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**Uncertainties in the servitization era:
managing risk in contract for
availability**

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ABSTRACT

Nowadays we are living in world surrounded by uncertainties. Business needs to develop practices to manage risks that rise from a rapidly changing context. To minimize the impact of unexpected events, management approaches need to change and be constantly adapted to the context in which they are used.

Unfortunately, methods and practices are not developed as quickly as the business environment is changing. An example is the current lack of a proper methodology that concretely helps companies, especially OEMs, in handling issues brought by servitization and longer relationships.

The purpose of this thesis is to have a fully understanding of current changes of business environment under the servitization era, to then structure a new approach to guide companies in handling what they are currently not used to consider.

The starting point was a detailed literature review about servitization, contracts for availability, risks and uncertainties to understand what companies are currently facing and how they handle the issues. Afterwards, a new methodology was structured to propose something new that could concretely help and support companies when dealing with CfA.

This thesis represents therefore a breakthrough compared to past approaches and methods. For the first time this specific context has been studied with the purpose of having a wider perspective to develop something to help companies in their risk management processes. A conceptual methodology was developed to help OEMs in facing new uncertainties brought by the servitization together with a framework to select the most suitable mitigation strategy.

The thesis fills the current gap and contributes with useful additions to the standard way of considering this topic. It has the attempt to redesign and reorient business thinking from being passive to proactively react, anticipating risks, uncertainties and their consequences. It suggests a risk management approach whose features enable users in considering risks and uncertainties due to longer relationships and to changes in role and responsibilities. Then, the tool defines an approach with new features to measure, monitor and then mitigate risks.

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LIST OF ABBREVIATIONS

B2B	Business to Business
B2C	Business to Consumer
CBA	Cost Benefit Analysis
CDRM	Company Dynamic Response Map
CfA	Contract for Availability
CfC	Contracting for Capability
CLS	Contractor Logistic Support
MOD	Ministry of Defence
OBC	Outcome Based contract
OEM	Original Equipment Manufacturer
PBC	Performance-Based Contract
PBH	Power by the Hour
PBL	Performance-Based Logistics
PSI	Prime Systems integrator
PSS	Product-Service System
R&U	Risks and Uncertainties
RM	Risk Management
T&MC	Time and material contracts

EXECUTIVE SUMMARY

Nowadays we are living in world surrounded by risks and uncertainties. A world where changes take place off-hand. Businesses need to continuously adapt and develop new attitudes and practices to manage all these new risks that surround any projects.

Servitization is the new reality where companies need to set their business, changing the way they currently operate, finding the right approach to be competitive on the market although the change.

Failure, in fact, comes from companies' inability in handling the external context and from inadequate implementation of risk management. To minimize the impact of unexpected events, the approaches need to change, need to be constantly adapted to the context in which they are used. That means they need to be accurate, feasible and concretely explain what should be included during the go-live of the approach, what the framework itself should embed, what should not, clarify tasks and responsibilities and the way it should be accomplished. Indeed, risk management is a procedure that, if correctly developed and applied, enables companies to optimize their decision making process, helping them in dealing with unexpected events.

Unfortunately, methods and practices are not developed as quickly as the business environment is changing. That means that currently there is a lack of a proper methodology that concretely helps companies, especially those ones involved in equipment provision, in handling issues brought by servitization and longer relationships.

Understanding companies' new real needs is therefore the key point to go further in this field and fill the gap represented by the absence of something that supports users in solving the situation: understand what new need to be taken into account first, and then have the proper approach to face it.

The purpose of this thesis is to have a fully understanding of current changes of business environment, to then structure a new methodology, a risk-based approach to guide companies in handling what they are currently not used to considered.

The work done is not limited in just giving a theoretical approach. With real cases found in the literature together with industrial interactions, it has been possible to have a practical point of view of these issues.

The advent of servitization comes together with the spread of contract for availability (CfA) or performance-based contract (PBC). Their nature is, in fact, intrinsically linked with the features of servitization. These kinds of contracts are different from traditional ones.

With the aspects they consider, they succeed in protecting companies from new uncertainties of longer and closer relationships between supplier and customers, allowing therefore to better manage all the issues that rise from a new business scenario.

Companies are totally surrounded by this new scenario and need to be proactive in the way they are doing their business as well as in the way they are protecting themselves with risk management practices without being caught unprepared by events they are not used to face. Role and responsibilities between partners change with the context. A new way of sharing risks charges suppliers with totally new tasks. Therefore, the thesis tries to develop a methodology to give them a risk-based approach structured to be implemented in a different scenario compared to the past ones. In this way something specifically created for handling typical uncertainties is given for the very first time to the company as a support.

The starting point was a detailed and accurate literature review about the topic. That means deeply analyse different authors and papers to get as much information as possible to be able in structuring a complete database about servitization and its characteristic. That implied not only a full understanding of this trend, but also understand all the issues that were linked with it to group together all what was mentioned so far in the literature. Once the work was completed, the logic that lies behind the development was absolutely clear: with the advent of the servitization, companies find themselves in operating in a context totally remodelled. They need to provide services rather than finished goods and things become even more complex when dealing with equipment. Providing spare parts or maintenance service is not enough anymore to fulfil their own responsibilities. Roles and responsibilities changed with the context. Being service providers implies establishing longer-term relationship with customers, creating complete new setting in which operate.

New risks and uncertainties are therefore already at the door, ready to gum up companies' everyday business. Companies need therefore to find new ways to protect themselves.

That brings the thesis in analysing other topics to get a 360 degree view.

Contracts for availability, or something in its stead were analysed together with risks and uncertainties definitions. They were studied not only to get their meaning but, most of all, to understand the logic the links together all these topics and why it was fundamental to go ahead with the work. In this way, it has been possible to draw up some conclusions, and then used them as a starting point. Once finding out that the setting has changed, bringing with it new uncertainties, companies need to proactively protect themselves.

That is why the state-of-the-art needed to be analysed to get its implications for business, to study and understand what practices are currently used by companies to implement risk management and to identify the gap. That is the reason why this thesis went further in the topic. Once the current state of the art was deeply analysed, it has been tried to structure a new methodology that embraced all those new aspects that have been believed as fundamental to face the new context. This methodology can be considered as the result of a complex study of the situation, that summarize what needs to be taken into account when becoming service provider in terms of risks, uncertainties and procedures to handle them.

It still remains something mainly conceptual, but at the same time it shades some light on the matter, representing something that never existed before. The next step is making it an operative tool, which can be concretely implemented within organizations' risk management processes.

Although this part is not an area of interest for this thesis, with its content, this paper gives an optimum starting point to go further in this direction, creating the basis on which the development could take place.

Indeed, this conceptual methodology comes together with the development of the first prototype of a tool structured to help companies in choosing the most suitable mitigation strategy to put each risk under control. It represents something new thanks to the criteria under which strategies are evaluated. Criteria do not just consider impact, likelihood and implementation costs, but also how a strategy can increase the confidence of events' occurrence. This aspect is actually something new and important to the context of which it has been spoken so far. Reducing the uncertainty of events and of their consequences can seriously change the final output of project.

This thesis represents therefore a breakthrough compared to past approaches and methods. For the first time, this specific context was studied with the purpose of having a wider prospective to be able to concretely develop something to help companies in their risk management processes. Not only giving a step by step procedure but making a step back and identifying why current practices are neither enough nor suitable anymore. Understanding the change and what kind of issues it brought with it, allows going deeper in the development of something new, able to fill the current gap. With its findings, the thesis contributes with useful additions to the standard way of considering this topic. First, with a new methodology to handle the servitization trend and its implication and then, with a tool to support companies in properly put each risk under control.

That has been possible also thanks to the possibility of spending few months abroad and work together with a real company.

To be more detailed, the initial part of this thesis was carried out at the Cranfield university with the support of researchers and the staff of the company. That allowed to create a consistent starting point from which developing a more detailed study about this topic.

During the last four months of this experience in UK, the literature survey was developed together with the case study. That work mainly focused on managing risks in the contract for availability, providing a useful tool to manage each risk. Afterwards, these contents were deeper developed and studied under new points of view to reach a fully understanding of the whole context, starting with a detailed analysis of the roots, to then understand the consequences for OEMs.

ITALIAN EXECUTIVE SUMMARY

Introduzione

Negli ultimi decenni il mondo manifatturiero è stato interessato da un profondo cambiamento. Numerose aziende sono state protagoniste del passaggio dall'essere semplici realizzatrici di prodotti finiti all'essere fornitrici di servizi. Il business è quindi cambiato radicalmente, introducendo modalità totalmente nuove nell'interfacciarsi con altri attori della catena produttiva, con la consapevolezza del ruolo fondamentale giocato da parti terze nel creare valore.

Si parla di "movimento verso un'economia basata sui servizi" (Guajardo, Cohen, Kim, & Netessine, 2011), dove le aziende riconoscono l'importanza sempre maggiore del poter offrire servizi insieme al prodotto finito.

Questo fenomeno, conosciuto come "*servitization*" o "*product-service system*", è un approccio strategico utilizzato dalle aziende per aggiungere valore al proprio business e allacciando relazioni più forti e durature con i propri clienti.

La nuova realtà è la seguente: le aziende non sono più realtà singole, ma necessitano di essere ben integrate con gli attori che prendono parte alla loro supply chain, sia in veste di fornitori sia in veste di clienti.

Partendo da un'ampia diffusione nel mercato B2C, questo shift ha preso poi piede nel mondo B2B andando a coinvolgere numerose aziende produttrici e fornitrici di apparecchiature e macchine industriali. Il cambiamento è stato radicale. Il settore dei beni capitali, di per sé già intrinsecamente complesso, ha visto aumentare la laboriosità nel gestire e tener sotto controllo le proprie performance. Numerose aziende operanti nei più svariati settori, dalla difesa al business di elettrodomestici, sono state protagoniste della cosiddetta trasformazione. Esse non sono rimaste spettatrice del cambiamento mantenendo inalterato il proprio business ma hanno guardato al di là del proprio mero operato, muovendosi a valle della supply chain per beneficiare dei vantaggi derivanti dall'essere fornitrici di servizi. Vantaggi che diventano particolarmente allettanti quando si parla, appunto, di industrie i cui prodotti sono particolarmente complessi e la cui mancata disponibilità e affidabilità può essere problematica e perturbante. Si tratta di casi in cui la realizzazione stessa del bene è complessa e critica ed ha un impatto enorme sul risultato finale nonché sulle performance, non solo dell'azienda produttrice ma anche del cliente finale.

La letteratura stessa presenta numerosi casi reali che illustrano come diverse aziende abbiano seguito il percorso suggerito dal trend della *servitization* e si siano trasformate in aziende di servizi, ponendo particolare enfasi sui benefici derivanti dal nuovo approccio. Nello specifico, nel corpo dell'elaborato saranno brevemente esposti tre esempi di tale trasformazione: Rolls Royce, BAE Systems e General Electric.

Considerando lo scenario in cui le aziende si trovano ora a competere, è necessario sviluppare una metodologia che consenta loro di gestire e controllare rischi e incertezze che derivano dalle nuove condizioni di contorno.

Un approccio basato sul rischio, strutturato in maniera tale da considerare la novità del contesto, è ciò che potenzialmente serve loro per mantenere il controllo su ciò che non erano solite fronteggiare in termini di problematiche e risk management.

Come già è stato accennato, la situazione è ben più complessa del passato. Questo implica la necessità di gestire incertezze e rischi in maniera totalmente nuova, partendo dal fatto che essi stessi non sono più i medesimi del passato. Le aziende devono gestire l'imprevedibilità degli eventi e delle loro conseguenze in un contesto in cui un ruolo importante e di notevole influenza è giocato da terze parti, con cui sono instaurate relazioni notevolmente più lunghe e, di conseguenza, dai contratti che con esse vengono redatti.

L'esperienza e lo stato dell'arte hanno rivelato che attualmente i cosiddetti *risk management processes* non permettono una gestione sistematica di rischi ed incertezze. Seppur il tema sia stato ampiamente trattato da autori differenti, i risultati non sembrano andare nel dettaglio e non offrono alle aziende strumenti specifici con cui andare a gestire ciò che deriva dalla *servitization*. La constatazione di questo fatto è un chiaro segnale di un vuoto nelle attuali modalità di gestione del rischio. Esse sono, infatti, inadatte a gestire le problematiche che un'azienda, che muove i primi passi nell'essere *service provider*, si trova a fronteggiare. Si tratta di metodologie sviluppate nel passato e perciò strutturate per gestire un determinato tipo di incertezza, senza ovviamente prendere in considerazione quello che è andato ad affermarsi come nuova realtà di business e cioè la *servitization* e tutto ciò che a essa è collegata.

Scopo, obiettivi e struttura del lavoro

Questa tesi tenta perciò di colmare questa mancanza analizzando il contesto come punto di partenza e proponendo una nuova metodologia, strutturata in maniera tale da avere un focus specifico su *Original Equipment Manufacturer (OEMs)* e *servitization*. In questo modo sarà possibile avere un quadro completo e accurato sullo stato dell'arte che fornisca il punto di partenza per proporre un approccio nuovo, basato su un'analisi completa della situazione corrente per evidenziare lacune correnti ed esigenze latenti.

L'elaborato si pone quindi l'obiettivo di proporre una metodologia completa e dettagliata che supporti gli *OEMs* in un contesto nuovo. Si tratta di proporre un approccio risk-based che vada ad inserirsi nei processi di gestione del rischio delle aziende, portando però una prospettiva più ampia che coinvolga fin dall'inizio eventuali parti terze.

Con un'analisi dettagliata e completa dello stato dell'arte, è possibile capire ciò che attualmente è presente sul mercato e ciò che invece non lo è, e rappresenta una nuova necessità. Ciò permette di individuare e studiare nuovi fattori di rischio e incertezza insieme alle pratiche che potenzialmente potrebbero essere messe in atto per gestirle. Le considerazioni tratte dall'analisi permettono a loro volta di strutturare una metodologia che abbracci la novità e che supporti concretamente le aziende che si muovono in quella che è stata definita *service-based economy*.

Questa tesi analizza nel dettaglio tre tematiche principali:

- L'avvento della *servitization*, sia in termini di caratteristiche intrinseche del trend sia come implicazioni economiche;
- I contratti, *contract for availability* e *performance-based contracts* nello specifico;
- Rischi, incertezze e opportunità, sia come definizione dei termini sia come processi per la loro gestione in un contesto di business.

Per quanto riguarda la *servitization*, essa è stata inizialmente analizzata a un livello di dettaglio piuttosto alto in modo tale da avere un'idea chiara, seppur generale, del significato del termine e delle sue implicazioni sul contesto economico e quindi sulle aziende. Successivamente si è entrati nello specifico in modo tale da circoscrivere l'analisi e farla vertere verso lo scopo ultimo. Di conseguenza è stato analizzato il ruolo degli *OEMs* in questo contesto nuovo e le implicazioni dell'offrire servizi piuttosto che prodotti finiti. Ciò che è palesemente emerso è stato il ruolo fondamentale occupato dalla forma contrattuale utilizzata per tutelarsi nel rapporto con i propri clienti. Offrire servizi significa legarsi in maniera molto più interdependente con altri attori della supply chain e di conseguenza diventa necessario conoscere il cambiamento che tali legami comportano, in termini di nuovi rischi e nuove incertezze che diventa necessario gestire.

Entrano in gioco quindi i “Contract for Availability (CfA) ” e i “Performance-Based Contracts (PBC)”, come forme contrattuali necessarie per gestire il nuovo contesto e le relazioni durature che si vengono a instaurare. In queste forme contrattuali la performance e il risultato finale diventano il fulcro.

Per questo, allineare gli obiettivi tra fornitore e cliente diventa fondamentale, insieme ad una corretta e consapevole gestione del rischio. Questa tipologia di contratto mitiga il problema, riuscendo a fornire a entrambe le parti che entrano in gioco un compromesso accettabile nell’allocare sia i rischi sia i benefici. Ciò che questa forma contrattuale tende a fare è un’allocazione dei rischi tale per cui ciascuno di essi sia gestito dalla parte che ha le risorse migliori per metterlo sotto controllo. Stessa cosa per i benefici.

Essa deve essere tale per cui vi sia un tornaconto legato all’esposizione al rischio sostenuta da ciascuna parte.

Per far ciò è ovviamente necessaria una profonda conoscenza del concetto di rischio e incertezza. Questo è il motivo per il quale, l’analisi va poi nel dettaglio in quest’ambito. Rischi e incertezze sono inizialmente analizzati in maniera generale per avere una definizione univoca ed anche una comprensione su come essi siano attualmente gestiti dalle imprese, successivamente vi è uno zoom che porta l’analisi verso il ruolo di rischi ed incertezze all’interno dei contratti.

Questo getta appunto le basi per sviluppare una metodologia, seppur teorica, che comprenda la novità. La tesi propone quindi una metodologia concettuale a supporto degli *OEMs* nel gestire rischi e incertezze quando utilizzano contratti incentrati sulla disponibilità del servizio da loro offerto. Ciò che viene proposto nella tesi è una discussione completa e dettagliata di ciò che è necessario. Attualmente la tesi si limita a proporre un approccio teorico accompagnato da un prototipo per la selezione della strategia più adatta alla mitigazione di un particolare rischio.

Quanto detto finora, oltre ad evidenziare la logica secondo la quale la tesi è stata strutturata, permette anche di anticipare in che modo essa dia il proprio contributo alla letteratura. È inoltre opportuno menzionare il fatto che i risultati a cui si è giunti sono il frutto di un lavoro iniziato presso la Cranfield university in UK, dove è stato possibile interagire con un’azienda operante nell’ambito della difesa e soprattutto gettare le basi per sviluppare un lavoro corposo e dettagliato sul tema grazie all’aiuto ed i supporto esperti del tema.

Per avere una solida base su cui sviluppare il caso studio, in sede estera è stata portata avanti un’analisi su rischi, incertezze e processi di gestione. Il lavoro è stato poi profondamente ampliato una volta rientrata in Italia. Il concetto di *servitization* è stato indagato nel dettaglio insieme a tutte le implicazioni ad esso legate, in modo tale da ritrovare le cause principali del cambiamento per poi andare a studiare le conseguenze di ciò su aziende di capital equipment e quindi contribuire con un lo sviluppo di un nuovo approccio.

I contributi apportati tramite il lavoro svolto possono essere sintetizzati in tre punti principali:

- Un'analisi dettagliata e completa dello stato dell'arte relativo al ruolo della *servitization*, dei contratti e del rischio e incertezza;
- Una metodologia concettuale per la gestione dei rischi e dell'incertezza nel contesto di *service-base economy*;
- Un prototipo per la selezione di strategie mitigative.

Essi saranno ora illustrati in maniera più dettagliata per permettere al lettore di avere un'introduzione auto-consistente che delucida brevemente i contenuti dell'elaborato complessivo.

Analisi della letteratura

La Servitization

Come anticipato, l'analisi è iniziata con uno studio dettagliato del concetto di *servitization*. Si è quindi cercata una definizione del termine in quanto concetto sempre più utilizzato e studiato. Figura 1 è, infatti, testimone di come sia cresciuta l'importanza e l'interesse nei confronti del tema.

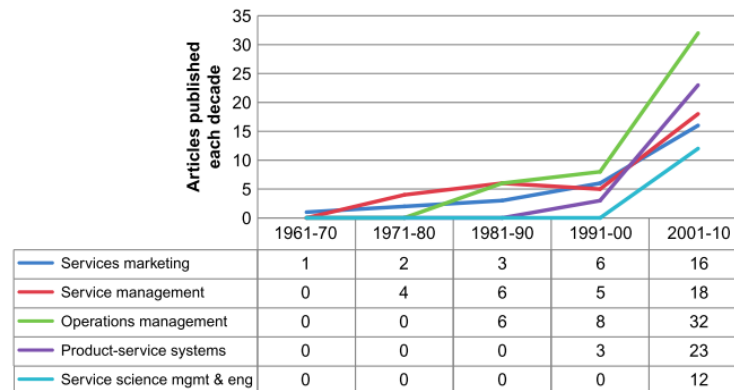


Figura 1 Evoluzione dell'attività di ricerca

La *servitization* è stata definita come *“the increased offering of fuller market packages or ‘bundles’ of customer focussed combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings”* (Vandermerwe & Rada, 1988) e va quindi a identificare la tendenza sempre maggiore nell'offrire “pacchetti”, una combinazione di prodotti finiti, servizi, supporto, conoscenza in modo da aggiungere valore alla propria offerta di mercato. Negli ultimi decenni lo scenario è profondamente cambiato. Le aziende sono passate dall'offrire prodotti finiti, all'accompagnare i propri beni con dei servizi associati, approdando infine all'offrire una combinazione di prodotto, servizio, supporto e conoscenza per raggiungere un livello di customer satisfaction più elevato e mantenersi competitivi sul mercato. Ovviamente questo è accaduto in maniera graduale e con profondi cambiamenti sia a livello organizzativo-culturale, sia in termini operativi.

Le caratteristiche principali di questo trend possono essere riassunte in tre punti:

- 1) La capacità di offrire al cliente un “pacchetto prodotto-servizio”;
- 2) Avere un orientamento incentrato sul consumatore (*customer-centricity*);
- 3) La capacità di instaurare e mantenere relazioni durature sia con i fornitori, sia con i clienti.

Si tratta di un cambiamento molto impegnativo e sfidante per le imprese, ma che presenta anche una serie benefici potenziali che lo rendono un'alternativa allettante rispetto al mantenimento di un profilo di pura azienda manifatturiera.

Il beneficio che ne deriva può essere riassunto in un concetto trovato nella letteratura: “undertaking a service and customer-centric strategy enables companies in locking out competitors, locking in customers and increasing the level of differentiation.” (Neely, 2009). I profitti tendono a essere più elevate e le stesse entrate più stabili.

Dall'altra parte però l'organizzazione deve essere ristrutturata sia nel suo modo di operare sia dal punto di vista culturale. Si devono sviluppare quelle capacità che consentano la progettazione e lo sviluppo di servizi, che risulta essere ben diversa e ben più complessa della progettazione di prodotti finiti. Bisogna essere in grado di interfacciarsi in maniera del tutto nuova con i propri clienti, avendoli come “centro” del proprio operato. Questo implica la volontà di sviluppare e mantenere relazioni durature e avere quindi un focus particolare sulle proprie strategie comunicative. Particolare attenzione è stata data alle aziende produttrici di beni durevoli. Il focus è stato posto sulle strategie operative che possono aiutare a implementare una *service supply chain*. Tutto punta sulla capacità di ridurre l'incertezza e la complessità così come sapere sfruttare economie di scala e di scopo per beneficiare dei vantaggi dell'essere *service-provider*.

La tabella sottostante riporta quindi una classificazione delle principali sfide della *servitization* insieme alle potenziali strategie per poter sfruttarne i benefici. Nell'elaborato è possibile trovare maggiori dettagli riguardanti le sfide e allo stesso tempo trovare le modalità con cui rendere operative le strategie.

Tabella 1 Sfide della servitization e strategie per sfruttarne i benefici

The challenges of servitization	Strategies
<ul style="list-style-type: none"> - Shifting mind-sets - Timescale - Business model and customer offering 	<ul style="list-style-type: none"> - Limit uncertainty and complexity - Benefit from economies of scale and pooling - Deploy multi-purpose resources - Profit from knowledge about the installed base - Surpass functional barriers. Limit uncertainty and complexity

Il capitolo si conclude con un intero paragrafo dedicato a casi industriali, in cui le aziende sono state protagoniste di questa trasformazione. L'obiettivo principale mira a comprendere il modo in cui le aziende manifatturiere abbiano configurato le loro funzioni per offrire servizi avanzati.

L'analisi è poi proseguita con uno studio approfondito dei contratti, concentrandosi su caratteristiche e peculiarità dei *Contract for Availability*, utilizzati per gestire le relazioni instaurate tra *OEMs* e i loro clienti.

In questo modo è stato possibile individuare tutti i fattori di rischio e incertezza derivante dall'utilizzo di una forma contrattuale totalmente nuova e quindi andare a identificare le caratteristiche per strutturare una metodologia di gestione del rischio aggiornata.

Il cliente non può essere più semplicemente visto come mero ricevitore dei prodotti finiti, ma partecipa attivamente al raggiungimento di performance ottimali. Per questo motivo le relazioni devono essere tutelate a 360°, tenendo in considerazione tutte le caratteristiche che le differenziano da quelle del passato.

Il *Contract for Availability* è appunto una forma contrattuale dall'ampia veduta che permette la tutela di ambo le parti andando a investigare le peculiarità di relazioni più forti, più durature e basate su un sistema di incentivi totalmente slegato dagli approcci passati.

Nella letteratura è possibile trovare termini e definizioni che contraddistinguono questa tipologia di legame. *Contract for Availability (CfA)*, *Contractor Logistic Support (CLS)*, *Outcome Based contract*, *Performance Based Contracting (PBC)*, *Performance Based Logistic (PBL)*, *Contracting for Capability* rappresentano appunto numerose sfaccettature del medesimo concetto.

Queste diverse terminologie sono maggiormente approfondite nel corpo dell'elaborato. È importante però porre l'accento sul fatto che il punto focale di esse sta nel concetto di disponibilità e affidabilità del servizio offerto, implicitamente garantita dal fornitore stesso.

I clienti pongono tutta la loro attenzione sul "cosa" è effettivamente richiesto in termini di performance e risultato finale, piuttosto che il "come" un determinato bene o servizio sia deliverato nel rispetto delle specifiche richieste.

Lo scopo finale diventa quindi quello di sviluppare capacità tali da consentire la redazione di un contratto completo. Questo significa avere chiaro l'obiettivo stesso del contratto e allo stesso tempo aver identificato a priori quali sono i rischi e le incertezze che possono manifestarsi nel ciclo di vita di un rapporto di business. Il risultato deve essere quindi un contratto tale da permettere una relazione duratura tra le parti dove tutte le aree di interesse sono state investigate per l'identificazione dei rischi specifici. Di fatto si parla di un approccio proattivo nella gestione del rischio che porta ad individuare tutti i potenziali fattori di incertezza in anticipo in modo da poterli includere nella redazione stessa del contratto.

Grazie allo studio di ciò che fino ad ora è stato analizzato nella letteratura, è stato possibile identificare gli elementi chiave per instaurare una relazione duratura, appunto la base dei CfA:

- I goal e gli obiettivi devono essere chiari a entrambe le parti fin dall'inizio;
- Suddividere il progetto in più parti diventa utile per sviluppare una programmazione più dettagliata, per migliorare la stima dei costi e pianificare le risorse richieste;
- Sviluppare un team integrato ed eterogeneo in modo da assicurare la competenza delle risorse e, allo stesso tempo garantire la presenza di tutte le abilità necessarie;
- Accordi e documenti che certifichino scopo ed aspettative rappresentano il primo step necessario per instaurare una relazione efficace.

Inoltre si è cercato di analizzare e categorizzare i rischi in modo da poterli più facilmente identificare e successivamente gestire. In particolare sono state individuate tre macro aree che possono essere considerate come diverse prospettive sotto cui andare ad analizzare i contratti per l'identificazione dei rischi:

- Specifiche operative;
- Approcci tecnici;
- Strategia di business.

Entrambi questi passaggi hanno rappresentato uno starting point per il raggiungimento dello scopo ultimo dell'analisi dei contratti, cioè l'identificazione dei nuovi rischi e incertezze e per suggerire approcci adatti alla gestione degli stessi. Vista la tipica durata di questo tipo di contratto, che generalmente può anche raggiungere decine d'anni, lo spettro dei rischi da considerare è ben più ampio.

Ciò che è mostrato in Figura 2 permette di avere un'idea di ciò che deve essere considerato nell'analisi.

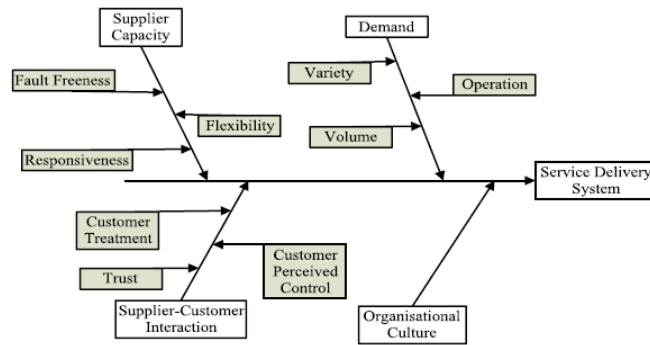


Figura 2 Come gestire un Service Delivery System (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010)

I contratti sono redatti in condizione di asimmetria informativa tra le parti. Razionalità limitata, potenziale comportamento opportunistico e specificità degli asset, che generalmente contraddistingue l'oggetto del contratto, aumentano esponenzialmente il numero di rischi e incertezze da gestire.

Da rilevare inoltre il fatto che l'offrire un servizio piuttosto che un prodotto finito trasferisce un numero non irrilevante di rischi dal cliente al fornitore, obbligandolo, di fatto, ad assumere un comportamento proattivo nel proprio processo di risk management.

Grazie allo studio effettuato, è stato possibile categorizzare sia i rischi sia le incertezze che sorgono con il cambiamento. I rischi sono stati suddivisi in due macro categorie: relational risks e performance risks.

Dall'altra parte, l'analisi delle incertezze può essere riassunta in Figura 3 riportata qui sotto.

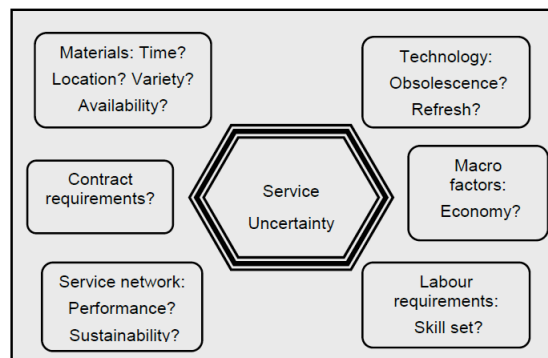


Figura 3 Tipologie di incertezza

Questa sessione permette quindi di identificare tutti i nuovi rischi e le nuove incertezze che devono essere considerate insieme a tutte le peculiarità a essi connesse e che gli *OEMs* si trovano ora a gestire tramite la redazione di queste forme contrattuali orientate al risultato e alla performance.

La tabella riportata qui sotto riassume appunto i cambiamenti legati all'avvento del trend della *servitization* e dell'utilizzo dei contratti e rappresenta le basi su cui strutturare una nuova metodologia di gestione.

Tabella 2 Cambiamenti principali

Main changes
<ul style="list-style-type: none">- Longer term contracts- Imperfect and asymmetrical distributed information between parties- Bounded rationality, opportunism and asset specificity- New roles and responsibilities for both parties (difference in sharing risks)- Confidence in the affordability of the offer (cost estimation of the project)- Time pressure- Many components to consider when set risk management procedures (demand, supplier capacity, supplier-customer interaction, organisational culture)- Alignment of goals of parties- Deeper consideration of both relationship and performance- Wider set of requirements (cost estimation, deadlines, quality and operational requirement)

Vista l'importanza acquistata dal concetto di rischio e di incertezza è stato portato avanti un approfondimento che indagasse sul significato dei termini e sui processi di risk management attualmente utilizzati dalle aziende.

Nella letteratura il tema è stato ampiamente trattato permettendo quindi di trovare diversi punti di vista riguardanti il medesimo concetto e avere quindi un general understanding.

L'approccio iniziale è stato quello di indagare sui termini legati a questi due concetti, arrivando a trarre le conclusioni riportate nella tabella sottostante.

Tabella 3 Termini legati al concetto di rischio e incertezza

Risk	Uncertainty
Loss and negative consequences	Possibilities
Uncertainty	Ambiguity
Event-triggered	Aleatory and epistemic
	Probability

L'analisi è poi proseguita indagando nello specifico il punto di vista di quattro autori principali, scelti perché ritenuti i più rilevanti e citati:

- Frank Knight;
- Douglas W. Hubbard;
- Michael Mauboussin;
- Tarje Aven.

I primi tre hanno dato avvio a una discussione avente l'obiettivo di identificare una definizione univoca che fosse adatta alle trattazioni successive.

È stato ritenuto fondamentale, infatti, identificare un'unica definizione per ciascun termine in modo da non creare ambiguità negli sviluppi successivi.

Limitando l'analisi a quanto trovato studiando i lavori di Knight, Hubbard e Mauboussin, l'approccio sarebbe però risultato incompleto.

Innanzitutto, le definizioni identificate e riportate qui per completezza, non mostrano alcun punto in comune una con l'altra e soprattutto riguardano un'accezione del termine che non permette di identificare i fattori chiave e rilevanti per il contesto di sviluppo della tesi

Tabella 4 Definizioni di rischio e incertezza - Knight, Hubbard & Mauboussin

	Frank Knight	Douglas W. Hubbard	Michael Mauboussin
Risk	Event subject to a known or knowable probability	A state of uncertainty where some of the possibilities involve a loss, injury, catastrophe, or other undesirable outcome (i.e., something bad could happen)	Unknown outcome. We know what the underlying outcome distribution looks like. Games of chance like roulette or blackjack are risky.
Uncertainty	Event for which it is not possible to specify numerical probabilities	The lack of complete certainty—that is, the existence of more than one possibility. The “true” outcome/state/result/value is not known.	Unknown outcome. We don’t know what the underlying distribution looks like. The outcome of a war is uncertain

Di conseguenza, l’analisi delle terminologie è stata estesa ai lavori di Aven. In questo modo è stato possibile ottenere un punto di vista che abbracciasse un’accezione più tecnica del termine, strettamente legata a specifiche e performance di sistemi complessi.

Nello specifico, Aven permette di guardare al rischio con una prospettiva diversa che tiene in considerazione tre aspetti fondamentali che fino ad allora non sono mai stati usati per indagarne il significato intrinseco.



Figura 4 La prospettiva di Aven

La prospettiva cambia completamente e va a considerare la “conoscenza” e l’“effetto sorpresa”. Essi sono, infatti, aspetti che influenzano la tipologia e la modalità con cui sono raccolte le informazioni durante il risk assessment, andando perciò a impattare sul processo decisionale.

Ciò cui si è giunti è riportato qui in breve: l’incertezza è vista come una proprietà del sistema mentre il rischio diventa il sistema di misurazione per definire l’entità dell’impatto dell’incertezza.

Per lo sviluppo di una metodologia coerente e applicabile, la tesi ha anche analizzato i processi che attualmente le aziende utilizzano per la gestione dei rischi. L’analisi può considerarsi costituita da due parti principali: la prima che verte direttamente sui processi di risk management, la seconda che concentra la propria attenzione sulle strategie di mitigazione degli impatti.

Con la prima si vanno a definire gli step principali del processo:

- 1- Plan risk management
- 2- Identify risks
- 3- Risk analysis
 - Quantitative risk analysis
 - Qualitative risk analysis
- 4- Plan risk responses
- 5- Monitor and control risks

Nella seconda invece sono analizzate nel dettaglio le tecniche che solitamente sono usate per controllare e mitigare l’impatto di eventuali minacce:

- Risk avoidance
- Risk reduction
- Risk transfer
- Risk acceptance

In questo capitolo, l’analisi cerca di abbracciare tutti i temi in qualche modo legati alla gestione dei rischi. Per questa ragione, ampio spazio è stato dedicato alla *Cost-Benefit Analysis (CBA)* poiché tecnica utilizzata per valutare quale strategia di mitigazione implementare, valutandone appunto rischi e benefici.

Altro tema ritenuto rilevante è la gestione delle opportunità. Esse sono quindi studiate mantenendo un approccio simile a quello seguito nell’analisi del rischio. È prima identificata una definizione e poi suggerito un approccio per aiutare le imprese nel coglierle.

La Tabella 5 e la Tabella 6 riportano rispettivamente la definizione scelta per identificare il concetto di opportunità ed il processo secondo il quale il contesto dovrebbe essere approcciato.

Tabella 5 Definizione di Opportunità

Risk	Opportunity
Any uncertainty that, if it occurs, would affect one or more objectives negatively	Any uncertainty that, if it occurs, would affect one or more objectives positively

Tabella 6 Processo di gestione delle opportunità

Risk response	Opportunity response
Avoid: alter the approach to the problem and bypass that path in the project network	Capture: align the work activities with the current path in the project network and incorporate the opportunity in the deliverables
Transfer: assign the risk to team that can mitigate the risk	Transfer: assign a team that can own the opportunity and incorporate it into the deliverables
Assume: the risk with no further action other than watch for a change	Ignore: the opportunity with no further action other than to watch for a change
Mitigate: the risk by executing the tasks needed to reduce its likelihood and any consequences form its outcome	Pursue: the opportunity by advancing the likelihood and consequences of it occurring

Avendo un contesto ben specifico su cui la tesi è stata sviluppata, anche per questo capitolo è stata strutturata una parte dedicata ai rischi e alle incertezze nel mondo specifico dei contratti, in particolare sulle strategie di mitigazione di essi.

Vengono qui riportate una serie di tabelle e figure che di fatto sintetizzano i principali findings sull'argomento.

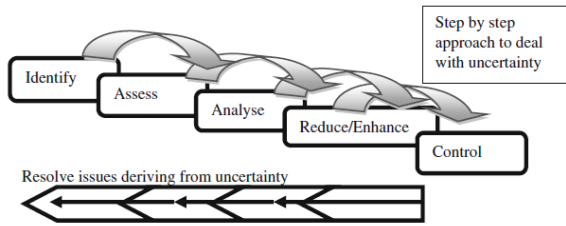


Figura 5 Processo di gestione e identificazione delle incertezze

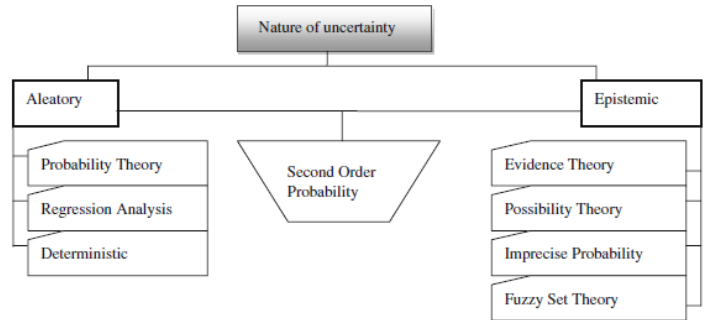


Figura 6 Approcci per la modellizzazione dell'incertezza

In seguito sono stati indagati i possibili metodi per gestirne l'impatto.

Tabella 7 Metodi per il risk assessment

Deterministic	Qualitative	Quantitative
Conservative benefit and cost estimating	Risk matrix	Probability distribution
Breakeven analysis	Risk registers coefficient of variation	Mean variance criterion
Risk-adjusted discount rate	SWOT analysis	Decision tree analysis
Sensitivity analysis	Brainstorming sessions	Simulation: Monte Carlo/Latin hypercube
Risk-adjusted discount rate	Influence diagram	Mathematical/analytical technique
Certainty equivalent technique		Artificial intelligence
Net present method		Fuzzy set theory
		Event trees

Il focus si è poi spostato su dei temi più specifici e di grande interesse per avere le basi corrette per lo sviluppo di una metodologia aggiornata, ma soprattutto completa: risk sharing e risk allocation.

Si tratta di temi fondamentali per costruire partnership solide e durature tra cliente e fornitore.

Il processo è brevemente descritto in Figura 7.

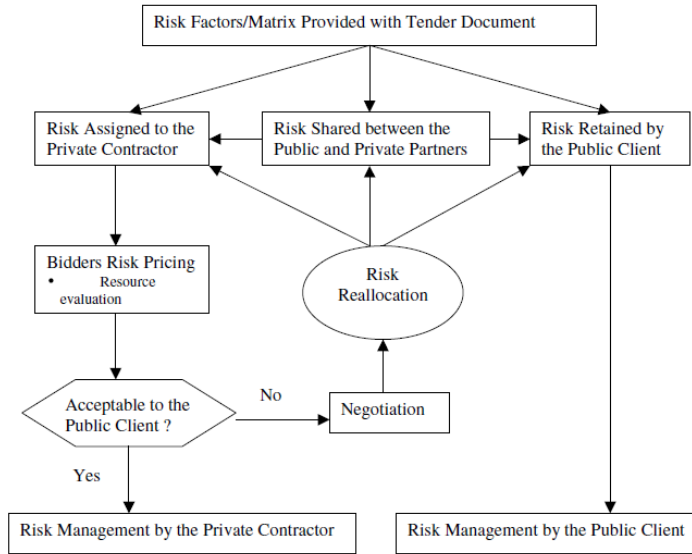


Figura 7 Risk sharing & Risk allocation

I processi di risk management si sono in realtà già mossi verso l'adattarsi al nuovo contesto portando alla strutturazione di metodi adatti alla gestione di contesti più complessi e particolarmente dinamici.

Due metodologie sono state quindi descritte nel dettaglio nell'elaborato:

- Company Dynamic Response Map (CDRM);
- Spring model.

L'analisi condotta fino ad ora ha permesso di ottenere una fotografia dettagliata e attuale di ciò che le aziende si trovano ad affrontare. Il business deve, di fatto, riorganizzarsi e sviluppare quelle capacità che gli consentono di gestire le nuove incertezze e affrontare le sfide che inevitabilmente gli si presenteranno davanti. Per questo motivo, questa tesi si pone l'obiettivo di sviluppare una metodologia nuova che possa rivelarsi un supporto concreto per tutte quelle aziende che muovono i primi passi in un contesto di *servitization*.

La proposta di un nuovo approccio

Identificate le lacune correnti, il lavoro svolto si è concentrato sulla strutturazione di un approccio che permetta alle aziende di reagire per tempo a tutti quegli imprevisti di un contesto nuovo, anticipando le potenziali incertezze e suggerendo la giusta modalità con cui gestirle.

Come già anticipato, la tesi propone sia una metodologia concettuale sia uno strumento operativo. La prima è stata sviluppata sulla base di tutti i gap individuati nelle pratiche correnti di risk management. Particolare attenzione è stata data all'introduzione di nuovi aspetti che permettessero di considerare tutti i cambiamenti dovuti alla *servitization*, all'utilizzo dei *contract for availability* e quindi alla necessità di instaurare relazioni più lunghe.

Nel corpo dell'elaborato è quindi dedicato ampio spazio alla customer side e supplier side, che sono considerati quasi un tutt'uno con la propria realtà aziendale e come tali devono essere gestite e rientrare nel perimetro dell'analisi e controllo dei rischi.

È quindi proposta una lista di sistemi e processi che devono essere valutati in ambito di risk management insieme ad un set di metriche di valutazione dei rischi che permettano di assestare lo scenario con una prospettiva più ampia.

Di conseguenza, questa metodologia rappresenta una svolta rispetto al passato proprio perché per la prima volta sono tenuti in considerazione una serie di aspetti di fondamentale importanza visto l'inevitabile cambiamento del mondo del business.

Tabella 8 Valutazione delle terze parti

Evaluation of third party side	
Supplier's systems and processes	Metrics
<ul style="list-style-type: none"> - Accounting System - Billing System - Configuration and Technical Data Management System - Parts Management System - Test & Evaluation System - Logistics Management System - Inventory Control System - Labour Accounting System - Material Management & Accounting System - Purchasing System - Quality Assurance System, should be evaluated to identify risk management factors as well as processes like - Supply chain management processes - Approaches to demand forecasting - Approaches to obsolescence management - Logistics surveillance processes - Risk management processes 	<ul style="list-style-type: none"> • Reliability/Maintainability/Availability <ul style="list-style-type: none"> - On time Delivery - Mean time Between Failures - Mean time Between Removal - Mean time Between Critical Failure - Time On Wing - Repair Turn Around Time (RTAT) - Production Lead Time (PLT) - Training times and availability - Technical data updates - Asset availability - Transportation times • Readiness <ul style="list-style-type: none"> - Mission Capable - Partially Mission Capable - Non Mission Capable - Asset visibility • Requisition <ul style="list-style-type: none"> - Backorder Age

La parte più complessa risulta quella di far diventare questo approccio, prettamente teorico, operativo. Nonostante il fatto che questa tesi non si sia posta l'obiettivo di concepire un software per l'implementazione concreta della metodologia, un primo tentativo è stato realizzato per proporre uno strumento operativo a supporto delle aziende.

