage adopt the process for the purpose of business continuity, while 6.7% as the mode in the responses use it for the purpose of compliance, for improving speed, while others claim it for public service. Overall, the result shows that the most IT industries use risk management process for different purpose rather than for management of IT projects. These answers are tabled below:

**Binlden respondents**

Question 3		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Information Security	9	60.0	60.0	60.0
	Business Continuity	4	26.7	26.7	86.7
	Reducing the slow times	1	6.7	6.7	93.3
	Compliance	1	6.7	6.7	100.0
Total		15	100.0	100.0	

*Table 24. Question 3 subcontractor 1*

SAFARI respondents 46.7 percent of the responses in question 3 use risk management functionality for the purpose of information security, 33.3 percentage adopt the process for the purpose of business continuity, while 20% as the mode in the responses use it for improving speed. Overall, the result shows that the most IT industries use risk management process for different purpose rather than for management of IT projects. These answers are tabled:

**SAFARI respondents**

Question 3		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Information Security	7	46.7	46.7	46.7
	Business Continuity	5	33.3	33.3	80.0
	Reducing the slow times	3	20.0	20.0	100.0
	Total	15	100.0	100.0	

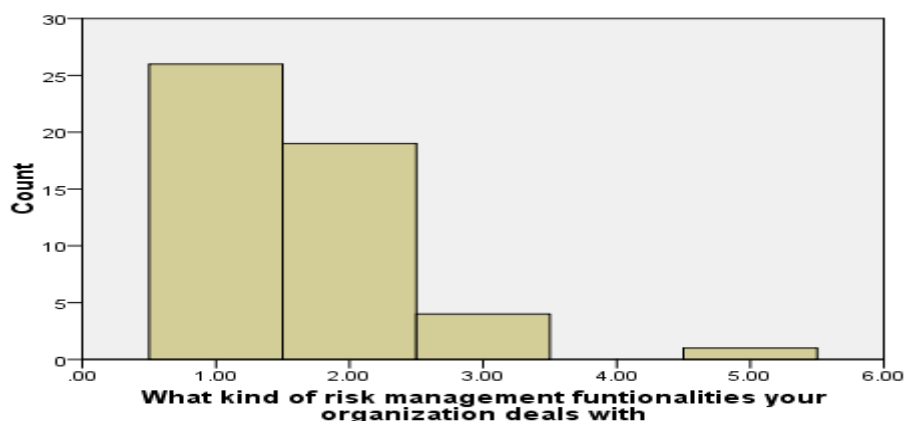
*Table 25. Question 3 subcontractor 2*

All organisations respondents 52% of the responses in question 3 use risk management functionality for the purpose of information security, 38% adopt the process for the purpose of business continuity, while 2% as the mode in the responses use it for the purpose of compliance, for improving speed. Overall, the result shows that the most IT industries use risk management process for different purpose rather than for management of IT projects. These answers are tabled and charted below:

**All organisations respondents**

Question 3		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Information Security	26	52.0	52.0	52.0
	Business Continuity	19	38.0	38.0	90.0
	Reducing the slow times	4	8.0	8.0	98.0
	Compliance	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

*Table 26. Question 3 results*



*Figure 40. Chart for Question 3*



**Question 4.** *Are there any separate department that consider risk management in your organisation?* GACA respondents 70% of the respondents reported that risk management is being practiced in their organization as a separate business function. Risk management can cross boundaries between organisations and functions more easily if it is the responsibility of all departments than if the responsibility of a single department. A collaborative approach to understanding and solving risk would also bring more exposure to risk management. Answers are tabled below:

**GACA respondents**

Question 4		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	14	70.0	70.0	70.0
	No	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

*Table 27. Question 4 responses*

Binlden respondents 53.3 percentage of the respondents reported that risk management is being practiced in their organization as a separate business function. Answers are tabled below:

**Binlden respondents**

Question 4		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	8	53.3	53.3	53.3
	No	7	46.7	46.7	100.0
	Total	15	100.0	100.0	

*Table 28. Question 4 subcontractor 1*

SAFARI respondents 93.3 percentage of the respondents reported that risk management is being practiced in their organization as a separate business function. Answers are tabled below:

**SAFARI respondents**

Question 4		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	14	93.3	93.3	93.3
	No	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

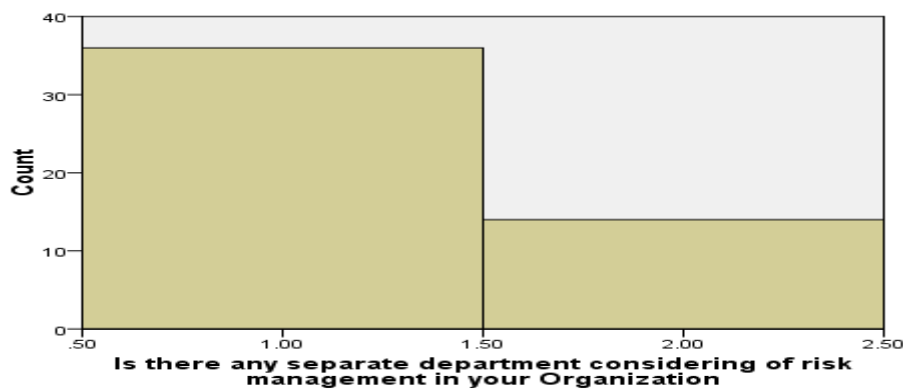
*Table 29. Question 4 subcontractor 2*

All organisations respondents 72% of the respondents reported that risk management is being practiced in their organization as a separate business function. Risk management can cross boundaries between organisations and functions more easily if it is the responsibility of all departments than if the responsibility of a single department. A collaborative approach to understanding and solving risk would also bring more exposure to risk management. Answers are tabled and charted below:

**All organisations respondents**

Question 4		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	36	72.0	72.0	72.0
	No	14	28.0	28.0	100.0
	Total	50	100.0	100.0	

*Table 30. Question 4 results*



*Figure 41. Chart for Question 4*

#### 5.1.4 Approaches adopt to conduct risk management in IT organisations

This issue was considered in questions 5, 6 and 7.

**Question 5.** *Select all of the departments in your organisation that are conducting risk management assessments?* GACA respondents, 60 % of the respondents had observed that IT applied risk management assessment. 5% indicated finance department of their organization engages in risk management assessment, 15% claim business department use it, and 20% agreed that the risk management assessment is used by general management, while two respondents answered ‘others’ and said that risk management assessments were conducted by “strategic” and “strategic planning.”

This shows that the level of awareness or training to adopt the risk management or assessment is very low. There is considerable scope for improving the adoption of risk management in the target organisations. This survey was conducted amongst respondents who had an Information Technology interest, but the results were particularly surprising for one organization function – finance. Governance and proper control of the business squarely falls within the finance function, but it appears that that area has little to do with risk management. Improved integration across the organization is indicated. These results are tabled below:

**GACA respondents**

Question 5		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	IT	12	60.0	60.0	60.0
	finance	1	5.0	5.0	65.0
	Business	3	15.0	15.0	80.0
	General management Others	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

*Table 31. Question 5 responses*

Binlden respondents 40 percentage of the respondents had observed that IT applied risk management assessments. 6.7% indicated finance department of their organization engages in risk management assessment, 40% claim business department use it and 13.3% agreed that the risk management assessment is used by general management. These results are tabled below:

**Binlden respondents**

Question 5		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	IT	6	40.0	40.0	40.0
	finance	1	6.7	6.7	46.7
	Business	6	40.0	40.0	86.7
	General management Others	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

*Table 32. Question 5 subcontractor 1*

SAFARI respondents 73.3 percentage of the respondents had observed that IT applied risk management assessments. 20% indicated finance department of their organization engages in risk management assessment, 6.7% claim business department use it.

This shows that the level of awareness or training to adopt the risk management or assessment is very low. These results are tabled below:

**SAFARI respondents**

Question 5		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	IT	11	73.3	73.3	73.3
	finance	3	20.0	20.0	93.3
	Business	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

*Table 33. Question 5 subcontractor 2*

All organisations respondents 58% of the respondents had observed that IT applied risk management assessments. 10% indicated finance department of their organization engages in risk management assessment, 20% claim business department use it.12% indicate general management. This shows that the level of awareness or training to adopt the risk management or assessment is very low. There is considerable scope for improving the adoption of risk management in the target organisations. This survey was conducted amongst respondents who had an Information Technology interest, but the results were particularly surprising for one organization function – finance. Governance and proper control of the business squarely falls within the finance function, but it appears that that area has little to do with risk management. Improved integration across the organization is indicated. These results are tabled and charted below:

**All organisations respondents**

Question 5		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	IT	29	58.0	58.0	58.0
	finance	5	10.0	10.0	68.0
	Business	10	20.0	20.0	88.0
	General management Others	6	12.0	12.0	100.0
	Total	50	100.0	100.0	

*Table 34. Question 5 results*

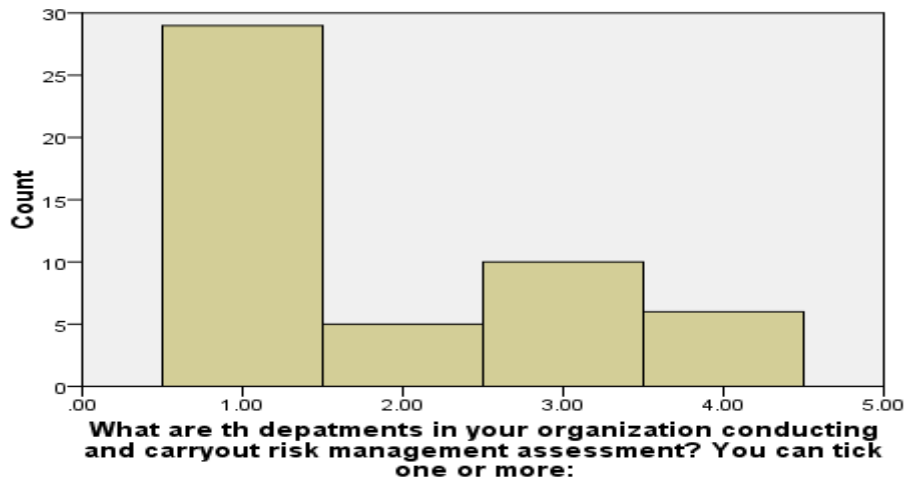


Figure 42. Chart for Question 5

**Question 6.** *How do you conduct risk management of IT projects in your organisation?* GACA respondents, slightly more than half of respondents use traditional passive approaches, outsource their risk management. This supports answers to question 2 that show some organisations are adopting a more proactive approach, and answers to question 5 that show some areas of the organization are not doing enough. These results are tabled below:

**GACA respondents**

Question 6		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Vital	3	15.0	15.0	15.0
	Dynamic	6	30.0	30.0	45.0
	Static	9	45.0	45.0	90.0
	Others	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

Table 35. Question 6 responses

Binlden respondents slightly more than half of respondents use traditional passive approaches or outsource their risk management. This supports answers to question 2 that show some organisations are adopting a more proactive approach, and answers to question 5 that show some areas of the organization are not doing enough these results are tabled below:

**Binlden respondents**

Question 6		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Vital	4	26.7	26.7	26.7
	Dynamic	7	46.7	46.7	73.3
	Static	4	26.7	26.7	100.0
	Total	15	100.0	100.0	

*Table 36. Question 6 subcontractor 1*

SAFARI respondents slightly more than half of respondents use traditional passive approaches or outsource their risk management. This supports answers to question 2 that show some organisations are adopting a more proactive approach, and answers to question 5 that show some areas of the organization are not doing enough these results are tabled below:

**SAFARI respondents**

Question 6		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Vital	7	46.7	46.7	46.7
	Dynamic	2	13.3	13.3	60.0
	Static	6	40.0	40.0	100.0
	Total	15	100.0	100.0	

*Table 37. Question 6 subcontractor 2*

All organisations respondents slightly more than half of respondents use traditional passive approaches or outsource their risk management. This supports answers to question 2 that show some organisations are adopting a more proactive approach, and answers to question 5 that show some areas of the organization are not doing enough. These results are tabled and illustrated below:

**All organisations respondents**

Question 6		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Vital	14	28.0	28.0	28.0
	Dynamic	15	30.0	30.0	58.0
	Static	19	38.0	38.0	96.0
	Others	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

*Table 38. Question 6 results*

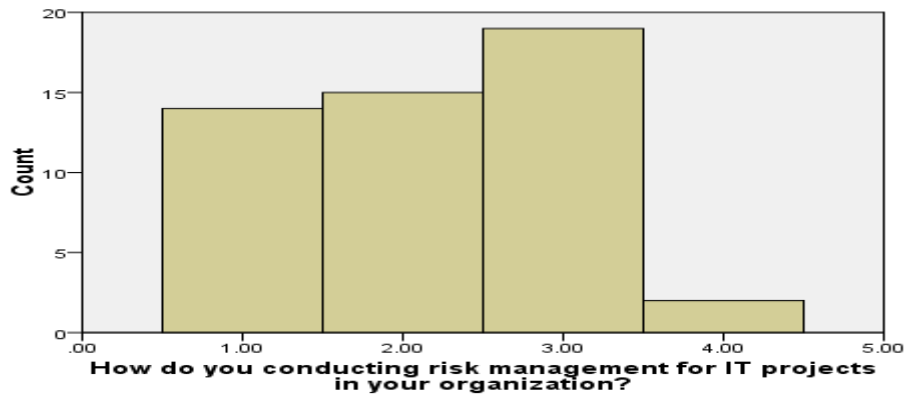


Figure 43. Chart for Question 6

**Question 7.** *The Distributed Risk Management Process confidence level measurement is almost 99%. How much likely your organisation has treated through DRMP dealing with IT projects?* GACA respondents 45% indicate low level of using risk management process, and 25% show strong confidence. In aggregate, IT industries have low level of awareness or are not confident to implement risk management process. These responses are tabled below:

**GACA respondents**

Question 7		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0>95% to 99%	5	25.0	25.0	25.0
	95% to 99%<0	6	30.0	30.0	55.0
	Non	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 39. Question 7 responses

Binlden respondents 26.7% indicate low level of using risk management process, and 73.3% show strong confidence these responses are tabled below:

**Binlden respondents**

Question 7		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0>95% to 99%	11	73.3	73.3	73.3
	95% to 99%<0	4	26.7	26.7	100.0
	Total	15	100.0	100.0	

Table 40. Question 7 subcontractor 1

SAFARI respondents 73.3% indicate low level of using risk management process, and 20% show strong confidence. In aggregate, IT industries have low level of awareness or are not confident to implement risk management process. These responses are tabled below:

**SAFARI respondents**

Question 7		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0>95% to 99%	11	73.3	73.3	73.3
	95% to 99%<0	3	20.0	20.0	93.3
	Non	1	6.7	6.7	100.0
Total		15	100.0	100.0	

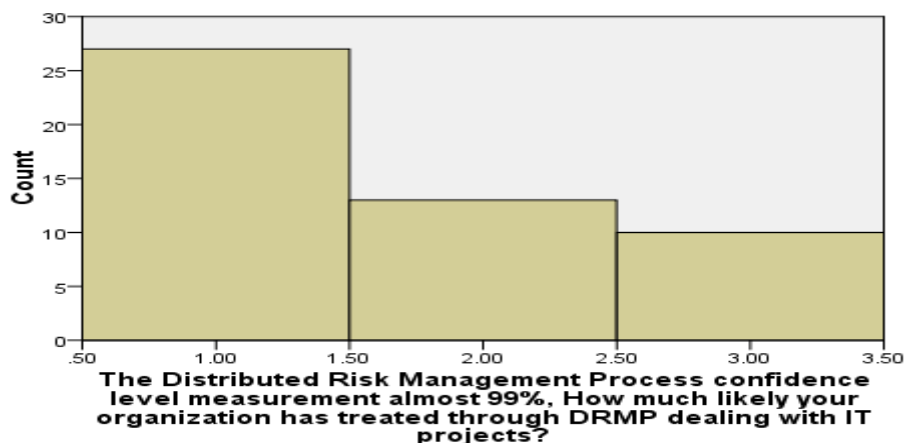
*Table 41. Question 7 subcontractor 2*

All organisations respondents 54% indicate low level of using risk management process, and 26% show strong confidence. In aggregate, IT industries have low level of awareness or are not confident to implement risk management process. These responses are tabled and charted below:

**All organisations respondents**

Question 7		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0>95% to 99%	27	54.0	54.0	54.0
	95% to 99%<0	13	26.0	26.0	80.0
	Non	10	20.0	20.0	100.0
Total		50	100.0	100.0	

*Table 42. Question 7 results*



*Figure 44. Chart for Question 7*



**5.1.5 Drivers of risk management adoption**

Question 8 addressed this issue.

**Question 8.** *How are the risk management aspects carried out in your organisation?* GACA respondent financial crisis and threats of intrusion accounted for 40 % of the answers given blew:

**GACA respondents**

Question 8		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Financial Crisis	8	40.0	40.0	40.0
	Recession Effects	1	5.0	5.0	45.0
	Changing IT Market demands	6	30.0	30.0	75.0
	Effects of threats from intrusion	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

*Table 43. Question 8 responses*

Binlden respondent financial crisis and threats of intrusion accounted for 53.3% of the answers given blew:

**Binlden respondents**

Question 8		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Financial Crisis	8	53.3	53.3	53.3
	Recession Effects	1	6.7	6.7	60.0
	Changing IT Market demands	6	40.0	40.0	100.0
	Total	15	100.0	100.0	

*Table 44. Question 8 subcontractor 1*

SAFARI respondent financial crisis and threats of intrusion accounted for 60% of the answers given blew:

**SAFARI respondents**

Question 8		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Financial Crisis	9	60.0	60.0	60.0
	Recession Effects	1	6.7	6.7	66.7
	Changing IT Market demands	4	26.7	26.7	93.3
	Effects of threats from intrusion	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

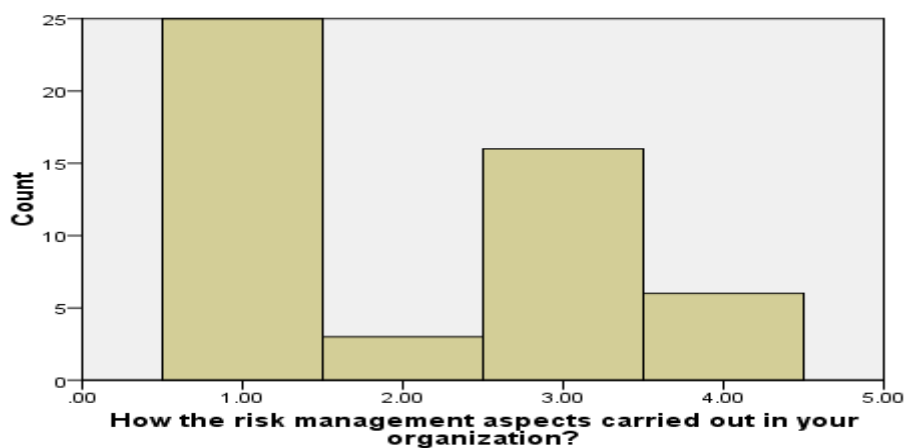
*Table 45. Question 8 subcontractor 2*

All organisations respondent financial crisis and threats of intrusion accounted for 53.3% of the answers given answers, tabled and charted below:

**All organisations respondents**

Question 8		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Financial Crisis	25	50.0	50.0	50.0
	Recession Effects	3	6.0	6.0	56.0
	Changing IT Market demands	16	32.0	32.0	88.0
	Effects of threats from intrusion	6	12.0	12.0	100.0
	Total	50	100.0	100.0	

*Table 46. Question 8 results*



*Figure 45. Chart for Question 8*

**5.1.6 Benefits achieve by implementing risk management principles**

Questions 9 and 10 addressed the issue of benefits.

**Question 9.** *What are the benefits your organisation achieved by implementing the risk management principles?* Improvement, either through preventing a repeat of past mistakes or through an active programme of continuous improvement, GACA respondents 35% indicated advantage of implementing risk management principle is for the purpose of monitoring in order to avoid repeated mistakes. 20% indicated for the purpose of managing resources. 35% which constitutes other group indicated for continuous improvement, 10% indicated for the purpose of reassuring the customers. Data is tabled below:

**GACA respondents**

Questions 9		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Avoiding the repeated mistakes	7	35.0	35.0	35.0
	Effective usage of Resources	4	20.0	20.0	55.0
	Continuous improvement	7	35.0	35.0	90.0
	Reassuring the customers	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

*Table 47. Question 9 responses*

Binlden respondents 40% indicated advantage of implementing risk management principle is for the purpose of monitoring in order to avoid repeated mistakes. 26.7% indicated for the purpose of managing resources. 33.3% which constitutes other group indicated for continuous improvement Data is tabled below:

**Binlden respondents**

Questions 9		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Avoiding the repeated mistakes	6	40.0	40.0	40.0
	Effective usage of Resources	4	26.7	26.7	66.7
	Continuous improvement	5	33.3	33.3	100.0
	Total	15	100.0	100.0	

*Table 48. Question 9 subcontractor 1*

SAFARI respondent 40% indicated advantage of implementing risk management principle is for the purpose of monitoring in order to avoid repeated mistakes. 26.7% indicated for the purpose of managing resources. 33.3% which constitutes other group indicated for continuous improvement Data is tabled below:

**SAFARI respondents**

Questions 9		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Avoiding the repeated mistakes	6	40.0	40.0	40.0
	Effective usage of Resources	4	26.7	26.7	66.7
	Continuous improvement	5	33.3	33.3	100.0
	Total	15	100.0	100.0	

*Table 49. Question 9 subcontractor 2*

All organisations respondent 38% indicated advantage of implementing risk management principle is for the purpose of monitoring in order to avoid repeated mistakes. 12% indicated for the purpose of managing resources 34% which constitutes other group indicated for continuous improvement 4% indicated for the purpose of reassuring the customers. Data is tabled and charted below:

**All organisations respondents**

Questions 9		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Avoiding the repeated mistakes	19	38.0	38.0	38.0
	Effective usage of Resources	12	24.0	24.0	62.0
	Continuous improvement	17	34.0	34.0	96.0
	Reassuring the customers	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

*Table 50. Question 9 results*

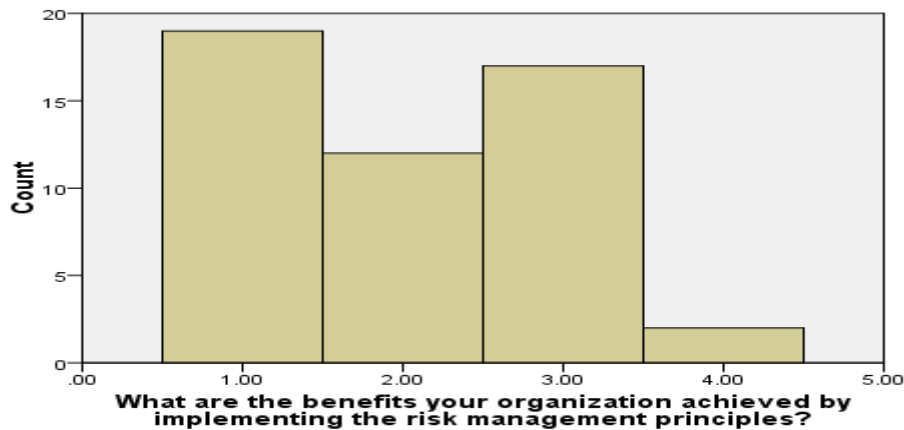


Figure 46. Chart for Question 9

**Question 10.** Does your organisation register the risk activities of IT projects during real time implementation? GACA respondents the majority, 80 percentage of respondents noted that their organisations used a risk registry to document project risks. Data is tabled below:

**GACA respondents**

Questions 10		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Risk registry	16	80.0	80.0	80.0
	Others	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

Table 51. Question 10 responses

The majority of Binlden respondents, 80 % of respondents noted that their organisations used a risk registry to document project risks. Data is tabled below:

**Binlden respondents**

Questions 10		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Risk logo	2	13.3	13.3	13.3
	Risk registry	12	80.0	80.0	93.3
	Risk trigger	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

Table 52. Question 10 subcontractor 1

The majority of SAFARI respondents 66.7 percentage of respondents noted that their organisations used a risk registry to document project risks. Data is tabled below:

**SAFARI respondents**

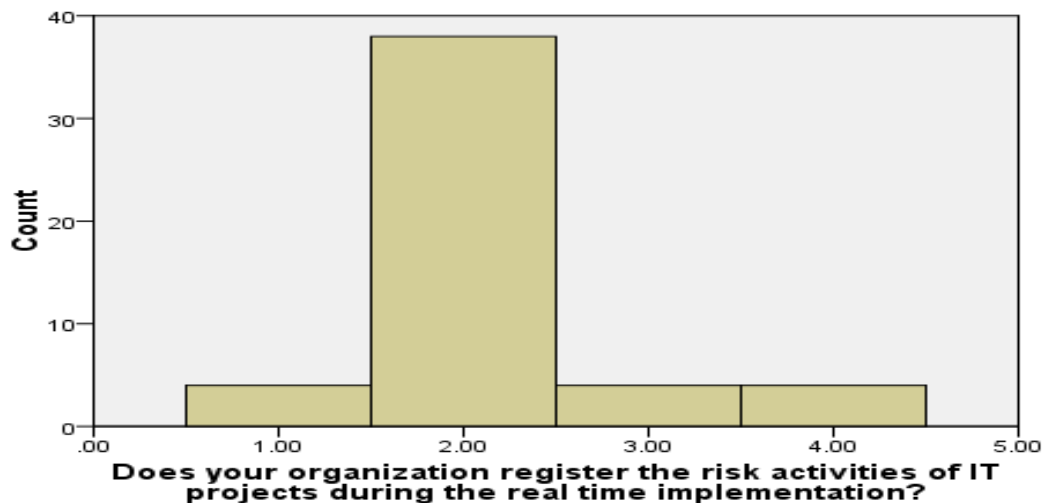
Questions 10		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Risk logo	2	13.3	13.3	13.3
	Risk registry	10	66.7	66.7	80.0
	Risk trigger	3	20.0	20.0	100.0
	Total	15	100.0	100.0	

*Table 53. Question 10 subcontractor 2*

**All organisations respondents**

Questions 10		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Risk logo	4	8.0	8.0	8.0
	Risk registry	38	76.0	76.0	84.0
	Risk trigger	4	8.0	8.0	92.0
	Others	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

*Table 54. Question 10 results*



*Figure 47. Chart for Question 10*

5.1.7 Other questions

**Question 11.** *How do you rate the impact of risk management in IT companies towards solving the following risks by considering out of 100%?* Whilst most respondents of GACA (60%) clearly acknowledged that risk management delivered cost savings, 60% saw it addressing recession risks and 60% felt risk management helped with disaster risks, they were less sure about the benefits in improving schedule overruns and recession risks. Data is tabled below:

**GACA respondents**

Q11 Answers	100 – 90 Excellent	89 – 75 V. Good	74 – 65 Good	64 – 50 Average	49 – 0 Poor	Mean
Cost saving	2	9	4	0		
Schedule overruns	0	9	5	1		
Unattainable users requirements	3	6	5	1		
Intrusion risks	0	4	10	1		
Recession risks	3	5	6			
Disaster risks	1	10	3	1		

*Table 55. Question 11 responses*

**Binladen respondents**

Q11 Answers	100 – 90 Excellent	89 – 75 V. Good	74 – 65 Good	64 – 50 Average	49 – 0 Poor	Mean
Cost saving	2	9	4	0		
Schedule overruns	0	9	5	1		
Unattainable users requirements	3	6	5	1		
Intrusion risks	0	3	10	1		
Recession risks	3	5	6	1		
Disaster risks	1	10	3	1		

*Table 56. Question 11 subcontractor 1*

**SAFARI respondents**

Q11 Answers	100 – 90 Excellent	89 – 75 V. Good	74 – 65 Good	64 – 50 Average	49 – 0 Poor	Mean
Cost saving	3	7	4	1		
Schedule overruns	7	6	2			
Unattainable users requirements	1	3	9	1		
Intrusion risks	0	9	5	1		
Recessional risks	0	11	4	0		
Disaster risks	0	5	9	1		

*Table 57. Question 11 subcontractor 2*

**Question 12.** *What are the key IT industry issues solved by using risk management process steps?*

This question enhanced the lists of benefits investigated in question 11. An arithmetic mean allows one to compare the relative weightings of each option.

**GACA respondents**

Q12 Answers	49 – 0 Not at all	64 – 50 Little	74 – 65 Average	89 – 75 V. Greatly	100 – 90 A lot	Mean
Better quality of information	0	2	8	4	1	
Better quantity of information	0	1	11	3	0	
Flexibility	0	0	8	3	4	
Reduce lead-time in production	0	0	8	7	0	
Cost saving	2	0	6	7	0	
Forecasting	2	1	6	5	1	
Resources planning	0	1	9	4	1	
Better operational efficacy	0	1	10	3	1	
Reduce inventory level	0	3	7	5	0	
More accurate costing	2	1	9	3	0	
Increase coordination among staff	0	2	8	4	1	
Better prospects for new projects	0	3	5	6	1	
Training programs to avoid risks	0	2	7	6	0	
Increased sales	0	0	6	6	3	

*Table 58. Question 12 responses*



<b>Binlden respondents</b>						
<b>Q12 Answers</b>	<b>49 – 0 Not at all</b>	<b>64 – 50 Little</b>	<b>74 – 65 Average</b>	<b>89 – 75 V. Greatly</b>	<b>100 – 90 A lot</b>	<b>Mean</b>
Better quality of information	0	2	8	4	1	
Better quantity of information	0	1	11	3	0	
Flexibility	0	0	8	3	4	
Reduce lead-time in production	0	0	8	7	0	
Cost saving	2	0	6	7	0	
Forecasting	2	1	6	5	1	
Resources planning	0	1	9	4	1	
Better operational efficacy	0	1	10	3	1	
Reduce inventory level	0	3	7	5	0	
More accurate costing	2	1	9	3	0	
Increase coordination among staff	0	2	8	4	1	
Better prospects for new projects	0	3	5	6	1	
Training programs to avoid risks	0	2	7	6	0	
Increased sales	0	0	6	6	3	

Table 59. Question 12 subcontractor 1

<b>SAFARI respondents</b>						
<b>Q12 Answers</b>	<b>49 – 0 Not at all</b>	<b>64 – 50 Little</b>	<b>74 – 65 Average</b>	<b>89 – 75 V. Greatly</b>	<b>100 – 90 A lot</b>	<b>Mean</b>
Better quality of information	0	0	0	5	10	
Better quantity of information	0	0	1	5	9	
Flexibility	0	0	3	9	3	
Reduce lead-time in production	0	1	2	6	6	
Cost saving	0	0	2	9	4	
Forecasting	0	0	2	6	7	
Resources planning	0	0	3	8	4	
Better operational efficacy	0	0	4	6	5	
Reduce inventory level	0	0	0	9	6	
More accurate costing	0	1	0	7	7	
Increase coordination among staff	0	0	4	6	5	
Better prospects for new projects	0	0	5	9	1	
Training programs to avoid risks	0	0	6	9	0	
Increased sales	0	0	7	7	2	

Table 60. Question 12 subcontractor 2

**Question 13.** *What is the potential impact of modified techniques on the organisation's current risk technique?* Whilst most respondents of GACA (60%) clearly acknowledged that modified technique will improve the progress of IT projects, 35% indicate that modified technique will expand the real time progress of IT projects Data is tabled below:

**GACA respondents**

<b>Question 13</b>				Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Modified technique will	hinders the progress of IT projects		1	5.0	5.0	5.0
	Modified technique will	improve the progress of IT projects		12	60.0	60.0	65.0
	Modified technique will	expand the real time progress of IT projects		7	35.0	35.0	100.0
	Total			20	100.0	100.0	

*Table 61. Question 12 responses*

(46.7%) respondents of Binlden acknowledged that modified technique will expand the real time progress of IT projects, 263.7% indicate that Modified technique will improve the progress of IT projects Data is tabled and below:

**Binladen respondents**

<b>Question 13</b>		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Modified technique will hinders the progress of IT projects	2	13.3	13.3	13.3
	Modified technique will improve the progress of IT projects	4	26.7	26.7	40.0
	Modified technique will expand the real time progress of IT projects	7	46.7	46.7	86.7
	None of the above	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

*Table 62. Question 12 subcontractor 1*

Whilst most respondents of SAFAR (73.30%) clearly acknowledged that modified technique will improve the progress of IT projects, 26.7% indicate that modified technique will expand the real time progress of IT projects Data is tabled below:

**SAFARI respondents**

Question 13		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Modified technique will improve the progress of IT projects	11	73.3	73.3	73.3
	Modified technique will expand the real time progress of IT projects	4	26.7	26.7	100.0
	Total	15	100.0	100.0	

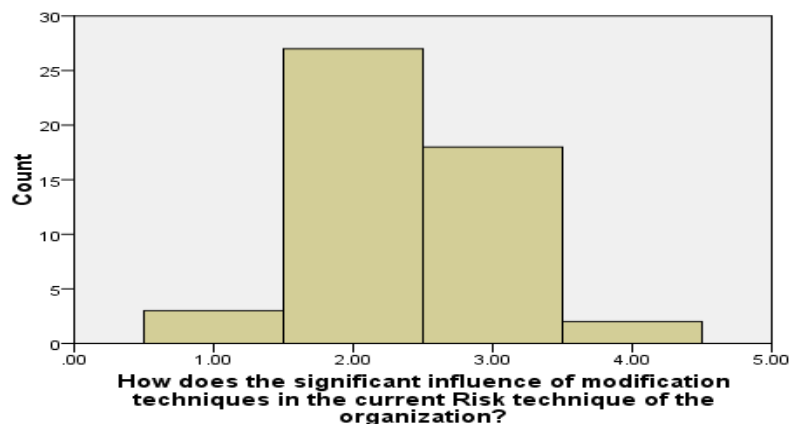
*Table 63. Question 12 subcontractor 2*

Whilst most respondents of all organisations respondents (54%) clearly acknowledged that modified technique will improve the progress of IT projects, 36% indicate that modified technique will expand the real time progress of IT projects. Data is tabled and charted below:

**All organisations respondents.**

Question 13		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Modified technique will hinders the progress of IT projects	3	6.0	6.0	6.0
	Modified technique will improve the progress of IT projects	27	54.0	54.0	60.0
	Modified technique will expand the real time progress of IT projects	18	36.0	36.0	96.0
	None of the above	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

*Table 64. Question 12 results*



*Figure 48. Chart for Question 13*

**Question 14.** *From your perspective, how your organisation will avoid events leading to unrecognised risk?* This question provided insights into the shortcomings of existing risk management approaches, GACA respondents 25% of the respondents indicated ‘top level’ with ‘risk assessing team’ as the type of management adopted, while 30% indicated Top Level with no awareness about risks involved in IT team., Data is tabled below:

**GACA respondents**

<b>Question 14</b>		<i>Frequency</i>	<i>Percent</i>	<i>Valid Percent</i>	<i>Cumulative Percent</i>
Valid	Top level with Risk assessing Team	5	25.0	25.0	25.0
	Top level with no awareness about risks involved in IT team	6	30.0	30.0	55.0
	Management with no Risk assessing Team	5	25.0	25.0	80.0
	Bottom Level involved with only IT team but no risk assessment at all	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

*Table 65. Question 14 responses*

Binladen respondents 40 percent of the respondents indicated ‘top level’ with ‘risk assessing team’ as the type of management adopted, while 13.3% indicated Top Level with no awareness about risks involved in IT team, and 46.7% percent operate a management with no risk assessing team. And the remaining percentage 16% Bottom Level involved with only IT team but no risk assessment at all. Data is tabled below:

**Binladen respondents**

<b>Question 14</b>		<i>Frequency</i>	<i>Percent</i>	<i>Valid Percent</i>	<i>Cumulative Percent</i>
Valid	Top level with Risk assessing Team	6	40.0	40.0	40.0
	Top level with no awareness about risks involved in IT team	2	13.3	13.3	53.3
	Management with no Risk assessing Team	7	46.7	46.7	100.0
	Total	15	100.0	100.0	

*Table 66. Question 14 subcontractor 1*

SAFARI respondents 66.6 percent of the respondents indicated ‘top level’ with ‘risk assessing team’ as the type of management adopted, while 26.7% indicated Top Level with no awareness about risks involved in IT team, and 6.7% percent operate a management with no risk assessing team. Data is tabled below:

**SAFARI respondents**

Question 14		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Top level with Risk assessing Team	10	66.7	66.7	66.7
	Top level with no awareness about risks involved in IT team	4	26.7	26.7	93.3
	Management with no Risk assessing Team	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

*Table 67. Question 14 subcontractor 2*

All organisations respondents 42% of the respondents indicated ‘top level’ with ‘risk assessing team’ as the type of management adopted, while 24% indicated Top Level with no awareness about risks involved in IT team, and 26% percent operate a management with no risk assessing team. Data is tabled and charted below:

**All organisations respondents**

Question 14		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Top level with Risk assessing Team	21	42.0	42.0	42.0
	Top level with no awareness about risks involved in IT team	12	24.0	24.0	66.0
	Management with no Risk assessing Team	13	26.0	26.0	92.0
	Bottom Level involved with only IT team but no risk assessment at all	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

*Table 68. Question 14 results*

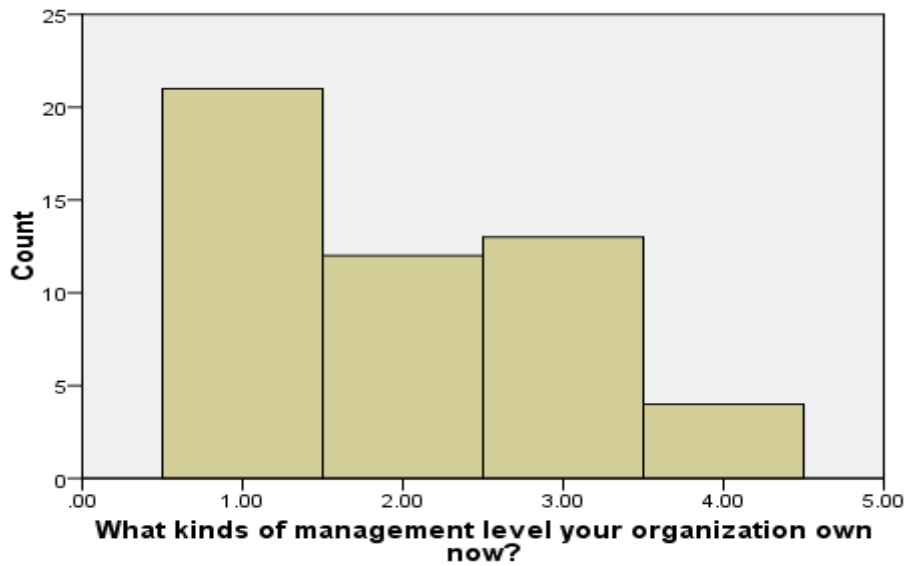


Figure 49. Chart for Question 13

**Question 15.** *What kinds of management level your organisation own now?* GACA respondents 25% of the respondents indicated ‘top level’ with ‘risk assessing team’ as the type of management adopted, while 30% indicated Top Level with no awareness about risks involved in IT team., Data is tabled below:

**GACA respondents**

Question 15		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Top level with Risk assessing Team	5	25.0	25.0	25.0
	Top level with no awareness about risks involved in IT team	6	30.0	30.0	55.0
	Management with no Risk assessing Team	5	25.0	25.0	80.0
	Bottom Level involved with only IT team but no risk assessment at all	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

Table 69. Question 15 responses

Binlden respondents 40 percent of the respondents indicated ‘top level’ with ‘risk assessing team’ as the type of management adopted, while 13.3% indicated Top Level with no awareness about risks involved in IT team, and 46.7% percent operate a management with no risk assessing team.

And the remaining percentage 16% Bottom Level involved with only IT team but no risk assessment at all. Data is tabled below:

**Binden respondents**

Question 15		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Top level with Risk assessing Team	6	40.0	40.0	40.0
	Top level with no awareness about risks involved in IT team	2	13.3	13.3	53.3
	Management with no Risk assessing Team	7	46.7	46.7	100.0
	Total	15	100.0	100.0	

*Table 70. Question 15 subcontractor 1*

SAFARI respondents 66.6 percent of the respondents indicated ‘top level’ with ‘risk assessing team’ as the type of management adopted, while 26.7% indicated Top Level with no awareness about risks involved in IT team, and 6.7% percent operate a management with no risk assessing team. Data is tabled below:

**SAFARI respondents**

Question 15		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Top level with Risk assessing Team	10	66.7	66.7	66.7
	Top level with no awareness about risks involved in IT team	4	26.7	26.7	93.3
	Management with no Risk assessing Team	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

*Table 71. Question 15 subcontractor 2*

All organisations respondents 42% of the respondents indicated ‘top level’ with ‘risk assessing team’ as the type of management adopted, while 24% indicated Top Level with no awareness about risks involved in IT team, and 26% percent operate a management with no risk assessing team. Data is tabled and charted below:

**All organisations respondents**

Question 15				Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Top	level	with Risk assessing Team	21	42.0	42.0	42.0
	Top level	with no awareness about risks involved in IT team		12	24.0	24.0	66.0
	Management	with no Risk assessing Team		13	26.0	26.0	92.0
	Bottom Level	involved with only IT team but no risk assessment at all		4	8.0	8.0	100.0
	Total			50	100.0	100.0	

Table 72. Question 15 results

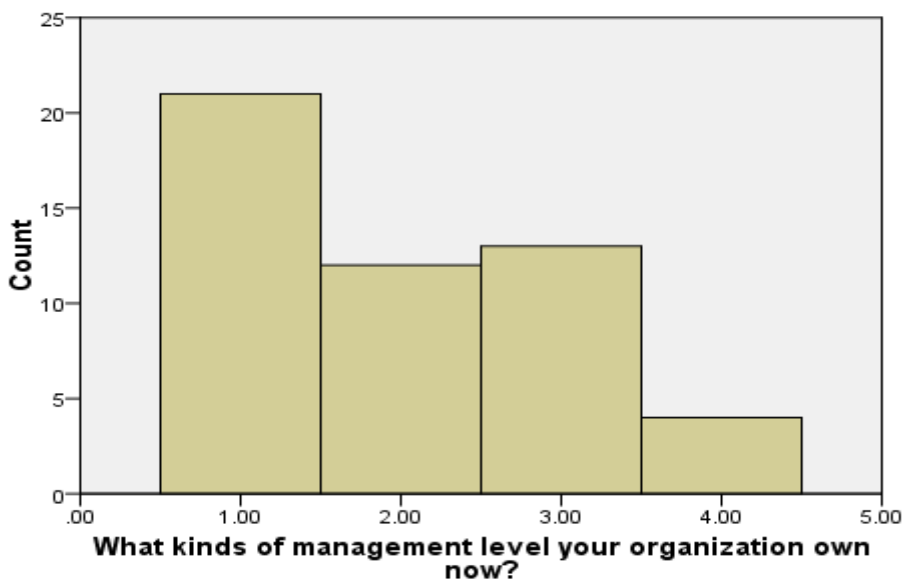


Figure 50. Chart for Question 15

**Question 16.** *If they are at top level, why they are not strong and committed enough to take the decisions related with risks in the IT projects?* 55% of GACA respondents the top level are not strong and committed enough to take the decisions related with risks in the IT projects is due to a lack of organization-wide commitment, while 20% indicate is due to Ineffective communication. Data is tabled below:



**GACA respondents**

Question 16		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Previous attempts to create change were hindered by various system factors	3	15.0	15.0	15.0
	A lack of organization-wide commitment	11	55.0	55.0	70.0
	Poor organizational relationships	2	10.0	10.0	80.0
	Ineffective communication	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

*Table 73. Question 16 responses*

46.7% of Binladen respondents the top level are not strong and committed enough to take the decisions related with risks in the IT projects is due to Previous attempts to create change were hindered by various system factors, while 26.7% indicate is due to A lack of organization-wide commitment. Data is tabled below:

**Binlden respondents**

Question 16		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Previous attempts to create change were hindered by various system factors	7	46.7	46.7	46.7
	A lack of organization-wide commitment	4	26.7	26.7	73.3
	Poor organizational relationships	2	13.3	13.3	86.7
	Ineffective communication	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

*Table 74. Question 16 subcontractor 1*

26.7% of SAFARI respondents the top level are not strong and committed enough to take the decisions related with risks in the IT projects is due to Previous attempts to create change were hindered by various system factors, while 66.7% indicate is due to A lack of organization-wide commitment. Data is tabled below:

**SAFARI respondents**

Question 16		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Previous attempts to create change were hindered by various system factors	4	26.7	26.7	26.7
	A lack of organization-wide commitment	10	66.7	66.7	93.3
	Poor organizational relationships	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

*Table 75. Question 16 subcontractor 2*

28% of All organisations respondents the top level are not strong and committed enough to take the decisions related with risks in the IT projects is due to Previous attempts to create change were hindered by various system factors, while 50% indicate is due to A lack of organization-wide commitment. Data is tabled and charted below:

**All organisations respondents**

Question 16		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Previous attempts to create change were hindered by various system factors	14	28.0	28.0	28.0
	A lack of organization-wide commitment	25	50.0	50.0	78.0
	Poor organizational relationships	5	10.0	10.0	88.0
	Ineffective communication	6	12.0	12.0	100.0
	Total	50	100.0	100.0	

*Table 76. Question 16 results*

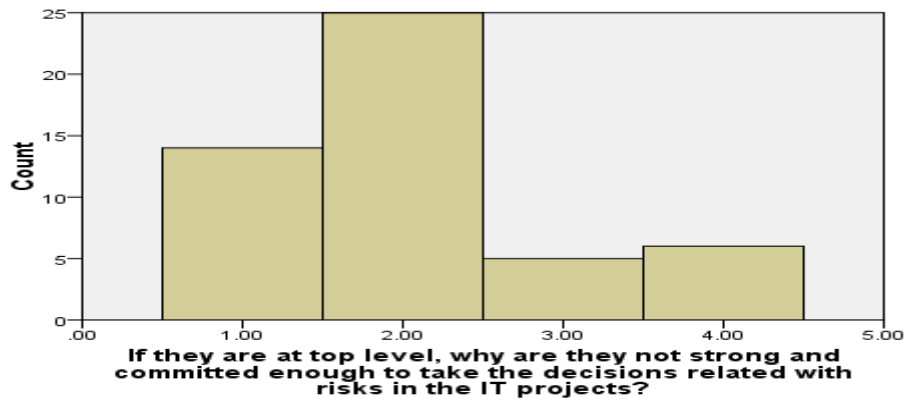


Figure 51. Chart for Question 16

**Question 17.** Does your organisation analyse criticality for the projects within the organisation?

The majority of GACA respondents saw their organisations analyzing risks, 70% of the respondents affirmatively stated that their organization conduct critical analysis of the project prior development while 30 percent said no. Data is tabled below:

Question 17		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	14	70.0	70.0	70.0
	No	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 77. Question 17 responses

Binlden respondents the majority of respondents saw their organisations analyzing risks, 93.3% of the respondents affirmatively stated that their organization conduct critical analysis of the project prior development, while 6.7 percent said no. Data is tabled below:

Question 17		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	14	93.3	93.3	93.3
	No	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

Table 78. Question 17 subcontractor 1

SAFARI respondents the majority of respondents saw their organisations analyzing risks, 93.3% of the respondents affirmatively stated that their organization conduct critical analysis of the project prior development while 6.7 percent said no. Data is tabled below:

**SAFARI respondents**

Question 17		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	80	80	80
	No	2	20	20	100.0
	Total	15	100.0	100.0	

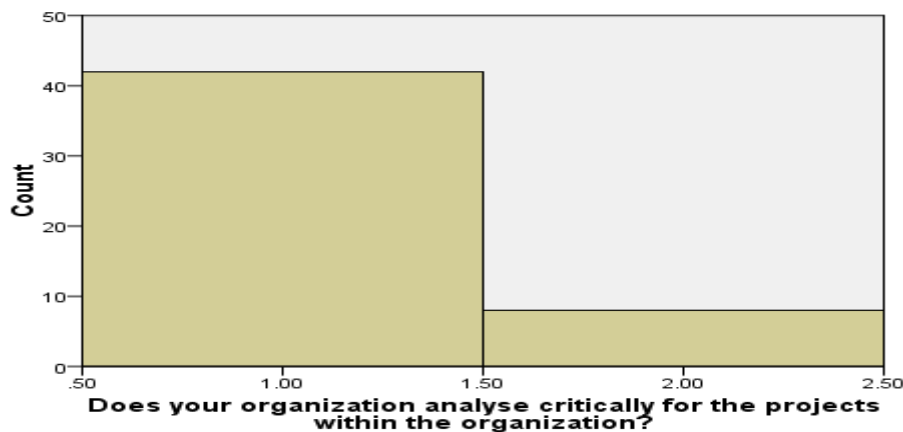
*Table 79. Question 17 subcontractor 2*

All organisations respondents the majority of respondents saw their organisations analyzing risks80% of the respondents affirmatively stated that their organization conduct critical analysis of the project prior development while 20 percent said no. Data is tabled and charted below:

**All organisations respondents**

Question 17		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	42	84.0	84.0	84.0
	No	8	16.0	16.0	100.0
	Total	50	100.0	100.0	

*Table 80. Question 17 results*



*Figure 52. Chart for Question 18*

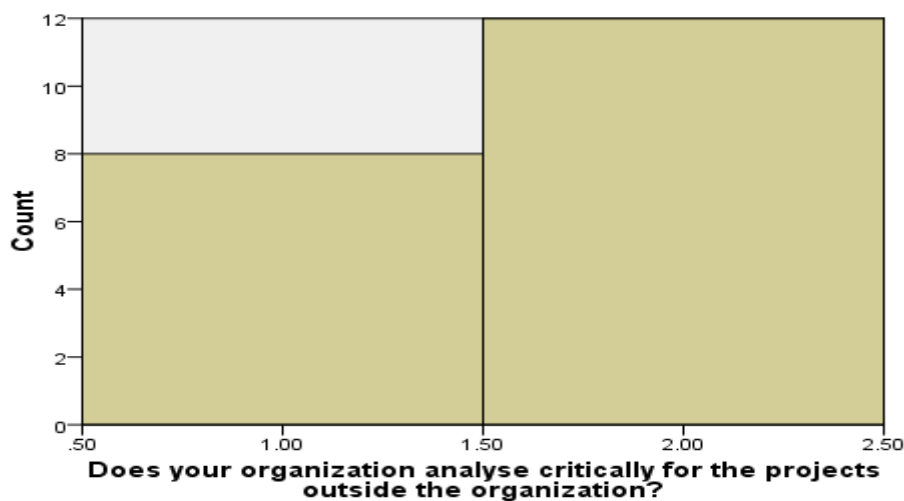
**Question 18.** *Does your organisation analyse criticality for the projects outside the organisation?*

GACA respondents 60% of respondents did not look critically at the risks originating outside the organization, particularly worrying given the number of respondents who observed risks from external sources (question 20). Data is tabled below:

GACA respondents					
Question 18		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	8	40.0	40.0	40.0
	No	12	60.0	60.0	100.0
	Total	20	100.0	100.0	

*Table 81. Question 18 responses*

The chart below reveals that more organisations do not critically analyse projects outside their own organisation. This is a high ratio considering that the risks in other areas are quite likely to affect their organisation.



*Figure 53. Chart for Question 18*

Binlden respondents the majority of respondents saw their organisations analyzing risks, 93.3% of the respondents affirmatively stated that their organization conduct critical analysis of the project prior development while 6.7 percent said no. Data is tabled below:

**Binlden respondents**

Question 18		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	14	93.3	93.3	93.3
	No	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

*Table 82. Question 18 subcontractor 1*

SAFARI respondents the majority of respondents saw their organisations analyzing risks, 93.3% of the respondents affirmatively stated that their organization conduct critical analysis of the project prior development while 6.7 percent said no. Data is tabled below:

**SAFARI respondents**

Question 18		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	14	93.3	93.3	93.3
	No	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

*Table 83. Question 18 subcontractor 2*

All organisations respondents The majority of respondents saw their organisations analyzing risks 68% of the respondents affirmatively stated that their organization conduct critical analysis of the project prior development while 6.7 percent said while 32 percent said no. Data is tabled below:

**All organisations respondents**

Question 18		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	34	68.0	68.0	68.0
	No	16	32.0	32.0	100.0
	Total	50	100.0	100.0	

*Table 84. Question 18 results*

The chart below reveals that more organisations critically analyze projects outside their own organization. This is a high ratio considering that the risks in other areas are quite likely to affect their organization:

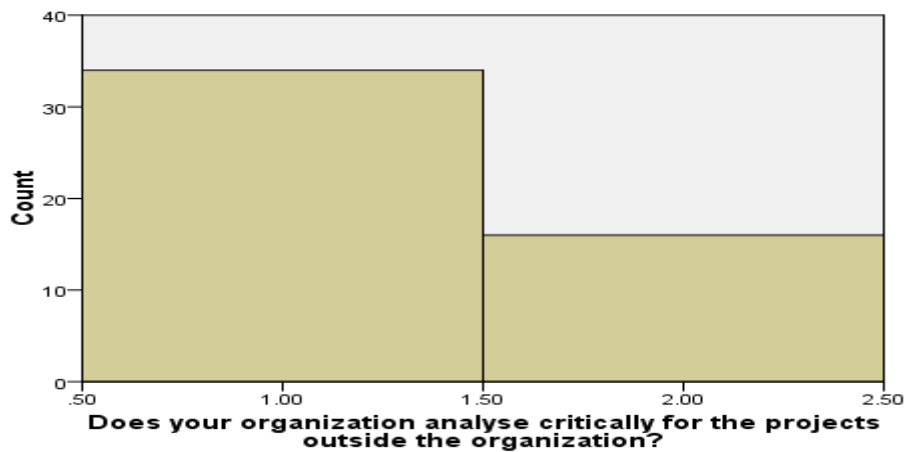


Figure 54. Chart for Question 18

**Question 19.** How do you rate failure that faced by your organisation for the projects within the organisation? 84% of the respondent responded to questions 19 and 20. 8% of the respondents indicated that occurrence of project failure is frequent, 36% state that occurrence of project failure is occasional, and 20% indicated that the occurrence is reasonable, none of the respondents indicated extremely unlikely.

A significant 65% of respondents were of the opinion that their organisations faced failure from internal projects, and 90% saw an appreciable chance of this happening. This indicates a low overall trust in their organization’s ability to handle large risks and crises. Data is tabled below:

GACA respondents

Question 19		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Frequent	2	10.0	10.0	10.0
	Occasional	11	55.0	55.0	65.0
	Reasonably Probable	5	25.0	25.0	90.0
	Remote	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

Table 85. Question 19 responses

Binlden respondents 80 percent of respondents did look critically at the risks originating outside the organization. The chart below reveals that more organisations do critically analyze projects outside their own organization. This is a high ratio considering that the risks in other areas are quite likely to affect their organization. Data is tabled below:

**Binlden respondents**

Question 19		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Frequent	1	6.7	6.7	6.7
	Occasional	5	33.3	33.3	40.0
	Reasonably Probable	5	33.3	33.3	73.3
	Remote	1	6.7	6.7	80.0
	Extremely Unlikely	3	20.0	20.0	100.0
	Total	15	100.0	100.0	

*Table 86. Question 19 subcontractor 1*

SAFARI respondents 13.3% of the respondents indicated that occurrence of project failure is frequent, 33.3% state that occurrence of project failure is occasional, and 40% indicated that the occurrence is reasonable, none of the respondents indicated extremely unlikely. This indicates a low overall trust in their organization’s ability to handle large risks and crises. Data is tabled below:

**SAFARI respondents**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Frequent	2	13.3	13.3	13.3
	Occasional	5	33.3	33.3	46.7
	Reasonably Probable	6	40.0	40.0	86.7
	Remote	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

*Table 87. Question 19 subcontractor 2*

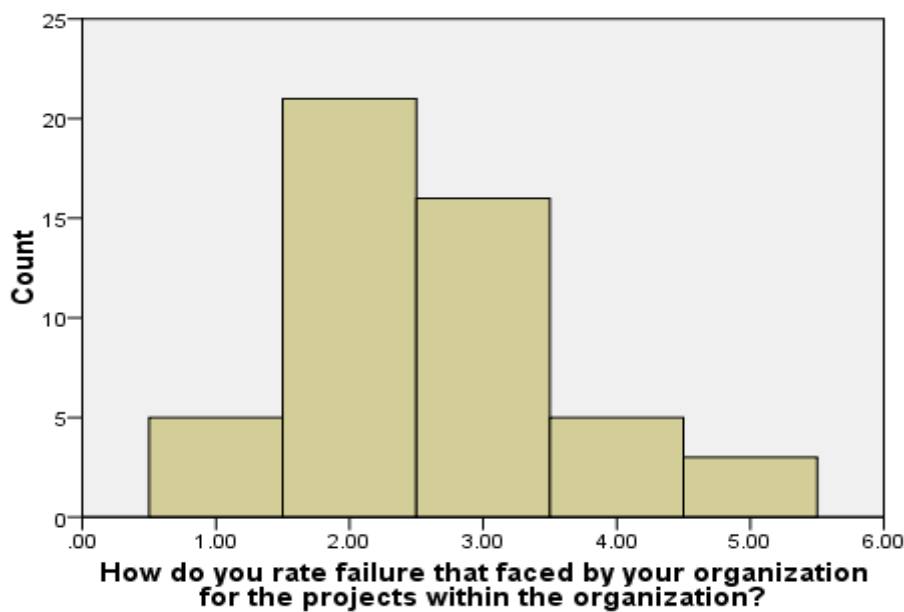
All organisations respondent No clear outcomes were given to this question, although the response to 'extremely unlikely' (6%) shows that a significant number of respondents felt that the organisation could be at threat of a crisis from external projects. This is in contrast to the previous question, showing respondents are less trusting of outcomes when they are not in control. Data is tabled and charted below:



**All organisations respondents**

Question 19		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Frequent	5	10.0	10.0	10.0
	Occasional	21	42.0	42.0	52.0
	Reasonably Probable	16	32.0	32.0	84.0
	Remote	5	10.0	10.0	94.0
	Extremely Unlikely	3	6.0	6.0	100.0
	Total	50	100.0	100.0	

*Table 88. Question 19 results*



*Figure 55. Chart for Question 19*

**Question 20.** *How do you rating failure that faced by your organisation for the projects outside the organisation?* No clear outcomes were given to this question, although the response to 'extremely unlikely' (6%) shows that a significant number of respondents felt that the organization could be at threat of a crisis from external projects. This is in contrast to the previous question, showing respondents are less trusting of outcomes when they are not in control. Data is tabled below:

**GACA respondents**

Question 20		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Frequent	3	15.0	15.0	15.0
	Occasional	2	10.0	10.0	25.0
	Reasonably Probable	8	40.0	40.0	65.0
	Extremely Unlikely	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

*Table 89. Question 20 responses*

Binlden respondents No clear outcomes were given to this question, although the response to 'extremely unlikely' (20%) shows that a significant number of respondents felt that the organisation could be at threat of a crisis from external projects. This is in contrast to the previous question, showing respondents are less trusting of outcomes when they are not in control. Data is tabled below:

**Binlden respondents**

Question 20		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Frequent	2	13.3	13.3	13.3
	Occasional	6	40.0	40.0	53.3
	Reasonably Probable	4	26.7	26.7	80.0
	Extremely Unlikely	3	20.0	20.0	100.0
	Total	15	100.0	100.0	

*Table 90. Question 20 subcontractor 1*

SAFARI respondents 53.3% of the respondents state that occurrence of project failure is occasional, and 26.7% indicated that the occurrence is reasonable, none of the respondents indicated extremely unlikely. This indicates a low overall trust in their organization's ability to handle large risks and crises. Data is tabled below:

**SAFARI respondents**

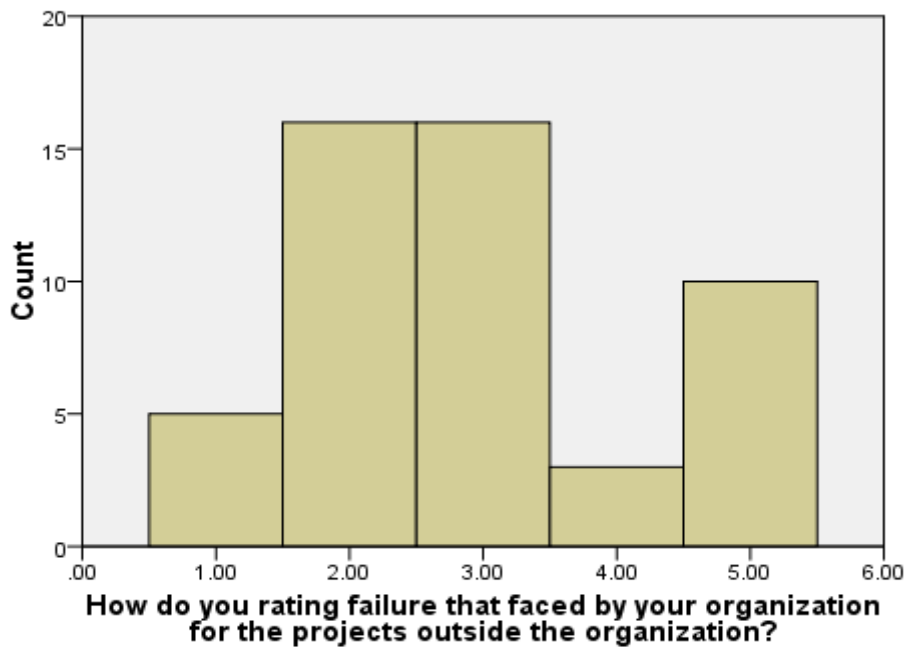
Question 20		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Frequent	8	53.3	13.3	13.3
	Occasional	4	26.7	40.0	53.3
	Reasonably Probable	3	20.0	26.7	80.0
	Extremely Unlikely	0	0	0.0	100.0
	Total	15	100.0	100.0	

*Table 91. Question 20 subcontractor 2*

**All organisations respondents**

Question 20		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Frequent	5	10.0	10.0	10.0
	Occasional	16	32.0	32.0	42.0
	Reasonably Probable	16	32.0	32.0	74.0
	Remote	3	6.0	6.0	80.0
	Extremely Unlikely	10	20.0	20.0	100.0
	Total	50	100.0	100.0	

*Table 92. Question 20 results*



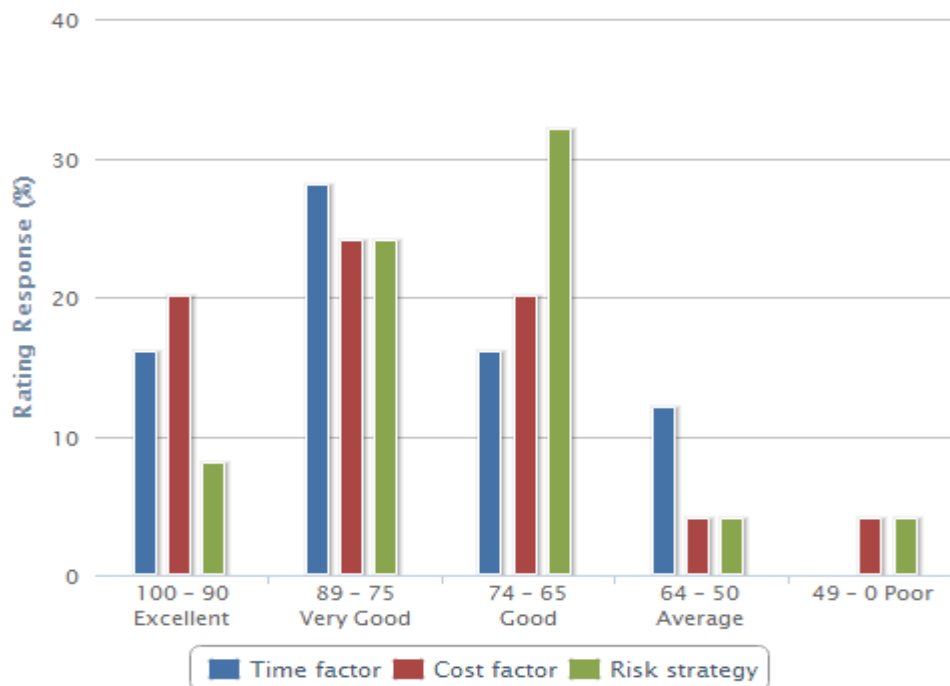
*Figure 56. Chart for Question 19*

**Question 21.** *What kind of rating can be given for the method of your organisation analysis with the following factors by considering out of 100%?* The results to this question show a tendency for respondents to assess their analysis of time, cost and risk strategy as good or very good. Respondents saw less commitment to the softer factors of customer feedback and employee opinion. Form this it appears that quantitative risk assessment and management approaches may be more appealing in organisations. Data is tabled below:

**GACA respondents**

Q21 Answers	100 – 90 Excellent	89 – 75 V. Good	74 – 65 Good	64 – 50 Average	49 – 0 Poor
Time factor	2	6	6	1	0
Cost factor	3	9	2	1	0
Risk strategy	0	9	4	1	1
Workers performance	2	6	5	1	1
Feedback of customers	4	3	6	0	2
Opinion of the employees	2	6	4	2	1

*Table 93. Question 21 responses*



*Figure 57. Chart for Question 21*

The chart above for question 21 reveals 16%, 20%, and 8% of the respondents indicated rating of the method of risk assessment as excellent in terms of time factor, cost factor, and Risk strategy respectively, while 4% of the respondents rated risk assessment methods adopted by their organisation is poor in terms of cost factor, and risk strategy. No response for time factor in terms of poor rating categories.