Il prototipo sviluppato si propone l'obiettivo di aiutare le aziende nell'analizzare i rischi del contesto in cui sono inserite e suggerire la strategia mitigativa più adatta al controllo di ciascun rischio.

Nonostante esso sia ancora uno strumento molto semplice, a livello concettuale alcuni aspetti son risultati fondamentali per lo sviluppo completo del supporto.

La Tabella 9 riporta gli aspetti chiave.

Tabella 9 Aspetti chiave dello strumento operativo

Aspetti chiave dello strumento operativo
<ul style="list-style-type: none">- Bring companies in using one single tool that calculates real time data, across different sources, linking them to relevant report (cross divisions utilisation)- Having an all-in-one risk management tool to enable users in better planning, correctly allocate resources and optimize operating costs thanks to cross training- Provide total visibility to allow users to both prioritize and change priorities on the run- Cost and budgeting should be included in the risk management steps in order to provide total transparency to project status and resources allocation- Possibility of real time checking of other business unit performance.- Include cash-flow analysis, considering all the potential uncertainties that can rise- Allow stakeholders in analysing different "what-if" scenarios and having an idea of impacts of contingency on cost and schedule

La realizzazione del tool è stata un processo iterativo fatto di molti cambiamenti rispetto alla versione iniziale. Ciò che è però importante definire è la logica dietro al funzionamento dello strumento e in particolare la modalità con cui le mitigation strategies sono valutate e confrontate. Per la prima volta il confronto non si basa più esclusivamente sulla capacità della strategia di ridurre l'impatto o la probabilità di accadimento di un fenomeno (considerando ovviamente i costi di implementazione) ma va anche a valutare la sua capacità nell'aumentare la confidenza del verificarsi di un determinato fenomeno.

Si tratta di un aspetto apparentemente banale ma in realtà profondamente rilevante per il contesto analizzato.

Dare all'azienda uno strumento che di fatto riduce l'incertezza rappresenta qualcosa che concretamente può aiutare nella gestione del rischio riducendo i potenziali impatti negativi dovuti a previsioni errate con conseguente scelta di azioni cautelative non idonee a gestire l'evento.

Nell'elaborato è riportata una descrizione dettagliata di tutte le caratteristiche del software e della modalità di funzionamento.

Figura 8 si limita a fornire la struttura dello stesso.

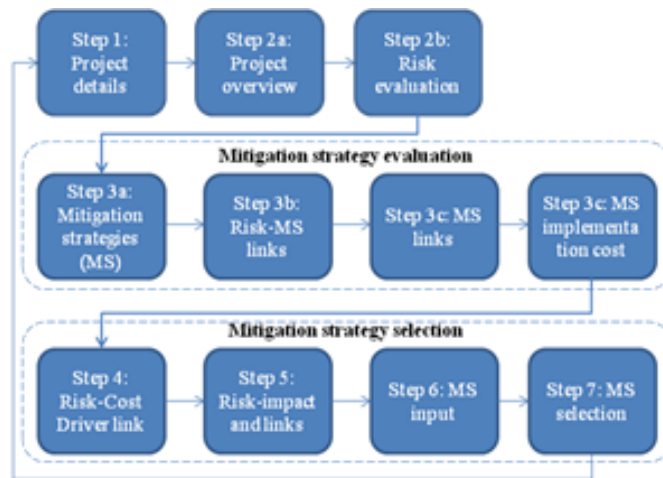


Figura 8 Steps

Nel tool stesso, costituito da un insieme di fogli excel, sono presenti tutte le istruzioni necessarie a una potenziale implementazione in azienda, insieme con una descrizione dettagliata per comprendere la logica del funzionamento e seguire l'utente passo a passo nell'applicare questo processo particolare.

Tabella 10 presenta una breve descrizione di ciascuna parte di cui il tool è costituito.

Tabella 10 Descrizione breve e dettagliata del tool

Tool description
<p>Aim: Develop a standard process to justify the reason why a specific mitigation strategy has been chosen</p> <p>Parts: - Risk Evaluation - Mitigation Strategy identification</p> <p>Sections: Project details In this section users are required to compile two tables to provide cost drivers and risks as starting point for the tool. Risk Overview In this section a short description about the first section is provided. Some guidelines are here reported to help users in providing right information Risk - Cost Driver Links In these sections (one for each risk category) users are asked to provide the links among Cost drivers and Risks Risk Evaluation In this section risks will be evaluated. The result will enable users to identify the most critical risks Input Guideline & Mitigation Strategy In these sections each mitigation strategy will be analysed in detail and compared with the others. This study will then result in some figures that will represent index to easily find the most suitable strategy. Spreadsheets: Tool Description Steps Step 1-Project Details Step 2a-Risk Overview Step 2b-Risk Evaluation Step 3a-Mitigation Strategies Step 3b-Risk-MS Links Step 3c-Mitigation Strategy Lis Step 3d-MS Implementation Cost Step 4E- Risk-Cost D. Links Step 5E-Risk Impact&Links Step 6E-MS inputs Step 7E-MS Selection</p>

È importante sottolineare il fatto che il tool sia stato sviluppato, implementato e validato da un'azienda operante nel settore della difesa. Un intero capitolo è stato perciò dedicato all'implementazione pilota di questo strumento. Tramite interazioni aziendali è stato possibile strutturare il tool in maniera tale da rappresentare un supporto alle pratiche interne di risk management.

Dieci incontri sono stati organizzati per allineare gli obiettivi e in seguito realizzare uno strumento ad hoc per le necessità evidenziate.

Questo prototipo è stato poi verificato e validato da tre ruoli aziendali chiave nelle pratiche di gestione del rischio (*Principal Reliability Specialist, Cost Engineering Manager, Risk Manager*).

Ciò ha permesso di verificare l'efficacia e utilità dello strumento ed eventualmente evidenziare i limiti futuri.

Il tool si è rivelato un mezzo efficace per rinnovare l'attuale approccio con cui i rischi sono gestiti. In particolare esso è uno strumento con una prospettiva nuova e innovativa che permette un approccio al rischio sistematico. È intuitivo e di facile utilizzo con una buona logica alla base. È possibile utilizzarlo nelle diverse fasi di un progetto così come in contesti di business differenti.

Inoltre, pur non riducendo la velocità di implementazione del processo, esso permette una miglior tracciabilità di ciò che viene fatto. Si tratta di uno strumento flessibile che cerca di evitare un cambiamento radicale rispetto alle modalità di esecuzione passate.

Ovviamente è un prototipo e in quanto tale presenta dei limiti. Richiede una conoscenza del contesto notevole e numerosi dati in input. L'impossibilità di testarlo con dati reali, inoltre ha impedito di verificarne l'effettiva consistenza.

Conclusioni

Concludendo è possibile affermare che il lavoro rappresenta una svolta rispetto al passato, che permette in primo luogo di colmare alcune mancanze rilevate durante l'analisi della letteratura, per poi proporre un approccio nuovo e innovativo per le pratiche di gestione del rischio.

Una discussione sistematica dei risultati permette di entrare nel merito.

In Tabella 11 sono appunto riportati i risultati chiave del lavoro svolto.

Tabella 11 Risultati chiave

Key results
<ul style="list-style-type: none">• A systematic analysis of the-state-of-the-art concerning three main topics:<ul style="list-style-type: none">○ The advent of the servitization trend○ The role played by contracts, especially the importance of contract for availability○ New risks and uncertainties together with risk management procedures• A conceptual methodology to help OEMs in facing new risks and uncertainties brought by the advent of servitization• A framework to help companies in selecting the most suitable mitigation strategy (just a prototype)

Il primo punto permette la creazione di un database completo e aggiornato sul tema, prestando particolare attenzione al ruolo degli *OEMs* in questo contesto. Esso rappresenta quindi uno strumento già di per sé molto utile per tutti coloro che in un futuro vorranno approfondire queste tematiche. Per la prima volta, aspetti differenti sono raggruppati e descritti seguendo una logica ben precisa per rilevarne il legame. Inoltre, insieme allo sviluppo della metodologia precedentemente descritta, seppur prettamente teorica, esso rappresenta uno step fondamentale nella realizzazione del cambiamento che le aziende devono necessariamente intraprendere per sopravvivere nel contesto della *servitization* e delle relazioni forti e durature.

Lo sviluppo di un nuovo approccio ha lo scopo di unire il vecchio e il nuovo, suggerendo un metodo innovativo nell'affrontare rischi e incertezze senza però rivelarsi impraticabile dal business.

Nuove incertezze vengono individuate e successivamente viene elaborato un approccio nuovo che le tenga in considerazione.

Le metodologia sviluppata, seppur teorica, va ad analizzare nel dettaglio le modalità con cui esse devono essere affrontate. Vista l'importanza assunta dalle relazioni con parti terze, la novità si può riassumere in quattro punti principali:

- Valutazione del fornitore (o cliente);
- Relazioni cliente-fornitore;
- Valutazione della domanda;
- Cambiamento culturale.

L'approccio propone infatti sistemi e metriche per una valutazione ex ante della parte terza e al tempo stesso si pone l'obiettivo di sviluppare uno strumento condivisibile tra le cliente e fornitore in modo da portare avanti un risk management process congiunto.

Il contesto è innegabilmente cambiato, le aziende devono prenderne atto e reagire proattivamente al cambiamento, anticipandolo.

L'analisi preliminare del contesto ha permesso di evidenziare gli aspetti nuovi e fondamentali da tenere in considerazione nel risk management: il ruolo delle parti terze diventa cruciale. La *servitization* crea la necessità di creare relazioni più lunghe e forti tra partner, cambiandone i ruoli e le responsabilità. I contratti giocano un ruolo fondamentale, in particolare i CfA iniziano a essere ampiamente diffusi grazie alle loro peculiarità nel gestire tutti gli aspetti che diventano fondamentali quando si abbraccia il mondo dei servizi.

La metodologia proposta, insieme al prototipo, rappresenta quindi un primo tentativo di portare il cambiamento all'interno del business. Lo sforzo massimo è stato appunto quello di far sì che la metodologia rappresentasse realmente un approccio innovativo quanto facilmente implementabile, che tenesse in considerazione gli aspetti menzionati.

In questo modo le pratiche aziendali di risk management potrebbero aggiornarsi e rappresentare un valido supporto per tutelarsi in uno scenario totalmente nuovo e particolarmente incerto.

Ciò che è stato raggiunto con lo sviluppo della tesi può considerarsi un valido punto di partenza per lavori futuri.

In particolare la metodologia potrebbe essere maggiormente sviluppata a livello concettuale in modo da avere realmente una prospettiva di 360° su contesto *servitization-CfA* e soprattutto essere sviluppata nella direzione tale da farla diventare uno strumento operativo.

Lo stesso tool, con le opportune competenze informatiche, potrebbe essere completato e diventare un utile supporto per la scelta della strategia mitigativa più adatta, cercando di minimizzare lo sforzo e la mole di informazioni richieste all'azienda, eventualmente preparando delle liste di default dalle quali i risk manager potrebbero direttamente attingere in base alle esigenze dell'azienda.

“I wanted a perfect ending.
Now I've learned, the hard way, that some poems don't rhyme,
and some stories don't have a clear beginning, middle, and end.

Life is about not knowing,
having to change,
taking the moment and making the best of it,
without knowing what's going to happen next.

Delicious Ambiguity.”

Gilda Radner

PREFACE

INTRODUCTION

Area of investigation

During the last decades a deep change in the manufacturing field took place. Companies turned from manufacturers to service providers, establishing a complete new world of business with different aspects and totally new ways of operating, involving for the first time external actors to create value.

There has been a “movement towards a service-based economy” (Guajardo, Cohen, Kim, & Netessine, 2011) and companies recognize the higher importance and impact of the service component on the product they offer. This new context is expected to create a win-win situation for both manufacturers and customers. (Guajardo, Cohen, Kim, & Netessine, 2011). This phenomenon, called servitization or product-service systems, is a strategic approach that companies started to undertake in order to increase the value of their businesses and to establish longer, and therefore more profitable, relationships with their customers. From the very beginning, companies tried to understand how to implement this strategy and be successful and more competitive on the market. This introduces the concept of the value supply chain. Companies are not stand-alone entities anymore. They need to involve their suppliers, as well as their customers, in their business.

Starting from a widely diffusion just in the B2C context, the influence came gradually also into the B2B world, involving therefore equipment and capital goods manufacturers. This completely changed the rules of the game, causing a major complexity in managing organisational performance in industries such as equipment provision (Smith, Maull, & Ng, 2014).

Different original equipment manufacturers (OEMs), ranging from defence contractors to home appliance manufacturers, started looking outside their business and moved downstream in the supply chain, benefitting the profits of offering services. This is especially true when speaking about companies that offer complex products and the consequences of unavailability can be disruptive and dangerous. In particular, real cases can be identified in the aerospace industry as well as in other field where products are critical and have an enormous impact on final performance.

In the following, we briefly describe three examples of companies that improved their performance embracing the servitization paradigm.

Rolls Royce, with its "Power by the Hour (PBH)" set a completely new approach in the way it was doing business, reshaping customer-supplier relationship. As the company itself states, it represents a breakthrough compared to past approaches.

"A complete engine and accessory replacement service was offered on a fixed-cost-per-flying-hour basis. This aligned the interests of the manufacturer and operator, who only paid for engines that performed well.

The service allows operators to remove risk related to unscheduled maintenance vents and make maintenance costs planned and predictable" (Power by the Hour': Can Paying Only for Performance Redefine How Products Are Sold and Serviced, 2007).

BAE Systems represents another example that can be mentioned as a company that is currently taking advantages from Performance-Based Contracts (PBC) implementation. As it can be seen from its own website, the company is currently undertaking many different projects, establishing long-term relationships with its customers. Everything is protected and guaranteed by PBC. One particular example is represented by the contract known as ATTAC (Availability Transformation: Tornado Aircraft Contract) under which BAE Systems will work in a partnered approach with the UK MOD's defence equipment & support organization. The approach enables the company in reaching benefits such as increase quality and reduce time to market, improve the uncertainty of product delivery and reduce cost (product development, delivery, failure, maintenance and opportunity).

General Electric gives a third example. This company has been awarded by the U. S. Navy a four-year Performance Based Logistics (PBL) contract covering the repair, replacement, consumables and program support for F414-GE-400 engine components for the F/A-18 E/F Super Hornet and EA-18G Growler aircraft. As it has been stated by the company itself, the goal is to provide the most cost-effective support option and optimize the overall readiness of the F414 engines. Moreover, the contract also works to strengthen GE's relationship with the Naval Inventory Control Point (NAVICP), as this is the fourth major, multi-year GE PBL contract. It represents "a true win-win for the Navy and GE," said Steve Knopping, F404/F414 PBL director. "The Navy benefits from GE providing availability of components in a firm fixed priced contract. GE benefits from providing additional value to the Navy beyond simply supplying spare parts." (GE Awarded F414 Performance Based Logistics Contract, 2006).

As it can be seen from the three cases reported above, big companies such as General electric, BAE Systems, Rolls-Royce, but also Caterpillar, Siemens represent just few of the many examples of business that already started in undertaking this pattern to become service providers rather than merely manufacture goods. The benefits of shifting to long-term service contracts are concrete and tangible.

That is the reason that justifies, companies' strategy movement from selling products towards a more integrated strategy of value co-creation together with the customer (Colen & Lambrecht, 2010).

However, this shift brings new responsibilities, as well as challenges, for the equipment provider. Profitability and benefits sharing need to be deeply analysed to ensure a fair allocation of constraints and advantages. Contracts become therefore the keystone of success, implying a deeper level of attention to long-term relationships and to all the issues rising with them. New uncertainties need to be taken into account. Companies need therefore to find ways to deal with them, both to protect themselves from negative events and take the opportunities that unknown scenarios can hide.

A risk-based approach becomes therefore the right method from which starting to develop something new that could help companies in handling all those management issues that rose from servitization. Since it represents the most common way to analyse and manage uncertainties, it can be seen as the means by which it will be possible to study all the potential effects, both positive and negative, on the contract caused by these longer relationships.

Things are even more complicated and complex than before. This implies therefore a complete different approach to face uncertainties, risks and opportunities. Companies need to take into account all the new roles created by this servitization trend. Approaches and methods developed to face the unpredictability of the future need now to include the roles played by suppliers and customers, contracts and long-term relationships.

Experience and the-state-of-art revealed that only few processes manage uncertainties in a systematic way. Many authors spoke about this topic, but without going into details and, therefore, without giving tools to help companies in dealing with all the issues linked to those new uncertainties brought from the advent of servitization. The work developed so far does not deal with this topic in depth. Therefore, there are no methods that find their applicability in real businesses. This means a lack of processes to develop and choose suitable mitigation strategies, as well as precautionary approaches within the current risk management practices. The approaches proposed so far by different authors tend to be ad hoc, undocumented and incomplete, revealing the impossibility of managing this new kind of uncertainties in a comprehensive way. Their functionalities are not clear to the users and are not intuitive. Their implementation tends to be hard to understand and to be developed together with existing business processes.

With the attempt to respond to these problems, the purpose of this thesis is to develop a standard methodology to help companies in managing new issues derived from a shift into a different scenario. In particular, the thesis is intended to, first, evaluate all those new uncertainties, i.e. risks and opportunities, that can rise from being service providers rather than pure manufactures and then develop a systematic approach to guide companies in dealing with them under a long-term and performance-based contractual framework.

To be more detailed, this paper provides a full description of the-state-of-the-art concerning servitization, the role of CfA, what new risks and uncertainties rise, trying to adopt a new point of view while carrying the analysis. The goal is to concretely understand the business implications of the new setting, since they are not currently taken into account when implementing risk management process. This is the only way to then define a framework, a risk based approach, that helps companies in dealing with them, putting threats under control with the most suitable mitigation strategy.

The methodology is developed on the idea of filling the current lacks of proper approaches, meeting the actual need, not yet satisfied, of OEMs.

Considering the fact that the thesis focuses on a very specific topic, all the steps involved in the processes to reach the different purposes are structured on its features. In fact, servitization, contracts and risk management processes were analysed under a viewpoint that aims to understand how OEMs need to change their way of doing business. This need to be kept in mind while reading the thesis to understand the outcome of each step and, most of all, how the approach developed can concretely fill the gap of the current practices and how it can help OEMs specifically.

Moreover, during the period in which the thesis has been carried out, a simple and basic framework embedded in a tool was developed to help companies in managing risks. From its validation, it is possible to affirm that this model can be applied successfully in monitoring and choosing suitable mitigation actions over different projects and life-cycle phases. It represents an innovative and systematic approach, even though just a prototype, which supports users in managing risks and their consequences.

This thesis represents therefore a breakthrough compared to past approaches and methods. It contributes with a useful addition to the standard way of considering this topic and it also provides an overview of what a complete risk management process is and how each of its steps can be successfully implemented during a project execution.

Thesis outline

The research started with an understanding of the current trend of servitization and of all the business implications linked with it.

In particular, the attention shifts from a general overview of the topic to a deeper analysis about OEMs environment. In this way, it was possible to contextualize the research, coherently with the final purpose of this study. This starting point was chosen because it represents the main cause of a deep change in the way of doing business between companies. Understanding all the features brought by this new trend, allows to consider a wider prospective when developing a method to deal with uncertainties, understanding all the new rising management issues. Role and responsibilities change and companies need to establish longer relationship with their clients.

Then a second section was developed to give details about contracts, in particular defining their features and the new role played when establishing long term relationships. It was the logical continuation of the analysis. In fact, as it was found in the literature “as many OEM firms in such industries reposition themselves to become service providers, it has become critical for them to evaluate and define contractual relationships with their customers for the provision of after-sales support. Traditionally, after-sales services have been performed under time and material contracts (T&MC), under which the supplier is compensated for the amount of resources consumed (such as spare parts and labour) whenever product maintenance is required. However, a new form of support contract has emerged with the movement towards servitization: performance-based contract (PBC). Under PBC, a supplier is paid based on the realized outcome of customer value. For example, an airline customer pays an engine service provider in proportion to the number of aircraft flying hours, which is affected by engine up-time (i.e., the number of hours the engine was available for use), and which determines the value derived by the customer.” (Guajardo, Cohen, Kim, & Netessine, 2011).

That is the reason why contract for availability and other types of service contract were analysed in details to understand the importance of their role within the changes brought by being a service provider. Different aspects need to be considered when drawing all the clauses up to ensure the success of the relationship. The servitization, in fact, implies closer relationship with third parties, suppliers as well as customers. The way to success is therefore being able to establish partnerships that align goals and objectives between companies, in order to create the maximum value for the final customer.

Contract represents therefore the only formal document in which it is possible to write down all the requirements, better considering responsibilities, risks, benefits and profit sharing.

PBC is the answer to mitigate the problem. It is the contract that succeeds in sharing risks among parties, so that the partner that can better manage a particular one will be charged and responsible for it. Not only for this reason, PBC is a kind of contract with a strong potential.

In the literature, it is possible to find articles that mention real cases in which the contract enables in having higher performance and lower costs.

Obviously the topic is something new and many complexities make the quantification of benefits and costs linked to PBC a challenging task.

Uncertainties, risks and opportunities assume then a specific role within the research. From a higher level of details, in which definitions were reported, it has been tried to go into a lower level in order to provide useful information for availability contract context and define the link between them. Knowing all the implications of this type of contract, underlines how uncertainties play an important role when speaking about servitization. The setting changed and new risks and uncertainties rose. Companies need to develop or follow a systematic approach that helps them in facing threats and opportunities of new scenarios. The research investigates also how they are currently managed by different companies to then develop a methodology, starting from consistent bases derived from past approaches. This study is therefore an important part of the methodology section, from which starting to develop a new approach to face the changes, filling the gap currently presented in the literature.

That was possible also thanks to the possibility of spending few months abroad and work together with a real company. To be more detailed, the initial part of this thesis was carried out at the Cranfield university with the support of researchers and the staff of the company. That allowed to create a consistent starting point from which developing a more detailed study about this topic.

During the last four months of this experience in UK, the literature survey was developed together with the case study. That work mainly focused on managing risks in the contract for availability, providing a useful tool to manage each risk. Afterwards, these contents were deeper developed and studied under new points of view to reach a fully understanding of the whole context, starting with a detailed analysis of the roots, to then understand the consequences for OEMs.

To be more precise, this thesis provides three distinct contributions:

- (1) It developed the first most rigorous systematic analysis to date on one of the most contentious issues currently being discussed in OEMs environment.
 - The advent of servitization
 - The role of the contract within this new context
 - New risks and uncertainties and how to manage them
- (2) A conceptual methodology to deal with all those new risks and uncertainties that rise from servitization
- (3) A simple and basic tool (prototype) to select the most suitable mitigation strategy to put each risk under control

The methodology behind the first point consists in looking for relevant publications, journals and papers, trying to find them using a wide range of keywords and sentences associated with CfA and then fully reviewing each article founded. In this way it was possible to get the starting key findings about servitization and its implications. With the database derived from this deep research it was possible to develop the second point of the list, stating what it was currently missed but needed by companies. Thanks to the collaboration of a company, it was possible to structure the basic tool mentioned in the third point, having their validation as a support of its applicability.

Study framework

The method followed to develop what has been just stated encompasses three main steps summarized in Figure 1

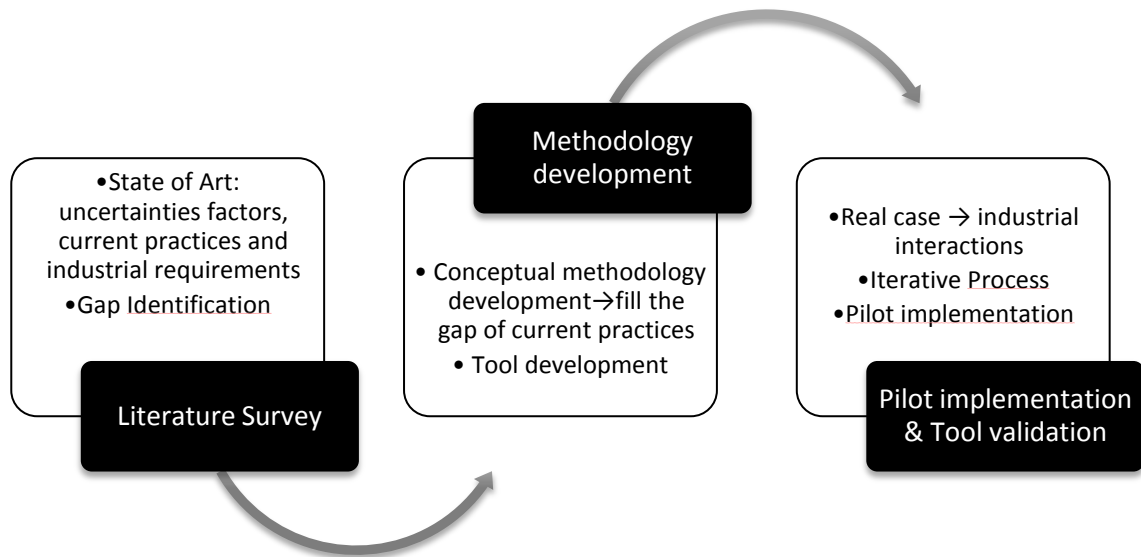


Figure 1 Methodology Steps

Literature survey

The first step was a deep analysis of three main topics:

- Servitization;
- Contracts for Availability;
- Risk and uncertainty definitions and management.

This first step is actually something more than a mere literature review. It allows going deeply into the topic to concretely identify all the implications of the new trend. In this way the pillars of the proposed methodology were settled. The purpose was accomplished by gathering and collecting data and information through an analysis of the state-of-the-Art. Several journals, papers, books and websites were analysed and discussed. Basing the first stages of the process on this groundwork, it was possible to develop an initial idea of how to create a complete and detailed methodology to help companies in dealing with uncertain context. First of all, the new drivers of uncertainties, derived from servitization, were analysed and it was tried to create a sort of list to then include them in a new approach. To reach a fully understanding, this analysis encompassed both the implications of this new trend and of availability contracts, due to the strong link between the two. Afterwards, it was looked at how risks and uncertainties were currently managed in different companies.

That to discover what news should be considered and what will be the perfect approach to manage them in a context that has completely changed.

The new context with its new features, the role of the contract and the definition of risk and uncertainties, as well as the process that are currently used to face unknown events, represent the first step in developing the core part of the thesis. They represent means to then develop a new methodology.

Research questions

As it has been stated in the introduction, the need of finding all the relevant information about the topic allows creating a huge database that is here summarized, giving therefore a concise and organized interpretation of the literature currently available.

In terms of research questions, this paper was developed starting with posing the questions reported below. They can be categorized in three main macro-groups. The first one developed to understand the context in which the topic will be inserted. In the second one are listed questions to gather all the information connected to this kind of contract while in the third one it is possible to find questions to study risks and uncertainties together with methods and techniques to manage them.

1. What does servitization mean?
 2. Are there other terms to identify the same concept?
 3. What are the business implications of this trend?
 4. What are the specific implications of this trend in OEMs context?
 5. What are the main benefits and challenges of this trend?
 6. Is there any example of real companies?
-
1. What is CfA and how it is commonly defined? What other terms are used to refer to this particular contract?
 2. Why is it linked to the advent of servitization trend?
 3. How does a company reconfigure itself to allow such implementation?
 4. How does CfA differ from a traditional contract?
 5. Is there any leading example about current practices or implementation?
 6. What are the risks and uncertainties involved in this contract? What are their drivers?

1. What is risk and how it is commonly defined?
2. What is uncertainty and how it is commonly defined?
3. How are they currently managed by different companies?
4. What are the implications of R&U in CfA?
5. Are there any methods or practice currently used by companies or already developed?
6. Where are the weakness and the strengths in the existing approach?
7. Why current risk management practices are not suitable for the new context?
8. Which features need to be considered but they are not yet taken into account in current practices?

These questions were listed at the very beginning of the research in order to lead the authors in finding the most important data about the topic, but at the same time, be aware that the literature could have had some gaps and been insufficient to find the key findings.

Search strategy

The research started identifying the relevant data sources, time frame and keywords. Initially many different databases were identified to have a huge range of different publication formats, including journal articles, conference proceeding, theses, books and article from trade journals. This database included Emerald, ELSEVIER along with sciencedirect and many other sources, editors and publishers. Obviously some keywords were first identified in order to find information that could have been associated to servitization, CfA and risks. Examples of these include: *Servitization, Servitized-Economy, Contract for Availability, Performance-Based Contract, Risk & Uncertainties, Risk Management processes, Risk and Uncertainty management methods, Opportunity Management, Risk Mitigation Practices* and many others that came from a different combination of the previous ones.

Initially, this analysis focused on the latest literature, including papers from 2005 to 2014, in order to capture all the most recent information. Then, their references have been cross-checked in order to capture any earlier publication that could have been useful for the study.

Keywords were then combined in different ways in order to cover a bigger spectrum and identifying all the information already published.

At the last, the same research was conducted surfing the internet for completeness, carrying on a process similar to the one used in the database.

Methodology development

Thanks to what was highlighted in the literature review, a specific methodology was developed.

Its development can be described as an iterative process made of two different parts. The first one with the attempt of defining a conceptual methodology and the second where a prototype was built. In this way it was possible to embed all the features that needed to be taken into account in the theoretical model and then start to develop a concrete tool that should perform what is described. Obviously, creating software is not an easy task and, at the same time, it is not the purpose of the thesis. Therefore, for what concerns the second part of this section, the tool developed represents the starting point of possible future works to make it exactly the mirror of what has been conceptually defined.

Pilot implementation & Tool validation

The analysis of a real case is the last step of the method followed to develop something that can concretely be used by companies and, most of all, which can be found as a useful tool in dealing with the context of servitization. Dealing with business is, in fact, the only way to discover the real needs felt by companies and how they act or react to solve the issues that cyclically come.

The work was carried out together with the major UK defence industry and it enables the development of a tool to systematically deal with risks and uncertainties. The tool, that was provided to them was developed with the attempt to help companies in evaluating risks and identifying the most suitable strategy to control each threat. Taking into account what OEMs need now to consider, this system reproduces the process to select an option among multiple choices, justifying the reason why a specific mitigation strategy has been selected.

Working together with a company meant developing concrete and consistent results for an external collaborator, putting efforts to reach good communication and collaboration between the parts.

Altogether ten meetings were arranged to be sure to work in the same direction and with the same objectives.

With semi-structured interviews, it was possible to improve the framework and make it usable for the company to reach its main objectives.

Many topics were discussed to reach agreements on different deliverables that were accomplished in the project. Different business roles took part in each of them. That was essential to have a full understanding of the company itself and, at the same time, to look at issues and questions under different points of view.

Hence, this paper is structured as follows. First, there are three main chapters in which the analysis of the-state-of-the-art is reported in details.

In particular, Chapter one describes the advent of the servitization trend with all its business implications, benefits and challenges.

Chapter two is structured to provide a fully understanding of contract for availability and the role of this kind of agreement within a servitized context.

The third chapter presents the definitions of the terms risk and uncertainty together with other terminologies and the descriptions of current risk management practices. This chapter has also two paragraphs structured respectively to deal with the cost benefit analysis and with opportunity management processes.

It is important to mention the fact the OEMs played the key role while carrying out the analysis. Each section is therefore structured to provide a particular insight of the topic.

In Chapter four the methodology is presented for the first time. It is the logical continuation of the conclusions drawn with the analysis of the literature. The conceptual methodology is here presented as an approach that could fill the current gap of the literature and it comes together with the first prototype of a tool created to select the most suitable mitigation strategy to put each risk under control.

In Chapter five the pilot implementation is presented. Here it is reported all the work that was carried out together with the company.

The last chapter provides the results and the discussion of the key findings in order to conclude the work and lay the foundations to develop further works.

CHAPTER 1

THE SERVITIZATION JOURNEY

1.1 Introduction

Since few years, manufacturing companies have been shifting from being pure manufacturers to service providers, mainly offering solutions and services, often associated with their products as addition (Neely, 2009).

The topic has been therefore deeply analysed, gaining greater importance in the last few decades. Figure 2 shows the profile of 50 years of servitization research activity carried out by 5 different research communities.

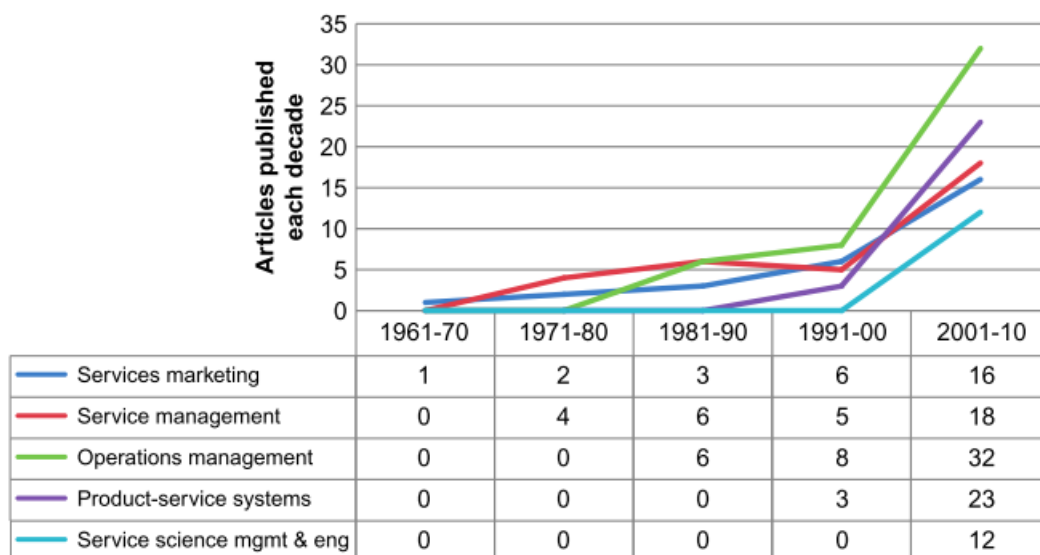


Figure 2 Research activity

In the literature, it is possible to find different terms to describe this shift toward integrated offerings of products and services, such as “servitization”, “transition from products to services”, “going downstream in the value chain”, “product service systems (PSS)”, “moving towards high-value solutions, integrated solutions and system integration” and “manufacturing/service integration” (Saccani, Visintin, & Rapaccini, 2014).

The reason behind this move lays in the volatility of the markets and global competitiveness. A passage from a traditional approach of value creation, centred in the product, to an approach centred in the customer becomes therefore necessary (Marques, Cunha, Valentea, & Leitãoa, 2013).

While the traditional approach is characterized merely by selling and delivering physical products, in a customer-centred prospective the purpose changes completely. Companies focus on understanding how customers value their activities.

Therefore, if in the past the stress was put on manufacturers' efforts on the production, paying little attention to their responsibilities beyond basic technical support and short to medium-term warranty, now the objective passes through understanding what activities are executed when using and operating a product throughout its life-cycle (Brady, Davies, & Gann, 2005).

Defining new business models becomes unavoidable to face this profound change. They represent the only way that enables companies in maintaining and improving their competitive position, thanks to long lasting relationships and closer collaborations with their customers. This innovative strategy obviously implies a greater effort for companies that need to integrate services in their core products. Core competencies on design, production and distribution of high quality and complex products allow this new kind of delivery in which products are an add-on to services. Thus, the definition and implementation of new business models that sustain the offer of new product-service is very close interlinked with the product and service development activities.

Going into deeper details it is possible to analyse this phenomena going through different aspects covered by the extant literature:

- Defining servitization;
- The evolution of servitization;
- Features of servitization;
- Drivers and benefits of servitization;
- Challenges and concerns in the adoption of servitization;
- Relationships in servitized context;
- Industrial examples of servitization adoption.

1.2 Defining servitization

Servitization has been defined as “the increased offering of fuller market packages or ‘bundles’ of customer focussed combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings” (Vandermerwe & Rada, 1988).

This definition has been taken from Vandermerwe and Rada, authors that used this terminology for the first time in the 1988. However, the-state-of-the-art includes a wider range of definitions.

Table 1 provides a list of the most cited ones

Source	Definition of servitization
Vandermerwe and Rada (1988)	“Market packages or ‘bundles’ of customer focussed combinations of goods, services, support, self-service and knowledge”
Vandermerwe and Rada (1988)	“Market packages or bundles of customer-focussed combinations of goods, services, support, self-service and knowledge”
Tellus Institute (1999)	“The emergence of product-based services which blur the distinction between manufacturing and traditional service sector activities”
Tellus Institute (1999)	“The emergence of product-based services which blur the distinction between manufacturing and traditional service sector activities”
Verstrepen and van Den Berg (1999)	“Adding extra service components to core products”
Verstrepen and van Den Berg (1999)	“Adding extra service components to core products”
Robinson et al. (2002)	“An integrated bundle of both goods and services”
Robinson et al. (2002)	“An integrated bundle of both goods and services”
Desmet et al. (2003)	“A trend in which manufacturing firms adopt more and more service components in their offerings”
Desmet et al. (2003)	“A trend in which manufacturing firms adopt more and more service components in their offerings”
Lewis et al. (2004)	“Any strategy that seeks to change the way in which a product functionality is delivered to its markets”
Lewis et al. (2004)	“Any strategy that seeks to change the way in which a product functionality is delivered to its markets”
Ward and Graves (2005)	“Increasing the range of services offered by a manufacturer”
Ward and Graves (2005)	“Increasing the range of services offered by a manufacturer”
Ren and Gregory (2007)	“A change process wherein manufacturing companies embrace service orientation and/or develop more and better services, with the aim to satisfy customer’s needs, achieve competitive advantages, and enhance firm performance”
Ren and Gregory (2007)	“A change process wherein manufacturing companies embrace service orientation and/or develop more and better services, with the aim to satisfy customer’s needs, achieve competitive advantages, and enhance firm performance”

Table 1 Definitions of servitization (Baines T., Lightfoot, Benedettini, & Kay, 2009)

Moreover, it is important to mention the existence of a wide range of servitization strategies. In the literature an important but implicit distinction among four main different concepts has been made. Here a more detailed description has been given in order to clarify common features and differences among the terms and thus having the chance of using them through this paper.

- 1) *Product–Service System* is an integrated product and service offering that delivers value in use;
- 2) *Servitization* involves the innovation of an organisation’s capabilities and processes so that it can better create mutual value through a shift from selling product to selling Product–Service Systems;
- 3) A *Servitized Organisation* designs, builds and delivers one or more integrated product and service offerings that deliver value in use;
- 4) *The Global Value System* is the globally distributed network of suppliers, customer and partners who have to co-operate to ensure that integrated product and service offerings deliver value in use. (Neely, 2009).

Further details are here considered worthwhile. The term PSS, product-service system, is in fact, commonly spread in a great number of papers, implying therefore a more accurate description. This approach frequently appears within the servitization context, identifying business models used by different companies to face actual market trends, such as differentiation, individualization and diversity in consumer solutions (Durugbo, 2013).

They can be described as “generic approaches to production that encourage companies to incorporate ‘value-added information intensive services’ for managing activities that create delivery expectations (Youngdahl & Loomba, 2000) in tandem with ‘high quality services’ associated with improved customer satisfaction, business performance, reduced cost and supplier profitability” (Seth, Deshmukh, & Vrat, 2006)

PSS can be categorized under three different forms: product oriented PSS, use oriented PSS and result oriented PSS. In product oriented PSS, ownership of the tangible product is transferred to the customer, but the manufacturer provides all those services directly related to the product. For use oriented PSS, ownership of the tangible product is kept by the service provider. The product function becomes the object of the transaction that characterize this kind of PSS. Functions are sold through modified distribution and payment systems, such as sharing, pooling, and leasing. In result oriented PSS, the PSS itself replaces services for products, e.g. voicemail service replacing answering machines (Neely, 2009).

1.2.1 The evolution of servitization

Analysing the-state-of-the-art, there is little evidence describing the evolution of servitization in the manufacturing field. Basically the pattern can be summarized as follows: at first, companies offered either good or services, then they moved to a different kind of offerings, associating their products to closely related services and finally became companies that offer 'bundles' consisting of "customer focussed combinations of goods, services, support, self-service and knowledge" (Baines, Lightfoot, Benedettini, & Kay, 2009).

This is basically the pattern that enables companies in reaching a higher level of customer satisfaction which guarantees economic viability. From this statement it is possible to derive another kind of evolution pattern that involves changes in internal business practices and models.

Satisfying specific customers' needs implies the formation of solution-oriented partnerships. A more complex system needs therefore to be created together with intermediate as well as end-users through the use of a platform to support this multi-level communication. Moreover, producer-consumer relationship needs to change as well. New notions of sale, ownership and consumption in which functions are delivered are the way to achieve this. This approach is in fact the way to encourage stakeholder participation and therefore achieve a greater customer loyalty (Durugbo, 2013).

1.2.2 Features of servitization

Analysing what servitization means and implies the first feature to mention is a strong customer centricity strategy. Therefore the nature of customer interactions needs to move from transaction-based to relation-based (Baines, Lightfoot, Benedettini, & Kay, 2009).

Figure 3 explains the product-service continuum, defining the shift as a move from "services as add-on" to "tangible good as add-on".

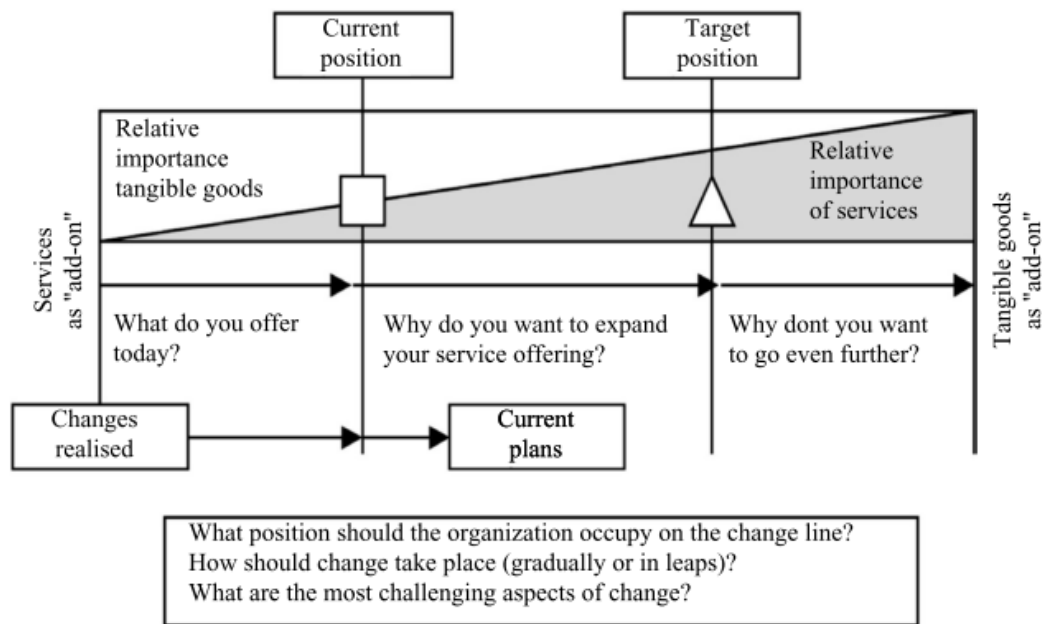


Figure 3 the product service continuum (Oliva & Kallenberg, 2003).