**Question 22.** *What kind of tool(S) you use for risk management handling?* GACA respondents, the most common tools used by respondents are assessment tools, used by 40% of respondents. These address only one aspect of risk management and do not offer the comprehensive approach needed to manage risk through the entire lifecycle. Data is tabled below:

**GACA respondents**

Question 22		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Integrating tools	1	5.0	5.0	5.0
	Assessment tolls	8	40.0	40.0	45.0
	Strategies and tools	6	30.0	30.0	75.0
	Quality improvement tools	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

*Table 94. Question 22 responses*

Binlden respondents the most common tools used by respondents are Strategies and tools, used by 80% of respondents. These addresses only one aspect of risk management and do not offer the comprehensive approach needed to manage risk through the entire lifecycle Data is tabled below:

**Binlden respondents**

Question 22		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Integrating tools	1	6.7	6.7	6.7
	Strategies and tools	12	80.0	80.0	86.7
	Quality improvement tools	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

*Table 95. Question 22 subcontractor 1*

SAFARI respondents the most common tools used by respondents are assessment tools, used by 40% of respondents. These address only one aspect of risk management and do not offer the comprehensive approach needed to manage risk through the entire lifecycle. Data is tabled below:

**AFARI respondents**

<b>Question 22</b>		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Integrating tools	2	13.3	13.3	13.3
	Assessment tolls	6	40.0	40.0	53.3
	Strategies and tools	6	40.0	40.0	93.3
	Quality improvement tools	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

*Table 96. Question 22 subcontractor 2*

All organisations respondents the most common tools used by respondents are Strategies and tools, used by 48% of respondents. These address only one aspect of risk management and do not offer the comprehensive approach needed to manage risk through the entire lifecycle. Data is tabled and charted below:

**All organisations respondents**

<b>Question 22</b>		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Integrating tools	4	8.0	8.0	8.0
	Assessment tolls	14	28.0	28.0	36.0
	Strategies and tools	24	48.0	48.0	84.0
	Quality improvement tools	8	16.0	16.0	100.0
	Total	50	100.0	100.0	

*Table 97. Question 22 results*

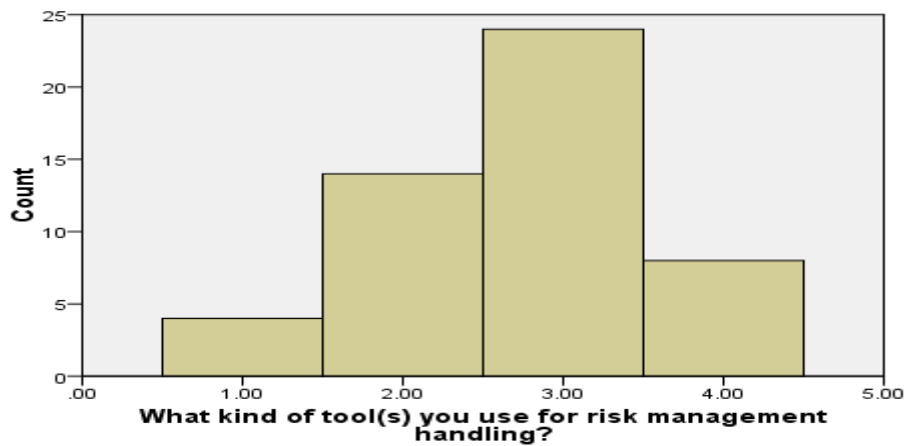


Figure 58. Chart for Question 22

**Question 23.** Does your organisation depend on other organisations for completing projects? GACA respondents the majority of respondents 80% worked in organisations that collaborated with other organisations on the completion of projects. This indicates distributed environments and hence the validity of using these respondents to investigate *Evolutionary Model*. Data is tabled below:

GACA respondents					
Question 23		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	16	80.0	80.0	80.0
	No	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

Table 98. Question 23 responses

Binlden respondents the majority of respondents 80% worked in organisations that collaborated with other organisations on the completion of projects. This indicates distributed environments and hence the validity of using these respondents to investigate *Evolutionary Model*. Data is tabled below:

**Binlden respondents**

Question 23		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	80.0	80.0	80.0
	No	3	20.0	20.0	100.0
	Total	15	100.0	100.0	

*Table 99. Question 23 subcontractor 1*

SAFARI respondents the majority of respondents 80% worked in organisations that collaborated with other organisations on the completion of projects. This indicates distributed environments and hence the validity of using these respondents to investigate Evolutionary Model. Data is tabled below:

**SFARI respondents**

Question 23		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	80.0	80.0	80.0
	No	3	20.0	20.0	100.0
	Total	15	100.0	100.0	

*Table 100. Question 23 subcontractor 2*

All organisations respondents the majority of respondents 80% worked in organisations that collaborated with other organisations on the completion of projects. This indicates distributed environments and hence the validity of using these respondents to investigate Evolutionary Model. Data is tabled and charted below:

**All organisations respondents**

Question 23		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	40	80.0	80.0	80.0
	No	10	20.0	20.0	100.0
	Total	50	100.0	100.0	

*Table 101. Question 23 results*



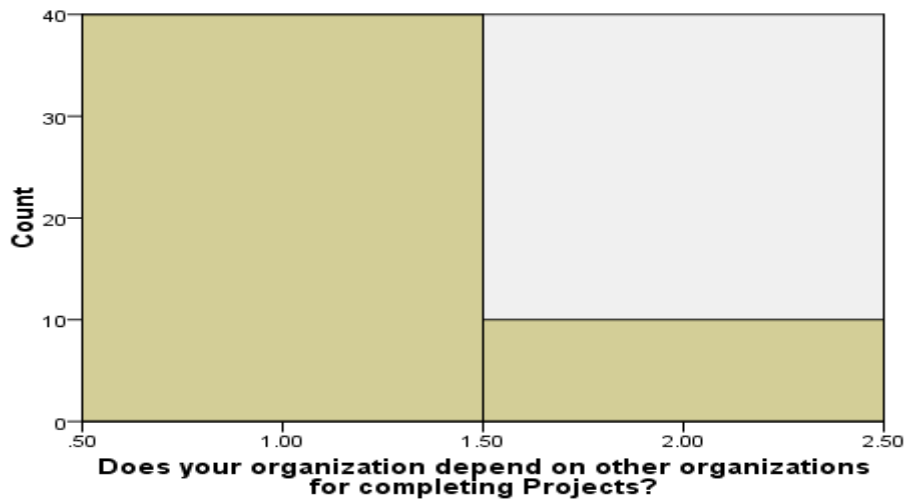


Figure 59. Chart for Question 23

**Question 24.** *If yes, do you assess all the above factors mentioned in question 21 about the organisation working for the projects?* GACA respondents .The majority of respondents 60% worked in organisations assess all the above factors mentioned in question 21 about the organization working for the projects. Data is tabled below:

**GACA respondents**

Question 24		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	60.0	60.0	60.0
	No	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 102. Question 24 responses

Binlden the majority of respondents 93.3% worked in organisations assess all the above factors mentioned in question 21 about the organization working for the projects. Data is tabled below:

**Binlden respondents**

Question 24		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	14	93.3	93.3	93.3
	No	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

Table 103. Question 24 subcontractor 1

SAFARI the majority of respondents 73.3% worked in organisations assess all the above factors mentioned in question 21 about the organization working for the projects. Data is tabled below:

**SFARI respondents**

Question 24		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	11	73.3	73.3	73.3
	No	4	26.7	26.7	100.0
	Total	15	100.0	100.0	

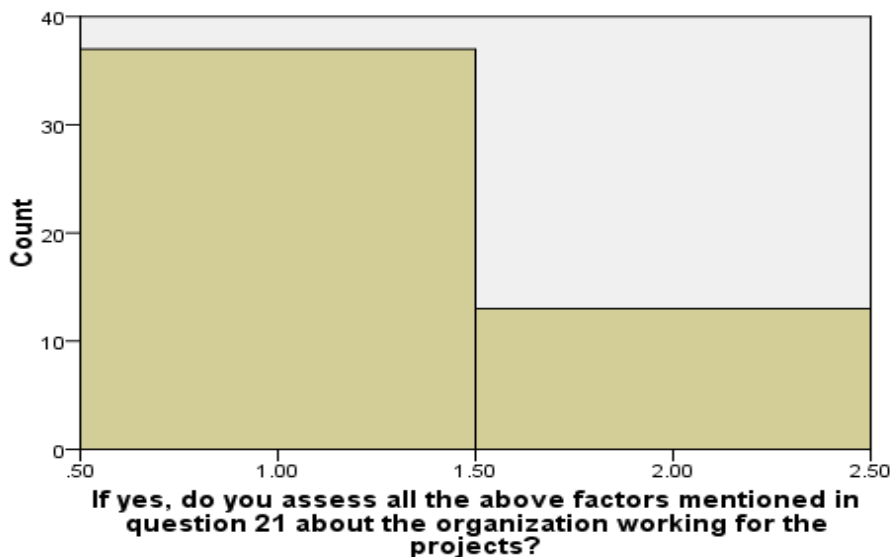
*Table 104. Question 24 subcontractor 2*

All organisations the majority of respondents 74% worked in organisations assess all the above factors mentioned in question 21 about the organization working for the projects. Data is tabled and charted below:

**All organisations respondents**

Question 24		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	37	74.0	74.0	74.0
	No	13	26.0	26.0	100.0
	Total	50	100.0	100.0	

*Table 105. Question 24 results*



*Figure 60. Chart for Question 23*

**Question 25.** *Finally, write your experience with distributed risk management process models implemented in your organisation?* Responses given were brief:

- Not applied informal risk management tools are used.
- Certainly very good experience in reviewing and preparing sheets which will help us in our future assignments.

### **5.1.8 Synopsis of survey data**

Experience of using risk management processes in IT industries (Q1) shows the percentage of the people with experience and existence of familiarity with risk management strategies (Q2-4) are very low in comparison to the rate of project failures which underscore importance of risk management awareness in terms of campaign.

There are wide ranging answers to the risk management approaches adopted (Q5-8), the benefits earned from implementing risk management principles (Q9-10), and the impact on IT industries (Q11-14). Every organisation has a different way of conducting risk management, and this is consistent with findings in literature (section 3.2.8 and 3.3).

There is no stipulated or standard of managing risk in IT industries. Management of risk goes beyond maintaining risk register during project development. As 48% claimed, only the IT departments conduct and maintain risk management during project development. Other stakeholders are left out of the process.

A Risk ontology suggests the full breadth of IT project development risks must include both technical and non-technical, and an ontology provides a reliable framework for the development of other risk management activities. 48% of the sample showed no formal ontological process or framework. This indicates a need for an event based risk management process to involve all stakeholders in the risk management process because influence of organisation management on risk management processes (Q15 and Q16) is crucial to management of risk within and outside the organisation. However, only 20% of the respondents have experience managing with a risk assessing team whilst 66% have no awareness of the risk management process.

The percentage of success and failure rate (Q19 and Q20) shows that project failure is inevitable if there is no risk management process for monitoring the development process. Rating assessment and risk management in use (Q21 to Q24) shows that organisations tend to measure the variables of risk, time, and cost during project development and their risk management process.

## 5.2 STRUCTURED INTERVIEW FINDINGS

This section describes the outcomes of interviews with selected experts in the field of information systems and risk management.

The experts consisted of a Vice President for IT Sector, IT Operation General Manager, IT Automation General Manager, IT Maintenance and Control Manger and four IT Project Managers. Members of the Saudi General Authority Civil Aviation (GACA) IT department were consulted. These were experts with more than five years working experience, and they shared their views by responding to interview questions provided in Appendix C. Deductions were then made based on critical analysis of their responses.

Their contributions have had an extensive effect on design and implementation of the *DRiMaP* extensions developed over the course of this research. These consisted of the following points:

- IBM *DRiMaP* model orientation and functionalities.
- Implementing the existing *DRiMaP* model and testing with the SysML and Monte Carlo simulation tools. This includes testing the risk variables and validated levels on the existing model in terms of the Requirements Traceability Measurements: Backward/Forward Horizontal/Vertical, Validated levels, and Versions or Conversions.
- Creating a new model that includes the goals of modelling the relationship between risk management and organisational and cross-organisational crisis management, and a better environment for control and monitoring of risk.
- Adding the distributions extension into the development model and thereby achieving a contribution of novelty.

All the questions posed are derived and built around information system theory that contributed to the *Evolutionary Model*. They are principally closed-ended questions, with the opportunity for deliberation to reduce the complexity of the anticipated model and to give the interviewees chance

of comprehending the questions (Denise F. Polit and Cheryl Tatano Beck, 2003).The following tables summarise the responses and reflections given by experts to the above points:

<b>Point1: IBM DRiMaP model orientation and functionalities.</b>	
Expert	Technical Feedback
Vice President for IT Sector	DRiMaP Extension model has to be complementing the actual DRiMaP risk management system with provision of collaborative platform across multi-organisational terrains.
IT Operation G.M.	Discuss the main features of DRiMaP and display extension activities.
IT Automation G.M.	Discuss to what extent those features are found in the proposed researches that has taken in each of DRiMaP integrity.
IT Maintenance and Control Manager	Transition time between the model state processes. What the dynamic system aspects.
IT Project Manager 1	Is the DRiMaP Model dynamic behaviour and examples?
IT Project Manager 2	The model is approved but need more analysis on the risk factors mentioned during the presentation.
IT Project Manager 3	A recent and specific risk management model to demonstrate the challenges or issues involve in order proffering solution.
IT Project Manager 4	Organizing the creation model stages by outlining and plans for outcome business packages.

*Table 106. Structured interview - Point 1*

<b>Point 2: Implementing the existing DRiMaP model.</b>	
Expert	Technical Feedback
Vice President for IT Sector	The three risk management models with critical analysis of the risk factors representative the current model disadvantages.
IT Operation G.M.	Choose and to adopt, focus and improve on the proposed research related to the extension model to be chosen.
IT Automation G.M.	Do you need to assess all the risks occur at every stage of business process model?
IT Maintenance and Control Manager	Reliable prototype structure and specifications but what are events you have to trace?
IT Project Manager 1	Also in this stage you have to apply the measurements approaches and definitions of (Managerial Risk Environment) in an organisation used a distributed system.
IT Project Manager 2	Express the risks and prioritizing the events in IT distributed system is it the right model function aims.
IT Project Manager 3	Reading Workflow Management Will be a (computer with mathematics) or Business process, Monitoring business constrain.
IT Project Manager 4	Distribute the risk of Contractor or partners Companies? Same things what about 2 organisations is the current model DRiMaP decompose the Risks (issue to be concern).

*Table 107. Structured interview - Point 2*

<b>Point 3: Creating a new model.</b>	
Expert	Technical Feedback
Vice President for IT Sector	The model monitoring and control environment provide the right triggers to express the risks and events prioritizing (by traceability, categorise, rationalise, and classification).
IT Operation G.M.	If you want to choose one state of the Business Process activities is it enough, Justify (Why we are choosing the implementation state for example).
IT Automation G.M.	Ask do the current model DRiMaP decompose all of the Risks of one organisation if yes (How many?).
IT Maintenance and Control Manager	Is the model giving a development approach for the distributed systems (clear two or three relationships of managing the risks between two organisations?)
IT Project Manager 1	What happens if I won't meet the project deadlines?
IT Project Manager 2	Events examples are fine but can I classify the events, categorise the events, Rationalise the events.
IT Project Manager 3	System Technology upgrades? Example: That all you need to apply and create them in my model extension the events, categorise the events, Rationalise the events.
IT Project Manager 4	Constriction of several projects required.

*Table 108. Structured interview - Point 3*

<b>Point 4: Adding the distributions extension</b>	
Expert Position	Technical Feedback
Vice President for IT Sector	Setting on the project parameters: Cost, Time, and Risk on run time method. Subsequently, need to improve the monitoring and control environment. Decision making features. Projects statues same time.
IT Operation G.M.	Executing: Over Run and event deadline, and event assign at run time. (A proper risk transfer).
IT Automation G.M.	Need to improve the monitoring and control environment by displayed an event executive summary form. (Cost, Time, Risk) as mentioned.
IT Maintenance and Control Manager	What extent are the following material and categorised risk distributions means used in IT Organisations?
IT Project Manager 1	Project has not to be delay and delivered.
IT Project Manager 2	Project development and complex nature to mitigate or difficulties.
IT Project Manager 3	Probability: the likelihood that a risk or opportunity will occur as an exact number.
IT Project Manager 4	The risk and the effect that the risk causes to the project will be identify.

*Table 109. Structured interview - Point 4*

### 5.3 FUNCTIONAL TESTS

Implementation in the form of a software tool for risk management formed an important part of the validation of the theoretical *Evolutionary Model*. A tool was developed as discussed in sections 4.4 and 4.5. This section describes the functional tests that were performed on the system, as well as any qualitative observations, as were recommended by Still's four forms of validation and testing in section 2.6.1.

It should first be noted that a simulated application was developed rather than full-blown software. Graphical interfaces were developed for the purpose of testing the APIs defined in Chapter Four. The functional tests are intended to verify that the application does what it is meant to.

The simulation comprises five components:

- Portal (DRiMaP Client).
- Web services (DRiMaP Service).
- Console application (DRiMaP Task).
- Transaction Core.
- DRiMaP HOME the database.

This section evaluates the above components to demonstrate usability and how it achieves the relevant research objectives. Eight functional tests were performed:

1. Register or create a new super user.
2. Add a new organisation.
3. Create a new project.
4. Define a new project phase.
5. Assign users to work on the project.
6. Move a project into a phase or change phase.
7. Create a Phaseitem for a phase.
8. Charting and task functionality.

Each of these are now discussed below:

### 5.3.1 Functional test 1 - register or create a new super user

Features: Register User functionality for DRiMaP Extension simulation.

Narrative: In order to show the basic registration functionality as a super user such as a IT project manager, I need to create a new super IT project manager as a user.

Scenarios: Given that: the user does not exist previously on the DRiMaP Service.

When: I register as the super user.

And: the User is created and stored in the data store.

Then: the data store contains the user data just created.

The GUI implementation of the above scenarios is illustrated in Figure 50 below. Further functionality is illustrated in the GUI screen captures in Appendix J, section 8.10.1.

Figure 61. Login detail

This GUI allows new user to register to use DRiMaP Service to managing the progress of the project. A user in this category could be a project manager who oversees project development and other related activities. While filling this form for registration, the administrator indicates the user to be a super user. *Password, Username, email, and internal org id* are data fields used to authenticate and authorise access to the application. Clicking the **Register** button, a User's Request is established through a user proxy generated from the consumed *user service*. The End Point Address (i.e. "<http://localhost:5144/drimapsvc/user.asmx>") is similar to the service Source Url in WSDL (web service definition language).



The Register User request from the DRiMaP client is passed to the service through the endpoint address described above. This calls the corresponding transaction core APIs Register User () methods with a persistent sql connection object to create the user registration asynchronously over the HTTP protocol. Internally, the *internal org id* (unique id entifier - GUID) is created to bind the user data to the organisation in one-to-many relationship, and it is required for subsequent authentication. The schema is called “DRiMaP\_User” which stores users’ data.

### 5.3.2 Functional test 2 - add a new organisation

Features: Create new organisation.

Narrative: In order to show the basic organisation functionality as a Project manager, I need to create a new organisation to be managed.

Scenarios: Given: organisation does not exist previously in the DRiMaP extension application.

When: I create the organisation.

And: the Organisation is created and stored in the data store.

Then: the data store contains the organisation data just created (CORRECT).

The GUI implementation is illustrated in Figure 51 below. Further functionality is illustrated in the screen captures in Appendix J, section 8.10.2.

*Figure 62. Registering a new organisation*

This organisation GUI allows a user to register a new organisation using the DRiMaP Service. Organisation, in this case, could be a group, subscribers to use the DRiMaP Service to manage the project for the existence of a risk process. While filling this form for registration, internally, clicking the **Register** button an organisation request is established through organisation proxy

generated from the consumed organisation service as shown below in the listing and the End Point Address (i.e. “<http://localhost:5144/drimapsvc/organisation.asmx>”) in the figures similar to the service Source Url in wsdl (web service definition language).

### 5.3.3 Functional test 3 - create a new project

Features: Create new project.

Narrative: In order to show the basic project functionality as a Project manager. I need to create a new project to be managed.

Scenarios: Given: the project does not exist previously in the DRiMaP extension application.  
When: I create the project.

And: the project is created and stored in the data store.

Then: the data store contains the project data just created (CORRECT).

The first step is to create project implementation, as illustrated in Figure 52 below. Further functionality is illustrated in Appendix J, section 8.10.3.

Organization Project Phase Reporting

**PROJECT DETAIL**

Deadline in Hours [Click to Refresh](#)

**Assigned user(s)** [Assign new user](#) Phase status:

No user is assigned to this project

Name:

Description:

Is Active?  
 Signed Off?

projecttypecode:

Project Cost: £

Deadline:

Indicate the percentage cost to be used for phase, phase items

specify ratio:

[Click here to create Newproject](#)

Figure 63. Create project information

### 5.3.4 Functional test 4 - define new phase for project

Features: Create new phase.

Narrative: In order to show the basic phase functionality as a Project manager, I need to create a new phase to manage the project in test specification 3 above.

Scenarios: Given: the phase does not exist previously in the DRiMaP extension application.

When: I create the phase.

And: the phase is created and stored in the data store.

Then: the data store contains the phase data just created (CORRECT).

The first step is to create phase implementation, as illustrated in Figure 53 below. Further functionality is illustrated in Appendix J, section 8.10.4.

Organization Project **Phase** Reporting

**PHASE DETAIL** [Click to Refresh](#)

Project: Innovator Project

Name: Phase 1 [Requirement Collection]

Description: Requirement collection stages

Is Active?

deadline: 23/07/2013 12:00:00

Percentage ratio: 0.3

[Click here to create Newproject](#)

Figure 64. Phase GUI for creating phase for the project specified

### 5.3.5 Functional test 5 - assign users to work on the project

Features: Assign user to work on the project.

Narrative: In order to show the basic **Assign User to Project** functionality as a Project manager. I need to have logged on and have *Super User* status to be true, and have created a project to be worked on prior to the assignment.

Scenarios: Given: the project and phase already exist. Users have not been assigned to work on project, and assigned users do not exist previously in the DRiMaP extension application.

When: I assign users to the project to work on it.

And: assigned users data should be stored against the project in data store.

Then: the data store contains the user and project data just created (CORRECT).

Assigning the users to work on project requires the GUI to allow users to be assigned to the project “Innovator Project” clicking **Assign** the user to the project. This is illustrated in Figure 54 below, and further illustrations may be found in Appendix J, section 8.10.5.

The screenshot shows a web application interface for 'PROJECT DETAIL'. At the top, there are tabs for 'Organization', 'Project', 'Phase', and 'Reporting'. The 'Project' tab is active. The main content area is divided into two columns. The left column contains project details: 'Deadline in Hours' (234 Days 0 Hours), 'Name' (Innovator Project), 'Description' (Risk Management Simulation), 'Is Active?' (checked), 'Signed Off?' (unchecked), 'projecttypecode' (Internal), 'Project Cost: £', 'Deadline: 30/12/2013 12:00:00', and 'specify ratio: 0.1'. The right column is titled 'Assigned user(s)' and shows 'Phase status: Not In Phase'. Below this is an 'Assign' section with radio buttons for 'Existing User' and 'New User' (selected). The 'New User' section has input fields for 'Firstname: James', 'Lastname: Morgan', and 'Email: kentkyken@programmer.net', with 'Is Active?' checked and an 'Assign' button. At the bottom of the form are 'Update' and 'Cancel' buttons, and a link to 'Click here to create Newproject'.

Figure 65. Assign users to project

### 5.3.6 Functional test 6 - move project into a phase or change phase

Features: Move project into a phase, or change current phase.

Narrative: In order to show the basic MOVE functionality as a Project manager, I need to retrieve the project created in test 3 above.

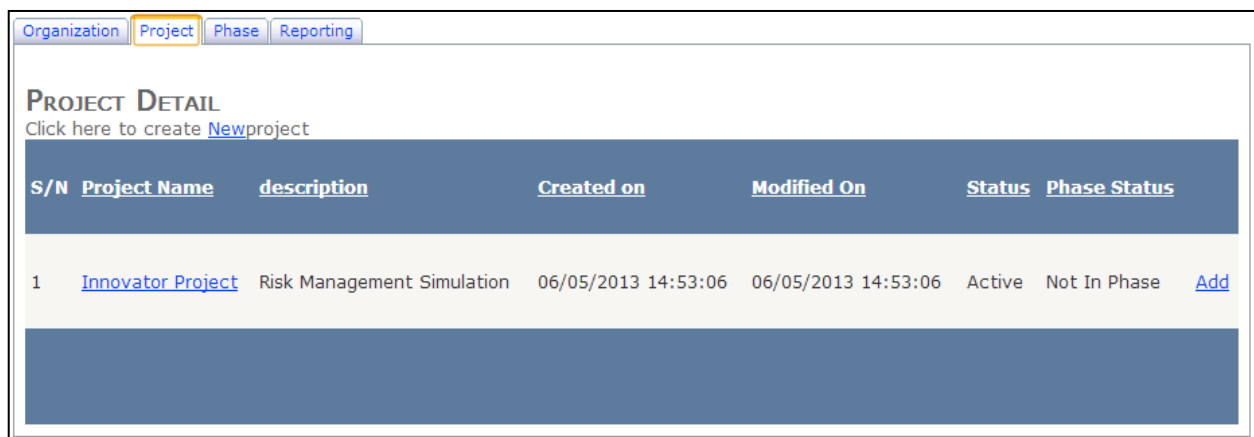
Scenarios: Given: the project and phase already exist but project has not been moved or attached to a phase, i.e. requirement phase, in SDLC, and does not exist previously in the application.

When: I move the project to the phase.

And: the project is attached to the phase and stored in the data store.

Then: the data store contains the information about the project and the current phase of the project moved (CORRECT).

To retrieve Project and move into Phase implementation, the current **Phase Status** of the "Innovator project" is "**Not in Phase**" Click the [Add](#) link to access Move functionality, shown in Figure 55 below. Further functionality is illustrated in Appendix J, section 8.10.6.



The screenshot shows a web application interface with a navigation bar containing 'Organization', 'Project', 'Phase', and 'Reporting'. Below the navigation bar is a section titled 'PROJECT DETAIL' with a link to 'Click here to create Newproject'. A table displays project information with columns for S/N, Project Name, description, Created on, Modified On, Status, and Phase Status. The table contains one row for the 'Innovator Project' with a status of 'Active' and 'Phase Status' of 'Not In Phase'. An 'Add' link is visible at the end of the row.

S/N	Project Name	description	Created on	Modified On	Status	Phase Status
1	<a href="#">Innovator Project</a>	Risk Management Simulation	06/05/2013 14:53:06	06/05/2013 14:53:06	Active	Not In Phase <a href="#">Add</a>

Figure 66. Retrieve Project GUI

### 5.3.7 Functional test 7 – create a phaseitem for a phase

- Features: Creating a phase item for any particular phase.
- Narrative: In order to show the basic phase item functionality that a project manager needs to add an item into the phase the project is currently moved to.
- Scenarios: Given: project and phase already exist but project has been moved or attached to a phase, i.e. requirement phase, in SDLC, and contents (i.e. phase items) of those phase do not exist previously in the DRiMaP extension application.
- When: I add phase item to the phase.
- And: the phase item is added to the phase and stored in the data store.
- And: email is sent out to the users assigned to work on the project.
- Then: the data store contains the information about the phase item (CORRECT).

The Phase Item implementation takes place as follows. The current **Phase Status** of the “Innovator project” is “*Already in Phase*” Click the **Folder** icon on phase detail to open phaseitem control functionality in Figure 56 below.

In the following screen click “View link” to see the contents of the phase. If no item is displayed, click **Add New** link create new item. Click the **Add Item** button to create the phaseitem by sending request to the *phaseitem service* and the response is serialised and passed through dataset, which is bound to the grid. The alert module is triggered to disseminate the output of the mitigation process: *Assessment Output* and *Control Output*. This output is sent out as email.

Screens and code fragments are illustrated in Appendix J, section 8.10.7.

S/N	project name	description	CurrentPhase	Created on	Modified On	
1	Innovator Project	Risk Management Simulation	Phase 1 [Requirement Collection]	06/05/2013 14:53:06	06/05/2013 14:53:06	<a href="#">View</a> ✓
2	Innovator Project	Risk Management Simulation	Phase 1 [Requirement Collection]	06/05/2013 14:53:06	06/05/2013 14:53:06	<a href="#">View</a> ✓

**Project Name: Innovator Project Current Phase: Phase 1 [Requirement Collection]**

Item Name:

Description:

Is Active?

Is Requirement Signed Off

percentage ratio:

specify deadline:

Figure 67. Move functionality

The internal mitigation logic that handles the processes and generates mitigation reports through the call Activity Risk Assessment Output. These are derived from the definition of risk assessment and review of all related materials and service. DRiMaP extension simulation strongly adheres to the principles of risk management process. The prioritisation is used to classify the risk according to the degree of impartation on the project; and it is enumerated as low, medium, and high.

Prioritisation output, other outputs from risk identification and analysis are merged as assessment output. This is passed into the Alert Module for dissemination through email. The **Activity Risk Control Output** holds all outputs from risk planning, risk resolution, and risk monitoring; all the outputs are concatenated and passed into the Alert Module (i.e Event Alert Process).

In the cause of this project, the two types of relationships (internal INTR1...INTR10, and external EXTR1 and EXTR2) occur at different points on the model. This differentiates their meaning and position they stand for. These are referred to cross-functional relationship because Mitigation Process intercepts every request emanating from a CRUD action before it gets to the transaction core. The mitigation activities as shown in the listing in Appendix J section 8.10.7.

A request coming to Risk Assessment and Control objects using the **Mitigation Id** then establishes the INTRS3 and INTRS4. Listings are provided in Appendix J section 8.10.7 for more detail.

### 5.3.8 Functional test 8 - charting and task functionality

As discussed earlier, DRiMaP task generated the risk activities in respect to the deadline (time), costs, and risk that occurs or identified during mitigation process. Also, mitigation process gets activated whenever there is CRUD operation on the simulated DRiMaP extension application. DRiMaP Task directly update and generates activity data for project, phase, and phase items. These activities are worked on by the task using “Bottom up” approach. This functionality cannot be tested independently because DRiMaP Task console application drives the activities that get plotted in the chart shown in the figure.

Features:        Plotting charts and interpretation.

Narrative:      In order to show the basic chart functionality as a Project manager. I need to start running the DRiMaP Task to create activities for phase, phaseitems and project respectively.

Scenarios: Given: phaseitem, phase and project activities do not exist in the application.  
 When: I start the DRiMaP Task every five minutes.  
 And: the chart gets plotted dynamically as the data got added to the data store.  
 Then: the chart reflects the activities: deadlines on project, deadlines on phase, and deadline on phaseitems (CORRECT) against the cost.  
 Then: the chart reflects the activities: risk on project, risk on phase, and risk on phaseitems (CORRECT) against the cost.

Implementation is as follows. The GUI shown in Figure 57 below is a window task scheduler which hosts the **DRiMaP Task** application. It runs at a specified time, 19:00 in the illustration, and disappears after completion. This uses a one-to-many relationship between these related entities:

- Deadline Activity On Phase, Deadline Activity On Project, and Deadline Activity On Phaseitem
- Cost Activity On Phase, Cost Activity On Project and Cost Activity Phaseitem
- Risk Activity On Phase, Risk Activity On Project and Risk Activity Phaseitem

These schemas are used to record the activities for each of the variables of cost, time, and risk.

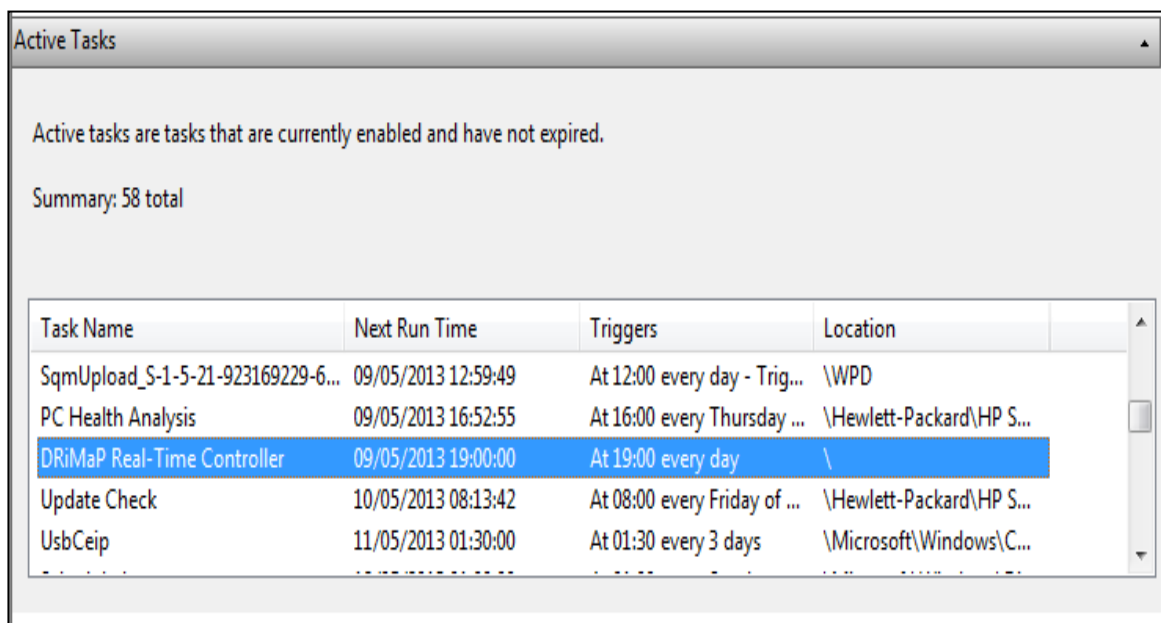


Figure 68. DRiMaP Real-Time Controller

At every execution of the task, ten observations are taken on Deadline On Project, Deadline On Phase and Deadline On Phaseitem. Risk activities only occur when a deadline is reached and the state of the project *signed off* is still "0".



Observations were made at every task execution which generated activity data on phase item, phase, and project in that order. These are illustrated in Appendix J section 8.10.

The activities are analysed and created against the variables of Time, Cost and Risk. However, it could be seen that as the deadline or time variables in each of the observations above approaches zero, the cost tends to increase. Consistently, the greater cost the lower the deadline. For example, if the phaseitem or phase, or project is signed off, the cost would be fixed and activities would not be generated. This implies that the item is successfully completed. At these points in the observation, Risk versus Cost activity remains null because no risk activity is created. Risk activities are created if the following conditions are met:

- Deadline is reached (deadline Elapsed is true) and **is Signed Off** state flag is still **false** or “0” on each of the following: project, phase, phase item.
- Deadline is reached and the cost is not enough to accommodate more activities like adding new phase to the project, or new requirements.

### **5.3.9 Summary of functional tests**

This section performed functional tests on the system to establish whether the system would perform as designed. The system can create objects, allocate alerts and produce graphic representation of project risk performance as designed. This tested the three major components of the model and their associated relationships. In so doing the system was found to perform as per the objectives of this research.

## 5.4 EXPERIMENT FINDINGS

Experiments were used to further validate the software tool that was developed from the *Evolutionary Model*. Section 4.4 described the implementation of the tool, and the previous section 5.3 showed how the system went some way to proving that the theoretical model was feasible.

Still (2000) recommends quantitative validation as one way to validate the system, as discussed in section 2.6.1). This section will describe the two experimental simulation techniques, SysML and Monte-Carlo, that were used to check the accuracy of the tool. These methods were selected on the basis of a literature search that showed them to be formal methods with the potential to assist in validating the models. Discussion in literature suggested disadvantages to using the methods, but the full impact of these disadvantages was not clear until the experiments were run.

### 5.4.1 Validation with the SysML experiment

The SysML method has wide range of benefits and is referred to as an extension of UML for application in system engineering domains. Kawahara *et al.* (2009) say that it has potential to develop fixed systems, integrate diverse elements, express continuous data flow, parametric constraints and can be used in wide range of modelling applications. SysML can be adopted by an organisation to model various requirements, behaviours and structures. It helps verification, validation, and simulation of software projects, and is capable of acting as a practical means of integrating and testing risk parameters (Hause and Holt, 2010).

Generally the behaviour of a system is described as a mixture of event-driven and continuous-time activities. It was discovered here that SysML could not practically define the continuous-time behaviour of the system. The present architecture is that of a dynamic model that needs to explain risk parameters alongside time-to-time activities.

Figure 68 below describes in more detail what is obtainable using a SysML simulation.

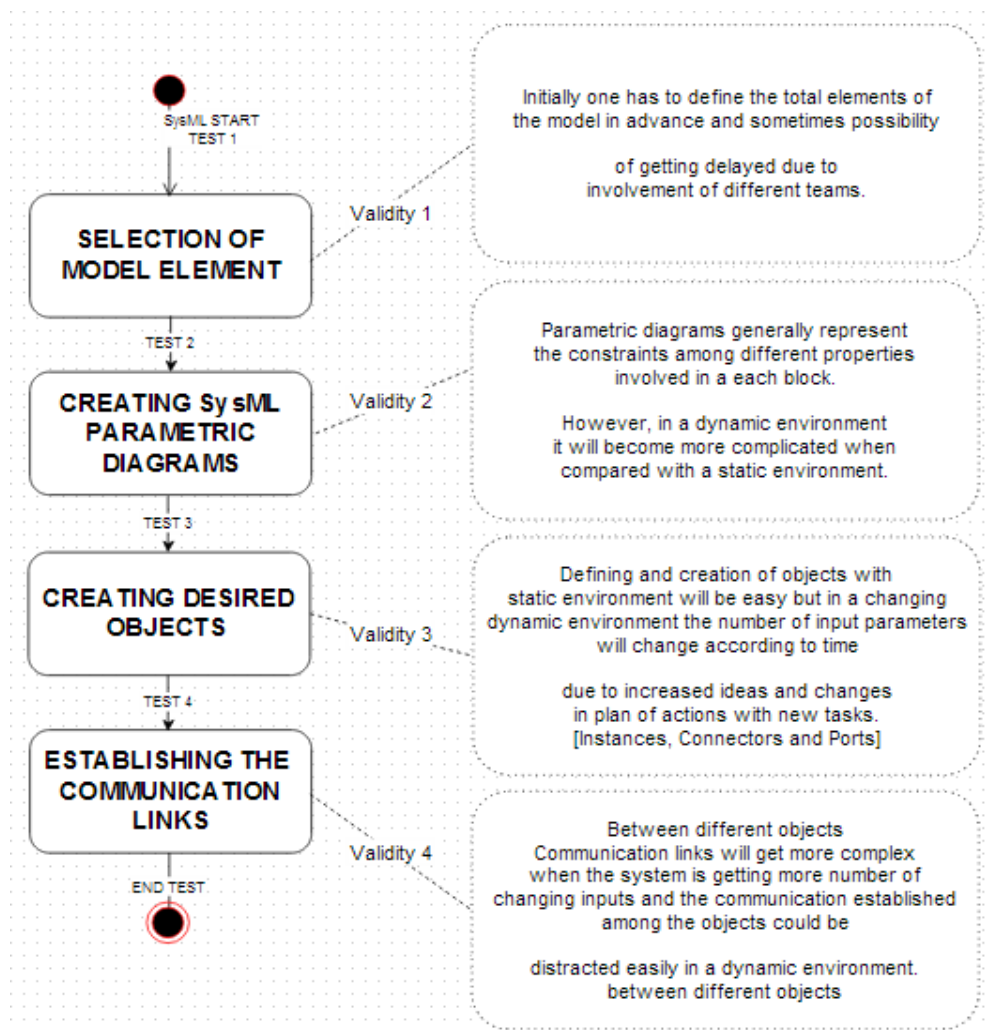


Figure 69. SysML simulation and validity in IT

#### 5.4.2 Validation with the Monte Carlo method

The Project Management Institute (2004, cited in Kwak and Ingall, 2007, p. 3) describes the Monte Carlo Simulation as “a technique that computes or iterates the project cost or schedule many times using input values selected at random from probability distributions of possible costs or durations, to calculate a distribution of possible total project cost and completion dates”. This method utilises a sequence of random numbers for performing statistical simulation of retrieved data from random variables (Rollett and Manohar 2004).

Many organisations use Monte Carlo tools and techniques to analyse real-time systems and modelling methods. This method uses quantified data and allows the project manager to understand, justify and communicate to management any unrealistic project expectations and outcomes. The Monte Carlo method can be implemented by project managers easily by adding adequate risk management education, training and current technologies.

The method can quantify the influence of risk and uncertainty in project budgets and schedules by providing a type of statistical indicator for the performance of a project (Kwak and Ingall, 2007).

Raychaudhuri (2008) stressed the strong reliability of this method when used with random sampling and statistical data analysis to compute the results of the experiments. Statistical distribution of the sample data will be considered as input parameters. After collecting data, random samples from each group are selected and used as input variables. The outputs parameters will depend on the different input parameters and are independent of the other set of output values.

Use in IT is described in Figure 69 below.

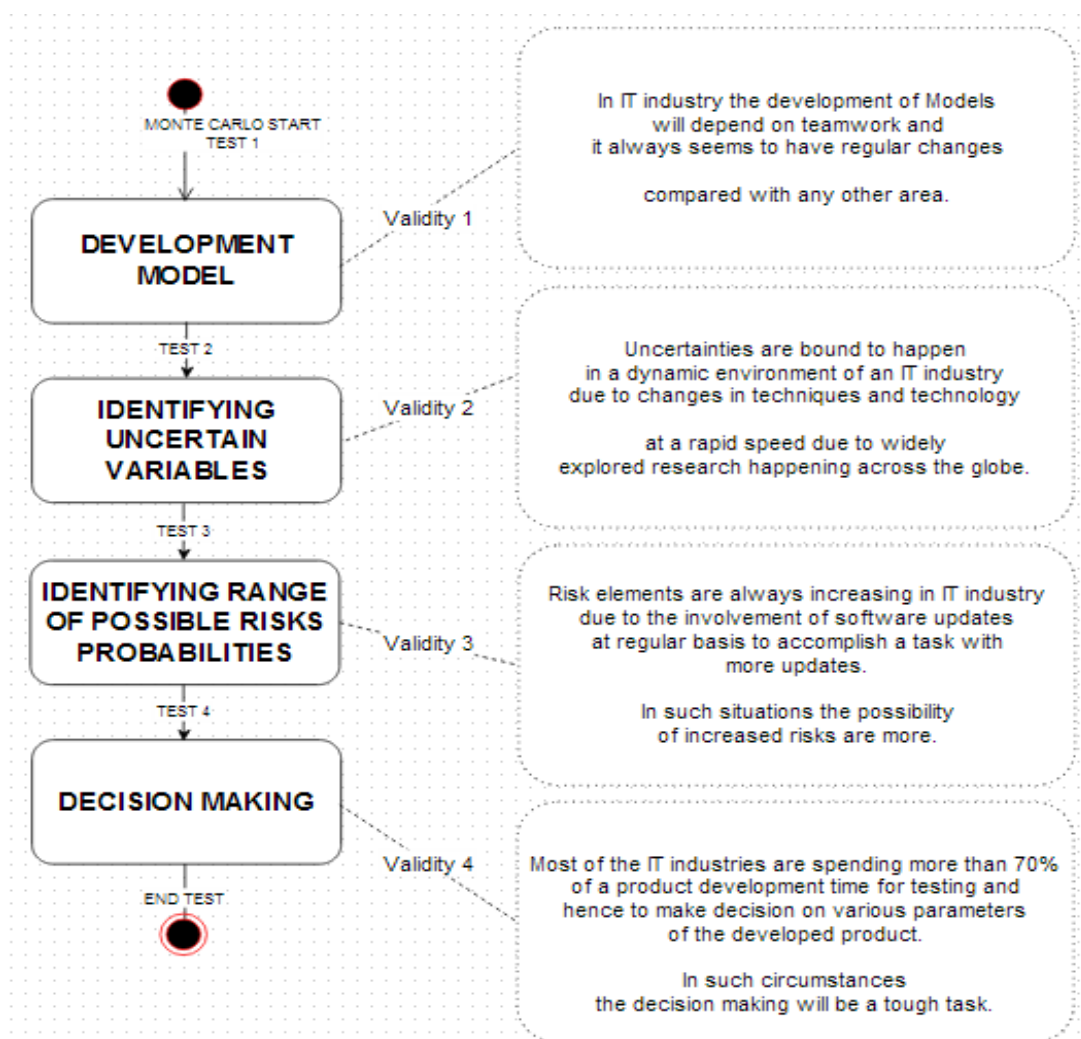


Figure 70. Monte Carlo simulation and validity in IT

The figure above identified the validity of Monte Carlo method in terms of the following: model development, identifying uncertain variables, identifying ranges of possible risk probabilities, and

decision making. A literature review suggests that the Monte Carlo method is really unsuitable when the entire simulation time is spent identifying relationships to make decision due to its lack of dynamic nature, lack of communication among the static variables, and lack of association of cost with time, and cost with risk which is measured as probability within a static context.

### 5.4.3 Experiments outcome

The original *DRiMaP* case study was used to run the experiment, illustrated in Figure 60 below. It was intended that the threshold, time variance and unexpected risk factors will be explained and this would help build a distributed risk management model. In the research conducted by Schonherr and Rose (2009), it was found that the SysML method was able to identify and structure significant properties of various processes in different production systems, but only on theoretical basis.

Due to the lack of a communication or event driven process, SysML does not support real-time events and communication through all the defined relationships in the model. Practically these are not obtainable. SysML has the ability to identify different part of the model in respect to concrete process and functionality of the simulation and all the resulting process are static in nature.

In a dynamic environment like the current research scenario, the Monte Carlo method failed to handle the situation due to the dynamic nature of the environment where the risk parameters of time, cost and risk vary per run-time and the simulation process that adopt this method could not identify the risk elements and factors (relationships) in real-time in a long run of the projects.

Many organisations observe that the Monte Carlo method is unsuitable for simulation in dynamic environments. Equally, the methods appear to be burdensome and it is good only for static environment. Kwak and Ingall (2007) showed it to be an unproductive method for simulation in a changing environment. Poor performance is another important disadvantage that is emphasised by Raychaudhuri (2008). Increase frequency of branching and frequent procedure calls are factors that limit Monte Carlo performance according to Zhou *et al.* (2010), and its limitation in testing static parameters makes Monte Carlo method unsuitable for simulation of the *DRiMaP* extension (Tongbong *et al.*, 2007; Zhou *et al.*, 2010; Kwak and Ingall, 2007).

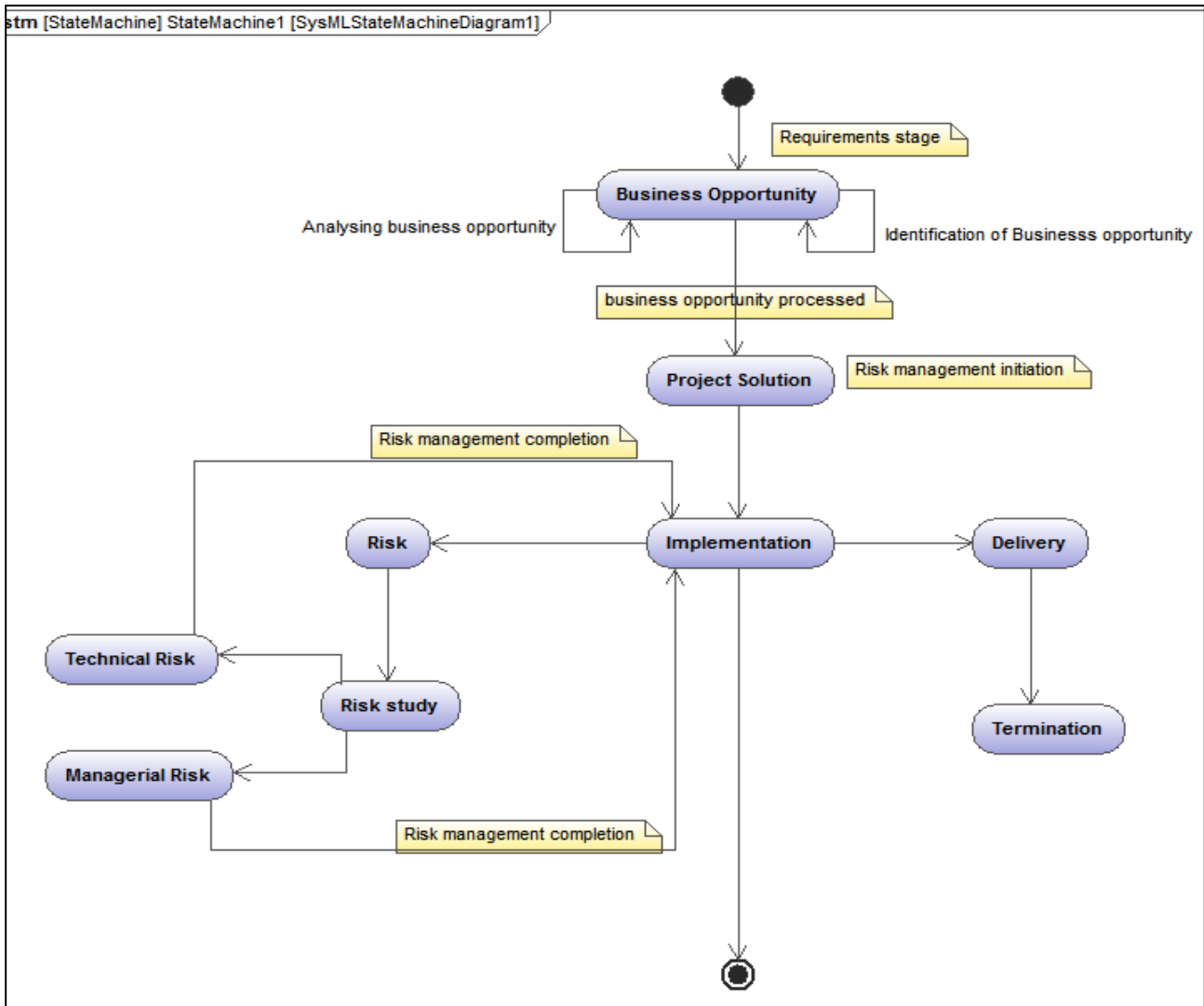


Figure 71. DRiMaP case study risk distribution

#### 5.4.4 Experiments conclusion

Most of the observations made using the SysML and Monte Carlo simulation methods were found to be too blurred and probabilistic to be considered by the IT industry. On the other hand the IT project developments need multiple criteria with multi-decision making problems for differentiate alternatives and these are generally complex in nature. Apart from this statistical distribution and diagrammatic representation of data or project inputs, understanding relationships and communication within these methods is difficult. This makes SysML and Monte Carlo unsuitable for modelling and testing *DRiMaP* extensions.

## 5.5 CHAPTER SUMMARY

Empirical research contributed to the development and then explored the feasibility of the *Evolutionary Model* using a survey, structured interviews with experts and experimental methods. The study generally found that the model is acceptable to a broad base of users.

Assessing the *Evolutionary Model* in terms of the survey questions and expert interviews shows the model is suited to managing risk in major information technology development projects in distributed environments. The model offers benefits that survey respondents and experts found to be important. Inspecting the software tool in terms of expectations derived from the survey and interview responses shows the tool is able to deliver sufficient functionality to satisfy the aim of this project.

The survey and interviews contributed to the development of the model and therefore partially satisfied the objective to satisfy novel techniques and improvements. By assessing the model and software tool, the project also satisfied the objectives of assessing models that may be suited to this environment, better understanding the relationship between risk and crisis management. Simulation data drawn from a real case study was used to assess the tool, and the findings showed the tool was functional and operated as intended.

After careful consideration of the performance and disadvantages of the two experimental methods described in section 5.3, it became clear over the course of this research that SysML and Monte Carlo are unsuitable methods to simulate *DRiMaP* extensions due to the event-driven nature of this model. These methods were known to have disadvantages prior to use, but these downsides had to be confirmed. Reporting the negative performance of these methods here is important as a warning to other researchers and practitioners against using these methods in this context.

## CHAPTER 6 .. CONCLUSIONS

Software projects in distributed environments exhibit a high rate of failure. This project investigated risk management in distributed software development environments, identified current risk management approaches, and found shortcomings. A new model called the *Evolutionary Model* was synthesised, and evaluated and empirically tested. This chapter summarises the thesis, considers the findings, draws conclusions for the theory, reviews practical applications of the model and presents recommendation for the future of the *Evolutionary Model*.

### 6.1 PROJECT SUMMARY

#### 6.1.1 Thesis summary

A review of literature discovered that software projects in general and distributed development projects in particular were susceptible to failure (s3.1.1), and that a wide variety of risks were responsible for much of this (s3.2). Large IT companies, large IT projects and any projects in which the development is spread across more than one team in more than one location (distributed software development, or DSD) experience additional complexity and challenges (s3.2.6 to 3.2.8).

Conventional approaches are not up to the task of managing this risk. Studies by authors such as Misra *et al.* (2007), Stern and Arias (2011) and Keshlaf and Riddle (2010) have found a number of deficiencies in many current models (3.3.2). A review of further theoretical models (s.3.3.3 and 3.3.4) and approaches used by practice (s.3.3.5) found only the *DRiMaP* model developed by Kajko-Mattsson *et al.* (2005) to be useful in this environment (s3.4). Review of this model found weaknesses and areas of improvement that had been identified by literature as being important. These shortcomings included methodological, structural and implementation issues (s4.1) and a number of improvements in the form of extensions and modifications were proposed (s4.2).

The theoretical *Evolutionary Model* was presented in section 4.3 as a solution for real-time distributed risk management in multiple-organisation, cross-platform distributed environments. This model sought to improve risk identification, monitoring and control whilst overcoming the limitations of the original *DRiMaP* model.



The extensions broadly consist of provisions for project phases (s4.2.4), continuous risk management (s4.2.5), risk migration (s4.2.6), risk mitigation (s4.2.7) and event driven alerts (s4.2.9). The primary contributions of this model (s4.3.4) are in enabling well informed decisions, increasing confidence levels, improved monitoring and control, minimising associated environment parameters of risk, time and cost, and identification of internal and external relationships between organisations and other project components.

The *Evolutionary Model* is theoretical. Three methods were chosen to validate this model. As discussed in section 2.3, the choice of these methods is consistent with other risk management studies by Lamersdorf *et al.* (2012), Miler (2005) and Jiminez *et al.* (2009). A survey was chosen to inform the study with user requirements (s 2.3.1 and s5.1), structured interviews were used to solicit expert opinion on the *DRiMaP* model and its extensions (s2.3.2 and s5.2), and key aspects of the *Evolutionary Model* were constructed using ASP.Net as a software system (s4.4 and s4.5) and then assessed using functional tests (s2.3.3 and s5.3) and two experiments (s 2.3.4 and s5.4).

### **6.1.2 Summary of results**

Survey findings (s5.1) show that IT software industry participants are not as familiar with risk management as they should be. This finding is consistent with those of Sengupta *et al.* (2006), Gutwin *et al.* (2004) and Prikladnicki *et al.* (2004) and others. Risk management approaches used by survey respondents vary widely, which reflects the situation presented by Keshlaf and Riddle (2010) and Misra *et al.* (2007). The benefits gained vary, the impact on the organisations differs in nature and intensity, and every organisation has a different way of managing risk. There is no standardisation in this industry and it appears that risk management is weak and not extended to other stakeholders or beyond the individual development teams. Whilst the literature calls for a reliable technical and non-technical ontology, 48% of the sample showed no formal ontological process or framework. Lack of experience, awareness and understanding are all apparent. Again, these findings are consistent with the failings of traditional risk management that have been established in literature. The ratio of success to failure as reported by respondents is unsurprising, as literature clearly shows a link between project failure and a lack of risk management processes. Organisations furthermore fail to address risks associated with the distributed environment (s3.2.8) and focus instead on the conventional variables of risk, time, and cost during project development.

The structured interview sought the opinions of 8 IT software development experts at varying positions in the organisation. These managers considered the *DRiMaP* model, the extensions to that model and implementation. The opinions were that the *DRiMaP* model needed improvements and additions, issues that the *Evolutionary Model* sought to improve were important to these experts, the *Evolutionary Model* shows benefits but also some limitations and the research should also focus on practical implementation of the models.

The model was then implemented as a simulated application rather than as full-blown software, in order to test aspects of the model rather than develop a commercial system. This form of study is known as constructive research (s2.3.3) and its use in IT research has been established. The application was then evaluated in three ways to fulfil Still's (2000) four methods of validation (s2.6); functional tests (s5.3), a SysML simulation (s5.4.1) and a Monte Carlo simulation (s5.4.2).

The functional tests revealed that a system could be developed to implement the *Evolutionary Model* and all its features. Three major model components and their associated relationships were implemented, and the system was found to perform as per the research objectives. The choice of the SysML and Monte Carlo simulation methods was found to be inappropriate. These methods were found to be too vague and probabilistic to perform accurately on the complex, event-driven, continuous nature of the *Evolutionary Model*. Understanding relationships and communication using these methods is difficult. Time limitations on this project prevented the use of an alternative simulation test technique.

## **6.2 THEORETICAL CONCLUSIONS**

This research developed a theoretical model for risk management in distributed software development environments, termed the *Evolutionary Model*. This theory extended and modified an existing theoretical model called *DRiMaP* using concepts drawn from literature, then evaluated it using mixed methods.

### **6.2.1 Conclusions for the DRiMaP extensions**

The *Evolutionary Model* was designed to resolve a number of shortcomings in the original *DRiMaP* model (s4.1). The following Table 35 assesses whether the *Evolutionary Model* addresses each of these shortcomings. The assessment was made by inspecting the model, tool and research findings in terms of each of the shortcomings.

This reveals that the Evolutionary model improves most of the shortcomings. Of those that it does not fix, some are methodological (testing of this model, use in joint ventures), some are related to implementation (like security and training), and some have been found to be very difficult to design out (organisation resistance).

Shortcoming	Addressed?	H1	H2	H3	H4	H5
Limited testing in diverse geographical and socio-cultural environments	Yes		X			
Limited testing of temporal separation	Yes		X			
Limited testing through the entire lifecycle	Yes		X	X		
A need to validate the model outside of IBM	Yes		X			
Failure to define a distributed development environment	Yes		X	X		
The large numbers of defined roles make it inflexible and difficult to adapt	Partial		X			
Limited ability to handle an iterative SDLC	Yes	X	X			
Lack of ability to manage a common ontology	Yes	X	X	X		
Does not thoroughly describe communications mechanisms	Yes		X	X		
Scalability of the model	Yes		X			
Does not address temporal issues sufficiently	Yes		X	X		
Placement of risk classes is not comprehensively thought out	No					
Limited testing through the entire lifecycle	No					
Need for greater focus on governance and planning	Yes		X	X		
Need for greater focus on effectiveness and value	Yes	X				
No provision for crisis management	Yes				X	X
Insufficient provision for continuous risk management	Yes		X	X		
Insufficient provision for migrating risk between project participants	Yes		X	X		
The requirements of large projects	Yes		X	X		
The need to protect information	No					
The model requires the organisation to adapt to the model, not visa-versa	Partial		X			
Overcoming organisation resistance to new ways of working	No					
Too unwieldy and inflexible to meet the needs of smaller participants.	Partial		X			
The use in joint ventures has not been explored	No					
Training in the new model.	No					
<b>Total</b>	25	3	17	9	1	1

*Table 110. Assessment of improvements*

Table 103 also shows which of the improvements helped address specific hypotheses (H1-5). Nineteen of the 25 identified improvements were resolved in part or in total by the *Evolutionary Model*. Of these:

- Hypothesis 1: Risk management process steps will help the IT organisation to improve the quality of their outputs. This is supported by three of the improvements (16%).
- Hypothesis 2: Adopting risk management techniques will help solve internal issues as well as improve complex work environments across the globe. This is supported by 17 (89%) of the improvements made.
- Hypothesis 3: A risk management model will help IT industries solve and mitigate risks. Nine (47%) of the necessary improvements.
- Hypothesis 4: The relationship between risk management and crisis management has been identified as critical. This hypothesis was supported by only one improvement (5%)
- Hypothesis 5: Good crisis prevention in the workplace will improve project outputs through the use of suitable communication techniques and methods. This hypothesis was supported by only one improvement (5%)

The *Evolutionary Model* therefore provides a significant improvement to the original *DRiMaP* model, particularly in solving internal issues and mitigating risks. It demonstrates a weak improvement over the original in the areas of quality, crisis management and crisis prevention.

### **6.2.2 Theoretical implications**

Section 4.3.4 presented a number of practical contributions that the *Evolutionary Model* makes. There are also conclusions that can be drawn from this study that may be of use to other researchers as well as provide a contribution to the body knowledge.

This research found that risk management in distributed software development is a complex area with many variables. Researchers do not present a detailed, comprehensive or even consistent view of what risks considering or how to address them. This lack of common understanding shows this area is immature and under-explored, but also reflects the situation that each participant and each project will have different requirements and problems. Creating a general model of risks or risk management requirements is situational and not a trivial exercise.

Risk management in a distributed environment requires attention to be paid equally to the risk strategy, risk processes and collaboration. In order to do this, systems have to include continuous risk management across all the project phases, migration of risk from one participant or phase to another, mitigation of risk, and promptly responding to the emergence of risks through alerts and governance. Risk management also requires integration with business, project and development processes in order to be effective.

### 6.2.3 Methodological conclusions (validity)

This project made certain assumptions and generalisations about risk and the environment. One example is the use of a coarse-grained scale for measuring risk in section 4.5.4. These are not indicative of any real-world practice (which may be quite varied) but were done to simplify calculations, explanations and generalisations. Risk management in this environment is also exceedingly complex. The scope of this project was therefore limited to a few specific areas, even though some aspects of risk management received less attention than they could have. These choices could affect the outcomes of any similar research.

In terms of reliability, results from each of the mixed methods study of the *Evolutionary Model* are consistent with each other. The survey and Delphi approach are simple and easily repeatable, and the results show no polarisation or patterns that would indicate unreliability. The implementation phase of the study used computer simulation that can be repeated infinitely without variation. This study can therefore be regarded as **reliable**.

The study scope is narrow and focuses on a specific model. The empirical study shows difference of opinion, but reflects the opinion of actual participants. The studies of the system are quantitative and measure the system itself in precise ways. The study can therefore be regarded as **accurate**.

Construct reliability is more difficult to assess. Risk is a complex phenomenon and its management involves human as well as machine involvement. There are a many factors that need to be borne in mind in the empirical study, and this research has attempted to focus on the key issues that have been raised in the literature. The design has also taken into consideration the main models and frameworks, and the research questions specifically target gaps in other models. This study therefore shows it has **content reliability** and **constructs reliability**.

There is a one-to-one correspondence between observations and phenomena in the simulation. Analysis of the empirical data took into account the variation in answers and the difficulties in asking particular questions. The results are therefore internally valid. The DRiMaP model has not been evaluated by other researchers, but the data used by the simulation has been drawn from external cases. The *Evolutionary Model* does address specific concerns described in literature, and its performance has been reviewed. For these reasons the results may be considered to have **external validity**.

#### 6.2.4 Conclusions for the aims and objectives

The aim of this study was to develop a model and tool suitable for managing risk in major information technology development projects in distributed environments. Table 35 and discussing in section 6.2.1 shows this aim has been achieved to a large extent.

The project has also addressed the four **objectives**:

- Identify and assess risk management models and frameworks suited to managing risk in major distributed information technology development projects. This was achieved in sections 3.3 and 3.4.
- Suggest novel techniques, improvements and extensions to selected models, paying particular attention to the relationship of risk management to crisis management, and providing a better environment for controlling and monitoring of risk. This objective was achieved in Chapter 4.
- Propose and design ways to practically implement any improvements and extensions. The application that was developed and described in sections 4.4 and 4.5 and tested in sections 5.3 and 5.4 satisfy this objective. These show that it is possible to practically implement the theoretical model.
- Evaluate the effectiveness of the suggested improvements, extensions and its implementation. Chapter 5 addresses this objective, and shows the improvements were generally effective.

### 6.2.5 Recommendations for future research

The *Evolutionary Model* has not been applied to a real-world project, although scenarios were applied to the model that was taken from real-world situations. This is primarily due to organisations probably being reluctant to commit the future of a project to untried methods. This is a failing that future research may wish to correct.

Collaboration is an important gap that this research that could have paid more attention to. Collaboration was identified as an issue in section 3.2.8 and other models in section 3.3, but its functionality and benefits were not specifically assessed in the empirical research and implementation. Collaboration therefore remains as an important area that future research may wish to concentrate on.

The model and system offers the following potential benefits that were not evaluated in this project. Researchers of information management may take advantage of:

- Improvement of risk management at a corporate level.
- Improvement of corporate governance.
- Compliance with legislation and regulation.
- Improvements to record keeping.
- Improvements to collaboration and knowledge management.

Other areas that this project identified but did not spend much time on include:

- The nature and requirements of multi-organisational platforms.
- Lack of education about risk management processes in IT industries.
- Role and use of standards, whether these are related to risk, governance, business or technology.
- Informal communications, as identified by De Farias *et al.* (2012) and noted in section 3.2.8.
- Risk standards, such as ISO 31000.
- Integration into project organisations' existing practices.

### 6.3 PRACTICAL CONCLUSIONS AND RECOMMENDATIONS

The *Evolutionary Model* is intended to make several important contributions to risk management in the IT industry. The research exposes many of the intricacies of risk management. Section 4.3.4 describes five important benefits; enabling well informed decisions, increased confidence levels, improved monitoring and control, management of environment parameters and identification of internal and external relationships.

The *Evolutionary Model* bridges gaps identified in industry and implement a solution that addresses most of the shortcomings of previous models. Implementation of this model would also help to establish collaboration, reduce the diversity of risk management methods in use that inhibit any enterprise efforts, and help to enforce standards such as ISO 31000 for risk management. In so doing, other key benefits may be derived from the distributed approach, including:

- Enabling and encouraging a collaborative environment.
- Establishing a unified management environment.
- Managing risks in real-time.

Implementation is however not a trivial exercise. This project developed a simulation and not a comprehensive application intended for enterprise use. As mentioned, risk management requires integration with business, project and development processes. This model could be implemented as a cloud computing application, which would equip it to serve multiple organisations such as described in Figure 75 (Appendix G). A cloud application would be cost effective to apply and easy to deploy.

### 6.4 LIMITATIONS

This project has involved a theoretical investigation into current thinking on risk, its management and a number of fields related to implementation. Current risk management approaches were reviewed and found lacking. A new model called the *Evolutionary Model* was synthesised, and then tested empirically and through simulation. There are a number of limitations that may be found in this research:



- The scope of investigation was limited. A more extensive investigation into risk, risk management and distributed development may have produced a more thorough model and one that could be generalised to suit more situations.
- The investigation did not examine the risk management practices of many organisations. It is possible that the study did not encounter important and useful techniques.
- The project specifically paid minimal attention to the following areas:
  - Governance theory.
  - Standards, like ISO 31000.
  - External relationships and integration within existing processes and systems.
  - Issues around adoption, such as resistance and training.
- The project did not derive a comprehensive list of risks and ways these may be managed. Although this was not a research objective, testing the model with a wide variety of risks and scenarios would have improved validation.
- Simulation was only partially successful, with two experiments failing to validate the model.
- The application that was constructed was not tested on a real project.

These limitations may be partially explained by the following:

- Risk management in these environments is exceptionally complex, and it is impractical to study all aspects within the scope of a single PhD.
- A less-than-effective selection of simulation and experimentation techniques.
- Funding for this project was withdrawn before the project was complete.