Moreover, servitization implies an innovative approach to make some organisational changes, to shift from “selling products to selling integrated product and service offerings that delivers value-in-use” (Bastl, Johnson, Lightfoot, & Evans, 2012). This represents the starting statement to develop a list of characteristics about servitization and its proposed solutions:

- (1) First, the necessity of delivering a comprehensive set of products with supplementary services put greater pressure on companies and their networks to be able to develop the right capabilities to achieve it.
- (2) Second, as it has been previously mentioned, customer orientation is a “must have” peculiarity, the solution changes from “product-oriented services to user process oriented services” (Bastl, Johnson, Lightfoot, & Evans, 2012). This is basically a move from focusing on “ensuring the proper functioning and/or customer use of the product, to pursuing the efficiency and effectiveness of the end-user’s processes related to their use of the solution” (Oliva & Kallenberg, 2003).
- (3) Third, the shift from transactional exchanges to relational ones; this represents, in fact, the easiest way to succeed in delivering services, thanks to a deeper relationship between partners, gaining a better knowledge about their needs and requirements.
- (4) Fourth, moving towards offering an integrated solution brings companies in “locking themselves into long-term relationships with customers, suppliers or both” (Verstrepen, 1999; Johnstone, 2009) (Bastl, Johnson, Lightfoot, & Evans, 2012).

1.2.3 Drivers and benefits of servitization

In the literature it is possible to find a wide set of drivers that lead companies in pursuing a servitization strategy. The most cited ones concern financial strategic and marketing fields.

For what concerns the financial fields, the main drivers commonly include higher profit margin and stability of income. Thanks to product-service combinations, the competition becomes less sensitive to the price. They tend to provide higher level of profitability, compared to those ones related to stand-alone products and, at the same time, they are more resistant to the economic cycles that affect investment and goods purchase (Oliva & Kallenberg, 2003).

As it has been mentioned in the first statement, servitization frequently occurs thanks to opportunities in improving financial situation, but also because companies will thus have the chance of making capital of new competitive opportunities and advantages as strategic drivers and thanks to better relationships with their customers and a higher level of product differentiation, that represent important marketing drivers (Baines T. , Lightfoot, Benedettini, & Kay, 2009).

The spectrum of benefits is actually wider. Researchers identified compelled environmental arguments (a lower consumptions of material and energy) and great opportunities in adopting this strategy (three quarters of wealth world-wide is now created through services (Royal Society, 2009)), as well as concrete proofs about commercial benefits of servitization (50 per cent of Roll Royce's revenue comes from services) (Baines & Lightfoot, 2014).

As we mentioned more than once, there is good chance for supplier to increase their sales revenue. However, at the same time this trend has advantages for both. Customers, in fact, are not excluded from benefitting the advantages linked to this approach. Risk can be drastically reduced, transferring the responsibility to the provider and, at the same time, gaining a more predictable trend for what concerns maintenance and support costs.

Basically this paragraph could be summed up with a short sentence that includes the turning point of servitization benefits: undertaking a service and customer-centric strategy enables companies in locking out competitors, locking in customers and increasing the level of differentiation (Neely, 2009).

1.2.4 Challenges and concerns in the adoption of servitization

Despite the great number of benefits, the implementation of a servitization strategy presents challenges, mainly linked with service design, organisation strategy and organisation transformation.

For what concerns the design of services, there are big differences if you compare it to that one of products because services are fuzzy and difficult to define (Slack, 2005). Therefore companies find expansion towards service dimension more difficult to undertake, most of all because a completely different kind of competition coming from unexpected rivals including their own suppliers, distributors, and customers (Vandermerwe & Rada, 1988) (Oliva & Kallenberg, 2003). Risk is then an aspect that needs to be taken into account because companies' portfolio includes now activities that were previously performed by customers. Underestimate their magnitude and impact can seriously compromise the benefits of increased profit potential.

Adopting a customer-centric strategy and therefore having closer relationships with customers implies a deep focus on communication strategies that clearly describes the value proposition to the customer (Baines T. , Lightfoot, Benedettini, & Kay, 2009).

Restructure the organisation and its processes becomes necessary. In fact, it is fundamental to define a concrete strategy to support the delivery of a combination of product and services. Moreover, the products become now customized, implying therefore the development of a set of capabilities to meet client requirements.

A cultural change is another aspect to care about. In fact, the service culture is specific and different from the traditional manufacturing culture and a shift of corporate mind-set is necessary. The main difference lays in long-standing practices and attitudes that need to be managed in a different way. The cultural changes need to take place within the organisation and its staff. That generally means meeting resistance from areas within the organisation where the service strategy is not understood or because of a fear of infra-structural change. The challenge is reach integrate and reconcile interests. Right environment within the organization and right people become the key elements to achieve success and competitive advantage, therefore this "service-culture" need to be spread among the whole company (Baines T. , Lightfoot, Benedettini, & Kay, 2009).

Servitization challenges are widely discussed in the literature and (Neely, 2009) used a different approach to analyse and categorize them.

Challenges are classified as follows: "the challenges of shifting mind-sets, the challenges of timescale and the challenges of business models/customer offerings" (Neely, 2009)

Table 2 shows the categorization of ten factors under these broad categories.

Table 2 The challenges of servitization (Neely, 2009)

The challenges of servitization	
Shifting mind-sets	Of marketing—from transactional to relational marketing
	Of sales—from selling multi-million dollar products to selling service contracts and capability
	Of customers—from wanting to own the product to be happy with the service
Timescale	Managing and delivering multi-year partnerships
	Managing and controlling long-term risk and exposure
	Modelling and understanding the cost and profitability implications of long-term partnerships
Business model and customer offering	Understanding what value means to customers and consumers, not producers and suppliers
	Developing the capability to design and deliver services rather than products
	Developing a service culture
	Embedding all of the above into a service organisation

1.2.5 Relationships

In this context, relationships play an important role. In fact, buyer-supplier relationships represent a source of competitive advantage and therefore, companies need to care about them since the very beginning. The adoption of servitization strategies has a deep impact on the nature of interactions with partners and two main aspects basically characterized them.

They are relational exchange, rather than mere transactional interactions and they are long-term relationships. That because they have the purpose of facilitating “greater levels of information and knowledge exchange, tighter social bonds, increased interdependency, increased levels of coordination and the acquisition of partnering competences and increased levels of cooperation” (Bastl, Johnson, Lightfoot, & Evans, 2012). Therefore they imply joint problem solving, interdependence and higher level of commitment and trust.

That implies a greater number of actors involved in each company’s business models and practices. The reason is because collaboration became a critical factor to achieve the scope of servitization strategies.

In particular (Finne & Holmström, 2013) cited three main protagonists, “end users, intermediaries and suppliers” and the importance of their supply chain that transforms to a triad in which these three parties are involved and interlinked with direct relationships.

That has brought authors in defining the meaning of “ service supply chain” as “the network of suppliers, service providers, consumers and other supporting units that performs the functions of transaction of resources required to produce services; transformation of these resources into supporting and core services; and the delivery of these services to customers” (Baltacioglu, Ada, Kaplan, Yurt, & Kaplan, 2007).

They are completely different from manufacturing supply chain and, most of all, they are more complex and challenging because of their triadic nature. This higher complexity is mainly caused by bidirectional operations in which actors are involved. In fact, suppliers are both supplier of the asset to be maintained and of the use and performance of the asset itself.

At the same time, they need to interact with the end-users as well, in order to get the premises where a set of operations will be performed. In this way they established a triadic supply chain in which all the three different partners are connected to each other (Li & Choi, 2009).

Relationships have been analysed in the literature through different methods to use a systematic approach to identify their features. Here we reported what has been found about them and their analysis.

First of all, the use of Cannon and Perrault’s (1999) framework is recurring in the papers. More than once it has been used as a lens to study buyer-supplier relationships in very details. In fact, it comprehends five different dimensions along which the different aspects of interactions can be analysed: information exchange, operational linkages, legal bonds, cooperative norms and buyer-supplier adaptations (Bastl, Johnson, Lightfoot, & Evans, 2012). These five dimensions have been called “connectors” and represent “dimensions that reflect the behaviours and expectations of behaviours in a buyer-seller relationship” (Cannon & Perreault, 1999).

Table 3 Relationship connectors (Cannon & Perreault, 1999)

Relationship connector	Description
Information exchange	Information exchange is an expectation of an open sharing of information that might be useful for both parties
Operational linkages	Operational linkages capture the degree to which the systems, procedures and routines of both parties (for example customer and supplier) have been linked to facilitate operations
Legal bonds	Legal bonds are detailed and binding contractual agreements that specify the obligations and roles of both parties in the relationship
Cooperative norms	Cooperative norms reflect expectations the two exchanging parties have about working together to achieve mutual and individual goals jointly
Buyer and supplier	Relationship-specific adaptations are investments in adaptations to process, product, or procedures specific to the needs or capabilities of an exchange partner

Looking at how relationships have been analysed in previous papers, it becomes important adding a further step to the utilisation of the mentioned framework. In fact, the service offered need to be categorized as well as it has been done for the nature of relationships. A general approach that considers all the services equal to the others would not be able to capture the features that really need to be considered when developing relationships with partners. For this reason, this source proposed a service categorization together with the Cannon and Perrault (1999) framework.

The features of each group are reported below.

Table 4 Classification of service types (Saccani, Visintin, & Rapaccini, 2014)

Service type	Aim of the service type	Examples of services	Characteristics
Product support (PS)	To ensure a product's functionality over time	Installation and commissioning, repair services, provision of spare parts and consumables, decommissioning and disposal services	Direct recipient: Product Intensity of the relationships: Low Customization: Generally Low
Customer Support (CS)	To facilitate the end-users' daily interaction with the product and help them to fully enjoy and use the product	Provision and update of technical documentation (e.g. procedure manuals, user guides), help desk for remote support, a website hosting product related forums, FAQs and chats	Direct recipient: Product user Intensity of the relationships: Medium to high, depending on the service and the role of technology Customization: Low to medium
Process relate (PR)	To help customers (re)design, manage and optimise the processes enabled by the product	Consultancy and professional services for process engineering, test, simulation, design and construction services, process-related training services	Direct recipient: Process owner Intensity of the relationships: Generally high Customization: High

There is another category that has not been reported in Table 4. These services are known as operational services or process delegation services. They go even deeper in the customer value chain, almost transferring all the responsibilities connected with operations directly to the supplier that will perform all the tasks on behalf of the customer.

The use of these two categorisations, both about connector and about services creates a research framework that can be used to deeply investigate buyer-supplier relationships.

Table 5 Research framework (Saccani, Visintin, & Rapaccini, 2014)

<p><i>Service type:</i></p> <p><i>Buyer–supplier relationship connector:</i></p>	<p>Product support (PS) Customer support (CS) Process related (PR)</p>
<p>Information exchange</p> <p>Operational linkages</p> <p>Legal bonds</p> <p>Relationship-specific adaptations (by the buyer or the supplier)</p> <p>Cooperative norms</p>	

Thanks to the work carried out by (Saccani, Visintin, & Rapaccini, 2014), it is now possible to have some data that can help companies in setting their relationships when adopting a servitization strategy.

Here are reported the case findings of the paper previously mentioned.

Table 6 Case findings (Saccani, Visintin, & Rapaccini, 2014)

	Product support services (PS)	Customer support services (CS)	Process related services (PR)
Information exchange	Suppliers provide limited information about their field activity, mainly triggered by contractual obligations (i.e. to get a refund for warranty repair). Buyers provide technical information to support service delivery	The relevant amount of information provided by a supplier allows the buyer to “keep in touch” with its end customers. Information from the buyer is aimed at supporting the supplier to carry out its activities efficiently and effectively	Together with technical and operational information, more long-term and strategic information is also exchanged
Operational linkages	Software platforms to exchange information and spare parts orders are imposed to suppliers by the buyers. Buyers set some service standards and procedures	Routines (monthly meetings) and KPIs allow buyer and supplier to improve and formalise both the information exchanged and the assessment of the relationship performance	Software platforms to exchange information and spare parts orders are imposed to suppliers by the buyers
Legal bonds	Detailed and binding contracts specify the obligation of the parties. However, contractual obligations' main role is to be a threat for suppliers. Relationships tend to be stable in practice	The contract sets the performance standards and the related pricing or bonuses. Therefore, it is used as an incentive mechanism rather than as a threat to quit the relationship by one party	Only a few aspects are covered by contracts (in particular the conditions under which suppliers are authorized to work for the buyers)
Relationship-specific adaptations	Suppliers invest in software tools and in conforming to the company standards and image. Buyers may contribute to such investments by suppliers and always invest in providing technical/commercial training to the suppliers	Heavy investment by the supplier. The “set-up” of the relationship (training effort and time needed to achieve the performance targets) makes it difficult also for the buyer to switch	Software, training, equity participation (in case of Company B)

Cooperative norms	<p>Commitment to the relationship is limited, but stronger on the supplier side, especially for Suppliers 1b and 1c, given their higher degree of dependency. Buyers tend to manage relationships at an arm's length. Formal or informal moments in which objectives are shared among parties and suggestions formulated are very rare</p>	<p>The service quality is a key factor for end-customer satisfaction and loyalty. Companies are committed to improve the performance, as well as to continuously reduce the service costs and fine-tune the incentive mechanisms</p>	<p>Partners have developed commitment and trust over time. Formal or informal exchange of information about future plans exists</p>
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Following the suggestions reported above, manufactures can now have a template to follow when evaluating their suppliers, paying particular attention to their capability and willingness of shaping a relational exchange.

For example, manufacturers should care about suppliers' availability of resources to make relationship-specific investments and their willingness in developing a trustworthy and professional relationship. Attention needs to be paid to existing relationships as well. Coherently with the framework, manufacturers should check for inconsistencies and areas needing improvement. Information is another important aspect. Constantly, both parties should check which information could be exchanges to generate benefits for one or both (Saccani, Visintin, & Rapaccini, 2014; Saccani, Visintin, & Rapaccini, 2014).

1.2.6 Industrial examples of servitization adoption

The theory of servitization strategy has been deeply studied by different authors as well as its adoption by companies. Different papers show case studies in which companies are analysed as examples to understand implementation, practices, benefits and challenges.

Generally, large companies represent the most spread example. They demonstrate "how traditionally based manufacturing companies have moved their position in the value-chain from product manufacturers to providing customers with integrated solutions that can include multi-vendor products" (Baines T. , Lightfoot, Benedettini, & Kay, 2009).

Table 7 shows industrial example of servitization.

Table 7 Industrial examples of servitization (Baines T., Lightfoot, Benedettini, & Kay, 2009)

Organization	Description	Source
Alstom	Maintenance, upgrade and operation of trains and signaling systems	Devies (2004)
ABB	Turnkey solutions in power generation	Miller <i>et al.</i> (2002)
Ericsson	Turnkey solutions to design, build and operate mobile phone networks	Devies (2004)
Nokia	Nokia's network-infrastructure solutions, providing network equipment and services to carriers	Wise and Baumgartner (1999) Devise <i>et al.</i> (2006)
Thales	Pilot training and simulator-building management	Devies (2004)
Rolls-Royce	"Power by the Hour" guaranteed flying hours for aero engines	Howells (2000)
Xerox International	Document management services. Guaranteed fixed price per copy	Mont (2001)
WS Atkins	System integration services and outsourcing solutions	Devies (2004)

For the purpose of this thesis, it is here important to analyse a specific context in which servitization took place. Advanced services need to be mentioned as a particular case in servitization. The topic mainly refers to contracts known as availability and performance contracts. The peculiarity of them lays in the importance of the delivered service for customers' core business process. For this reason, providers need different capabilities to those ones merely linked with production and a lack of them often leads manufactures to fail in achieving the anticipated benefits of adopting a servitization strategy.

Here Table 8 shows a categorisation of different product-services offered by manufacturers.

Table 8 Categorization of product-services offered by manufacturer (Baines & Lightfoot, 2014)

Type	Defined by	Organisational stretch	Examples of service offered
Base services	An outcome focused on product provision	Based on an execution of production competence (i.e. we know how to build it)	Product/equipment provision, spare part provision, warranty
Intermediate services	An outcome focused on maintenance of product condition	Based on exploitation of production competences to also maintain the condition of products (i.e. because we know how to build it we know how to repair it)	Scheduled maintenance, technical help-desk, repair, overhaul, delivery to site, operator training, condition monitoring, in field service
Advanced services	An outcome focused on capability delivered through performance of the product	Based on translation of production competences to also manage the products performance (i.e. because we know how to build it we know how to keep it operational)	Customer support agreement, risk and reward sharing contract, revenue-through-use contact

Examples of companies delivering advanced services include Alstom and ABB, Thales Training and Simulation, and Rolls-Royce Aerospace (Baines & Lightfoot, 2014).

Little details can be given synthesizing few features that characterized advanced services. Frequently they are labelled by: “

- performance incentives (i.e. penalties if the product fails to perform in service);
- revenue payments structured around product usage (e.g. power-by-the-hour);
- long-term contractual agreements (i.e. five, ten, and 15 year durations are common)” (Baines & Lightfoot, 2014).

More details about manufacturers’ operations have been founded in the literature and are here provided in Table 9

They represented a starting point from which a deeper research was carried out to identify how practices and technologies differ from other contexts and how companies can structure themselves to deliver advanced services.

The challenge is to define what form these should take to support the effective delivery of integrated product/service offerings (Datta & Roy, 2011).

Table 9 Characteristics of operations

Infrastructural		Structural	
Human resources	Tend to need workers with high levels of product knowledge and relationship development	Process and technology	Tend to exploit a range of technologies, throughout operations, to achieve efficiency in production and effectiveness in service delivery
Quality control	Tend to be product assurance methods combined with customer satisfaction assessments	Capacity	Tend to experience varying demand signals at multiple customer “touch points” and so need to operate with differing levels of capacity utilisation
Product/service range	Tend to have limited range combined with “bundles” of supporting services	Facilities	Tend to combine both centralised manufacture, but mainly focusing on product final assembly and test, along with multiple field facilities for maintenance and repair located close to market
New product/service introduction	Tend to use centralised capabilities for product design, taking particular account of maintenance and repair, and that complement services co-created with the customer	Supply chain positioning	Tend to retain vertical integration in product manufacture and a range of closely integrated partners to deliver services
Performance measurement	Tend to use product availability, response time and customer satisfaction	Planning and control	Tend to focus on the optimisation of product availability
Supplier relations	Tend to integrate internal and external supply chains into delivery process to achieve cost effective flexibility in supply		
Customer relations	Tend to have strong interaction with customers through relationships based on product availability and performance		

This paragraph therefore tries to analyse how manufacturers can configure their operations to correctly delivered advanced services. Information shown in Table 10 represents the key findings identified through case studies analysed by (Baines & Lightfoot, 2014). They go through different business areas giving a detailed overview about all the aspects that need to be considered in the shift toward a service-centric strategy.

Table 10 Key findings (Baines & Lightfoot, 2014)

Area	Findings
Facilities and their location	To deliver advanced services manufacturers deploy facilities that are co-located and distributed throughout their customer’s operations. This enables responsive and reliable maintenance, along with on-going product design improvements. This practice is relaxed by product portability, built-in redundancy, and remote monitoring capabilities.
Micro-vertical integration and supplier relationships	To deliver advanced services manufacturers integrate forwards to adopt a wide range of customer activities, and also backwards to retain design and production capabilities for complex and high-value subsystems. This enables responsiveness, continuous improvements to product designs, and offers a route to transfer best practices from production. This practice is relaxed where suppliers are willing and able to provide capabilities that reflect the manufacturers’ contractual obligations to customers.
Information and communication technologies	To deliver advanced services manufacturers deploy ICTs that provide remote monitoring of product (asset) location, condition and use. This enables actions to manage maintenance, repair, field operation, and improvements to product design. The sophistication of ICTs is relaxed by asset location, proximity of facilities, built-in redundancy, and existing ICT systems.
Performance measurement and value demonstration	To deliver advanced services manufacturers adopt performance measures that reflect outcomes aligned to individual customers, and these are then cascaded into various forms throughout the service delivery system, and complemented by a set of more emotional measures that demonstrate value to the customer. These are necessitated to reflect the outcomes required by the customer, effective alignment of the manufacturers’ activities to reflect these, and the on-going reassurance of efficient contract fulfilment
People deployment and their skills	To deliver advanced services manufacturers deploy people in their front-line (front-office) facilities that are skilled in flexible working, building relationships, service-centricity to empathise with customers, authentic and committed behaviour, technically adept and resilient to the stresses induced by this environment. These skills facilitate positive and sustained customer relationships. They are relaxed as staff move away from the front-line into more support activities (towards the back-office)
Business processes and customer relationships	To deliver advanced services manufacturers deploy business processes that are integrated into a wide range of customer “touch-points”. These enable strong inter-organisational relationships, which are designed to proactively manage people, information and facilities to maintain the condition, use and location of products as they are used by customers. This practice is relaxed where incentives for contract fulfilment are less demanding.

1.3 OEMs and Servitization – The five main challenges

For the purpose of this thesis, a brief excursus about OEM and servitization needs to be done. In this way, the topic can be identified within the word of manufacturing firms and be therefore suitable to lay some foundations to understand specific features about the real case mentioned in next chapters.

As we stated, what really pushes companies in shifting towards services are all the benefits involved. Service oriented strategies' supporters point to strategic, economic and environmental benefits of pursuing a service oriented strategy. The main benefits can be listed as high margins, stable revenues and high quality service, aspects that lead companies in buying new equipment (Wise & Baumgartner, 1999). Particular attention need to be paid to the strategic prospective linked with this shift. Offering services brings companies in establishing close and long-term relationships with customers, an effort to locks-out competitors as well.

Offering a product-service system means providing integrated solutions, which are by definition less easy to copy and create therefore a source for of differentiation (Oliva & Kallenberg, 2003).

However, being a service industry implies facing many new challenges. In particular, this dissertation focuses on five service operation strategies that can help the OEM while setting up a service supply chain (Colen & Lambrecht, 2010). They mainly focus on the importance of reducing uncertainty and complexity while developing services and service operations. Moreover, they explain how scale and pooling effects can give OEMs the opportunity to outshine local service providers.

1. Limit uncertainty and complexity

The fact that service contracts often tend to last several years makes service operations more uncertain than manufacturing ones. The impact of decisions is also longer in this environment and therefore it amplifies the detrimental effects of uncertainty and complexity, but at the same time it can represent an opportunity for the OEM. The most important thing becomes therefore how to design the service products and the equipment. It allows the manufacturer to effectively control his service operations and avoid problems linked with peaks in workload or high variability in spare part demand (Colen & Lambrecht, 2010).

The importance of mitigating uncertainty and complexity when designing PSS is the first service operations strategy. How?

1.a Move from reactive to scheduled service

Moving from reactive to scheduled (proactive) service represents the first step to take in limiting uncertainty and complexity. Timing is the main source of uncertainty. Services can be delivered in different way, based on the logic behind the contract and, in particular, based on who has the power of taking decisions about timing: the service provider or the customer (leading then to service-on-request, service-on-appointment or service-by-schedule (Colen & Lambrecht, 2010)). By scheduling the service provision, either service-on-appointment or service-by-schedule rather than performing service-on-request, the OEM can avoid argument with customers and stream his operations. Being proactive can reduce costs thanks to an improved capacity scheduling and less emergency shipments.

1.b Bundle and standardize services

Having a wide range of products obviously increases costs for the manufacturers. Due to a higher complexity, costs such as design, inventory and quality cost rise. As well as in the manufacturing, services need to be tailored to the needs of customers, keeping the cost at a low level. Therefore companies need to deal with the trade-off between standardization and customization. (Colen & Lambrecht, 2010) propose two different approaches.

Companies can propose pre-selected product bundles or they can offer standard services and customers can personalized with some add-ons selected from a choice menu. Both methods aim to reduce the number of “service configurations”. Whatever is the choice, it will be a challenging target to reach.

1.c Take on more responsibility

Offering services implies a high level of customer involvedness that represents an obstacle for the OEM to increase efficiency. The customer plays a predominant role in taking choices, such as which services will be performed or which employee will be allowed to perform the services. Here come problems of goal alignment between customer and OEM. Succeed in having a high level of control and alignment of incentives allows both partners to create a higher service gain compared to those relationships with less responsibilities.

This is a matter of reducing uncertainties in service operations. However allocating the risk is a challenging task. It is important to share responsibilities taking into account which partner is better equipped to take on the service risk.

Figure 4 shows how responsibilities can be shared. Manufacturer passes from selling spare parts to undertake a performance based contracting.

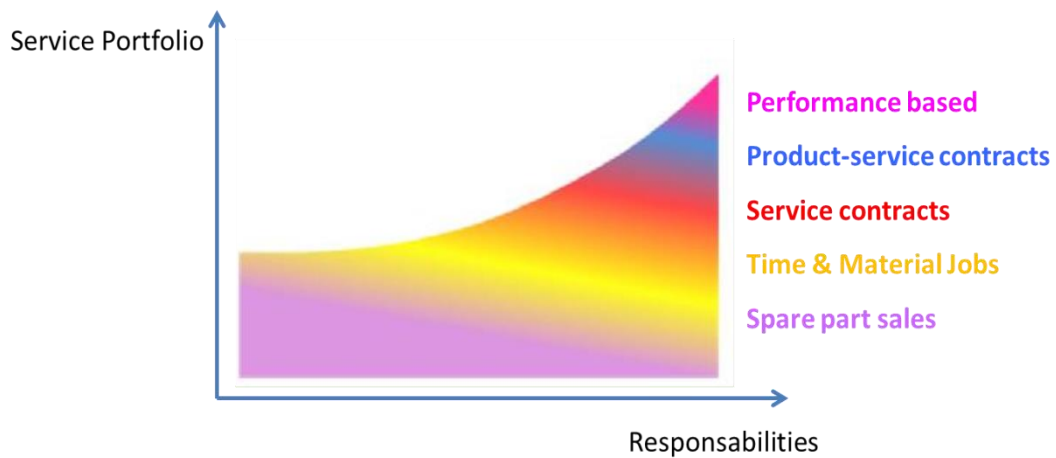


Figure 4 Service Portfolio (Colen & Lambrecht, 2010)

Despite the increasing importance of services, products still play an important role. The OEM will have to manage a portfolio of different service products. Obviously the larger the portfolio is the higher will be the potential profit from this contract.

Manufacturers need to have a deep knowledge about risks and responsibilities involved in their relationships in order to define the right price according to their risk and value to the customer and get therefore high profitability.

1.d Adapt end-product design

The equipment itself and its design play an important role in influencing the uncertainty and complexity of sales services. Therefore, manufacturers can simplify their service operations when developing new equipment.

Basically this means design equipment suitable for offering services, guaranteeing reliability and maintainability. That implies developing equipment that has a low failure rate by using redundancy in components and more extensive engineering efforts for what concerns reliability (Hussain & Murthy, 2003). Dealing with maintainability implies provide support services and, for example, ensure that service related goals are met, the early involvement of maintenance experts and the use of quantitative analysis and lifetime models. (Goffin & New, 2001)

2. Benefits from economies of scale and pooling

To operate with a service-oriented strategy, a responsive and efficient supply chain is necessary. A successful pursuit of a service-oriented strategy mandates a service supply chain that is responsive and efficient.

2.a Centralize the spare part supply chain

Speaking about services related to the provision of spare parts, the supply chain becomes more complex compare to that one of manufacturing end products. There are multiple reasons that explain this complexity: a multi-echelon structure, a high number of SKUs, the localization of sites geographically dispersed that need to be served with repairable and consumables. The objective of this supply chain is therefore being able to deliver the right parts to the right place within an agreed-upon time frame at the lowest possible cost (Colen & Lambrecht, 2010). Everything is therefore linked to a choice of location. The main choices need to be taken conscientiously in order to optimize. Centralize or decentralize the stock of spare parts and select the position of the stock in the product hierarchy (individual component, module, sub-assembly or end product) (Cohen & Agrawal, 2006). Obviously many aspects should be taken into account; the spare part supply chain is both rich and challenging because customer needs always to be considered creating a sort of two interrelated hierarchies.

2.b Pool customers & service territories

Dealing with service implies difficulties in balancing workload. In fact there is a direct link between demand and workload because services are intangible and therefore impossible to be stocked. The demand needs therefore to be pooled in order to smooth the workload and make the service provision more reliable. There are many methods to do this. For example, by pooling customers with negatively correlated demand, the server will experience a balanced workload throughout the year. Otherwise, the same balance can be obtained by pooling the service territories of different service engineers (Colen & Lambrecht, 2010). In this way it will be possible to decrease the level of demand variability. Reduction of response times and capacity levels are the rewards for the OEM that takes up the challenge of balancing workload (Hopp & Spearman, 2000).

2.c Group service tasks

Trying to decrease the cost is not an easy task to perform. The main reason behind this lays in the fact that manufacturers need to perform different tasks for their customers, with different frequency. Moreover, whatever action is undertaken, benefits need to be reached from both parties. Therefore being flexible is the only way to succeed.

3. Deploy multi-purpose resources

Multi-purpose resources represent a way to increase company flexibility. Although they are more expensive, they help manufacturers in dealing with emergency situations without deploying excess resources. Problems with equipment needs to be solved as quick as possible, therefore, flexibility is the only answer to be responsive and efficient, avoiding having back-up equipment.

3.a Be smart with inventory

Transshipment represents another way to increase flexibility and reduce cost. It consists of moving parts from one stocking location to another one, following the needs of the supply chain. This action can be implemented choosing well-positioned distribution centres to manage exceptional shipments. Obviously, emergencies can be managed with last-minute shipments that are more straightforward but at the same time implementing an approach that makes the company enjoy pooling benefits.

Inventory can be smartly managed also using spare parts for multiple demand types. That allows companies to face potential stock-outs in an easier way, delivering substitute parts that can perform the same task or even having a better performance compared to the original configurations.

3.b Create a flexible workforce

A service-oriented strategy implies managing something different and more complex than just selling spare parts. That means having a workforce able to execute the service being sold. Basically workers should be available at any time and trained to perform in any place. That is a really difficult goal to reach, and companies can try to face this challenge by enhancing the flexibility of their workforce. That means work for reaching a high level of cross-training and of flexible working hours.

In this way the OEM has workforce cross-trained, able to perform any service tasks. With this group of engineers, companies will be able to manage each emergency.

On the other side of the coin, obviously having a cross-trained workforce implies higher costs- therefore it becomes fundamental identifying the right level of training. This topic has been deeply studied in the literature and although cross-training drastically lowers labour requirements, only a small amount of cross-training is sufficient to realize most of the advantages of full cross-training (Wallace & Whitt, 2005).

3.c Adapt service policy based on field data

Being able to base choices on real time data improve companies' performance, increasing their level of responsiveness and efficiency and at the same time their customers' satisfaction.

In other words, service OEM should work for making promises to their customer bases on current information, being flexible to improve conformance with customer expectations (Colen & Lambrecht, 2010)

3.d Be fast when it counts

After having increasing their level of responsiveness, companies should set some priorities rules in order to be fast when it counts. That means being able of organizing scarce resources for maximal value creation (Colen & Lambrecht, 2010).

Obviously this implies not only defining when and which services should be performed first, but also prioritizes spare parts investment and allocation. All the cost elements (such as carrying the part) need to be taken into account together with potential benefits derived from well-performed service (measured by using customer- oriented measures such as waiting time, order fill rate or spare part criticality) (Colen & Lambrecht, 2010).

Reorganizing the inventory with higher level of spare parts that matter and decreasing that one of expensive and irrelevant stock as well as having a reserving inventory represent way to improve performance.

4. Profit from knowledge about the installed base

Providing services implies putting more effort in reducing uncertainty and complexity to perform after market activities. That means gathering information and using them to make the unpredictable predictable (Colen & Lambrecht, 2010). In this way, the OEM can outshine its competitors and create closer relationship with its customers.

4.a Diagnose

Gathering information has become easier with internet, therefore manufacturers can now obtain a great amount of data about operations and conditions of the equipment built. Data, together with data mining and statistical techniques (Jeong, Leon, & Villalobos, 2007), allow companies to answer some questions such as potential main causes of breakdown or which spare parts are most likely needed for a certain service job (Colen & Lambrecht, 2010).

4.b Perform reliability analysis

Knowing how often equipment fails is fundamental information for designing and pricing of maintenance service contracts. Intelligence about the risks of equipment failures helps the OEM at determining the service requirements of equipment. The OEM will now have the capability to proactively recruit and train employees to cope with the future (predicted) workload.

4.c Forecast demand

OEM is asked not only to be able in performing services but also in predicting spare parts demand. With reliable forecasts, the OEM can anticipate future spare part needs and adapt his inventory allocation and procurement practices accordingly. Acting in an intelligent way, basing choices on installed based data, allows the manufacturer to optimize his service operations and to make well-founded decisions about marketing, design, service portfolio etc. (Colen & Lambrecht, 2010).

5. Surpass functional barriers

Creating an independent service organization represents a key point to reach success in service. It is important to consider the fact that, in a product service systems, equipment and service are integrated in one sole solution, and therefore design is reciprocally influenced. However, services activities need to be kept separately from the product division to allow reaching economies of scale. Obviously this is not an easy objective to reach because this separation can be considered as a threat by the manufacturing units. Both divisions, manufacturing and service, can choose to optimize their own profitability with disregard of corporate interests. Therefore, the alignment of decisions becomes crucial.

“Is the core manufacturing business willing to increase production cost in order to lower servicing cost? Does the service division deliver high quality service leading to new equipment sales? What is the optimal mix between manufacturing and servicing profitability?” (Colen & Lambrecht, 2010). These are the main issues when demanding an approach that surpasses functional barriers. The main difficulty lays in the fact that incentives of the manufacturing and service division can differ. Therefore it becomes fundamental setting a common goal in order to surpass the functional barriers and increase corporate value. Using a quantitative model can help both parties involved in accepting the common goal, since it calculates the total costs of ownership.(Cohen & Whang, 1997).

1.4 Conclusions

Servitization emerged as a widely used concept in the literature.

However it is impossible to find papers that deeply analysed the term and all its features, giving a complete overview of the topic.

Therefore this first chapter attempts in filling this gap, developing a good and detailed research that puts together all the aspects and issues that need to be taken into account when dealing with this new trend.

It can be considered the first huge database that encompassed all the relevant publications that has been cited in the literature during the last decades, touching upon the most important aspects of the topic, defining what can be considered as a helpful container of information where people can glean facts and data to develop further studies about this trend and all those industrial implications that come together with it.

To summarise, a detailed description has been given about this trend, concerning its definition, evolution, features, drivers, benefits and challenges.

The last part of the section already represents a first guideline in helping companies in getting by within these new risks and uncertainties. In fact, it lists concrete actions and aspects as steps of a path to follow towards being a service provider, especially when placed in OEMs environment.

Having real industrial examples and applications gives a surplus value to this thesis, laying the foundations of what will be developed afterwards. It is a theoretical approach and guideline in considering and therefore in trying to facing (or at least taking into account) the existence of new challenges and situations. It can be considered as the first step of the bigger purpose of giving companies the right methodology in facing all those issues brought by the shift from product sellers to service providers.

This chapter has therefore the purpose of settle a general understanding of this trend and getting all those useful information to contextualize companies within this situation. That allows discovering what all the problems that arise from it are and defining what companies really need to emerge victorious from this deep change in their way of doing business.

Having clear in mind what has been discovered thanks to a literature analysis, the conclusion that can be drawn is that companies need the right tools together with a structured methodology to follow this trend and be competitive on the market. This become therefore the focal point of the core part of this thesis that aims in developing instruments to overcome these new difficulties, since companies are now in a more complex setting.

Therefore the next steps of this thesis is gathering information in order to identify all those uncertainties and risks that come together with the servitization and then study in details how they are currently managed. Particular attention will be paid to new issues that rise because of longer relationship that implies a different way of managing partnerships and agreement. CfA and PBC are contracts already used by companies to simplify their life, but they need to be understood in details especially to get their features to handle this different setting. That means, firstly, carry out a structured and complete analysis of this particular kinds of contract. This will have the purpose of define a detailed taxonomy of all the uncertainties linked with it, since they are long-term contracts and based on performance, therefore influenced by multiple factors

CHAPTER 2

CONTRACT FOR AVAILABILITY: key characteristics and uncertainties

Describing the role of contract for availability becomes the following step.

It goes without saying that the revision of the literature leads up to a systematic discussion of the main features of this contract type. In particular, the analysis pays attention to the specific context of capital equipment and has also the attempt of defining a taxonomy of all the potential uncertainty factors.

In this way it will be possible to have a starting point from which analysing how they should be managed by companies to take into account all the peculiarities of these new risks and uncertainties, proper to this contract. This is the reason why this paragraph eventually tries to identify those criteria that need to be taken into account to choose the proper model and methodology to manage risks and uncertainties in the whole life-cycle of availability contracts.

2.1 Servitization and long-term relationships: the role of the contract

As it has previously stated, long-term relationships become the key point of following the actual trend of servitization and being competitive on the market. Companies start to understand that a collaborative and cooperative behaviour is the right way to work with supply chain partners. In particular, this trend completely changes the role of clients. The OEM cannot consider them as mere recipient of goods and services but they represent the main and only source from which receiving information (and obligations) to develop the right output. Value for the final customer is created together. Becoming a service provider implies therefore a deeper effort to be compliant with what the client wants. Requirements, specifications and requests change completely. Supplier tasks are not complete just providing the service requested. Working for a client basically becomes a never ending commitment. It means reorganize tasks, workflow and internal performance to satisfy client's needs during the whole duration of the relationship, starting in providing the service and then keep it working.

How is it possible establishing a long-term relationships taking into account concerns implied in providing a service for the whole duration of a partnership?

Keeping focused on OEMs, contracts play a key role in ensuring the collaboration between partners, defining all the aspects that need to be considered to protect both partners and manage all those operational issues involved in the partnerships.

The advent of servitization, and therefore of all those services that firms offer to their customers, changes completely the previous setting. The term contract does not really reflect the complexity of the situation and of those relationships that need to be undertaken between service providers and clients. The importance of the new role played by the client makes new uncertainties, risks and opportunities rise. Suppliers, that basically need to adapt their performance to what is now the request, have to develop capabilities and systematic approaches to manage them in the best possible way.

Contract for availability is the concept that needs to be studied to access this new way of making business since it encompasses all the aspects involved in closer relationships between partners. The incentive structure becomes an important element in reaching great agreement, making the contract the place where all the terms and conditions can set the legal foundations behind a partnership.

2.2 Definition: a wide spectrum of terms

Going into deeper details, it becomes fundamental to provide a structured classification of all the terms used in the literature.

In fact, during the research it has been possible to prove that the concept behind the term “Contract for availability” has been expressed by different terminologies. Often, different terminologies have been used indistinctly while in other papers they have been reported showing particular features to underline typical points of each denomination.

Table 11 reported different terms together with their definitions

Table 11 List of definitions

Term	Definitions
Contract for Availability (CfA)	Under a CfA contract, industry is required to deliver outcomes defines in terms of availability. Initially defined in terms of platform (ship, aircraft, vehicle etc.) availability has evolved into outcomes more clearly linked to the MoD's operational requirements such as available flying hours ¹ . Under CfA, the contractor needs to maintain an acceptable number of "Forwarded available Fleet (FAF)" as availability. The company has to manage spares supply and also provide technical support staff. ²
Availability Based contracting	Type contract in which the end customer contracts out through-life support of equipment based on availability levels, as opposed to the traditional model where assets and services are purchased on demand ³
Contractor Logistic Support (CLS)	This type of contract shifted from merely giving contractors responsibility for holding inventory and supplying spares to Private Finance Initiative (PFI) solutions where contractors provide everything from the facilities to the manpower ¹ .
Outcome Based contract	OBC is a contracting mechanism that allows the customer to pay only when the firm has delivered outcomes, rather than for merely activities and tasks. OBC focuses on achieving required outcomes rather than performing to a set of prescribed specifications. In short, the buyer purchases the result of the product used (utilization of service or outcome) and not ownership of the product. Interestingly, the customer no longer directly manages or possibly even owns resources such as the inventory of spares. ⁴
Performance Based Contracting (PBC)	Performance-based contracting is a form of contracting that explicitly includes a clear definition of a series of objectives and indicators by which to measure contractor performance, collection of data on the performance indicators, and consequences for the contractor based on performance such as provision of rewards (such as performance bonuses or public recognition) or imposition of sanctions (such as termination of the contract or public criticism) ⁵ .

¹ Contract for Availability and capability in the Defence environment, C.J. Hockley, J.C. Smith, L. J. Lacey, 2011

² A simulation study on maintainer resource utilization of a fast jet aircraft maintenance line under availability contract, P. Datta, A.Srivastava, R.Roy, 2013

³ <http://www.defenseindustrydaily.com>

⁴ Outcome-based service contracts in the defence industry – mitigating the challenges, I. Ng, S. Nudurupati, 2010

⁵ Cost modelling techniques for availability type service support contracts: A literature review and empirical study, P. Datta, R. Roy, 2010

Performance Based Logistic (PBL)	Performance Based Logistics support is usually documented in a contractual arrangement (commercial, organic or combination of both) where the provider is held to customer oriented performance requirements, such as reliability improvement, availability improvement, and reduced delivery times with the end goal of improving logistics support to the war fighter. ⁶
Contracting for Capability	Under a CfC contracting model industry is required to deliver a complete capability which by definition would include operators, maintainers and all the support. ¹
Performance Based Life-Cycle Product Support	Performance Based Life Cycle Product Support (also commonly referred to as Performance Based Logistics or PBL) is an outcome-based product support strategy for the development and implementation of an integrated, affordable, product support package designed to optimize system readiness and meet requirements in terms of performance outcomes for a weapon system through long-term product support arrangements with clear lines of authority and responsibility ⁷ .
Power-By-Hour	Customers who choose this contract type are invoiced by a predetermined rate per flight hour. The benefits for this type of arrangement include: Fixed price to provide predictable maintenance costs and reduction in financial risk. All aspects of an overhaul are covered under one fixed price. ⁸
Service Level Agreement	A Service Level Agreement is a contract type used to define the level of a service that exists between a service provider and their customer. The document includes technical terms for defining the service and it is often part of a wider service contract. A Service Level Agreement can either be an informal contract between parties or a legally binding contract. It may address several areas including the availability of the service, the performance of the service, how it will operate, priorities and responsibilities of involved parties, guarantees and warranties. As well as defining key areas, the Service Level Agreement may also specify a level of service, including targets and a minimum level that can be reached. ⁹

From the statements listed above it is possible to draw some conclusions. There is no clear evidence of big differences among the terms. It also true that each of them presents little hints of particular aspects of the term it refers to. All definitions mainly mention few conditions and terms, in particular referring to a specific kind of deliverable in terms of what needs to be guaranteed, terms of payment (price), relationships between service provider and client. They mainly focus on the peculiarity of providing operational availability through an integrated and effective support solution, generally by industry.

⁶ Performance Based Logistics (PBL) Support Guidebook, S. Bogusz, M. Taylor, 2002

⁷ Performance Based Logistics and Project Proof Point, J. Boyce, 2012

⁸ A proposed framework for managing service parts in automotive and aerospace industries, R. Souza, A. Othman, 2011.

⁹ SLA management in federated environments, P. Bhoj, S. Singhal, Chutani S., 2001

The general meaning that shines through all of them is about a deep shift away from the mere service procurement practices. Customers are now focusing on “what” is required in terms of equipment operations rather than “how” a facility (a spare/repair action) is to be delivered according to set technical specification (Datta, Srivastava, & Roy, 2013).

2.2.1 Risks and uncertainties

Taxonomy for OEMs

Speaking about contracting and risks linked with it, little more specific information can be obtained by looking at the literature. First of all it is important to mention the concept of “different prospective”.

In fact, it is also necessary to keep in mind that there are two main different prospective under which a contract can be analysed in term of risks. Contractors and customers represent two different points of view. They need to know and understand the point of view of the other part. If, from one hand, under contactors’ point of view there are these main points to think about objectives, requirements, standards and measures, on the other hand, customers have the same ones but seen under a different prospective. Indeed, they become benefits, outcomes, performance and metrics (Baines T. , Lightfoot, Peppard, Johnson, Tiwari, & Shehab, 2009).