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## Appendices

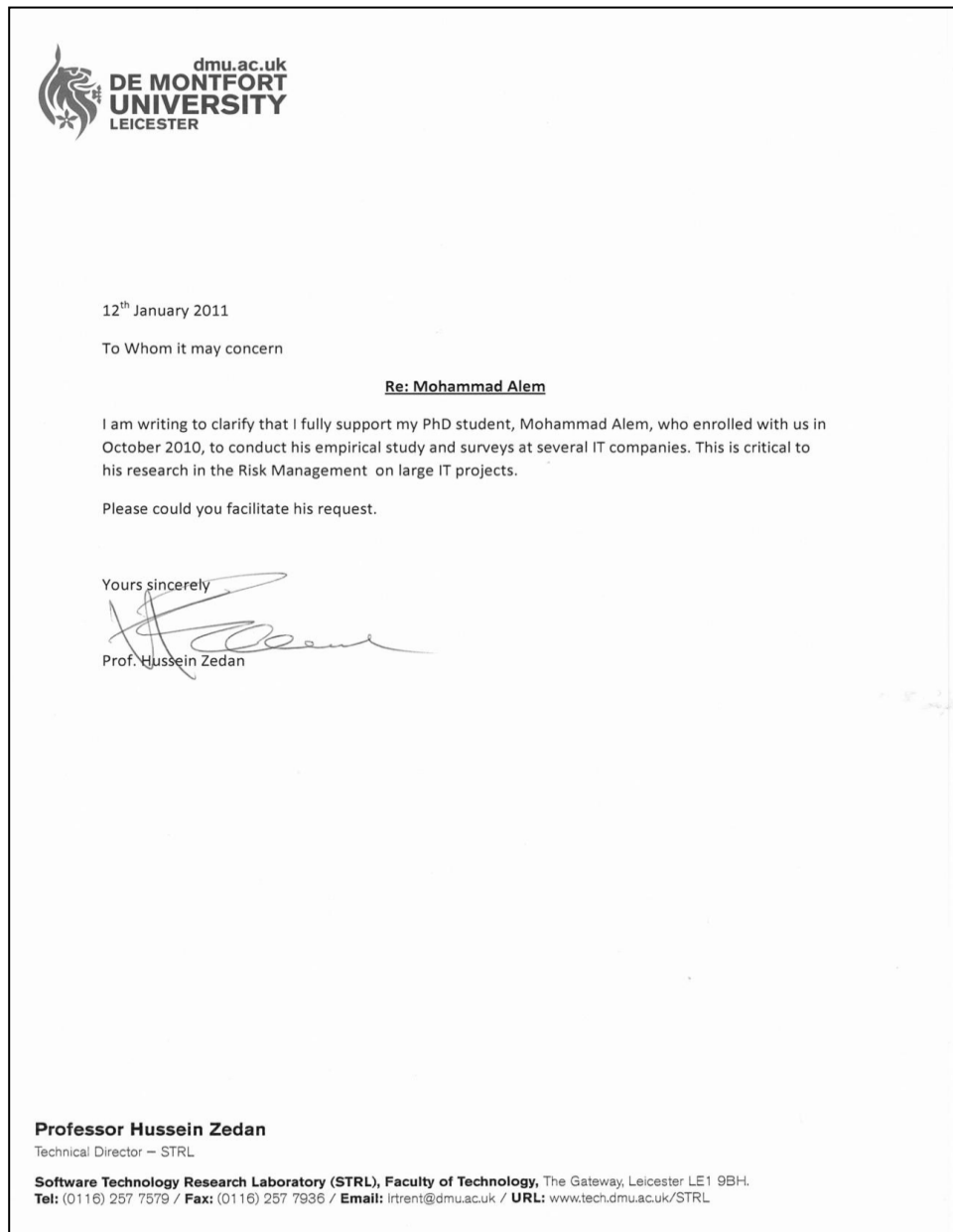
The appendices contain a collection of material that is referenced by relevant sections in the thesis. Appendices provided are:

- Appendix A. Ethics and Empirical Study
- Appendix B. Participant Information and Consent Form
- Appendix C: Questionnaire
- Appendix D: Experts Interview
- Appendix E: Modelling and Design
- Appendix F: Implementation DRiMaP Service
- Appendix G: Large IT project details
- Appendix H: Class diagram details
- Appendix I: Interface detail
- Appendix J: Functional tests

## Appendix A. Ethics and Empirical Study

Ethical aspects of this project were discussed in section 2.7

### De Montfort University permission



*Figure 72. Research permission granted by University*

General Authority of Civil Aviation Permission

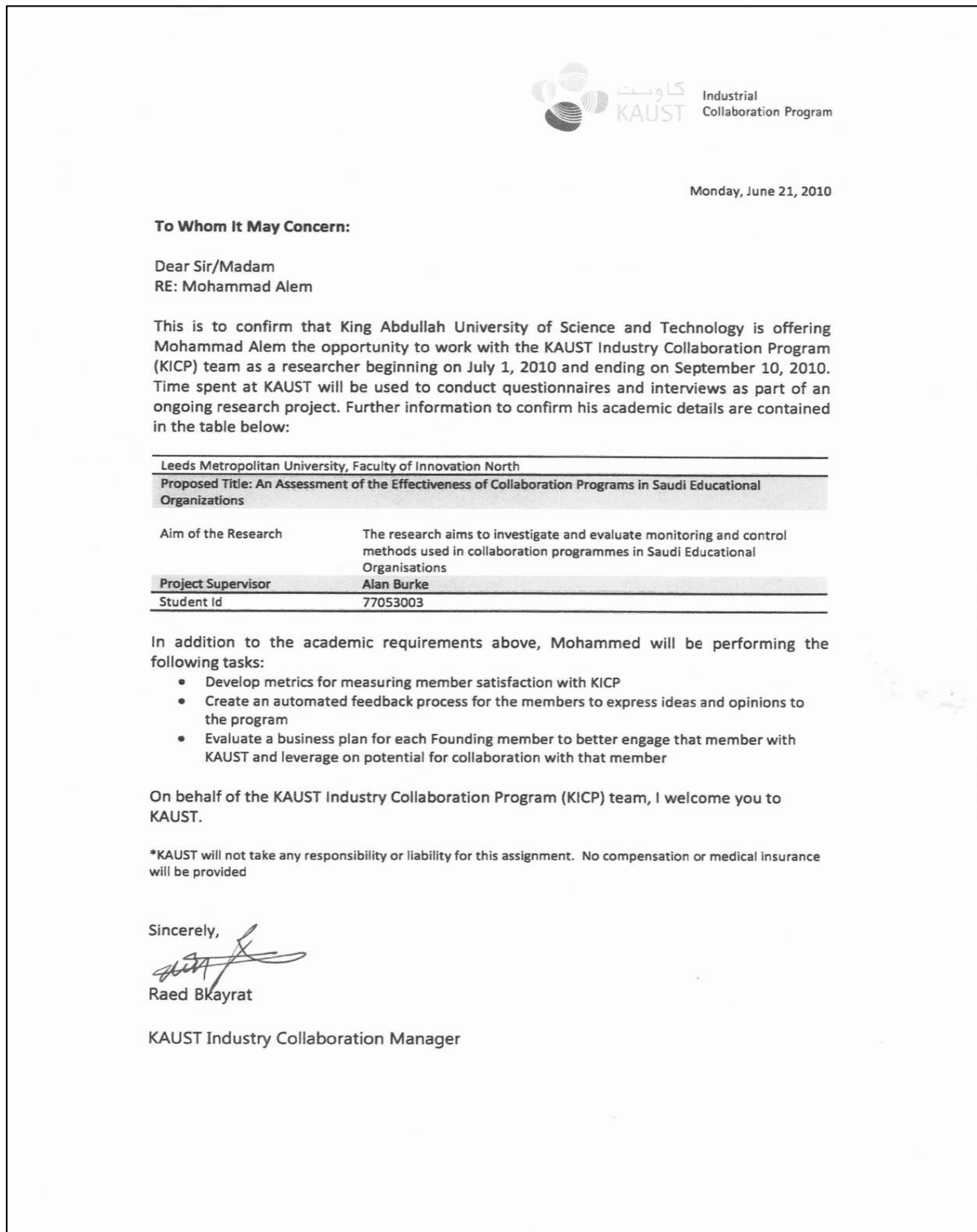
<p><i>Kingdom of Saudi Arabia</i>  <b>General Authority of Civil Aviation</b>          Information Technology Sector</p>		<p>المملكة العربية السعودية  <b>الهيئة العامة للطيران المدني</b>          قطاع تقنية المعلومات</p>
<p>To : Mr. Mohammed Zain Alem          Research Student          De Mont Fort University          Faculty of Technology</p>		<p>الى: الأستاذ/ محمد زين عالم</p>
<p>Subject: Visit and Conference for          Research Work</p>		<p>الموضوع: الزيارة والتداول من أجل البحث العلمي</p>
<p>Greetings</p>		<p>السلام عليكم ورحمة الله وبركاته:</p>
<p>Your request to visit GACA IT Sector and hold conference for writing and completion of Research thesis on Risk Management on large IT Project is hereby approved.</p>		<p>يسرني إفادتكم بموافقة قطاع تقنية المعلومات بالهيئة العامة للطيران المدني للزيارة والتشاور بخصوص أطروحتكم العلمية بعنوان إدارة المخاطر في مشاريع تقنية المعلومات الكبيرة.</p>
<p>You may visit our premises and staff in cooperation with Engr. Ahmed M. Bahaziq (IT Operations G. M.) phone 02-684-7391 or mobile 0555695655.</p>		<p>ويمكنكم زيارة القطاع والمسؤولين بالقطاع بالتنسيق مع المهندس/أحمد محمد باحاذق (مدير عام عمليات تقنية المعلومات) هاتف رقم ٧٣٩١ - ٦٨٤ - ٠٢ أو الجوال ٥٥٥٦٩٥٦٥٥</p>
<p>However, while you are conducting research the condition as mentioned in the Consent Form attached will be strictly adhered and complied with in full conformity.</p>		<p>كما نود التأكيد عليكم بأن إجراءات البحث والتشاور يجب أن تكون مقيدة وضمن نموذج الحصول على المعلومات المرفق.</p>
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<p>Best regards.</p>		<p>وتقبلوا وافر تحياتي.</p>
	<p>نائب الرئيس لتقنية المعلومات          Vice President for IT</p>	
		
	<p>د. طارق بن فؤاد حمدي          Dr. Tarik F. Himdi</p>	
		<p>نسخة لمساعدة مدير عام عمليات تقنية المعلومات المحترم</p>
		

Figure 73. Research permission from GACA

General Authority of Civil Aviation Permission GACA IT Sector

<p>Kingdom of Saudi Arabia General Authority of Civil Aviation Information Technology Sector</p>		<p>المملكة العربية السعودية الهيئة العامة للطيران المدني قطاع تقنية المعلومات</p>
<p>إفادة Statement</p>		
<p>إلى من يهمه الأمر To whom it may concern</p>		
<p>Subject: Survey Completion</p>	<p>الموضوع: إكمال جمع المعلومات والإحصاء لرسالة علمية</p>	
<p>Greetings General Authority of Civil Aviation (IT sector) certify that Mr. Alem has completed his survey work for his degree during the period of 01/07/2012 to 31/08/2012. This certificate issued to Mr. Alem without any obligations on GACA.</p>	<p>السلام عليكم ورحمة الله وبركاته: يفيد قطاع تقنية المعلومات بأن الأستاذ/ محمد زيني عالم قد اكمل جمع المعلومات والإحصاء لرسالته العلمية في قطاع تقنية المعلومات وذلك من تاريخ ٢٠١٢/٠٧/٠١ م إلى ٢٠١٢/٠٨/٣١ م ، وقد صدرت هذه الإفادة دون أدنى مسئولية على قطاع تقنية المعلومات بالهيئة العامة للطيران المدني.</p>	
<p>Best regards.</p>	<p>وتقبلوا وافر تحياتي.</p>	
	<p>نائب الرئيس لتقنية المعلومات Vice President for IT  د. طارق بن فؤاد حمدي Dr. Tarik F. Himdi</p>	
<p>IT5917.doc</p>	<p>نسخة لسعادة مدير عام عمليات تقنية المعلومات المحترم</p>	

Figure 74. Research permission for GACA IT

**KAUST Permission**

*Figure 75. Research permission from KAUST*



## Appendix B. Participant Information and Consent Form

Project Title:	Event based Risk Management of Large Scale Information Technology Projects
Principal Investigator:	Mohammed Alem
Address:	Software Technology Research Laboratory <a href="#">De Montfort University</a> , Room BI 1.19, Bede Island Building, The Gateway, Leicester LE1 9BH, England Telephone: ++44 (0)116 250 6152 Fax: ++44 (0)116 257 7936 Email: <a href="mailto:p10458420@myemail.dmu.ac.uk">p10458420@myemail.dmu.ac.uk</a>
Duration of the study:	01 July 2012 To 31 August 2012
Where it will take place:	General Authority of Civil Aviation Saudi Arabia GACA
Time:	

### FORM NOTES

Please read this form carefully. Take time to ask as many questions as possible. If there are any words, expressions, or information you do not really understand, please do not hesitate to ask the question for clarification by directing the question to the address of the primary investigator above. Each page of this form, i.e. four pages, must be carefully read and initialised and the last page must be signed and dated prior participation in this research.

### INTRODUCTION

I am undertaking my PhD research study, at De Montfort University, which is searching to improve risk management model of large scale systems.

You are, however, invited to take part in research study of Event based Risk Management of Large Scale Information Technology Projects. As part of my research I have perused all the relevant publications and documentations available in regard to your work and I would like to discuss with

you or those who are involved in the design of Risk management project. The aim of this discussion would be to ask few questions to substantiate the process employed and how successful the outcome of adopting the process was.

## **INTERVENTION**

Your participation in this research study is entirely voluntary. If you resolve to participate, you are free to withdraw your consent and to discontinue participation at any time. This research study requires number of people who have little or profound experience in the area of study. Volunteers are not going to be financially compensated neither will they receive any other form of compensation.

## **PURPOSE**

The purpose of this study is to find answers to the following questions to enable me to evaluate the resulting outcome of this research:

- How do you manage risks that exist in your IT projects?
- What do you consider was successful?
- What do you consider was unsuccessful?
- What would you have done differently and why?
- These questions may lead to further questions which depend on answers provided.
- What do you have to do?

The work will be basically questionnaires with some documentary analyses. Information and data will be collected by sending out questionnaires to 30-40 of Risk Management Systems specialists at different IT companies. The participation will be completely voluntary and participant will not be penalised in any way for not taking part. If at any point in time you have questions, concerns, or decide to end your participation, simply write the primary investigator at the address above.

**What are the possible risks of taking part?**

There are no risks in participating in this research study.

**Compensation or Reimbursement?**

Volunteers are not being financially compensated or reimbursed for expenses. As there will be no expenses incurred.

**Will my taking part in this study be kept confidential?**

Yes. All information that will be collected about any participant during the course of the research will be strictly confidential. Your name and personal information will not be used in any reports and will not be given out to anyone.

**What will happen to the results of the research study?**

The information gained from these questionnaires will only be used for the above objectives. It will not be used for any other purposes not mentioned in this form.

**What are the possible benefits of taking part?**

There are no personal benefits to participant as an individual as a result of participating in this study. The only possible benefit is the effect that this research may have on future Risk Management Model or design.

**PROVISION FOR NON-ENGLISH SPEAKERS**

Non-English participant will be provided interpretation only on request via e-mail.

Participant information that references any form of identity that would compromise the anonymity will be removed prior to the production of the research reports or publications. Obtaining trust will be established right from start by explaining the research objectives and promising that this information will be used for academic purposes only.

Thank you,  
 Yours sincerely,  
 Mohammad Alem

Software Technology Research Laboratory  
 De Montfort University,  
 Room BI 1.19,  
 Bede Island Building,  
 The Gateway,  
 Leicester LE1 9BH, England  
 Telephone: ++44 (0)116 250 6152  
 Fax: ++44 (0)116 257 7936  
 E-mail: [p10458420@myemail.dmu.ac.uk](mailto:p10458420@myemail.dmu.ac.uk)

**STATEMENT OF CONSENT AND AUTHORISATION**

I confirm that I have read and understood this form, four pages. And that my participation is voluntary and that I am free to withdraw at any time without giving any reason. And I agree to be contacted again by the researcher if my responses give rise to interesting findings or cross references.

Yes    No

My preferred method of being contacted is:

Telephone .....

Email .....

Other .....

Participant		Consent taken by	
Name:		Name	
Signature:		Signature	
Date		Date	

## Appendix C: Questionnaire

### Event Based Risk Management of Large Scale IT Projects

Risk management is the sensitive and critical procedure being initiated by the IT industry to ensure the growth process in which major risks are solved and are progressing to high levels without losing most of its budgets. Information Technology projects are driven by dynamism or incessant changes in IT infrastructure and dynamic market which are global in nature. On the basis of the outcome of this questionnaire, an organisation can easily evaluate the percentage of success of the Risk Management applications and to apply the same in major IT projects.

### Survey Questions

May I know your total experience with risk management teams in the IT industry?

- Less than 12 months       1 – 5 years       5 – 10 years       10 – 15 years       More than 15 years

What kind of risk management strategy your organisation adopts?

- Challenging the competition in the market
- Filling the organisation with Pioneering ideas and people
- Reducing the Slow times
- Implementing latest trends and Cycle methods with updates of market
- Others (\_\_\_\_\_)

What kind of risk management functionalities your organisation deals with?

- Information Security       Business Continuity
- IT Audit       Compliance

Others (\_\_\_\_\_)

Is there any separate department considering of risk management in your organisation?

Yes       No

What are the departments in your organisation conducting and carryout risk management assessment? You can tick one or more

IT                                       finance

Business                                       General Management

Others (\_\_\_\_\_)

How do you conducting risk management for IT projects in your organisation?

Vital       Static

Dynamic     Others (\_\_\_\_\_)

The Distributed Risk Management Process confidence level measurement almost 99%, how much likely your organisation has treated through DRMP dealing with IT projects ?

0 > 95% to 99%       95% to 99% < 0

Non

How the risk management aspects carried out in your organisation?

Financial Crisis                                       Recession Effects

Changing IT Market demands     Effects of threats from intrusion

Others (\_\_\_\_\_)

What are the benefits your organisation achieved by implementing the risk management principles?

Avoiding the repeated mistakes       Effective usage of Resources

Continuous improvement       reassuring the customers

Others (\_\_\_\_\_)

Does your organisation register the risk activities of IT projects during the real time implementation?

Risk logo       Risk registry

Risk trigger       others (\_\_\_\_\_)

How do you rate the impact of risk management in IT companies towards solving the following risks by considering out of 100%.

	Excellent (100-90)	V.Good (89-75)	Good (47- (64-50)	Averag (64-50)	Poor (49-
Cost Savings					
Schedule Overruns					
Unattainable user requirements					
Intrusion risks					
Recessional risks					
Disaster Risks					

What are the key issues solved in IT industry using risk management process steps?

	Not at (49-0)	Littl (64-	Avera (47-	Grea (89-	A lot (100-
Better quality of information					
Better quantity of information					
Flexibility					
Reduced lead-time in production					

Cost saving					
Forecasting					
Resource planning					
Better operational efficiency					
Reduced inventory level					
More accurate costing					
Increased coordination among staff					
Better prospects for new projects					
Training programs to avoid risks					
Increased sales					

How does the significant influence of modification techniques in the current risk technique of the organisation?

- Modified technique will hinders the progress of IT projects
- Modified technique will improves the progress of IT projects
- Modified technique will expands the real-time progress of IT projects
- Non of above

From your perspective, how your organisation will avoid events leading to unrecognised risk?

- Proactively identify steps in a process that could reduce or eliminate future failures
- Prevent errors by attempting to identify all the ways a process could fail
- Evaluate alternative processes or procedures as well as to monitor change over time
- All of above

What kinds of management level your organisation own now?

- Top Level with Risk assessing Team
- Top Level with no awareness about risks involved in IT team



Management with no Risk assessing Team

Bottom Level involved with only IT team but no risk assessment at all

If they are at top level, why they are not strong and committed enough to take the decisions related with risks in the IT projects?

Previous attempts to create change were hindered by various system factors

A lack of organisation-wide commitment

Poor organisational relationships

Ineffective communication

Does your organisation analyse criticality for the projects within the organisation?

YES

NO

Does your organisation analyses criticality for the projects outside the organisation?

YES

NO

How do you rate failure that faced by your organisation for the projects within the organisation?

Frequent

Reasonably Probable

Occasional

Remote

Extremely Unlikely

How do you rating failure that faced by your organisation for the projects outside the organisation?

Frequent

Reasonably Probable

Occasional

Remote

Extremely Unlikely

What kind of rating can be given for the method of your organisation analysis with the following factors by considering out of 100%.

	Excellent (100-90)	V.Go (89- <sup>d</sup>	Good (47-65)	Avera (64- <sup>d</sup>	Poor (49-0)
Time factor					
Cost Factor					
Risk Strategy					
Workers performance					
Feedback of the customers					
Opinion of the Employees					

What kind of tool(s) you use for risk management handling?

Integrating tools

Assessment tools

Strategies and tools

Quality improvement tools

Does your organisation depend on other organisations for completing projects?

YES

NO

If yes, do you assess all the above factors mentioned in question 21 about the organisation working for the projects?

YES

NO

Finally write your experience with distributed risk management process Models implementation in your organisation.

**Organisation Professionals Details**

Name -----

Address -----

Country -----

Tel -----

Fax -----

Website -----

Contact person -----

Position in company -----

Email -----

Contact Details Please (Optional):

Be assured that these details will remain confidential and will be secured in safe custody if needed the information will be destroyed in safe observation after completing the needs of this research. I sincerely convey my thanks for your time and patience that will help me to complete my research successfully.

## **Appendix D: Experts Interview Questions**

1. Does sector use and process the risk management electronically?
2. Do you have access to the IT projects and companies that your IT sector deals with in term of risk management?
3. What are the risk information elements you want to distribute?
4. Are there any parts of risk information that you have to access daily and necessary to carry out your job?
5. Who do you think is the controller of a risk system record in the IT sector?
6. Who do you think is the controller of a risk system record in IT companies?
7. Are there any conditions to risk management staff to access to risk management system?
8. Can you modify/change/delete in the risk information record (if yes, are there any restriction)
9. Are you aware that your IT sector has collaborated with several projects several IT companies?
10. Do you think officials in monitoring and controlling necessary to have benefited from the risk management system?
11. What are the risk management aspects you follow in your organisation and how?
12. What are the benefits your company achieved by implementing the risk management principles?
13. Do you wish to improve current risk management to improve further (please mention the sectors and also justify your idea)?
14. What are the key issues solved in IT industry using risk management process steps?
15. From your perspective, over the next five years what will be the top five biggest unrecognised risks?
16. Which tool(s) you use for risk management handling?
17. What are the factors that your company need to analysis and more concern?
18. What is the impact of risk management in IT companies towards solving?

## Appendix E: Modelling and Design

Modelling and design of the software tool is discussed in section 4.4.

### IBM Software Quotation

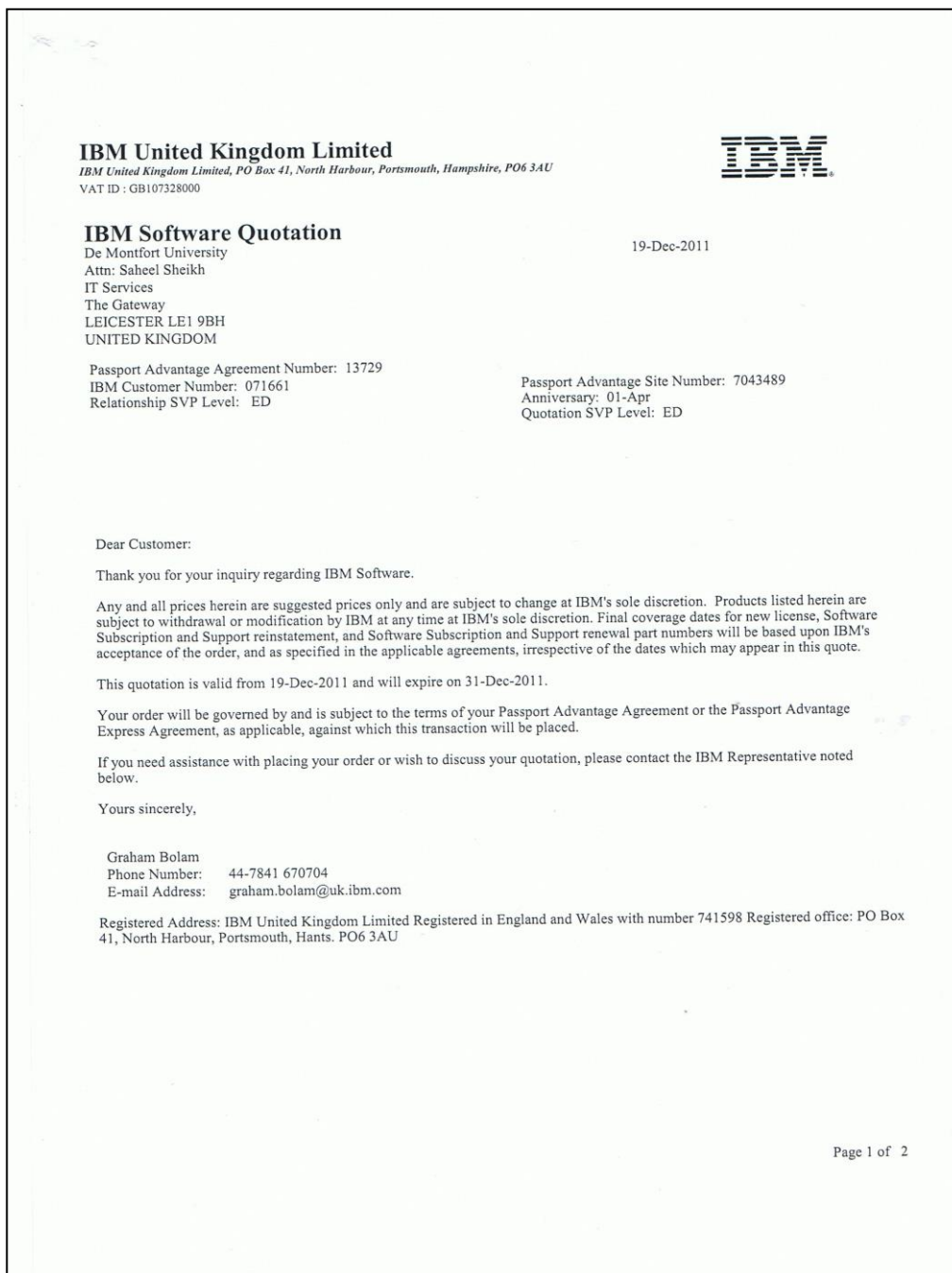



Figure 76. IBM software quotation

**IBM United Kingdom Limited**  
 IBM United Kingdom Limited, PO Box 41, North Harbour, Portsmouth, Hampshire, PO6 3AU  
 VAT ID : GB107328000



Quotation Number: 15667089  
 IBM Contact: Graham Bolam  
 Phone Number: 44-7841 670704

Quote Effective Date: 19-Dec-2011  
 Quote Expiration Date: 31-Dec-2011

Passport Advantage Agreement Number: 13729  
 IBM Customer Number: 071661  
 Relationship SVP Level: ED

Passport Advantage Site Number: 7043489  
 Anniversary: 01-Apr  
 Quotation SVP Level: ED

Customer:  
 De Montfort University  
 Attn: Saheel Sheikh  
 IT Services  
 The Gateway  
 LEICESTER LE1 9BH  
 UNITED KINGDOM

Item	Part Number	Quantity	Points	Unit SVP Price	Extended Amount
IBM Rational Rhapsody Architect for Systems Engineers Authorized User License + SW Subscription & Support 12 Months 001 D09PVLL 1 4.12 251.00 251.00 19-Dec-2011 - 31-Dec-2012					
IBM Rational Rhapsody Architect for Software Authorized User License + SW Subscription & Support 12 Months 002 D09MULL 1 15.10 922.00 922.00 19-Dec-2011 - 31-Dec-2012					
Applicable tax will be recalculated at the time of order processing.					
<b>Total Points: 19.22</b>					<b>Subtotal in GBP: 1,173.00</b>
<b>Estimated Tax in GBP (20.00%):</b>					<b>234.60</b>
<b>Total in GBP:</b>					<b>1,407.60</b>
Your order is governed by and subject to the terms of your Passport Advantage Agreement or the Passport Advantage Express Agreement, as applicable, against which this transaction will be placed.					

Useful/important web resources:

Passport Advantage information, customer secure site access, training, etc.: [ibm.com/software/passportadvantage](http://ibm.com/software/passportadvantage)  
 IBM's International Program License Agreement and product License Information documents: [ibm.com/software/sla](http://ibm.com/software/sla)  
 IBM Software Support web site: [ibm.com/software/support](http://ibm.com/software/support)

IBM Customer Number: 071661  
 Page 2 of 2

Figure 77. IBM quotation

**DRiMaP and IT Project SDLC Phases**

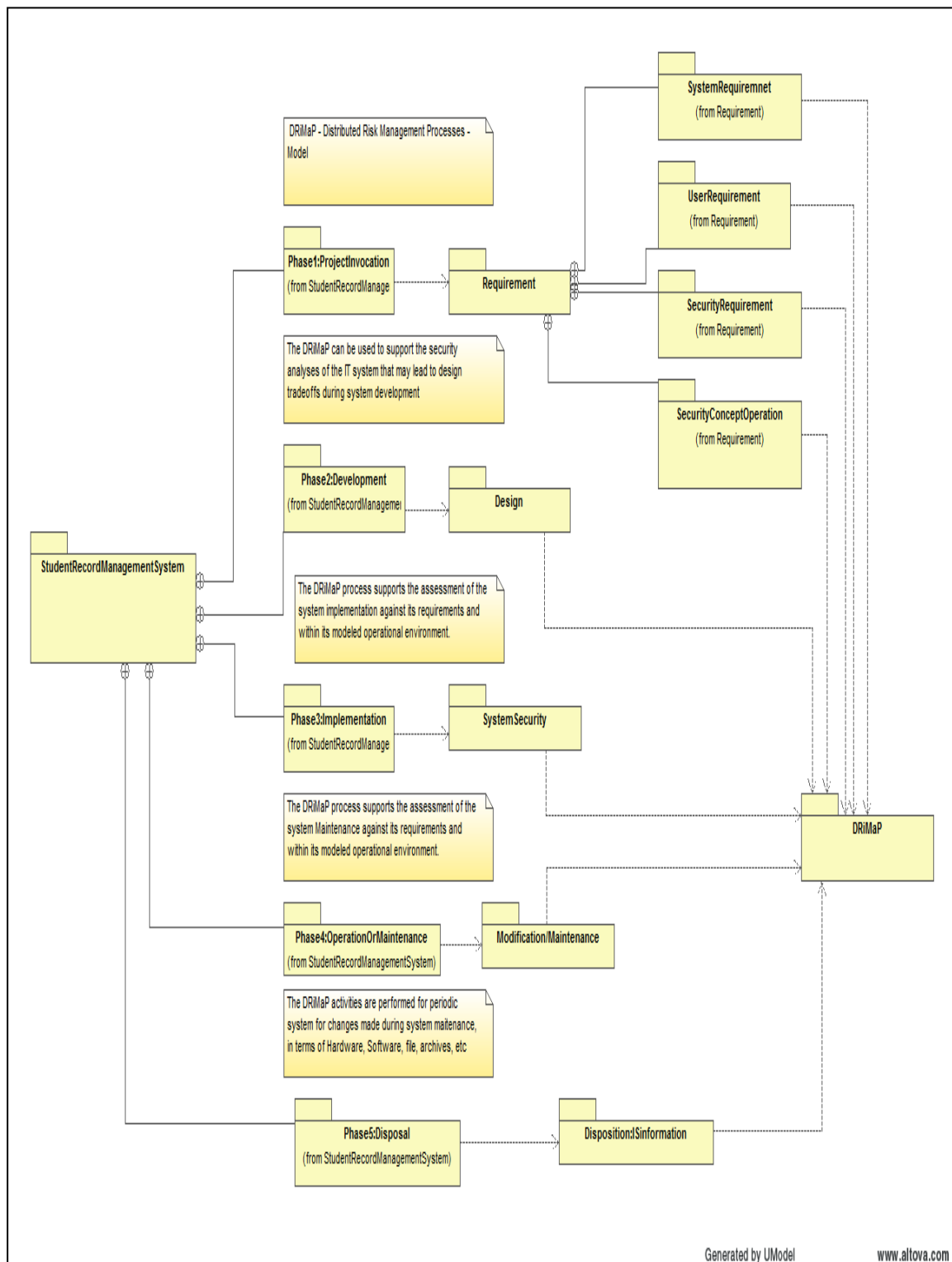


Figure 78. Project SDLC phases

**DRiMaP and IT Project Extension and Modification**

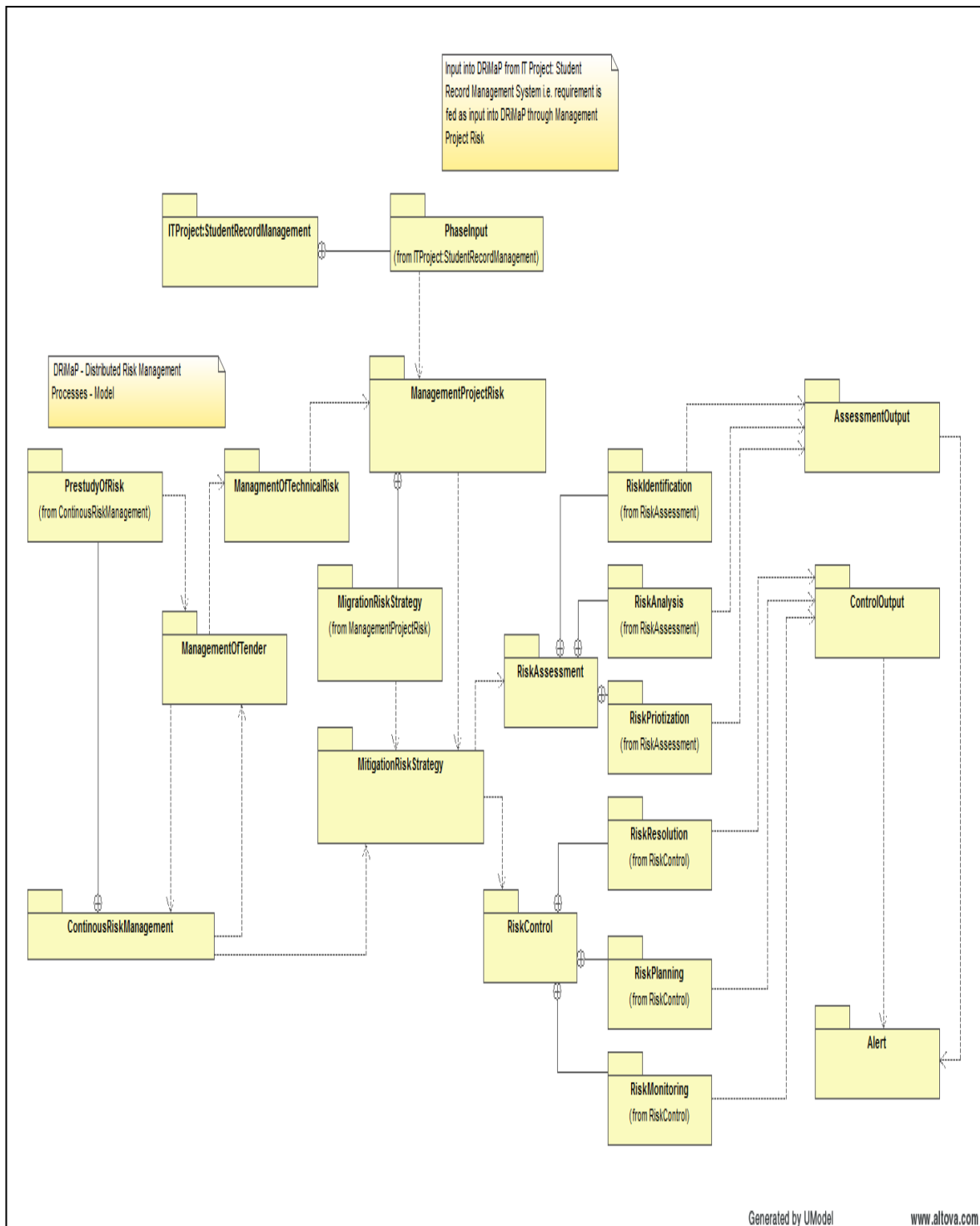
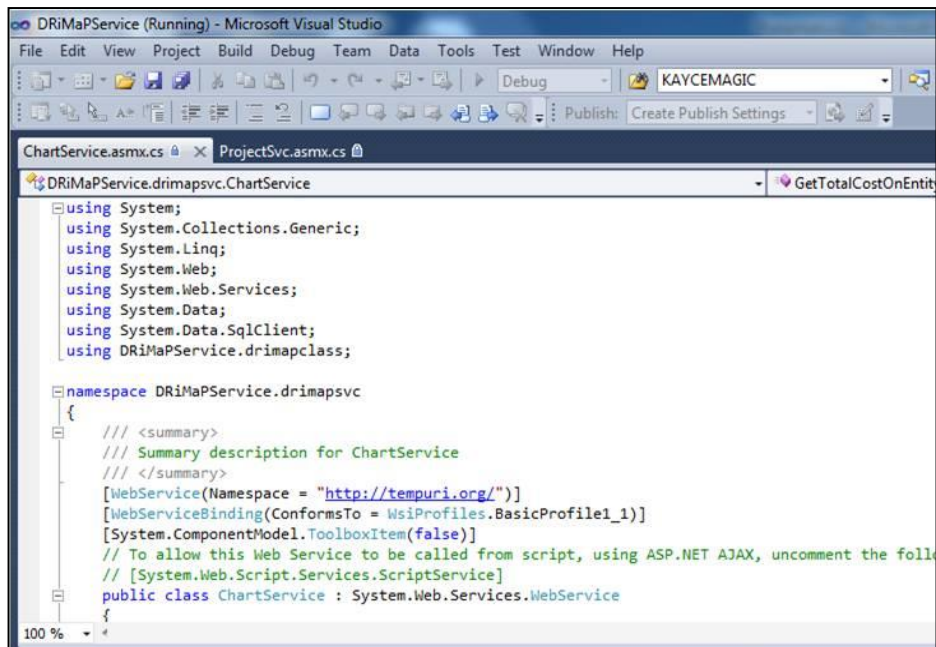


Figure 79. Extensions and modifications



## Appendix F: Implementation DRiMaP Service

Implementation is discussed in section 4.4.



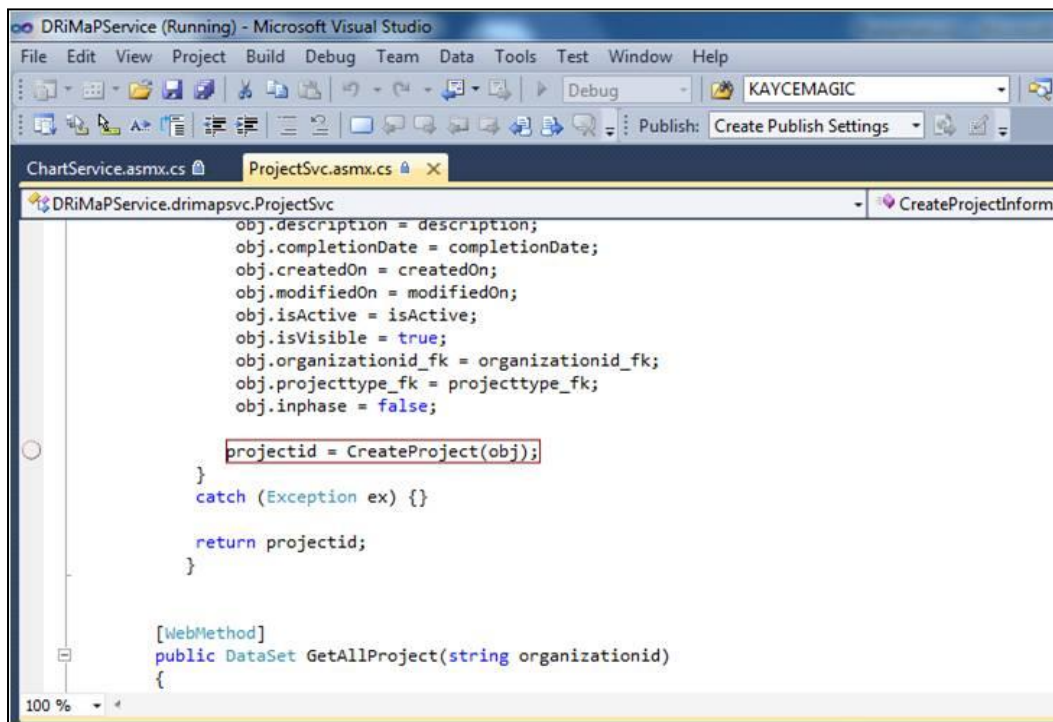
```

using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;
using System.Web.Services;
using System.Data;
using System.Data.SqlClient;
using DRiMaPService.drimapclass;

namespace DRiMaPService.drimapsvc
{
    /// <summary>
    /// Summary description for ChartService
    /// </summary>
    [WebService(Namespace = "http://tempuri.org/")]
    [WebServiceBinding(ConformsTo = WsiProfiles.BasicProfile1_1)]
    [System.ComponentModel.ToolboxItem(false)]
    // To allow this Web Service to be called from script, using ASP.NET AJAX, uncomment the following line.
    // [System.Web.Script.Services.ScriptService]
    public class ChartService : System.Web.Services.WebService
    {
    }
}

```

Figure 80. Chart service code fragment - Chart Service.asmx.cs



```

obj.description = description;
obj.completionDate = completionDate;
obj.createdOn = createdOn;
obj.modifiedOn = modifiedOn;
obj.isActive = isActive;
obj.isVisible = true;
obj.organizationid_fk = organizationid_fk;
obj.projecttype_fk = projecttype_fk;
obj.inphase = false;

    projectid = CreateProject(obj);
}
catch (Exception ex) {}

return projectid;
}

[WebMethod]
public DataSet GetAllProject(string organizationid)
{
}

```

Figure 81. Project SVC code fragment - Project Svc.asmx.cs

```

drClient.CampaignSummaryControl
    projectDs = _proservice.ClientProjects(organizationid);
    bindProjectData(projectDs, ddlProject);
    bindProjectData(projectDs, this.ddlProjectRiskVsCost);
    string productid = getProjectId(projectDs);

    if (productid != "")
    {
        ChartSvc.ChartData[] projectdata = _chartservice.GetProjectActivityChartDa
        CreateProjectActivityReport(projectdata);
        Session["projectdata"] = projectdata;
        project_totalcost = _chartservice.GetTotalCostOnEntity(productid);
        calcpercentage = getCalculatedPercentageOnEntity(riskpercentage, project_t
        PlotRiskVsCostOnEntity(calcpercentage, riskpercentage, "project");

        phaseDs = _phaseservice.GetPhasesByProjectId(productid);
        bindPhaseData(phaseDs, this.ddlPhase);
        bindPhaseData(phaseDs, this.ddlPhaseRiskVsCost0);

        string phaseid = getPhaseId(phaseDs);

        if (phaseid != "")
    
```

Figure 82. CS control code fragment - CS Control.aspx.cs

```

Client Objects & Events
    <%@ Control Language="C#" AutoEventWireup="true" CodeBehind="CampaignSummaryControl.aspx.cs" Inherits="
    <asp:UpdatePanel ID="updatepanelRiskVsCost" runat="server" ChildrenAsTriggers="true">
    <ContentTemplate>
    <div>
    <div align="center">
    <div align="center"><h4>Risk Vs Cost on: </h4><br />
        <div>
            <asp:UpdateProgress ID="UpdateProgress2" runat="server">
                <ProgressTemplate>
                    <div class="progress"><br />
                </ProgressTemplate>
            </asp:UpdateProgress>
        </div>
        <asp:DropDownList ID="ddlProjectRiskVsCost" runat="server" Width="20%"
            AutoPostBack="True"
            onselectedindexchanged="ddlProjectRiskVsCost_SelectedIndexChanged"></asp:DropDownList>
        &nbsp;<asp:DropDownList ID="ddlPhaseRiskVsCost0" runat="server" Width="20%"
    
```

Figure 83. Project control code fragment - Project Control.aspx.cs

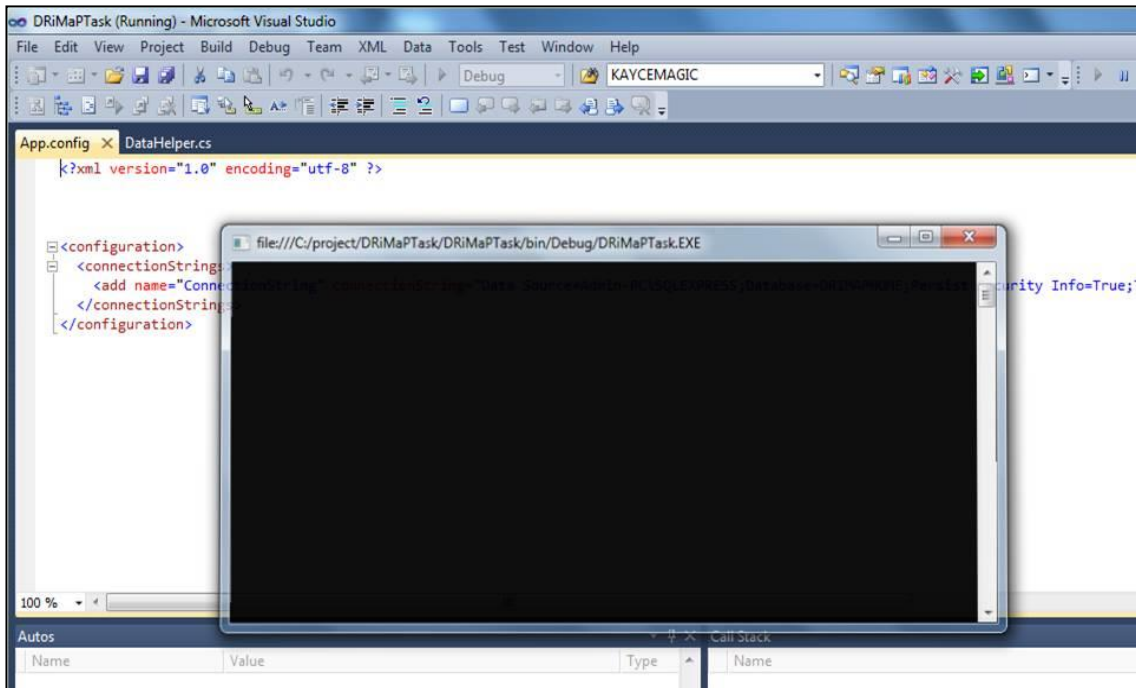
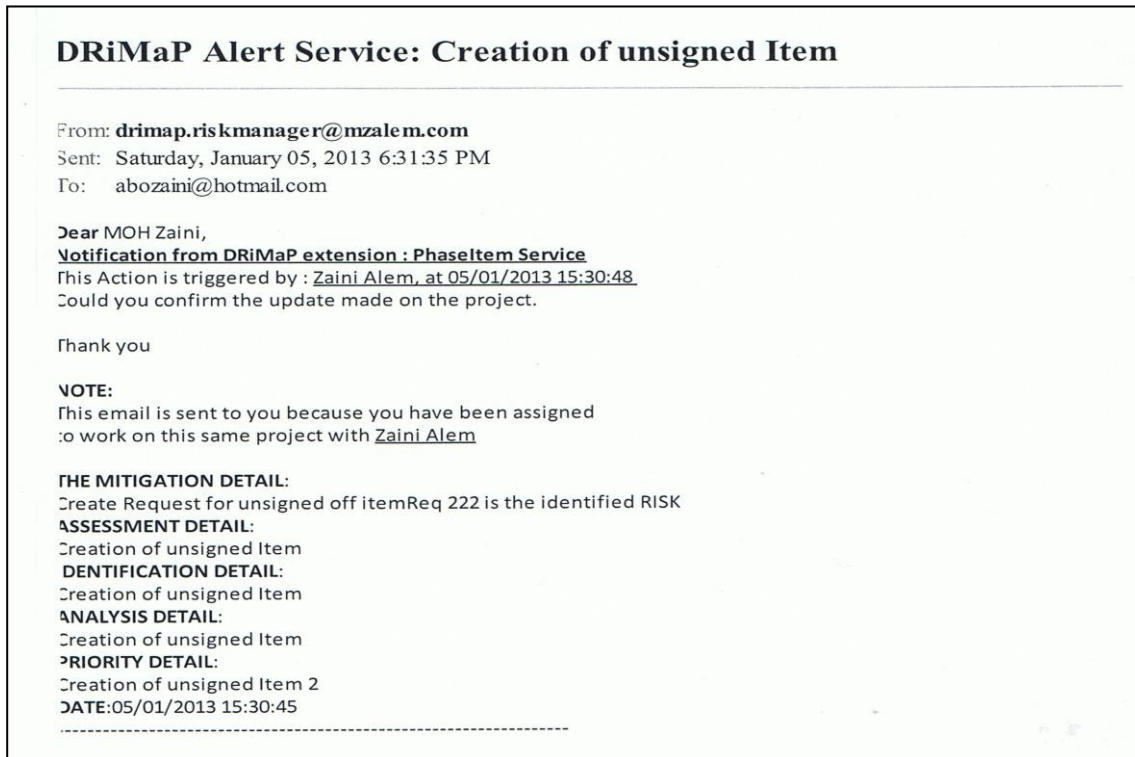


Figure 84. Real-Time Event Alert Service and Task

## DRiMaP Event Alert Service email example

Implementation of the Alert service is discussed in section 4.4.14.



*Figure 85. Alert service creation email*

# Appendix G: Large IT project details

## Large IT Project Multi-Platform Example

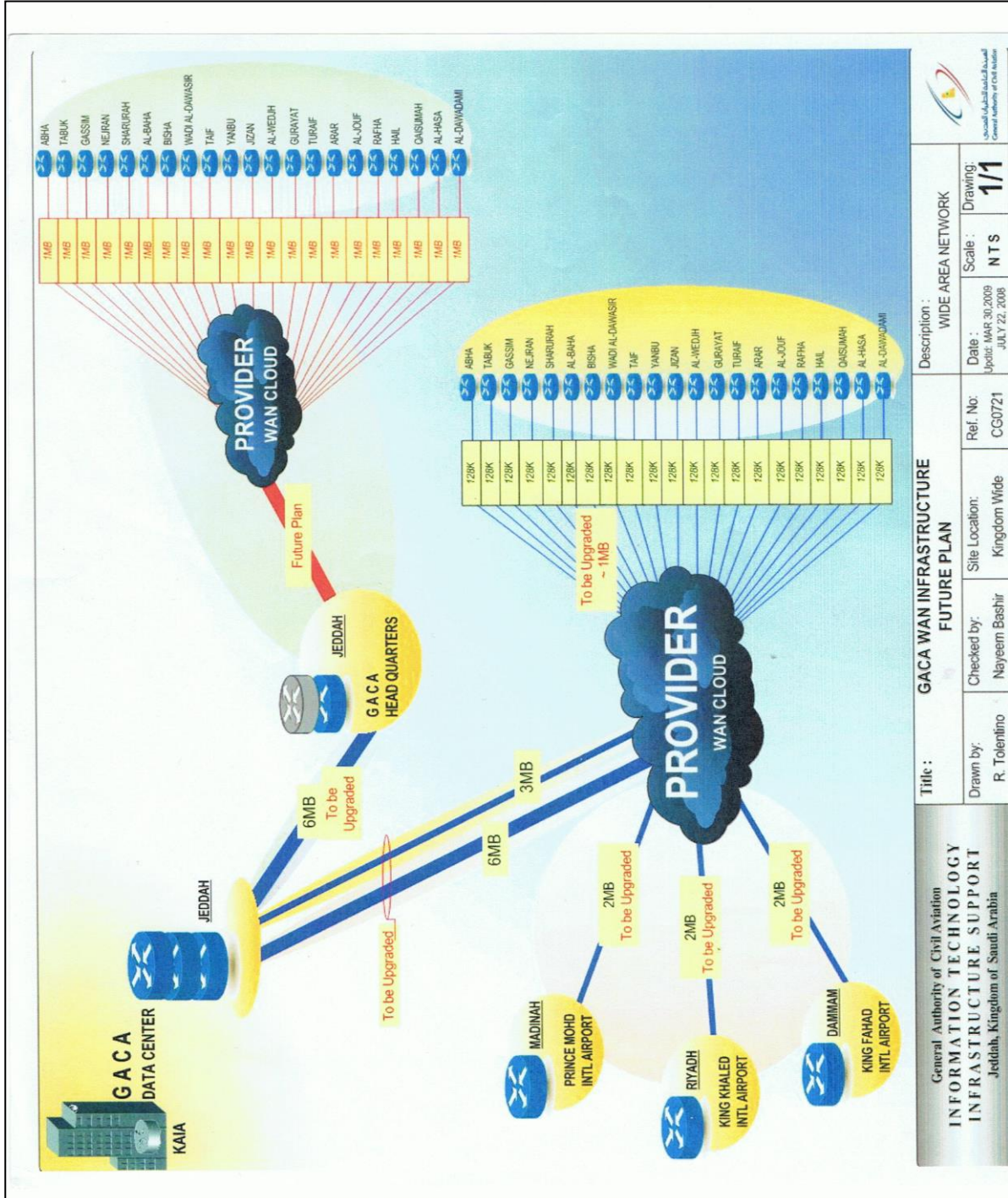


Figure 86. Large IT project system overview

# Large IT Project Events Example

**IT&T Transformation - GACA Asset Management and Transfer**  
 Current annual cost Discontinue assets.  
 The list below is an initial assessment (pending further detailed review) of the annual cost of GACA's Discontinue environment (Local Currency)

Category	Subcategory	Asset/Resource	Annual Costs	All Locations	GACA HQ	Jeddah A/P	Riyadh A/P	Madinah Airport	Dman A/P	Fundamental to Operation?	Building Future?	Staffing numbers
Data Centre Services	Facilities	Comm Hubs, Main Computer Rooms, Telecom Closets										
Data Centre Services	Staffing	Data Centre Management and Support										
Data Centre Services	Facility Mgmt and Support	Help Desks										
Data Centre Services	Facility Mgmt	Power Distribution/Backup										
Data Centre Services	Facility Mgmt	RWAC										
Data Centre Services	Facility Mgmt	Security										
Data Centre Services	Facility Mgmt	UPS										
Data Centre Services	Facility Mgmt	Control and Monitoring										
Data Centre Services	Server Technologies	Operating System Licenses										
Data Centre Services	Server Technologies	Hardware (Servers)										
Data Centre Services	Storage Technologies	SAN Switches										
Data Centre Services	Storage Technologies	Storage Arrays										
Data Centre Services	Storage Technologies	Tape Libraries										
Data Centre Services	Storage Technologies	Midrange Technologies										
Data Centre Services	Storage Technologies	Midrange support										
Data Centre Services	Storage Technologies	Mainframe support										
Others												
Desk top	Facility Mgmt	Desk Top and PC support and maintenance for Data Centre										
Servers at airport sites	Server Technologies	Hardware (Servers)										
Database	Storage Technologies	Database support										

Figure 87. Large IT project events list

## Appendix H: Class diagram details

Details of the classes and relationships in the class diagram in Figure 27 (section 4.4.2) are provided below.

Classes	Description
Organisation	Shell Stores information about organisation
Project	Store information about the organisation
Servicerequest	Store information about service call
ManagementProjectRisk	Stores project type
DirectSource	Project source; either procurement which is external, or developed internally
Migration	Track migration details
Mitigation	Tracks mitigation details
Assessment	Stores assessment details
Identification	Stores identification details
Priotisation	Stores prioritisation details
Analysis	Stores analysis details
Control	Stores Control details
Monitoring	Stores Monitoring details
Resolution	Stores Resolution details
Planning	Stores Planning details
ControlOutput	Stores output from planning, resolution, and monitoring
Alert	Stores alert information generated from AssessmentOutput and ControlOutput

*Figure 88. Class diagram class descriptions*

Relationships	Descriptions
organisationrequest	This represents the Unique identifier of the organisationshell class
projects	Unique identifier of the project class
Servicerequest	Unique identifier of the ServiceRequest
managementprojectrisresource	Unique identifier of the managementProjectRisk
migrationrisk	Unique identifier of the Migration class
identification	Unique identifier of RiskIdentification class planning
prioritisationoutput	Unique identifier of the RiskPrioritisation class
analysisoutput	Unique identifier of Analysis
identificationoutput	Unique identifier ofIdentificationOutput class
planingoutput	Unique identifier of PlanningOutput class
monitoringouput	Unique identifier of MonitoringOutput class
resolutionoutput	Unique identifier of ResolutionOutput class
alertoutput	Unique identifier of Alert class
Control	Unique identifier of Control class
assessment	Unique identifier of Assessment class
assessmentoutput	Unique identifier of AssessmentOutput

*Figure 89. Class diagram relationships descriptions*



## Appendix I: Interface detail

### WebGUI Interface

Interfaces described in section 4.4.5 are illustrated below.

The screenshot shows a web browser window with the address bar displaying 'localhost:10001/Login.aspx'. The page has a dark blue background and is titled 'Login Detail'. It contains three input fields: 'Username', 'Password', and 'Internal Org. Id'. To the right of the 'Internal Org. Id' field is the text 'Copy and Paste it'. Below the input fields are two buttons: 'Login' and 'Cancel'. At the bottom, there is a link: 'Click here to [Register](#) here, if you have no previous login.'

Figure 90. User GUI, authentication and user service

The screenshot shows a web browser window with the address bar displaying 'localhost:5144/drimapsvc/User.asmx?op=UserLogon'. The page has a dark blue header with the word 'User'. Below the header, it says 'Click [here](#) for a complete list of operations.' The main section is titled 'UserLogon' and contains a 'Test' section. It instructs the user: 'To test the operation using the HTTP POST protocol, click the 'Invoke' button.' Below this is a table with two columns: 'Parameter' and 'Value'. The table contains three rows: 'username:', 'password:', and 'internalorgid:'. Each row has an input field. To the right of the 'internalorgid:' row is a checkbox labeled 'Is Super User?'. Below the table is an 'Invoke' button. At the bottom, it says 'SOAP 1.1' and 'The following is a sample SOAP 1.1 request and response. The placeholders shown ne'.

Figure 91. User GUI, Register new user vs. user service RegisterUser method

The screenshot shows a web browser window with a dark blue background and is titled 'Login Detail'. It contains several input fields: 'Firstname', 'Lastname', 'Username', 'Password:', 'Confirm Password', and 'Email:'. To the right of the 'Lastname' field is a checkbox labeled 'Is Super User?'. To the right of the 'Confirm Password' field is the text 'Copy and Paste it'. Below the input fields are two buttons: 'Register' and 'Cancel'. At the bottom, there is a link: 'Click here to [Login](#) here, if you have no previous login.'

Figure 92. Login detail

Figure 93. Registered user screen

## WebGUI service listing

This listing is a fragment from the WebGUI component, discussed in section 4.4.5.

```
public void CreateUserLoginStatus(UserLoginStatus obj)
{
    //bool isSuccess = false;
    int rowaffected = 0;
    SqlConnection scn = new SqlConnection(DrimapConnection.setconnection(new
                                        SqlConnection()).ConnectionString);

    try
    {
        DataSet ds = new DataSet();
        SqlCommand spcmd = new SqlCommand("sp_CreateUserLoginStatus",scn);
        spcmd.CommandType = CommandType.StoredProcedure;
        spcmd.Parameters.Add(new SqlParameter("@userloginstatusid",
                                             obj.userloginstatusid));
        spcmd.Parameters.Add(new SqlParameter("@loggedOn", obj.loggedOn));
        spcmd.Parameters.Add(new SqlParameter("@createdOn", obj.createdOn));
        spcmd.Parameters.Add(new SqlParameter("@signedOut", obj.signedOut));
        spcmd.Parameters.Add(new SqlParameter("@currentstatus",
                                             obj.currentstatus));
        spcmd.Parameters.Add(new SqlParameter("@userid_fk", obj.userid_fk));

        if (scn.State == ConnectionState.Closed)
        {
            scn.Open(); rowaffected = spcmd.ExecuteNonQuery();
        }
        else { rowaffected = spcmd.ExecuteNonQuery(); }
    }
    catch (SqlException ex) { ex.Message.ToString(); }

    finally { scn.Close(); }
```

## Web UI and organisation service

The organisation web UI and organisation service screenshots discussed in section 4.4.6 are presented below.

The screenshot shows a web browser window with the URL `localhost:10001/ClientTabs.aspx?intid=1d091d6b-b690-42dd-b876-1386e91e0844&grid=6b572879-a598-46b0-a1...`. The page title is "DRiMAP EXTENSION - CLIENT INTERFACE" and there is a "[ Log In]" link in the top right. Below the title bar, there is a "User" dropdown menu. A navigation menu contains "Organization", "Project", "Phase", and "Reporting", with "Organization" selected. The main content area is titled "ORGANIZATION DETAIL" and contains the following form fields:

- Company Name:
- Description:
- Is Active?:
- Org. Type:

At the bottom of the form are "Update" and "Cancel" buttons. Below the buttons, there is a link: "Click here to [go Back](#) or click cancel button".

Figure 94. Organisation Web UI for Update request

The screenshot shows a web browser window with the URL `localhost:5144/drimapsvc/organization.asmx?op=updateOrganization`. The page title is "organization". Below the title bar, there is a link: "Click [here](#) for a complete list of operations." The main content area is titled "updateOrganization" and contains a "Test" section. The "Test" section includes the instruction: "To test the operation using the HTTP POST protocol, click the 'Invoke' button." Below this instruction is a table with two columns: "Parameter" and "Value".

Parameter	Value
organizationid:	<input type="text"/>
organizationname:	<input type="text"/>
organizationdescription:	<input type="text"/>
isActive:	<input type="text"/>
internalorgid:	<input type="text"/>

At the bottom right of the table is an "Invoke" button. Below the table, there is a section titled "SOAP 1.1" with the text: "The following is a sample SOAP 1.1 request and response. The placeholders shown need to be replaced with actual values."

Figure 95. Organisation service

## Project UI interface

The project user interface discussed in section 4.4.7 is illustrated below.

The screenshot shows a web interface for 'PROJECT DETAIL'. At the top, there are tabs for 'Organization', 'Project', 'Phase', and 'Reporting'. The main content area includes:

- Deadline in Hours:** 246 Days 0 Hours, with a 'Click to Refresh' link.
- Assigned user(s):** No user is assigned to this project. A link 'Assign new user' and 'Phase status: Already in Phase' are visible.
- Name:** A text input field.
- Description:** A text input field.
- Is Active?:** A checkbox.
- Signed Off?:** A checkbox.
- projecttypecode:** A dropdown menu currently set to 'Internal'.
- Project Cost:** A text input field with a pound sign (£).
- Deadline:** A date and time picker set to '06/12/2013 12:00:00'.
- Indicate the percentage cost to be used for phase, phase items:** A text input field.
- specify ratio:** A dropdown menu set to '0.1'.
- Buttons:** 'Createt' and 'Cancel'.

Figure 96. Project UI and Project Service

The screenshot shows the 'ProjectSvc' interface. It includes a header 'ProjectSvc' and a link 'Click here for a complete list of operations.' Below this is the section 'CreateProjectInformation' with a 'Test' sub-section. The test section contains the following table:

Parameter	Value
projectname:	<input type="text"/>
description:	<input type="text"/>
createdOn:	<input type="text"/>
modifiedOn:	<input type="text"/>
isActive:	<input type="text"/>
organizationid_fk:	<input type="text"/>
projecttype_fk:	<input type="text"/>
completionDate:	<input type="text"/>

An 'Invoke' button is located at the bottom right of the table.

Figure 97. Create Project Information screen

## Visual Studio prototype screens

The following screens are described in section 4.5.

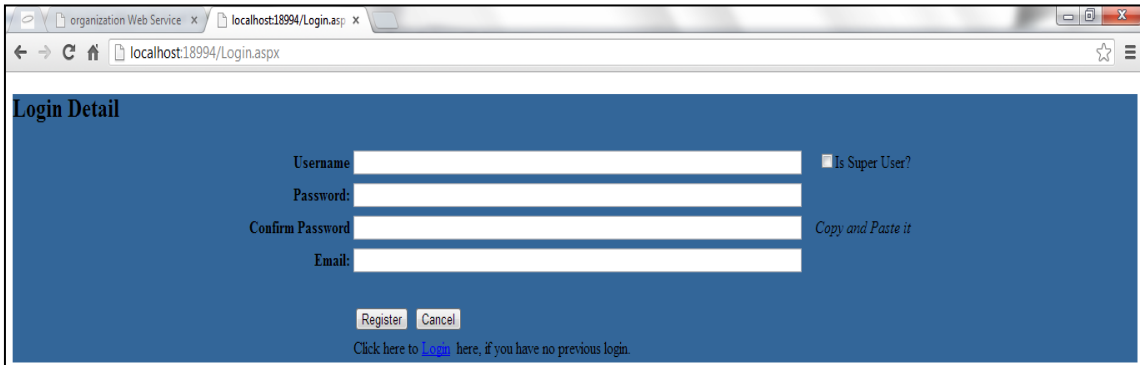


Figure 98. Register New User

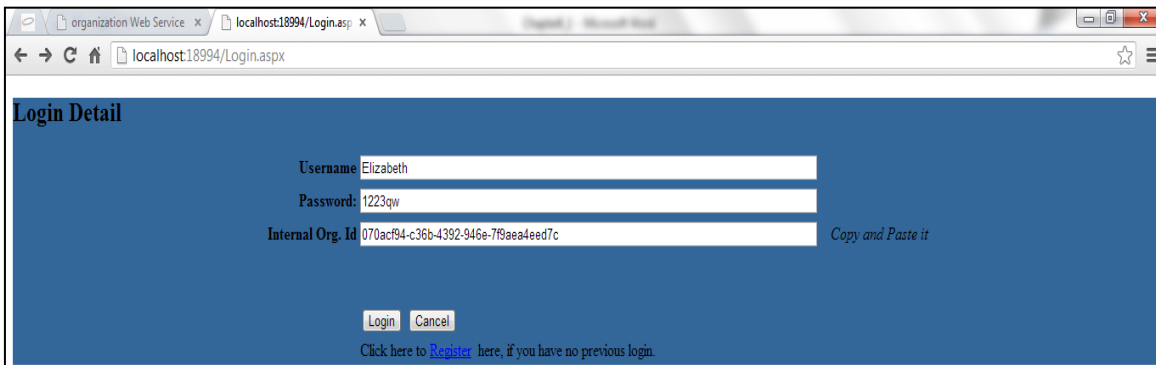


Figure 99. Returning User Login form

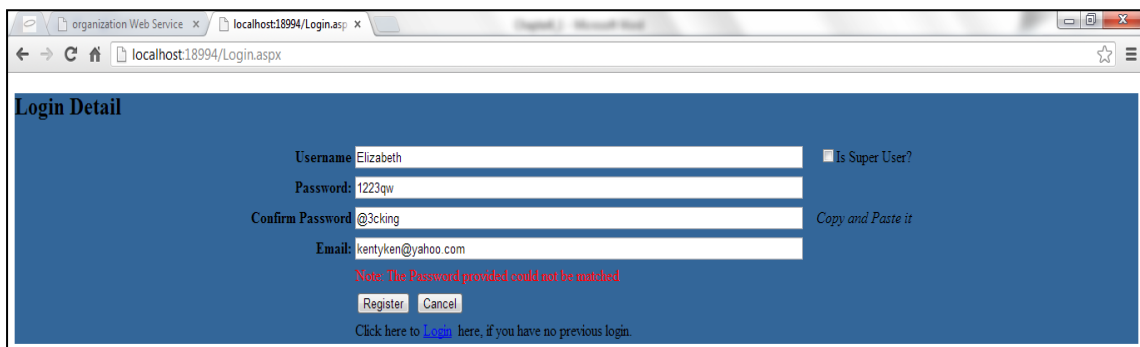


Figure 100. Mismatched credential form

DRiMAP EXTENSION - CLIENT INTERFACE [ Log In ]

Registration

Organization **Project** Phase

**ORGANIZATION DETAIL**

S/N	Organization Name	Description	Created On	Modified On	Active Status
1	<a href="#">PortalHome</a>	home of the portal	15/10/2012 20:14:09	15/10/2012 20:14:09	Active

Figure 101. Organisation form tab view

DRiMAP EXTENSION - CLIENT INTERFACE [ Log In ]

Registration

Organization **Project** Phase

**PROJECT DETAIL**  
Click here to create [New](#) project

S/N	Project Name	description	Created on	Modified On	Status	Phase Status
1	<a href="#">NovaScholar_2</a>	Student Registration System 2	26/10/2012 13:31:41	26/10/2012 13:31:41	Active	Already in Phase <a href="#">Add</a>
2	<a href="#">Toolkit</a>	test	26/10/2012 13:44:00	26/10/2012 13:44:00	Active	Already in Phase <a href="#">Add</a>
3	<a href="#">Mzalem DRiMaP</a>	Drimap designer	27/10/2012 12:55:32	27/10/2012 12:55:32	Active	Already in Phase <a href="#">Add</a>

Figure 102. Project View

DRiMAP EXTENSION - CLIENT INTERFACE [ Log In ]

Registration

Organization **Project** Phase


**PROJECT DETAIL**


Name

Description:

Is Active?

projecttypecode:

Proposed End Date  

Phase status: 

Click here to create [New](#) project

Figure 103. Create Project View

DRiMAP EXTENSION - CLIENT INTERFACE [ Log In ]

Registration

Organization Project **Phase**

**PHASE DETAIL**  
Click here to create [New](#) project

S/N	Phase Name	description	Created on	Modified On	Active Status
1	<a href="#">Phase 1 [Requirement Collection]</a>	Requirement collection stages	15/10/2012 20:22:41	26/10/2012 15:22:00	Active <input checked="" type="checkbox"/>
2	<a href="#">Phase 2 [System Specification Collection]</a>	System Specification Collection stage	15/10/2012 20:26:21	15/10/2012 20:26:21	Active <input checked="" type="checkbox"/>
3	<a href="#">Phase 3 [System Analysis and Design]</a>	System Analysis and Design stage	15/10/2012 20:28:49	15/10/2012 20:28:49	Active <input checked="" type="checkbox"/>
4	<a href="#">Phase 4 [System Implementation and Testing]</a>	Implementation and Testing state	15/10/2012 20:31:47	15/10/2012 20:31:47	Active <input checked="" type="checkbox"/>
5	<a href="#">Phase 5 [Documentation]</a>	Documentation stage	15/10/2012 20:35:50	15/10/2012 20:35:50	Active <input checked="" type="checkbox"/>

Figure 104. Phase View

DRiMAP EXTENSION - CLIENT INTERFACE [ Log In ]

Registration

Organization Project **Phase**

**PHASE DETAIL**

Name:

Description:

Is Active?