Contracting implies an agreement between two or more parties; therefore relationship becomes the key word in this context.

The list below represents necessary key points to ensure the development of a long term relationship:

- Project goals and objectives need to be clear for both the parties from the beginning;
- Stage the project can be useful to develop a more detailed and careful schedule, cost estimate and to plan required resources;
- Developing an integrated team ensures that members are competent, capable and available and skilled for different areas of examination (to find all the potential risks involved in the overall);
- Documentation and agreement on scope and expectations represent the starting point for a successful relationship (Chatt, 2011)

OEMs: risks and uncertainties proper to availability contracts

In this section some key risks and uncertainties are listed.

First of all it is important to identify three main areas under which contracts should be analysed and in which risks need to be identified.

- **Operational requirements** – this area implies a research for risks associated mainly with the functionality and performance of items/service provided with the contract.
- **Technical approach** – it focus on risks associated with the technical characteristics of the products and the impact on integrating them into a customer's system
- **Business strategy** – those risks associated with the entire life of the contract. Maintenance and availability of support for the products over time are the main source of issues.

Looking at what it will be stated below, it is possible to understand that the analysis has been carried out concerning a specific area (military and defence).

In this part three tables are provided to have some examples about all those risks and uncertainties that OEMs are used to face when dealing with availability of the equipment requested from their customers. They respectively refer to the operational requirements, technical approach and business strategy. They represent aspects that should be taken into account when an analysis has carried on.

Obviously this list comes together with potential strategies that companies can implement to put risks and uncertainties under control. This part will be discussed in details in the next section when studying risk management processes.

Risks and uncertainties involving Operational Requirements

All these risks can be grouped together. In fact they mainly are derived from good or bad communication with the customer and from the level of detail following which the agreement has been settled.

Detailed requirements need to be specified by the customer and once an agreement has been reached it is important to stick to it.

Modify a contract once the agreement has been established implies higher cost and time.

Table 12 Operational Requirements: risks and uncertainties, (Engert & Clapp, 2001)

Potential Risks and Uncertainties
Availability: fully understanding of level of availability required by the customer and of the systems used to develop and provide product and service
Functionality and Performance: if products are not as advertised, then the system may not meet its requirements.
Requirements Gap: if the product does not match the operational requirements or procedures and these cannot be changed, then products cannot be used.
Security and Safety Issues: if there are stringent security requirements, it is important to consider how to test the system since the beginning (without its implementation)

Risks and Uncertainties Involving Technical Approach

This section involves technical aspects and it mainly links them with conformance and security issues. Some features, like adaptability or portability need to be taken into account in order to ensure to meet customer expectations over time. The most challenging task is to be up to date during the whole project.

Table 13 Technical Approach: risks and uncertainties, (Engert & Clapp, 2001)

Potential Risks and Uncertainties
Conformance to MOD Standards: conformity needs to be ensured to place product on the market.
Conformance to Commercial Standards: conformity needs to be ensured to place product on the market.
Request of capability Integration: check technical experience of the customer to evaluate the option of integration.
Quality Requirements: if product does not meet quality requirements (e.g., reliability, performance, usability) then cost, schedule, and operational capability may be impacted.
Adaptability: if products do not fully support initial and evolving requirements and do not have built-in flexibility, then custom code may be needed or the product may be difficult to integrate with other products and may become unsuitable as the system changes.
Portability: consider alternative building locations and sites, building material and all building needs.
Evolution: compatibility of upgrades or replacements.

Risks and Mitigation Actions Involving Business Strategy

Analyse these risks means having an over view on project duration. In fact, in this area, different customer's characteristic (financial weakness or instability) are analysed in order to avoid a contract failure and ensure payments. At the same time all the business environment is checked to be sure that competitors do not represent threat.

Table 14 Business Strategy: risks and uncertainties, (Engert & Clapp, 2001)

Potential Risk and Uncertainties
Alternatives on the market: monitoring competitors.
Customer Reliability: potential customer's financial weakness or instability.
Cost and Schedule Completeness: consider all the on-going costs when compiling cost and schedule estimate.
Business Skills: skill in establishing long-term relationship.
Statement of Work: keep state of work updated to avoid that cost and schedule slip.

Baseline to the methodology: new facts to consider

As it has been stated in the description, contract for availability implies writing long-term and complete contracts. This represents an important issue that creates a context completely different from the traditional contract environment in terms of risks and uncertainties. Contracts need to be redacted under conditions of imperfect and asymmetrical distributed information that means difficulties in writing complete contingent claims contract, especially when contracts cover a lengthy period of time.

The main reason that explains this situation can be directly linked to an increase in the number of risks and uncertainties due to bounded rationality, opportunism and asset specificity (Parker & Hartley, 2002). The result is obvious: one or the other party of a contract may always run the risk that the other may exploit his or her information advantage.

Here, it can therefore be stated that having good information obviously lows the risk of opportunism but at the same time a big effort is required to both parties to seek out information that will improve their contracting ability. Incomplete information, disagreement between information sources, imperfect communication and variation in circumstances represent, in fact, the main sources of risks and uncertainties (Erkoyunku, Roy, Shehab, & Wardle, 2009).

Risks and uncertainties gain therefore a central role in the bidding phase of these contracts. As the descriptions says, risks represent threats or losses that come with unexpected event while uncertainties refer to the difference between an anticipate outcome and the confirmed one. Risks and uncertainties are transferred from the customer to the supplier. What are the implications of this new approach? An expanded set of uncertainties and risks need to be considered to draw a contract up that is both profitable for the supplier and affordable for the customer (Erkoyunku, Roy, Shehab, & Wardle, 2009). The duration of contract for availability is typically from 10 to 30 years and there is usually an agreement between parties to periodically re-baseline terms and conditions at shorter intervals. Thanks to these iterations, estimations become smaller.

Figure 5 shows uncertainties reduction during the duration of a project.

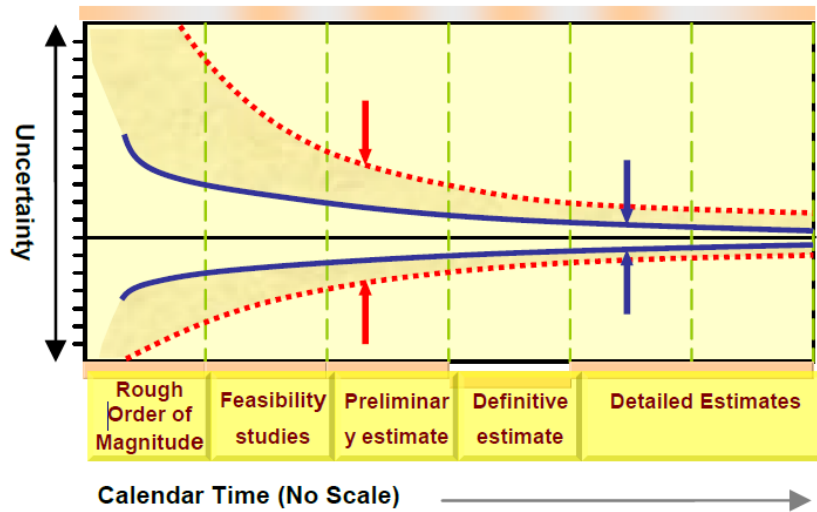


Figure 5 Estimating accuracy trumpet (Erkoyunku, Roy, Shehab, & Wardle, 2009)

However, companies need to quantify risk and uncertainties sufficiently and with an adequate levels of confidence to guarantee affordability (customer side) and profitability (internally and supply chain side). This is not possible until the assessment stage, when uncertainties can be studied and analysed with more accurate estimating methods. A framework is generally used to manage uncertainties.

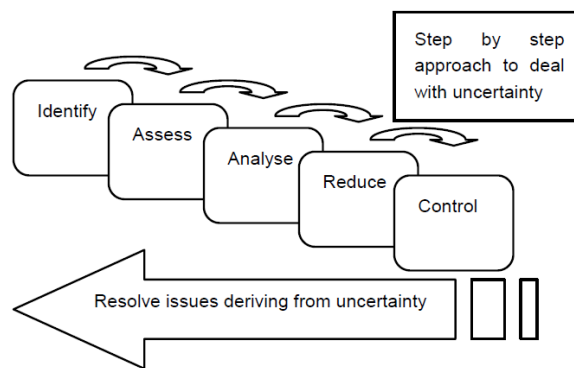


Figure 6 Managing uncertainty (Erkoyunku, Roy, Shehab, & Wardle, 2009)

The main challenge faced by suppliers in dealing with uncertainties is to be confident with estimations in order to ensure their own profitability as risks have been transferred from customer to them. Moreover, the trend from traditional contracting towards availability contracting sustains another challenge, to be confident in the affordability of their offering (e.g. to be assured of both winning the bid in the competitive situation, and of winning the value-for-money argument with the customer in the single bid situation). (Erkoyunku, Roy, Shehab, & Wardle, 2009).

This issue has obvious consequences on cost estimation of a project. Risks and uncertainties are difficult to segregate and therefore difficult to be considered in calculations. Often they are incorrectly categorised, causing unreliability. This problem usually occurs quite often during the whole life of a project and not only at the very beginning because once a risk register has been created risks and uncertainties may change. Time becomes an enemy in the analysis and causes troubles to the supplier in analysing and estimate risks (Erkoyunku, Roy, Shehab, & Wardle, 2009).

Moving from traditional contract towards those based on availability, a wider set of risks and uncertainties need to be considered. Speaking about the service delivered with this type of contracts, different components can be seen as primary elements of the system behind: demand, supplier capacity, supplier-customer interaction and organisational culture (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010).

Figure 7 shows the main elements that need to be considered in analysing CfA.

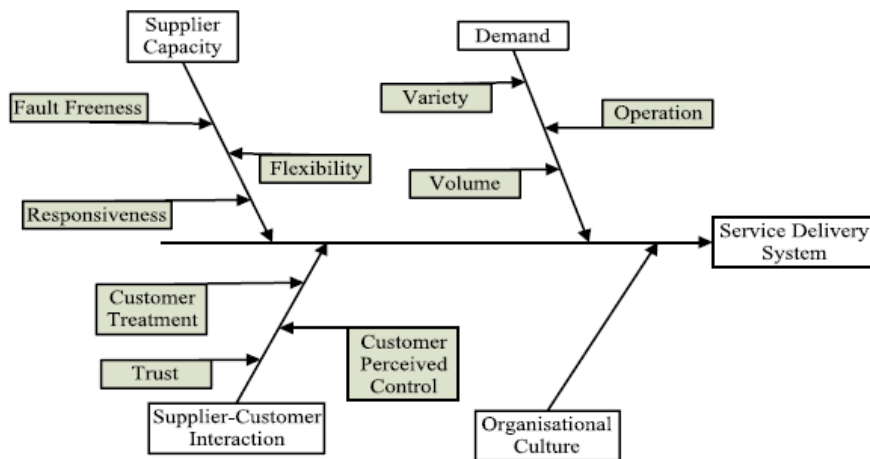


Figure 7 Managing a Service Delivery System (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010)

Figure 7 helps therefore in having in mind all the components that need to be analysed in terms of risk and uncertainties, not only at the bidding phase, but within a process that goes through the whole life of the project.

Risk and Uncertainties classification

Further considerations come because of the strong alliance behind the contract. Two new and main aspects need to be taken into account: relationship and performance. Relational risk is concerned with whether the co-operation among partners will go smoothly.

Performance risk involves the prospect of achieving the strategic goals of the alliance, given full compliance by all partners.

These two types of risk are conceptually independent to each other because they are rooted in two different domains: one in inter-firm co-operation and the other in the competitive environment (Das & Teng, 1996).

To be more specific, relational risk address to problems within the relationship between partners. This means that parties do not fully commit themselves to join efforts. In other words, it could happen that partners do not row in the same direction, toward mutual interests, as it was expected from the contract.

Speaking about performance risk, it can be used to consider all the events that lead to an incomplete and unsuccessful achievement of goals, although all parties co-operate fully. Therefore, that means consider all types of hazards except those linked with cooperation. They can lead to the failure itself of the relationship or increase the magnitude of loss from the alliance (Das & Teng, 1996).

This macro categorisation can be seen as comprehensive of all the potential scenarios that should be considered at the beginning of a project and during its development. In this way, it is possible to work to keep the most serious effects of risk under control:

- Failure to keep within the cost estimate;
- Failure to achieve the required completion date;
- Failure to achieve the required quality and operational requirement (Syed, Riaz, & Darshi De Saram, 1999).

As well as risks, uncertainties need a deeper analysis in order to obtain a better accuracy while estimating costs. It is a necessary step in order that availability contracts can be successfully negotiated and delivered in the future. The main uncertainties can be summarised in Figure 8. Data have been collected based on interviews.

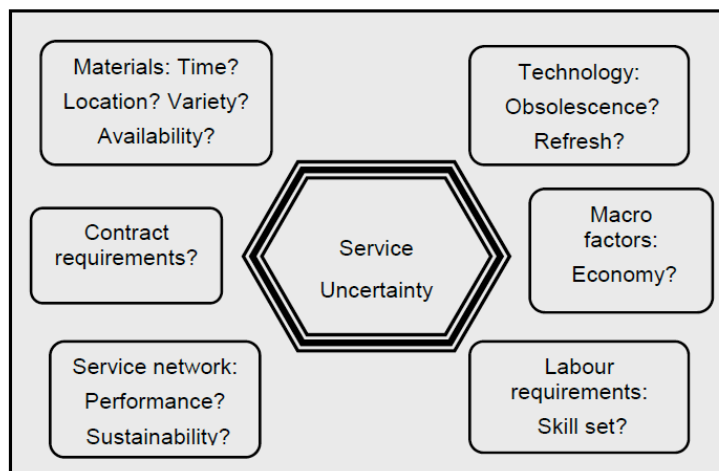


Figure 8 Types of Uncertainty (Erkoyunku, Roy, Shehab, & Wardle, 2009)

Along with this categorisation, it is also important to understand how those uncertainties evolve over the life cycle of the project (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010).

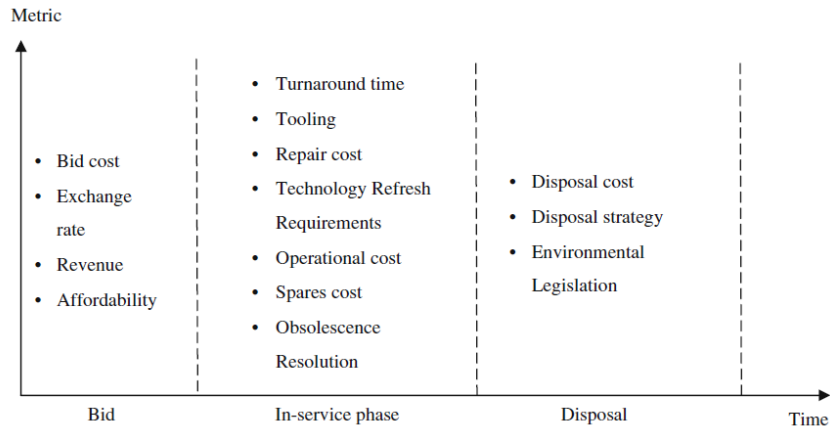


Figure 9 Evolution of uncertainty from service bid to disposal (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010)

Before going in deeper details about uncertainty, it is important to mention the fact that mainly affects the quality of the provided service and the productivity rate for resources: the match between supply and demand. That is the reason why uncertainties that arise from demand and supply are the main challenges that need to be faced. The uncertainty in demand may occur from the complexity (dependent on know-how) of the delivered equipment, the machine usage conditions/environment, or usage levels, along with the customer willingness to pay level. On the other hand, the uncertainty in supply may get influenced by resource availability and the capacity across the service supply chain (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010).

Table 15 Source of Uncertainty (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010)

Service demand uncertainty		Service supply uncertainty	
Type	Nature	Type	Nature
Reliability	Aleatory	Mean time to repair	Aleatory-epistemic
Availability	Aleatory	Supply chain: capacity, capability	Aleatory-epistemic
Mean time between failure	Aleatory	Human involvement	Epistemic
Scope of service	Epistemic-aleatory	Fault freeness	Epistemic
Delivery urgency	Aleatory	Responsiveness	Aleatory
Difference across customer demand	Aleatory	Repair time	Aleatory
Maintainability	Epistemic-aleatory	Maintenance requirement	Aleatory
Obsolescence	Epistemic-aleatory	Stock level	Epistemic

As it can be seen from the Table 15 sources of uncertainties are listed in the table together with their main characteristic. Epistemic or aleatory. As it has been stated at the very beginning of the report, uncertainties identified with the former are mainly caused by a lack of information while aleatory refers to something that cannot be controlled.

Supplier and customer relationship

CfA involves therefore serious issues due to long-term contracting and risks and uncertainties that during the whole duration of this alliance arise from supply and demand side. As it has been mentioned before, relationship between parties assumes a central role as well as controlling the performance during the entire period of the assets. Customer themselves may perform important tasks and therefore evaluating the final output becomes more difficult due to their involvement (Datta & Roy, Incentive issues in performance-based outsourcing contracts in the UK defence industry: a simulation study, 2012). It becomes important to understand the difference in terms of risks and responsibilities between supplier and customer. Performance, for example, tends to be a responsibility for the supplier, including the transfer of the risk for investments, ownership, maintenance, utilised capability, recycling and resale (Glas & Essig, 2008). Overall, PCB better aligns risks and incentives between supplier and customer, compare to traditional contract. In fact, in those contracts customers delegate some risks to the supplier, specifying the output they want (Kim, Cohen, & S., 2007).

Moreover, establishing relationships that support those contracts involves an internal and external re-organisation of the companies. Externally, because of the need of work closely with partners, companies have to connect their capabilities with suppliers and customers' ones. Research about this topic, allows this paper to report only a summary of the changed prospective. Four points represent the main bullet points that better express the idea behind the re-organisation: (1) from product-based value to total value in the customer relationship, (2) from short-term transactions to long-term relationships, (3) from core product (goods or services) quality to total customer perceived quality in enduring customer relationships and (4) from the production of technical solutions as the key process to developing total perceived quality and value as key processes (Datta & Roy, Incentive issues in performance-based outsourcing contracts in the UK defence industry: a simulation study, 2012).

Concrete examples come from the need of spare parts. In a tradition contract, when a piece of equipment broke, the supplier would provide a new one. This has represented a big business for suppliers, because spare parts create more work and therefore more revenues. Contract for availability completely changed the rule of the game. A mutual interest need to be followed. Industries are now required to minimize downtimes and the need of spare parts, providing reliable and capable equipment. Personal benefits take a second place to the overall goal of providing availability. CfA become the only way of ensuring this kind of support in reaching this purpose, thanks to the terms of the contract themselves. The contract itself, assume therefore a central role in managing risks and uncertainties and, thus in the success itself of the partnership.

In fact, each contract has different implications in terms of incentives, responsibilities and risk allocations. Different purchasing contracts include fixed price, cost-plus contract, cost-reimbursable contracts, and output-based contract. In fixed-price all the risks are bear by the supplier with an advantage of few performance incentives. In a cost-plus contract, risks are shared between customer and supplier but with few or no incentives for the supplier to reduce cost (Kim, Cohen, & S., 2007). On the opposite side, availability contracts promote partnered approaches in which assets are managed to reduce maintenance and support cost, such as training, repairs and logistics. In this way partners' benefits are much more aligned. In fact, if on one side customers can count on more reliable equipment and lower operating costs, on the other, suppliers have a stable source of revenues (Datta & Roy, Inentive issues in performance-based outsourcing contracts in the UK defence industry: a simulation stady, 2012).

This part is fundamental for the further steps that represent the core part of the thesis. In fact, with the purpose of developing a proper methodology to help companies in surviving to this new setting, a full understand of the current situation is necessary.

With this section, it has been possible to identify all the new risks and uncertainties that need to be taken into account and also have in mind all the peculiarities brought to OEMs business by the contract and the new rules of this trend.

Here

Table 16 briefly reports the main changes brought together with the advent of servitization and the utilisation of contract for availability. They should be used as a starting point to make current practices up to date.

Table 16 Main changes

Main changes
<ul style="list-style-type: none">- Longer term contracts- Imperfect and asymmetrical distributed information between parties- Bounded rationality, opportunism and asset specificity- New roles and responsibilities for both parties (difference in sharing risks)- Confidence in the affordability of the offer (cost estimation of the project)- Time pressure- Many components to consider when set risk management procedures (demand, supplier capacity, supplier-customer interaction, organisational culture)- Alignment of goals of parties- Deeper consideration of both relationship and performance- Wider set of requirements (cost estimation, deadlines, quality and operational requirement)

New risks and uncertainties sources together with all the peculiarities that companies need to face when placed in this new context have to be the new awareness to be ready in handling all the issues that rise. That means developing a new methodology with a strong logic behind it in order to be sure to consider all these new aspects.

CHAPTER 3

RISK AND UNCERTAINTY MANAGEMENT

Once all the risk and uncertainty factors have been obtained thanks to a deep analysis of this specific context, it is necessary to understand how to manage them. For this reason, in this chapter a detailed research of risk management has been carried out.

First, it has been tried to find a definition from which to start. It is a fundamental step to proceed since there are many different terms and definitions and it can be useful to set a unique point of view.

To do that, an analysis of different points of view has been done. The attempt has been to find those authors who dealt with this topic in a systematic way and gave a definition linked with the specific context of the thesis.

For this reason, Frank Knight and Michael Hubbard's works together with those ones of Aven and Michael Mauboussin have been checked.

Then, risk management current processes and practices have been studied and summarized paying particular attention to availability contract. In this way it is possible to create a mind-set to build a new methodology based on how usually risks are handled, but with new features to properly consider a different environment.

The chapter ends with a brief analysis of cost-benefit analysis as well as opportunity management process. These two topics have been included in the thesis to have a complete overview also of other aspects.

While the first one is widely discussed in the literature and used as a way to make a choice among different mitigation strategies, the second is a less common topic. That is the reason why it is here analysed with the purpose of paying attention also to opportunities while implementing risk management processes.

3.1 Risks and uncertainties definition

Nowadays we are living in a world surrounded by uncertainty. Therefore businesses need to develop attitudes and practices to manage the uncertainty. Risk and uncertainty management is a procedure that, if correctly developed and applied, enables companies to optimize their decision making process, helping them in dealing with and facing risk and uncertainty.

Considering what has been described in the chapters above, a great level of attention needs to be paid when developing contracts. Referring to contract for availability, complexity becomes even higher. Risks and uncertainties are hidden behind every corner of this setting and need therefore to be deeply analysed since the very beginning to succeed in the implementation of this kind of relationship. Contracts represent in fact the place where manager should put big effort to protect the business from uncertainties.

The entire process starts with “Identify risk . . . and manage it according to the company’s risk appetite,” as Gary Patterson (Patterson, 2012) said in his book, *Million Dollar Blinds Spots: 20/20 Vision for Financial Growth*.

However, in order to measure something it is very important to understand and have clear in mind the meaning of each object of measurement. A wrong understanding and consequently wrong actions and decisions can seriously harm economic results.

The likelihood of running this risk is rather high. There is no common understanding of risk and uncertainty. Even among experts in this field there are no common definitions and their meanings still remain ambiguous.

There are lot of mutually exclusive ideas about risk, uncertainty and their management processes. To reach any progress, it is necessary to develop a solution to deal with differences.

Companies need their own “vocabulary” and concepts before starting any process to deal and manage any risks.

3.1.1 The state-of-the-art

Looking at the literature to have an idea about the-state-of-art, it is clear that no agreement has been reached on what the words “risk” and “uncertainty” mean. Actually it is not a simple issue: multiple definitions and undifferentiated use of them can easily be found in different papers and journals.

These concepts appear in varying formats and have been covered in many articles. Looking at their explanations, it is possible to find either that different sources share common expressions to describe them or use completely different terminologies.

Terms and definitions

Table 17 and

Table 18 describe both the common and the different use of terms.

First of all, it is important to mention the reason why these sources have been chosen among several ones. During the development of this section, several papers, documents, journals and web sites have been studied to identify the main schools of thought about these definitions. Once all the relevant papers have been collected, the selection of papers suitable for the purpose has been carried out following these key points:

- Using papers in which definitions are clear and unambiguous;
- All the possible aspects under which these concepts could be analysed have been take into account;
- Progress and changes over time;
- Expertise in different fields (try not to be just linked with industrial and economic environment)

Uncertainty

Definitions for key terms related to uncertainty are provided below

Possibilities

As it can be seen from the tables, the concept of uncertainty is mainly linked with the possibilities of having more than one potential scenario in the future and concept that they are unknown. One of the causes can be identified in the lack of information.

Ambiguity

The potential existence of ambiguity is also mentioned. Therefore authors link ambiguity with lack of clarity and the existence of multiple meanings.

Aleatory and epistemic

Moreover, others terms have been used to define them: aleatory and epistemic. Their meanings are respectively linked with randomness and lack of knowledge concerning a situation. They will be described in more details in the next section.

However, this briefly description is enough to understand the importance of the role played by knowledge and general randomness in causing uncertainty.

However, they do not represent very widespread thinking, probably because of the complexity of their meanings.

Probability

The concept of probability is stressed as well. Common opinion is the possibility of calculating the probability of the occurrence of potential outcomes. Actually this point of view came after Knight's perception of uncertainty, changing completely his point of view.

Risk

Definitions for key terms related to risk are provided below.

Loss and negative consequences

First of all, as it can be seen from the X-shape in the cells, risk is mainly linked with loss and negative consequences.

Uncertainty

At the same time, for many authors the concept of risk involved uncertainty. This means that uncertainty can be considered an umbrella-term that includes risk and not vice versa.

On the contrary, it is not common opinion considering risk a potential opportunity. Following this statement it is possible giving rise to consider opportunity a part of uncertainty.

Event-triggered

To conclude, it is also important to mention the fact that risk is event-triggered. That means identifying, or looking for, a specific event whose occurrence causes the exposure to loss and therefore underlining that this situation differs from a general uncertain situation with its effect on the future.

Sources of definitions are reported in the References section.

Table 17 Keywords used to define uncertainty

Uncertainty	Possibilities	Unknown Outcome	Assigned Probabilities	No Probability	Estimates	Threats/ Opportunity	Ambiguity	Lack Of Info/Knowledge	Epistemic	Aleatory
Hubbard	X	X	x							
Knight, F.				X	x					
Grote, G.(2009)	X	X					X	x		
Erkoyuncu, J. A.		X								
Bernstein, P. L.		X								
AACE (2009)						X	X			
Paté-Cornell, E.	X		x							
McVean, J.R'	X									
May, R. (2001)								x		
R. J. Budnitz, (1997) ⁽									x	x
Gough, J., (1988)	X		x				X			
Baker, B., (1984)	X							x		
Alfredo, H. S., Wilson, H.									x	x

Table 18 Keywords used to define Risk

Risk	Exposure to loss	Event triggered	Opportunity	Knowable Probability	Uncertainty	Hazard	Negative Consequence
Hubbard D. W.	x			x	X		x
Knight, F.				x			
Erkoyuncu, J. A.	x				X		x
Bernstein, P. L.	x						x
AACE, (2009)							
Paté-Cornell, E				x	X	x	x
McVean, J.R.	x						
May, R. (2001)							
Gough, J., (1988)	x	X	X		X	x	
Rowe, W. D., (1977)	x	X	X				

Knight, Hubbard Aven and Mauboussin

Despite the multiple meaning and ideas about these risk and uncertainty, two main points of view (Knight vs. Hubbard) are the most largely widespread and followed by economists, academics, professionals but also business managers. For these reason this report states their points of view. Looking at different papers, it appears, quite clearly, that most of the authors refer and cite these two definitions and share therefore the idea.

The authors of these two trends are Frank Hyneman Knight with his book “Risk Uncertainty and Profit”, in which he gave his point of view and Douglas W. Hubbard that mainly proposes a different opinion of the topic that seems to summarise the popular and practical use of the terms. Despite Hubbard’s work is mainly focused on solving current business issues, in his books he clearly gives his opinion about risk and uncertainty, putting himself in contrast with Knight’s perception.

Knightian risk and uncertainty are linked with the concept of probability. In fact Knight defined risk as “events subject to a known or knowable probability” and uncertainty as “events for which it is not possible to specify numerical probabilities” (Knight, 1921).

He based his definitions on a threefold classification of unknown outcomes. (1) A priori probabilities, which are derived deductively, as in rolling dice; (2) statistical probabilities which are generated by empirical evaluation of relative frequencies, as in a life insurance; and (3) estimates, in which “there is no valid basis of any kind for classifying instances” (Knight, 1921). Knight categorized risk with points (1) and (2) and uncertainty with (3). He defined two different kinds of uncertainty: the first one measureable and the second one un-measurable. He identified the former with the term “risk” and the latter with “uncertainty”.

According to Knight, we have uncertainty when we are unable to quantify the probabilities of various outcomes whereas risk applies to situations where the odds of various possible outcomes can be known (Knight, 1921).

On the other hand, looking at Hubbard’s works, the definition of risk and uncertainty appears completely conflicting with Knight’s view. Hubbard clearly defines these concepts in each book he published and he states exactly this distinction:

- Uncertainty: The lack of complete certainty—that is, the existence of more than one possibility. The “true” outcome/state/result/value is not known.
Measurement of uncertainty. A set of probabilities assigned to a set of possibilities. For example, “There is a 60% chance it will rain tomorrow, and a 40% chance it won’t.”

- Risk: A state of uncertainty where some of the possibilities involve a loss, injury, catastrophe, or other undesirable outcome (i.e., something bad could happen).

Measurement of risk. A set of possibilities each with quantified probabilities and quantified losses. For example, “We believe there is a 40% chance the proposed oil well will be dry with a loss of \$12 million in exploratory drilling costs.” (Hubbard, 2009).

After analysing these two different opinions it is almost impossible to find any common point, which may create confusion. Knight never implied the concept of loss as part of risk. The core of its meaning is just the possibility of measuring probability of outcomes. Moreover, by defining uncertainty as “un-measurable”, his definition results in contrast with researchers and professionals’ point of view. These focus on “uncertainty quantification”. Actually, Knight’s definition of risk is what most others would call uncertainty.

With his distinction, Hubbard seems to express the common understanding of the terms. He directly mentions that his point of view is widely spread among people and easy to understand. Being against Knight’s view, he states: “... it was generally understood that uncertainty can be represented quantitatively by probabilities and that risk must include loss.” (Hubbard, 2009).

Moreover, other different aspects need to be taken into account when describing risk and uncertainties definitions. For this reason, this paper state another point of view about this topic to provide a detailed overview that encompasses all those features linked to this word.

Following his studies, Michael Mauboussin in his book “More Than You Know: Finding Financial Wisdom in Unconventional Places” comes out with a short definition that tries to separate the concepts behind the two terms: “Risk has an unknown outcome, but we know what the underlying outcome distribution looks like. Uncertainty also implies an unknown outcome, but we don’t know what the underlying distribution looks like. So games of chance like roulette or blackjack are risky, while the outcome of a war is uncertain. Knight said that objective probability is the basis for risk, while subjective probability underlies uncertainty” (Mauboussin, 2013).

However, for the purpose of this paper it is important to look for a different point of view about this topic. What has been stated above, in fact, succeed in giving a general overview about the terms and their everyday usage but it lacks of a systematic and technical prospective.

In fact, this paper applies the concepts behind these two terms to a particular sector, where risks are not only linked to operations but, most of all, they are closely link to requirements and performance of technological and complex systems. Therefore a deep analysis of this context has been undertaken. In particular, great attention has been paid to Aven’s works.

Analysing different papers, for technological applications, risk has commonly been considered as expected loss and as the pair of losses and probabilities (Aven, 2012)

In particular, a definition that actually encompasses the common understanding has prevailed: “risk is equal to the triplet (s_i, p_i, c_i) , where s_i is the i^{th} scenario, p_i is the probability of that scenario, and c_i is the consequence of the i^{th} scenario, $i=1,2, \dots N$; i.e., risk captures: What can happen? How likely is that to happen? If it does happen, what are the consequences?” (Aven, 2012)

As we previously mention, this explanation is actually what different papers state. In fact, two other examples of definitions of risk capturing more or less the same ideas: risk is a measure of the probability and severity of adverse effects (Lowrance, 1976) and risk is the combination of the probability and extent of consequences (Ale, 2002).

These perspectives on risk are all probability-based, and several authors have argued that these perspectives need to be replaced by broader risk perspectives which are not linked to one specific measure of uncertainty, namely probability. Aven is one of them. In particular he stated that additional characteristics need to be considered when describing risk. In his new risk prospective, the analysis should not be based only on probability but further insights can be provided by considering aspects such as knowledge and lack of knowledge, as well as potential surprises/black swans. Figure 10 shows what the new prospective encompasses.

The new risk prospective

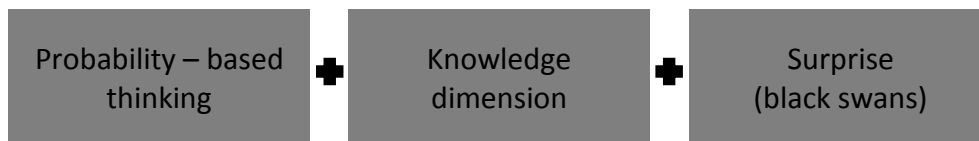


Figure 10 Basic features of the new risk perspectives compared to the traditional probability-based perspectives (Aven, Practical implications of the new risk perspectives, 2013)

Therefore, it becomes important to address to risks in a different way. Basically, this means having a complete different output from the risk assessment phase. In fact, it will now produce a risk description that covers identified events and consequences, assigned probabilities, uncertainty intervals, strength of knowledge judgements, as well as considerations about black swans.

The assessment and its results provide insights that the decision maker and other stakeholders can use to support the decision-making and their views on relevant issues, such as choosing between alternatives, the implementation of risk-reducing measures, etc. (Aven, Practical implications of the new risk perspectives, 2013).

The importance of citing this new prospective lays in the fact that it completely changes how risks are described, communicated and managed.

In other words, this approach changes the rules. Considering knowledge and surprise effect as new aspects of risk changes completely the information gathered during the risk assessment phase and therefore affects the decision making process.

Other terms used in the literature

Moreover, it is also necessary to have a large-scale picture of the context in which ambiguity, variability, epistemic and aleatory uncertainty, opportunity are largely used. Others words appear frequently when this topic is handled. Usually they try to explain risk and uncertainty meanings under a 360° view, including different features that characterized these concepts

These terms are, in fact, different scenarios which companies and project managers need to deal with. An understanding of the term definitions may help to identify events that can impact on the performance, to manage the effect and mitigate it.

Starting with ambiguity, it differs from uncertainty. A question arises: “What is different between a situation that is characterized by a lack of information (uncertainty) and a situation characterized by a lack of clarity (ambiguity)?” (Martinez, 2011).

The former, as it has been said, describes a situation in which the problem solver does not know the characteristics of potential outcomes yet. However, he has a sufficiently clear understanding of the problem structure. On the other hand, problem solving under ambiguity is characterized by an unsatisfactory understanding of the problem structure. The solver has no mental model that can guide the problem solving process. This lack of understanding is mainly caused by multiple meanings and prospective. Situations are analysed under different point of views, without recognizing which one is the right one.

At the same time there is an important distinction between variability and uncertainty; the two should not be used interchangeably and kept separate in risk analyses.

Variability is the effect of chance and a function of the system. It is not reducible through either study or further measurement (may be reduced through changing the system) because it is a property of the system. It is an attitude of a general phenomenon to appear under different ways and modalities. (Insureware)

An important aspect in this context is also the distinct and separate treatment of aleatory and epistemic uncertainty.

These two types of uncertainty are defined by SSHAC, Senior Seismic Hazard Analysis Committee as:

- Epistemic: the uncertainty attributable to incomplete knowledge about a phenomenon that affects our ability to model it.
- Aleatory: the uncertainty inherent in a nondeterministic (stochastic, random) phenomenon.

Epistemic uncertainty is due to limited data and knowledge, therefore it may be reduced with time as more data are collected and more research is completed. Aleatory uncertainty, on the other hand, cannot be reduced by further study, as it expresses the inherent variability of a phenomenon and it represents the natural randomness in a process. (R. J. Budnitz (Chairman), 1997)

Errors as well are linked with uncertainty. They become an obvious consequence of this lack of clarity. They can be defined as a state or condition of being wrong in conduct or judgement.

Does it mean that uncertainty is synonymous of error? It is important to clarify the difference in order to avoid that they are considered interchangeable. In fact, uncertainty in the environment can cause error in measuring and forecasting, but this does not mean that these two terms represent the same concept.

Uncertainty cannot be avoided but it can sometimes be reduced by gathering more information and changing measurement systems. At the same time, the uncertainty itself prevents to have the complete control of the situation. Therefore, it is perfectly possible to analyse a situation in a very accurate way and be erroneous at the same time. Indeed, uncertainty creates the possibility to get wrong results and it also makes it hard to know when you are making an error (School Science and Technology Resource Center).

3.1.2 How to manage multiplicity of terms and definitions

As said before, what has been stated above leads to inconsistency of the use of the terms “risk” and “uncertainty”. However, it does not mean that it is impossible to shed some light on this matter. To reach clarity further details need to be added. It is important to define them in a way that is relevant to the decisions that need to be taken in this context.

What is the impact of risk and uncertainty in Contracting for Availability? What are the implications of a management process?

Identify a definition

Because of the multiplicity of terms and definitions a common idea will be difficult to be developed. Using concepts from literature a questionnaire has been developed with the aim of avoiding any misunderstanding between the terms. These require simple yes/no type responses to the questions in order to differentiate the risk and uncertainty meanings. To identify uncertainty (risk) in these questions, the answers have to be those ones marked with “x” in the cell.

Table 19 questionnaire to identify Risk or Uncertainty

QUESTIONS (x refers to when it is risk or uncertainty)	YES	NO
UNCERTAINTY		
• Do I know all the potential scenarios that could occur and know which one will occur (taking into account the context)?		X
• Is there just one possible outcome?		X
• Is my level of knowledge enough to have a clear picture of the future?		X
• Are there many possibilities involved in the outcome?	X	
• Can more than one scenario be generated in the future?	X	
• By gathering more information could I improve my understanding and know that there will be just one outcome?		X
RISK		
• Is there any possibility to have an “undesirable outcome”?	X	
• Is the outcome event triggered?	X	
• Could the outcome be linked with hazard?	X	
AMBIGUITY, EPISTEMIC & ALEATORY UNCERTAINTY AND OPPORTUNITY		
• Could there be more than one point of view in interpreting data? (Ambiguity)	X	
• Do you have a lack of knowledge or information? (Epistemic uncertainty)	X	
• Do you perceive that the cause is natural randomness? (Aleatory Uncertainty)	X	
• Could a threat of loss reveal a chance of realizing opportunity? (Opportunity)	X	

As a matter of fact, in this context risk managers need to be aware of the existence of different explanations and at the same time have a clear understanding of the specific meaning that is selected and the reason why all the others have been rejected.

It is easier to find people that share Hubbard's point of view. In fact a simple test is proposed to demonstrate that Knight's prospective is neither easy to understand nor commonly used. A quick questionnaire demonstrates this.

1. "If I were to flip a coin, would you be uncertain of the outcome before I flipped it?"

2. "What is the chance that the outcome will be tails?"

3. "Assume you are not betting anything on the flip or depending on the flip in any other way. Do you have risk in the coin flip?"

(Hubbard, 2009)

By asking these questions to people it is probable that these results would be reached:

Almost anyone you asked would answer "yes, 50%, and no." Knight's definitions would have to answer "no, 50%, and yes". The answer to question number 2 asserts that probability can be quantified. Knight's point of view has been refuted; Knight would have to say a coin flip is not uncertain (he says uncertainty is immeasurable) even though almost anyone would say it is.

This means that it would be easier trying to understand this definition rather than fully understanding Knight's opinion.

This section proposes therefore, a definition of these two terms. In this way, going through the document, there will be no doubts or misunderstandings about the meaning and use of risk and uncertainty.

Thanks to its easier understanding, Hubbard's definition has been chosen for this thesis and reported below.

- "Uncertainty. The lack of complete certainty—that is, the existence of more than one possibility. The "true" outcome/state/result/value is not known.
- Risk. A state of uncertainty where some of the possibilities involve a loss, injury, catastrophe, or other undesirable outcome (i.e., something bad could happen)." (Hubbard, 2009)

In other words, this paper states a unique point of view about this topic.

Uncertainty can be seen as a property of a system, an event, a performance while risk becomes the measurement system to define the entity of the impact of uncertainty.

3.2 Risk And Uncertainty Management Process

3.2.1 Introduction

Once uncertainty is part of the environment in which the project will be developed, it becomes necessary to be able to deal with it. This means choosing and adopting the most appropriate risk management process in order to identify potential risks and mitigate their effects.

3.2.2 Risk management process

A risk management process represents a series of steps that enable users to identify, analyze and prioritize risks in order to develop mitigation strategies to reduce, avoid or transfer the effects of impact.

Despite some differences exist among the approaches, all of them are structured in a similar way; five steps represent the guideline of the implementation.

- 1- Plan risk management
- 2- Identify risks
- 3- Risk analysis
 - Quantitative risk analysis
 - Qualitative risk analysis
- 4- Plan risk responses
- 5- Monitor and control risks



Process steps

Once a risk management process has been planned, the starting point is represented by an analysis to identify the existing and potential threats that could impact on the performance of the project. It is important to consider all the sources from which these threats can come. Brainstorming, surveys, questionnaires, SWOT analysis can be useful tools to complete this first step and generate a risk register. Template for risk categories can also be helpful to simplify this task.

Working with the risk register, it is possible to analyze and prioritize the risk that might occur. Probability and impact matrix together with expert judgment represent the best technique to carry on this phase. It is important to obtain a top risk list on which risk managers can focus and reach a deeper level of detail. In this way focused solutions can be developed.

Once top risks have been identified, mitigation strategies need to be developed. At this step it is important to understand which approach the risk management board would like to adopt. Risks can be faced in different ways, achieving different results. The main criteria to mitigate threats are:

- Risk avoidance
It is a proactive risk control following which activities that could carry risks are avoid.
- Risk reduction
It is a preventive risk control that tries to reduce the loss and the likelihood of potential loss
- Risk transfer
It is a corrective risk control that aims to transfer the risk to a third party in order to directly avoid the impact and its effect
- Risk acceptance
It is a corrective risk control that is adopted when the costs to manage risk and its impact are considered acceptable. (Berg, 2010)

Once also this step has been complete, it is crucial to regularly review the entire process. Through a variance and trend analysis, technical performance measurement and status meetings, new risks can be identified, the current ones can be reassessed and the outdated ones can be closed. Only in this way everything will be periodically updated. This could mean re-doing the risk analysis, test mitigation strategy and developing new and more appropriate ones. (Rajabi & Virkus, 2011)

3.2.3 Six Standard processes

Risk management is a constantly evolving discipline. However, six standard processes have been developed that can be considered the most common and implemented ones among different companies and contexts.

- ISO 31000: 2009
Risk Management - Practices and Guidelines
- OCEG "Red Book" 2.0: 2009
GRC Capability Model
- BS 31100: 2008
Code of Practice for Risk Management
- COSO: 2004
Enterprise Risk Management - Integrated Framework
- FERMA: 2002
A Risk Management Standard
- SOLVEN CY II: 2012
Risk Management for the Insurance Industry

General purposes

Among these different strategies it is possible to identify common aspects and differences. First of all, all of them generally aim to reach one of the following purposes:

- Meeting or exceeding an organization's objectives
- Adhering to control-based objectives, rules and/or controls
- Complying with regulatory requirements.

It is important to have clear in mind the main desired objective and a risk management strategy in order to identify the most suitable standard for the organization purpose.

- ISO 31000:2009

It is a process that mainly focuses on helping the organization to improve its cost performance. Through the measurement of deviations between expected and actual outcomes, it helps the organization in achieving its desired objective.

It is very simple to implement and it can be adapted to any kind, size or type of business and it guarantees flexibility in its practices

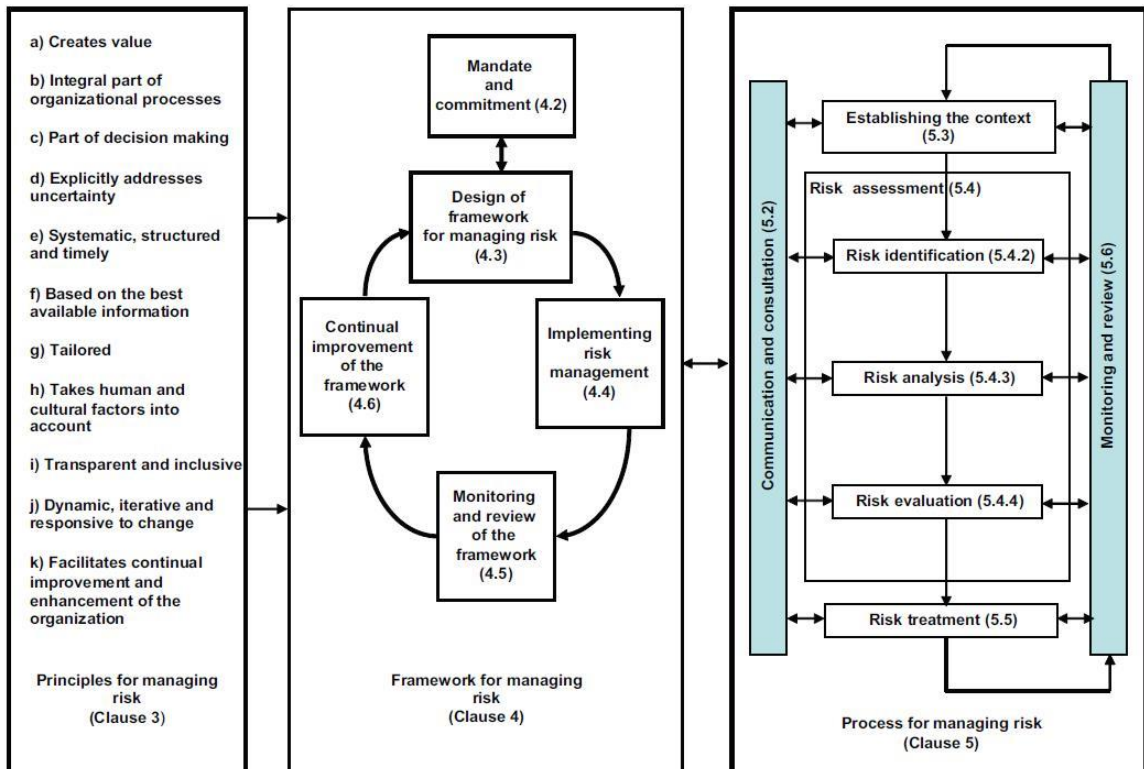


Figure 11 ISO 31000 - Risk Management

- OCEG “Red Book” 2.0:2009

The Open Compliance and Ethics Group (OCEG) describes itself as “a nonprofit think tank that helps organizations drive principled performance by providing standards, tools and resources that enhance corporate culture and integrate governance, risk management, compliance, internal control and ethics processes.”

The utilization of this approach aims to reach one of these outcomes:

- Achievement of business objectives
- Enhancement of the organizational culture
- Increase in stakeholder confidence
- Preparation and protection of the organization
- Prevention, detection and reduction of adversity
- Motivation and inspiration of desired conduct
- Improvement in responsiveness and efficiency
- Optimization of economic and social value

Therefore it is clear that through response plans, this method aims to mitigate and control the risks.

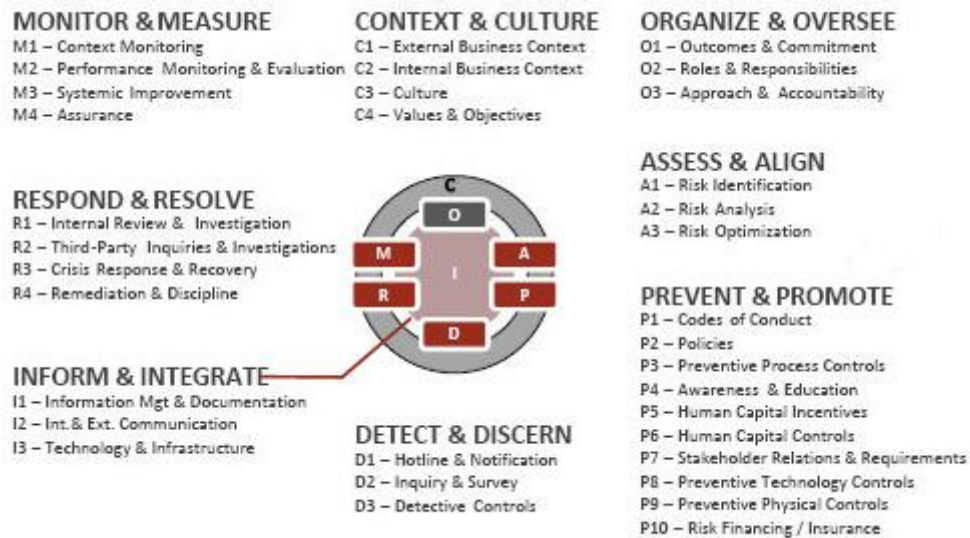


Figure 12 OCEG “Red Book” 2.0: 2009 GRC Capability Model Elements

- BS 31100:2008

The main advantage of this process is its adaptability to any kind of level within the organization: from strategic to operational perspective.

As it has been stated for OCEG method, also in this context it is possible to identify the following main objectives that can be reached with its implementation:

- Ensuring an organization achieves its objectives
- Ensuring risks are proactively managed in specific areas or activities
- Overseeing risk management in an organization
- Providing assurance on the effectiveness of an organization’s risk management
- Reporting to stakeholders through disclosures in annual financial statements, corporate governance reports and corporate social responsibility reports

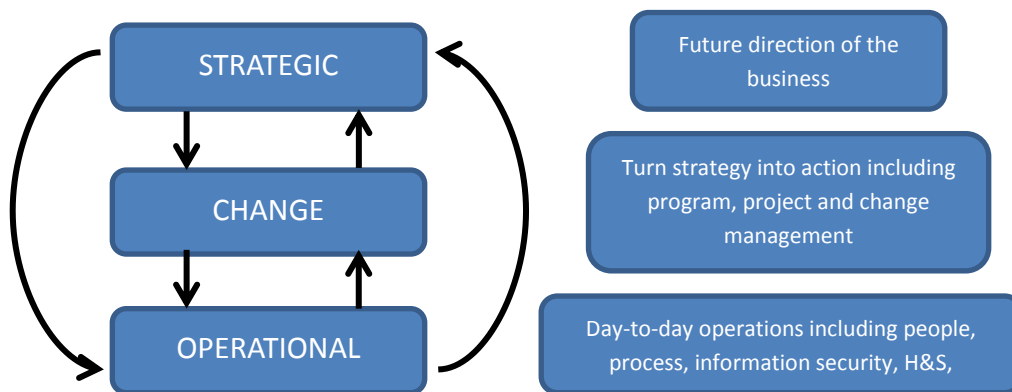


Figure 13 BS 31100: Risk Management Perspective

- COSO: 2004

The main objectives of COSO approach are:

- Understand the entity’s risk philosophy and concur with the entity’s risk appetite.
- Know the extent to which management has established effective enterprise risk management of the organization.
- Review the entity’s portfolio of risk and consider it against the entity’s risk appetite.
- Be apprised of the most significant risks and whether management is responding appropriately.

The implementation provides a top-down view of the key risk factors. The purpose of the objectives is to achieve a better integration of strategy, risk, control and governance in order to improve organization performance.

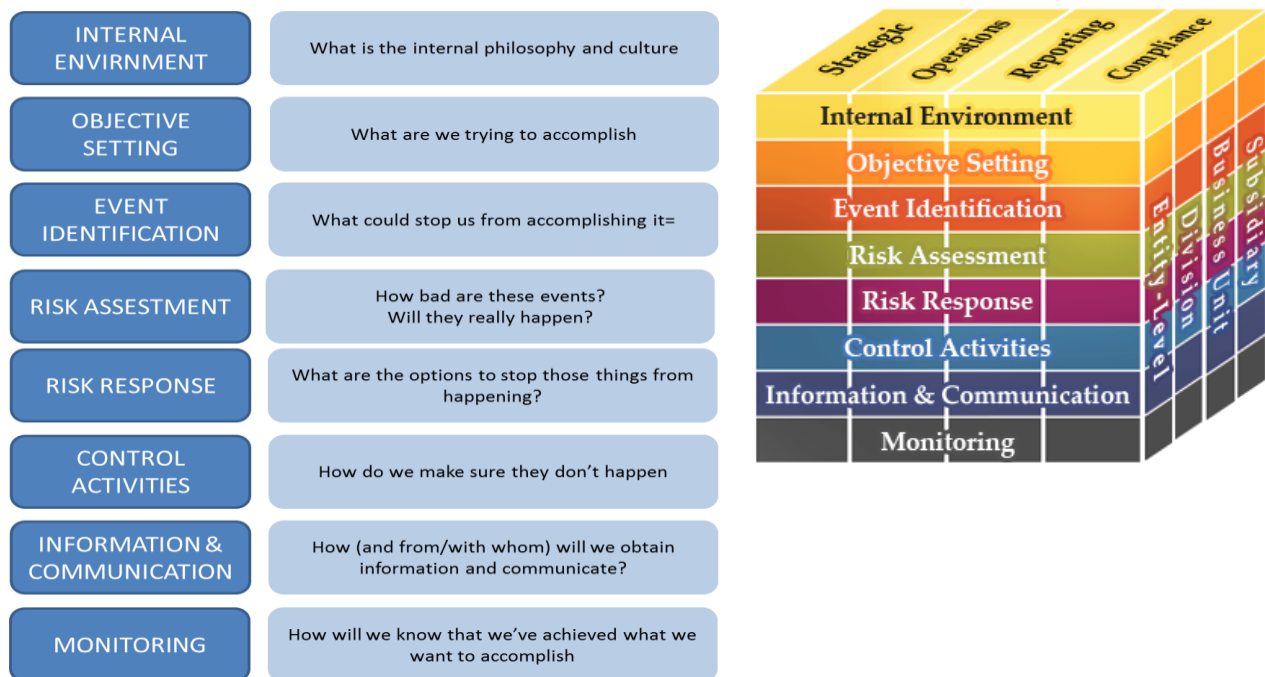


Figure 14 COSO Enterprise Risk Management Framework

- FERMA:2002

It is important that this process is integrated in the organization's culture. Only in this way higher operation efficiency can be promoted and reached.

The standard sets out a strategic process, starting with an organization's overall



objectives and aspirations, through to the identification, evaluation and mitigation

Figure 15 FERMA: 2002 Risk Management Process

- SOLVENCY II: 2012

SOLVENCY II is a particular standard widely used among insurance companies. Its strategy can be identified in a “three lines of defense” approach that enables organization to reduce and avoid risks.

Once a standard has been chosen, it is important to adapt it to the context in which it will be used. In fact, following the specific analysis that has to be carried on, there will be a different implementation that will involve details concerning particular area of risk investigation. Different business operations involve different kind of risk and different risk analysis need to be followed. Effective handling of risk ensures the successful growth of an organization.

The main types can be summarized in the following list:

- Operational Risk Management;
- Financial Risk Management;
- Technology Risk Management;
- Enterprise Risk Management;
- Project Risk Management;
- Market Risk management.

(Finance Map of the World)

Table 20 below summarizes five of the six processes, comparing their steps.

Table 20 Six Standard Processes

SIX STANDARD PROCESSES					
STEPS	ISO 31000	OCEG	BS 31100	COSO	FERMA
	1.Establishing the context	1.Organize and oversee	1.Future direction of the business	1.Internal environment	1.The organization strategic objectives
	2.Risk identification	2.Asses and align	2.Turning strategy into action (program, project and change management)	2.Objective setting	2.Risk assessment Risk analysis Risk identification Risk description Risk estimation Risk evaluation
	3.Risk analysis	3.Prevent and promote	3.Day-to-Day operations (people, processes, information security, H&S, business continuity)	3.Event identification	3.Risk reporting, threats and opportunity
	4.Risk evaluation	4.Detect and discern		4.Risk assessment	4.Decision
	5.Risk treatment	5.Respond and resolve		5.Risk Response	5.Risk treatment
		6.Monitor and measure		6.Control Activities	6.Residual risk reporting
				7.Information and communication	7.Monitoring
				8.Monitoring	
	COMMUNICATION & CONSULTATION MONITOR & REVIEW	CULTURE & CONTEXT INFORM & INTEGRATE	STRATEGIC CHANGE OPERATIONAL	STRATERGIC-OPERATIONS- REPORTING-COMPLIANCE & ENTITY LEVEL-DIVISION- BUSINESS UNIT-SUBSIDIARY	MODIFICATION & FORMAL AUDIT

3.2.4 Mitigation processes

Introduction

Once risks have been identified and analysed, it becomes very important to develop a plan to mitigate their impact on the performance of a project. This means to identify methods, techniques, tools that enable users to set the risks at an acceptable level.

As a whole, this step of the risk management process takes the name of risk mitigation planning.

This process represents a series of activities to identify, evaluate and select options to reduce the impact and/or the likelihood of potential risks. Risk mitigation planning can be considered as a set of steps to:

- Examine all the possible approaches and techniques to control and reduce potential risk roots (what)
- Define a schedule to execute all the risk mitigation tasks (when)
- Identify responsibilities and who is responsible for each risk area and its mitigation tasks (who)

Risk mitigation planning

Trying to go into a deeper level of details, these points can be considered the main body of risk mitigation planning:

- Risk evaluation
Analysis of each risk and identification of interactions and common causes.
- Mitigation strategies
Identification of alternative mitigation strategies for the key risks
- Strategy prioritization
Identification of the most feasible and appropriate alternative
- Founding identification
Evaluation of costs linked with the chosen mitigation approach
- Communication
Sharing plan and initiatives among all the project participants for implementation
- Lesson learned
Capturing data and lessons learned for future potential benefits (Lee, 2002)

However, it is important to have a general overview that ensures to have all the information needed to create a proper plan and achieve results.

In particular, attention needs to be paid to:

- Risk, that includes:
Brief description, roots, likelihood, impact, triggers and current status description.
- “Risk owner”, that means:
Monitoring and controlling responsibilities for what concern root causes.
- Mitigation alternatives, that includes:
Brief description, tools & techniques used, residual risk level, resources budget and time, approval level and contingency or fall-back. (Oversight and Assessment of U.S. Department of Energy Project Manager, 2005)

Moreover, all the costs linked with this process need to be identified from the beginning in order to provide an initial estimate and identify the foundations required to accomplish the chosen risk mitigation strategies.

Concrete approach

Moving to a concrete approach, a way to start the process involves asking these three questions:

1. What can be done and what options are available?
2. What are the trade-offs in terms of all costs, benefits, and risks among the available options?
3. What are the impacts of current decisions on future options? (U.S Department of Transportation)

To develop the first step, an understanding of all the potential risks need to be achieved first. The following classification represents a helpful tool to categorize risks and formalize risk mitigation planning.

- Unrecognized, unmanaged, or ignored (by default)
- Recognized, but no action taken (absorbed by a matter of policy)
- Avoided (by taking appropriate steps)
- Reduced (by an alternative approach)
- Transferred (to others through contract or insurance)
- Retained and absorbed (by prudent allowances)
- Handled by a combination of the above

(Wideman, 1992)

Mitigation strategies

Only once all the risks have been classified, it is possible to choose the most suitable strategy for each of them and, at a later stage, to develop specific actions and methods to implement the strategy itself. There are four main strategies among which it is possible to choose, following risks' features.

- Acceptance
- Avoidance
- Transference
- Mitigation

A brief description can be provided to list some features of each approach.

Assuming (acceptance)

The risk is accepted. No strategy is implemented to mitigate the effect of the occurrence of a potential event. The cost associated with this are considered acceptable, likelihood and severity of impact are at a low level. This does not mean the risk is ignored; it still needs to be entered into the risk tracking system.

Avoiding

Avoiding risks involves reconfiguring some aspects of the project to eliminate the root causes and the consequence of the risk.

Transferring

It means reallocating risks to a different "owner". The risk is transferred to another party that has now the responsibility of monitoring its probability, impact and developing a mitigation strategy. It can mean moving the risk to an external party, to avoid any links with it or to another part of the system itself that has skills to manage it.

Controlling

This method seeks to reduce the probability (or likelihood) that a risk root cause occurs and/or the severity of the impact (or consequence) if it does occur. (Lee, 2002)

Mitigation solutions

Going in deeper level of details, some options are presented. They represent general methods and techniques to control the risk and mitigate its impact. They can be used when a decision not to transfer the risk has been taken. People involved in the mitigation process decide therefore to cope with the risk and lower the severity of its impact, trying to prevent any occurrence of dangerous future setting.

- Risk buffering
- Organisational flexibility
- Project reconfiguration
- Project partitioning
- Simulation
- Options approach

(Oversight and Assessment of U.S. Department of Energy Project Manager, 2005)

Solution selection

When all the potential solutions have been identified, it is important to select the most suitable one. The underlying questionnaire represents a guideline to identify the best strategy for each risk.

1. Is the option feasible to implement?
2. Will the option be effective in reducing program risk to an acceptable level?
3. Is the option affordable?
4. Is there time to develop and implement the option, and is there a schedule impact?
5. How does the option affect the system's technical performance?
6. If the option results in a design change, what is the impact to other system areas (e.g., test, manufacturing, logistics, etc.)?
7. What is the residual risk after the mitigating option is implemented? "Residual" risk is the amount of risk remaining because the root cause of the risk is not totally eliminated (in other words, there is still some risk remaining after the probability and/or impact are reduced, but not eliminated).
8. Are any secondary risks created? Secondary risks are risks that are created as a direct result of implementing a particular risk mitigation strategy, i.e., the mitigation actions create a new risk that is not present prior to implementing the mitigating actions.
9. What are the risk root cause triggers? Triggers are early warning signs that indicate a root cause is about to occur.
10. What is the contingency or fall back strategy if the selected strategy is not effective?
11. Is the option within the existing scope and terms of the program contract(s)? (Lee, 2002)

Further steps

Before making the final choice, a deeper analysis needs to be carried out in order to perfectly understand all the potential side effects that can occur together with the chosen option. This represents an essential step to avoid the occurrence of a bigger risk in the future.

Record the progress of the process, all the decision-making processes involved and the reasons that explain why a choice has been taken is very important. In this way documentation about the current situation can be developed. It can represent a good template and starting point to face similar situations in the future. It enables users to have a route to reach the same benefits and avoid making the same mistakes.

Risk mitigation in contracting

As it has been previously introduced in Chapter 2, OEMs need to face particular risks and uncertainties due to the setting in which they are currently doing their business and the role of contract for availability that completely change the rules.

Here is reported the list of risks and uncertainties already mentioned but together with potential mitigation strategies to put them under control.

As it has been done for the previous section, three main areas are analysed. A right column has been added to provide examples of mitigation strategies that can be implemented to mitigate the impact. They can be used as a template or starting point to manage different scenarios.

Risks and Mitigation Actions Involving Operational Requirements

Table 21 Operational Requirements: risks and strategies, (Engert & Clapp, 2001)

For This Potential Risk...	Consider These Mitigation Actions
<p>Availability: fully understanding of level of availability required by the customer and of the systems used to develop and provide product and service</p> <p>Functionality and Performance: if products are not as advertised, then the system may not meet its requirements.</p> <p>Requirements Gap: If the product does not match the operational requirements or procedures and these cannot be changed, then products cannot be used.</p> <p>Security and Safety Issues: If there are stringent security requirements, it is important to consider how to test the system since the beginning (without its implementation)</p>	<ul style="list-style-type: none"> • Conduct market research to gather Information about Commercial Products and Services • Solicit customer inputs (e.g., Request for Information, industry day, demonstrations). • Encourage customer to stick to their requirements. Make impossible to modify them during the project execution (penalties or higher rewards) • Ask customer to conduct demonstrations. • Evaluate through prototyping or simulation before deliver the final product/service. • Consult experts to understand requirements and meet customer expectation • Re-evaluate customer requirements by keeping them involved in trade-offs between products functionality, requirements, and cost and schedule. • Maintain an up-to-date Operational Requirements document, • Document requirement and operational procedure deviations. • Designed to reduce the vulnerability of product to an acceptable level

Risks and Mitigation Actions Involving Technical Approach

Table 22 Technical Approach: risks and mitigation strategies, (Engert & Clapp, 2001)

For This Potential Risk...	Consider These Mitigation Actions
<p>Conformance to MOD Standards: conformity needs to be ensured to place product on the market.</p>	<ul style="list-style-type: none"> • Make every effort to find candidate (and deliverable) products that comply with current, relevant standards. • Investigate ways to obtain waivers or to add the product to accepted standards.
<p>Conformance to Commercial Standards: conformity needs to be ensured to place product on the market.</p>	<ul style="list-style-type: none"> • Establish and maintain an integration facility to verify conformance. • Determine if results are available from other verification or operational activities.
<p>Request of capability Integration: check technical experience of the customer to evaluate the option of integration.</p>	<ul style="list-style-type: none"> • Specify customers' selection criteria to include demonstrating experience with selecting, integrating, and testing products. • Make sure the customers are familiar with the specific products they proposed. • Determine the customer's ability to perform their system engineering (e.g., past performance).
<p>Quality Requirements: If product does not meet quality requirements (e.g., reliability, performance, usability) then cost, schedule, and operational capability may be impacted.</p>	<ul style="list-style-type: none"> • Use market research to determine size and satisfaction of customer base. • Conduct demonstrations, prototyping before final selection. • Consult other users with similar requirements.
<p>Adaptability: If products do not fully support initial and evolving requirements and do not have built-in flexibility, then custom code may be needed or the product may be difficult to integrate with other products and may become unsuitable as the system changes.</p>	<ul style="list-style-type: none"> • Assess ability of products to be adapted, tailored, extended, and integrated. • Determine how "open" the system interface (if any, components for example) is for adding capability and integrating with other products. • Evaluate tools available to tailor a product. • Take a pro-active role in influencing commercial standards so that commercial products will better integrate into military systems.
<p>Portability: consider alternative building locations and sites, building material and all building needs.</p>	<ul style="list-style-type: none"> • Check customer platform. If not OK, new locations need to be suggested since the beginning.
<p>Evolution: compatibility of upgrades or replacements.</p>	<ul style="list-style-type: none"> • Market, product and services upgrades need to be known • Develop alternative methods and tools for system fault diagnosis.

Risks and Mitigation Actions Involving Business Strategy

Table 23 Business Strategy: risks and mitigation strategies, (Engert & Clapp, 2001)

For This Potential Risk...	Consider These Mitigation Actions
Alternatives on the market: monitoring competitors.	<ul style="list-style-type: none"> • Evaluate alternatives such as other potential competitors in the field. • Seek contract terms that give the most favourable conditions based on requirements and utilization.
Customer Reliability: potential customer's financial weakness or instability.	<ul style="list-style-type: none"> • Assess customer's market share and financial status. • Evaluate customer's previous business contracts and relationships.
Cost and Schedule Completeness: consider all the on-going costs when compiling cost and schedule estimate.	<ul style="list-style-type: none"> • Consider market research results when developing estimates for initial cost. • Include cost of integration lab, license renewals, continuing market research, version upgrades, etc. in annual budgets for development as well as support.
Business Skills: skill in establishing long-term relationship.	<ul style="list-style-type: none"> • Assess ability of customer to establish business relationships with vendors, including product services and licensing. • Consider and evaluate customer's preferred vendor list.
Statement of Work: keep state of work updated to avoid that cost and schedule slip.	<ul style="list-style-type: none"> • Task statements should specify: <ul style="list-style-type: none"> - Do early and frequent prototyping - Do continuous market research

In this context, the purpose of the implementation has some particular features that diversify it from a general mitigation approach.

Developing a plan in advance, at an early stage of the bidding phase, enables contractors to understand all the contractual changes needed. In this way accurate personal is involved since the beginning. Each person involved will focus on a specific area of the contract. Defining responsibilities, it will be ensured that all the important aspects of the agreement will be taken into account. All the potential risks will be identified and mitigation approaches will be developed by different members of the team that therefore will be able to just focus on detailed solutions

Current methods and practices

As described in the previous chapter, contract for availability implies a list of features that need to be faced with different methods and procedures, compared to those ones currently used in risk management processes.

This is an awareness that is already settled in companies' strategy and therefore specific procedures have already been developed. In fact, an essential element of success for availability contracts is the mechanism to identify risks and uncertainties and then, find or create ex-novo methods and practices to put them under control.

Here it has been reported what has been found in the literature. They represent methods and practices that are currently spread among companies when dealing with uncertainties and risks concerning contract for availability. The next charts report a short and visual description of the current practices that businesses tend to use to face risks and uncertainties. Figure 16 represents a visual summary of the main steps of the process. The same ideas can be used to deal with risks. In Table 24 some methods are reported to have an overview of the current practices while in Figure 17 uncertainties and the relative mitigation strategies go in a deeper level of details, splitting the group in two main categories: aleatory and epistemic uncertainties.

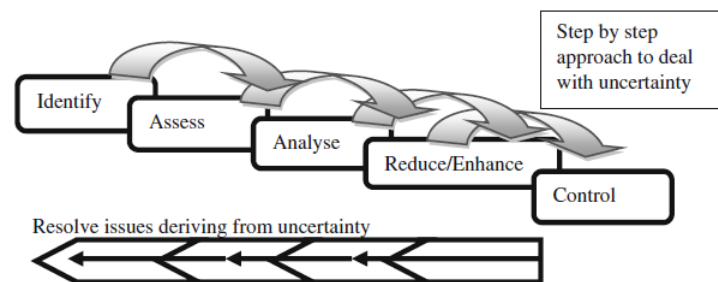


Figure 16 Managing Uncertainty (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010)

Table 24 Assessment methods (Erkoyuncu, Roy, Shehab, & Cheruvu, 2010)

Deterministic	Qualitative	Quantitative
Conservative benefit and cost estimating	Risk matrix	Probability distribution
Breakeven analysis	Risk registers coefficient of variation	Mean variance criterion
Risk-adjusted discount rate	SWOT analysis	Decision tree analysis
Sensitivity analysis	Brainstorming sessions	Simulation: Monte Carlo/Latin hypercube
Risl-adjusted discount rate	Influence diagram	Mathematical/analytical technique
Certainty equivalent technique		Artificial intelligence
Net present method		Fuzzy set theory
		Event trees

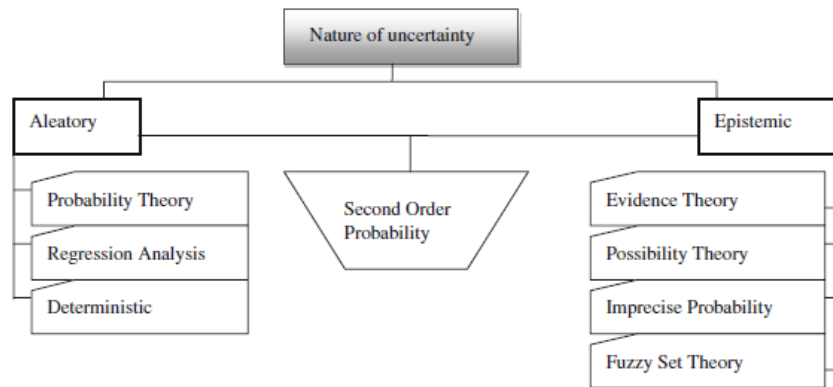


Figure 17 Uncertainty modelling approaches for natures of uncertainty

As it can be seen from what have been reported above, many researches have been carried out to develop methods to reduce the impact of risk and uncertainties, to define definitions of the two terms, to identify some applicable practices rather than just focusing on a theoretical point of view.

Risk sharing and risk allocation

In the literature, useful information can be found about this topic. First of all about risk sharing and risk allocation that seem to be the drivers of the whole risk management processes. In fact, this practice gained importance as soon as the CfA became the most popular contract type between businesses. They obviously represent a necessary but not sufficient starting point to lay the right foundations to develop a partnership that protects both parties. Thus, the complexity and uncertainty that surrounded incentives in PCB contracts need to be studied in details, considering the dynamic aspects of risk sharing between customer and suppliers.

Risk allocation refers to a primary measure of assignment between the projects' direct participant. The process is shortly described in Figure 18. It combines risk management practices with risk sharing. The first step implies the risk identification within a project and recording them into a risk register. The most severe risks will be then set out for each stage of the project, adding their likelihood of occurrence and their impact in terms of financial consequences. This analysis represents an important tool for the customer in identifying those risks, in terms of type and quantum, that it wants to transfer to the supplier (Bing, Akintoye, Edwards, & Hardcastle, 2005).

Now the attention shifts to the supplier that will receive this tender documents and it will carry out its own analysis and assessment of the risks. The bidders, in fact, need to price the risks that have been assigned to its responsibility and look for a way to recover the estimated cost needed to manage them. Once the risk allocation is defined and an agreement has been reached, partners will deal with the next step, risk treatment stage in contract management.

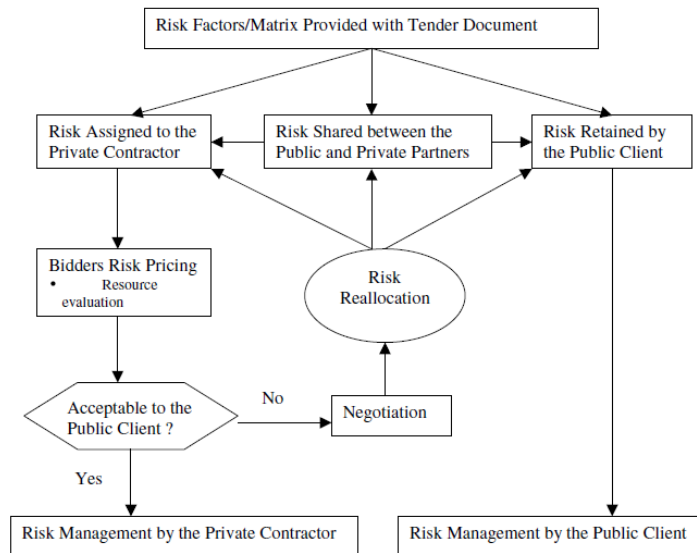


Figure 18 Risk allocation process in PPP/PFI contract procurement (Bing, Akintoye, Edwards, & Hardcastle, 2005)

Going into a deeper level of details about the phases previously mentioned, it is possible to give further information about methods to identify and categorize risks and then find a logic to allocate them between parties. First, a catalogue or checklist of risks can be developed to identify those risks that are faced by parties, and then a macro categorization can be carried on in order to group risks and facilitate the identification of a common pattern to follow in the final allocation.

The following Table 25 shows a catalogue of risks that may occur in stipulating and keep an availability contract.

Table 25 Categorised catalogue of PPP/PFI

Risk meta-level	Risk Factor category	Risk factor group	Risk factor
Macro level risks	Political and government policy		-Unstable government
			-Expropriation or nationalisation of assets
	Macroeconomic		-Poor public decision-making process
			-Poor financial market
			-Inflation rate volatility
Legal		-Interest rate volatility	
		-influential economic events	
Social		-Legislation change	
		-Change in tax regulation	
Meso Level risks	Project selection		-Industrial regulatory change
			-Lack of tradition of private provision of public service
	Project finance		-Level of public opposition to project
			-Force majeure
			-Geotechnical conditions
Residual risk Design		-Weather Environment	
		-Land acquisition (site availability)	
Micro level risks	Relationship		-Level of demand for project
			-Availability of finance
	Construction		-Financial attraction of project to investors
			-High finance costs
			-Residual risks
Operation		-Delay in project approvals and permits	
		-Design deficiency	
Third party		-Unproven engineering techniques	
		-Construction cost overrun	
			-Construction time delay
			-Material/labour availability
			-Late design changes
			-Poor quality workmanship
			-Excessive contract variation
			-Insolvency/default of sub-contractors or suppliers
			-Operation cost overrun
			-Operational revenues below expectation
			-Low operating productivity
			-Maintenance costs higher than expected
			-Maintenance more frequent than expected
			-Organisation and co-ordination risk
			-Inadequate experience in PPP/PFI
			-Inadequate distribution of responsibilities and risks
			-Inadequate distribution of authority in partnership
			-Differences in working method and know-how between partners
			-Lack of commitment from either partner
			-Third Party Tort Liability
			-Staff Crises

First a meta-classification is proposed based on three levels of risk factors. The three levels comprehend: macro level risks, meso level risks and micro level risks the macro level of risk comprises risks sourced exogenously. This level focuses on the risks at a national or industry level status, and upon natural risks. The risks at this level are often associated with political and legal conditions, economic conditions, social conditions and weather. In essence, these risks arise from risk events occurring beyond the system boundaries of a project, but whose consequences cross the project boundary to impact upon the project and its outcomes.

The meso level of risk includes risks sourced endogenously, i.e., risk events and their consequences occurring within the system boundaries of the project. These represent the implementation problem, involving issues such as project demand/usage, location, design and construction and technology.

The micro level of risks represents the risks found in the stakeholder relationships formed in the procurement process, due to the inherent differences between the public and private sectors in contract management. These are also endogenous risks, but differ from meso risks in that they are party-related rather than project-related (Bing, Akintoye, Edwards, & Hardcastle, 2005).

Moreover, as it has been shown, other subcategories have been identified to classify risks based on their nature. Grouping risks represents a good starting point that facilitates the development of a strategic approach to risk management. It can also help in identifying a common approach to analyse, treat and therefore monitor and control risks in their management process.

Moving to risk allocation, four different categories are identified:

- Risk should allocated to the public sector,
- Risk should be allocated to the private sector,
- Risk should be shared between public and private sectors and,
- Risk allocation strategy depends on individual problem circumstances (this means those ones that it is not clear in which previous categories should be collocated) (Bing, Akintoye, Edwards, & Hardcastle, 2005)

Table 26 records risk allocation and important perceptions. These are results of a questionnaire conducted to evaluate the present perceptions of contractors and suppliers regarding risk importance and allocation.

Table 26 Summary of risk allocation and importance perceptions (Syed, Riaz, & Darshi De Saram, 1999)

Risk description	Risk allocation (%)			Importance			
	Owner	Shared	Contractor	(Average) 1–10	Low 1–3 (%)	Mid 4–7 (%)	High 8–10 (%)
Acts of God (force majeure)	22	61	17	6.0	32	32	36
Change in work	67	28	5	6.8	16	32	52
Change order negotiations	22	72	6	6.6	16	47	37
Changes in government regulations	28	55	17	6.0	32	32	36
Contractor competence	39	28	33	7.7	5	32	63
Cost of legal processes	0	94	6	6.1	32	42	26
Defective design	61	28	11	7.8	5	21	74
Defective materials	5	17	78	7.1	12	26	58
Deficiencies in specifications and drawings	67	22	11	7.2	11	31	58
Delayed payment on contracts	45	22	33	9.1	5	5	90
Delays in resolving contractual issues	18	70	12	8.7	0	11	89
Delays in resolving litigation/arbitration disputes	5	67	28	6.8	21	32	47
Environmental hazards of the project	16	68	16	6.5	16	42	42
Financial failure—any party	0	89	11	8.1	16	11	73
Inflation (lump-sum and unit price contracts)	0	56	44	6.5	26	32	42
Labour and equipment productivity	0	0	100	7.1	16	26	58
Labour disputes	0	22	78	6.1	26	48	26
Labour, equipment and material availability	0	33	67	7.8	11	16	73
Permits and ordinances	17	61	22	7.2	16	21	63
Political uncertainty after July 1997 handover	22	67	11	5.3	37	52	11
Quality of work	0	22	78	8.0	0	21	79
Safety	0	44	56	8.2	5	16	79
Site access/right of way	33	34	33	6.5	5	58	37
Suppliers/subcontractors poor performance	0	33	67	7.6	11	11	78
Third party delays	39	55	6	7.0	16	26	58
Unforeseen site conditions	28	55	17	7.3	11	37	52

More than once, this study has been carried out in the past. Another source gives details about PPP/PFI projects. Parts of the final results are here reported.

Table 27 Preferred risk allocation in PPP/PFI projects (Bing, Akintoye, Edwards, & Hardcastle, 2005)

Risk factors	Risk group	Responses by public sector respondents		
		Public (%)	Private (%)	Shared (%)
Poor financial market	Macro	0	100	0
Poor quality of workmanship	Meso	8	77	15
Construction cost overrun	Meso	0	85	15
Frequency of maintenance	Meso	0	85	15
Availability of labour/material	Meso	0	92	8
Insolvency of subcontractors/suppliers	Meso	0	92	8
Low operating productivity	Meso	0	83	17
Design deficiency	Meso	0	100	0
Unproven engineering techniques	Meso	0	92	8
Operation cost overrun	Meso	0	92	8
Higher maintenance cost	Meso	0	92	8
Construction time delay	Meso	0	92	8

Risk factors	Risk group	Responses by private sector respondents		
		Public (%)	Private (%)	Shared (%)
Poor financial market	Macro	0	85	15
Poor quality of workmanship	Meso	0	100	0
Construction cost overrun	Meso	0	96	4
Frequency of maintenance	Meso	0	96	4
Availability of labour/material	Meso	0	96	4
Insolvency of subcontractors/suppliers	Meso	0	96	4
Low operating productivity	Meso	0	100	0
Design deficiency	Meso	0	92	8
Unproven engineering techniques	Meso	0	100	0
Operation cost overrun	Meso	0	100	0
Higher maintenance cost	Meso	0	100	0
Construction time delay	Meso	0	100	0

Analysing the results, some conclusion can be drawn up. Public sector should bear site availability and political risks. Other risks, such as relationship risks, force majeure risks and the risks of legislation changes should be shared between partners. Private sector should retain the majority of the remaining risks, in particular those ones categorized in the meso risk level. Obviously there are also those risks that need to be handled on a case-by-case basis. The nature of the risk itself creates the impossibility of neither allocate them to a particular partner nor shared. In this group there are four risk factors: level of public support, project approval and permits, contract variation and lack of experience (Bing, Akintoye, Edwards, & Hardcastle, 2005).

Once again the importance of the completeness of a contract is underlined. The first step of establishing a contract is therefore reaching a mutual acceptable risk allocation scheme, only in this way it is possible to achieve value for money objectives in these projects. Risk allocation represents the first and most important step to start a proper risk management process.

Without introducing any complicated incentive mechanism, in fact, performances of these contracts can be drastically improved. Introducing a simple mechanism of sharing variability-related cost, all parties can take advantages both in terms of financial aspects and customer-specific performance measures.

A deep analysis, in fact, reveals some current trends that need to be understood and avoided when drawing these kinds of contract. Customer and suppliers need to be aware of the other party's perception. Usually suppliers tend to allocate more risks onto themselves compared to what is expected from customers. The reason lays in current practices, in fact following them, contractors are expected to bear many risk whether they could appropriately manage it or not. However, customers will be charged for them because, obviously the contractor will price them in the agreement. Therefore it is important having an innovative approach in dealing with risks and their allocation in order to allocate them to the party that could best handle them.

Spring model and CDRM

As it has been explained above organisational complexity is drastically increased and risk evolution is causing proliferation of risks.

Different methods have been therefore developed to help organisation in facing risks and managing them. However, most of the approaches founded in the literature present a lack of consideration of dynamic capabilities. Internal and external resources are not enough anymore to undertake a risk management process. Dynamic capabilities are becoming more and more important in the decision making process and therefore they need to be taken into account. In fact, they are considered a means by which companies can deal and manage with the variability of their performance caused by internal and external uncertainties (Arena, Azzone, Cagno, & Trucco, 2013).

This paper reports two methods that have been recently developed to fill the literature gap, giving companies a more complete approach to manage risks and uncertainties.

The first one is called The Company Dynamic Response Map (CDRM), with which it is possible to undertake and integrate risk management procedures across different organisational level. From its original description, the CDRM can be used to (1) graphically represent and analyse the RM strategies adopted by project-based companies; (2) pinpoint strengths and weaknesses of RM practices; and (3) improve operational and strategic RM choices across different organizational levels, in light of a more comprehensive understanding of available RM strategies (risk treatment options) (Arena, Azzone, Cagno, & Trucco, 2013).

Figure 19 shows the tool.

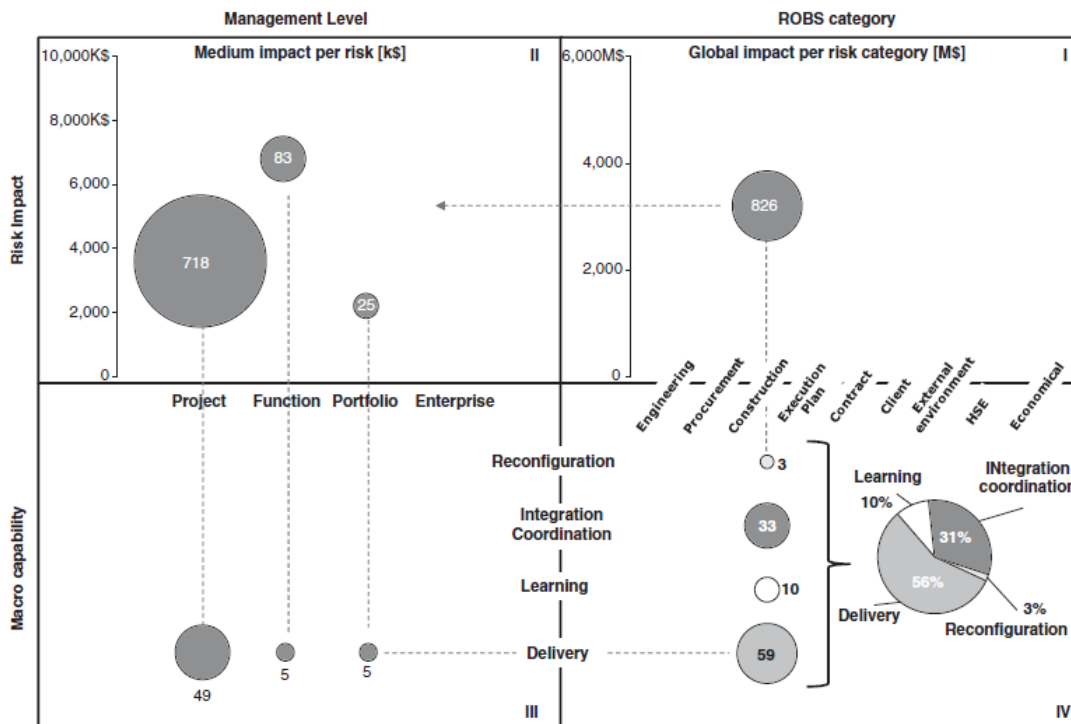


Figure 19 Company Dynamic Response Map (Arena, Azzone, Cagno, & Trucco, 2013)

It is represented by a matrix where risks and their mitigation strategies are linked with dynamic capability, organisational levels and financial impacts. In the upper-right quadrant risk categories are linked with their financial impacts, moving anti-clockwise the average impact is related to organizational level in which risks are managed. In the last two quadrants, the matrix focuses on company’s response strategies (capabilities). This tool therefore helps companies in having a visualization of their risk register and of their mitigation strategies and support them in their decision making process. Thus, the tool can be used to analyse risk management strategies and improve their response mechanism and at the same time it can be useful as a managerial tool, to support operational and strategic decision making. The model claims to exceed the traditional operational risk registers, by creating a representation that either can be adapted to any circumstances or that can analyse business risks as a whole (Arena, Azzone, Cagno, & Trucco, 2013).