Click here to create [New](#) project

Figure 105. Create Phase

DRiMAP EXTENSION - CLIENT INTERFACE [ Log In ]

Registration

Organization Project **Phase**

**PHASE DETAIL**

Name:

Description:

Is Active?

Click here to create [New](#) project

Figure 106. Update Existing Phase

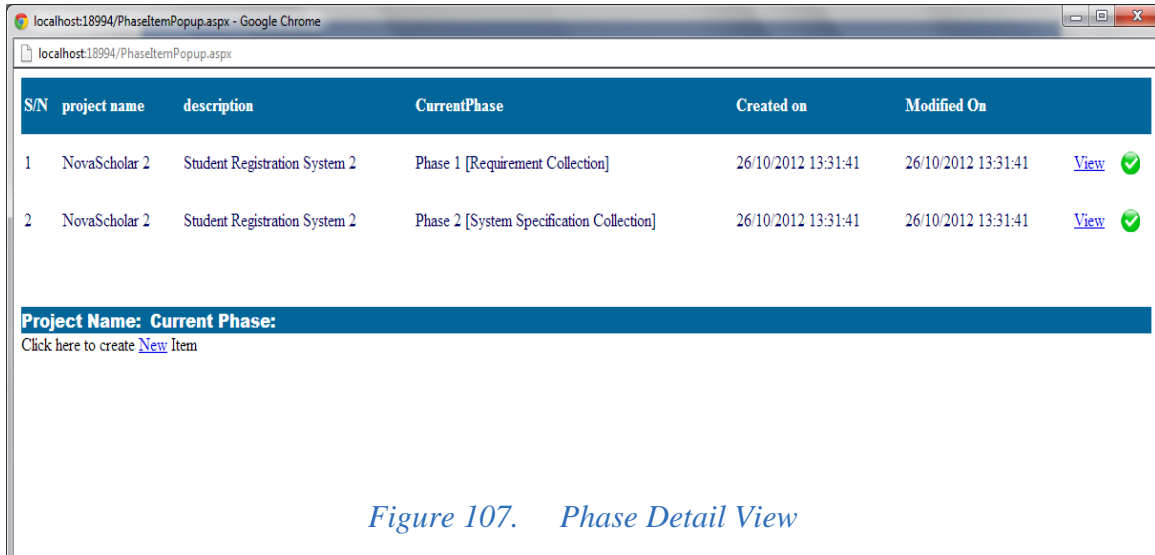


Figure 107. Phase Detail View

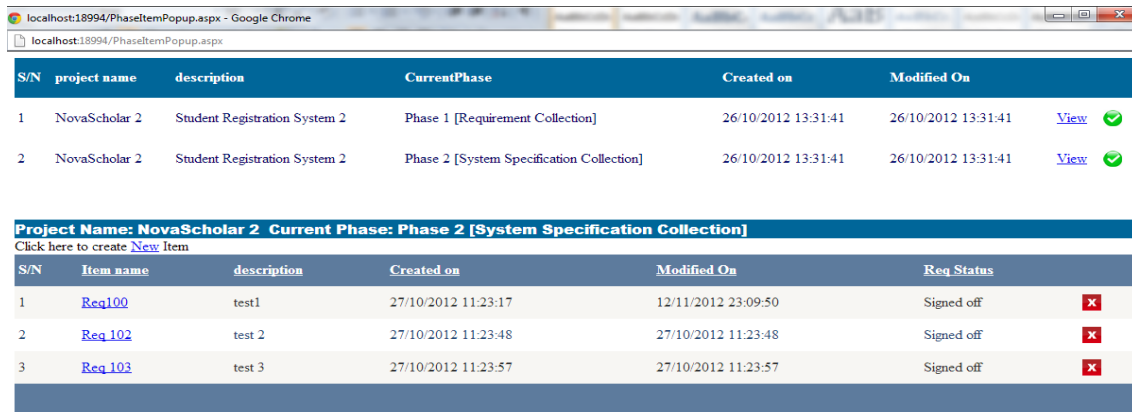


Figure 108. Phase Detail and Phase Item Views

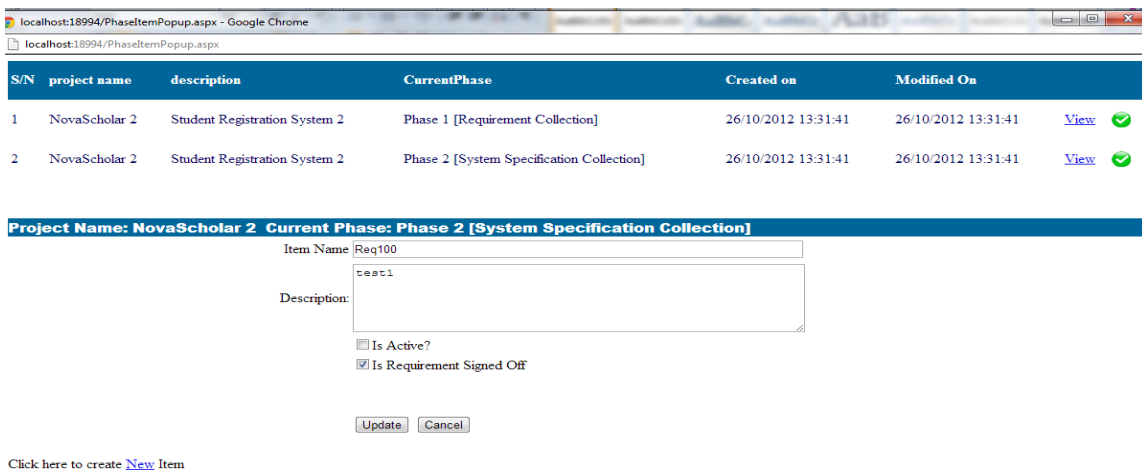


Figure 109. Update Phase Item View



## Appendix J: Functional tests

### Register a new user

The figures in this section illustrate functional tests discussed in section 5.3.1.

```
public UserSoapClient(System.ServiceModel.Channels.Binding binding, System.ServiceModel.EndpointAddress remoteAddress) :
    base(binding, remoteAddress) {
}

public bool RegisterUser(string firstname, string lastname,
    string username, string password, string email, bool isVisible,
    bool isActive, string internalorgid, bool superuser) {
    return base.Channel.RegisterUser(firstname, lastname, username,
        password, email, isVisible, isActive, internalorgid, superuser);
}
```

Figure 110. Listing excerpt for the User proxy

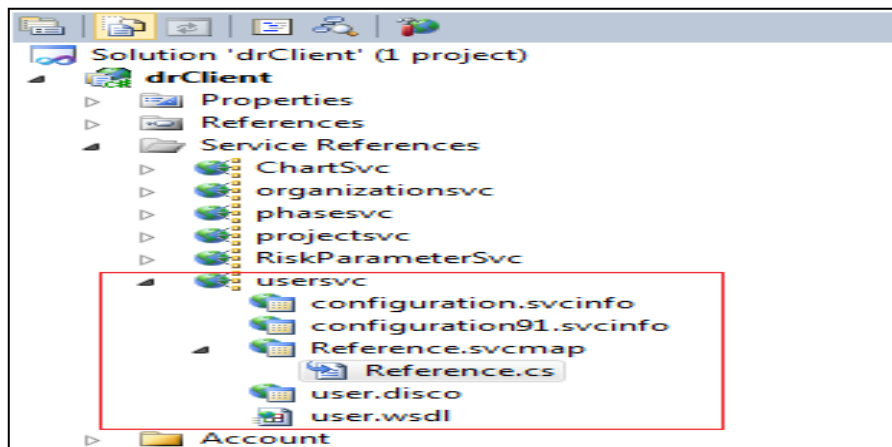


Figure 111. User service reference, proxy and wsdl file with endpoints

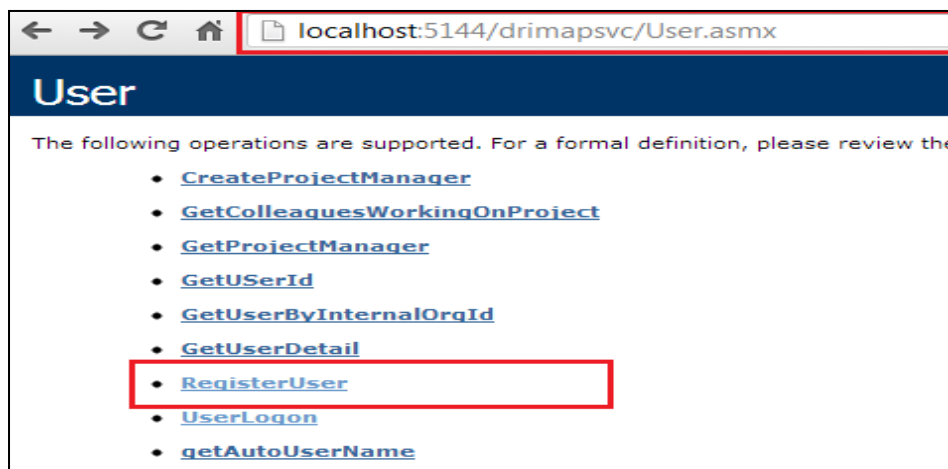


Figure 112. User service and EndPointAddress

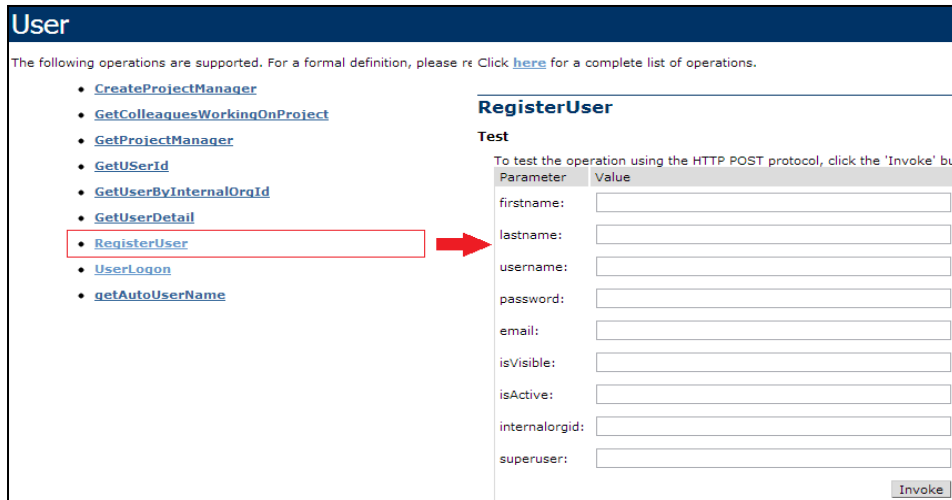


Figure 113. User service reference, proxy and wsd file with endpoints

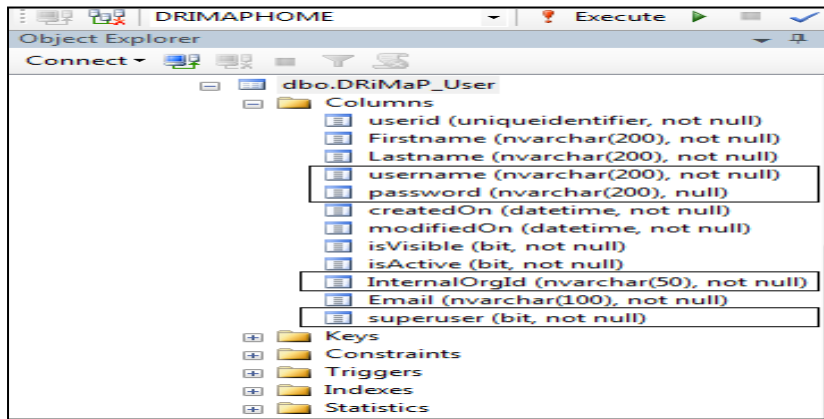


Figure 114. User service reference, proxy and wsd file with endpoints

	userid	Firstname	Lastname	username	password	crea...	modi...	isVisible	isActive	InternalOrgId	Email
1	DE7586C0-D27E-41...	ayo	Keh	Elizabeth	1223qw	201...	201...	1	1	4716d5a9-9ae8-4f1d-9545-88b3a2894f37	kentyken@
2	BD99C6CF-4698-4B...	Abiola	Kehinde	Elizabeth2	1223qw1	201...	201...	1	1	1d091d6b-b690-42dd-b876-1386e91e0844	kentyken@
3	B0063A9C-53BD-45...	Adam	RAM	1c2948d5c670	8234fd9	201...	201...	1	1	1d091d6b-b690-42dd-b876-1386e91e0844	kentyken@
4	3753CD0C-F218-4D...	Ayo	Alem	64008290ec96	3242bc7d	201...	201...	1	1	1d091d6b-b690-42dd-b876-1386e91e0844	kentyken@
5	130305E7-B4D7-4C...	Abiola	Kehinde	fb3c325cb9ff	fcf63405	201...	201...	1	1	1d091d6b-b690-42dd-b876-1386e91e0844	abiolakehni
6	6A8E50BF-FD96-4A...	Adam	Alem	e220b79d6762	0f0a3852	201...	201...	1	1	1d091d6b-b690-42dd-b876-1386e91e0844	kentyken@
7	C030C84D-36C2-47...	Manager	ITUser	Ptester	tester1	201...	201...	1	1	ee2a8fd6-e79b-4be7-995d-6f0de32c28a8	kentyken@

Figure 115. DRiMaP User schema for storing user information

## Add a new organisation

Figures in this section illustrate functional tests discussed in section 5.3.2.

```

public organizationSoapClient(string endpointConfigurationName, System.ServiceModel.EndpointAddress remoteAddress) :
    base(endpointConfigurationName, remoteAddress) {
}

public organizationSoapClient(System.ServiceModel.Channels.Binding binding, System.ServiceModel.EndpointAddress remoteAddress) :
    base(binding, remoteAddress) {
}

public void createOrganization(string organizationname, string organizationdescription, bool isVisible, bool isActive, string internalorgid) {
    base.Channel.createOrganization(organizationname, organizationdescription, isVisible, isActive, internalorgid);
}

public void updateOrganization(string organizationid, string organizationname, string organizationdescription, bool isActive, string internalorgid) {
    base.Channel.updateOrganization(organizationid, organizationname, organizationdescription, isActive, internalorgid);
}

public System.Data.DataSet RetrieveOrganization(string internalorgid) {
    return base.Channel.RetrieveOrganization(internalorgid);
}

public string RetrieveOrganizationId(string internalorgid) {
    return base.Channel.RetrieveOrganizationId(internalorgid);
}

```

Figure 116. Registering new organisation (organisation proxy)

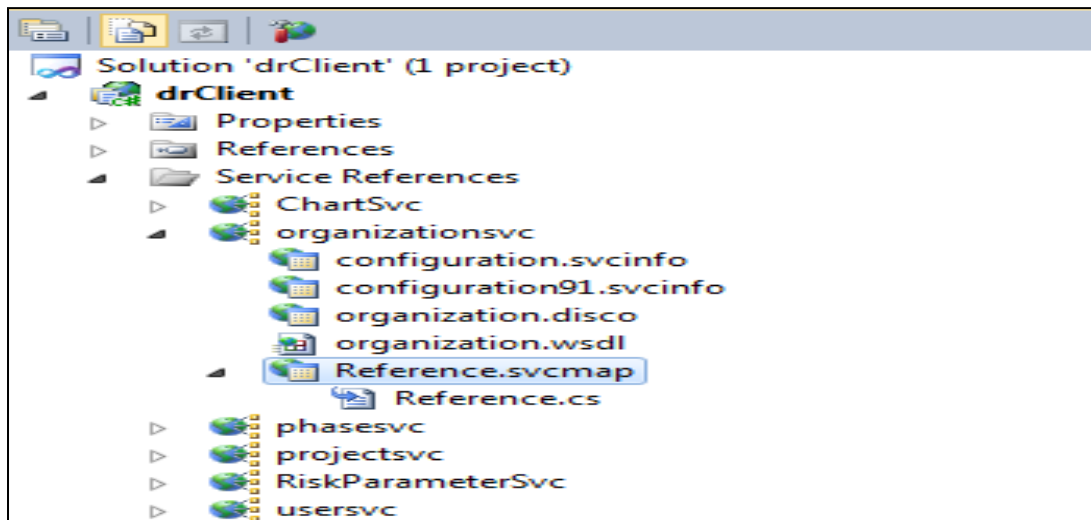


Figure 117. Organisation reference, proxy and wsdl file with endpoints

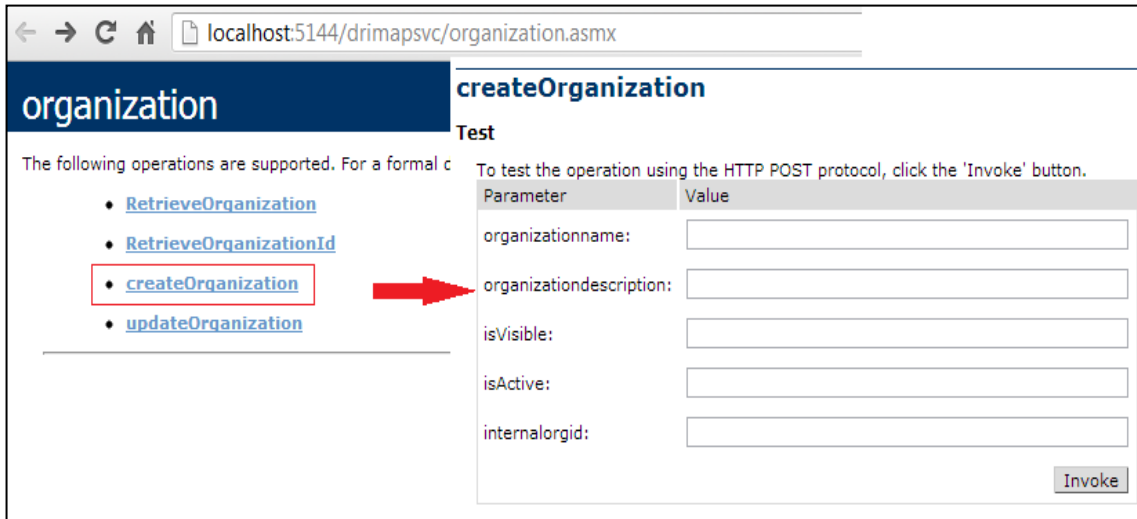


Figure 118. Organisation service

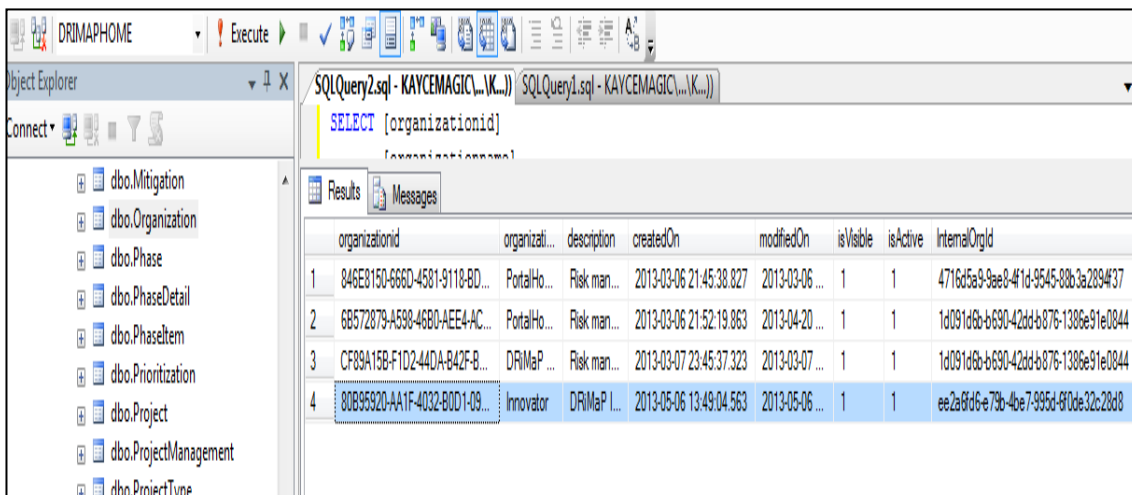


Figure 119. Organisation schema for storing organisation information

## Create a project interface

Figures in this section illustrate functionality discussed in section 5.3.3.

```

public ProjectSvcSoapClient(string endpointConfigurationName, string remoteAddress) :
    base(endpointConfigurationName, remoteAddress) {
}

public ProjectSvcSoapClient(string endpointConfigurationName, System.ServiceModel.EndpointAddress remoteAddress) :
    base(endpointConfigurationName, remoteAddress) {
}

public ProjectSvcSoapClient(System.ServiceModel.Channels.Binding binding, System.ServiceModel.EndpointAddress remoteAddress) :
    base(binding, remoteAddress) {
}

public System.Data.DataSet ProjctcTypeInfoInformation() {
    return base.Channel.ProjctcTypeInfoInformation();
}

public System.Data.DataSet ProjectUpdateInformation(System.Guid projectid, string projectname,
    string projecttype_fk, string description, System.DateTime modifiedOn, bool isActive,
    System.DateTime completionDate, bool isSignedOff) {
    return base.Channel.ProjectUpdateInformation(projectid, projectname, projecttype_fk, description, modifiedOn, isActive, completionDate, isSignedOff);
}

public string CreateProjectInformation(string projectname, string description, System.DateTime createdOn,
    System.DateTime modifiedOn, bool isActive, string organizationid_fk, string projecttype_fk,
    System.DateTime completionDate) {
    return base.Channel.CreateProjectInformation(projectname, description, createdOn,
        modifiedOn, isActive, organizationid_fk, projecttype_fk, completionDate);
}

```

Figure 120. Listing for the project proxy generated from project service

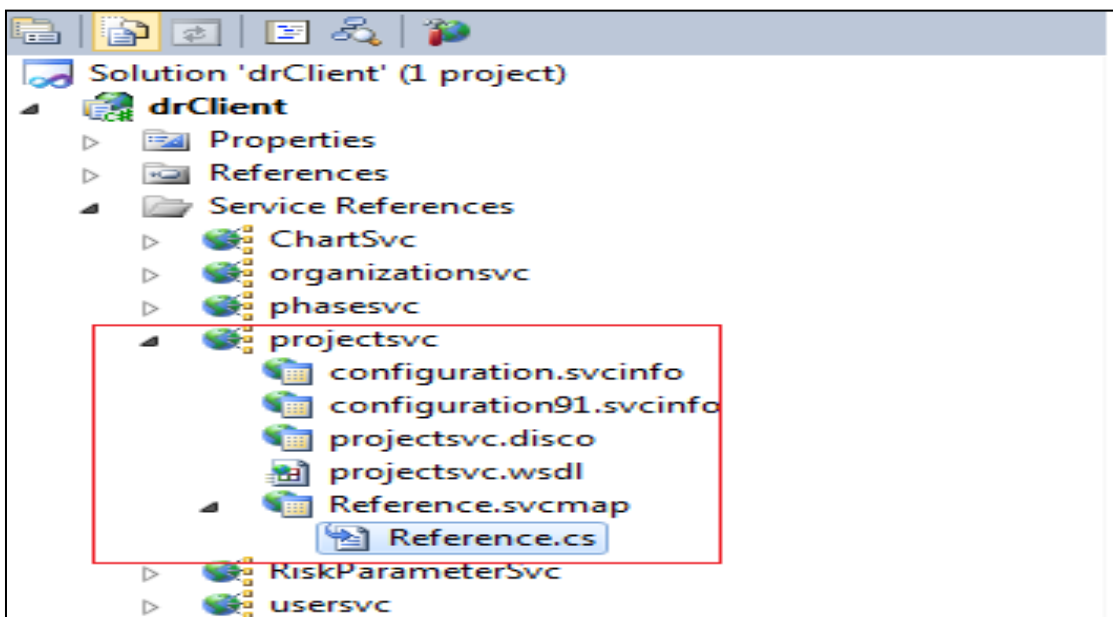


Figure 121. Project proxy files (Service reference in square box)

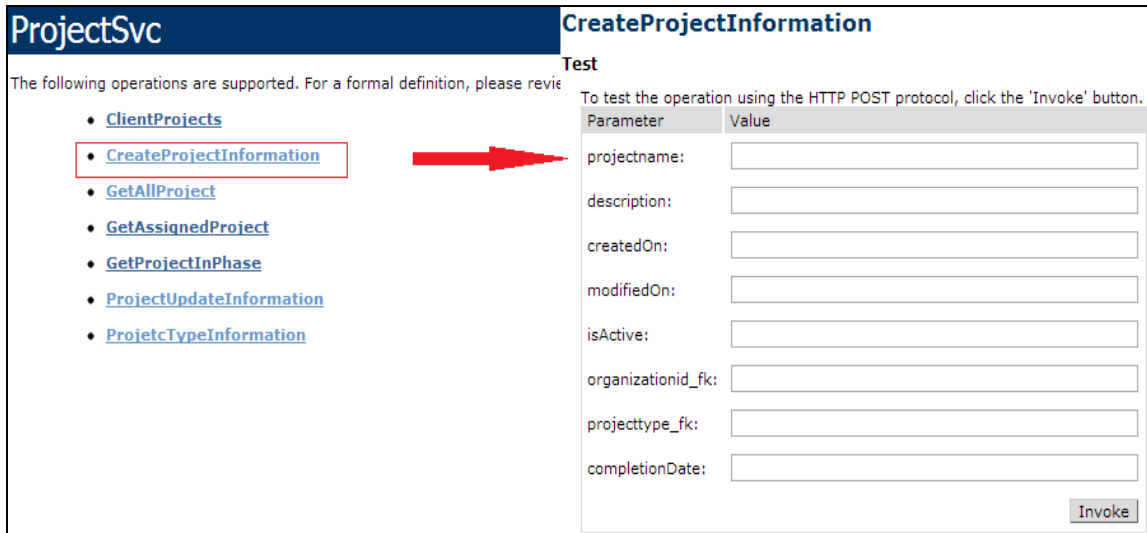


Figure 122. Project service interface

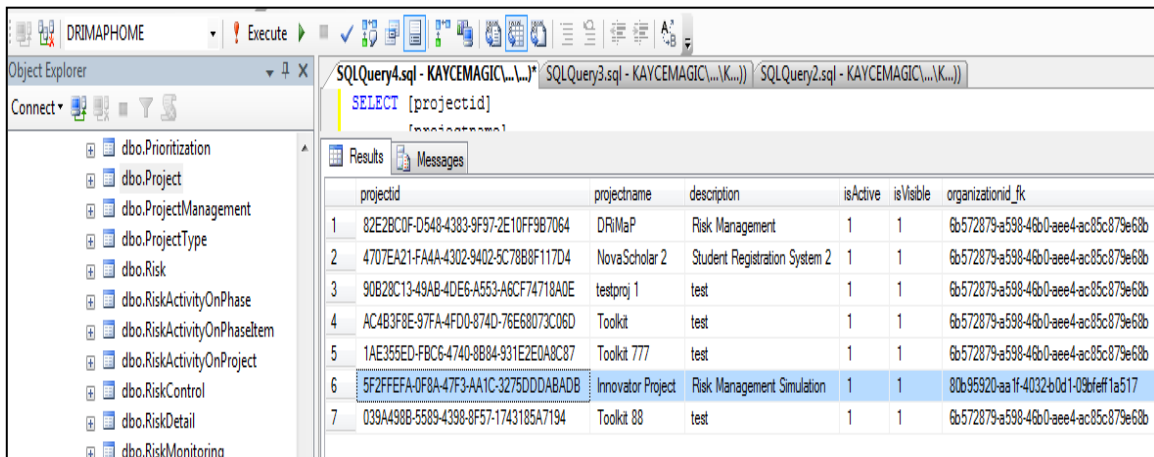


Figure 123. Project schema for storing project data

## Create a phase

Figures in this section illustrate functionality discussed in section 5.3.4.

```

public System.Data.DataSet UpdatePhaseInformation(System.Guid phaseid, string phasename, string description, System.DateTime modifiedOn, bool isActi
return base.Channel.UpdatePhaseInformation(phaseid, phasename, description, modifiedOn, isActive, organizationid_fk);
}

public System.Data.DataSet GetAllPhases(string organizationid_fk) {
return base.Channel.GetAllPhases(organizationid_fk);
}

public void CreatePhaseDetail(System.DateTime modifiedOn, System.DateTime createdOn, bool isActive, string projectid_fk, string phaseid_fk) {
base.Channel.CreatePhaseDetail(modifiedOn, createdOn, isActive, projectid_fk, phaseid_fk);
}

public string CreatePhaseItem(string phaseitemname, string description, System.DateTime modifiedOn, System.DateTime createdOn,
bool isActive, bool signed_off, string phasedetailid_fk, int actioncode, string InternalOrgId, string projectid, string userid) {
return base.Channel.CreatePhaseItem(phaseitemname, description, modifiedOn, createdOn, isActive, signed_off, phasedetailid_fk,
actioncode, InternalOrgId, projectid, userid);
}

public System.Data.DataSet GetPhaseItemInfo(string phasedetailid) {
return base.Channel.GetPhaseItemInfo(phasedetailid);
}

```

Figure 124. Excerpt Phase Proxy for creating Phase for Project

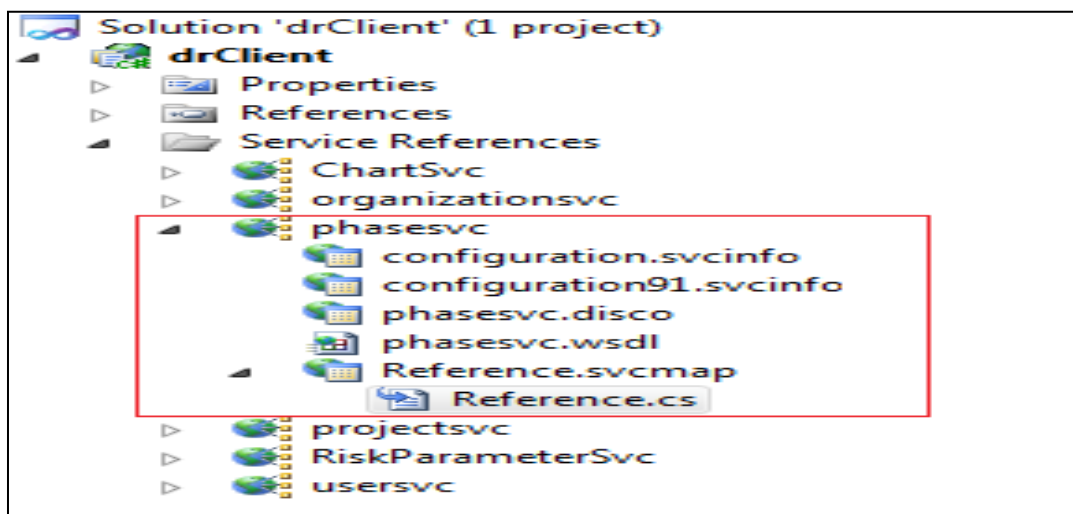


Figure 125. Phase Service reference files

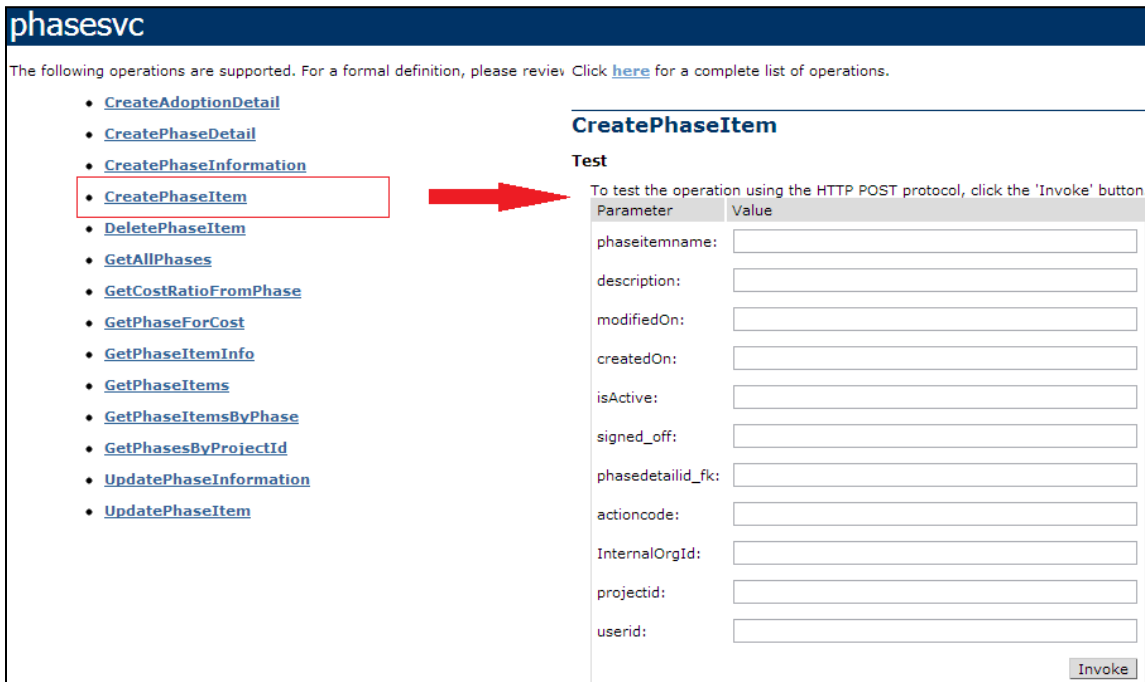


Figure 126. Phase Service Interface for creating a phase

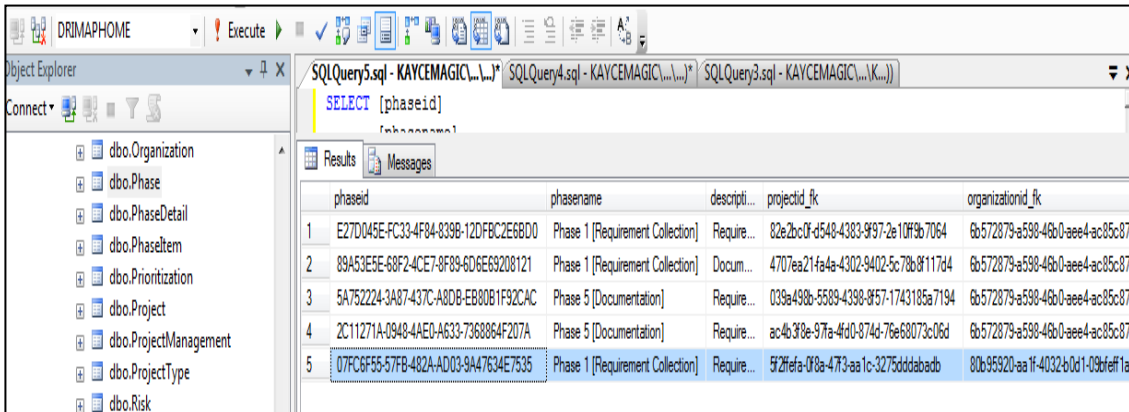


Figure 127. Phase Schema for storing phase information



## Assign a user

Figures in this section illustrate functionality discussed in section 5.3.5.