Moving from these considerations, this paper proposes another method to support the transition of risk management procedures from the governance sphere to the operational units. To reach its objective, the “Spring Model” details how risks can have an impact on different parts of the organisation as well as they can be managed by different organisational levels through companies’ dynamic capabilities (Silvestri, Arena, Cagno, & Trucco, 2011).

The model basically details how different business levels interact with the dynamic of risk identification and management, proposing therefore an alternative approach in managing threats and opportunities.

With its deployment, an explanation about these three aspects can be obtained:

- How risk can impact different organizational entities
- How risk can propagate across the organization
- How risk can be effectively managed, at the proper organizational level, through the organization's dynamic capabilities (Silvestri, Arena, Cagno, & Trucco, 2011).

The main concept behind this tool is the integration between the initial situation with the objective, through a full understanding of the business mitigation strategies and all the dynamic capabilities currently presented in the company.

This means that the model supports the refinement and improvement of risk definition in order to enhance the integration of risk management into operational practices. It is important the risk definition that allowed to understand the core principle behind the model and the linkage between threats/opportunity with the capabilities. A risk can be defined as "the interaction of internal or external events and the dynamic capabilities of the organization that may influence the degree of achievement of company's objectives" (Silvestri, Arena, Cagno, & Trucco, 2011). The model can be easily visualized in the following Figure 20

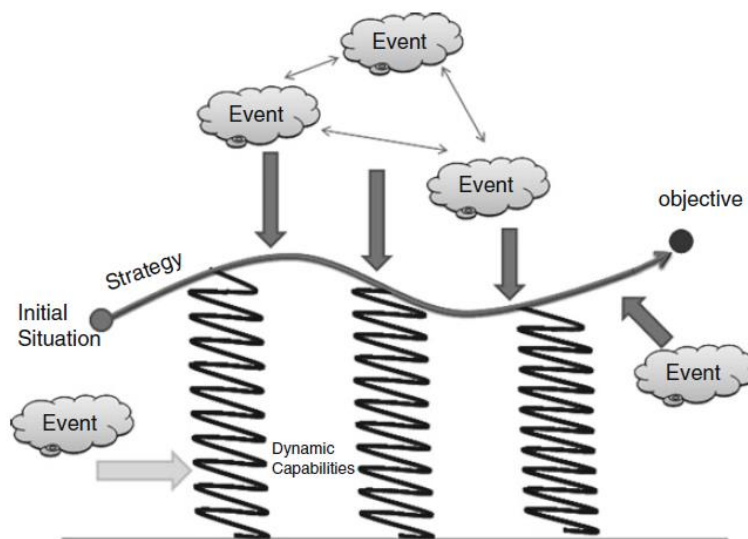


Figure 20 The "Spring" model (Silvestri, Arena, Cagno, & Trucco, 2011)

Defence

Here a short digression about the defence industry has been reported to obtain an overview about this environment and clarify the reason why this sector performs a central role in this discussion.

Defence is a sector that is dominated by “national security” concerns and therefore might be expected to be far away from availability contract with the private sector (e.g. “national security cannot be left to a partnership with private industry”, (Parker & Hartley, 2002)). However, in the past decade it open its business to private contractors, establishing strong partnership to mainly ensure the availability of the equipment needed.

The context becomes even more complex. In fact, a distinctive feature of defence’s business is the necessity of providing operational capability in peace, crisis and war and therefore, contracts and the supplier themselves need to meet this criterion.

Performing the role of the customer, the defence sector is focusing on establishing partnership based on trust and reputation rather than having a detailed contractual control. Partners become therefore involved in an agreement that require commitment from both parties to reach common objectives, also if they have completely different goals and principles. Private party obviously need to satisfy its stakeholders while MoD needs to focus on its political masters and voters.

Being mainly a kind of contract for availability, this kind of agreement implies all the difficulties previously listed. In addition, these contracts involve other features that imply choices under uncertainty. Further conditions about the value for money need to be taken into account and competitions among bidders need to be undertaken. Additionally, the contractor will be paid only when the service will be delivered. As many other contracts, also this one, where the defence sector is involved, cross long period of time. This means two sides of the coin: on one of them, suppliers are incentivized to undertaken this project but on the other it also creates a long-term monopoly and scope for “hold-up”. The reliance on partnership, trust and reputation become fundamental. Different types of pricing mechanism can be undertaken, together with establishing penalties for late delivery or poor performance (Parker & Hartley, 2002).

These features could have a positive effect on the relationship and bringing the MoD to renew the contract with the existing supplier, thus reducing the competition and minimizing the cost of the long-term supply

3.3 Cost-Benefit Analysis: a guideline to choose

Once all the potential mitigation strategies have been identified, it is important to select the most suitable one to implement and reach the best results. In other words this means having criteria to be able to compare options and make a choice among them.

Cost benefit analysis (CBA) reveals to be an unquestionable indicator to make the right choice, based on numbers and figures. Following this approach, options are compared taking into account all the resources required to implement them together with all the benefit and improvements that they bring. Emphasis is also put on feasibility and benchmarking. They can be considered a sort of starting point as well as the last step to make the final choice. The former ensures that the option is possible, while the latter allows the users to have an overall picture. Indeed, it means studying the practices currently used in other similar organizations and see which results have been achieved.

3.3.1 CBA steps

The CBA can be summarized in 12 steps that can help the user as a guideline to complete it properly

Step 1: Define the problem

Define the problem to be addressed by the analysis. In this context, it means having a clear understanding of the risk and uncertainty involved in a project. It also involves establishing the perspective and scope and determines the structure and composition of the CBA.

Step 2: Select the options

This is usually an assessment of several options that can be taken into account as strategies to solve an issue or mitigate its impact.

Step 3: Specify the baseline scenario

Specify the baseline scenario means understanding the context in which strategies will need to be implemented. In fact, each scenario involves a different kind of approach based on the severity of the risk. Options generally include no intervention, a minimum level of intervention or continuation of the current level and form of intervention.

Step 4: Estimate costs for the options

Estimate the costs of the options at market values and in real terms (usually at the price level at the time of analysis), obviously all the potential and significant changes of the cost over time need to be taken into account since the beginning. It is also important to express the costs of each control option, reflecting the pattern of activities over time, and indicate any ongoing or subsequent expenses.

Step 5: Identify the impacts of the options

Identify all relevant consequences and impacts of the possibilities (even when it is not possible to quantify or value them): consider positive and negative, direct and indirect, tangible and intangible across environmental, socio-cultural and economic aspects. To have an objective indicator, it is indispensable to define these effects in terms of specific outcomes.

Step 6: Quantify these impacts

Quantify the impacts in terms of outcomes relative to the identified scenario. In this way, an unquestionable indicator will be the result. It will therefore ensure an easier comparison between strategies.

Step 7: Value these effects

That means valuing effects in real terms (price/money). In this way, it is possible to identify any significant changes in real unit values over time.

Step 8: Consider the timing of these effects

In this step, the main purpose is being able to express the effects of each strategy (positive or negative) as annual benefits and costs. It becomes important being able to model them over time, this means understand when the effects commence and how they develop during a period of time.

Step 9: Discount annual costs and benefits

Translate cost and benefit (value) to their present values (usually in the year of the analysis).

Step 10: Calculate decision criteria

Rank and prioritize the strategies according to the criteria in order to identify the most suitable option.

Step 11: Perform sensitivity analysis

Examine the sensitivity of the results obtained (most of them are value that can be subject to uncertainty and variability). In this way, it is possible to understand how results can change.

Step 12: Report on the CBA

Register the final outcomes and results of the analysis in a report. This should comprehend findings and recommendations for the team involved (New Zealand Treasury, 2005)

This specific step-approach has been chosen because it represents a very detailed and well defined method to implement this analysis. With its 12 steps, it takes into consideration many different aspects under which a strategy should be analyzed. However, looking at the literature, many different step-processes can be found. They have not been reported in detail because they can be considered as a shortened version of the 12 steps process.

Below some other steps are reported in order to show clearly that they merely are part of the CBA steps stated above.

- Stage 1- Sensitivity analysis of events occurring
Stage 2: - Discounting the future value of benefit
Stage 3: - Comparing the costs and benefits to determine the net social rate of return
Stage 4: - Comparing net rate of return from different projects (Riley, 2012).
(Cellini & Kee, 2010) also provides a structure for the process. In fact, here it has been reported a series of steps that comprise a generic cost-benefit analysis

- 1. List alternative projects/programs.
2. List stakeholders.
3. Select measurement(s) and measure all cost/benefit elements.
4. Predict outcome of cost and benefits over relevant time period.
5. Convert all costs and benefits into a common currency.
6. Apply discount rate.
7. Calculate net present value of project options.
8. Perform sensitivity analysis.
9. Adopt recommended choice.

From the book *Down to earth* some similar steps can be excerpted

- 1. Specify the possible options for action.
2. List all the possible outcomes (i.e. sets of consequences) for each option.
3. Determine the probability of each outcome of each option.
4. Assign a value (positive or negative) to each outcome of each option.
5. Select the option (or, in case of a tie, any one of the options) that maximizes expected value. (Nolt, 2001)

Looking for information and details about CBA, some concepts appear very often in books and documents.

For example, CBA cannot be considered as a general standard that enables user to make a choice just using limited resources. The context needs to be analyzed in detail and the analysis needs to be adapted to it. It does not merely represent a tool that can solve problems without putting efforts in it. (Richardson, 1999)

Moreover, the concepts of risk and uncertainty appear very frequently in the analysis itself. Therefore outcomes of this analysis are associated to probability and they cannot be known with 100% accuracy. "These alternatives outcomes will be accommodated by placing probability estimates on them.

Then by some specific rules these probability-weighted outcomes are aggregated to obtain the decision result " (Brent, 1996).

3.3.2 CBA to evaluate mitigation strategies

Each situation is different from the others. Therefore a general approach or fixed steps are not enough to ensure optimum results. This means that a flexible approach is required in order to develop a series of steps appropriate for the context. First of all it is important to identify under which metrics the different options wanted to be compared.

After analysing the current state-of-the-art, the practical part of this thesis would like to develop a framework to recreate a sort of cost-benefit approach, to specifically analyse risk and uncertainty mitigation strategies. Two different approaches will be defined. Strategies will be compared under two main different aspects to be able to determine the most suitable one. The main purpose will be to obtain a single index for each strategy in which the entire value of a strategy has been summarise. Users will be able to easily compare options. Two aspects will be used to compare risk mitigation strategies as well as two other ones to compare uncertainty mitigation strategies. The comparison will be based on impact and likelihood reduction for what concerns risk. For what concerns uncertainty, it will be based on cost/time reduction and confidence.

3.4 Opportunity management

Another important aspect of this discussion is the concept of opportunity. This section has been created to throw more light on the relationship between the definition of “risk”, “uncertainty” and “opportunity” and on potential links and differences among them. In fact, a debate is currently carried out over the definition of risk, in terms of whether it includes both threat and opportunity or if it is limited to the former (Hillson, 2003).

Looking at dictionary definitions and at real experiences among different projects, it is clear that the second understanding is more widely spread. “Risk equals threat” is in fact the traditional thinking within a risk management process. But, “Is the effect of risk always and wholly negative?” (Hillson, 2003). Following the ideas mentioned and summarised in this paper, the answer is no.

3.4.1 School of thought

Risk, as well as uncertainty can be considered as a “container” of opportunity. The main issue is to decide if the term risk comprehends both opportunities and threats or if it just has a negative meaning and therefore it is necessary to consider opportunity qualitatively distinct.

Two schools of thought can be considered:

“1) “Risk” is an umbrella term with two varieties:

- “Opportunity” which is a risk with positive effects
- “Threat” which is a risk with negative effects.

2) “Uncertainty” is the overarching term with two varieties:

- “Risk” referring exclusively to a threat, i.e., an uncertainty with negative effects
- “Opportunity” which is an uncertainty with positive effects” (Hillson, 2003).

This paper aims to describe the term opportunity as a positive outcome of uncertainty. In fact some uncertainty could be adverse (threat or risk) but at the same time, some others could help in achieving objectives (opportunity).

Table 28 Relationship between risk and opportunity, (Olsson, 2007)

Risk	Opportunity
Any uncertainty that, if it occurs, would affect one or more objectives negatively	Any uncertainty that, if it occurs, would affect one or more objectives positively

As (Hillson, 2003) stated in his book, some uncertainties involve negative aspects, representing therefore threats that need to be checked and their effect mitigated.

However, other uncertainties are potential opportunities that need to be identified and exploited.

3.4.2 Meaning of opportunity

Now it becomes therefore important to clarify the meaning of opportunity. It should not merely be seen as the reverse side of threat. In fact, following this idea, opportunity does not exist in a proper and own right. Indeed, if opportunity is defined as “no threats”, than risk management becomes an “only-way street” (Hillson, 2003), with a unique option of meeting or not the objectives. Opportunities exist in their own right and they represent chance of achieving better results such as deliver early, cost less, increase customer satisfaction, improve competitiveness, enhance company reputation, etc. If it was true the opposite, the result would be missing some opportunity and therefore the possibility of improving performance.

3.4.3 Managing Opportunity

Unlike the term risk, which has always been mentioned in the industrial environment, opportunity has not. In fact, as it can be seen from the literature, it has not been analysed and studied in the same way (Lewis & Fowler).

Despite it seems that a negative outcome of uncertainty has the most attention compared to the positive one, researchers start now arguing about the need to modify the risk management process in order to include opportunity (Olsson, 2007).

Therefore, risk management should be defined under a different prospective. It is no longer about fear of failure rather, it becomes a tool to remove barriers to success, identifying potential opportunity rather than threats.

Although, the PMBOK¹⁰ definition is useful to understand the concept of risk management, now it is important to understand that something changed. In fact, using a different description “Managing in the Presence of Uncertainty” (Lewis & Fowler), both risk and opportunity are now considered in the process. In this way, the analysis will also aim to identify opportunities rather than only focus on risk. In fact, it is important to define and then implement actions in order to capture opportunities within the whole life of a project.

From the literature it is possible to identify how uncertainty differs from opportunity. When uncertainty is considered there is a lack of a holistic view. Thus the opposite can be stated dealing with opportunity. However, it is also clear that the distinction between risk and opportunity is not unanimous. Different studies have been carried

¹⁰ The *Guide to the Project Management Body of Knowledge* from the Project Management Institute (PMI PMBOK) defines risk management as “The systematic process of identifying, analysing, and responding to project risk. It includes maximising the probability and consequences of positive events and minimising the probability and consequences of negative events to project objectives.”

out and their results show that opportunities are “not part of the normal project management vocabulary” (Olsson, 2007).

Managing opportunity needs therefore to become a process itself. A similar structure to the risk management process can therefore be developed for the opportunity management one. Some key points and strategies can be identified to successfully implement it, as presented in Table 29

Table 29 Risk and Opportunity management strategies, (Lewis & Fowler)

Risk response	Opportunity response
Avoid: alter the approach to the problem and bypass that path in the project network	Capture: align the work activities with the current path in the project network and incorporate the opportunity in the deliverables
Transfer: assign the risk to team that can mitigate the risk	Transfer: assign a team that can own the opportunity and incorporate it into the deliverables
Assume: the risk with no further action other than watch for a change	Ignore: the opportunity with no further action other than to watch for a change
Mitigate: the risk by executing the tasks needed to reduce its likelihood and any consequences form its outcome	Pursue: the opportunity by advancing the likelihood and consequences of it occurring

However, many other factors should be taken into account in order to improve the ability in managing opportunities. They can be categorized in two main group, project internal factors and project external factors.

The internal factors include competence, team spirit and internal communication.

In any kind of project, the main roles are played by the team involved and by a project manager. Therefore it is necessary to link competence to each of them. For what concerns the team, it refers to expertise presented in the group and to the ability to work as a team player. For a project manager it is more complex; he or she needs to have the ability to handle the group, to clear understand the customer point of view and organisation requirements.

Team spirit involves the ability of both the team and the project manager in creating an environment in which easily share ideas and thoughts.

Communication is fundamental; it represents a key aspect to successfully complete a project. The project manager has the responsibility to enable and promote it.

The external factors are mainly two aspects: the ability to communicate with the customer and understanding its point of view in terms of project results. Again, the importance of communication has been underlined. Therefore information from external sources becomes another key point.

Both these kinds of factors enable project members to create a holistic view.

This allows having a prospective of the project “from above” and to oversee customer’s expectations as well as communicate relevant information to the partners (Olsson, 2007).

Once the right importance has been given to the external and internal factors, a sort of foundation has been therefore laid; it is now possible to focus on the opportunity identification.

The analysis starts and achieves its main results in the bidding phase. It is, in fact, considered the major area for identifying opportunities, in which a management process reveals to be a useful tool for this purpose. However, it is not the most suitable one to completely manage opportunities.

This seems to lead to a use of a proper opportunity management process. But, what has been studied so far clearly shows a gap in the literature, and the absence of a well-defined method to manage opportunities.

3.4.4 Conclusion and further work

Nowadays, it becomes therefore indispensable that the concept of uncertainty (or in his stead, risk for example) includes opportunity rather than just threats and that the risk management process deals with them in the same way if objectives are to be achieved.

To conclude, the first step to deal with opportunity is developing a holistic view. Then through a step approach it will be easier to identify opportunities.

Therefore further work needs to be carried out; the gap of the literature needs to be filled. This paper aims to describe an attempt in developing a step approach to identify and realize opportunities in contracting. Below a starting point is reported. It represents a draft of an opportunity management process. It has been developed following the steps of risk management processes and creating a sort of parallel.

1. Explore areas of opportunity for your organisation

This step involves a deep analysis of the entire work/project environment, look at different elements of it, to identify if the occurrence of any event could have a potential positive outcomes.

Consider the possible consequences of success as well as potential problems (negative outcome – downside).

2. Assess how likely and beneficial the opportunities are

To identify positive impact and likelihood the probability-impact matrix can be used. As well as it could be done in a risk environment, also in this context the matrix can help users in classifying opportunities. In fact, it might be useful to give each opportunity a score in order to plot them in a matrix.

3. Rank and prioritize opportunity

Obviously it is impossible to take advantages and manage every opportunity that could occur. Therefore, the matrix reveals to be the perfect tool to make a choice. It is better to know how to “capture” the most likely ones, being focus on just few of the list in order to manage them properly.

4. Agree appropriate measures to manage opportunity

This step involves taking a decision about how the opportunity has to be managed; therefore it could involve more than one response.

Capture, transfer, ignore and pursue. For more details, descriptions are provided in Table 29, in the previous section.

The choice needs to be made taking into account its feasibility and the resource needed to implement it.

5. Design a process for monitoring and reviewing your key opportunity and associated plans

Outcomes and likelihood can change over time. Therefore opportunity and plan to deal with them need to stay relevant. This continuous controlling enables users to keep information updated.

6. Communicate opportunity management plan

In this step, it is important to have a very good communication among the team. Everyone in the team needs to know his own responsibility and needs to have support.

This chapter lays the foundations of what will be developed further in next sessions and states therefore few important concepts that need to be kept in mind to understand the logic behind the whole work.

First of all one unique definition of risk and uncertainty has been chosen. Stating that “uncertainty can be seen as a property of a system, an event, a performance while risk becomes the measurement system to define the entity of the impact of uncertainty”, allows to deal with risks in a different way, considering a wider horizon of analysis. In particular, it enables users to take into account features of a new risk prospective such as a probability based thinking, the knowledge dimension and surprises (black swans), that are fundamental in risk management processes when dealing with equipment availability, performance and reliability.

Have a better focused picture of the scenarios in which companies are placed allows to better compile a risk register, avoiding errors to better share risks between partners and to consider all the consequences potentially involved in the outcomes of events.

The detailed analysis carried out so far also allows to set some standards from which it is possible to start in developing a new methodology that embrace all those features that are important to first identify all the potential risks and uncertainties and then handle them, taking into account that the setting changes completely.

The most important features are here listed together with the reason why they should be the basis of the development of a new framework proposition.

Table 30 Important features for the new methodology

Feature	Reason Why
Step by step process	Logical and intuitive for end-users Linkage with previous processes
Provide a risk register	Easy to group risk together Manage each group following standards
Based on measurement of deviation between expected and actual outcomes	Improve organisation cost performances
From strategic to operational level of analysis and vice versa	Easily involve all the organisation's levels as a whole and integrate risk management procedure across the company
Cultural changes: Integrated in the organisation's culture Helping in developing partnership between parties Promoting and suggesting incentive mechanisms	Communication as the first trigger in succeeding in managing risks and uncertainties. Importance of trust, reputation and mutual commitment. Mutual acceptable risk allocation scheme
Adaptability	No additional efforts are asked to the users to adapt the methodology to the context
Different assessment methods (Deterministic, qualitative and quantitative)	Complete overview of the setting to better analyse risks (as a step of the process)
Help in sharing risks	The context is more complex than before and the risk sharing process becomes the first step to better split risks, being sure that they are allocated to the party that can better manage it
Help in pricing the risk CBA and opportunity management	Many responsibilities shift now to the supplier 360° view of scenarios to better choose the right mitigation strategy and evaluate all the potential consequences (emphasis on potential positive outcome)

This is a very detailed starting point from which it has been possible to develop a new methodology that represents a breakthrough compared to previous processes and fills the gap of the current procedures.

OEMs could now have a tool that perfectly understands their needs and allows a risk analysis with concrete results to better manage a setting characterized by a deep and different uncertainty.

CHAPTER 4

A METHODOLOGY FOR MANAGING UNCERTAINTIES IN CfA

4.1 Objectives

Starting from the in-depth analysis reported in previous chapters, it was possible to identify the main gaps between literature and companies' needs to enhance current risks and uncertainties management practices. Indeed, companies need to develop and maintain the profitability of their business in an uncertain world. With the advent of servitization things are becoming even more complex, creating new challenges for manufacturers, and for OEMs in particular.

The economic theory, as well as experts of this field, has always tried to define methods and approaches to help companies in dealing with all the management issues that rise from the context in which they compete. This has brought in developing many different risk management processes to support companies with predefined structured procedures. However, time passes and changes take place. That means that, cyclically, the standards adopted till that time changes.

That is the scenario that came together with the advent of servitization. Companies need to reorganize their business and develop capabilities to face new uncertainties and therefore new challenges in the business landscape. OEMs play completely different tasks compared to what they were used to, just few years ago. Long-term relationships with their clients bring equipment providers in thinking how they can assume responsibilities that they never had. The change of setting completely reshapes the way of building relationships with partners.

Since when a new trend starts its diffusion process, experts begin to draw a new chapter of the literature, developing and writing down all the knowledge about the topic. Real cases start to be analysed and examined to discover all those practices and procedures that are currently used to face new business scenarios. This leads in defining one important objective of the thesis itself: create a well-organized database where it is possible to find all what has been mentioned about CfA and risk management processes. That is exactly the starting point to define a systematic approach to face new challenges in a structured way, and reach therefore this second objective: a new methodology.

In fact, analysing the-state-of-the-art, a lack of systematic procedures and methods is what shined through. No structured processes have been developed yet.

There are no suggested procedures that can be undertaken by companies in managing uncertainties, risks and opportunities.

Therefore, this thesis has been directed towards the objective of developing an original methodology that could help companies in having a systematic approach to move their first steps in a servitized context.

What has been provided in the previous chapters lays the foundations on which it will be possible to develop something new. Identify the list of factors that companies need to take into account together with the analysis of how a new methodology should be built, represent in fact the first step to match them to create exactly the right tool. The second chapter ends, in fact, listing all the factors that OEMs need now to take into account. Then, looking at current risk management processes is clear that what they did in the past is not enough anymore.

In this regard, we want to structure a methodology to guide companies in proactively behaving towards risks, proficiently managing uncertainties, mitigating the impact of unknown event and taking advantages of hidden opportunities. The key concept is avoiding that companies live this trend totally unready of managing all the new implications involved.

Thanks to what was discovered with a deep analysis of the literature, it is now possible to lay some basis to develop a new methodology.

OEMs need support to cope with the advent of the servitization. To briefly summarize, they are currently placed in a context notably more complex, where the right contract with the right partner represents the key way to success. As it has been said, contracts play an important role. What needs to be understood is that each CfA is “hand-crafted” and therefore totally different from other availability contract. OEMs need now to take a number of functions that were normally performed by other parties. Examples are determining spare parts requirements, physical distribution, warehousing of material, depot level maintenance, configuration management and some engineering functions (Bogusz & Taylor, 2002). Despite the complexity, this kind of contracts allows to overarching few important goals such as compress the supply chain, eliminate non-value added steps, reduce Total Ownership Cost, and improve readiness for systems and commodities (Bogusz & Taylor, 2002).

The servitization brings with it the trend of delivering products faster at lower cost, but maintaining high quality level.

There is a need of coordination because partners are from a number of different organizations around the world. That is why a different approach need to be developed to meet these challenges of planning and executing programs and projects, thanks to the possibility of building strong customer relationships. What need to be involved is basically an alignment of resources, a system to control costs and continuous improvement program together with other parties. The market itself has changed, bringing many companies to bankruptcy.

That is the reason why risk management has to consider OEMs' partners. Losing orders due to a non-fulfilment of a third part is not an option anymore.

Therefore, it is necessary to middle in their affairs in order to be sure to have their total commitment and respond quickly to a changing environment, avoiding delays. A new risk management practice need therefore to take all these aspects into account: analyse all the risks that arise from closer partnerships, new way of sharing role and responsibilities as well as the role of the contract as a protection form. If before everything was responsibility of suppliers, now customers play a role with the same impact on final results. That makes risk assessment absolutely crucial to ensure the success of projects. But something is differently performed. Since the very beginning, clients and suppliers are bundled together as a sole entity.

Having stated this, it implies a deep involvement of customer, sharing this methodology with partners. This basically means developing something that already fit for this wider purpose, structure and features should be thought not only to be implemented on supplier side but to allow an automatic involvement of the customer. In fact, teaming with partners in the early bidding phase can make a notably difference in the success of a PBL contract.

4.2 The methodology

4.2.1 Methodology conceptual design and specifications for development

This methodology aims to support the implementation of Performance Based Logistics contracts. Therefore it wants not only to provide knowledge and prospective into the concepts and requirements of PBL, but also to delineate a technique in how to provide valuable insight to better manage all those new features linked with it (risks and uncertainties management).

Risk assessment needs to analyse also the supplier side. Their systems and processes should be evaluated in order to rate risks, basing on past performance.

Example can be given to better clarify this point. Systems as

- Accounting System
- Billing System
- Configuration and Technical Data Management System
- Parts Management System
- Test & Evaluation System
- Logistics Management System
- Inventory Control System
- Labour Accounting System
- Material Management & Accounting System
- Purchasing System
- Quality Assurance System, should be evaluated to identify risk management factors as well as processes like
- Supply chain management processes
- Approaches to demand forecasting
- Approaches to obsolescence management
- Logistics surveillance processes
- Risk management processes
- Quality Assurance plans
- Partnering Arrangements
- Government Furnished Equipment
- Overhaul and Repair, to assess contractors' capabilities related to PBL contracts.

This also means a bigger effort to improve customers' performance. OEMs should be willing to assist them in selecting capable suppliers, identify acquisition risks, and developing contracts that can be successfully completed.

Now more than ever, involvement of the customer is fundamental. Success can be reach when schedule are respected as well as budget, delivering results to clients.

Cancellation of long term contracts and related orders as well as delays are behind the corner if funds have not be rightly split over the whole period and if risks have not be correctly considered. This is even more probable because in this new context there are many factors that are difficult or impossible to predict and therefore increase the risk of exposure.

Companies need a solution to all those issues that inevitably rose. What kind of solution? How companies can actually handle all these threats and survive in the future? They basically need a better method to face the paradox of “managing long-terms programs in an environment of short-term change” (OracleCorporation, 2010)

Risk management practices are the first and the most important parts that need to be brought into discussion and change. Why? Because companies need to be ahead of the game by anticipating and planning for the risks that come with changes.

Risk management processes need to add a new feature to what they currently perform. They need to guarantee visibility to projects managers, a wider prospective of programs and of how their subcontractors are performing.

Performance need to be measured in real time using a unique set of metrics. That means having a risk assessment process with an open-mindness. These metrics should therefore be part of one of the first steps of the new methodology in order to really analyse all the causes that can lead to failure.

Here few metrics are reported as an example.

- Reliability/Maintainability/Availability
 - On time Delivery
 - Mean time Between Failures
 - Mean time Between Removal
 - Mean time Between Critical Failure
 - Time On Wing
 - Repair Turn Around Time (RTAT)
 - Production Lead Time (PLT)
 - Training times and availability
 - Technical data updates
 - Asset availability
 - Transportation times
- Readiness
 - Mission Capable
 - Partially Mission Capable
 - Non Mission Capable
 - Asset visibility

- Requisition
 - Backorder Age
 - Backorder Rates
 - Requisition Response Time
 - Fill Rate
- Inventory Turnover Rate

Despite the fact that monitoring and validating contractors' metrics performance is only one element of the support offered by a new methodology, checking all these features while drafting the contract will enable users to take corrective actions, check and share updates with customers, higher management and business partners. Put risk managers in front of the evidence of new critical factors that need to be evaluated means having a proactive approach that is what companies need to survive. This is the reason why visibility is a fundamental part to identify and then handle projects risks.

The tool developed is made of a set of spreadsheet but it is obviously not enough to solve risk management issues. Introducing this kind of methodology, companies will run the risk of duplicating data in other tools already implemented and errors may occur because a big amount of manual work is usually required to perform data input. Eventually the continuous development of this new methodology needs to bring to a final result of a tool that embeds all those features, fundamental to support managers in collect and analyse information to handle risks.

That to ensure that every step of a project meets customers' expectation and it has been performed on time and within the budget.

Although the tool is still a very simple framework, conceptually few aspects have been considered of high priority.

- Bring companies in using one single tool that calculates real time data, across different sources, linking them to relevant report (cross divisions utilisation)
- Having an all-in-one risk management tool to enable users in better planning, correctly allocate resources and optimize operating costs thanks to cross training
- Provide total visibility to allow users to both prioritize and change priorities on the run
- Cost and budgeting should be included in the risk management steps in order to provide total transparency to project status and resources allocation
- Possibility of real time checking of other business unit performance.
- Include cash-flow analysis, considering all the potential uncertainties that can rise
- Allow stakeholders in analysing different "what-if" scenarios and having an idea of impacts of contingency on cost and schedule

Risk analysis should be basically incorporate in all the projects undertaken by companies that provide equipment, sharing the implementation with partners and try to have it since the very beginning.

These are therefore just few features that, thanks to what was studied in the literature, could concretely help companies in facing new uncertainties and risks. Basically the new setting in which they are now placed create permanent uncertainty that companies are not able to manage with current practices. They are charged of more responsibilities and without the ability of handle them, they cannot meet customers' expectation, exceeding deadlines and budget.

The framework aims therefore in including features that help in doing that. Therefore with an involvement of the direct customer of each single project, the risk management process should include the possibility of calculate costs, time activities, evaluate performance, prioritize actions in order to completely fulfil what is expected for a service provider

Risk management processes need to have the same objectives of the project itself in order to actually reach the overall goals of the economic theory of being a profitable company. It basically means protect themselves from the impact of unpredictable events but, at the same time, meet schedule and reach a high level of customers' satisfaction.

4.2.2 Detailed description of the proposed methodology

This methodology was developed to help companies in evaluating risks and identifying the most suitable strategy to control each threat. This system reproduces the process to select an option among multiple choices, justifying the reason why a specific mitigation strategy has been selected. This methodology is focusing on the manufacturing and service delivery, in particular due to the high risks that are faced and the collaboration with the case company, which is in defence. The applicability is not limited to this sector, however, further test will need to be applied.

Its development can be described as an iterative process. Many changes were made and its first version was constantly updated till reaching a final and revised standard interface, able to meet company demands.

The most important changes are linked to the logic behind the evaluation and comparison of different mitigation actions. In fact, after meetings and interviews new aspects, as implementation cost and confidence increasing were taken into account to produce comparative indexes to easily compare them. Mitigation strategy evaluation has become more complex, consistent and precise. Tables were added to provide a default list of mitigation strategies and mechanisms were created to easily link them to each risk, avoiding excessive typing. Moreover, importance was given to accurate numerical data concerning likelihood and impact of each risk. That meant adding tables in which users are able to provide the right values for each risk.

Through a verification and validation process it was possible to confirm the consistency of the framework. Basically it involved a deep analysis of the framework itself, in terms of inputs required, interfaces and user-friendliness and a test to verify the validity and consistency of the outputs obtained.

Looking at the literature, at how it was suggested to theoretical conduct risk management and at industrial current practices, it was possible to define some guidelines to set the methodology.

Below Figure 21 provides an overview of the main steps of the methodology.

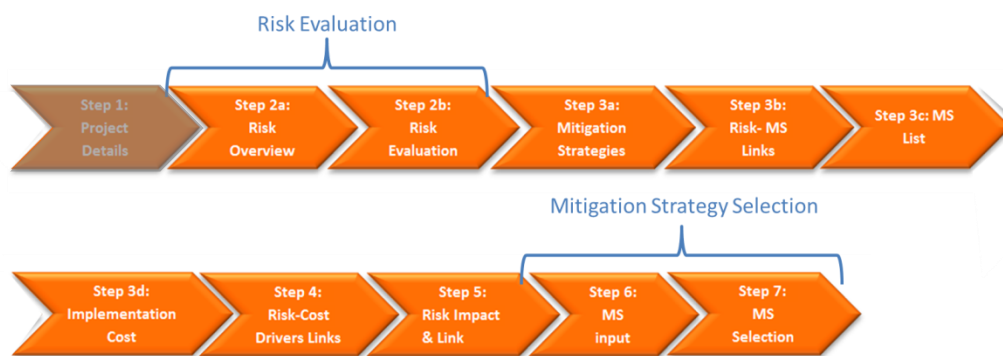


Figure 21 Overview of the methodology

It can be described as composed by two main parts:

- Risk evaluation
- Mitigation strategy selection

Risk evaluation

Risk evaluation can be described as a method of evaluating risks and classifying them based on their likelihood and on the severity of their impact. By doing this it is possible to identify the most severe ones and give them the highest priority. This process takes place in Step 2a and Step 2b.

Risks will be therefore classified using a matrix, shown in Figure 24, that has ranges of impacts (consequences) and likelihood as the axes.

This approach is simple to use and understand, it does not require any extensive knowledge and it is widely spread in the literature and in common-use risk management practices. Moreover this mechanism enables companies to increase the visibility of risks and assist management decision making. In fact, having a wide range of likelihood and consequences, five of each that therefore provide 25 different contexts, enables users to cover the full spectrum of potential scenarios.

Mitigation strategy selection

For what concerns the development of this part, the research has been longer and more difficult. In fact, there is no one single method spread commonly used among companies.

It was decided that strategies will be evaluated based on their implementation cost, their capability to decrease the impact of risks, decrease their likelihood and increase the confidence of the occurrence of a certain outcome. This choice was taken because it allows the users to conduct a deeper analysis of mitigation strategies. This process takes part in Step 6 and Step 7.

Users can therefore consider a new capability of the mitigation strategy that increases the likelihood of the occurrence of one precise outcome rather than let it vary in between a widespread range. This new aspect was never been mentioned in previous process or method and therefore allows the framework to be updated compared to existing ones.

Figure 22 represents this capability.

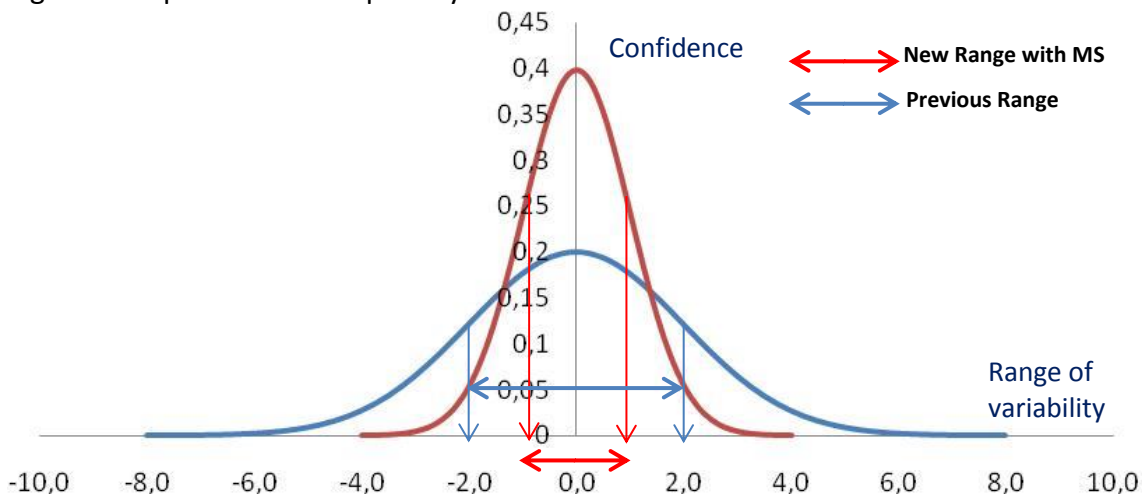


Figure 22 Range Reduction

The link between risks and mitigation strategies was taken into account. In this way strategies are not simply evaluated for the improvements that they can create when implemented but the risks that they control is also taken into account. This leads to different results even dealing with the same strategy, a difference caused by the context.

Another improvement was represented by a classification of the risks based on their impact. In fact more calculations were added to the framework in order to select just five risks for each cost driver.

Risks are not selected randomly but they are first listed in order of severity and then presented in a summary sheet. In this way, even if just a limited number of risks will be analysed, it will be possible to select the most critical ones.

Altogether the framework is embedded in several excel sheets that enable users to prioritize risks first and then evaluate different mitigation strategies and choose the most suitable one. The tool will be able to identify two optimum mitigation strategies following the indexes produced. Currently the mechanism analysed each single strategy alone, without considering any potential combination. The result of a combination of more than one strategy represents a good starting point to develop new features for the framework.

From the first sheet it is possible to understand the structure of the framework. There are different and sequential sections that, through functions, calculations and macros, allow the users to easily provide inputs and then reach the main purpose.

As recorded in Figure 23, the framework starts with a simple initial interface in which aim and main structure are provided. A line at the top of the page functions as a navigator in the whole framework.

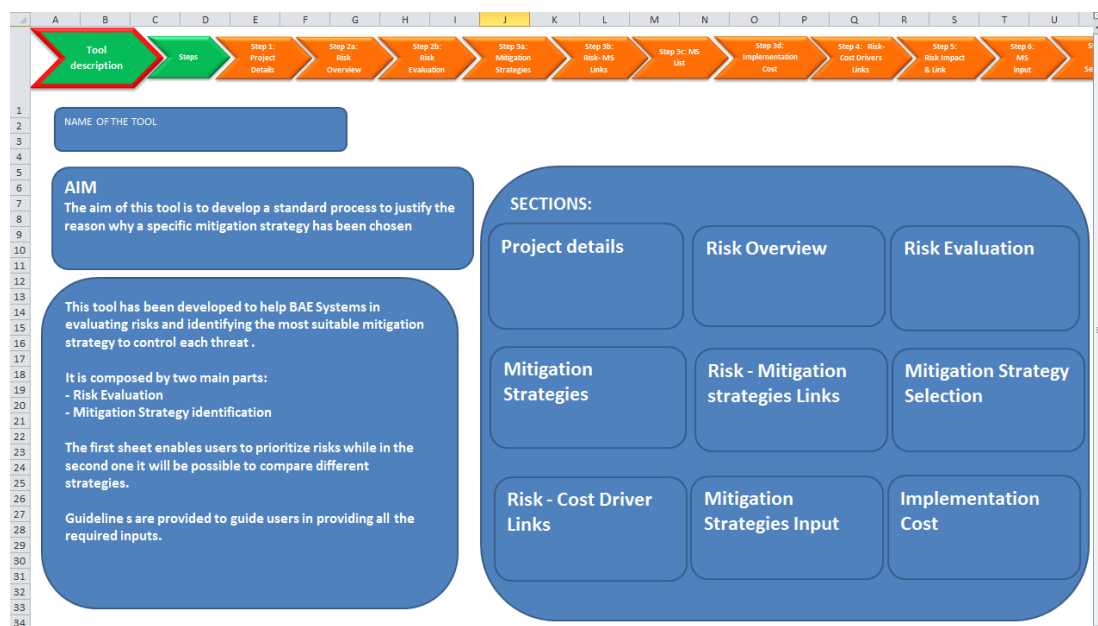


Figure 23 Interface 1: Framework Description

Users will easily understand in which part of the framework they currently are and go directly to a specific section just clicking on the box. They will also easily identify when they are asked to provide inputs, with cells coloured in light blue.

Tool description

The first sheet provides a short description of the framework. Here aim and objectives are provided together with a brief introduction for the next pages.

Steps

In this second page a simple process is reported to easily and clearly show users the main body and functions of the framework. Four main steps are presented together with the inputs required for each of them. In this way an overview of the framework is provided, allowing users to get a general understanding from the very beginning.

Step 1-Project Details

In this page, users need to fill out two main tables in order to provide those inputs that will allow the framework to start working. Users are required to provide a list of cost drivers and their descriptions in the first table and a list of risk in the second one, always together with a brief explanation.

In this way data will be characterized by an ID, short and unique that will be used in the rest of the framework and also by a short description that provide information about the context. These two tables represent the starting point from which the framework can start elaborating and evaluating the data provided.

Step 2a-Risk Overview

Before going to the sheet in which risks are evaluated, short instructions are provided as guideline to help users in compiling the “Step 2b-Risk Evaluation” sheet.

Looking at the literature the easiest way to classify risks is using their likelihood and the severity of their impact.

In this way it is possible to prioritize them following the matrix presented below.

		Insignificant	Minor	Moderate	Major	Catastrophic
		1	2	3	4	5
Very High	5	M	H	H	E	E
High	4	M	M	H	H	E
Medium	3	L	M	M	H	E
Low	2	L	M	M	H	H
Very Low	1	L	L	M	M	H

Figure 24 Risk Matrix

The page “Step 2a-Risk Overview”, in fact, has been designed to guide users in evaluating risks.

The likelihood will be chosen following the probability of occurrence, while impact can be evaluated under different prospective:

- People,
- Reputation
- Business Process & Systems
- Financial

However, this analysis can lead to controversial results.

Therefore consequences can also be evaluated just under a financial point of view, to reach results just linked with money. Both ranges, under which likelihood and impact have been evaluated, have been chosen together with the company. Users can also provide ranges (both for likelihood and impact) different from the default ones. With this opportunity data can vary and be more consistent with the context. Figure 25 and Figure 26 provide a visual explanation of what have been stated above.

	Probability Default:	Probability input:	Historical:		
Likelihood	90%		Is expected to occur in most circumstances	5	Very High
	60%		Will probably occur	4	High
	40%		Might occur at some time in the future	3	Medium
	15%		Could occur but doubtful	2	Low
	5%		May occur but only in exceptional circumstances	1	Very Low

➡ **Default Values**
➡ **Possible New Inputs**

Figure 25 Likelihood Guidelines

For further details and information about evaluation criteria and guidelines please refer to Annex B.

Step 2b-Risk Evaluation

“Step 2b-Risk Evaluation” represents the first main page in the framework. In fact in this sheet the framework will be able to evaluate risks and prioritize them. The calculations will be based on the product between the value of likelihood and the value of the impact (its severity) Values are directly linked with each category based on percentages and figures reported in “Step 2a-Risk Overview”.

In this page risks will automatically appear from the “Step 1-Project Details” sheet and users will be asked to provide likelihood and impact for each of them.