Organization | **Project** | Phase | Reporting

### PROJECT DETAIL

Deadline in Hours: **234 Days 0 Hours** [Click to Refresh](#)

Name:

Description:

Is Active?  
 Signed Off?

projecttypecode:

Project Cost: £

Deadline:

Indicate the percentage cost to be used for phase, phase items

specify ratio:

[Click here to create Newproject](#)

[Assign new user](#) Phase status: **Not In Phase**

S/N	Name	Created on	Status
1	<a href="#">James Morgan</a>	06/05/2013 16:49:53	True

**Assign**

Existing User  New User

Firstname:

Lastname:

Email:

Is Active?

Organization | **Project** | Phase | Reporting

### PROJECT DETAIL

Deadline in Hours: **234 Days 0 Hours** [Click to Refresh](#)

Name:

Description:

Is Active?  
 Signed Off?

projecttypecode:

Project Cost: £

Deadline:

Indicate the percentage cost to be used for phase, phase items

specify ratio:

[Click here to create Newproject](#)

[Assign new user](#) Phase status: **Not In Phase**

S/N	Name	Created on	Status
1	<a href="#">James Morgan</a>	06/05/2013 16:49:53	True
2	<a href="#">Ayomide Kehinde</a>	06/05/2013 16:51:45	True

**Assign**

Existing User  New User

Figure 128. Assign User to Work on the project steps

```

public string[] getAutoUserName() {
    return base.Channel.getAutoUserName();
}

public System.Data.DataSet CreateProjectManager(string Firstname, string Lastname, string userid_fk, string projectid_fk, bool isActive) {
    return base.Channel.CreateProjectManager(Firstname, Lastname, userid_fk, projectid_fk, isActive);
}

public string GetUserId(string InternalOrgId, string password, string username) {
    return base.Channel.GetUserId(InternalOrgId, password, username);
}

public System.Data.DataSet GetProjectManager(string projectid_fk) {
    return base.Channel.GetProjectManager(projectid_fk);
}

```

Figure 129. Listing for User Proxy (CreateProjectManager)

## User

The following operations are supported. For a formal definition, please review the

- CreateProjectManager
- [GetColleaguesWorkingOnProject](#)
- [GetProjectManager](#)
- [GetUserId](#)
- [GetUserByInternalOrgId](#)
- [GetUserDetail](#)
- [RegisterUser](#)
- [UserLogon](#)
- [getAutoUserName](#)

## CreateProjectManager

**Test**

To test the operation using the HTTP POST protocol, click the 'Invoke' button.

Parameter	Value
Firstname:	<input type="text"/>
Lastname:	<input type="text"/>
userid_fk:	<input type="text"/>
projectid_fk:	<input type="text"/>
isActive:	<input type="text"/>

Figure 130. User Proxy (CreateProjectManager)

## Move project into phase

Figures in this section illustrate functionality discussed in section 5.3.6.

The screenshot shows a web application interface for project management. The main section is titled 'PROJECT DETAIL'. It contains several input fields: 'Name' (Innovator Project), 'Description' (Risk Management Simulation), 'Deadline' (30/12/2013 12:00:00), and 'Project Cost'. A dropdown menu for 'Phase' is currently set to '-- Project --' and is highlighted with a red border. To the right, there is a table of 'Assigned user(s)' with columns for S/N, Name, Created on, and Status. Below the table is an 'Assign' section with radio buttons for 'Existing User' and 'New User'. At the bottom, there are 'Move to>>' and 'Cancel' buttons.

Figure 131. Move functionality

```

public System.Data.DataSet UpdatePhaseInformation(System.Guid phaseid, string phasename, string description, System.DateTime modifiedOn, bool i
    return base.Channel.UpdatePhaseInformation(phaseid, phasename, description, modifiedOn, isActive, organizationid_fk);
}

public System.Data.DataSet GetAllPhases(string organizationid_fk) {
    return base.Channel.GetAllPhases(organizationid_fk);
}

public void CreatePhaseDetail(System.DateTime modifiedOn, System.DateTime createdOn, bool isActive, string projectid_fk, string phaseid_fk) {
    base.Channel.CreatePhaseDetail(modifiedOn, createdOn, isActive, projectid_fk, phaseid_fk);
}

public string CreatePhaseItem(string phaseitemname, string description, System.DateTime modifiedOn, System.DateTime createdOn,
    bool isActive, bool signed_off, string phasedetailid_fk, int actioncode, string InternalOrgId, string projectid, string userid) {
    return base.Channel.CreatePhaseItem(phaseitemname, description, modifiedOn, createdOn, isActive, signed_off, phasedetailid_fk,
        actioncode, InternalOrgId, projectid, userid);
}

public System.Data.DataSet GetPhaseItemInfo(string phasedetailid) {
    return base.Channel.GetPhaseItemInfo(phasedetailid);
}
    
```

Figure 132. Listing to move project into phase in service reference

S/N	project name	description	CurrentPhase	Created on	Modified On	
1	Innovator Project	Risk Management Simulation	Phase 1 [Requirement Collection]	06/05/2013 14:53:06	06/05/2013 14:53:06	<a href="#">View</a>

**Project Name: Current Phase:**  
 Click here to create [NewItem](#)

Figure 133. View current phase of the Project and other project information

## Create a phase item

Figures in this section illustrate functionality discussed in section 5.3.7.

```

public System.Data.DataSet GetAllPhases(string organizationid_fk) {
    return base.Channel.GetAllPhases(organizationid_fk);
}

public void CreatePhaseDetail(System.DateTime modifiedOn, System.DateTime createdOn, bool isActive, string projectid_fk, string phaseid_fk) {
    base.Channel.CreatePhaseDetail(modifiedOn, createdOn, isActive, projectid_fk, phaseid_fk);
}

public string CreatePhaseItem(string phaseitemname, string description, System.DateTime modifiedOn, System.DateTime createdOn,
    bool isActive, bool signed_off, string phasedetailid_fk, int actioncode, string InternalOrgId, string projectid, string userid) {
    return base.Channel.CreatePhaseItem(phaseitemname, description, modifiedOn, createdOn, isActive, signed_off, phasedetailid_fk,
        actioncode, InternalOrgId, projectid, userid);
}

public System.Data.DataSet GetPhaseItemInfo(string phasedetailid) {
    return base.Channel.GetPhaseItemInfo(phasedetailid);
}

public System.Data.DataSet UpdatePhaseItem(System.Guid phaseitemid, string phaseitemname, string description, System.DateTime modifiedOn, bool
    return base.Channel.UpdatePhaseItem(phaseitemid, phaseitemname, description, modifiedOn, isActive, signed_off, phasedetailid_fk, actioncod
}
    
```

Figure 134. Listing to move project into phase in the service reference

S/N	project name	description	CurrentPhase	Created on	Modified On	
1	Innovator Project	Risk Management Simulation	Phase 1 [Requirement Collection]	06/05/2013 14:53:06	06/05/2013 14:53:06	<a href="#">View</a>
<b>Project Name: Innovator Project Current Phase: Phase 1 [Requirement Collection]</b>						
Click here to create <a href="#">NewItem</a>						
S/N	Item name	description	Created on	Modified On	Req Status	
1	<a href="#">Req 100</a>	Req 100	06/05/2013 17:45:05	06/05/2013 17:45:05	Not Signed off	
2	<a href="#">Requirement 1</a>	Requirement 1	08/05/2013 22:24:21	08/05/2013 22:24:21	Not Signed off	

Figure 135. PhaseItem of the Requirement Phase

```

#region Assessment
Mitigation.RiskIdentification _identification = new Mitigation.RiskIdentification();
_identification.identificationid = Guid.NewGuid();
_identification.description = description;
_identification.createdOn = DateTime.Now;
_identification.assessmentid_fk = assessmentid.ToString();
Guid identificationid = _transobj.CreateIdentification(_identification);

Mitigation.RiskAnalysis _analysis = new Mitigation.RiskAnalysis();
_analysis.analysisid = Guid.NewGuid();
_analysis.description = description;
_analysis.createdOn = DateTime.Now;
_analysis.assessmentid_fk = assessmentid.ToString();
Guid analysisid = _transobj.CreateAnalysis(_analysis);

Mitigation.RiskPrioritization _priortization = new Mitigation.RiskPrioritization();
_priortization.prioritizedid = Guid.NewGuid();
_priortization.description = description + " " + riskcode.ToString();
_priortization.prioritisecode = riskcode;
_priortization.assessmentid_fk = assessmentid.ToString();
_priortization.createdOn = DateTime.Now;
Guid prioritizedid = _transobj.CreatePrioritization(_priortization);

Mitigation.AssessmentOutput _assoutput = new Mitigation.AssessmentOutput();
_assoutput.assessmentoutputid = Guid.NewGuid();
_assoutput.identificationid_fk = identificationid.ToString();
_assoutput.analysisid_fk = analysisid.ToString();
_assoutput.prioritizedid_fk = prioritizedid.ToString();
_assoutput.createdOn = DateTime.Now;
Guid assessmentoutputid = _transobj.CreateAssessmentOutput(_assoutput);
#endregion

```

Figure 136. Listing of mitigation and call activity risk assessment output

```

Mitigation.Assessment _assessment = new Mitigation.Assessment();
_assessment.assessmentid = Guid.NewGuid();
_assessment.description = description;
_assessment.createdOn = DateTime.Now;
assessment.mitigationid_fk = mitigationid.ToString();
Guid assessmentid = _transobj.CreateAssessment(_assessment);

Assessment
#region Control
Mitigation.RiskControl _control = new Mitigation.RiskControl();
_control.controlid = Guid.NewGuid();
_control.createdOn = DateTime.Now;
_control.description = "Possible project deadline extension;Modification may require additional resource: Cost and Time;";
control.mitigationid fk = mitigationid.ToString();
Guid controlid = _transobj.CreateControl(_control);

#endregion

DRiMaPAlert.DRiMaPAlertMessage _alertmsg = new DRiMaPAlert.DRiMaPAlertMessage();
DRiMaPAlert _alartobj = new DRiMaPAlert();
_alartobj.alertid = Guid.NewGuid();
_alartobj.sentOn = DateTime.Now;
_alartobj.createdOn = DateTime.Now;
_alartobj.recipientid = InternalOrgId;
DataSet msgDs = getAlertMessage(assessmentoutputid.ToString());

int sentstatus = 0;

```

Figure 137. Listing of mitigation and call activity risk control output

```
protected void MitigationProcess(PhaseItem Obj, int actioncode, string InternalOrgId, string projectid, string userid)
{
    string message = string.Empty;
    DataSet phaseDs = new DataSet();
    string mainstr = "<b>Email has been sent in respect to the Mitigation Process output:</b><br/>";
    string description = "";
    int riskcode = 0;
    string riskdescr = string.Empty;
    string confirmUrl = string.Empty;
    Mitigation _mitigation = new Mitigation();
    _mitigation.mitigationid = Guid.NewGuid();

    switch (actioncode)
    {
        case 0: riskdescr = "Create Request for unsigned off item"; break;
        case 1: riskdescr = "Update request on signed-off "; break;
        case 2: riskdescr = "Delete request on signed-off "; break;
        case 3: riskdescr = "Update Request on Project deadline"; break;
        default: break;
    }

    _mitigation.description = riskdescr + Obj.phaseitemname + " is the identified RISK";
    _mitigation.createdOn = DateTime.Now;
    _mitigation.phaseitemid_fk = Obj.phasedetailid_fk;

    Guid mitigationid = _transobj.CreateMitigation(_mitigation);

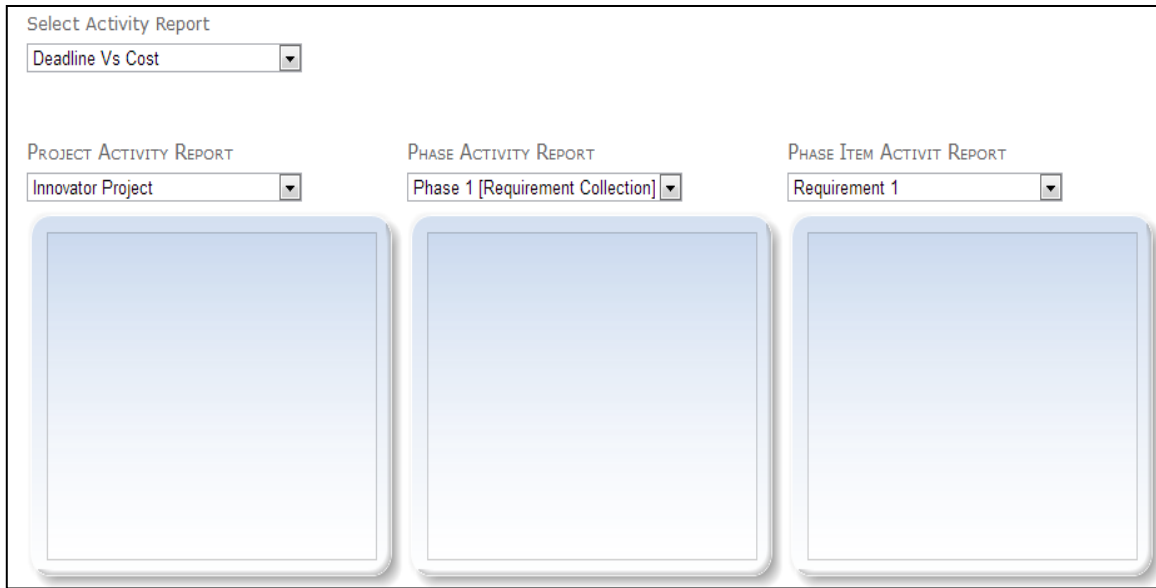
    switch (actioncode)
```

Figure 138. Listing of alert and risk activity input

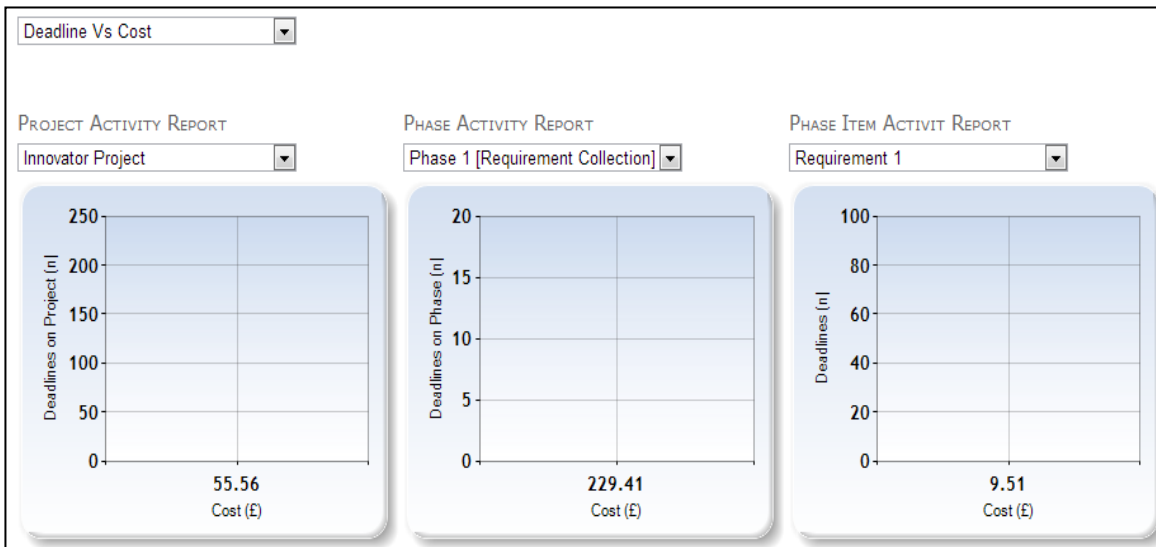
**Functional observations**

This section describes observations of the charting functionality discussed in section 5.3.8.

**Before the Task gets executed**, the graph is blank because no activities exist for the project “Innovator Project” and its corresponding Phase (Phase 1 [requirement collection]) and phase item (Requirement 1) respectively.



*Figure 139. Activity report for observation 1*



*Figure 140. Activity report for observation 2*

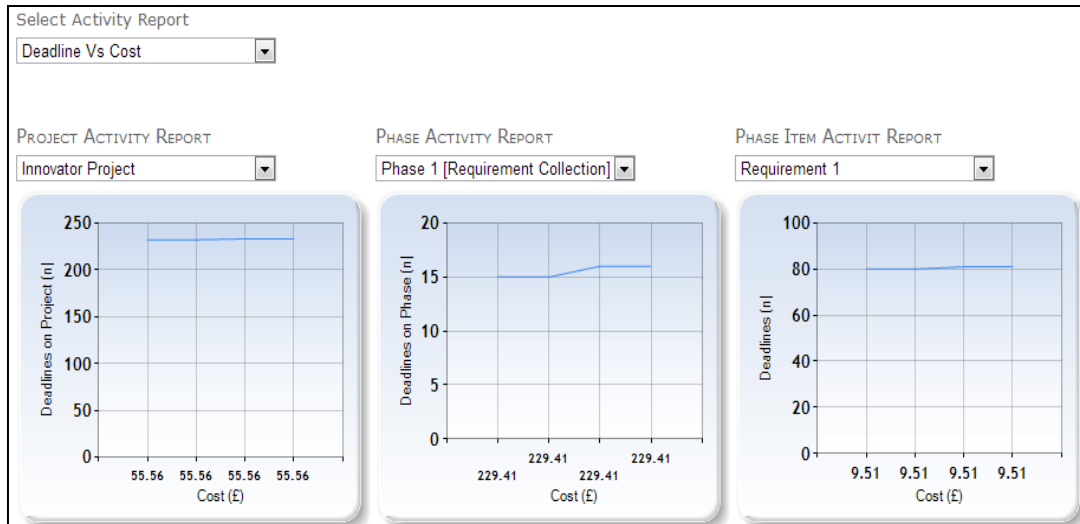


Figure 141. Activity report for observation 3

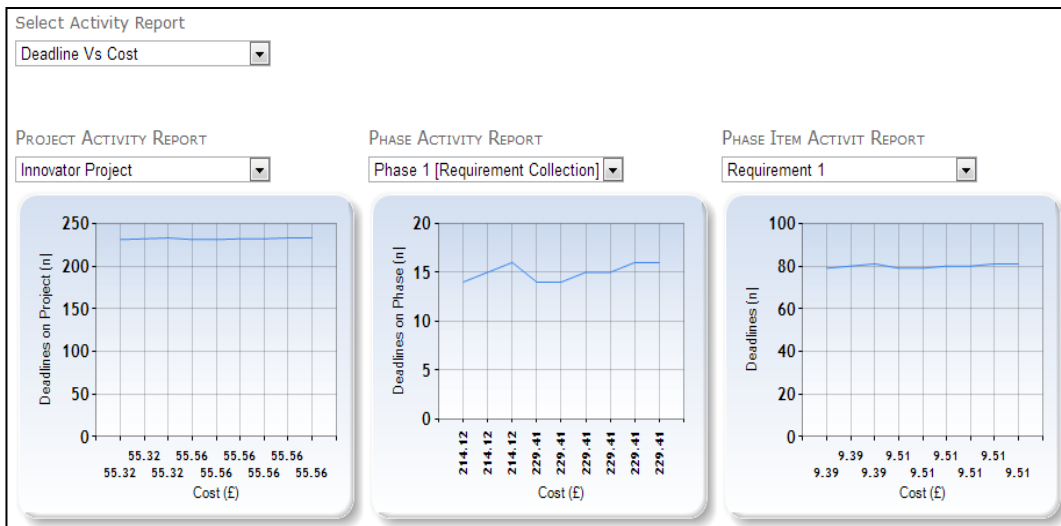


Figure 142. Activity report for observation 4

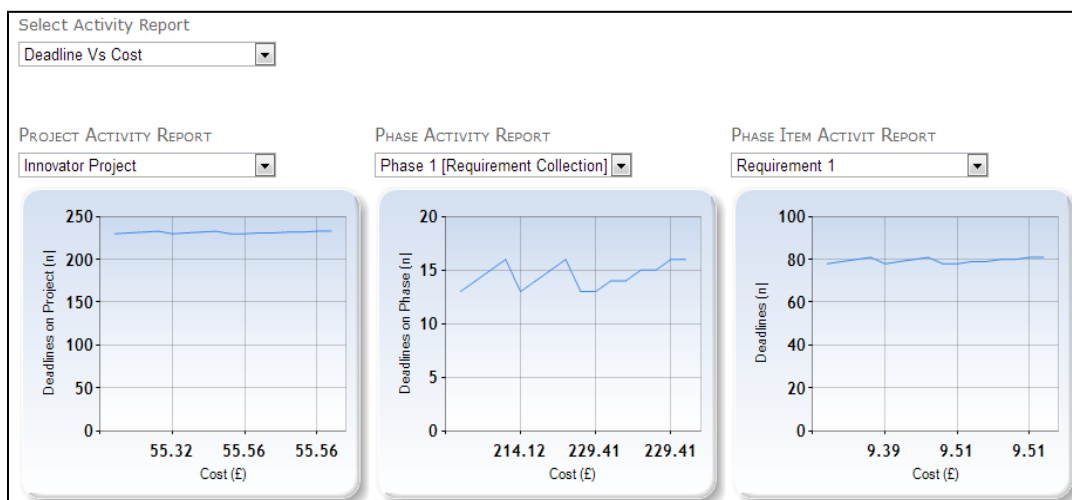


Figure 143. Activity report for observation 5



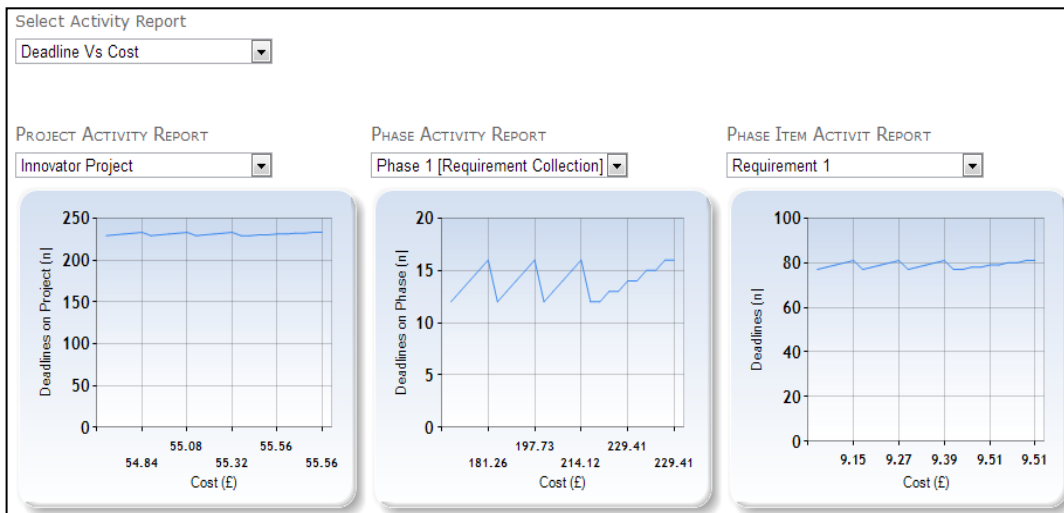


Figure 144. Activity report for observation 6

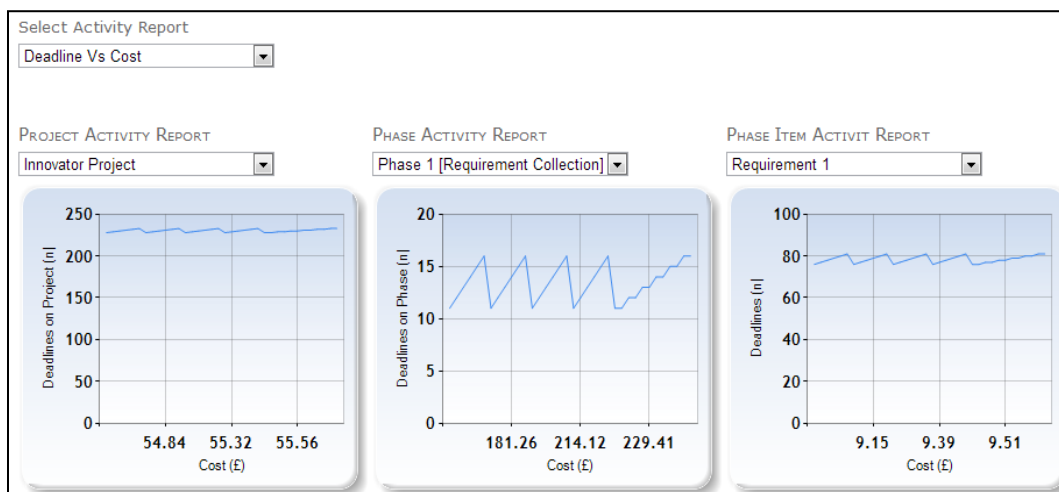


Figure 145. Activity report for observation 7

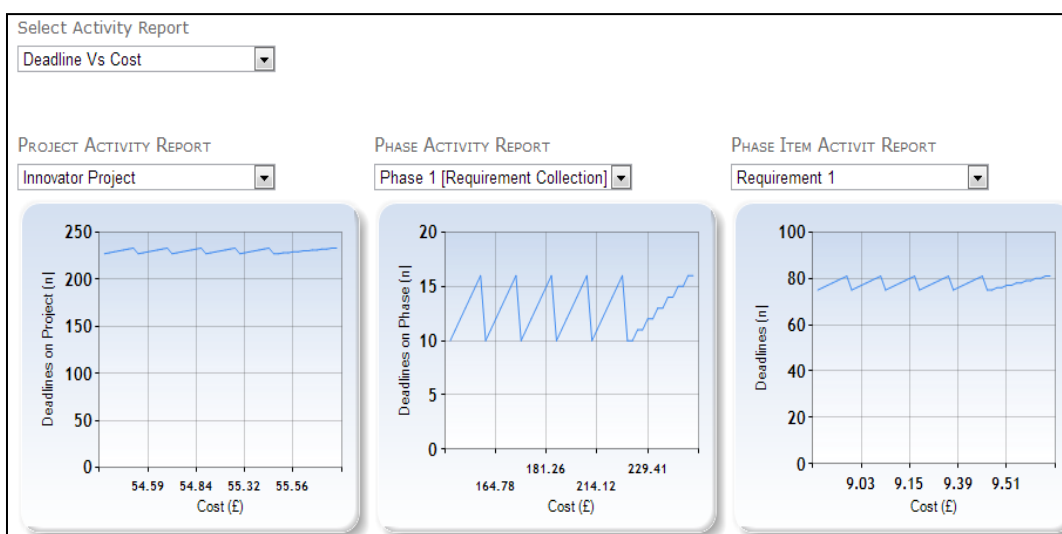


Figure 146. Activity report for observation 8

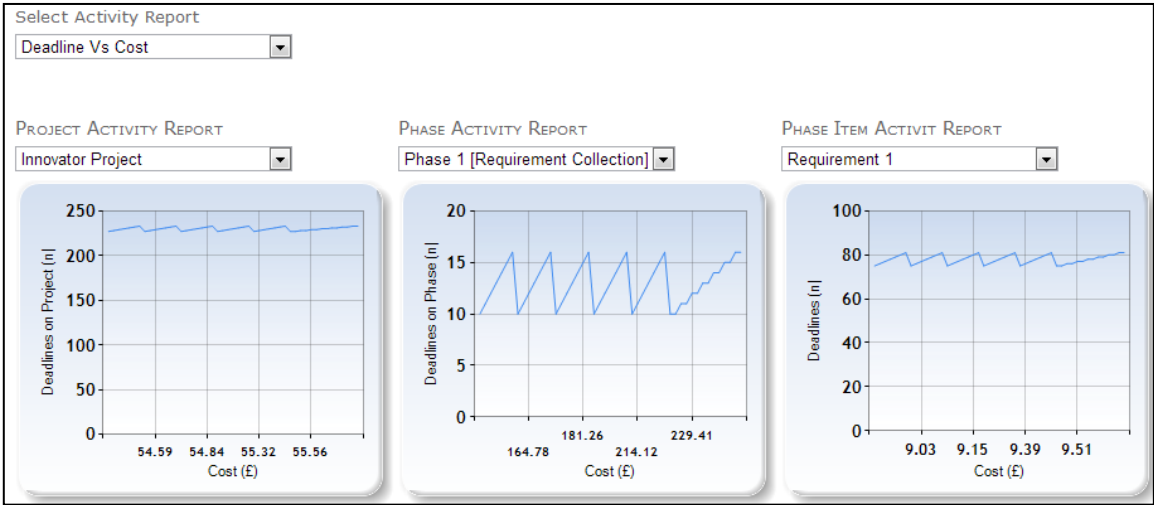


Figure 147. Activity report for observation 9

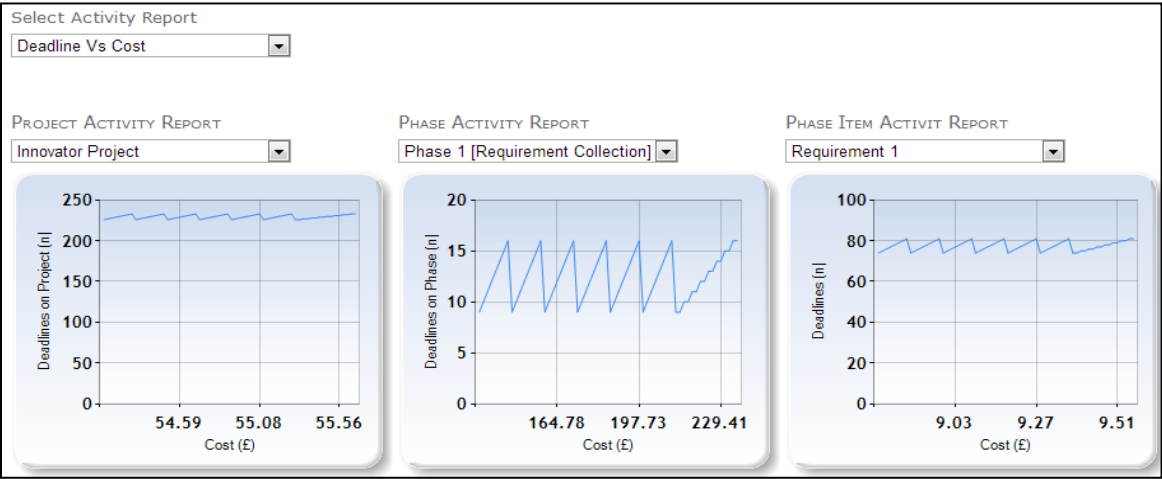


Figure 148. Activity report for observation 10