		Consequence				
People	Injuries or ailments not requiring medical treatment.	Minor injury or First Aid Treatment Case.	Serious injury causing hospitalisation or multiple medical treatment cases.	Life threatening injury or multiple serious injuries causing hospitalisation.	Death or multiple life threatening injuries.	
Reputation	Internal Review	Scrutiny required by internal committees or internal audit to prevent escalation.	Scrutiny required by external committees or ACT Auditor General’s Office, or inquest, etc.	Intense public, political and media scrutiny. Eg: front page headlines, TV, etc.	Assembly inquiry or Commission of inquiry or adverse national media.	
Business Process & Systems	Minor errors in systems or processes requiring corrective action, or minor delay without impact on overall schedule.	Policy procedural rule occasionally not met or services do not fully meet needs.	One or more key accountability requirements not met. Inconvenient but not client welfare threatening.	Strategies not consistent with Government’s agenda. Trends show service is degraded.	Critical system failure, bad policy advice or ongoing non-compliance. Business severely affected.	
Financial Default	1% of Budget 5	2.5% of Budget 50	> 5% of Budget 500	> 10% of Budget 5000	> 25% of Budget 10000	
Financial Input	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	
	Insignificant	Minor	Moderate	Major	Catastrophic	
	1	2	3	4	5	

 Possible New Inputs

 Default Values

Figure 26 Consequence Guidelines

In particular users will have to choose among:

- Very low,
- Low,
- Medium,
- High,
- Very High,

as likelihood values and among:

- Insignificant,
- Minor,
- Moderate,
- Major,
- Catastrophic,

for what concerns the impact.

These inputs will provide the foundation to make the framework working and classifying the risk under four main categories:

- Low
- Medium
- High
- Extreme

A coloured cell will allow the user to identify the category of each risk. Clicking on the button presented in the page, macros connected with this sheet will classify risks under the four categories previously mentioned and prioritize them basing their calculation on the values of likelihood and consequences of each of them.

Figure 27 provides an overview of the excel sheet described above.



RISK REGISTER AND EVALUATION

TOOL DESCRIPTION

This sheet enables user to prioritise risks. A traffic light system will permit to categorized risks under 4 main categories:

E – Extreme risk – for which detailed action plan will be required (Red Cell)
H - High risk – for which senior management attention is needed (Orange)
M – Medium risk – for which it necessary to specify management responsibility (Yellow)
L – Low risk – that can be managed by routine procedures (Green)

INPUT

Users need to be able to provide:

- LIKELIHOOD - probability of occurrence of the event
- IMPACT- severity of consequences of the event

Users need to provide them both in terms of money/percentage and under a qualitative point of view.

Press this button once all the fields are filled

Risk ID	Likelihood	Impact	Result	Severity
r1	1:Very Low	5:Catastrophic	5	H
r2	3:Medium	5:Catastrophic	15	E
r3	1:Very Low	1:Insignificant	1	L
r4	3:Medium	1:Insignificant	3	L
r5	1:Very Low	4:Major	4	M
r6	1:Very Low	5:Catastrophic	5	H
r7	1:Very Low	4:Major	4	M
r8	4:High	5:Catastrophic	20	E
r9	1:Very Low	4:Major	4	M
r10	1:Very Low	2:Minor	2	L
r11	3:Medium	5:Catastrophic	15	E
r12	1:Very Low	1:Insignificant	1	L
r13	1:Very Low	3:Moderate	3	M

Figure 27 Step 2b-Risk Evaluation

The following four sheets have been developed after a meeting with the company in which an important topic has been discussed: how to evaluate and compare different mitigation strategies. In fact, while risk evaluation has been based on information collected in the literature, for what concerns mitigation strategy evaluation, a fully understanding of company current practices and procedures was fundamental. Following company suggestions it has been decided to evaluate mitigation strategy taking into account their capabilities to reduce likelihood and impact, to increase the confidence and their implementation cost. Therefore one step has been added to the first version of the framework in order to have a list of mitigation strategies and provide their implementation costs.

Step 3a-Mitigation Strategies

Step 3b-Risk-MS Links

Step 3c-Mitigation Strategy List

Step 3d-MS Implementation Cost

These four sheets can be described with one single general overview, without explaining details of each of them.

First of all users are asked to provide a mitigation strategy default list. It represents the very starting point to then link strategies with risks and evaluates them. In this list users will insert any strategies that can mitigate any kind of risk.

Strategies will be identified both with an ID and a description. A second step is to define all the possible mitigation strategies associated with one single risk. Figure 28 represents the interface to complete this task.

	A	B	C	D	E	F	G	H
7								
8	Risk ID	Risk Description	MS ID	MS Description	MS ID	MS Description	MS ID	MS Description
9	-		0					
10	-		0					
11	-		0					
12	-		0					
13	-		0					
14	-		0					

Figure 28 Risk-Mitigation Strategies Links

If the mitigation strategy is recorded in the default list, it will be enough providing the strategy ID to have its description. When a new strategy will be filled in the table, it will be automatically recorded in the previous sheet (default list). If some changes are made to strategy descriptions, these changes will be automatically recorded in the previous sheet

Then a complete mitigation strategy list is provided in the following page. From this list a new but equal list will be reported in the “Step 3d-Implementation Cost” sheet to help users in providing this cost for each of them. In this page detailed instruction are provided to guide users in calculating the right implementation cost. They will be then used in a formula to provide the first index, reported in part Step 7-MS Selection, under which strategies will be evaluated.

In particular, the following chart details which cost items should be considered in the implementation.

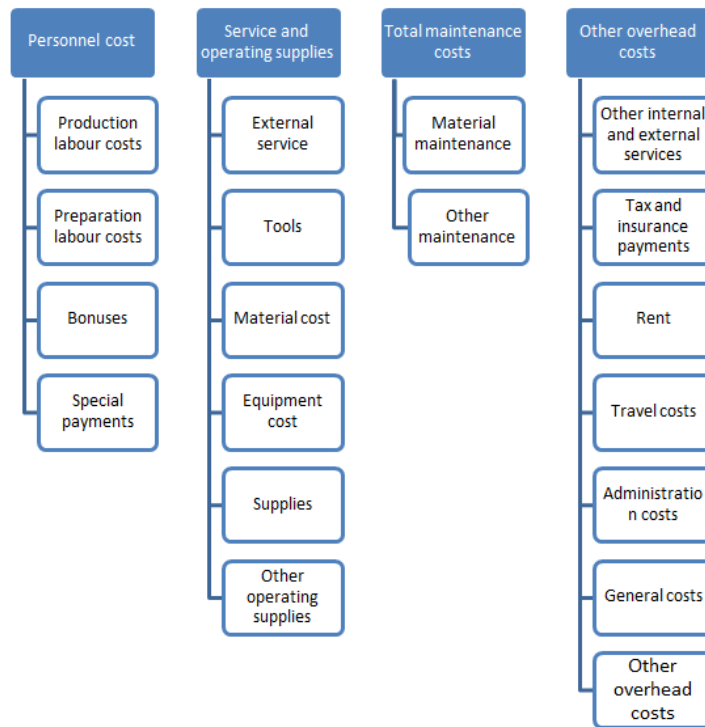


Figure 29 Implementation Cost Guideline

From now on the framework will deal with each category separately in order to make the process easier to follow. For each category different sheets will be used to evaluate mitigation strategies.

The selection of a single mitigation strategy will be carried through a series of steps split in different excel sheet.

- Step 4 - Risk-Cost D. Links
- Step 5 -Risk Impact&Links
- Step 6 -MS inputs
- Step 7-MS Selection

Step 4 - Risk – Cost Driver Links

First of all risks will be linked to the cost drivers. Users will be required to identify the link between risks and cost drivers in order to settle a basic connection that will remain unchanged in the whole framework. The importance of these links lays in the differences among the impact of risks that influence different cost drivers. In fact, in evaluating the severity of each risk, this link cannot be left out of consideration.

The structure of the page is that one recorded in Figure 30 and links will be settled putting an "x" in the cell that connects a specific risk with a specific cost driver.

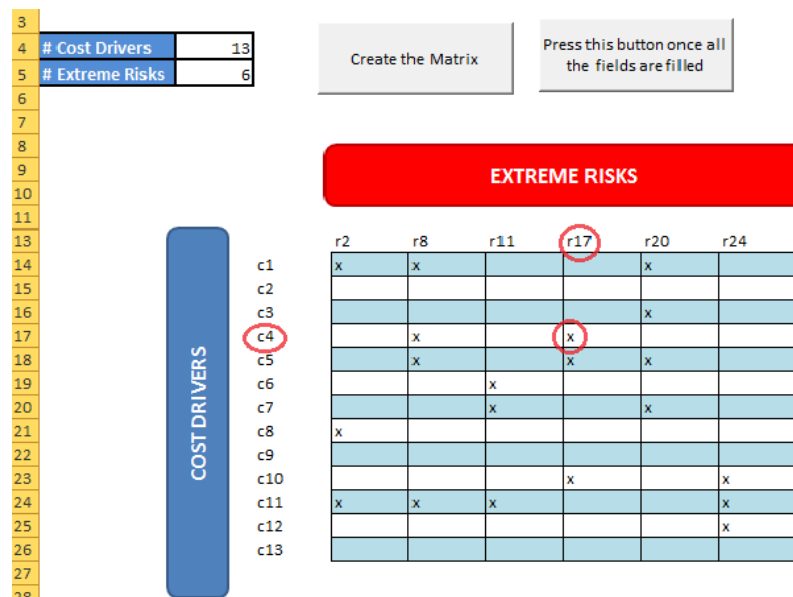


Figure 30 Step 4 - Risk-Cost Drivers Links (Extreme Risks)

Starting from this input, after some elaborations, the framework will provide a table to summarize these connections and make them clear to the users.

Step 5 -Risk Impact &Links

In “Step 5 -Risk Impact &Links” sheet, the table mentioned above has been created. Here, each cost driver will automatically appear together with five (set as a limit to make the compilation of the tool interfaces feasible in a short amount of time, but effective at the same time) risks, whose impact will have consequence on the cost.

The selection of these five risks will be based on the combination of likelihood and impact values, provided in the “Step 2b-Risk Evaluation” sheet. Moreover, based on links provided in “Step 3b-Risk-MS Links” sheet, each risk will appear with five mitigation strategies as it has been shown below.

	A	B	C	D	E	G	
5							
6		Cost Driver	Risk		Mitigation Strategy		
7		ū	r20	Impact	ms13		
8					3	ms89	
9				Likelihood	m1m1		
10				67%	ms1		
11					ms3		
12			r8	Impact	msa		
13					6	ms1	
14				Likelihood	msbmsb		
15				35%	ms5		
16					ms3		
17			r2	Impact	ms24		
18					7	tata	
19		Likelihood		lololo			
20			45%	koko			
21				popo			
22		-	Impact		0		
23						0	
24			Likelihood			0	
25					0		
26					0		
27		-	Impact		0		
28						0	
29			Likelihood			0	
30					0		
31					0		
32					0		

Figure 31 Cost Driver-Risks-Mitigation Strategies Links

Users are here required to provide a more specific impact and likelihood value (compare to that one provided in “Step 2b-Risk Evaluation” sheet) taking into account the cost driver – risk link.

Starting from these links (Cost Driver – Risk and Risk – Mitigation Strategy) the next page “Step 6E-MS inputs” will be partially but automatically completed.

Step 6E-MS inputs

Figure 32 shows the structure of this sheet.

15																						
16	Cost driver	c1																				
17																						
18	Risk	r20																				
19	Impact	3																				
20	Minimum	1	Most Likely	3	Maximum	5	Range	4														
21	Likelihood	67.00%																				
22																						
23																						
24	Strategies	Impact reduction	%	Final Impact (€)	Likelihood reduction	%	Final Likelihood %	Confidence increasing	%	Minimum	Most Likely	Maximum	Final Range (€)	Benefits								
25	ms13	75	0.750	31	46%	20	1.40	3	4.60	3.20												
26	ms89	40	1.800	50	34%	30	1.60	3	4.40	2.80												
27	ms1	25	2.250	70	20%	40	1.80	3	4.20	2.40												
28	ms1	60	1.200	54	44%	50	2.00	3	4.00	2.00												
29	ms3	50	1.500	50	34%	60	2.20	3	3.80	1.60												
30																						
31																						
32	Risk	r8																				
33	Impact	6																				
34	Minimum	3	Most Likely	6	Maximum	6	Range	6														
35	Likelihood	35.00%																				
36																						
37																						
38	Strategies	Impact reduction	%	Final Impact (€)	Likelihood reduction	%	Final Likelihood %	Confidence increasing	%	Minimum	Most Likely	Maximum	Final Range (€)	Benefits								
39	msa	40	3.60	90	4%	80	5.40	6	6.60	1.20												
40	ms1	60	2.40	75	9%	50	4.50	6	9.00	4.50												
41	msbmsb	80	1.20	25	26%	65	4.95	6	9.00	4.05												
42	ms5	10	5.40	35	23%	32	3.96	6	9.00	5.04												
43	ms9	20	4.80	10	32%	40	4.20	6	9.00	4.80												
44																						
45																						
46	Risk	r2																				
47	Impact	7																				
48	Minimum	5	Most Likely	7	Maximum	9	Range	4														
49	Likelihood	45.00%																				
50																						
51																						

Figure 32 Step 6E-MS inputs Interface

As it can be seen from Figure 32 each strategies will be linked to a specific risk that in turn will be linked to a cost driver. Cells of Cost driver, risk, strategies, likelihood and impact will be automatically filled out by the framework (input will be taken from Step 5 -Risk Impact &Links). However users will be required to identify and evaluate some aspects linked with each strategy. In particular they need to be able to evaluate:

- range of impact (maximum and minimum values),
- impact reduction,
- likelihood reduction,
- confidence increasing,

that each strategy can provide.

In fact the last three items represent the main factors under which the framework will compare different strategies in order to identify the most suitable one. Providing these inputs the framework will calculate the final impact and likelihood of the risk, after implementing each mitigation strategy. Moreover new value for the upper and lower bounds of the impact range will be recorded, identifying the final benefit provided by each implementation. This data have been then summarized in the next page.

Step 7-MS Selection

In “Step 7-MS Selection” sheet in fact, users can simply find a table in which all the strategies, linked to a specific risk, are reported together with the results derived from the previous inputs and calculations. Each strategy is placed side by side to the impact reduction, likelihood reduction and confidence increasing that it can promise together with its implementation cost.

Combining these values it will be possible to create two main indexes for each strategy and therefore compare them easily.

Strategies	Implementation Cost	Impact R.	Likelihood R.	Cost/Benefit Result	Confidence I.
ms1	1	1.00	20%	0.20	60%
MMM	6	0.50	30%	0.025	20%
ms2	2	1.50	20%	0.15	10%
ms3	3	3.00	10%	0.1	50%
ms4	4	4.50	90%	1.0125	60%

Figure 33 Step 7 MS Selection-Interface

In this page the framework is able to compare each mitigation strategy with the others. This comparison is based on two indexes:

Index 1:

$$\text{Cost Benefit Result} = \frac{\text{Impact Reduction} \times \text{Likelihood Reduction}}{\text{Implementation Cost}}$$

Equation 1 Mitigation Strategy Evaluation - Index 1

Index 2:

Confidence Increasing

The first one combines implementation cost, impact and likelihood reduction. Based on the value of this index the framework is able to identify, colouring it in red, the mitigation strategy with the highest value. The second index is the confidence increasing itself. With it, it is possible to identify the mitigation strategy that guarantees the highest result. This strategy will be coloured in green.

Cost driver		cd1			
Risk		r1			
Strategies	Implementation Cost	Impact R.	Likelihood R.	Cost/Benefit Result	Confidence I.
ms1	10	2,50	50%	0,13	20%
ms2	20	4,50	30%	0,0675	30%
ms4	4,4	1,50	25%	0,09	60%
MMM	12	3,00	70%	0,175	10%
NNN	21	1,00	90%	0,042857143	50%

Figure 34 Mitigation Strategy Selection

Based on the result obtained, further considerations need to be done by users. In fact, it is important to analyse the options chosen by the framework and make a choice. Either one single strategy can be selected or they can be used together for better result.

CHAPTER 5

PILOT IMPLEMENTATION

5.1 CASE STUDY: A real example of a defence contractor

5.1.1 Company overview

As it has been stated in the previous chapter, the methodology development was realized together with one of the largest defence companies in UK. This meant developing concrete and consistent results for an industrial partner for guidance on a real life challenge.

First of all, it is important to introduce the company and its role within the servitization context.

The organisation is an international defence, aerospace and security company and with an annual turnover exceeding £15 billion is one of the world's largest defence contractors. The Company has responsibility for delivering several major defence platforms, and with an ever-increasing emphasis on risk-sharing, faces many challenges.

One such challenge is coping with the uncertainty that surrounds the ability of a complex product to perform effectively; this is driven by a multitude of factors including not only the design and build quality of its thousands or millions of parts but also the effectiveness of the supply chain that supports it. In an availability contract the company takes on much of the risk associated with sustaining an agreed level of availability at an agreed price.

In such a context, ignoring uncertainty can lead to unplanned costs and significant overspend. On the other hand, building in uncertainty to cost modelling can lead to predictions that may be unaffordable for the customer. In order to achieve high confidence in achievability at an affordable cost it may be necessary to reduce level of spread of possible model outcomes; this requires effective processes and tools for dealing with the risk and uncertainty that form part of the inputs to the model.

The rising cost of maintenance, operations and support coupled with the need to mitigate the increasing complexity of equipment and systems as well as the difficulty of providing resources (cost of staff, complexity of training and staff retention) places increasing pressure on budgets. The spectrum of PBL solutions represents therefore a sort of catalyst to enable logistics transformation and incentivize a cost-down, availability up outcome.

Having its major operations across five continents and customers and partners in more than 100 countries, inevitably means inherent complexity and large scale projects.

That is the reason why PBL start to be largely used in the defence environment. Becoming service provider rather than a mere equipment vendor brought those companies in facing new issues and uncertainties.

Specifically, the company is basically undertaking a deep shift in the way it is doing business. Instead of acquiring goods and services transactionally, support is based upon an integrated performance package designed to optimise system readiness (IFS-Applications, 2010). Agreements last over longer period of time and need therefore to be protected by contracts in which all the new risks are taken into account and lines of authority and responsibility are clearly stated.

Therefore risk management procedures assume a primary role in the context. Risks need, first of all, to be correctly identified and the right corrective actions need to be implemented.

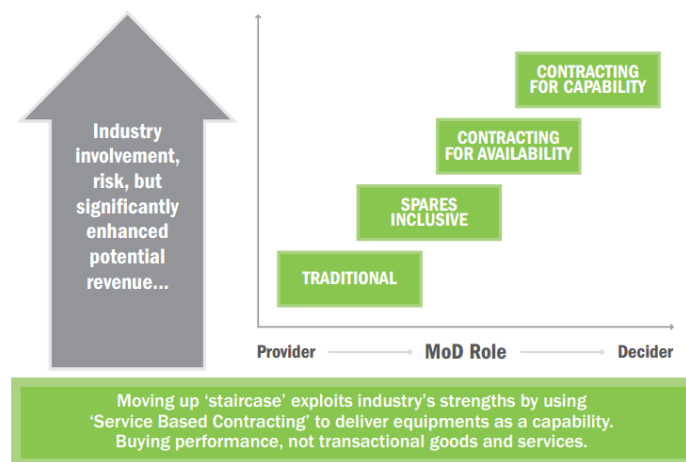


Figure 35 Contracts and risk sharing

As it can be seen from Figure 35, the contract itself bases its features on how the risks are shared among partners. In fact, to briefly give an explanation, Contract for Capability (CfC) differs from Contract for Availability (CfA) in that in CfA the supplier is responsible for delivering platforms and equipment to agreed performance and output standards whereas, under CfC the supplier is responsible for providing a capability (e.g. Air to Air Refuelling) to agreed performance standards.

It is important to mention the fact that this company is usually involved in partnered approach with governmental authorities, such as the Ministry of Defence (MoD), partnerships that increase risk exposure because of the complexity and the importance of the subject of the negotiation. Contracts potentially worth in the region of billion dollars over a period of time that lasts even more than ten years.

Being a world-wide company potentially means different management practices around the world.

Speaking about what is currently done in UK context, the adaptation of this kind of contract is something new, most of all when dealing with MoD. That means developing the ability of involving this particular customer in the right way, keeping in mind that roles and responsibilities change. In fact, if the defence contractor was accustomed to take part in contract where it just needed to provide discrete maintenance, repair services and the provision of spares and parts, now it is involved in something new with new tasks.

Contract for availability is an innovative operating model and the prime contractor is charged with meeting key output measures, such as aircraft available flying hours. The contractor acts as a Prime Systems integrator (PSI) for the key operations needed to deliver the desired outcomes, such as supply chain management, fleet maintenance activity, airworthiness, training and technical support. In general, the contractor then becomes responsible for streamlining processes and reducing overall costs. Overall the company will be responsible for ensuring the required aircraft at an agreed capability are provided to the front line when they are needed. (Accenture, 2009).

To be successful with availability contracting contractors need to adopt a service oriented business model. This typically requires a new organisational design, a new culture of working closely with the customer and suppliers and new business processes. Key to it all is having optimal risk management process and organisational designs that can support, and develop, the new contracting model (Accenture, 2009). All what has been described so far justify the need of a risk management procedure change. The company need something that:

- Integrates capabilities to manage the technical interfaces to connect the company and third-party systems
- Monitors business performance against contractual and performance indicators.

The purpose itself is deeply linked with the profitability of the company. Having a well-defined risk register that takes into account all the potential events as well as the ability of selecting the right mitigation option enables the company in increasing asset availability and working capital utilisation while delivering efficiencies and operational enhancements through improved asset management and maintenance processes and an integrated supply chain, improving therefore capability outcomes and reducing the total cost of ownership.

5.1.2 The Company involvement

This phase of the project has been structured in three main steps:

Step 1: Presentation of the framework

The framework has been literally presented to the company. In this way it has been possible to understand how the framework works, the logic behind its functions.

Step 2: Testing the framework

The framework and tool embedded in it have been then tested on a sample case. Dummy data has been used to validate the mechanisms and logics behind its working process. It has represented a sort of debugging to find and then correct possible bugs or defects of the program.

Step 3: Validation Questionnaire

Some questions have been developed to get the users' perception of the framework. Few questions have been conceived to mention the concept of responsibilities and usability. The reason behind this mainly lays in testing the usability itself and in understanding how confident users feel during the utilization. A considerable section has been dedicated to benefits and limitations of the framework itself in order to obtain concrete suggestions to improve it following company's requirements. The last questions refer to the framework assessment and results. Answering these questions, users can easily provide a feedback about the usefulness and accuracy of the output obtained.

As it has been already mentioned, ten meetings were initiated, whilst each lasted two hours. With semi-structure interviews, it was possible to design and improve the framework and to make it usable for the case company.

Here a description of each of them has been reported.

1st Meeting

Topic: Project Launch, aim, objectives, tasks and deliverables

Attendees: Principal Reliability Specialist, Risk Manager, Head of Cost Engineering, Cost Engineering Managers, Principal Estimator

In this first meeting the project has been presented to the company to explain our understanding of the main purpose and objectives. After an introductory presentation, some suggestions have been made by the Principal Reliability Specialist in order to have a clear and unique starting point from which the project could have been launched. Therefore aim, objectives, tasks and deliverables have been settled together with the company. In particular, a specific and detailed aim has been set for the project. It has been defined in the following statement: developing a framework that supports with identifying the risks and uncertainties, defining management strategies, and supporting with evaluating the suitable management strategies.

Moreover an agreement on a series of objectives has been achieved in order to set a sort of step-by-step process that led to the final purpose.

- Identify a process for risk management
- Identify risk based on a real project
- Develop a comprehensive risk-mitigation strategy list
- Quantification of selecting mitigation approach
- Validation of the methods through case studies

Finally two main tasks have been defined together with some requirements that needed to be delivered within prefixed deadlines. Going into details:

Task 1: Literature Review and Report

Task 2: Tool Enhancement and Validation

This first meeting has been, therefore, indispensable to align our future work with the company needs.

2nd Meeting

Topic: Aim & objectives, tasks & deliverables presentation

Attendees: Principal Reliability Specialist, Risk Manager, Cost Engineering Manager

In this second meeting a final agreement on the purpose of the project has been reached. A review of what was the topic of the previous meeting has been shown to the company in order to make each point of the discussion clear. In this way it has been possible to understand their needs and define our future work to fulfil their requirements.

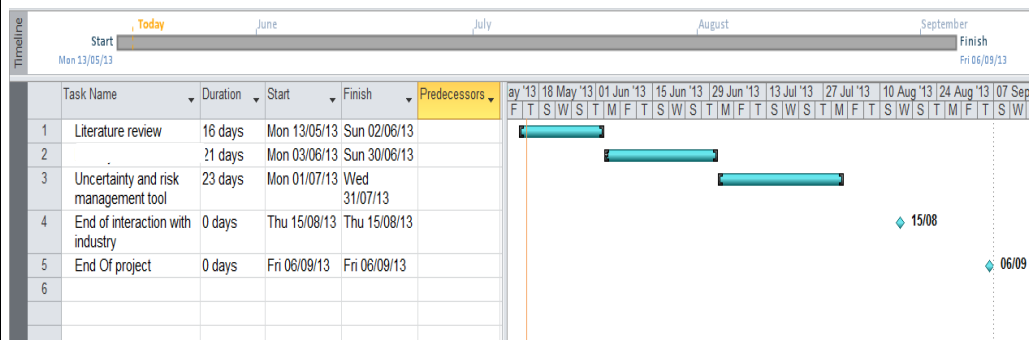
Table 31 Task & Deliverable

Task	Deliverable
<p>Task 1: State of Art Review</p> <ul style="list-style-type: none"> • Review of existing Risk, Opportunity and Uncertainty management and mitigation processes <ul style="list-style-type: none"> • Industry • Academia • Critical comparison (cost/benefit) between different management and mitigation approaches • Definitions to support distinguishing Risk, Uncertainty and Opportunity 	<p>→ Deliverable 1: State of Art Review</p> <ul style="list-style-type: none"> • Report on output of Task 1 <ul style="list-style-type: none"> • Definitions <p>Assessment and comparison existing Risk, Opportunity and Uncertainty management and mitigation processes in Industry and academia</p>
<p>Task 2: Consolidation of Risk, Opportunity and Uncertainty data from the Company</p> <ul style="list-style-type: none"> • Generation of generic Risk and Opportunity Register for CfA projects <ul style="list-style-type: none"> • Capture of sanitised risk/opportunity registers and related information <ul style="list-style-type: none"> • In context of type of CfA programme (e.g. domain, duration, organisation) • Identification of mitigation strategies • Consolidation of mitigation strategies identified with existing mitigation strategies • Validation of previously captured uncertainties <ul style="list-style-type: none"> • Review/comparison with recent programmes 	<p>→ Deliverable 2: Consolidation of Risk, Opportunity and Uncertainty data from the Company</p> <ul style="list-style-type: none"> • Report on types of Risk, Opportunities and Uncertainty relevant to CfA programmes <ul style="list-style-type: none"> • Mitigation strategies (risk/uncertainty) • Exploitation strategies (opportunity) • Impacts of characteristics of CfA programme on Risk, Opportunity and Uncertainty
<p>Task 3: Development of Risk, Opportunity and Uncertainty Management Tool</p> <ul style="list-style-type: none"> • Cost-benefit analysis of selecting mitigation approaches <ul style="list-style-type: none"> • e.g. How does a mitigation action reduce risk or uncertainty (or increase opportunity realisation)? • Validation (Company feedback) • Generation of guidelines for selecting mitigations according to CfA programme characteristics <ul style="list-style-type: none"> • Validation (Company feedback) • Encapsulation of guidelines in software tool • Validation of the methods through a case study 	<p>→ Deliverable 3 – Guidelines and Tool for managing Risk, Opportunity and Uncertainty</p> <ul style="list-style-type: none"> • Draft Guidelines Report <ul style="list-style-type: none"> • Final Guidelines Report (following review) • Initial User-friendly Software tool • Final Prototype tool (following review)

Dependencies – Required inputs from participating Business Units

- To the degree possible, provision of data:
 - Sanitised risk/opportunity registers and uncertainties
 - Sanitised information regarding of CfA programme (e.g. domain, duration, organisation)
 - Sanitised risk/uncertainty mitigation approaches
- To the degree possible, provision of time for interviews and/or questionnaire responses
 - Expected max: 5 hours per person
- Feedback on deliverables
 - As appropriate to Business Needs

Gantt chart:



3rd Meeting

Topic: First Deliverable - Literature Survey

Attendees: Principal Reliability Specialist, Risk Manager, Cost Engineering Manager

In the third meeting the first deliverable has been completed and presented to the company. A description of the literature review has been therefore prepared to easily show the company the-state-of-art about the topic.

The discussion mainly focused on the meaning of the terms risk and uncertainty. At the beginning there was no a clear and common understanding of the two terms, there were dissenting opinions between what had been presented and the idea spread among the company. Therefore, it has been very important to reach and maintain an agreement on this, since it represents the main concept of the whole thesis.

For this reason a questionnaire was developed. Questions were though to go through all the topics that were cited in the literature.

Table 32 Questionnaire

Questionnaire
<ul style="list-style-type: none"> • Risk and uncertainty definitions <ol style="list-style-type: none"> 1. How would you define Risk and Uncertainty? • Risk management process (importance of a risk register, use it and make it bigger with some risk not mention yet – maybe from the literature) <ol style="list-style-type: none"> 1. Have you already a well-defined step-by-step approach to deal with risks? What is it? 2. Which people are involved? 3. What kind of expertise is involved? 4. Which tools/techniques/methods have been used so far to assist with risk management? 5. Do you already have a risk register for Contracting for availability? (up to date) What is covered about each risk? (where it is going to impact, who is responsible for it, cost ...) 6. How do you prioritise risk and categorize them? 7. How do you study the context of contract? Which areas or aspect are taken into account?(Which areas are involved? Is it possible identify some specific areas?) 8. Is there a unique strategy to deal with risk? Or one for each risk. (Avoidance, transferring ,reduce...) 9. Are you already using one of the six standard processes presented? • Mitigation approach <ol style="list-style-type: none"> 1. Do you classify risk before undertaking any strategy? How? Which aspects are taking into account? 2. Are there any mitigation strategies already in use? How did you develop them? 3. How do you develop new one? 4. How do you rank and prioritize them?(evaluation) (CBA- propose: cost reduction and level of confidence in the occurrence, what do you think about this?) 5. How do you evaluate them qualitatively and quantitatively? Is there any step-approach? Are you currently using a cost-benefit analysis? 6. How do you quantify cost? Benefit? Which ones are you taking into account? 7. How do you like the tables presented in the report (risk and strategies)?they presented risks and strategies that can be used in this context as well, what do you think about it? Can they be representative? (maybe just a starting point) 8. Could you provide something similar (more appropriate and detailed) about your business? Have you ever compiled a similar table? • Opportunity management <ol style="list-style-type: none"> 1. Are you currently managing opportunity? How? 2. Do you have and well-defined process to handle with them? (steps) 3. Do you manage them within the risk management process? 4. What is your understanding about the difference between risk and opportunity? 5. How do you manage a potential positive impact? How do you ensure your company to take fully advantage from it? 6. Do you have any approach to deal just with opportunity?

When the questionnaire was presented to the company it came together with the list of risks and mitigation strategy already reported in chapter 3. Please refer to that section for further details.

4th Meeting

Topic: Framework - Starting point

Attendees: Principal Reliability Specialist

After the third meeting, a meeting was arranged to speak with the Principal Reliability Specialist and let him know what would have been our next future works. During this conversation the idea of developing a framework to manage risks and mitigation strategies became more concrete.

5th Meeting

Topic: Framework - First launch

Attendees: Principal Reliability Specialist, Risk Manager, Cost Engineering Manager

In this meeting, the framework has been launched for the first time. As expected the company did not fully understand all its functions and capabilities. However, a discussion about the purpose of the framework has been started to lay the right foundations to develop a proper program that would have been able to reach the goal previously and commonly settled. The company needs a proper process to deal with risks and their mitigation strategy. Most of all a clear method to choose, following proper criteria, the most suitable risk mitigation strategy needed to be developed.

6th Meeting

Topic: Framework - Improvements and presentation

Attendees: Principal Reliability Specialist

In the sixth meeting the framework has been presented a second time. The version was updated and comprehensive of all their suggestions to improve the framework.

Usability of the framework has been an important question to discuss. The company, in fact, mentioned the possibility of different uses of the framework itself. Therefore the possibility of using categories rather than single risks has been topic of conversation. In this way, the utilization of the framework became easier and intuitive and tasks could have been shared among business unit.

Important to mention is that a validation for the purpose of the framework has been given by the company. In this way attention could have been paid 100% on the development of the framework, being sure to meet company requirements.

7th Meeting

Topic: Framework - Final version presentation

Attendees: Principal Reliability Specialist, Cost Engineering Manager

In the seventh meeting the final version of the tool has been presented to the company. A complete description of its functionalities and processes has been the main session of this meeting. It has been indispensable focus the attention on logic behind the tool itself to be sure that the results met company needs.

During the presentation further suggestions have been provided by the Principal Reliability Specialist in order to reset the tool in a most suitable way for the company usage. Another aspect to evaluate mitigation strategies has been mentioned.

Implementation costs have been set as the fourth feature under which different options will be compared. Moreover he also suggested little changes basing on his own experience in dealing with contracts and risks.

The structure of the tool itself has been modified to make the usage easier to understand and similar to previous risk management processes and approaches.

Finally a questionnaire has been prepared to validate the framework. In this way it has been possible to identify strengths and weakness and improve the tool, making it more user-friendly and perfectly suitable for company utilization.

The meeting ended with arranging some deadlines to completely validate the framework and have some data or real cases to test its functions and usability.

The questionnaire is reported in Annex A.

8th Meeting

Topic: Framework - Verification

Attendees: Principal Reliability Specialist

The eighth meeting has been arranged to start the framework verification and validation.

Emphasis has been mostly given to one improvement that has been made after the previous feedback. Now the framework has the capability of using mitigation strategies presented in a default list but also recording new mitigation strategies that users add during the use of the framework in the previously mentioned default list.

The framework has been then tested with some dummy data just to understand the process behind the interface and the logic of it.

For further details about the test, please see the video attached.

It has represented a sort of debugging to find and then correct possible bugs or defects of the program.

The meeting ended arranging future meetings with different people in order to definitely validate the framework.

The Cost Engineering Manager and the Risk Manager have been mentioned as the right roles within the company to conclude this task. Moreover the questionnaire has been fully completed by Principal Reliability Specialist, it has been reported in Annex A providing a very good and useful feedback to understand their opinion about the framework and lay foundations for any kind of further improvements.

9th Meeting

Topic: Framework - 2nd Validation

Attendees: Cost Engineering Manager

As it had been suggested during the previous meeting, a different business role has been involved in the framework validation. Therefore the framework has been presented and tested a second time by the Cost Engineer Manager to have a different point of view for the validation. He was satisfied with the logic and format of the framework. Moreover he was positively surprised of its potential usability thanks to its good way of dealing with cost drivers and mitigation strategies.

The only concern was about the values associated as default ones to the likelihood of events. The values presented were not consistent with the scenarios that the company was used to deal with and therefore it has been settled to be modified and make them more close to their context.

He also completed the questionnaire, providing suggestions and comments for the framework validation. The questionnaire has been reported in the annexes.

10th Meeting

Topic: Framework - 3rd Validation

Attendees: Principal Reliability Specialist, Risk manager

The final meeting has been organized to obtain the third validation. The framework has been presented to the risk manager who provided further suggestions about its functionalities and interfaces to make it more flexible and efficient. Mainly the discussion focused on potential improvements that, with further works, can be implemented in the current framework.

This meeting has been therefore a good starting point to settle new foundations to develop future features.

Moreover the questionnaire has been filled in by the risk manager, providing a very detailed feedback to immediately improve the framework.

Table 33 Industrial interactions - summary

INDUSTRIAL INTERACTIONS		
<p>1st Meeting Project Launch, Aim and Objectives development</p> <p>Duration: One day Meeting - Company Visit</p>	<p>Attendees: Principal Reliability Specialist, Risk Manager, Head of Cost Engineering, Cost Engineering Managers, Principal Estimator</p>	<ul style="list-style-type: none"> • Project presentation: <ul style="list-style-type: none"> - Aim & Objectives development - Tasks identification and schedule
<p>2nd Meeting Aim & objectives, tasks & deliverables agreed and presentation</p> <p>Duration: 2h - Conference Call</p>	<p>Attendees: Principal Reliability Specialist, Risk Manager, Cost Engineering Manager</p>	<ul style="list-style-type: none"> • Project purpose presentation: <ul style="list-style-type: none"> - Final agreement on aim, objectives, task and deadlines
<p>3rd Meeting First Deliverable – Literature Survey</p> <p>Duration: 2h - Conference Call</p>	<p>Attendees: Principal Reliability Specialist, Risk Manager, Cost Engineering Manager</p>	<ul style="list-style-type: none"> • Presentation and delivery of the first deliverable <ul style="list-style-type: none"> - Literature Survey - Company Feedback - Discussion on: <ul style="list-style-type: none"> Meaning of risk → agreement with the company Concept of opportunity (Lack of Opportunity Management Process)
<p>4th Meeting Framework initialization</p> <p>Duration: 30 Mins - Phone Call</p>	<p>Attendees: Principal Reliability Specialist</p>	<ul style="list-style-type: none"> • Framework initialization: <ul style="list-style-type: none"> - Brainstorming with Principal Reliability Specialist

<p>5th Meeting Framework – First launch</p> <p>Duration: 2h - Conference Call</p>	<p>Attendees: Principal Reliability Specialist, Risk Manager, Cost Engineering Manager</p>	<ul style="list-style-type: none"> • Framework launch: <ul style="list-style-type: none"> - Agreement on the purpose - Criteria to evaluate risk and mitigation strategies: <ul style="list-style-type: none"> ▪ Risk evaluation based on: <ul style="list-style-type: none"> - Impact - Likelihood ▪ Mitigation Strategy evaluation based on: <ul style="list-style-type: none"> - Impact reduction - Likelihood reduction - Confidence increasing
<p>6th Meeting Framework – Improvements and presentation</p> <p>Duration: 2h - Conference Call</p>	<p>Attendees: Principal Reliability Specialist</p>	<ul style="list-style-type: none"> • Framework initial verification: <ul style="list-style-type: none"> - Explanation of mitigation strategies evaluation criteria - Framework usability • Framework validation
<p>7th Meeting Framework - Final version presentation</p> <p>Duration: One day Meeting - Company Visit</p>	<p>Attendees: Principal Reliability Specialist, Cost Engineering Manager</p>	<ul style="list-style-type: none"> • Final version presentation: <ul style="list-style-type: none"> - Description of functionalities, processes and logic - Further suggestions and improvement: Consider implementation cost in strategy evaluation • Validation questionnaire (strengths and weaknesses identification)
<p>8th Meeting Framework - Verification</p> <p>Duration: 2h - Conference Call</p>	<p>Attendees: Principal Reliability Specialist</p>	<ul style="list-style-type: none"> • Framework validation: <ul style="list-style-type: none"> - Presentation with detailed description of the whole renewed framework - Test with dummy data - Further suggestions: New way of providing risk impact and likelihood values - Questionnaire analysis • New validation meetings arrangement, involving different business roles

9th Meeting Framework – 2nd Validation Duration: 2h - Conference Call	Attendees: Cost Engineering Manager	<ul style="list-style-type: none"> • Framework validation (2): <ul style="list-style-type: none"> - Feedback and suggestions - Modification of likelihood and impact default values - Questionnaire analysis
10th Meeting Framework – 3rd Validation Duration: 1h - Conference Call	Attendees: Principal Reliability Specialist, Risk Manager	<ul style="list-style-type: none"> • Framework validation (2): <ul style="list-style-type: none"> - Feedback and suggestions - Brainstorming about potential future improvements (increasing the number of items currently presented in the tool) • Questionnaire analysis

5.1.3 Methodology verification and validation

Particular attention need to be paid to the verification and validation phase. It represents the moment in which it is possible to understand the real utility of what has been developed, if it could concretely help the companies, if results have been achieved and objectives met.

The verification and validation of the framework have been thought to prove the consistency, the efficacy and the usability of the framework.

Three business roles took part in the validation phase: the principal reliability specialist, the cost engineer manager and the risk manager. Each of them provided an important and decisive contribution to obtain the final results. The framework was shown to each of them and each of them was asked to respond to a questionnaire. As it has been said before, for further details please check the video and refer to the questionnaire provided in Annex A

The result of these analyses has been reported below.

- *Principal Reliability Specialist – 18 years of experience*

Following the analysis and feedback provided by the Principal Reliability Specialist this conclusion can be drawn:

First of all the framework has revealed to be easy to use and to understand, an opinion that therefore confirms its usability. Moreover no major weaknesses have been found; on the contrary a strong point has been mentioned. Evaluating strategies on their capabilities in reducing risk likelihood and impact, in increasing the confidence of occurrence and on their implementation cost goes beyond what people normally do.

However, at this level of details the ability to specify a numerical quantity for a risk becomes a key requirement not easy to achieve and at the same time outputs and results could be better shown to the users separating them from the rest of calculation. Furthermore, it offers an enhancement to the current practice by building a direct link between mitigation strategy and multiple risks. That was highlighted to be not easy to achieve, though it would improve effectiveness in risk analysis and to reduce resources that are put into handling risks.

- *Cost Engineering Manager – 32 years of experience*

Analysing the questionnaires compiled by the cost engineering manager other aspects can be mentioned.

The framework was suggested to be complicated then, the user testified that it is clear and not hard to use and a good documentation of mitigation strategies is provided. Moreover, it was highlighted that the framework might not make the process any quicker, instead the traceability offered will be better. It would be an initial framework that would capture the development of risks with the final position held in the existing risk repository.

The main suggestion that can be drawn from this analysis concerns the framework usability, in fact in these answers it has been stated that it should be as clear as possible in order to be used and understood by different users.

- *Risk Manager – 8 years of experience*

With the third validation, a different point of view was captured. The respondent highlighted that the framework offers a unique consideration with evaluating the confidence in the data provided for the risk occurrence and impact. Also, it was suggested that the tool represents a useful support in assessing individual risks and can be used at any point in contracts and is transferrable to any industry. If a set of standard mitigation strategies is available to the company, the use of this tool can guarantee consistency across the project and improved effectiveness. Moreover some potential improvements have been suggested. Attention must be paid when other tools are used because there may be issues in transferring data. Further features should be developed to cope with non-cost mitigation strategies in order to make the tool more flexible.

5.1.4 Results

The key findings and results of the development of this methodology are:

- New criterion to evaluate mitigation strategies
- A systematic framework to prioritize risks and then select the most suitable mitigation strategy
- Detailed guideline to support the framework utilization while implementing risk management process

This new criterion creates a framework to analyse mitigation strategies not only considering implementation cost and their capability to reduce risk impact and likelihood but also their capability to increase the confidence of a specific risk impact occurrence.

Implementing this criterion in the framework itself, it provides the main foundation on which the logic of the process has been designed. Then, mitigation strategies are compared and the framework identifies the most suitable one to put each risk under control. Through a series of calculation the framework combines different values, (impact decreasing, likelihood decreasing and confidence increasing), in two main indexes. With these indexes, users can easily compare each strategy with the others and select the best one based on the benefit.

Moreover detailed instructions are provided in each section of the framework. For the first time, users are therefore guided through the compilation of the whole framework. In this way they will be able to provide the right input at the right time. A wider research has been carried out to be sure of encompassing all the aspects that need to be taken into account. Great importance need to be given to cost and budget. That is the reason why detailed sections about how to evaluate likelihood and impact of risk together with mitigation strategy's implementation cost have been included in the framework. That makes the tool unique in the way it is structured and the logic that lies behind its functionalities.

5.1.5 Discussion

“Mitigation actions for Risks are addressed systematically one risk at a time. Moreover, including increased confidence as a measurement of the impact of mitigation is a useful addition to the standard way of considering this topic, i.e. reducing impact and/or probability.”

These words from the Principal Reliability Specialist confirm that a fresh and innovative point of view has been taken into account in developing and design this new framework.

The current approach looks at different type of risks independently, thus the corrective actions can be taken locally, for each single project. The idea at the basis of the model is to define a sort of algorithm that properly chooses the best corrective action.

Two main aspects should now be mentioned in order to better clarify and discuss the result obtained. First of all how risks are evaluated in the framework and how this procedure can benefit the company and then how considering a new aspect in analysing mitigation strategies can lead to a better final choice.

- Risk evaluation
Basing the development on information collected in the literature, a mechanism to evaluate risks has been developed. Its functionality enables users to list risks in four categories, which group together events that imply different criticality and need a different level of attention. It is now possible to focus the attention just on the most critical ones, creating therefore a short cut compared to having one single big list.
- Mitigation strategy analysis, comparison and selection
After analysing and understanding company current practices and procedures, a new aspect has been taken into account to reach a holistic view about mitigation strategies.
Confidence increasing represents a new way of looking at mitigation strategies capabilities. It refers to their capability in reducing the range of variability around a specific value of risk impact. With a deep analysis, reached thanks to this new feature, a more consistent final choice (the most suitable strategy) can be taken.

Therefore, this can be considered a great contribution to the literature as well as to companies that can count on it as a concrete support to better manage their decision making process and avoid risk management failure and its consequences. It offers an insight in to quantifying risk mitigation strategies. From its validation, it is possible to

affirm that this model can be applied to quantify mitigation options across different project and lifecycle phases.

However, it also important to discuss few critical points that company could face. For example, each business unit could already have an existing framework set, with which it is comfortable. Some aspects of this framework could duplicate activities that potential users already perform, while others (e.g. the cost driver dimension) may be novel to them and not readily accepted. This may make it harder for them to buy in to the risk mitigation evaluation feature which could add value to current processes.

These factors are what have been stated before. In other words they represent the risk of having huge amount of manual work and duplication of data across the organisation, increasing the probability of mistakes or misunderstanding.

5.1.6 Limitations

As it has been described in the section dedicated to the methodology development, this framework represents the first concrete application of the concept that lies behind its functionalities. This means that it can be considered as a prototype. As a prototype, therefore, it presents some limitations that offer opportunities to further work and improvements. In previous sections, some limitations have already been listed and analysed in details. In these parts different ones have been mentioned; they are mainly linked with the pilot implementation itself and how it has been carried out together with the company.

It is important to mention that no real data or cases were available to test the framework. This represents a big limitation for the project itself in obtaining results from which draw some conclusions. It would have been helpful having a real case to test its functionalities and logics and most of all understand if the process accurately identified the most suitable strategies. This lack of reality has also led in developing a qualitative questionnaire rather than a quantitative analysis. Therefore the framework evaluation has been based merely on qualitative questions that could not provide a complete feedback on its accuracy and usability.

Therefore, this methodology needs further work to become a useful tool in helping company with their risk management processes. With all the knowledge gathered in previous chapters, there is the entire conceptual basis on which a software development could be based.

CONCLUSIONS

CONCLUSIONS

The work carried out so far started with a full understanding of the problem. The advent of the servitization changes completely the way companies are doing business. New risks and uncertainties need to be taken into account, giving a lead role to contract as a protection for both partners when establishing longer and closer relationships. Companies are actually unready to face all those issues that rise with this new trend of being service providers rather than providing goods, possibly with spare parts and maintenance services.

Current approaches, methods, procedures and practices cannot actually properly help. They are not the right tools to enable companies in handling this new situation. They come from the past and they are therefore structured to fit with features of an environment already obsolete. These risk management processes are not suitable anymore. They are somehow incomplete and they do not represent a valid support anymore. They are step-by-step process that guides users in identifying, prioritizing and then putting each risk under control but their limitations are undeniable.

Long-term relationships, together with risks and uncertainties that they imply and performance-based contracts are the new established fact. They did not exist in the past and therefore their impact and consequences were obviously not considered when structuring risk management practices.

Something needs to change and to be adapted to the new way of doing business, especially for OEMs. Companies need something new that makes them able to be competitive on the new business scenario, protecting them completely from hitches totally new and that have never been taken into account before.

The prospective of these new approaches need to be wider. That is the reason why a deep analysis was carried out: having the right starting point to properly structure a methodology that could concretely help and support companies when dealing with contract for availability.

Different authors together with their works were deeply analysed to have a wide prospective about the topic. Each section of this thesis had its own authors and topic to follow. While during the analysis of risk and uncertainty definitions just few authors have been deeply studied to get and possibly share their point of view, for what concern servitization and contracts a wider spectrum of authors has been considered relevant for the purpose.

Indeed, for finding a definition Tarje Aven, Michael Mauboussin together with Frank Knight and Douglas W. Hubbard represent the main points of view reported in the thesis, while for the other topics the research has been carried out basing the choice of papers on key words in the title rather than authors' names. Servitization, long-term agreement, PSS, role of the contract are just few examples of words used for the research. The list would be too long to be here reported. For further details please refer directly to the References.

The web itself was surfed in order to get business practices that are currently on the market and used by the company.

Analyses done by consultancy firms or software corporations such as Accenture and Oracle were checked to understand what they suggest to face risks and uncertainties. Companies' website, together with reports of department of defence from different countries have been analysed to understand their approaches to the topic and if they had guidelines or supports to survive within performance-based contract.

The analysis of the literature, carried out following a precise logic and pattern, consented to:

- Understand the most important features of the servitization
- Understand the impact of longer-term relationships
- Understand the role of the contract and how role and responsibilities change when establishing performance-based contracts
- Identify all those new risks and uncertainties brought by this new trend, clarifying the proper meaning that lays behind these concepts
- Analyse how risk and uncertainties are currently managed by companies, thanks to a deep research within risk management processes
- Understand what these process actually miss to properly support companies in this new scenario

Next step has been therefore structuring a methodology that embraced a new business scenario.

Result

As it has been revealed in advance in the introduction, the key findings of the thesis are:

- A systematic analysis of the-state-of-the-art concerning three main topics:
 - The advent of the servitization trend
 - The role played by contracts, especially the importance of contract for availability
 - New risks and uncertainties together with risk management procedures
- A conceptual methodology to help OEMs in facing new risks and uncertainties brought by the advent of servitization
- A framework to help companies in selecting the most suitable mitigation strategy (just a prototype)

The first point represents an important achievement to all those people that will deal with the topic. In fact, with a logic pattern among all the different subjects analysed, the thesis gives a clear view about the current situation.

It represents the first attempt of creating a complete and unique database concerning these topics and all the most important implications that have an impact on business. The way the topic has been analysed gives the reader both a theoretical view and a practical approach to deal with the issue. Thanks to real cases, as well as current practices and procedures reported in the thesis, the paper is not limited solely to provide a purely academic prospective.

With this thesis, experts will have, first, a clear understanding of the spread of servitization trend in the OEMs environment and then, a well-developed analysis of what is linked with it.

Contracts themselves have a central role, stating all the new risks and uncertainties that need to be taken into account. The concept of risk, uncertainty and opportunity has been stressed to give an overview of what it is really embedded in these terms, especially those ones linked with this new context.

For what concerns the last two results, they are closely linked one each other.

While the conceptual methodology tries to theoretically group together all the features that are currently absent in risk management practices, the tool tries to make the approach more operative and usable by means of spreadsheets.

The methodology is obviously taking into account a great number of aspects. It is more a discussion of what is currently missing rather than being a pure method to implement. However, it is a fundamental step to bring the change. Indeed, making the methodology concretely operative would represent the real breakthrough.

The analysis of the-state-of-the-art enables the authors in understanding the current approach and then adds all those features that probably would help OEMs in facing new challenges. The addition of them has been thought in a way so that it would not be perceived as something disruptive, totally in disagreement with what is currently done.

The development of the methodology tends to be a sort of research that bundles together the old and the new, trying to create something useful to manage new risks and uncertainties without creating neither confusion nor aversion within the organization.

For what concerns the tool itself, it is composed by a set of spreadsheets in which the user is guided to properly select the most suitable mitigation strategy to put each risk under control. It is just an early design but a strong logic lies behind its operation.

As it has been described in the dedicated chapter, the choice of the strategy is based on two main indexes that consider not only the capability of reducing likelihood and impact together with implementation cost, but also how each strategy can increase the confidence of a specific occurrence.

In this way the tool gives its contribution to past approaches, considering a new criterion to evaluate that is not commonly used in risk management processes.

Moreover, this result is the only one that has been presented to the company, receiving therefore a validation from business.

Even if tested with dummy data, due to high confidentiality and restriction of information typical of the defence industry, the verification carried out by the company confirmed the fact that it fits for the purpose it has been created and its freshness in the way it handles risks and uncertainties. In fact, statements prove that the framework effectively supports the process of evaluating risks and selecting the most suitable strategy.

“The basis for recommending a mitigation approach appears to be sound, and the two recommendations based on reduction of impact and reduction of uncertainty to be worthwhile. Including increased confidence as a measurement of the impact of mitigation is a useful addition to the standard way of considering this topic. This is a strong point as it goes beyond what people normally do.”

These are words from the Principal Reliability Specialist that confirm the consistency and effectiveness of the framework.

Discussion

In spite all the efforts in managing risks potentially involved in a project, businesses still witness severe and large-scale accidents. A basic question is: has an adequate approach been developed to cope with these issues?

First of all it is important to mention the fact that this thesis represents the first attempt in deeply analysing and grouping together different aspects of the current situation and describing the logic that links them. It can be seen as a huge database that collects all the information about servitization and its implication in a business environment.

In this way, it is possible to have a complete and concise starting point to develop further works concerning the subject. The context analysed represents in fact one of the main topic of discussion of the last decades. Having a good overview of what is currently going on in this environment is necessary to enable researchers in giving their own and new contribution, avoiding to repeat the same analysis in the future.

For the very first time, a particular logic was followed to deal with the topic. The advent of servitization brought with it a great number of new risks and uncertainties that OEMs need to handle. The main reason behind this proliferation of contingencies and threats lays in a way of doing business, striking up long-term relationships with customers. Contracts become therefore the real lead role of this context, since with their clauses they formalize agreement between partners.

The analysis of the-state-of-the-art, carried out following this pattern, enables in understanding what is currently missing both in the literature and in the business environment.

The key findings of this work represent the basis of the methodology developed.

The methodology developed is composed of two main parts. The first one can be seen as the conceptual methodology that encompasses all the aspects that were found during the analysis of the literature. It is true that it represents something not entirely developed but it is the first attempt in creating something new that, embraces new features that have never been taken into account.

It is important to specify what is currently available to companies in terms of risk management processes. These approaches tend to be generally developed to help companies in handling everyday risks when managing their relationships with customers, providing goods, spare parts or maintenance services.

Issues rise with the awareness of the ongoing changes. Thanks to a deep analysis of current trend as well as current risk management practices, it was possible to understand what companies actually miss to handle the new business environment in which they need to survive.

This conceptual methodology makes its own contribution giving something to business.

How? Suggesting a risk management approach whose features enable users in considering risks and uncertainties due to longer relationships and to changes in role and responsibilities brought by the servitization.

In other word, the approach has a wider prospective, involving the customers first, to concretely create the right prerequisite to help companies in carrying out different projects and tasks successfully.

It is here necessary a brief digression to better discuss the result achieved. It can be useful to make a cross-references between the analysis of the-state-of-the-art and the features of the methodology developed. In this way, it is possible to see the real contribution of the thesis.

On the left side of Table 34, the new uncertainties to consider when operating in a servitized context are listed.

Then a mark has been put when the aspect has been considered by the methodology.

Table 34 Uncertainties managed by the methodology

Uncertainties	
Third party capacity	√
Supplier-Customer Interaction	√
Demand	
Organisational culture	

This list, actually, just synthetizes a bigger group of uncertainties that have been already mentioned in Chapter one, two and three. However, it provides enough information to start a discussion.

For what concern the third party capacity, this thesis provides a list of systems and metrics to check supplier and customer performance in advance. In this way, it will be possible to evaluate the partner in a complete way, avoiding to select the wrong one.

Having in mind that relationships are the key point of servitization, the methodology developed has the attempt of being an approach that can easily be used together with partners. It tries to be easy to use and to be shared. What wants to be achieved with a wider implementation that overpasses company's boundaries, involving the customer itself, is an alignment of resources between partners, a shared cost control system and the development of a continuous improvement programme.

For what concerns the last two points of the list, the explanation becomes more complex. In fact, for the Demand nothing has been explicitly said while developing the methodology.

However, an ambitious result could be developed a default list of risks together with possible mitigation strategies. With further work and studies, in fact, it would be possible to have a very detailed picture of the ongoing change with all the risks and uncertainties that can potentially rise to then define actions to mitigate their impact. The organizational change has been mentioned in previous chapters but it was not actually analysed in details. The analysis revealed that deep changes need to be undertaken from both sides but the methodology does not concretely state how to accomplish this result.

For the very first time, customers are taken into account, though as a fundamental role in implementing risk management procedures. The attempt, that for the moment still remains a theoretical concept, is to have something that enables users in anticipating potential events that can have an impact on important projects. That means having a framework that considers what-if scenarios in which different aspects, such as cost, time and performance can be taken into account in once. That is something new because so far neither articles nor processes have been thought specifically for the context of being service providers establishing stronger and closer relationship with customers as well as change responsibilities. Having the change as a starting point, allows to develop something “ad hoc” for reaching the purpose of protecting companies in the world of performance-based contracting.

Few more words should be spent speaking about the tool developed and its contribution. The framework itself, even though just a prototype, represents something new compared to past approaches and methods.

What has been discovered through the literature researches shows that risk management processes are now crossing the entire organization with the attempt to identify potential events that may affect the achievement of entity objectives (COSO, 2004). Papers, journals and documents analysed have clearly shown a lack of a simple and systematic approach to select a mitigation strategy that puts each specific threat under control. In fact, the diagramming technique and Monte Carlo simulation together with alternative risk management strategies such as risk avoidance, risk transfer, risk retention, loss reduction, and risk prevention and insurance represent traditional intuitive but unsystematic approaches (Al-Bahar & Crandall, 1990). In fact, analysing the literature it is possible to find only few contributions exploring how risk management processes work in practice, while most of the extant research deals with the role of risk management in the corporate governance debate (Scapens & Bromwich, 2010). Only a small number of processes might manage risks in a systematic way. Besides the scarcity of approaches, they also tend to be ad hoc, undocumented and half-finished, revealing therefore the impossibility of managing risk in a complete way. Their functionalities are not clear to the users and are not intuitive.

Their implementation tends therefore to be hard to understand and to be developed together with existing business processes.

The strength of this new tool, that differentiates it from the past methods, lies in the specific steps in which the process has been divided and designed.

Mitigation strategy can now be directly evaluated and compared through the framework utilization that will also select the best option among them.

To achieve this fundamental result, important aspects have been selected in order to analyse strategies in a more complete way. That has been achieved analysing strategies, not only under their capability in reducing risk impact and probability but also under their capability in increasing the confidence of the occurrence of one specific event.

Therefore it can be considered as a new paradigm to identify and manage risks.

The methodology attempts to propose an operation risk management framework that supports a transition from the governance sphere to the operational units. This means finding ways to identify concrete solutions to mitigate risks at all level of business.

It was developed as a step by step process in which users are guided. A whole parts has been dedicated to an analysis of service cost drivers; starting from them it is something unusual for what concern risk management processes. This actually helps in defining a complete risk register.

Having a well-defined list of risks represent a very important first step to be sure of taking all the potential events and uncertainties into account. Obviously it is not easy to get and it implies a change in the organisational culture. In fact, uncertainties need to be handled by the company as a whole without creating a specific function with this purpose. Therefore the method needs to be well-integrated within the organisation to allow every function in making its contribution in the analysis of the context.

Taking into account costs and impact on costs allows using a costs-benefits analysis as a way to select the most effective strategies to mitigate identified risks, as well as having an exact index of the potential impact on performance. That is the reason why during the literature analysis a whole part has been dedicated to CBA.

This new methodology actually needs to take into account how CBA is currently carried out by companies but at the same time sets new standards to consider new aspects.

What really changes, compare to the past is the setting where companies are placed and therefore the presence of new potential benefits as well as cost items. Companies are not used to this context and therefore need to have a guide that shows them an overall picture of what it is new around them. Right now, companies are sort of blind entities that do not know what they will face. A methodology that tests the context for them is what they really need to cope with this new scenario.

The methodology aims in making every step easier for the user, providing therefore all the information that can help during the implementation of a risk management process. Moreover, companies will have a tool that compares mitigation strategy in a very analytical way. Obviously, decisions cannot be based on a numerical result given by a tool, since their consequences could have a very big impact.

However it could represent a useful starting point to make a list of potential strategies that can be taken into account, reducing the list considerably.

There is also a new way of comparing mitigation strategy; confidence increasing represents an index that it is not common to find in risk management procedures. Actually, it is really important in the specific context analysed in the thesis. Selecting a strategy that can increase the confidence in having an outcome is fundamental for OEMs to correctly set all the clauses of a contract.

This thesis proposes an approach with new features to measure, monitor and then mitigate risks. Risks that are completely different from those ones of the past.

A framework has been developed to support the implementation of risk management process. With its logic and functionalities it attempts to go beyond the literature limitations.

Limitation and further work

Servitization requires its own risk management processes in order to take into account new aspects that have now impact on companies performance: new roles and responsibilities, closer and longer relationships with their customers, payment based on their performance and the contract such as PBC and CfA that support it.

This thesis has therefore the attempt to redesign and reorient business thinking from being passive to the advent of this trend to proactively react, anticipating risks, uncertainties and their consequences.

To succeed in this, this work proposes first a detailed description of the current situation to, at a later stage, develop a new methodology to help companies in facing the change.

The maturity of the method proposed actually depends on its use within the company. Clearly it is not a step-by-step process whose implementation solves OEMs' problems. It is a deep analysis that presents companies with a fait accompli: the business scenario has changed as well as the way of doing business, therefore risk management processes need to change as well.

Therefore some suggestions are here provided to help companies during this change within the organization and with external partners.

As the methodology has been developed, it presents its limitation. It represents an approach merely theoretical. For this reason, the same research should be carried on together with a business partner to comprehend an applied approach.

The tool itself has been thought as a first attempt to support OEMs in doing what has been mentioned above.

Obviously, the main contributions of this work can be further developed. The research could be extended with other real cases as well as the conceptual methodology.

Having concrete examples helps in refining what has been already developed. Only working directly in business environment could enable researchers to truly understand how to define a new approach which fits with the context.

Moreover, the thesis mainly focuses on risks and uncertainties without going deeply into details for what concerns opportunities and opportunity management. This could represent a logical continuation of what has been carried out so far in order to support companies also in taking advantages from hidden chances. Opportunity as well as risk needs to be studied and understood in order to act proactively to catch them. Therefore a step-by-step process could be developed.

The tool itself should be completed. Computer skills could deeply help in making a step forward and develop software that truly embeds all the functionalities in support of a risk management approach, specifically developed for service providers within PBC or CfA context. The current functionalities could actually be tested with real data.

Its usage within an organization will provide a useful feedback to improve its performance and results, possibly change some logics on which it is based.

Moreover, as it has been mentioned before, further studies can help in developing a default list of risks, cost drivers and mitigation strategies from which users can select their own ones and identify how to control potential threats. This will considerably reduce the amount of work required by the users, making the tool easier to be accepted and implemented.

However, it represents the first concrete application of the concept that lies behind its functionalities. Many changes could be implemented to make it more user friendly and suitable for what has been conceptually conceived.

What has been stated as a conceptual risk model includes many different new aspects that should be now considered. They represent something that companies were not used to face and therefore should be somehow included in the framework. In this way the methodology will act as the eyes of the companies, putting them directly in front of evidence that otherwise could have been not considered.

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<http://www.baesystems.com/>

General Electric:

<http://www.geaviation.com/>

Rolls Royce:

<http://www.rolls-royce.com/>

ANNEXES

ANNEX A – VALIDATION QUESTIONNAIRES

Questionnait form:

RISK MANAGEMENT TOOL FRAMEWORK VALIDATION QUESTIONNAIRE

A. General:

1. Name:
.....
2. Organisation:
.....
3. Role:
.....
4. Years of experience (in Risk Mgmt):
.....

B. OVERVIEW OF THE CASE STUDY

1. Description of the case study
.....
.....
.....
2. The information that is available
.....
.....
.....

C. LOGIC

1. How logical is the way of dealing with risks and mitigation strategies (like considering likelihood and consequences as main features of risks and evaluating mitigation strategy under three main aspects- likelihood and impact reduction and confidence increasing- and combine them together) (Assign a circle around the suitable number)

1	2	3	4	5	6	7	8	9	10
Totally Unsuitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally Unsuitable

If there are deficiencies please describe them:

.....
.....
.....

2. Is the framework suitable for the bidding phase?

1	2	3	4	5	6	7	8	9	10
Totally Unsuitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally Unsuitable

If it is not totally suitable, please explain the reasons:

.....

Are there any improvement suggestions:

.....

3. Can the framework be applied in alternative phases to the bidding stage? Yes No

If yes, please specify which phases

.....

D. GENERALISABILITY

1. Please comment on how generalizable the framework is within the defence industry

.....

2. Please comment on how generalizable the framework is for other contexts or sectors (not just CfA and Defence Industry)

.....

E. RESPONSIBILITY

1. How should the framework be used across the supply network? (e.g. only solution provider (OEM), or with the customer and/or suppliers) Why?

.....

2. What team or department should have ownership or responsibility of the model within the company?

.....

3. How could the team or department owning the framework maintain it?

.....
.....
.....

F. BENEFITS OF USING THE FRAMEWORK

1. How would the framework benefit the company?

.....
.....
.....
.....

2. How would the framework benefit in dealing with risks? Can it make the evaluation process quicker?

.....
.....
.....
.....

3. Is it reasonable to consider the choice made by tool as the most suitable mitigation strategy? Are all relevant aspects taken into account? Express an opinion and make some suggestions

.....
.....
.....
.....

G. LIMITATIONS OF THE FRAMEWORK

1. What are the potential limitations and challenges in using and implementing the tool?

.....
.....
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2. What are the potential organisational limitations and challenges that arise in using the software tool?

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.....
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3. How could the background of people filling the tool affect the output?

.....
.....
.....

4. Risk evaluation: should other aspects be taken into account? Yes No

If yes, which ones?.....

.....
.....

5. Mitigation Strategy selection: should other aspects be taken into account? Yes No

If yes, which

ones?.....

.....

.....

6. Can a single index be representative of a strategy? Can the three main aspects be grouped together?

.....

.....

.....

7. Are all the required inputs available to the users?

.....

.....

.....

H. USEABILITY OF THE SOFTWARE PROTOTYPE

1. Assessment of the usability of the tool in terms of features

a. What are the strongest features?

.....

.....

.....

b. What are the weakest features?

.....

.....

.....

2. Assessment of the usability of the tool in terms of features

a. How clear and appropriate are the considered terminologies in the framework?

.....

.....

.....

b. Please suggest possible improvements

.....

.....

.....

3. Does the tool provide sufficient amount of information to guide the user? Yes No

If no, please explain:

.....

4. Assess the time required to populate the tool for implementation on a project

.....

.....

.....

5. Please assess the following aspects in the tool

- a. Layout
.....
- b. Use of colour.....
- c. Ease of navigation.....
- d. Level of intuition
.....

6. Is the tool flexible enough to be applied with different levels of information availability?

I. ASSESSMENT OF THE FRAMEWORK

Please assess the completeness/suitability of the framework for the following questions

- a. Evaluation of the Risk severity by considering likelihood and impact (consequences)

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies				Suitable with minor deficiencies				Totally comprehensive

If it is not totally comprehensive, please explain the reasons:

- b. Evaluation of the Strategies by considering Likelihood and Impact reduction and Confidence increasing

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies				Suitable with minor deficiencies				Totally comprehensive

If it is not totally comprehensive, please explain the reasons:

- c. The approach to define the weight of the three previously mentioned aspects

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

- d. Calculation of the Mitigation strategy score based on the multiplication of likelihood and impact reduction and confidence increasing weighted on their importance

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

.....

- e. The approach to define cost drivers - risks linkage (Causes of variation on risk impact)

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

.....

- f. The inputs required

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

.....

- g. The suggestions for providing the right set of inputs

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

.....

- h. The process of turning a three point estimate into a single point estimate (Strategy selection)

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies				Suitable with minor deficiencies				Totally comprehensive

If it is not totally comprehensive, please explain the reasons:

.....
.....
.....

J. RESULTS

1. Evaluation of the output of the tool after populating it with information from the case study

.....
.....
.....

Evaluation of the repeatability of the tool after populating it with the same information from the case study

.....
.....

Questionnaire from: Principal Reliability Specialist
RISK MANAGEMENT TOOL FRAMEWORK VALIDATION QUESTIONNAIRE

A. GENERAL:

- 5. Name:*Richard Parker*
- 6. Organisation:*BAE Systems Advanced Technology Centre*
- 7. Role:*Principal Reliability Specialist*
- 8. Years of experience (in Risk Mgmt.):*8*

B. OVERVIEW OF THE CASE STUDY

3. Description of the case study

Sanitised extract from a Risk Register concerned with the in-service support of a major platform.

4. The information that is available

Risks and mitigation actions. Artificial example numbers used to quantify risks.

C. LOGIC

4. How logical is the way of dealing with risks and mitigation strategies (like considering likelihood and consequences as main features of risks and evaluating mitigation strategy under three main aspects- likelihood and impact reduction and confidence increasing- and combine them together) (Assign a circle around the suitable number)

1	2	3	4	5	6	7	⑧	9	10
Totally Unsuitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally Suitable

If there are deficiencies please describe them:

Mitigation actions for Risks are addressed systematically one risk at a time. This makes sense, but it would be helpful if the user had some assistance with consolidating the information thus gained into a single output. For instance when mitigation actions for a risk have been assessed (Step 7), to be able export copies of the Step 7 analysis, rows 18 to 26, to a separate worksheet.

On the positive side, including increased confidence as a measurement of the impact of mitigation is a useful addition to the standard way of considering this topic, i.e. reducing impact and/or probability.

5. Is the framework suitable for the bidding phase?

1	2	3	4	5	6	7	8	9	10
Totally Unsuitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally Suitable

If it is not totally suitable, please explain the reasons:

Same as for Q1. Documenting the output clearly would be a key requirement. However, the process that the tool is supporting is definitely very relevant at the bid phase.

Are there any improvement suggestions:

Supporting consolidation of the analysis has already been mentioned. In addition, the user needs to be able to quantify the probability of each risk explicitly – the midpoint of the range as currently used can be provided as a default but should be over-rideable. In the longer term a means of integrating this tool to existing risk registers would facilitate exploitation. It would have been desirable to populate the tool with some of the example risk data that were provided but I appreciate that time may have not allowed for this, and it was more important to get the functionality in place.

6. Can the framework be applied in alternative phases to the bidding stage? Yes No

If yes, please specify which phases

Risk management, and hence this tool, is relevant through the life of a project and applies to all phases from bid through to decommissioning.

D. GENERALISABILITY

3. Please comment on how generalizable the framework is within the defence industry
I don't think it needs to be generalised. I see nothing that makes it specific to e.g. naval applications any more than land or air. Only the data that the tool (or a given instance of the tool) contains make it specific.

4. Please comment on how generalizable the framework is for other contexts or sectors (not just CfA and Defence Industry)
As per Q1. The underlying principles are applicable to a wide range of sectors.

E. RESPONSIBILITY

4. How should the framework be used across the supply network? (e.g. only solution provider (OEM), or with the customer and/or suppliers) Why?
It could be used at multiple levels, each with a different and more or less specific risk focus, across the supply network; risk matters to everyone!

5. What team or department should have ownership or responsibility of the model within the company?

For each business unit, it should ideally reside within an overarching Project Management team, or Risk Management team if separately distinguished, and be flowed down to individual project teams. For businesses that do not have such a PM team, it would reside within a process modelling and enhancement capability or at the project/product level.

6. How could the team or department owning the framework maintain it?
Documentation of the methods used will be very important to enable enhancements, such as those described herein, to be added. It would require both Risk Management and Excel skills.

F. BENEFITS OF USING THE FRAMEWORK

4. How would the framework benefit the company?

It would be most effective as a decision support tool in the context of mitigating high hitting risks. The risk classification facility is useful in this respect, but it is also likely that risks would be prioritised within existing risk registers and then assessed. So the tool might not be applied from beginning to end, but this does not reduce its usefulness.

5. How would the framework benefit in dealing with risks? Can it make the evaluation process quicker?

It might not make the evaluation process any quicker – in fact it might take longer because more factors are taken into consideration; but for the same reason, the evaluation would have more credibility. As suggested earlier, users would generally be selective about when to apply it.

6. Is it reasonable to consider the choice made by tool as the most suitable mitigation strategy? Are all relevant aspects taken into account? Express an opinion and make some suggestions

The basis for recommending a mitigation approach appears to be sound, and the two recommendations based on reduction of impact and reduction of uncertainty to be worthwhile. A major assumption is that the mitigations are treated as mutually exclusive alternatives when in reality a combination of mitigations might be applied. It is recognised that allowing for this would significantly increase complexity (e.g. either the tool would have to make an assumption about how the combined impact of two mitigations should be determined or the user would have to provide additional information) but it would be worth considering this in any future development.

G. LIMITATIONS OF THE FRAMEWORK

8. What are the potential limitations and challenges in using and implementing the tool?

As always, the effectiveness of the tool will be limited by the data and knowledge available to its users. In the current absence of integration features, practical use would require the user to develop a process for using the tool alongside existing tools.

9. What are the potential organisational limitations and challenges that arise in using the software tool?

Each business unit will have an existing toolset, with which it is comfortable. Some aspects of this tool will duplicate activities that potential users already perform, while others (e.g. the cost driver dimension) may be novel to them and not readily accepted. This may make it harder for them to buy in to the risk mitigation evaluation feature which could add value to current processes.

10. How could the background of people filling the tool affect the output?

Inevitably the tool will benefit from the experience, or otherwise, of its users. Initially at least, it would be best used by the risk author (an expert in the domain to which the risk applies) with the aid of a facilitator (risk specialist) who can see how to get the best out of the tool.

11. Risk evaluation: should other aspects be taken into account? Yes No

If yes, which ones? *Possibly. Sometimes time or performance is more important than cost. However, treating all impacts ultimately as a cost impact enables a common view to be taken. This really comes down to how the tool is used.*

12. Mitigation Strategy selection: should other aspects be taken into account? Yes No
If yes, which ones? *Again, one may wish to distinguish reduction on different types of impact, but this would increase the complexity of the implementation.*

13. Can a single index be representative of a strategy? Can the three main aspects be grouped together?
This relates to the previous questions. Depends on the user, the project, and perhaps the specifics of the risks under consideration.

14. Are all the required inputs available to the users?
By the nature of the problem there will be uncertainty around the inputs – even the probabilities! However, where there are reasonable data available the approach should add value.

H. USEABILITY OF THE SOFTWARE PROTOTYPE

7. Assessment of the usability of the tool in terms of features

c. What are the strongest features?

Definitely the assessment of mitigation actions in my view

d. What are the weakest features?

No major weaknesses Integration with other tools would require further consideration in the future. Also flow through of changes to mitigation actions isn't complete. Hopefully a means of entering a specific numerical estimate of risk probability rather than always assuming the mid-point of a general range will be added.

8. Assessment of the usability of the tool in terms of features

c. How clear and appropriate are the considered terminologies in the framework?

They seem clear to me and I don't think someone familiar with the domain would have problems

d. Please suggest possible improvements

As noted elsewhere, a means of capturing the analysis for each risk in turn in a central location would be very beneficial. Although it keeps things simple to have separate worksheets for assessing differing risk levels, this means there is a lot of near-duplication, which brings with it a maintenance burden. Perhaps in the future a means of generalising this aspect could be considered?

9. Does the tool provide sufficient amount of information to guide the user? Yes No

If no, please explain:

It would be useful to distinguish the worksheets that require inputs from the information-only worksheets, e.g. by colour coding the tabs.

10. Assess the time required to populate the tool for implementation on a project
To be addressed with final version of tool.

11. Please assess the following aspects in the tool

- e. Layout *Good*
- f. Use of colour *Good*. Colour coding is used effectively but with restraint
- g. Ease of navigation *Good*. The navigator at the top of the screen is very helpful.
- h. Level of intuition *Generally good* but some aspects not obvious

12. Is the tool flexible enough to be applied with different levels of information availability?
Probably, but this would have to be determined by usage on different case studies.

I. ASSESSMENT OF THE FRAMEWORK

Please assess the completeness/suitability of the framework for the following questions

- i. Evaluation of the Risk severity by considering likelihood and impact (consequences)

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies			Suitable with minor deficiencies			Totally comprehensive		

If it is not totally comprehensive, please explain the reasons:
At this level of detail, the ability to specify a numerical quantity for a risk becomes a key requirement. Fixing this will yield a higher score.

- j. Evaluation of the Strategies by considering Likelihood and Impact reduction and Confidence increasing

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies			Suitable with minor deficiencies			Totally comprehensive		

If it is not totally comprehensive, please explain the reasons:
It is of limited value to consider the reduction of probability of impact without having a specific estimation of probability as a starting point (point a)

- k. The approach to define the weight of the three previously mentioned aspects

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies			Suitable with minor deficiencies			Totally suitable		

If it is not totally suitable, please explain the reasons:
Not clear to which part of the tool this refers.

- l. Calculation of the Mitigation strategy score based on the multiplication of likelihood and impact reduction and confidence increasing weighted on their importance

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies			Suitable with minor deficiencies			Totally suitable		

If it is not totally suitable, please explain the reasons:

I think this is a strong point as it goes beyond what people normally do. As an observation, the tool makes the assumption that probability, impact and confidence can only ever stay the same or improve through a mitigation action. This is probably true in almost all cases, but there may be exceptions, so perhaps the sliding scale should not start at the current value.

m. The approach to define cost drivers - risks linkage (Causes of variation on risk impact)

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

I still can't decide on this one so haven't scored. Not clear what this linkage is adding. It is true that risks can be classified into subgroups other than by impact and probability, and this is important if the number of risks is large. But this might be on the basis of criteria other than cost drivers. I feel the tool would be usable (and might be used) without this feature.

n. The inputs required

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

The inputs are appropriate if one assumes this functionality adds value, so positive response to this question - but the broader comment still applies!

o. The suggestions for providing the right set of inputs

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

Not clear to which part of the tool this refers.

p. The process of turning a three point estimate into a single point estimate (Strategy selection)

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies				Suitable with minor deficiencies				Totally comprehensive

If it is not totally comprehensive, please explain the reasons:

Not clear to which part of the tool this refers. Where is a 3 point estimate turned into a single point estimate?

J. RESULTS

2. Evaluation of the output of the tool after populating it with information from the case study to *be addressed with final version of tool.*
3. Evaluation of the repeatability of the tool after populating it with the same information from the case study
To be addressed with final version of tool.

Questionnaire from: Cost Engineering Manager
RISK MANAGEMENT TOOL FRAMEWORK VALIDATION QUESTIONNAIRE

A. General:

- 9. Name: Antony Higham
- 10. Organisation: BAE systems Submarines
- 11. Role: Cost Engineering Manager
- 12. Years of experience (in Risk Mgmt.): None however over 20 years of developing and price risk

B. OVERVIEW OF THE CASE STUDY

5. Description of the case study

.....

6. The information that is available

.....

C. LOGIC

7. How logical is the way of dealing with risks and mitigation strategies (like considering likelihood and consequences as main features of risks and evaluating mitigation strategy under three main aspects- likelihood and impact reduction and confidence increasing- and combine them together) (Assign a circle around the suitable number)

1	2	3	4	5	6	7	8	9	10
Totally Unsuitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally Unsuitable

If there are deficiencies please describe them:

.....

8. Is the framework suitable for the bidding phase?

1	2	3	4	5	6	7	8	9	10
Totally Unsuitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally Unsuitable

If it is not totally suitable, please explain the reasons:

.....
.....
.....

Are there any improvement suggestions:
The tool must be simple or it will not be used

Can the framework be applied in alternative phases to the bidding stage? Yes No
If yes, please specify which phases

The mitigation tracker is an ideal part of the tool that should be used part the bid stage to understand if the mitigation action has been completed properly, through life of the project.

D. GENERALISABILITY

5. Please comment on how generalizable the framework is within the defence industry
All the categories are covered

6. Please comment on how generalizable the framework is for other contexts or sectors (not just CfA and Defence Industry)
It should cover all sectors

E. RESPONSIBILITY

7. How should the framework be used across the supply network? (e.g. only solution provider (OEM), or with the customer and/or suppliers) Why?
.....
.....
.....

8. What team or department should have ownership or responsibility of the model within the company?
The risk team with the Cost Engineering supplying information at the bid stage

9. How could the team or department owning the framework maintain it?
This would be kept under configuration control by the risk team

F. BENEFITS OF USING THE FRAMEWORK

7. How would the framework benefit the company?
It would be an initial tool that would capture the development of risks with the final position held in our current risk repository

8. How would the framework benefit in dealing with risks? Can it make the evaluation process quicker?
I don't believe it will be any quicker but the traceability will be better

9. Is it reasonable to consider the choice made by tool as the most suitable mitigation strategy? Are all relevant aspects taken into account? Express an opinion and make some suggestions

Yes it is reasonable to assume that it will produce the most suitable, however I haven't been able to test the tool with real information yet.

G. LIMITATIONS OF THE FRAMEWORK

15. What are the potential limitations and challenges in using and implementing the tool?
After running through the tool a few times it becomes clear that it's not that hard to use, but at first it looks complicated.

16. What are the potential organisational limitations and challenges that arise in using the software tool?
Integrating it with other tool currently being used

17. How could the background of people filling the tool affect the output?
Given the clear instructions this minimises this affect

18. Risk evaluation: should other aspects be taken into account? Yes No
If yes, which ones?.....
.....
.....

19. Mitigation Strategy selection: should other aspects be taken into account? Yes No
If yes, which ones?.....
.....
.....

20. Can a single index be representative of a strategy? Can the three main aspects be grouped together?
A diagram showing the three areas and how they interact together would be useful; this could be as an overview

21. Are all the required inputs available to the users?
Yes

H. USEABILITY OF THE SOFTWARE PROTOTYPE

13. Assessment of the usability of the tool in terms of features
e. What are the strongest features? **The documentation of the mitigation options**
f. What are the weakest features?
On first viewing the tool it appears large and hard to use, but after using it, it becomes clear. For smaller type bids it could have a short cut incorporated

14. Assessment of the usability of the tool in terms of features
e. How clear and appropriate are the considered terminologies in the framework?
Good
f. Please suggest possible improvements

.....

15. Does the tool provide sufficient amount of information to guide the user? Yes No

If no, please explain:

.....

16. Assess the time required to populate the tool for implementation on a project

Per each risk about an hour each

17. Please assess the following aspects in the tool

- i. Layout - **Very Good with the arrows at the top**
- j. Use of colour – **Good**
- k. Ease of navigation – **Very easy**
- l. Level of intuition – **Medium.**

18. Is the tool flexible enough to be applied with different levels of information availability?

Only tried with a small amount of data today but looks like it is

I. ASSESSMENT OF THE FRAMEWORK

Please assess the completeness/suitability of the framework for the following questions

q. Evaluation of the Risk severity by considering likelihood and impact (consequences)

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies				Suitable with minor deficiencies				Totally comprehensive

If it is not totally comprehensive, please explain the reasons:

Further tests required by use to understand the suitability.

r. Evaluation of the Strategies by considering Likelihood and Impact reduction and Confidence increasing

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies				Suitable with minor deficiencies				Totally comprehensive

If it is not totally comprehensive, please explain the reasons:

.....

s. The approach to define the weight of the three previously mentioned aspects

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

Further tests required by use to understand the suitability.

- t. Calculation of the Mitigation strategy score based on the multiplication of likelihood and impact reduction and confidence increasing weighted on their importance

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

.....

- u. The approach to define cost drivers - risks linkage (Causes of variation on risk impact)

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

.....

- v. The inputs required

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

.....

- w. The suggestions for providing the right set of inputs

1	2	3	4	5	6	7	8	9	10
Totally suitable	Suitable with major deficiencies				Suitable with minor deficiencies				Totally suitable

If it is not totally suitable, please explain the reasons:

.....

- x. The process of turning a three point estimate into a single point estimate (Strategy selection)

1	2	3	4	5	6	7	8	9	10
Totally Incomprehensive	Suitable with major deficiencies				Suitable with minor deficiencies				Totally comprehensive

If it is not totally comprehensive, please explain the reasons:

.....
/.....

J. RESULTS

- 4. Evaluation of the output of the tool after populating it with information from the case study **Have only done part tests on this and therefore require further time to understand, but looks capable**
- 5. Evaluation of the repeatability of the tool after populating it with the same information from the case study **Looks good**

ANNEX B - FRAMEWORK DESCRIPTION AND DEVELOPMENT

Information provided below has been taken from the ACT government website. The provided a useful support in developing the framework and its guidelines.

Source: <http://www.cwd.act.gov.au/act-insurance-authority/risk-management>
(ACT Government - Actia, 2004)

RISK MANAGEMENT TOOLKIT



Insurance & Risk Management Strategies

Attachment 1 – Risk Assessment Matrix

E – Extreme risk – detailed action plan required
 H - High risk – needs senior management attention
 M – Medium risk – specify management responsibility
 L – Low risk – manage by routine procedures

High or Extreme risks must be reported to Senior Management and require detailed treatment plans to reduce the risk to Low or Medium.

				Consequence					
				People	Reputation	Business Process & Systems	Financial		
				Injuries or ailments not requiring medical treatment.	Minor injury or First Aid Treatment Case.	Serious injury causing hospitalisation or multiple medical treatment cases.	Life threatening injury or multiple serious injuries causing hospitalisation.	Death or multiple life threatening injuries.	
				Internal Review	Scrutiny required by internal committees or internal audit to prevent escalation.	Scrutiny required by external committees or ACT Auditor General’s Office, or inquest, etc.	Intense public, political and media scrutiny. Eg: front page headlines, TV, etc.	Assembly inquiry or Commission of inquiry or adverse national media.	
				Minor errors in systems or processes requiring corrective action, or minor delay without impact on overall schedule.	Policy procedural rule occasionally not met or services do not fully meet needs.	One or more key accountability requirements not met. Inconvenient but not client welfare threatening.	Strategies not consistent with Government’s agenda. Trends show service is degraded.	Critical system failure, bad policy advice or ongoing non-compliance. Business severely affected.	
				1% of Budget or <\$5K	2.5% of Budget or <\$50K	> 5% of Budget or <\$500K	> 10% of Budget or <\$5M	>25% of Budget or >\$5M	
				Insignificant	Minor	Moderate	Major	Catastrophic	
				1	2	3	4	5	
Likelihood ↑	Probability:	Historical:							
	>1 in 10	Is expected to occur in most circumstances	5	Almost Certain	M	H	H	E	E
	1 in 10 - 100	Will probably occur	4	Likely	M	M	H	H	E
	1 in 100 - 1,000	Might occur at some time in the future	3	Possible	L	M	M	H	E
	1 in 1,000 - 10,000	Could occur but doubtful	2	Unlikely	L	M	M	H	H
1 in 10,000 - 100,000	May occur but only in exceptional circumstances	1	Rare	L	L	M	M	H	